Evolutionary Game Analysis of Navigation Disputes Based on Information Asymmetry

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***Abstract*—Based on game theory and information economics, this paper establishes a game model of disputes between airlines and passengers with information asymmetry and studies its evolutionary stability strategy. The model can be used to predict and evaluate the status of the relationship between airlines and passengers, and to regulate the development of the relationship between airlines and passengers in a benign direction by adjusting the unit income cost and the degree of information asymmetry. The causes and processes of disputes between airlines and passengers are discussed, and policy suggestions are put forward to improve the relationship between airlines and passengers and to build the trust of airlines based on game theory.**

Key words—information asymmetry, evolutionary game, airline and passenger disputes

I. THEORETICAL CATEGORY OF GAME THEORY

In the past 20 years, game theory, as a tool for analyzing and resolving conflicts and cooperation, has been widely used in management science, international politics, ecology and other fields. Simply put, game theory is to study how decision-makers make decisions under given information structure to maximize their own utility, and the equilibrium of decision-making among different decision-makers. Game theory consists of three basic elements: decision-making subject, which can also be translated into participants or players; given information structure, which can be understood as the participants' choice of strategies and action space, also known as strategy set; utility, which is the interests of participants that can be defined or quantified, is what all participants really care about, and it is called preference or payment function. Participants, strategy sets and utility constitute a basic game.[1]Game theory can be divided into cooperative game and non-cooperative game. The difference between the two is whether the participants can reach a binding agreement in the game process. If not, it is called non-cooperative game. Non-cooperative game is the focus of modern game theory. When choosing their own actions, the participants give priority to how to safeguard their own interests.[2]

II. ANALYSIS FRAMEWORK OF INFORMATION ASYMMETRY

Information asymmetry is one of the important characteristics of civil aviation transport disputes game. The amount of transport information that both sides of the shipping industry have determines the strategy choice of the participants in the game, the development direction of the shipping disputes, the degree of the conflict and the benefits of both sides. Asymmetric information between airlines and passengers leads to incomplete identification of responsibility for flight delays and other issues. According to information economics, information asymmetry results in the imbalance of interests of both parties in market transactions, and affects the principles of social fairness and justice, as well as the efficiency of market allocation of resources. In the case of incomplete information, Airlines tend to blame force majeure factors, such as climate, to shirk responsibility. Similarly, passengers tend to blame airlines for flight delays and claim compensation. The cost of obtaining responsibility information about flight delay is different from each other. The cost of obtaining relevant information by airlines is obviously lower than that of airline passengers. Therefore, in protecting the property right of delay time, passengers are at a disadvantage and their interests are often occupied by airlines. For example, airlines use information asymmetry to explain the reasons for flight delays, and to hide more or less intentionally the attempts and actions of passengers in order to evade liability for compensation. Therefore, passengers often hold a distrustful attitude towards the delay explanation of airlines, which deepens the degree of divergence and conflict between the two sides.[3]

A. Model Hypothesis

Assuming that the liability for compensation for the faults of the civil aviation air company industry is F, F, as the benefit shared by both sides of the aviation industry, both sides are eager to obtain more of this benefit. The degree of asymmetry of navigation information is i, $i \in [0, 1]$. Because the principle of liability for fault is applied in civil aviation transportation damage compensation, the degree of asymmetry of travel information determines the amount and proportion of the passengers' knowledge of the airline's fault, and then determines the amount and proportion of compensation, so it is assumed that the benefit shared by passengers is proportional to the degree of asymmetry of travel information (i), and the benefit shared by airlines is proportional to the degree of residual information (1-i) that passengers do not know.

B. Model Construction

Based on the above assumptions and the classical eagle-pigeon game model, a civil aviation transport disputes game model with the degree of asymmetry of navigation information is established. In the game, both sides can adopt cooperative strategy or conflict strategy, and cooperative strategy (pigeon strategy) can distribute the revenue for both sides through cooperative attitude negotiation. Negotiations are distributed proportionally according to the amount of air transport information i that the two parties have at their disposal. Conflict strategy (hawk strategy) upgrades and confronts contradictions and disputes, and the total cost of conflict is C. Although the cost of the conflict is higher for the airlines, the cost paid by the airlines is ultimately shared by the passengers. According to the principle of positive correlation between revenue and cost, assuming that the conflict cost is proportional to the benefit of both parties, the conflict cost of passengers is proportional to i, and the conflict cost of airlines is proportional to 1-i. If one of the participants adopts cooperative strategy and the other adopts conflict strategy, the one of the cooperative strategy cannot get the benefits, and the other of the conflict can get all the benefits. Let u1 be the passenger's revenue function and u2 be the airline's revenue function.[4]

C. Model Solution

When fault liability is greater than conflict cost, conflict strategy is a strict superior strategy for both sides of the voyage when F is greater than C. At this time, the Nash equilibrium of the game is solved as (conflict, conflict). The Nash equilibrium solution airline fault liability is heavier, especially in the case of liability accidents or serious damage, passengers to safeguard their legitimate rights and interests, must resolutely adopt the right-advocating strategy, the more serious the damage, the stronger the will to advocate rights, even at the risk of serious conflicts. In order to avoid serious civil liability and severe administrative accountability, airline employees and their affiliated organizations will do their utmost to cover up the facts of violation of laws and regulations and deny the fault and responsibility when a liability accident or serious damage occurs. In this case, the conflict of navigation contradictions is inevitable, so the Nash equilibrium solution of the airline and passenger disputes game is the theoretical root of the difficulty to reconcile the contradiction of navigation in the event of a liability accident or serious damage.

At this time, the returns of both sides are u2=(1-i)(F-c),u1=i(F-c).

When the fault liability is less than or equal to the conflict cost, when F < c, neither side of the voyage has strict superior strategy nor inferior strategy, but when one participant chooses conflict strategy, the other participant can only adopt cooperative strategy, otherwise the other participant's profit is negative, so this game has two pure strategy Nash equilibrium solutions: (conflict, cooperation) and (cooperation, conflict) The revenue of both sides is u1=F,u2=0 and u1=0,u2=F, respectively.

Nash equilibrium solution (conflict, cooperation) is the theoretical root of "air rage" and "the more terrible the trouble, the more compensatory it will be" in reality. Because as long as the passenger side resolutely adopts the conflict strategy, the airline enterprise can only adopt the cooperative strategy, otherwise its profit is negative and the loss is not worth it. The more the passenger side makes trouble, the higher the conflict cost caused, the more the airline enterprise may compensate. Nash equilibrium solution (cooperation, conflict) is the theoretical basis of effective "air rage ". The prepaid cost of hiring a group of professional troublemakers to provoke trouble at airports and other places is also high. For the unreasonable and excessive demands put forward by the " air rage " passengers, as long as the airlines resolutely adopt the strategy of conflict and non-cooperation, at the same time let the passengers clearly understand their firm attitude and high negative returns, as well as the possible criminal responsibility, the rational passengers can only adopt the strategy of cooperation in the end, otherwise their economic losses will be very high.[5]

The Nash equilibrium solution of these two pure strategies is unstable, because any participant in the game cannot always choose the conflict strategy to obtain the maximum benefit, because the other party cannot always bear the outcome of zero profit, it will take the conflict strategy with a certain probability, punish the opponent, and make the opponent lose all his money. Therefore, there is a mixed strategy Nash equilibrium solution in this game: the participants of the game adopt conflict strategy with a certain probability P, and choose cooperation strategy with a probability of 1-P. The participants in the game can adjust the probability value of their strategy constantly according to the strategy choice and benefits of other participants, and through learning and imitation, so as to maximize the benefits of themselves and their own groups. The combination of strategies that maximize the return of both groups is the evolutionary stabilization strategy of the evolutionary stable group.

According to the Heisani transformation, suppose that at a certain moment, the passengers with x probability in the passenger group choose the conflict strategy, the passengers with (1-x) probability choose the cooperation strategy, the airlines with y probability in the airline enterprise group choose the conflict strategy, and the airlines with (1-y) probability choose the cooperation strategy.[4]

For the passenger side, the expected revenue of the conflict strategist is: u1 conflict =i(F-c)y+F(1-y), and the expected revenue of the cooperation strategist is: u1 cooperation = iF (1-y), then the total expected revenue of the passenger group under the mixed strategy is u1=xu1 conflict +(1-x)u1 cooperation. The partial derivative of u1 is obtained:

$$\frac{\partial_{i1}}{\partial_x} = u_{1\text{conflict}} - u_{1\text{cooperation}} = \mathrm{F}(1 - \mathrm{i}) - \mathrm{y}(\mathrm{ic} + \mathrm{F})$$

when:

$$\mathrm{y}_0 = \frac{F\,(1 - i)}{F + ic - 2iF} \tag{1}$$

Similarly, the expected returns of those who adopt conflict strategy are:u2 conflict = x (1-i) (F-c) +F (1-x), u2 cooperation =(1-i) F (1-x), and the total expected returns of those who adopt mixed strategy are: u2 = yu2 conflict + (1-y) u2 cooperation. The partial derivative of u2 is obtained:

$$\frac{\partial_{i2}}{\partial_y} = u_{2\text{conflict}} - u_{2\text{cooperation}} = \mathrm{x}(F - c - 2iv + ci) + vi, \text{when } \frac{\partial_{u1}}{\partial_x} = 0:$$

$$\mathrm{x}_0 = \frac{iF}{c + 2Fi - ci - F} \tag{2}$$

Let c/F=m(m≥0), define m as the unit cost of revenue, which can be obtained from formulas (1) and (2):

$$x_0 = \frac{i}{2i + m(1 - i) - 1} \quad (3)$$

$$y_0 = \frac{1 - i}{im + 1 - 2i} \quad (4)$$

According to the Nash equilibrium theorem of mixed strategy, the Nash equilibrium solution of mixed strategy in the game of navigation disputes is[(x0 ,1-x0),(y0 ,1-y0)]. At the equilibrium solution, the group income of both sides reaches the maximum value. Game participants will constantly adjust their strategies to the Nash equilibrium solution of the mixed strategy according to their own income situation, so as to maximize their own and the group's income. According to the evolutionary game theory, the Nash equilibrium solution of the mixed strategy is the evolutionary stable strategy of the navigation dispute game.[1]

When m is constant (10,20,50 respectively), using Excel 2010 to draw the diagram, the change rule of the probability of the conflict strategist adopted by both sides of the voyage with the degree of the asymmetry of the voyage information is obtained. With the increase of the degree of the asymmetry of the voyage information, the probability of the conflict strategy adopted by the passenger side increases gradually, tends to the maximum value of 1, and the probability of the conflict strategy adopted by the voyage enterprise side decreases gradually. When the minimum value is 0 and the degree of information asymmetry is unchanged, the probability of conflict strategies adopted by both sides gradually decreases with the increase of unit revenue cost, and tends to the limit value of 0. If the probability of disputes is P, P∈[0, 1], then P =x0 y0 substitutes the formulas (3) and (4).

$$P = \frac{1 - i^2}{(2i + m - mi - 1)(im + 1 - 2i)} \quad (5)$$

When m is constant (10,20,50, respectively), we use Excel 2010 to plot the change rule of the probability of disputes with the degree of asymmetry of navigation information under the evolutionary stability strategy.(See Figure 1.)

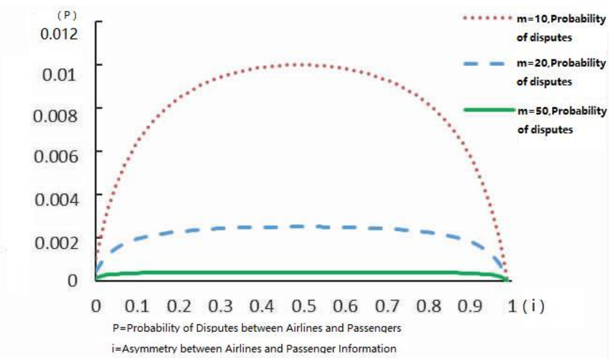

Figure 1

With the increasing degree of asymmetry of navigation information, the incidence of navigation disputes increases first and then decreases. When the degree of information asymmetry tends to zero, the probability of disputes tends to zero. This is mainly due to the fact that passengers are totally unaware of the responsibility of the airlines, so there will be no disputes in general. When the degree of asymmetry of navigation information tends to be 1, the probability of disputes tends to be 0. This is mainly due to the fact that when the information of navigation is symmetrical, both sides have no objection to the liability for shipping damage, and both sides take the initiative to negotiate and resolve the disputes, which is not easy to produce conflicts. When the degree of asymmetry of navigation information reaches about 0.5, the probability of disputes reaches the highest point. This may be due to the fact that passengers reach the state of "half-knowing". From about half of the information obtained, problems are found, doubts are aggravated, or doubts about liability for shipping damage are strengthened. Therefore, at this time, navigation disputes are intensified. The incidence is high and the conflict is serious.[5]

III. Suggestions on Model Application and Construction of Harmonious Airlines and Passenger Relations

This model can be used to predict and evaluate the status of the regional navigation relationship from macro perspective. By investigating the two indicators of the degree of asymmetry of navigation information (i) and the cost of unit revenue (m) in a certain area, and substituting formulas (3) (4) and (5), we can preliminarily evaluate the occurrence of the regional navigation disputes and the evolution and stabilization strategy of the regional navigation disputes game, so as to obtain the status of the regional navigation relationship. Preliminary evaluation was made. This model can not only predict and evaluate the navigation relationship of a certain area from the macro perspective, but also guide the two sides to choose strategies in specific disputes from the micro perspective, providing reference and reference, so that the participants in the game can get the greatest profits in the game of navigation disputes and better safeguard the legitimate rights and interests of both sides.

Information asymmetry (i) and unit revenue cost (m) are the key parameters determining the strategy choice, revenue and evolutionary stability strategy of the participants (both sides of the voyage) in the voyage game. Therefore, by improving the information asymmetry and regulating the unit revenue cost, the voyage dispute game can be promoted to evolve in a benign direction and the voyage harmony can be promoted.[6]

A. Improving Information Asymmetry

Improve the asymmetric situation of navigation information, let passengers have a clear understanding of weather conditions, operation arrangements of aviation enterprises, flow control, etc., rationally view the characteristics of civil aviation transportation, rationally arrange travel planning, actively obey the arrangements of aviation enterprise staff, and have a certain psychological expectation of force majeure risks such as possible weather changes and flow control. Passengers will have sufficient psychological and ideological preparation, will not be surprised and questioned, anger on the staff of the aviation enterprises, and thus fundamentally reduce the possibility of the occurrence of navigation disputes. Improving the asymmetry of navigation information can be achieved mainly by strengthening the communication and disclosure of navigation information, strengthening the education and training of navigation staff and the education of passengers' civil aviation related knowledge, fulfilling informed consent notification, and improving passengers' understanding of the content of notification. By improving the asymmetric status of navigation information, reducing adverse selection and moral hazard caused by information asymmetry, preventing distorted information from influencing passengers' rationality, eliminating hidden dangers of navigation disputes and promoting navigation harmony.[7]

B. Increasing unit revenue cost

Increasing unit revenue cost can regulate the evolution and stabilization strategy of navigation disputes game to develop towards harmony of navigation by reducing the liability for shipping damage and increasing the cost of civil aviation rights protection in illegal way.

Avoiding Fault Liability and Reducing Air Transport Damage

Shipping enterprises and their employees should strictly follow the relevant laws, regulations, rules, Advisory notices and guidance and other normative documents to avoid fault liability. When shipping damage occurs or is unavoidable, shipping enterprises and their employees should take effective measures in time, make every effort to reduce the occurrence of damage, avoid the expansion of harm, protect the rights and interests of passengers, the smaller the fault liability and damage, the more conducive to the settlement of disputes.

Increasing the cost of conflict of civil aviation rights protection in illegal way and reversing the predicament of "tragedy of public land"[8]

After the occurrence of civil aviation rights protection in illegal way, aviation enterprises should dare to say no to unreasonable demands, resolutely refrain from compromising with "air rage" persons, take legal ways and means to safeguard their legitimate rights and interests, and actively initiate the procedure of safeguarding rights for those who cause property and economic losses by illegal protection of rights, requiring the relevant responsible persons to bear civil liabilities and increase the number of civil liabilities. Adding the cost of "air rage" and "unreasonable fussy" will make the fussy bear great negative benefits and completely change and adjust the game of navigation disputes towards the direction of justice and harmony. I believe that rational travelers will make the right choice. Passengers have the nature to learn and imitate. The former's strategy choice and poor profits can serve as an example for later generations to learn and imitate, and constantly change and adjust their strategies, constantly reversing the plight of "the more terrible the trouble, the more compensatory it will be". Every airline enterprise should take responsibility. Starting from it, don't expect other airlines to turn around the predicament, hitch a ride and enjoy its success. Otherwise, each airline enterprise will fall into the "tragedy of public land" and be unable to extricate itself. The predicament of "the more terrible the trouble, the more compensatory it will be" will continue, even worsen.[9]

C. Game Analysis of Trust in Navigation

Navigation relationship is a kind of market transaction relationship. At the beginning of civil aviation transportation, both sides of the voyage have reached some kind of implicit contract, which corresponds to the probability distribution estimation of each other's anticipated behavior, and the essence of the problem of voyage trust is also contained in it. In terms of understanding the core connotation of trust, from the perspective of institutional function, trust is a rational simplification mechanism of information and behavior, which can reduce the complexity of social life and social interaction. On the other hand, from the perspective of incorporating interpersonal trust into the action of social system, trust is a kind of risky behavior, which is a rational market economic behavior produced by the repeated rational game between the principal and the trustee (i.e. the agent). As a form of social capital, it can reduce the cost of supervision and punishment. Reasonable people must choose between giving and rejecting trust in order to maximize personal benefits under uncertain risk conditions. It can be seen that whether the two sides of the voyage choose trust or distrust at last, the result is the rational choice made by the actor under certain rules of the game, and the purpose is to maximize their respective interests.[7]

IV. CONCLUSION

This paper establishes a game model of disputes between airlines and passengers with asymmetric information, studies the evolutionary stabilization strategy of disputes game, and verifies the model through empirical research, with a view to predicting and evaluating the status of disputes and regulating the relationship between airlines and passengers. Evolutionary analysis results of game model of air travel disputes with degree of information asymmetry show that it fits the reality of airline-passenger relationship well. The game model can be used to predict and evaluate the status of airline-passenger relationship. The macro-relationship between airline and passenger can be achieved by improving the status of information asymmetry of air travel and regulating the cost of unit business income. Regulate and control, and promote the harmonious and healthy development of airline and passenger relations.

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