Application of Game Theory in Airport Cooperation Alliance

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Abstract

According to the Airport Production Statistics Bulletin 2018 issued by the Civil Aviation Administration, the annual passenger throughput of China's airports reached 1.264 billion in 2018, an increase of 10.2% over 2017. The bulletin statistics the development data of each airport: 37 airports with annual passenger throughput of more than 10 million people. By the end of 2018, there were 235 airports in China, of which 53 accounted for 95.2% of the total airport passenger throughput and 98.7% of the total airport cargo and postal throughput.This set of data means that the passenger throughput of 235 airports in China accounts for only 5% of the annual passenger throughput of all airports, while the cargo and postal throughput accounts for 2.6% of the total cargo and postal throughput of all airports. The serious uneven distribution of business leads to a loss of 65% of the airports in China.There are two reasons for this phenomenon: first, part of the airport is for the purpose of "face-saving project". It does not consider the real local air transport demand at all. The local government considers the optimization of the investment environment brought about by the construction of the airport more than the break-even of the airport operation.Secondly, some airports have been built to meet the growing demand for air transport, but the local passenger and cargo flow has been greatly overestimated in planning and design. Airport Cooperative Alliance mainly opens air routes. For airports whose main revenue comes from aircraft take-off and landing charges and terminal charges, airline cooperation is the most substantial win-win situation.Apart from opening the air express line, there is still much cooperation between airports.For example, we should explore the network construction of freight stations in other places, develop cooperation in airport planning and personnel IT, expand the market through joint marketing and air express lines, and strengthen the combination of trunk and branch.The airport can also unite with the outside world to win the support of Civil Aviation Bureau for the right flight schedule, customs and other support for intermodal inspection, to open low-altitude airspace, to strive for "group purchase preferences", and to win the government's financial support for seamless transfer of various means of transport.

Keywords

Application, Game , Airport Cooperation.

1. Summary of Game Theory

Game theory, also known as game theory or game theory, studies how rational players choose their own strategies in order to maximize their own interests and the equilibrium of such strategies in situations where interests interact with each other.It is a branch of applied mathematics. It is not only a new branch of modern mathematics, but also an important subject of operational research.At present, biology, economics, international relations, computer science, politics, military strategy and many other disciplines have a wide range of applications.This paper mainly studies the interaction between formulaic incentive structures (game or game). It is not only a mathematical theory and method to study the phenomena of struggle or competition, but also an important subject of operational research.In the real economy, there are numerous examples of the interaction between people's decision-making behavior.For example, oligopoly enterprises choose the price and output of their products; OPEC member countries choose the output of oil; family members'decision-making on household consumption; labor negotiations between employers and trade union organizations; contracts between supervisors and regulated persons; negotiations between banks and customers, etc. These are typical game problems, and the application of game theory can be seen from this. The basic elements of game structure are players, strategies, rules, information, payoff and equilibrium.

Nash equilibrium is an optimal strategic combination of all participants (the strategic combination can be defined as: assuming n individuals participate in the game, each person chooses his own optimal strategy under the given strategy of others (the individual optimal strategy may or may not depend on the strategy of others). The strategy chosen by all participants constitutes a strategic combination.Nash equilibrium means that given the strategy of others, no single participant has the initiative to choose other strategies, so no one has the initiative to break the balance.According to the above concept of game theory, the participants in the game analysis of airport strategic alliance are national airports. The interests of these participants depend on each other and influence each other. The simplification of airport payment function is mainly influenced by the decision-making of other participants.Table 6-L lists the corresponding relationship between the game framework and the airport alliance, and further illustrates that the airport alliance can be regarded as a game structure.

Table 1-1 Correspondence between Airport Alliances

Play a game	Airport Alliance
Participant	National Civil Airport
union	Airport Alliance
strategy	From Daily Management to Long-term Development Strategy
Result	Financial support, more airspace resources, integration of regional airline resources, etc.

2. Game Model of Airport Strategic Alliance

Let the probability of cooperative behavior of airport A be P, and the corresponding probability of selfish behavior is 1-p; the probability of cooperative behavior of airport B is q, and the corresponding probability of selfish behavior is l-q.Simplified listing of game matrices is shown in Figure 1-1 below.

		Airport B	
		Cooperation (q)	Betrayal (1-q)
Airport A	Cooperation (p)	F_{1A} , F_{1B}	0, F_{2B}
	Betrayal (1-p)	F_{3A} , 0	0 , 0

Figure 1-1 Airport Strategic Alliance Payment Matrix

Cournot (1883) oligopoly competition model can be said to be the earliest version of Nash equilibrium.In the Kurnot model, there are two participants, namely Enterprise 1 and Enterprise 2. Each enterprise strategy chooses output; Payment is profit, which is the function of output of two enterprises.We use the output representing the first enterprise as a continuous separable variable, the cost function, the clearing price function, and the profit function of the second enterprise as follows:

$$\pi_i(q_{1,}q_2) = q_i P(q_1 + q_2) - c_i(q_i) \tag{1-1}$$

It is Nash's balanced output, which means that profits must be met; and maximizing:

$$\begin{cases} \pi_1(\max) = q_1 P(q_1 + q_2^*) - c_1(q_1) \\ \pi_2(\max) = q_2 P(q_1^* + q_2) - c_2(q_2) \end{cases} \tag{1-2}$$

One way to find out Nash equilibrium is to find the first derivative of each enterprise's profit function and make it equal to zero.

$$\begin{cases} \dfrac{\partial \pi_1}{\partial q_1} = 0 \\ \dfrac{\partial \pi_2}{\partial q_2} = 0 \end{cases} \tag{1-3}$$

In order to obtain more specific results and to facilitate the elaboration of the problem, we will consider the simplicity of the above model, assuming the following:

(1) Enterprise 1's output is; Enterprise 2's output is; Total market output

(2) Market clearing price function

(3) The two enterprises have the same invariable unit cost, i.e.

(4) The two enterprises operate independently in the market and do not ventilate each other.

Then the first-order conditions of optimization are:

$$\begin{cases} \dfrac{\partial \pi_1}{\partial q_1} = a - (q_1 + q_2) - q_1 - c = 0 \\ \dfrac{\partial \pi_2}{\partial q_2} = a - (q_1 + q_2) - q_2 - c = 0 \end{cases} \tag{1-4}$$

(q_1^*, q_2^*) It is Nash equilibrium output, which is solved by two formulas in formula 6-4.

$$q_1^* = q_2^* = \frac{1}{3}(a-c) \tag{1-5}$$

Nash Equilibrium Profits for each enterprise are:

$$\pi_1(q_1^*, q_2^*) = \pi_2(q_1^*, q_2^*) = \frac{1}{9}(a-c)^2 \tag{1-6}$$

Now the two enterprises can be regarded as a monopoly through alliance.The total profits of monopoly enterprises are:

$$\underset{Q}{Max}\, \pi = Q(a - Q - c) \tag{1-7}$$

It is easy to calculate the optimal output of monopoly enterprises.

$$Q^* = \frac{1}{2}(a-c) < q_1^* + q_2^* = \frac{2}{3}(a-c) \tag{1-8}$$

Monopoly profits are:

$$\pi^* = \frac{1}{4}(a-c)^2 > \frac{2}{9}(a-c)^2 \tag{1-9}$$

It can be seen from this that the total amount of Oligarchy Competition is larger than the alliance, and the profit is less than the alliance, which is obviously uneconomical. Therefore, it is beneficial for both sides to choose the alliance.There are some irrationality in the investment of airport facilities in China, and the scale construction is also insufficient, which affects the efficiency of airport operation. In order to effectively improve the efficiency and efficiency of airport operation, we can adopt the mode of airport cooperation alliance.

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