

The Application of Game Theory in Library Booking System

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Abstract

Library booking is an important problem nowadays, which decides budgets of the whole library. Therefore, we should present proper model or method to solve this problem. This paper applies cooperative game theory and non-cooperation game theory when designing a library booking system to analyze the above problem. More especially, we analyze the problems in library booking system towards the view of game theory. Then we present two applications of cooperative and non-cooperation game theory respectively. Simulation experiments are set up according to the applications and the results are of consistence to the former analyses. Therefore, we solve the booking problem with game theory. Finally we conclude that game theory is an efficient tool, which can solve various problems in library booking and can also give credible results to improve efficiencies.

Keywords: Booking System; Nash Equilibrium; Cooperative Game; Non-cooperation Game

1 Introduction

Since 1990s', information technology especially computer technology are widely applied in the management in school, company and government etc. With the perfect development of information and markets, entities in the whole society raise higher requests for the service level and capacity of library such that libraries should improve their service level and capacity according to the requests. Therefore, some changes must be taken in information collection, organizing processing, information service, management model etc.

This paper mainly studies how to solve the above problems by using game theory. More specifically, we analyze the union benefit assignment using cooperative game theory and analyze the submitted booking data using non-cooperative game theory. The library booking system based on game theory is much well and hommization. Furthermore, library booking model can not only save money but also can satisfy the requests.

2 Basic Notions of Game Theory

Game theory devote to the study of strategic decision making. In other words, it discusses mathematical models with conflict and cooperation among intelligent rational decision-makers[1]. Game theory is also called interactive decision theory, where a more descriptive name for the discipline[2]. Normally, game theory is mainly applied in economics, political science, and psychology, as well as logic, computer science, and biology. There are various kinds of games in game theory such as zero-sum game, non-zero-sum game, cooperation game and non-cooperation game etc. Zero-sum games mean that one person's gains exactly equal to the losses of the other participants.

Cooperation game means that parties can conform to one mandatory agreement. It emphasizes collective rationality to reflect efficiency and fairness. On the other hand, non-

cooperation game emphasizes individual rationality and optimal choice for individuals. The results may be effective or may be not. Parties in non-cooperation games will have to cooperate in order to get maximum payoffs. Complete rationality assumed in non-cooperation game is rare in reality since most parties are limited rational, which makes difference between theoretic equilibrium and real choice. Therefore, bring cooperation game into non-cooperation game is a trend in game theory.

Non-cooperation game means one kind of game where parties can not reach a constraint. This game has a sense of incompatibility. Non-cooperation game studies how to maximize their own payoff where parties interact with each other. In non-cooperative games, the most famous notion is the Nash equilibrium, which is defined as follows: if each strategy represents a best response to the other strategies, then a set of strategies is Nash equilibrium. Therefore, all parties have no incentives to deviate if all the parties are playing the strategies according to a Nash equilibrium. The reason is that the strategy in Nash equilibrium is optimal for them[3-4].

Nowadays, game theory has a wide range of behavioural relations. In addition it has developed into an umbrella term for the logical side of decision science, including both humans and non-humans such as computers, insects or animals etc.

The basic idea of modern game theory derives from the idea with respect to the existence of mixed-strategy equilibriums in zero-sum games and its proof by John von Neumann. The original proof used Brouwer fixed-point theorem on continuous mappings into compact convex sets, which became a standard method in game theory and mathematical economics. Oskar Morgenstern considered cooperative games of several players. Lately, the second edition of this book provided an axiomatic theory of expected utility. The expected utility allowed mathematical statisticians and economists to regard decision-making as

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uncertainty.

Game theory was developed extensively in the 1950s by many researchers and was later explicitly applied to biology in the 1970s. Although similar developments can be retrospect at least as far as the 1930s, it is popular recently. In many fields, game theory has been widely recognized as an important tool. There are altogether eleven game-theorists have now won the economics Nobel Prize. The most recently Nobel Memorial Prize in Economic Sciences is achieved by game theorist Jean Tirole in 2014. John Maynard Smith was awarded the Crafoord Prize for his application of game theory to biology.

In the fields of competing behaviors of interacting agents, game theory is used as a major method to model mathematical economics and business problems[5]. Many applications can use game theory including a wide array of economic phenomena and approaches, such as auctions, bargaining, mergers & acquisitions pricing[6], fair division, duopolies, oligopolies, social network formation, agent-based computational economics[7], general equilibrium, mechanism design[8], and voting systems[9]; and across such broad areas as experimental economics[10], behavioral economics[11], information economics[12], industrial organization[13], and political economy[14-15].

The notion of payoffs in game theory generally represents the utility of individual parties. Normally in some economic situations the payoffs represent money, which is simple to compute an individual's utility[16].

A classical paper in game theory in the fields of economics would like to present a game as an abstraction of a particular economic situation. There is one or more solution concepts are chosen, and the author demonstrates which strategies are equilibriums of the appropriate type. Parties may have no idea how to use this information should be put. Economists and business researcher suggest two primary usage as mentioned above: descriptive and prescriptive[17].

3 Game Theory in Library Booking System

As a special organization, library has scale economy and step into marketization in various fields of management. Most libraries of other countries tend to provide deregulation, integration services. During the process of introducing competence, there are lots of unprecedented new topics to confront. Fortunately, some of these topics can be solved by game theory. As participants of the market, libraries or book subscribers can analyze markets by using game theory and study how to order the price in order to maximize their income. Firstly, the developers analyze the market, choose development objects, and study the details of supply and demand etc. before they design a system. Secondly, they can make flow chart and functions for each model. Thirdly, they should choose proper development platforms and software to design system interface and write back-end codes.

The usage of game theory in this paper is to guide the system to choose correct models and solutions according to the characters of library booking systems. The main functions of a library booking system consist of the follows. Users enter into the system, and then they can browse or query book information. Users can place orders through shopping cart after they registered in the system. The system shows the details of order forms including book names, price, numbers etc. If users are not satisfied with these books, they can also update or abandon the orders. If users decide to remain the orders, then they will choose the methods of payment and delivery. Then users fill in detailed address and contact information after submit the order forms. Furthermore, administrators can manage books and customer data.

In this library booking system, there are lots of places to use game theory. For example, the case where two comparable IT companies provide service is fit for Cournot model and Nash bargaining solution method. The case where library and network provide service is fit for Stackleberg model. It involves credible commitment and Nash equilibrium after submitting the order forms. The whole system involves supply chain coordination problems and the choice of delivery. Furthermore, there are also some other problems such as alliance problem. That is, how to recognize partners and how to fairly assign among alliance.

In the library market, booking as a service, should solve the following problems such as system maintenance, networked and fixed investment. These problems have different solutions, such as stable sets, kernel and Shapely value etc. It is an urgent problem to properly choose or create relatives solutions.

In addition, the setup of database is an important part in library booking system and the toughest task in the automated build process. The main task of this process is to access the database and communicate with other business models. This process needs lots of manpower and material. Therefore, most libraries may choose outsourcing this part to database contractor. The outsourcings have two methods. One is according to card information and the other is according to document information. The problem of which one can bring more payoffs is also can be solved by game theory. The former method is simple and economical. However, it may not reach correct information due to lacking information of cards. The latter method is good.

4 Case Analyses

4.1 THE APPLICATION OF COOPERATION GAME THEORY

Two keynote points in cooperation game are: how to form an alliance and how to assign benefits among them. Suppose there are there users in the system: Library A, book supplier B and system developer C. They face the problem of how to form alliance. The alliance and individual income is shown in Table 1.

TABLE 1. The alliance and individual income

Alliance	Independently	Two merge, one independ			Merge
Pattern	A B C	AB C	AC B	BC A	ABC

Income	32 23 6	59 5	45 22	39 30	77
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Whether A,B and C make an alliance depends on if it is reasonable to assign by using Nash-Harsanyi Bargaining model. The results show that they have optimal payoffs if they merge as one alliance. Therefore, it should correctly process the relationships between system developer and book supplier when we choose proper cooperation object.

Library booking service includes collection, editing and assignment. The books bibliography data are distributed when booking online is completed. Otherwise, if these works are done manually, it costs a lot. Therefore, if the book suppliers want survive under the market economic environment, must be customer-centric to satisfy the requirement of customers. This competition bring additional discount and service including bibliographic data distribution and security article, stamp collections, barcode and label manual processing. If libraries sign with book supplier to cooperate, then library database constructions (e.g. book barcode, label, stamp collection book etc) are done by book suppliers.

Meanwhile, library can also cooperate with system developer and outsource the system management works to system developer. On one hand, libraries can make up the inadequacy of their own through intellectual resources. On the other hand, libraries can improve its advancement by alliance since they can not introduce senior technician due to objective factors.

Once the alliance if formed, it becomes the research contents to properly assign their benefits. Note that two basic conditions in cooperation game are: (1) the whole benefit is higher than the total of individual benefits; (2) there should exists an assignment rule which satisfies Pareto property. Pareto property means that every party in one alliance can not achieve more if they do not participate in an alliance. We can use optimal method, stable set, and Shapley

TABLE 3 Finding intersections for suppliers

		Buyer				
		Book1	Book2	Book3	Book4	Minimum
Supplier	Scheme1	6	1	5	1	1
	Scheme 2	1	2	3	4	1
	Scheme 3	4	3	5	5	3
	Scheme 4	4	2	1	6	1
	Maximum	6	3	5	6	

In Table 3, if the maximum among the minimize line is equal to the minimum among the maximize lien, and then the corresponding value is called pure strategy. Here we call it saddle point. Maximin show that each participant has a

value method to guarantee the above requests. Although this is not fall in the problem in booking system, we must consider them when set up library system.

4.2 THE APPLICATION OF NON-COOPERATION GAME THEORY

When designing library booking system, product original price and current prices should be provided. This requirement uses the concept of game theory. Suppose library is supplier and book order is buyer. The object s is books for both of them. Buyer hope price the lower the better, while the supplier hope a higher price. Suppose there are four books which have similar contents but come from different publishers. Buyers should decide to book one of them while supplier gives four prices for each book as shown in Table 2.

TABLE 2 Prices for each book and supplier

		Order			
		Book1	Book2	Book3	Book4
Supplier	Scheme 1	6	1	5	1
	Scheme 2	1	2	3	4
	Scheme 3	4	3	5	5
	Scheme 4	4	2	1	6

If they only consider their own benefit in their points and do not be at loggerheads with. The conflicts between them are only aggravated without any results. However, if supplier can be rational and find the minimum value in the intersection in Figure 3, then the problem can be solved.

high limit. That is, supplier should choose scheme 3. Furthermore, these results can be simulated by software as shown in Figure 1 and 2.

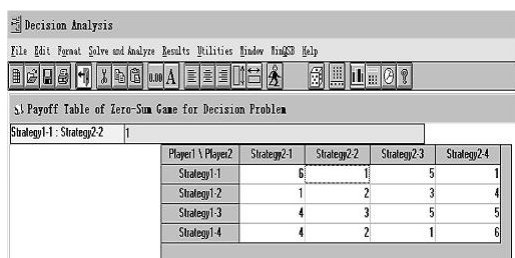


FIGURE 1 Inputs of data

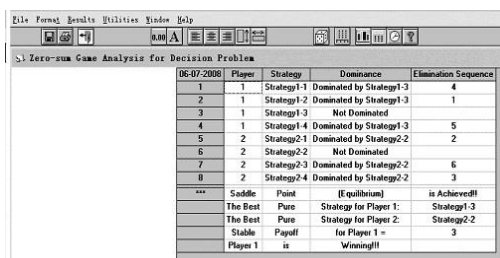


FIGURE 2 Results analysis

We can easily find optimal scheme for them from the figures. Therefore, two prices may appear when designing system such that users may choose one. During this course, users should consider the benefits of others and they should choose optimal price willingly.

Furthermore, as an economic method, the transaction information can be analyzed by using Nash equilibrium when ordering data is submitted. This method can lead to proper service and transaction prices for supplier and buyers. Furthermore, we can also use a two-stage iterative calculation method to handle the coordination of external trade and internal books scheduling. The game model in two-stage iterative calculation method is non-zero game and utilizes Nash negotiation justice as the arbitration procedures. Finally, reasonable prices can be reached. This analysis is totally based on complete information game

5 Conclusions

The key function of library is knowledge and information, which can be products, contents, or service etc. That is, they

can be various forms here. Either group users or personal users, library can both find their own industry price and profit source in order to find its own industry entity. Designation of library booking system can efficiently share resource to avoid wasting the sources. Furthermore, it can also bring considerable economic benefit for library, such as membership fee income, investment income and online publication sales revenue etc. In this paper, we choose game theory as an application method to solve the problem of library booking and simulate the results of our model. The results show that game theory has broad application in this field.

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