Study on Passenger Travel Behavior under Abnormal Flight Based on Regret Theory

Xingyi Li

School of Economics and Management, Beijing Jiaotong University
Jiaoda East Road, Beijing, China

Email: Lixy708@163.com

ABSTRACT. At present, there is a high occurrence of abnormal flights in China. It holds practical significance to investigate the decision-making process of passengers when faced with abnormal flight conditions, aiming to enhance service recovery and minimize airline losses. In this study, a model based on regret theory is developed to analyze passenger behavior selection when flights experience significant delays or cancellations on the Beijing-Shanghai and Beijing-Guangzhou routes. By calculating regret values for each route separately and classifying passengers accordingly, optimal solutions are determined for different scenarios of abnormal flight conditions. The actual choices made by passengers under such circumstances are obtained through questionnaires and compared with the theoretical model's calculations. The findings demonstrate that the regret theory effectively explains passenger choice behavior.

Keywords: Abnormal Flights, Regret Theory, Behavior Choice, Multi-attribute Decision-making.

1 Introduction

According to the industry development statistical communique issued by the Civil Aviation Administration, in March 2022, 60.87% of flights were canceled due to the epidemic. With the development of transportation, passengers no longer blindly pursue low-cost transportation methods as in the past, but consider more subjective factors such as comfort and so on. In the case of abnormal flights, the choice of passengers plays an important role in the operation and development of airlines, so it is of great significance to study the behavior choice of passengers under abnormal flights. Based on the regret theory, this paper uses the multi-attribute decision model to analyze the multiple-choice behaviors of passengers under abnormal flights, and puts forward reasonable suggestions for airlines based on the research results.

R. Chitrakar et al. (eds.), *Proceedings of the 4th International Conference on New Computational Social Science (ICNCSS 2024)*, Advances in Social Science, Education and Humanities Research 844,
https://doi.org/10.2991/978-2-38476-230-9_19

2 Theoretical basis

2.1 Research status

Relevant studies on flight delay mainly focus on issues such as influencing factors and control models [1] and departure flight delay prediction[2].Jiang Hong and Ren Xinhui used prospect theory to analyze the optimal choice behavior of passengers during flight delay[3].On regret theory,Yang Junyi used a model containing regret weight parameters that could reflect the bias of passenger decision making to provide a basis for the calculation of route utility for subsequent traffic allocation[4]. By establishing a random regret minimization model, Xu Yuan studied the relationship between routing behavior and traffic network equilibrium[5]. To sum up, there is still relatively little research on behavioral choice using regret theory.

2.2 Regret Theory Utility Function

Regret theory states that an individual's preference for a choice depends on other alternatives. If there are n options, it is considered that when selecting option j1, compared with option j2, the regret value caused by factor.

$$r_{ij12} = x_{ij1} - x_{ij2} \tag{1}$$

x_{ij1} and x_{ij2}separately indicates the utility value of factor i in j1 and j2 scheme.

2.3. Attribute Weight

In this paper, the qualitative attribute quantization method in the subjective weighting method is used to calculate the attribute weight. Since people's cognition of things is usually a certain interval, this paper uses fuzzy semantics to collect questionnaires, and uses set-valued statistics to calculate the final score. If the interval of r evaluators for attribute c_i is $[a_{1i}, b_{1i}]$,...,$[a_{ri}, b_{ri}]$,then the statistician can use formula (2) to calculate the final score value of each attribute.

$$\overline{c_i} = \frac{1}{2}\sum_{r=1}^{q} v_k[(b_{ri})^2 - (a_{ri})^2] / \sum_{r=1}^{q} v_k(b_{ri} - a_{ri}) \tag{2}$$

Where c_{max} and c_{min} are the upper and lower intervals of attribute estimates given by different evaluators respectively.

2.4. Solving Procedure

2.4.1. Create the Attribute-schema Matrix

Suppose the solution set of the multi-attribute decision problem is: $\{ S = S_1, \dots, S_n \}$,$S_n(\mathrm{n} = 1,2 \dots, \mathrm{n})$ represents the n'th scheme, and the attribute set is $\mathrm{Q} = \{\mathrm{Q}_1, \dots \mathrm{Q}_\mathrm{m}\}$, $\mathrm{Q}_\mathrm{M}(\mathrm{m} = 1,2, \dots, \mathrm{m})$ represents the m'th attribute, and the element r_{nm} of

R is the regret value of the attribute of scheme $S_n$under the attribute value Q_m, which can be calculated by using formula (1).

2.4.2. Matrix Normalization

Since the units and orders of magnitude of each attribute are different, this paper uses vector norm method to process the attribute value before decision evaluation.

Table 1. Normalization formula

Class	Beneficial Type	Cost t\Type
Formula	$b_{ij} = a_{ij}^R / \sqrt{\sum_{j=1}^{n} (a_{ij}^L)^2}$	$b_{ij} = \frac{1}{a_{ij}^L} / \sqrt{\sum_{j=1}^{n} (\frac{1}{a_{ij}^R})^2}$

2.4.3. Sort by Topsis Method

Topsis method[6], also known as the approach to the ideal point sorting method. Let the solution set of the multi-attribute decision problem be S={ $S_1, S_2, \dots \dots, S_n$ }, S_n (n=1,2,… ... ,n) represents the n'th scheme, and the attribute set is Q={$Q_1, Q_2, \dots \dots Q_m$},,$Q_m$(m=1,2,…,m) represents the m'th attribute, the relative importance of each factor, that is, attribute weight reuse $w_1, w_2, \dots \dots, w_m$ indicates that the attribute weight should satisfy the normalization condition, that is, $\sum_{j=1}^{m} w_j = 1, w_j \geq 0$.

Firstly, determine the absolute positive ideal solution Z^+ and the absolute negative ideal solution Z^-. Based on regret theory, the positive and negative ideal solutions are $Z^+ = (-1,-1,-1,-1), Z^- = (1,1,1,1)$ respectively; Secondly, use formula (3), (4) to calculate the Euclidean distance of different alternatives from positive and negative ideal points; Thirdly, use formula (5) to calculate the relative proximity vector$D^* = (D_1^*, D_2^*, \dots, D_m^*)^T$; Finally, according to the stochastic regret minimization model, The larger the value of D^*, the better the scheme S^*.

$$d_i^+ = \sqrt{\sum_{j=1}^{n} w_j (v_{ij} - Z_j{}^+)^2} \quad (3)$$

$$d_i^- = \sqrt{\sum_{j=1}^{n} w_j (v_{ij} - Z_j{}^-)^2} \quad (4)$$

$$D^* = \frac{d_i^-}{d_i^+ + d_i^-} \quad (5)$$

3 Decision scenario and behavior selection scheme

3.1 Scenario Selection

This paper discusses four scenarios of flight delay for 2h, 4h, 6h and flight cancellation, three behavioral choices of waiting for flight, changing flight, changing to other transportation, and the short and medium distance Beijing-Shanghai route (1200km) and the long distance Beijing-Guangzhou route (2120km).

3.2 Attribute and Weight Determination

In this paper, speediness, economy, comfort and convenience are selected to describe the attributes of the scheme. Rapidity refers to the consumption time of the travel mode chosen by the passenger; Economy refers to the cost of the travel mode chosen by the passenger; Comfort refers to the passenger's subjective rating of the chosen travel mode; Convenience refers to the transfer time between the final mode of transportation chosen by the passenger and the first mode of transportation chosen.

According to the heterogeneity analysis of delayed passengers[7], passengers are divided into four categories: economic efficiency passengers, experience-oriented passengers, economic comfort passengers and comprehensive measurement passengers. The corresponding number of passengers in the questionnaire is 44, 42, 43 and 45 respectively. According to the score of the questionnaire and the attribute score, Formula 3 can be calculated to obtain the attribute weight as shown in the Table 2.

Table 2. Attribute weights of four types of passengers

Weight	Speediness	Economy	Comfort	Convenience
Economic Efficiency	47.93%	26.11%	10.23%	15.73%
Experience-oriented	16.11%	13.19%	32.50%	38.20%
Economic Comfort	17.96%	35.11%	30.67%	16.26%
Comprehensive Measurement	29.24%	21.05%	21.53%	28.18%

4 Empirical analysis

4.1 Model Calculation

Taking 2h delay Beijing-Shanghai as an example, TOPSIS method was used to sort the results, as shown in the Table 3.

Table 3. Euclidean distance and relative proximity vector of positive and negative ideal points

		Speediness	Economy	Comfort	Convenience
Euclidean distance of positive ideal point	Original flight (vs change)	1.17	1.04	0.94	1.09
	Original flight (vs high-speed rail)	0.51	0.74	0.66	0.64
	Change (vs original flight)	1.12	1.09	1.31	1.13
	Change (vs high-speed rail)	0.80	0.89	1.00	0.87
	High-speed rail (vs high-speed rail)	1.56	1.34	1.44	1.45
	High-speed rail (vs change)	1.50	1.24	1.18	1.35
Euclidean distance of negative ideal point	Original flight (vs change)	1.12	1.09	1.31	1.13
	Original flight (vs high-speed rail)	1.56	1.34	1.44	1.45
	Change (vs original flight)	1.17	1.04	0.94	1.09
	Change (vs high-speed rail)	1.50	1.24	1.18	1.35
	High-speed rail (vs high-speed rail)	0.51	0.74	0.66	0.64
	High-speed rail (vs change)	0.80	0.89	1.00	0.87
Relative proximity vector	Original flight (vs change)	0.49	0.51	0.58	0.51
	Original flight (vs high-speed rail)	0.75	0.64	0.69	0.69
	Change (vs original flight)	0.51	0.49	0.42	0.49
	Change (vs high-speed rail)	0.65	0.58	0.54	0.61
	High-speed rail (vs high-speed rail)	0.25	0.36	0.31	0.31
	High-speed rail (vs change)	0.35	0.42	0.46	0.39

4.2 Model Verification

The model and real choice pairs of the two routes are shown in Table 4 and 5.

Table 4. Beijing-Shanghai passenger behavior selection results

Passenger Type	An Abnormal Flight Situation	Wait for the Original Flight	Change	Take the High Speed Train	Questionnaire Dominance Behavior	Model Dominance Behavior
Speediness	Delay 2h	69.23%	26.92%	3.85%	Wait	Wait
	Delay 4h	34.62%	57.69%	7.69%	Change	Change
	Delay 6h	19.23%	30.77%	50.00%	Train	Change
	Cancel		56.23%	43.77%	Change	Change
Economy	Delay 2h	57.14%	28.57%	14.29%	Wait	Wait
	Delay 4h	14.29%	57.14%	28.57%	Change	Wait
	Delay 6h	14.29%	57.14%	28.57%	Change	Change
	Cancel		51.29%	48.71%	Change	Change
Comfort	Delay 2h	60.00%	30.00%	10.00%	Wait	Wait
	Delay 4h	60.00%	20.00%	20.00%	Wait	Wait
	Delay 6h	50.00%	20.00%	30.00%	Wait	Wait
	Cancel		60.00%	40.00%	Change	Change
Convenience	Delay 2h	66.67%	16.67%	16.67%	Wait	Wait
	Delay 4h	16.67%	50.00%	33.33%	Change	Change
	Delay 6h	16.67%	42.67%	40.67%	Change	Change
	Cancel		58.34%	41.66%	Change	Change

Table 5. Beijing- Guangzhou passenger behavior selection results

Passenger Type	An Abnormal Flight Situation	Wait for the Original Flight	Change	Take the High Speed Train	Questionnaire Dominance Behavior	Model Dominance Behavior
Speediness	Delay 2h	73.08%	23.08%	3.85%	Wait	Wait
	Delay 4h	41.31%	43.31%	15.38%	Change	Change
	Delay 6h	26.92%	38.46%	34.62%	Change	Change
	Cancel		58.34%	41.66%	Change	Change
Economy	Delay 2h	71.43%	14.29%	14.29%	Wait	Wait
	Delay 4h	28.57%	42.86%	28.57%	Change	Wait
	Delay 6h	28.57%	28.57%	42.86%	Train	Change
	Cancel		70.43%	29.57%	Change	Change
Comfort	Delay 2h	50.00%	30.00%	20.00%	Wait	Wait
	Delay 4h	60.00%	30.00%	10.00%	Wait	Wait

Passenger Type	An Abnormal Flight Situation	Wait for the Original Flight	Change	Take the High Speed Train	Questionnaire Dominance Behavior	Model Dominance Behavior
	Delay 6h	50.00%	10.00%	40.00%	Wait	Wait
	Cancel		60.00%	40.00%	Change	Change
Convenience	Delay 2h	58.33%	25.00%	16.67%	Wait	Wait
	Delay 4h	16.67%	50.00%	33.33%	Change	Change
	Delay 6h	8.33%	50.00%	41.67%	Change	Change
	Cancel		58.33%	41.67%	Change	Change

5 Conclusion

In two classes of routes, the model and the actual selection were consistent in 87.5%. However, there are still some inconsistencies, such as in the short and medium distance routes, when the flight is delayed for 6h, the model chooses to change the flight, but the actual choice is to change the high-speed rail. When the flight of experiential passengers is delayed for 4h, the model chooses to wait for the original flight, but actually chooses to change the flight. In summary, the inconsistency may be related to the small number of samples in this paper and the single ranking method.

Based on the above research results, the rationalization suggestions for airlines are put forward. In the case of abnormal flights, for passengers with no history of civil aviation, airlines can determine the type of passengers by scoring their attributes on the spot; for passengers with history of civil aviation, airlines can use the characteristics of passenger history to judge the type of passengers, and use the above-mentioned research results to predict the behavior choice of passengers. Provide a suitable combination of travel modes or ancillary services to enhance passenger satisfaction.

References

1. Cheng Jun. Research on Influencing Factors and Control Model of Flight delay [D]. (Master's thesis). Guangzhou: Guangzhou University, 2020.
2. XU Haiwen, Fu Zhenyu et al. Departure flight delay prediction based on time-sensitive information and deep learning [J]. Science Technology and Engineering, 2019, 20 (34): 14126-14132.
3. Jiang Hong, Ren Xinhui. Flight delay passenger behavior choice model considering risk preference [J]. Journal of Integrated Transport, 2019,41 (11): 85-89+104.
4. Yang Junyi. Research on passenger flow allocation in Rail Transit Based on Regretful Choice Behavior [D].(Master's thesis). Beijing: Beijing Jiaotong University, 2020.
5. Xu Yuan. Research on Road Choice Behavior and Traffic network Equilibrium Based on Regret Theory [D] (Doctoral dissertation).Nanjing: Nanjing University, 2019.
6. Hu Yonghong. Improvement of TOPSIS method for comprehensive evaluation [J]. Mathematics in Practice and Understanding, 2002, (04):572-575.
7. Ren Xinhui, Sun Yinan et al. Heterogeneity of passenger travel behavior under flight delay [J]. Beijing Jiaotong University, 2022,46 (1):40-50.