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Significant Factors of Aviation Insurance and Risk Management Strategy: An Empirical Study of Taiwanese Airline Carriers

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Aviation insurance premiums have become a heavy burden for the airline industry since September 11, 2001. Although the industry must constantly balance its operations between profitability and safety, the reality is that airlines are in the business of making money. Therefore, their ability to reduce cost and manage risk is a key factor for success. Unlike past research, which used subjective judgment methods, this study applied quantitative historical data (1999–2000) and gray relation analysis to identify the primary factors influencing ratemaking for aviation insurance premiums. An empirical study of six airlines in Taiwan was conducted to determine these factors and to analyze the management strategies used to deal with them. Results showed that the loss experience and performance of individual airlines were the key elements associated with aviation insurance premiums paid by each airline. By identifying and understanding the primary factors influencing ratemaking for aviation insurance, airlines will better understand their relative operational strengths and weaknesses, and further help top management identify areas for further improvement. Knowledge of these factors combined with effective risk management strategies, may result in lower premiums and operating costs for airline companies.

KEY WORDS: Airline; aviation insurance; premiums; risk management

1. INTRODUCTION

The aviation industry has faced numerous challenges over the past decade, such as the Asian financial crisis, September 11, SARS, and high fuel prices. These economic, public health, and political events have caused severe financial losses to the industry. The September 11 terrorist attacks resulted in fundamental and dramatic changes in the global aviation and insurance industries. New airport security requirements and passenger concern about flight safety caused a precipitous decline in passenger demand. Consequently, a large number of airline and insurance companies have either gone bankrupt or restructured.

Historically, insurance theory was based on "the law of large numbers," which can be defined as a device for reducing risk by combining a sufficient number of homogeneous exposure units to make individual losses collectively predictable. Due to the inherent risk and the large insurance premiums paid by the airlines, insurers consider the pricing increasingly difficult and volatile. Most of the literature written for and about the airlines has concentrated on the operation and management of the industry, but very few studies have examined the question of aviation insurance. Most articles about airline insurance have focused on aviation laws and practices

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(El-Kasaby *et al*., 2003; Margo, 1989; Wells & Chadbourne, 2000; White, 1974), responses after September 11 (Abeyratne, 2002; Caplan, 2004; Margo, 2002), aviation insurance underwriting (Woods, 1993), and pricing issues (Lane, 2005). We hope that the ranking of influential factors and risk management strategies of individual airlines will help top management identify the critical areas in which their airline needs improvement.

2. RISK AND AVIATION INSURANCE

Aviation insurance is a unique field based on business, legal, and regulatory standpoints (El-Kasaby, 2003). After September 11, aviation insurance, which is essential to airline operations, became a key factor in airline management. Aviation risks are very complex and costly; thus, the risks are usually shared by several insurers with a specific aviation insurance market. Each insurer is liable for that part of the risk it agrees to cover. Furthermore, direct insurers place their part of the risk on the reinsurance market to spread out the cost of the risks of assuming financial responsibility for compensation.

The assessment of aviation risks is concerned with rare events that occur at irregular intervals (Thomson *et al*., 2004). Airlines buy aviation insurance to transfer the cost of their potentially catastrophic daily risks. Although insurance does not remove the risk of accident, it does help the airlines avoid the financial distress occasioned by airline accidents (Lane, 2005).

Aviation insurance is an ideal risk management tool from the airline's financial standpoint. Its objective is to manage pure risks in order to assure the financial solvency of the firm at the lowest possible cost (Wells & Chadbourne, 2000). Most importantly, it plays a critical role in the management of airlines. Even though advanced technology provides extremely capable machines, aircraft accidents still happen. Hence, risk transfer through insurance is essential, and risk evaluation is required. For example, traditionally, fair premiums in insurance pricing were equated with the expected loss resulting from the underwritten risk (Tsanakas & Desli, 2005). Therefore, the airlines cannot ignore the importance of risk management to obtain more favorable premiums.

Based on these arguments, we used a two-dimensional risk analysis matrix to analyze exposures. The degree of the loss is displayed on the vertical axis, and the frequency is displayed on the horizontal axis (Fig. 1). The resulting four quadrants are Avoidance and Controlled Loss, Transferred Risk, Undertaken or Ignored Risk, and Prevention-Reduction Risk.

In the Avoidance and Controlled Loss quadrant, the high frequency and high severity characteristics of the exposure mean that these are probably not transferable. Measures to avoid loss completely or the use of crisis management to control loss should be implemented. The characteristics of the losses in the Transferred Risk quadrant are important to airlines with large assets under risk management. Because firms should avoid paying losses of this magnitude using company resources, they should attempt to transfer these exposures to others. The high costs of an accident can be reduced through insurance coverage. In the Undertaken or Ignored Risk quadrant, airlines usually handle adequate funds, utilize deductibles and self-insurance programs, or establish a captive insurance company to manage these risks or ignore them altogether because they would result in only a minor drain on the firm's resources. The Prevention-Reduction Risk quadrant contains exposures with low severity but relatively high frequency. As discussed above, airlines are currently developing and using new safety management techniques to prevent large disasters associated with human errors.

3. THE FACTORS OF PRICING AVIATION INSURANCE PREMIUM RATES

3.1. The Related Factors of Pricing Aviation Insurance Premium Rates

Unlike other forms of insurance, aviation insurance contracts are customized to suit specific needs. There is no standard, formal aviation policy used worldwide. Therefore, the London insurance market uses slips and policies to display aviation risk. A slip is often used as a means of obtaining a quotation for a risk. The premium rates are highly correlated with an airline's previous experiences and the current economic cycle (Abdel-Bary, 1991; Wells & Chadbourne, 2000).

Based on previous studies, there are numerous relational factors that will affect the ratemaking by underwriters (Abdel-Bary, 1991; Farrell, 2002; Frauenfelder *et al*., 1996; Margo, 1989; Rollo, 1987; Wells & Chadbourne, 2000; Woods, 1993). Fleet profile is the first element to be considered. This includes, for example, the number of aircraft, their average age, types, and insured value. The rate can be affected by changes to the fleet profile as a result of buying, selling, leasing, or having joint airlines on one insurance policy (Abdel-Bary, 1991). Most airlines use "fleet basis" to insure their coverage. In other words, airlines may insure similar planes collectively, and 747s, 737s, A330s, and MD11s as fleet groups have similar claim frequen-

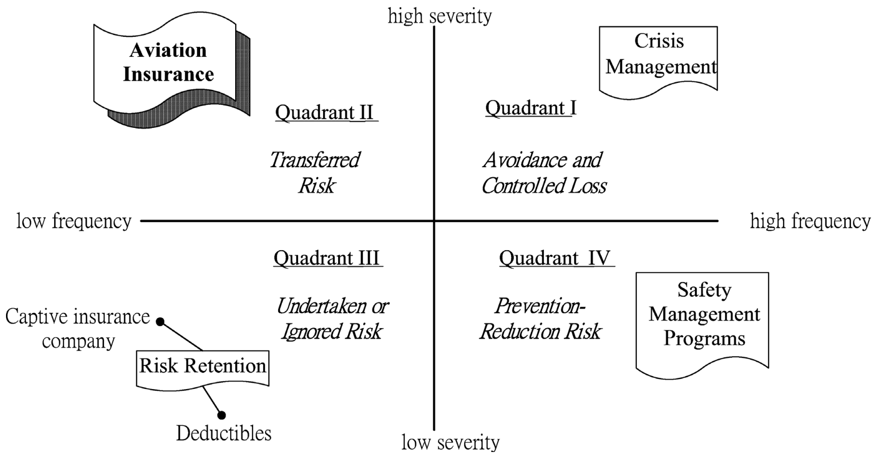

Fig. 1. Frequency-severity analysis matrix.

cies and severities. The London market has a model to figure out the base rate (e.g., total claims divided by average fleet value during three to seven years for the hull insurance and total claims divided by revenue passenger kilometers (RPKs) for liability insurance). Furthermore, premiums for hull insurance are calculated as a fixed sum or as a percentage of the total value of the aircraft.

An airline's passenger liability insurance premium is usually assessed according to the total volume of revenue passenger miles (RPMs) flown by the insured airline (Margo, 1989; Wells & Chadbourne, 2000). Another problem identified by Farrell (2002) is that past methods of ratemaking have been inequitable, and have not accurately reflected the risk profile of an airline. He proposed that RPMs/RPKs be replaced by the number of passengers carried and the number of departures made, based on statistical findings that over 57% of commercial jet airplane accidents occur during take-off (12%) and landing (45%) (Boeing Company, 2003). Aircraft with more frequent landings and take-offs may be susceptible to greater loss because of their safety systems.

As pointed out by a Swiss Re report (Frauenfelder *et al.*, 1996), in the hull business, North America shows the lowest loss experience, followed by Europe, the Middle East, and the Far East, including Australia and New Zealand. Latin America and Africa both have a particularly unfavorable loss history. Regional loss experience is influenced primarily by the relative degree of economic development. Because some areas lack advanced navigation facilities as well as suffer bad weather, hazards during flight operations vary significantly. Based on these points, the geography of the airports used and areas of most concentrated flying also have a decided effect on an underwriter's risk evaluation. Additionally, two reports (Frauenfelder *et al.*, 1996; Wells & Chadbourne, 2000) indicate that geographical area is more important for liabilities than for hulls. For instance, personal injury cases on international flights are often settled according to the Warsaw Convention. In the United States and Japan, however, airlines have unlimited liability for personal damage incurred on domestic flights. Obviously, insurers will attempt to raise premium rates for airlines in areas with higher limits or unlimited liability.

In addition to the fleet profile of individual airlines, the flight crew experience and operations conditions are other important factors in ratemaking. Pilot experience and ability are also important to underwriters when they evaluate aircraft risk (Wells & Chadbourne, 2000). Ordinarily, underwriters require a great deal of information to evaluate pilot name and age, pilot certification and ratings, personal physical and flight history, etc. Airlines in developing countries may have to pay higher rates due to greater risk from civil unrest (Rollo, 1987). Predictably, most large airlines spend more on training and maintenance, while smaller airlines are usually under severe financial pressure to reduce their safety management costs. Hence, they inevitably must pay higher premiums than larger airlines do.

3.2. Selection of Dimensions and Factors of Pricing Aviation Insurance Premium Rates

We can generalize and say that the main factors influencing aviation insurance prices are loss experience, the global insurance cycle, financial market yields, overall economic development and shortages of capital in the aviation insurance market itself (Frauenfelder *et al.*, 1996; Lane, 2005). Because the degree of external environmental influence on each airline is the same, this study focuses specifically on internal operational factors at six Taiwanese airlines. Due to difficulties in obtaining aviation-insurance premium data and individual airline operational information, we selected 22 relational factors and classified them into five dimensions: (a) fleet profile, (b) operations, (c) losses, (d) flight crew performance, and (e) financial stability. The relational factors within each dimension are shown in Table I and briefly discussed below.

3.2.1. *Fleet Profile (C1)*

Premiums for hull insurance typically take into consideration the total value of an airline's fleet (C11–C13). If an airline owns a large number of aircraft, has a young fleet, and has a large number of available seats, then its fleet value will be high. On the other hand, the more yearly flight time an aircraft has, the higher its rate of depreciation will be (C14).

3.2.2. *Operations (C2)*

The passenger liability insurance premium rate is based primarily on the operational performance of each airline, especially in RPKs/RPMs (C21). In addition, the number of passengers carried and number of departures are used to calculate aviation premiums (Farrell, 2002). Therefore, the number of flights per year (C22) and the number of passengers (C23) will be measured in this study. A high passenger load factor (C24) indicates better utilization of aircraft and crew; it also measures the level of operational profits (Oum & Yu, 1998). Regional loss experience is influenced by the degree of regional economic development. In addition, the results of claims are different depending on the nationalities of the passengers carried, their destinations, and the different legal environments in which airlines operate. Following Frauenfelder *et al.* (1996), we divided the world airline market into six areas: North America (The United States, Canada, and Mexico), Europe, Latin America, Africa, the Middle East, and the Far East (including Australia and New Zealand). C25 measures the risk index of geographical regions of major air routes by taking the burn rates (loss-to-cover ratio) and safety multiplier (history of accidents of the airline over the previous 12 years) into account and multiplies them by the number of flight routes.

Table I. Dimensions and Factors Affecting Aviation Insurance Premium Rates

Dimension	Factor and Measure
A_0 Aviation Insurance premiums	Aviation hull and liability insurance premiums (New Taiwan Dollars, NTDs)
C_1 Fleet profile	C_{11} Number of aircraft
	C_{12} Average age of fleet (years)
	C_{13} Available seats of fleet
	C_{14} Annual flight hours of aircraft (the yearly flight time per aircraft)
C_2 Operations	C_{21} Revenue passenger kilometers (RPKs)
	C_{22} Number of flights per year
	C_{23} Number of passengers
	C_{24} Load factor (%)
	C_{25} Risk index of geographical regions of major air routes
C_3 Losses	C_{31} Number of fatalities in previous year (persons)
	C_{32} Claims in previous year (NTDs)
	C_{33} Number of accidents in previous year
	C_{34} Number of incidents in previous year
C_4 Flight crew performance	C_{41} Ratio of defects of flight crews to number of total checks (checked by Civil Aeronautics Administration, CAA)
	C_{42} Ratio of defects of maintenance/mechanics to number of total checks (checked by CAA)
	C_{43} Pilots' average flying hours (hours)
C_5 Financial stability	C_{51} Debt ratio (total liabilities/total assets)
	C_{52} Current ratio (current assets/current liabilities)
	C_{53} Return of assets (operating income/average assets)
	C_{54} Return of equity (net profit after tax/average stockholders' equity)
	C_{55} Assets turnover ratio (revenue/average assets)
	C_{56} The growth rate of operation revenue ((operating revenue this year/operating revenue last year) − 1)

3.2.3. Losses (C3)

Generally speaking, the pricing of insurance is calculated as the contribution that each policyholder bears as its fair share of losses and expenses (Wells & Chadbourne, 2000). In practice, today's premiums always pay for yesterday's claims. C31 and C32 measure historical losses (frequency and severity) and will determine the short-term trend (Farrell, 2002; Frauenfelder, 1996). In addition, the International Civil Aviation Organization (ICAO) (2005) put forth the pioneering "1:600 Rule" (1–10-30–600 ratio), which estimates that for every 600 reported incidents, there will be 30 accidents, 10 serious accidents, and one fatal accident. Therefore, we cited the 1:600 Rule to measure the number of accidents (C33) and incidents (C34) to weigh and reflect the potential risk of an airline.

3.2.4. Flight Crew Performance (C4)

According to the Boeing Company (2003), from 1994 to 2003, 62% of aircraft accidents with known causes were caused by flight crew errors. C41 is checked by Taiwan's CAA to measure the number of flight crew defects. Many incidents are caused by human errors and not by mechanical failures or faulty maintenance procedures (McDonald *et al.*, 2000). The CAA also checks on the errors of maintenance crews (C42). In addition, underwriters usually investigate the background, experience, and accident records of all pilots (C43) to determine their level of risk to aircraft (Wells & Chadbourne, 2000; Woods, 1993).

3.2.5. Financial Stability (C_5)

Some researchers regard the financial stability of an airline to be an indicator of its investments in safety (Noronha & Singal, 2004; Rose, 1990). According to the U.S. General Accounting Office (GAO), financial stability is a main factor in the safe operation of airlines (Rhoades & Waguespack, 2000). Financial ratios are important sources of information to external stakeholders. They are also used for internal managerial purposes. Moreover, financial ratios are used to evaluate the performance of airlines (Feng & Wang, 2000). Therefore, we used C51–C56 to reflect an airline's financial condition and measure its relationship with aviation insurance premiums.

4. METHODOLOGY AND DATA

As the aviation insurance premiums are an important operational cost driver, it is difficult to collect complete data sets for the factors that influence the premium rate of any particular airline. Consequently, this study used gray relation analysis as its analytical tool, which is appropriate when the sample size is small or the distribution of residuals is unknown (Feng & Wang, 2000). Gray relation analysis is a useful mathematical method used to sort out the correlation extent of effect factors in a system with uncertain information (Deng, 1982, 1989; Fu *et al.*, 2001). The advantages of this method of analysis include (a) simple and easy calculation, (b) a limited amount of samples required, and (c) that quantified outcomes from a *gray relational grade* do not contradict conclusions from qualitative analysis (Deng, 1982; Shi, 1990). The degree of influence is called a *gray relational grade*, which is measured by comparing the geometric similarity between the main factor (referential sequence) and each compared factor (comparative sequence). The original data were normalized with various units and transformed into a similar numeric order. The general form for the gray relation model is as follows:

$$\text{The referential sequence}: A_0 = (A_0(1), A_0(2), A_0(3), \ldots\ldots\ldots\ldots, A_0(n)), \quad (1)$$

$$\text{the comparative sequence}: C_i = (C_i(1), C_i(2), C_i(3), \ldots\ldots\ldots\ldots, C_i(n)), \quad i = 1, 2, \ldots, m. \quad (2)$$

Next, to calculate the individual gray relational coefficient, $\xi(\mathrm{A}_0, C_i)$

$$\xi(A_0(k)), C_i(k)) = \frac{\min_i \min_k |A_0(k) - C_i(k)| + \rho \max_i \max_k |A_0(k) - C_i(k)|}{|A_0(k) - C_i(k)| + \rho \max_i \max_k |A_0(k) - C_i(k)|} \quad k = 1, 2, \ldots, n. \quad (3)$$

where $\rho \in (0, 1)$ is the distinguishing coefficient, which is used to adjust the range of the comparison environment and control the differences of the relational coefficients; its value is usually 0.5. The gray relational grade is obtained by averaging relational coefficients:

$$r[\mathrm{A}_0, C_i) = \frac{1}{n} \Sigma r(A_0(k), C_i(k)]. \quad (4)$$

The relational grade $r = (\mathrm{A}_0, \mathrm{C}_\mathrm{i})$ represents the influence between the comparative sequence A_0 and the referential one C_i in a given gray system, and the numeric values are between 0 and 1. Usually, $r = \geq 0.9$

Table II. Summary of Sample Data

Dimensions and Factors/Airline Codes:	A1	A2	A3	A4	A5	A6
Scale of business						
Total assets (NTD millions)	107,528	17,713	4,616	19,793	85,945	14,649
Number of employees	8,999	1,541	1,011	1,937	4,977	1,561
Aviation insurance premiums (NTD millions)	1,700	34	140	46	110	22
Fleet profile						
Number of aircraft	54	14	15	29	35	19
Average age of fleet	7.4	4.8	5.7	3.6	4.8	3.3
Available seats of fleet	12,543	2,399	1,138	2,819	7,119	2,398
Annual flight hours of aircraft	3,219.3	1,836	1,832.3	1,525.7	4,069.8	2,091.5
Operations						
Revenue passenger kilometers (RPKs, millions)	22,220	1,730	2,321	1,410	18,200	1,911
Number of flights per year	42,623	47,008	44,154	79,676	22,382	59,607
Number of passengers (thousands)	7,878	4,847	1,853	4,538	4,036	4,281
Load factor (%)	72.24	61.55	71.44	57.67	74.75	58.79
Risk index of geographical regions of major airline routes	12.86	4.99	8.16	7.88	8.77	6.09
Losses						
Number of fatalities in previous year	202	0	13	0	0	0
Claims of in previous year (NTD millions)	5,000	0	275	0.8	0.35	0.6
Number of accidents and serious incidents in previous year	2	0	2	4	0	0
Number of incidents in previous year	94	1	13	30	12	27
Flight crew performance						
Ratio of defects of flight crews to number of total checks (%)	11.99	5.54	5.05	4.13	5.66	6.38
Ratio of defects of mechanics to number of total checks (%)	23.83	22.69	13.19	23.87	31.07	24.01
Pilots' average flying hours	6,978	6,970	12,787	5,730	9,123	4,320
Financial stability						
Debt ratio (%)	66	58.44	52.78	84.32	68.43	70.33
Current ratio (%)	73.3	107.97	195.6	72.36	70.73	29.23
Return of assets (%)	−3.81	−3.52	1.91	−4.61	2.39	−13.21
Return of equity (%)	−5.75	2.36	2.8	−26.39	0.27	−43.71
Assets turnover ratio (%)	0.51	0.36	0.47	0.31	0.52	0.37
The growth rate of net income from operation (%)	−310.71	−343.09	−75.7	−401.89	−37.62	−158.52

indicates a marked influence, $r = \geq 0.8$ is a relatively marked influence, $r = \geq 0.7$ is a noticeable influence, and $r = \geq 0.6$ is a negligible influence (Fu *et al.*, 2001). To sum up, the main purpose of gray relation analysis is to discover which irregular pattern will significantly relate to the referential sequence.

We evaluated data for six Taiwanese airlines: two international carriers (China Airlines and Eva Airways) and four domestic carriers (Far Eastern Air Transport, Mandarin Airlines, Uni Airways, and TransAsia Airlines). The A1–A6 labels were randomly assigned. These data were collected from insurance companies in Taiwan that are provided in the 1999 annual report of the Insurance Institute of the Republic of China, and from the Taiwan CAA. Table II below summarizes the data.

5. EMPIRICAL RESULTS

The results of the gray relation analysis (Table III) explicitly capture the top 11 influential factors ($r \geq 0.7$), which are the number of fatalities and claims in the previous year, RPKs, number of accidents in the previous year, the ratio of defects of flight crews to number of total checks, the available seats of the fleet, the number of aircraft, the risk index of the geographical regions of major air routes, the number of incidents in the previous year, the average age of the fleet, and the annual flight hours of the fleet.

No matter what type of insurance the underwriters provide, the most important factor for premium ratemaking is an individual client's previous claims. The major finding of this research is that loss experience is the most critical dimension in determining premium level. The number of fatalities and claims in the previous year are ranked the first and second most influential factors.

The relevant literature showed that most aviation passenger liability insurance premiums are based on RPKs and the number of passenger seats. In this study, RPKs is ranked third. Also, because flight crews are a key determinant of flight safety, the ratio of flight

Table III. The Gray Relation Coefficient (r) and Rankings of Factors and Dimensions with Aviation Insurance Premiums (A_0)

Dimension	r	Ranking	Factor	r	Ranking
C_1 Fleet profile	0.7722	***2***	C_{11} Number of aircraft	0.8068	***7***
			C_{12} Average age of fleet	0.7393	***10***
			C_{13} Available seats of fleet	0.8122	***6***
			C_{14} Annual flight hours of aircraft	0.7303	***11***
C_2 Operations	0.7148	***3***	C_{21} Revenue passenger kilometers (RPKs)	0.8804	***3***
			C_{22} Number of flights per year	0.5567	***19***
			C_{23} Number of passengers	0.6918	***12***
			C_{24} Load factor	0.6880	***13***
			C_{25} Risk index of geographical regions of major airline routes	0.7573	***8***
C_3 Losses	0.8904	***1***	C_{31} Number of fatalities in previous year	0.9771	***1***
			C_{32} Claims in previous year	0.9742	***2***
			C_{33} Number of accidents in previous year	0.8685	***4***
			C_{34} Number of incidents in previous year	0.7419	***9***
			C_{41} Ratio of defects of flight crews to number of total checks	0.8469	***5***
C_4 Flight crew performance	0.6666	***4***	C_{42} Ratio of defects of mechanics to number of total checks	0.5342	***22***
			C_{43} Pilots' average flying hours	0.6187	***16***
C_5 Financial stability	0.5893	***5***	C_{51} Debt ratio	0.5823	***17***
			C_{52} Current ratio	0.6204	***15***
			C_{53} Return of assets	0.5427	***21***
			C_{54} Return of equity	0.5700	***18***
			C_{55} Assets turnover ratio	0.6712	***14***
			C_{56} The growth rate of net income from operation	0.5491	***20***

crew defects to the number of total checks is also influential and was ranked fifth in importance. Taiwan's top two serious accidents in 1998, for example, were determined to have been caused by improper flight crew operations.

Accidents and incidents are typically caused by a combination of multiple interrelated sequential events and failures (Chang & Yeh, 2004). Undoubtedly, these events and failures will become the primary factors used to determine the potential risks for unanticipated future losses. Moreover, insurance premium rates also depend on the previous accumulation of numerous small claims. Therefore, the number of accidents and incidents in the previous year are ranked fourth and ninth, respectively.

The fleet profile is another major dimension that affects aviation hull premiums. The premiums are relatively high if the airline owns a large fleet with a variety of sizes of aircraft. In addition, the older the aircraft, the higher the probability that equipment failure will occur; hence, premiums are higher for older fleets. Therefore, the influential factors are the available seats, the number of aircraft, the average age, and the annual flight hours of the fleet.

In the operational dimension, statistical reports show that aircraft take-offs and landings are the most crucial periods during the flight. Therefore, the number of flights per year is another important factor. This is, however, a relatively new consideration for the aviation insurance market. In terms of the risk index of geographical regions of major air routes, the burn rates and safety multipliers of different regions were considered, and this factor is ranked eighth in importance.

This article used gray relational analysis to evaluate the performance of Taiwan's six airlines. Their performance ranking was A2, A5, A6, A4, A3, and A1. It was clear that A1 and A3 were weak in safety performance because in 1998 they had a large number of claims and recorded fatalities. A4 had a great many minor injuries and near misses, and its financial condition was poor in previous years; therefore, its overall performance was not good either.

Finally, after normalizing original loss data, we used a risk analysis matrix to compare the loss severity against loss frequency of the six airlines (Table IV). Aviation insurance is an indispensable part of an airline's operations. Without question, airlines must purchase aviation insurance to transfer risks to other parties. For this reason, we used loss severity and frequency for the six airlines and redrew the risk management matrix (Fig. 2). Because of the

Airline Code	A1	A2	A3	A4	A5	A6
Loss severity	1	0	0.55	0.0016	0.0007	0.0012
Loss frequency	1	0	0.999879	0.039724	0.0000121	0.000156

Table IV. The Loss Severity and Frequency of Six Airlines

severity and frequency of their losses in 1998, A1 and A3 were allocated to the "Avoidance and Control Loss" quadrant. Consequently, both airlines need to develop significantly better crisis management capabilities to deal with high severity and frequency risks as they continue to expand. A4 was allocated to the "Prevention-Reduction Risk" quadrant because it had a large number of serious incidents in previous years. Therefore, the primary task for A4 is to utilize the new aviation safety management techniques and facilities to reduce risks and prevent future incidents. Three airlines were allocated to the "Undertaken Risk" quadrant: A2, A5, and A6. Because A5 and A4 belong to an international business group that owns a captive insurance company to deal with total insurance policies, with a better loss experience, these airlines will have a good chance of being charged lower premiums. A2 and A6 have similar operational backgrounds; they used a pooled-fleet strategy to get the best premiums in prior years. If they can maintain their low loss levels in the future, buying insurance deductibles is another viable choice.

6. CONCLUSIONS AND IMPLICATIONS

In contrast to past research that focused on subjective judgment methods, this study used gray relation analysis as the theoretical basis for exploring the significant influential factors and dimensions determining aviation insurance premium rates, including an evaluation of the performance of Taiwan's six airlines. Moreover, this research used a risk analysis matrix to suggest the best risk management strategies at different loss severity and frequency levels. The results indicated that the primary factors affecting aviation insurance rates were the number of fatalities and claims in the previous year, and that the degree of an airline's loss experience was most strongly associated with its aviation insurance premiums and overall performance. The results are compatible with the relevant literature and current practice. Although this research was developed in Taiwan, it is likely exportable to any world region due to similarities in the insurance rate determination process. This article is focused on traditional pre-9/11 conditions because of

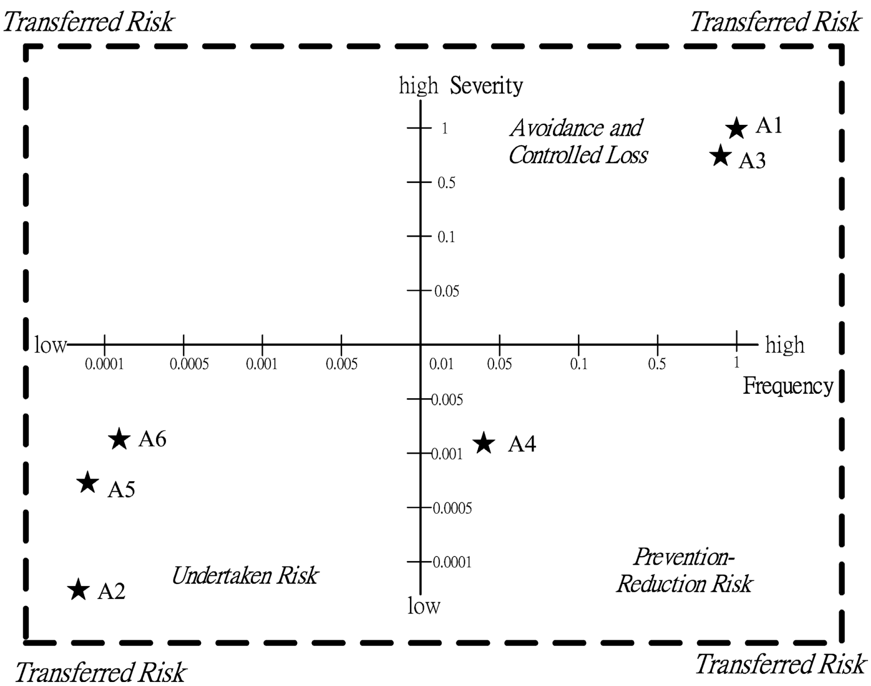

Fig. 2. Aviation risk management map.

the difficulties in collecting data on aviation insurance premiums, which are classified "highly confidential." However, we think that further research can be based on the aviation insurance conditions of war and terrorism insurance coverage after 9/11.

This study presents a general framework for advancing the knowledge of underwriting aviation insurance. The results of this study provide airlines with information about the overall risk management map as well as individual influential factors that aviation insurers consider when determining insurance premiums. It may help airlines improve their operations and safety management strategies and, we hope, lead to reduced aviation insurance premiums. In particular, these factors may help underwriters focus on the major operational and managerial weaknesses of individual airlines in specific divisions. Furthermore, airline insurers also must ensure greater transparency and consistency in pricing the risks, and provide more detailed analyses of each airline so that individual airlines might obtain more accurate risk profiles of their business.

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