Research on the Influencing Factors of Aviation Insurance on the Perspective of Risk Management —— An Empirical Study on the Five Major Airlines in China

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Abstract: Aviation insurance has become more and more important in the risk management of airlines since 9/11 attacks, and high insurance expenses have become a major cost and heavy burden for airlines, so how to improve the abilities of risk management, reduce operating costs and make more profits under safety become a strategic theme of airlines. Different from previous studies using subjective judgment method, the historical data and grey correlation analysis method is used to determine how the main factors affect insurance premium in this paper, and also we selected 15 infection factors, and completed an empirical study on actual data of 5 major airlines in China, To research the degree of correlation between these factors and insurance premiums, and analyse the key influencing factors, so to build the basis for the strategies to increase the safety of air and decrease the risk management cost of airlines.

Keywords: Airlines; Risk Management; Insurance Premiums; Influencing Factor

1. Introduction

The significance of risk management for enterprise operation is beyond doubt. With a complex and ever-changing external environment, enterprises must do a good job in risk management to reduce operational and safety risks, and achieve healthy and stable development. Dionne believes that risk management is a form of self insurance that can establish a liquid reserve of funds to compensate for losses caused by accidents or negative market fluctuations (Dionne, 2013). Scholars, such as Songling Yang, believe that enterprise risk management practices enable companies to reduce different types of costs related to operational and non operational activities (Yang Songling, 2018)[1]. Scholars have made many research achievements in enterprise risk management, but there is relatively little research on airline risk management, and even less research on aviation insurance as an important measure for airline risk transfer.

Since entering the new century, the aviation industry has encountered many challenges. From the 9/11 terrorist attacks, the global financial crisis in 2008, to the COVID-19 in the past three years, these economic or political events have caused serious losses to the aviation industry. And some catastrophic major aviation accidents (such as plane accidents, large-scale air accidents, etc.) not only directly affect the safety of air passengers and airline employees, but

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also bring significant economic losses to airlines. Therefore, it is of utmost importance for airlines to do a good job in aircraft safety risk management, effectively control aviation transportation risks, and improve aviation safety and reduce risk costs (Shu Wei et al.,2018) [2].

This article is based on the perspective of risk management, using the operational data of the five major airlines in China as the basis, and using the grey correlation analysis method to empirically study the factors that affect the aircraft insurance premiums of airlines. The correlation between each influencing factor and the premium is determined, and countermeasures are proposed based on the empirical results, providing reference for airlines to effectively control risks, reduce the probability of aircraft accidents, reduce accident losses, and control insurance costs.

2. Risk management and aviation insurance

The objective existence of risks often leads to economic losses for individuals and organizations, so people study coping strategies by identifying, analyzing, and evaluating the risks they face. Risk management is the use of various technological means and natural resources to recognize, prevent, control, and handle risk events that cause loss of people's interests. Insurance is one of the response methods for enterprise risk management and an effective means to reduce financial losses after risk accidents occur. Enterprises can not only transfer risks based on this, achieve maximum economic benefits, but also stabilize costs and plan budgets reasonably.

Aviation insurance is a type of insurance that provides risk diversification and loss compensation for air transportation activities. For airlines, the core of aviation insurance is aircraft insurance. As the core asset of airlines, airplanes have the characteristics of high value, high cost, and heavy responsibility. Once a risk accident occurs, the losses are extremely serious. After the 9/11 incident, aircraft insurance became a crucial factor in the operation and management of airlines, aiming to transfer the economic losses caused by potential risks in the air transportation process and solve the financial difficulties caused by it. From a financial perspective, aviation insurance is an essential risk management tool that aims to ensure a company's financial solvency at the lowest cost by managing pure risk.

During air transportation, aircraft flight faces numerous uncontrollable factors. Currently, internationally recognized aircraft risk losses and their sources of risk are shown in Table 1:

Table 1. Aircraft Risk Losses and their Risk Sources [1]

Aircraft risk losses	Risk sources
(1) Aircraft body loss; (2) Loss of passengers and their luggage; (3) Third party losses outside of the aircraft; (4) Loss of air freight cargo; (5) Losses related to airport facilities and business; (6) Product responsibility of aircraft manufacturers and glass makers;	(1) Design factors, including equipment, work tasks, etc; (2) Program and actual operation work, including file system and checklists; (3) Communication, including communication methods, terminology, and language; (4) Organizational factors, such as company recruitment policies and resource allocation; (5) Work environment factors, such as noise, vibration, temperature, lighting, protective equipment, and clothing; (6) Regulatory factors, including the applicability and enforcement of regulations, certification of personnel,

(7) Injuries suffered by pilots, flight attendants, passengers, etc. while boarding an aircraft.	equipment, and procedures, and industry supervision; (7) Protective measures, including accident detection and warning systems, as well as equipment fault tolerance, etc; (8) Personnel performance, including physical condition and physical limitations.

3. Analysis of Factors Influencing the Aircraft Insurance Premiums for Airlines

Airframe All and Statutory Liability Insurance (hereinafter referred to as Airframe Insurance) belongs to the basic insurance of airlines, which covers the relevant risks of the aircraft listed in Table 1. It is responsible for compensating for aircraft damage caused by accidents, as well as losses to passengers, cargo, and third parties. In addition, aircraft insurance also has multiple types of insurance, including war risk, parts risk, and non deductible insurance. At present, transportation aircraft of various airlines in China are covered by fuselage all risk and legal liability insurance, as well as war insurance. Due to the high value of the aircraft fuselage, the large number of passengers on board, and the value of the cargo, the insurance amount is correspondingly high, resulting in very high insurance costs. Therefore, studying the factors affecting the determination of aircraft insurance premiums and exploring how to reduce insurance costs has become a focus of attention for airlines[3].

According to the premium allocation rules of the international aviation insurance market, various factors related to airline and aircraft risk accidents can affect the determination of premiums, such as historical payout rates, airline internal management systems, training systems, pilot's flight experience, route and airport conditions, aircraft use and model, insurance coverage and deductible, etc. The rate of aircraft insurance for Chinese airlines is usually based on international rates, taking into account the situation of both the airline and the aircraft itself.[4] Given the uncontrollable external environment, this article focuses on the controllable factors within airlines that affect the determination of aircraft insurance premiums from the perspectives of risk management and cost control, starting from the internal control of airlines.

Based on the analysis results in the previous section, this study selected a total of 15 internal factors that affect the determination of airline insurance premiums, including five dimensions: fleet overview, operational status, risk accident losses, pilot status, and financial stability. The study aimed to investigate their impact on airline insurance premiums and provide policy recommendations for risk management and internal control of airlines.

In summary, from the perspective of airline risk management, five dimensions and 15 influencing factors are selected to determine their impact on the airframe insurance premium rate[5][6] (as shown in Table 2).

Table 2. Dimensions and factors affecting aviation insurance premiums[7][8]

dimension	Factors and Measurement
Fleet Overview C1	Number of aircraft (C11) Average age of aircrafts (C12) Aircraft and engine depreciation (C13)

Operation of Airlines C2	Available seat kilometers (C21)
	Passenger volume (C22)
	Average passenger occupancy rate (C23)
Risk Accident Losses C3	Accident losses last year(C31)
	Number of major accidents last year (C32)
Overview of Pilots C4	Number of pilots (C41)
	Annual average flight hours of pilots (C42)
	Annual average fatigue coefficient of pilots(C43)
Financial Stability C5	Current ratio (current assets/current liabilities)(C51)
	Return on assets (after tax net profit/total assets) (C52)
	Revenue Growth Rate (C53)
	Debt ratio (total liabilities/total assets) (C54)

4. Empirical Analysis of the Importance of Factors Influencing Aviation Insurance

4.1 Research methods

The cost of aircraft insurance is an important component of the operating costs of airlines, and it is also an important node for airlines to control costs. Therefore, determining the key influencing factors of premiums is the basis for airlines to control risk costs. This study uses the grey correlation analysis method to empirically analyze the influencing factors of aircraft insurance costs. This method is simple to calculate, requires limited sample size, and can be combined with qualitative analysis. It is suitable for samples with small sample size or unknown residual distribution, or for analyzing the correlation degree of effect factors in systems with uncertain information [9]. The degree of influence of each factor is called the grey correlation level, which is measured by comparing the geometric similarity between the main factor (reference sequence) and each comparison factor (comparison sequence). In model calculations, it is necessary to normalize the original data and convert it into numerical sorting.

The general form of the grey correlation model is as follows[10]:

Reference sequence: $A_0 = (A_0(1), A_0(2), A_0(3), A_0(4), A_0(5))$

Comparison sequence: $C_i = (C_i(1), C_i(2), C_i(3), ..., C_i(n)), i = 1, 2, ..., 5$

Next, to calculate the individual grayscale correlation coefficient: ξ（A_0、C_i）

$$\xi(A_0(k)), C_i(k)) = \frac{\min_i \min_k |A_0(k) - C_i(k)| + \rho \max_i \max_k |A_0(k) - C_i(k)|}{|A_0(k) - C_i(k)| + \rho \max_i \max_k |A_0(k) - C_i(k)|}$$

$$k = 1, 2, \ldots, n. \quad (1)$$

Among them, $\rho \in (0,1)$ is the resolution coefficient used to adjust the range of the comparison environment and control the difference in correlation coefficients, which is usually 0.5. The grey correlation degree is obtained through the average correlation coefficient, which is:

$$r(A_0, C_i) = \frac{1}{n} r(A_0(k), C_i(k)) \quad (2)$$

The correlation level $r=(A_0, C_i)$ represents the degree of influence between the comparison sequence A_0 and the reference sequence C_i in a given grey system, with values ranging from 0 to 1. Then, based on the correlation degree of each observation object, sort them and obtain a comprehensive evaluation result.

4.2 Experimental data

This article selects relevant data from five large listed domestic airlines for analysis: China Southern Airlines, Air China International, China Eastern Airlines, Hainan Airlines, and Spring Airlines, represented by A1-A5. Due to the special reasons of public health and safety events such as the COVID-19 in recent three years, China's air transport industry has been hit hard, and the industry development curve deviates from normal. However, with the end of the epidemic, China's air transport industry will gradually recover, return to the status of 2019 and continue to develop. Therefore, this article uses the data from the end of 2019 as the basic data for empirical analysis (as shown in Table 3), but previous data and data from the epidemic period cannot be abandoned. Therefore, the data from 2018 and 2021 are selected as auxiliary for empirical analysis, and the empirical results are comprehensively analyzed to eliminate interference factors and randomness, and obtain credible conclusions that are more in line with reality and universal laws.

Table 3. Data on annual premium payments and influencing factors for aviation insurance of the five major airlines in China in 2019

	Indicator	Unit	A1	A2	A3	A4	A5
Aircraft premium of airlines [1]	Annual insurance cost (insurance premiums)	Millions (￥1,000,000)	1474.30	1895.82	772.23	512.99	108.77
	Number of aircraft		862	699	734	361	93
Fleet Overview C1	Average age of the fleet	Years	6.72	6.96	6.40	5.36	5.10
	Aircraft and engine depreciation	millions ￥1,000,000	23,477	21,203.59	19,704	4,970.64	2,017.58
Operation of Airlines	Available seat kilometers	million seat kilometers	344,061.86	287,787.61	270,254.00	174,344.58	43,706.53

[1] Due to the fact that aircraft premiums and accident loss compensation amounts are core confidential Information of airlines and insurance companies and should not be disclosed, this article has processed the actual data of premiums and compensation, but the proportion between them remains unchanged, which does not affect the analysis results of this article.

C2	Passenger volume	Thousands person-times/year	15,163.22	11,500.61	13,029.74	8,169	2,239.25
	Average passenger occupancy rate	%	82.81	81.02	82.02	83.38	90.81
Risk Accident Losses C3	Accident losses last year	Millions(￥)	8,332	6,613	3,738	6,636	462
	Number of major accidents last year	times	3	3	1	1	1
Overview of Pilots C4	Number of pilots	persons	6379	5172	4826	2889	1069
	Average annual flight hours	hours/year	813	803	901	783.25	793.2
	Annual average fatigue coefficient		0.907232877	0.761424658	0.891178082	0.931589041	0.969123288
Financial Stability C5	Current ratio (current assets/current liabilities)	%	17.53	32.97	25.19	41.77	112.37
	Return on Assets (After Tax Net Profit/Total Assets)	%	1.26	2.46	1.23	0.38	6.26
	Growth rate of operating revenue	%	7.45	-0.43	5.16	6.83	12.88
	Debt ratio (total liabilities/total assets)	%	74.87	65.55	75.12	68.4	48.78

Data source: Annual reports of various airlines in 2019

4.3 Empirical results

4.3.1 Grey correlation analysis

Perform dimensionless processing on the data in Table 3, followed by grey correlation analysis. The analysis results are shown in Table 4. The results show that all 15 factors have an impact on insurance premiums ($r \geq 0.7$), with 6 factors having a significant impact ($r \geq 0.9$).

Table 4. The result of Grey correlation analysis in 2019

dimension	Relevance	Ranking	factor	Relevance	Ranking
Fleet Overview C1	0.934113423	3	C11	0.948670663	4
			C12	0.901110442	10
			C13	0.951319543	3
Operation of Airlines C2	0.92560377	4	C21	0.947041434	6
			C22	0.936385366	9
			C23	0.873381677	13
Risk Accident Losses C3	0.948293682	1	C31	0.959776519	1
			C32	0.949349793	7
Overview of Pilots C4	0.946923043	2	C41	0.951468668	2
			C42	0.942497097	8

Financial Stability C5	0.828088064	5	C43	0.947096016	5
			C51	0.712085269	15
			C52	0.815953738	14
			C53	0.891525059	11
			C55	0.889626665	12

The ranking of the five dimensional indicators in 2021 is exactly the same as in 2019, with slight differences in 2018. The order of ranking is C4 company size, C3 risk accident losses, C2 operation status, C1 fleet summary, and C5 financial stability.

4.3.2 Result analysis

Overall, empirical results show that risk accident losses, pilot profile, fleet profile, and company operating conditions are all important factors affecting aviation insurance premiums. The correlation between these four primary indicators and insurance rates exceeds 0.9, with only financial status having a slightly lower correlation at the 0.83 level. First of all, the risk accident loss factor is the most critical dimension affecting the cost of aircraft insurance for airlines, which is consistent with the key factor determining the insurance premium rate of insurance companies. The number of risk accidents and compensation amount of airlines in the previous year are directly related to the adjustment coefficient of the premium rate or the discount coefficient of the insurance company's premium. Secondly, the pilot's technical level, risk accident handling ability, and even psychological quality are important factors that determine whether the aircraft can fly normally and affect flight safety, and directly determine the probability of risk accidents occurring. Thirdly, the condition of the fleet and the operation of the company also indirectly affect the aircraft safety and the probability of risk accidents. The complexity of the fleet, the number of flights, as well as the passenger and cargo volume of the company, also affect the probability of aircraft accidents, insurance premiums, and coverage amounts. Finally, empirical results show that although the financial condition of airlines has a certain impact on aircraft premiums, the correlation is weak and not an important factor in risk management.

5. Suggestions on controlling airline premium costs and improving aviation safety

According to empirical research results, airlines should improve aviation safety, reduce the probability of aircraft risks and accident losses.

Firstly, strengthen the training of crew members and enhance the comprehensive literacy of pilots. Airlines not only provide pilots with driving skills training, but also strengthen psychological training and disaster education in emergency situations to enhance their risk response capabilities.[11] When encountering internal and external emergencies such as aircraft malfunctions, weather, and bird strikes, they can scientifically and calmly handle them, avoid risks, and reduce risk losses. At the same time, flight schedules should try to avoid pilots carrying out takeoff and landing tasks during periods with potential fatigue risks[12]. Secondly, try to unify aircraft models, simplify fleet structure, reduce maintenance complexity, and

increase aircraft safety factors. At present, the fleet structure of large domestic airlines in China is very complex, with various types of aircraft such as Boeing series, Airbus series, regional aircraft, etc. The more complex the aircraft, the greater the difficulty of maintenance, and the lower the ability to ensure flight safety. Thirdly, optimize the route network, adjust the flight structure, and increase the operational and security capabilities of airlines. Airlines should conduct in-depth analysis and identification of risk factors on their operating routes and routes, establish risk assessment models, optimize route routes, and reduce risk probabilities. In short, airlines can only ensure aviation safety while reducing insurance premiums and economic losses by implementing risk management for aircraft flight safety, minimizing the probability of risk accidents and losses.

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