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A Study on Social Effects of Aviation Accidents on Airlines and Users

（航空事故が航空会社と利用者に及ぼす社会的影響に関する研究）

Doctoral Dissertation

by

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Submitted to the Department of Built Environment
in fulfillment of the requirement for the degree of

DOCTOR OF ENGINEERING

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Tokyo, Japan

Abstract

This research studies on the social influences, public perception to aviation accidents, and process of the airline's decision making for safety measures. Repeated aviation accidents happened in Taiwan in half of a year to the same airline, TransAsia Airways, aroused huge public safety concerns, resulting in safety problems. Therefore, the study selects Taiwan as a case study, aims to develop a comprehensive structure of accident influences covering multiple stakeholders, and provides a prospective to enhance the long-term level of aviation safety from perspectives of users and the airline and to minimize impacts of accidents. Through the data collection of stock price fluctuation, online survey toward Taiwanese citizens, a site visit to air crash site, and an interview with TransAsia Airways, fruitful outcomes covering diverse aspects are drafted. This dissertation is composed of six chapters.

Chapter 1 tackled the research background, showing recent accidents in Taiwan and Malaysia. This motivates us to explore the influences of accidents and aims to prevent risk. Objectives and the structure clarify the research process and give an overview across the entire dissertation.

Chapter 2 explained the difference between safety and safety perception. Literatures about risk analysis were described to further discuss public safety perception. Accident causes, databases and diverse safety ranking criteria were summarized. Factors that dominate people's worry and behavioral intention were also reviewed and explored.

Chapter 3 analyzed social and economic effects, and collected information via site investigation. A structure of accident crisis covering the user, society, airline, and government sides identified the potential consequences it may bring. Several measures have been proposed to minimize social panic and the loss associated with accidents. When an accident happens, the media usually exaggerates the consequences and people may worry about airline safety management, resulting in loss of passengers and social panic. Firstly, a stakeholder analysis and economic fluctuation using event study method were described to express social influences, stock price fluctuation, and the correlation with the media index. Via our field visit to Penghu, Taiwan, interview results were summarized to reveal local impacts of an aviation accident.

Chapter 4 conducted a survey to collect data for exploring influences on public perception, formation of safety concerns, analysis of worry duration, and users' behavioral intention change. Accidents of TransAsia Airways were selected for the case study. After the accident of GE222 on July 23, 2014, subjective data were collected through an online survey with Taiwanese citizens to investigate their perception about the airline considering. While sending out the questionnaire, another accident occurred with the same airline on February 4, 2015 (GE235). This unique data allowed us to analyze influences on the aviation market and public attitude change toward airlines for two different groups of respondents: those who answered six months after the first accident, and those who answered immediately after the second accident. We used regression analysis to find the factors that associated with formation of safety perception. The Cox proportional hazards model was used to quantify the strength of worry with time scale as the worry duration, and to estimate the variables that dominate their concerns. Lastly, a structural equation model was built to clarify the attributes of user' behavioral choice intention.

Chapter 5 focused on the interaction between the airline and users to discuss airline motivation for safety measures via game theory. The airline may not conduct safety measures after accidents and tend to do promotion to attract more passengers because of people's abating of worries and continual usage, causing safety and long-term aviation development problems. This makes a tradeoff of safety and profit between the airline and customers, and can be expressed with a non-cooperative game. The game of safety improvements consists of two players with two strategies respectively, the airline (do safety measures, do promotion) and customers (use the airline, not use the airline). We also quantified each player's payoff to make a simulation for diverse scenarios to display different outcomes, conducted sensitivity analysis to observe variable differences, and found the win-win condition. The purpose is to enhance the overall safety level, and our theory is also supported through an interview with TransAsia Airways about practical safety affairs.

Conclusions of each chapter and recommendations for future research were summed up in Chapter 6.

This is an overall research considering diverse stakeholders, the society, users, and the airline. This study provides a strong reference to understand public reaction and to deal with crisis management. Currently, to the best of our knowledge, there is no similar research to study multiple stakeholders' performances after repeated accidents, making our results meaningful and innovative. Airlines may also make more efforts to implement safety management measures in order to prevent accidents from happening. Users have to pay more attention to aviation safety, because their consciousness may alter safety level as well. Therefore, a safety information sharing mechanism or risk communication is necessary among stakeholders to avoid information asymmetry, and to enhance safety.

Acknowledgment

It was a long journey to pursue a PhD degree. My first time came to Yai lab was in 2008 via AOUTLE summer exchange student program. It was short, but I did find many things new to me, and dreamed to come to Japan again. During my undergraduate in National Taiwan University, I studied hard, made efforts to learn Japanese, and fortunately received Yoshida scholarship to enroll integrated doctoral program in Tokyo Institute of Technology.

In the beginning, I tried to view and experience as much as possible, but I found there was a gap between research and study. In Yai lab, all students are trained to find and solve problems by themselves, which took a long time and sometimes I was confused what should I do for the next step. Thanks to my lab mates, Kheang, Andra, Motohashi, Miyanoue, Guanzhong, Zhao, Lin Dan, and Hanlu, they provided me strong encouragement for research and life experience. James, Kan Chen, Tokyo Tech Taiwanese students, and friends in Taiwan, USA, Europe, without your supports, I cannot finish it.

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This dissertation received a lot of feedback from Professor Yasuo Asakura, Associate Professor Daisuke Fukuda, and TSU members. Your comments were carefully examined to improve research quality. I appreciate committee members, Professor Hitoshi Morikawa, Associate Professor Yasunori Muromachi, and Associate Professor Shinya Hanaoka, for reading my dissertation and to help me fulfill the degree.

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Tokyo, Japan
June, 2016

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Chapter 1

Introduction

1.1 Background

Currently, in spite of developments in aeronautical technology, many aviation accidents cannot be prevented. Most accidents are serious and fatal, so media announcements may arouse widespread public concerns and responses. Crash events are catastrophic and terrifying, despite paucity in most markets. The media exaggerates the consequences and focuses too much on fatalities, which may produce negative spillover effects in the aviation market. Consumers, unlike aviation industry experts and staff, lack professional aviation safety knowledge but tend to believe unfounded information or perception, resulting in incorrect prejudice and unprovoked safety concerns toward air transport. Individual safety perception of airlines is dominant in airline selection, and is also easily and significantly affected by crash events, influencing consumers' refusal to use airlines with accident records for a period, due to distrust and worries about safety management.

According to Boeing (2013), number of accident fatalities is decreasing, but aviation accidents still exist in Figure 1.1. Fatality rate of total accidents (2004-2013) is 18%. Top three accident causes to commercial jet fleet are loss of control in flight, controlled flight into or toward terrain, and runway excursion (landing), abnormal runway contact, undershoot/overshoot in Figure 1.2.

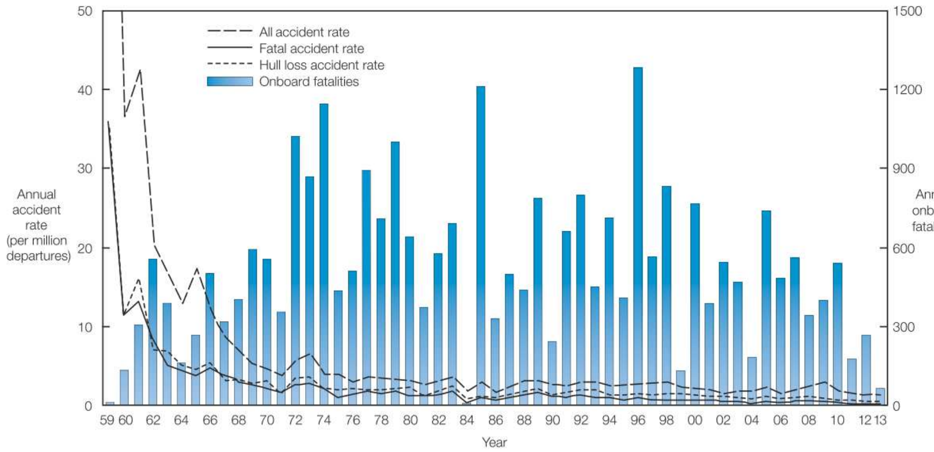


Figure 1.1 Fatalities and accidents history (1959-2013)

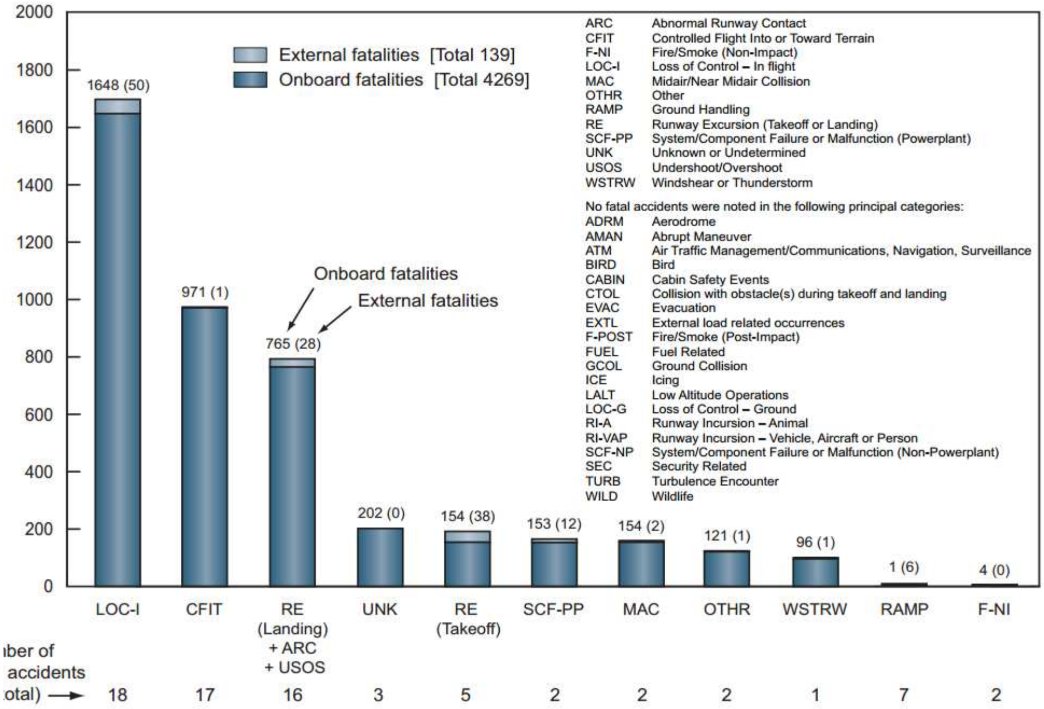
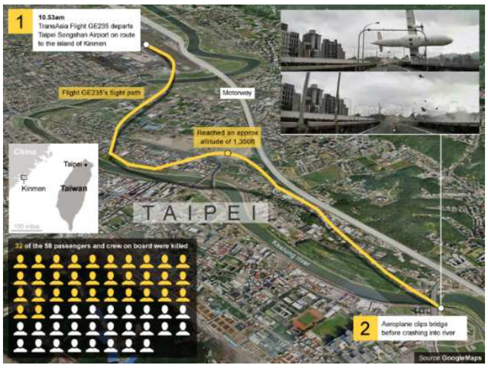


Figure 1.2 Accident cause and fatalities worldwide (2003-2012)

1.1.1 TransAsia Airways Accidents in Taiwan

Currently there are four airline companies operating domestic routes, UNI Air, Mandarin Airlines, TransAsia Airways, and Far Eastern Air Transport. Two aviation accidents occurred in Taiwan involving the same airline, TransAsia Airways, the third-biggest airline company operating domestic and regional international routes. The GE222 accident, in Penghu on July 23, 2014 (ATR 72-500), and the GE235 accident in Taipei on February 4, 2015 (ATR 72-600), resulted in a number of fatalities, with 48 of 58 total occupants and 43 of 58 total occupants killed, respectively in Table 1.1. These two events aroused social panic, and significantly impacted the entire aviation market. Figures 1.3 and 1.4, from the Civil Aeronautics Administration, MOTC, demonstrate five airlines’ passenger numbers and load factors for domestic routes in Taiwan. The GE222 and GE235 accidents had a substantial influence on consumers, who were discouraged to use TransAsia Airways. People’s motivation to travel was also decreased, and affected local tourism industry.

Table 1.1 Recent accidents in Taiwan

	GE222 Accident	GE235 Accident
Date	23 July 2014 19:06 Wednesday	4 February 2015 10:54 Wednesday
Carrier	TransAsia Airways ATR 72-500	TransAsia Airways ATR 72-600
Fatalities	crew 4/pax 44 (58)	crew 4/pax 39 (58)
Airplane damage	out of path in en route phase before landing	impacted a highway viaduct and the river after takeoff
Flight path	 	

(Source: Aviation Safety Network, Aviation Safety Council, Telegraph)

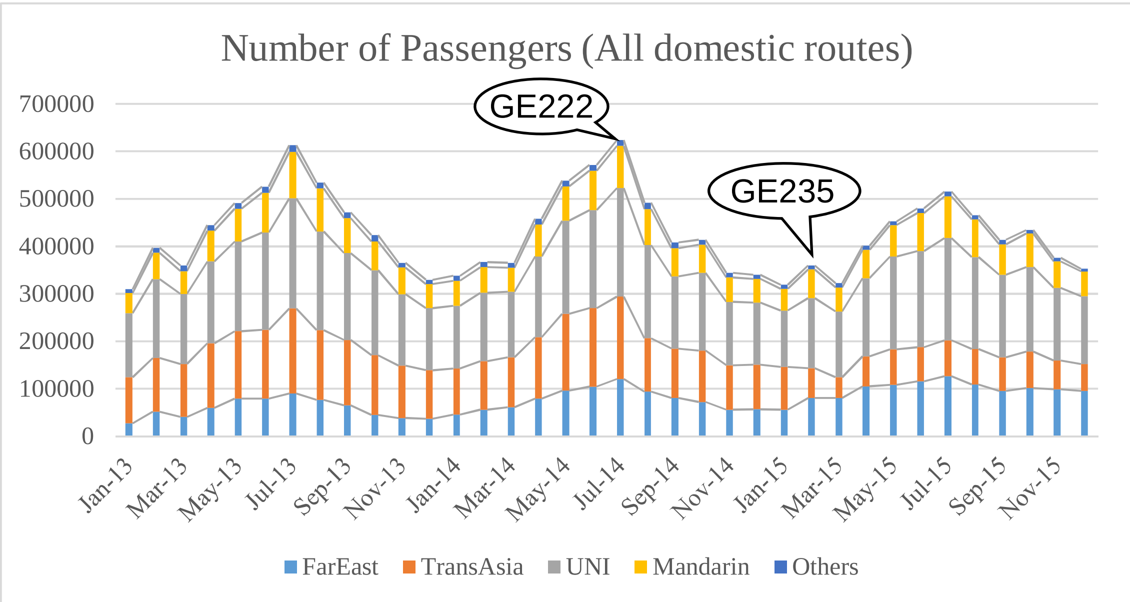


Figure 1.3 Number of passengers for Taiwan domestic routes (2013-2015)

(Source: Civil Aeronautics Administration, MOTC)

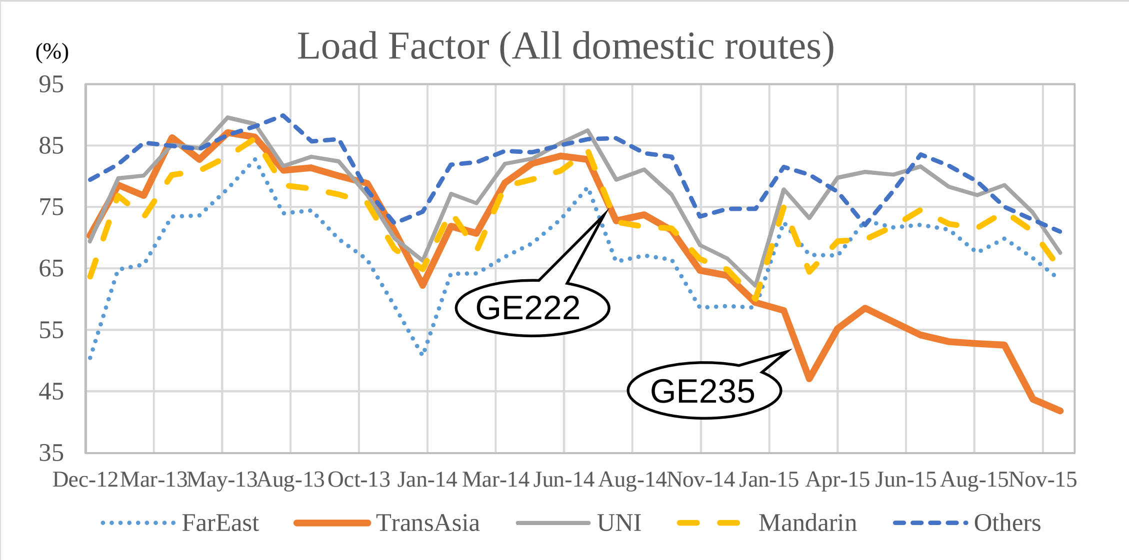


Figure 1.4 Load factor for Taiwan domestic routes (2013-2015)

(Source: Civil Aeronautics Administration, MOTC)

Wong and Yeh (2003) indicated that other airlines may lose passengers as well due to a public fear of flying, but in this case, TransAsia Airways's market share and load factor have decreased for all domestic routes in Taiwan. However, this may be problematic for airline operations, the balance of the aviation market, and safety issues. Rival airlines will receive the shifted customers, but these customers may return to the involved airline after a period due to the abating of concerns, as long as the airline can financially overcome an accident's impact. Neither airline is motivated to improve safety management, hindering safety development and a sound aviation industry. Therefore, an evaluation is essential to analyze this phenomenon and to explore customers' duration of worry after an accident. The objective is to enhance the safety level, to help airlines understand customers, and to salvage the air transport market. It is rare for two accidents to occur involving the same airline and country in six months, which justifies the necessity of researching this situation and investigating the influence of repeated accidents on consumers' perception.

1.1.2 Accident History and Passenger Number: Cases in Taiwan

On average, an accident occurs during or just before an off-peak period, the involved airline may face 22.11% monthly traffic decline, and other airlines may also lose 5.62% of passengers monthly because of public fear of flying in Taiwan (Wong and Yeh, 2003). Based on public safety concerns, recent accidents can be inferred to reduce customers' confidence toward the aviation market, and to change people's airline selection criteria.

Nevertheless, according to data from Civil Aeronautics Administration, the Ministry of Transportation and Communications (MOTC) of the Republic of China (Taiwan), market share among airlines after these two accidents show different outcomes in Figure 1.5. Currently there are five airlines operating domestic routes in Taiwan, and market share of airlines for domestic routes indicates that TransAsia Airways lost customers right after the GE222 Accident, but recovered in half a year. Another accident (GE235) occurred to the same airline, and induced a serious decline since then, revealing a big difference of two accident social influences.

This explains the second accident had much stronger impacts on people's behaviors than the first one. It also shows that one accident does not change the market performance much, while repeated accidents strongly and continuously discouraged people to use the airline.

A similar situation occurred to Taiwan in 2002 in Figure 1.6. A big flag carrier in Taiwan, China Airlines international flight CI611 (B747-200) in-flight breakup accident on May 25, 2002, with 225 fatalities of all occupants, decreased market share for a period but recovered after then, as enforcement of GE222 Accident on the market performance.

Therefore, it can be inferred that customers are still willing to use the involved airline after one accident such as CI611 and GE222 cases, but risk of accidents still exists, resulting in a repeated accident (GE235). There were several airlines suffering from financial crisis or bankruptcy after air crash events including Pan American World Airways (Pan Am), Swissair, and Malaysia Airlines. Previous experiences and the above-described phenomenon in Taiwan expressing the differences after accidents motivated us to explore the relationship between airlines' consideration and customers' perception.

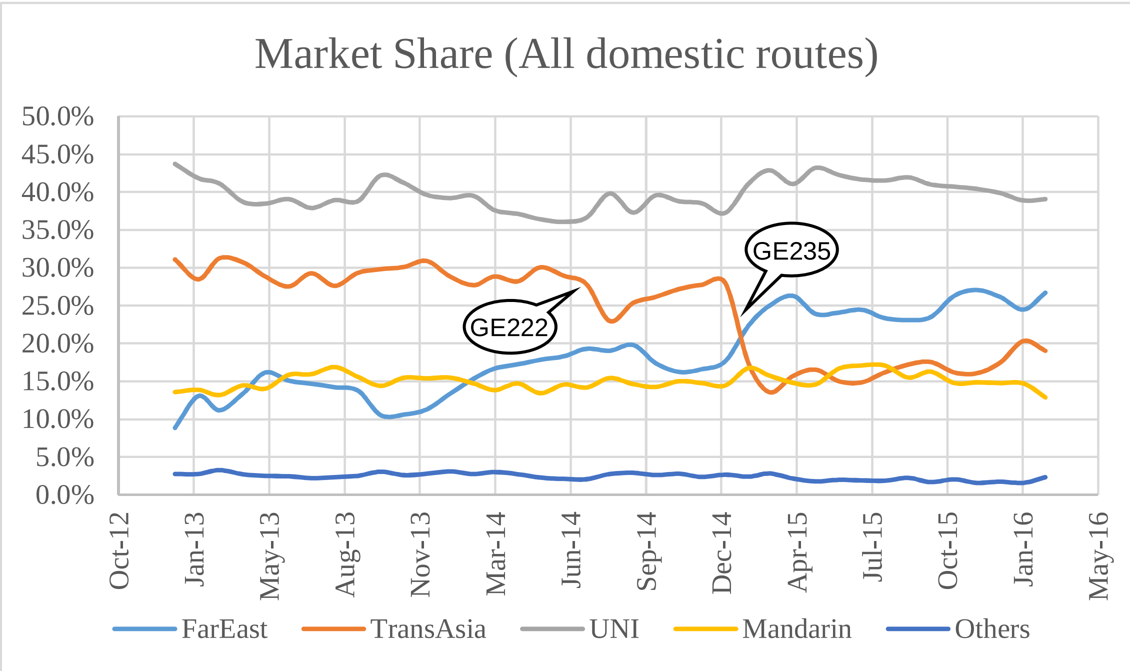


Figure 1.5 Market share of domestic routes from Dec. 2012 to Mar. 2016

(Source: Civil Aeronautics Administration, the Ministry of Transportation and Communications, Taiwan)

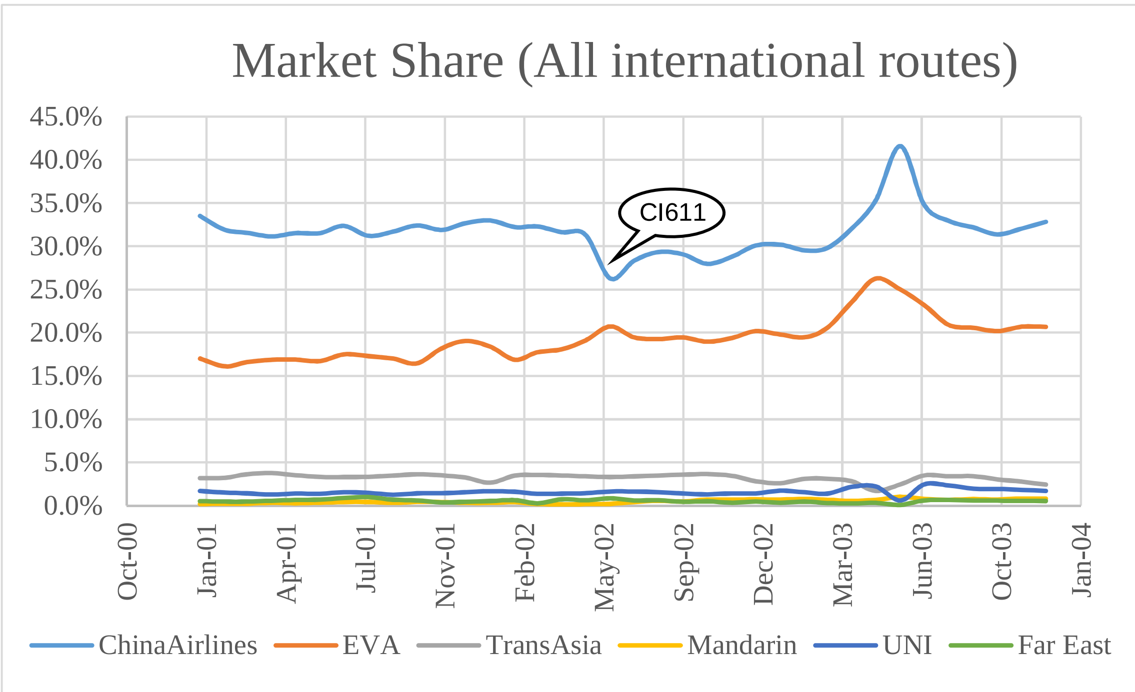


Figure 1.6 Market share of international routes from Jan. 2001 to Dec. 2003

(Source: Civil Aeronautics Administration, the Ministry of Transportation and Communications, Taiwan)

1.1.3 Accident History and Passenger Number: Cases in Malaysia

Malaysia Airlines, which is operated by Malaysian Airline System Bhd, had two accidents: MH370 (March 8, 2014 KUL – PEK), and MH17 (July 17, 2014 AMS – KUL) in 2014. After MH17, around 20-30% cancellation may add to the financial difficulties. Malaysia Airlines, which racked RM4.13 billion in losses in the past three years, will probably lose more than RM1 billion in 2014 (Malay Mail Online, 2016).

To investigate how the airline made efforts to rebuild market confidence, it is important to compare passenger usage with other airlines in Malaysia. Figure 1.7 and Figure 1.8 show international and domestic passenger movements for four major airlines in Kuala Lumpur International Airport (KLIA) (Malaysia Airports Holdings Berhad, 2016).

If we compare 2014 and 2013, international passengers for Malaysia Airlines decreased slightly, while AirAsia, AirAsia X and Malindo Air had positive growths. Besides, during that period, airfare was lowered to attract more passengers, so we can infer that MH370 and MH17 did influence customers' willingness. This situation is similar with TransAsia Airways that repeated accidents happened to the same airline in a short period, making it a rare case study to explore the consequences.

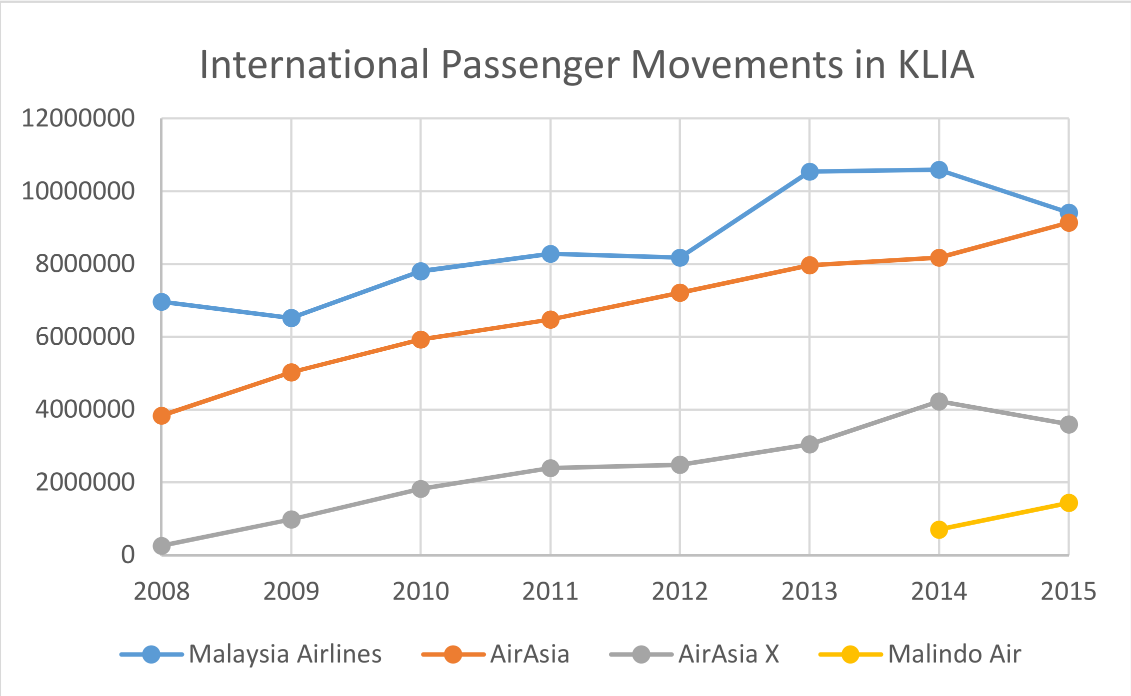


Figure 1.7 International passenger movements in KLIA

(Source: Malaysia Airports Holdings Berhad Annual Report 2008-2015)

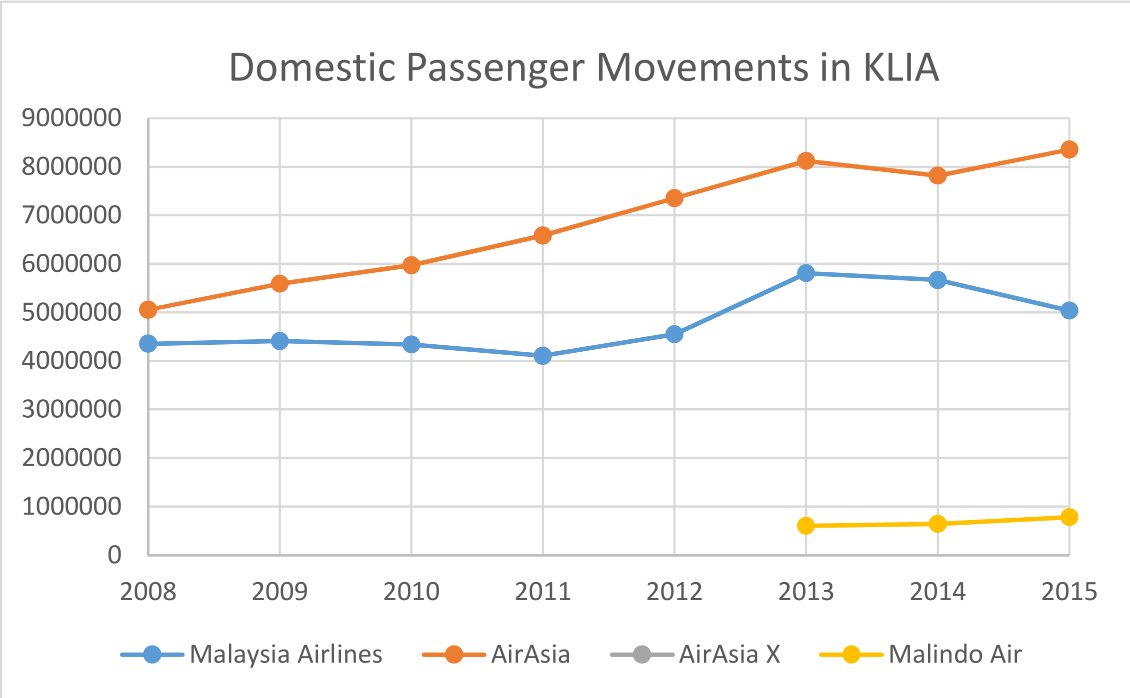


Figure 1.8 Domestic passenger movements in KLIA

(Source: Malaysia Airports Holdings Berhad Annual Report 2008-2015)

1.2 Motivation

Observing two examples in Taiwan and Malaysia, aviation accidents do change people's intention and market performance. Figures 1.9 to 1.12 show TransAsia Airways accident situation. Casualties and economic loss were serious, so to prevent dangers, safety is always important. Definition of aviation safety is expressed in many ways. Transport Canada Civil Aviation (2012) defines safety as "the condition where risks are managed to acceptable levels." The ICAO Air Navigation Commission (2001) defined it as "the state of freedom from unacceptable risk of injury to persons or damage to aircraft and property". We can find that aviation safety is to control levels of risk to some degree, and prevent possibility of occurrence of accidents.

Aviation safety plays an important role, because it can satisfy passenger transport demand, promote aviation industry, and also stimulate regional development. Thus, research in aviation safety is necessary and should encompass the theory, investigation, categorization of flight failures, and the prevention of such failures through regulation, education, and training.

Figure 1.9 GE222 accident (1)

Figure 1.10 GE222 accident (2)

Figure 1.11 GE235 accident (1)

Figure 1.12 GE235 accident (2)

To prevent aviation accidents happen, a sound flight safety management system (SMS) is necessary. An airline company is the main controller of SMS and makes efforts to fit aviation standards, to think how to avoid accidents, to take active behaviors and attitudes, and to keep improving. From the history of SMS (China Airlines, 2012), we can find that even until now SMS is only emphasized on "operator side" in Table 1.2, and lack of interaction with users and consideration of passengers' feelings. As a result, the feasibility of inclusion of passenger safety perception as part of SMS is of interest, because safety should be mutually involved, instead of merely operators' tasks.

Table 1.2 Safety management system history

Period	SMS Contents	
1960s	Technical	Improvement of mechanics and techniques
1970s	Human error	Preventive measures of human errors
1990s	Socio-technical	Improvement of organizational and systematic aspects
2000s	Organizational culture	Improvement of organizational safety contents and culture
2010s?	Safety perception?	Improvement of public safety knowledge, and minimization of social influences

Besides, since SMS is usually operated by airlines and audited by the government, risk communication with the public is insufficient, making a gap of perception. Without a platform for operators and the public to exchange their thoughts and experience, users can only judge the level of safety by themselves merely by operation performances, services, previous accident records, etc. Consequently, a problem is stated here, generally those judgments of safety are sometimes wrong or over subjective. A structure in Table 1.3 to explain the phenomenon. Type I error indicates that the airline is safe but people think it is unreliable, while type II error shows oppositely. Therefore, this study is going to explore Type I to discover the reasons that cause them worried.

Table 1.3 Gap of safety and safety perception

		Safety perception	
		Safe	Unsafe
Real safety	Safe	True	Type I error
	Unsafe	Type II error	True

Individual safety perception toward airlines is a key to selecting which airline to use. Objective safety may not be an adequate measure for passengers because they cannot correctly comprehend it, so subjective safety perception may be more relevant to them. This motivates us to research how people perceive accidents, and how airlines consider social and public reaction for safety measures to prevent risk.

1.3 Objectives

In order to explain the differences of market performance after accidents, to understand how people’s behavior change and airline’s safety measures is the focus of this research. The previously observed problems are stated as follows: how people perceive the airline before and after an aviation accident, and how to analyze the influences on the society and customers; how to measure people’s subjective perception toward the airline, and what factors dominate their worries and airline selection criteria; how airlines improve safety to prevent risk. Hence, it is important to select a real accident as a case study and conduct a survey to build a mathematical model to explain customers’ perception and airline safety measures.

The structure of key problems in this research was drawn in Figure 1.13 to provide an overview of diverse stakeholders and influences. Due to distrust of airlines and concerns after accidents, a loss of passengers might result in severe financial conditions (Walker et al., 2005). Aviation companies would prefer to retrieve passengers from other airlines to sustain their business, as a loss of customers coupled with accident compensation may cause a budget burden and cause bankruptcy. Therefore, it is necessary to understand the influence of aviation accidents. In other hands, if airlines assume passengers will return due to abating of worries and unawareness of safety measures, they may conduct less safety measures and focus on promotion, which will decrease the level of safety.

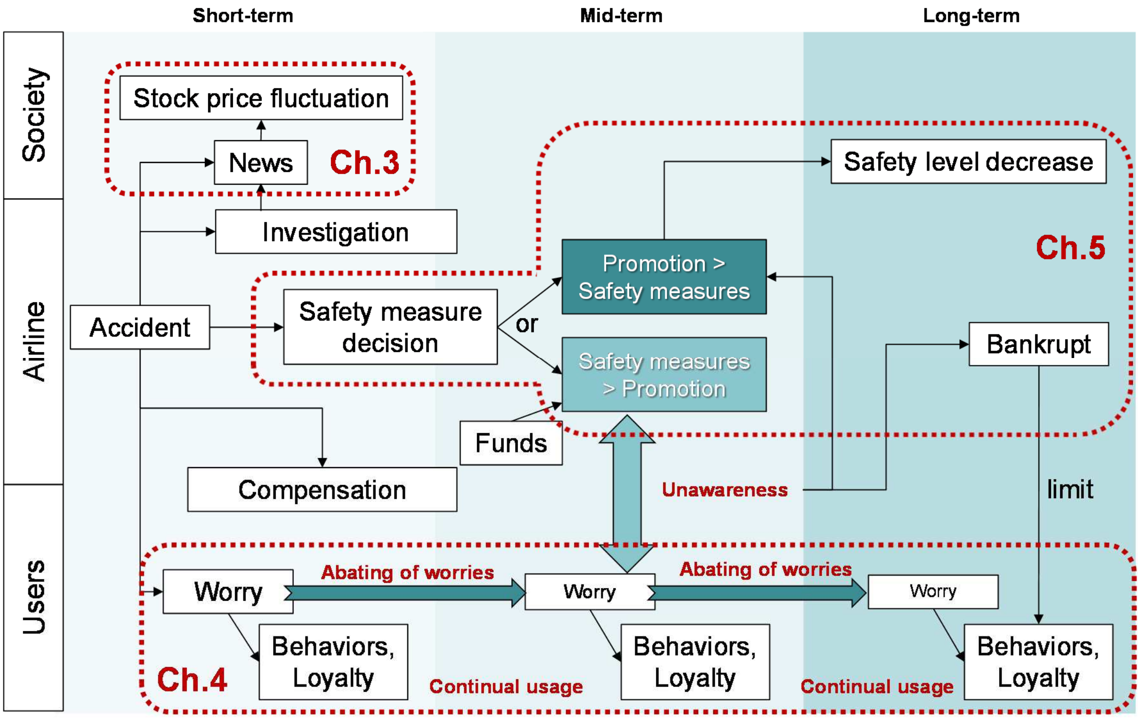


Figure 1.13 Structure of key problems in this research

The objectives of this research are: (i) to identify the social effects associated with aviation accidents, (ii) to indicate the impacts of an accident on public perception by comparing users' behaviors in a real case, (iii) to model public perception with quantification of safety concerns, (iv) to build a structural equation model to clarify the attributes of airline selection criteria and behavior, and (v) to explore the interaction between the airline and customers to find motivation for safety measures. The overall purposes are to minimize impacts of accidents, and to enhance long-term aviation safety.

This study, by recognizing social effects, public perception and airline's actions, could provide a perspective for airline policy making. The results can indicate people's safety concerns and minimize accidents' impacts. Currently, and to the best of our knowledge, limited research exists regarding the negative influences of aviation accidents, public safety perception and interactive decision making with airlines; therefore, this study will be innovative in its analysis of this phenomenon.

1.4 Structure of the Dissertation

This dissertation is composed of six chapters. Chapter 1 and Chapter 2 are research background and related studies. Chapter 3 analyzes social and economic effects, and gathers information via site investigation. Chapter 4 conducts a survey to collect data for explore influences on public perception, formation of safety concerns, analysis of worry duration, and users' behavioral intention change. Chapter 5 focuses on the interaction between the airline and users to discuss airline's motivation for safety measures via game theory. Conclusions and recommendations are presented in Chapter 6. The overall structure of the dissertation is depicted in Figure 1.14.

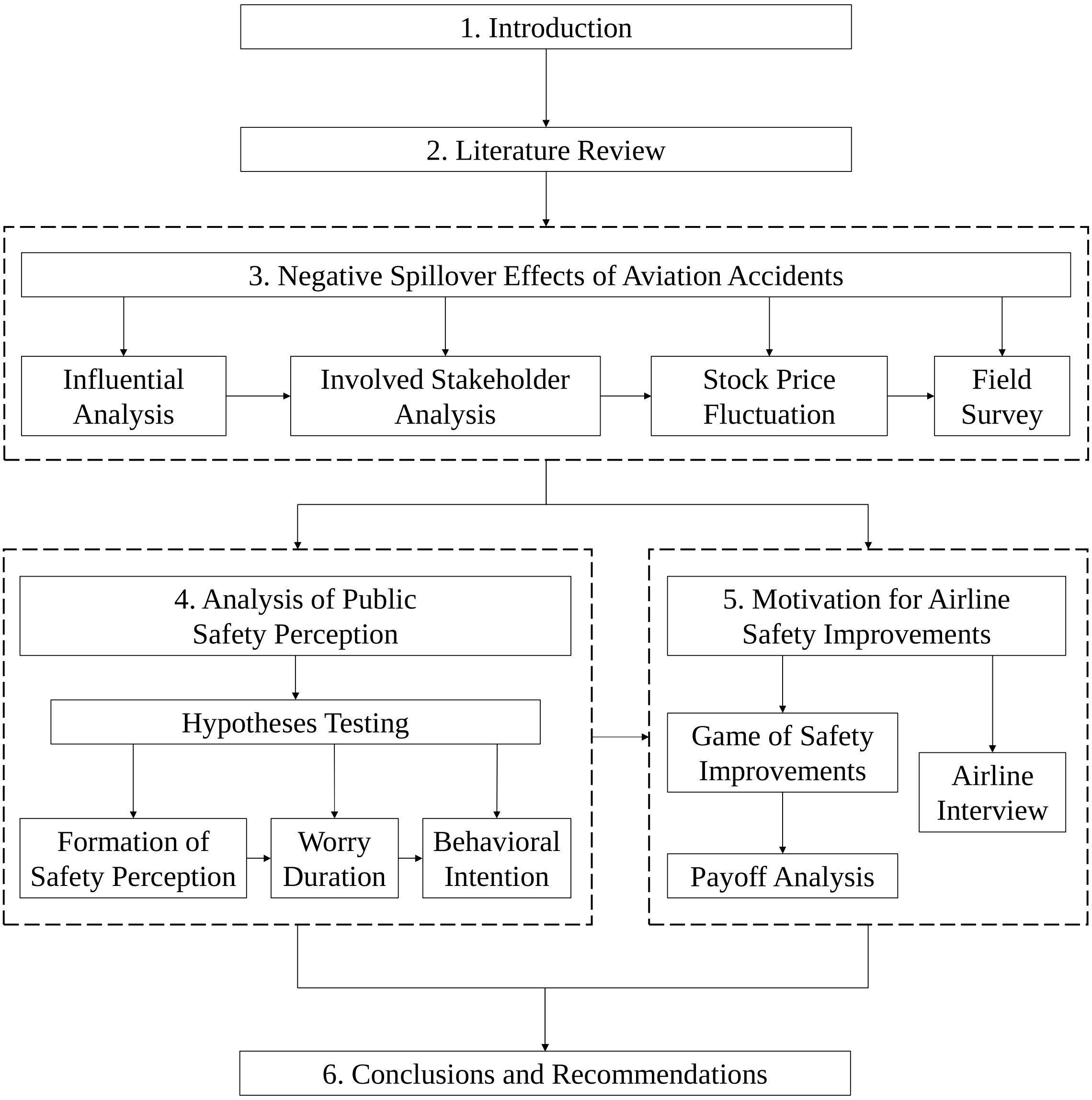


Figure 1.14 Dissertation structure

Chapter 2

Literature Review

2.1 Aviation Safety and Risk Analysis

2.1.1 Safety and Safety Perception

Definitions of safety and safety perception are different. Safety is an objective and realistic concept: it is safe if the possibility of aircraft accident occurrences is low. Safety perception is a subjective and spiritual concept: each person has his own criteria, so someone feels safe while others are not the same as them. (Kinoshita, 1999).

The causes that result in safety perception are diverse. Insufficient knowledge makes people perceive with their limited information (JSDA, 2011). The relationship of knowledge and safety perception is non-linear. For anyone who does not know anything will not feel safe at all, but when obtaining more and more knowledge, level of safety perception will be increasing. Moreover, real safety and safety perception to X-ray and nuclear power was conducted to compare the personal perception gap. Slovic (1987) showed the discrepancy of risk assessment between different groups. An ordering of perceived risk for 30 activities or technologies for four groups were tested. The results showed that experts considered X-rays to be risky and nuclear power as not, while the public though oppositely. Experienced experts adopt objective risk assessment to evaluate dangers, while most people rely on risk perception influenced by experiences, media, insufficient knowledge and other factors. This can be contributed to severity of disaster and existence of high risk of fatality, making people perceive apart from experts toward the same thing. To sum up, perception of airline is similar to nuclear power. Most of people do not familiarize with how airlines work and only understand accidents might cause huge fatalities, so they can only infer from their past experiences or the mass media, resulting in a huge gap of safety cognition.

2.1.2 Risk Analysis

Every experts have their own definition of risk perception. Sjöberg (1998) concluded that perceived risk consists of three factors: cognitive (probability), emotional (worry), and consequences. Uruno (1975) defined risk is subjective danger that represents for possibility of people's danger estimation. Bouyer et al. (2001) said two directions of risk perception: aspect linked to the risk hazard, and aspect linked to the risk perceiver.

Risk analysis (FAO/WHO, 1995) is widely used for the management of public health hazards in food safety. Figure 2.1 illustrates the relationship between the three components of risk analysis: assessment, communication, and management. Risk assessment is to identify the risk and to estimate the effects it might bring. Risk management is to make decisions and policies to decrease risk. Both of them are mutually established by operators and experts and then reported to regulators, i.e. the government. At the process of assessment and management, all stakeholder groups should be involved to communicate and to exchange information.

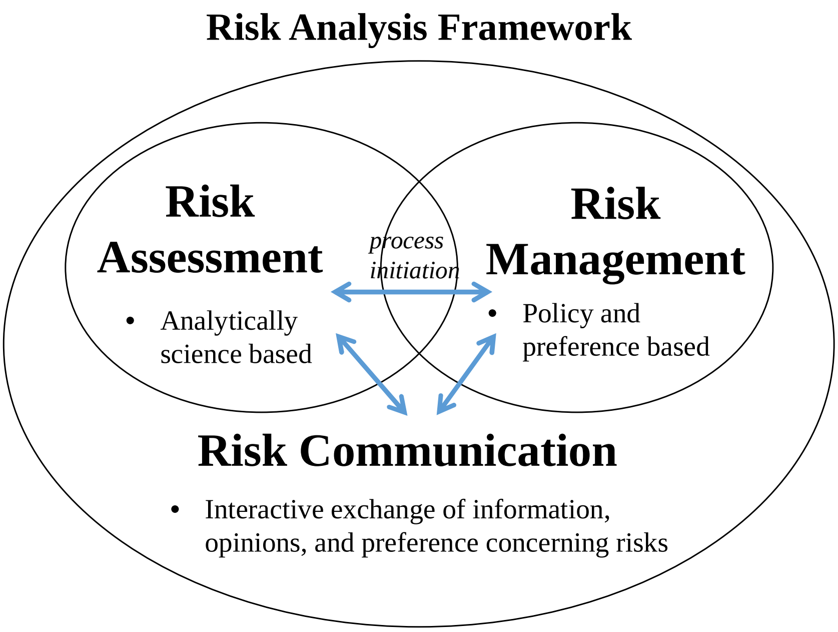


Figure 2.1 Three components of risk analysis
(FAO/WHO, 1995)

Figure 2.2 (USACE, 2010) shows risk analysis steps, where communication and consultation are implemented for all procedures to confirm whether opinions are truly conveyed. It makes all parties aware of the process at each stage of the assessment and management, and helps to ensure that the logic, outcomes, significance, and limitations of the assessment are clearly realized by all groups (FAO/WHO, 1998). By doing so, stakeholders can be fully engaged in, and appropriately share the responsibility for risk management.

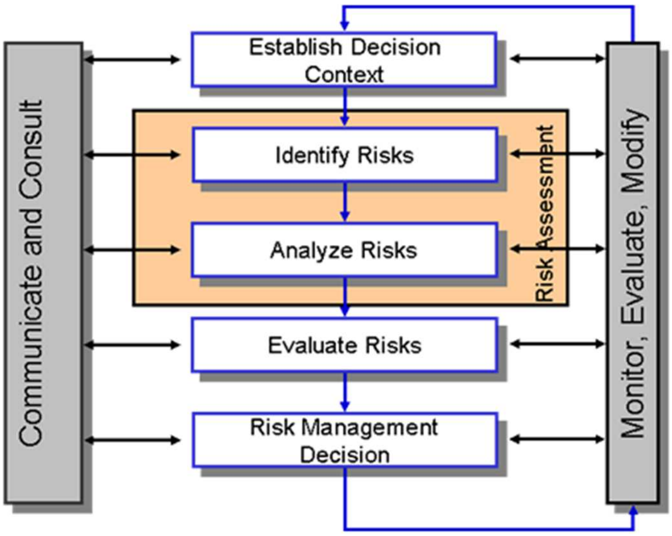


Figure 2.2 Risk analysis steps

(USACE, 2010)

To be specifically discovering, risk communication is defined. FAO/WHO (1995) said it is an integral and interactive process of exchange of information and opinion on risk among risk assessors, risk managers, and other interested parties. USACE (2010) indicated that risk communication is the open, two-way exchange of information and opinion about risks and uncertainties leading to a better understanding that will facilitate risk management decisions.

For airlines, safety management system (SMS) represents for risk assessment and risk management. Stakeholders involved in risk communication are not only the government, experts, industries, but also customers and the media. Apparently, part of the public still distrust some airlines even there is no accidental records. Slovic (1993) addressed the empirical finding that risk communication is not working well to obtain and restore public trust in risk managers because there is a gap in risk perception between lay people and experts as well as the risk managers. Consequently, even now, many people do not understand airline SMS, thus they can only partially get the information from the media, airlines' previous performance and personal used experiences to estimate and evaluate the degree of safety of airlines.

Generally we know risk is a combination of judgment of probability and seriousness of consequences. Aviation accidents are extreme events as floods, earthquakes, storms and the Chernobyl event, but because of rare occurrence and tremendous casualties, perception in aviation sector makes it unique and worth studying.

2.1.3 Aviation Safety Perception

The aviation market is a highly competitive environment. People still base on their individual perception to select an airline. The delivery of high-quality service to airline passengers is important for the airline's survival, competitiveness, profitability and sustained growth (Suki, 2014). Even though fatal aviation accidents are extremely rare, the rapid growth in aviation industries has caused increasing exposure to risk. Airlines need to understand what passengers expect in order to better serve their demands and achieve the highest level of satisfaction.

This section focuses on consumers' concerns, psychologically termed "subjective risk" (Backer-Grøndahl and Fyhri, 2009), or "subjective worries." People have individual perceptions of both consequences and probability. Public perception and social reaction are targets of the research because lay people constitute a major portion of the aviation market. Perception of an airline can be illustrated as the airline's image, safety perception, trust, and willingness to use and recommend, which control significant loyalty and customer purchase behaviors (Suki, 2014). Here safety perception is explained as follows.

Customers' anxiety and safety concerns may increase following an aviation accident, and this could result in a loss of usage for airlines. Gilbert and Wong (2003) conducted a survey in Hong Kong prior to the September 11, 2001 attacks in the United States and found that safety is passengers' priority, followed by punctuality, promptness, and hospitality. Chang and Hung (2013) also explained that safety is a factor in passengers' loyalty toward low-cost carriers, but Vlachos and Lin (2014) rejected the hypotheses of ticket price, schedule, flight frequency, and safety as airline loyalty variables for business travelers because they have more experience and knowledge than lay people.

Airline safety perception is controlled by several factors such as individual personal traits, cultural background, knowledge, and the environment they are staying. Fyhri and Backer-Grondahl (2012) investigated the relationship between risk perception in transport and personality, and they defined personality as an individual's enduring patterns of thoughts, feelings and behaviors. Moreover, You et al. (2013) tested the relationship of pilots' locus of control among risk perception and safety operation behaviors. Risk perception is also determined by cultural variations such as nationality. Lund and Rundmo (2009) examined the cultural differences in risk perception and attitudes toward traffic safety and risk, taking behaviors in Norway and Ghana, and their results found differences between two countries. Gill and Shergill (2004) surveyed businesses and individuals throughout various sectors of the aviation industry in New Zealand, and indicated that people think role of safety education, training and rules is important for the organizations to improve safety management, but pilots and aviation industry experts think luck is highly related, which is totally different from view of the public. External factors like environment and facilities also affect risk perception. Han (2013) found that all passengers and airline employees want to avoid risk from potential safety hazards because air quality, temperature, layout and amenity have an effect on people's feelings.

Considering passengers' perception toward the airline as one of the service quality would offer a perspective for airlines, enabling them to identify passengers' behaviors and expectation for better market segmentation. Understanding people's behaviors will bring a significant importance to airline strategic management to improve its airline service quality, customer satisfaction and safety management efficiently.

2.2 Aviation Safety Evaluation

Since everyone has their individual perception and risk assessment toward safety, so a general criteria to provide more objective information is necessary. In this section, accident causes, database, and safety ranking will be introduced.

2.2.1 Accident Causes and Database

To analyze aviation safety of its dangerous factors and potential factors, accidental causes can be summarized as four main categories: human, facility (aircraft and equipment), environment and regulation in Table 2.1 (CAA).

Table 2.1 Aviation accident causes (CAA)

1	Human	All staff of flight, maintenance, navigation, airport, security and operation, their safety cognition and technical skills have to meets the standard and requirement of safety management.
2	Facility	Design, equipment and routine maintenance of aircrafts should be fully practiced to confirm aircrafts' best performances and conditions to ensure safety.
3	Environment	Natural environment: natural obstacles like the weather and the geography (especially high mountain and skyscraper) would influence aircraft operation, so professionals have to precisely estimate the situation with advanced equipment and abundant experiences and provide accurate aviation environmental information.
		Artificial environment: it includes airport and navigation aids, ILS, aviation lights, and all of them have to be regularly maintained to support pilots finish takeoffs and landings.
4	Regulation	All technical regulations, procedures, laws related to aviation made by the government or ICAO/IATA have to be strictly obeyed by all aviation stakeholders, and they should update periodically to meet the latest standard.

Walker et al. (2014) also summarized all aviation accidents into six groups by causes in Table 2.2. We can know most of reasons are due to airline faults, especially human errors.

Table 2.2 Aviation accident causes (Walker et al., 2014)

1	Nature	Weather (wind shear, icing) and animal related (birds)
2	Airline Fault	Negligence or errors made by airline personnel (including poor maintenance by the ground crew such as improper hydraulic systems configuration, failure to de-ice airplane or failure to refuel and pilot/crew errors such as errors made during instrument approach, overloaded airplane, premature descent, overrun runway)
3	Mechanical	Mechanical failure (engine failure, equipment failure, design flaw, instrument failure)
4	Air Traffic Control	Air-traffic control error (incorrect commands issued to pilot, e.g. landing clearance when runway occupied)
5	Crime/Terror	Criminal activity (hijacking, explosive device, terrorist attack)
6	Other/Unknown	Other/unknown

To gather more details of accident data, full reports, detailed description of the accident including the cause, the number of fatalities, etc. are available as listed in Table 2.3.

Table 2.3 Aviation accident database

USA	National Transportation Safety Board	1935~(detail report: 1994~) http://www.ntsb.gov/
Canada	Transportation Safety Board of Canadian	
Australia	Australian Transport Safety Bureau	
Japan	Japan Transport Safety Board (運輸安全委員会)	1974~ http://www.mlit.go.jp/jtsb/
Taiwan	Aviation Safety Council (飛航安全調查委員會)	1999~ http://www.asc.gov.tw/
Indonesia	National Transportation Safety Committee (Komite Nasional Keselamatan Transportasi)	1997~ http://www.dephub.go.id/knkt/
Global	Online databases	http://www.airdisaster.com/ http://aviation-safety.net/ http://airdisasters.co.uk/

2.2.2 Criteria of Airline Safety Evaluation

Safety is a vague concept, risk assessment between stakeholders are also different. To eliminate discrepancy of risk estimation (Slovic, 1987), there are various online airline safety ranking which adopts diverse methodologies and results in vast outcomes. Evaluation conducted by two organizations: JACDEC and ATRA are convincible and authorized. The other two rating from Australian magazine (Askmen.com) and airline safety assessment (AirlineRatings.com) also have reputation on safety evaluation.

- Jet Airliner Crash Data Evaluation Centre (JACDEC) (Germany)

With 12 years of accident analysis experiences, JACDEC uses a number of factors to determine its annual accidents and serious incidents in the last 30 years in relation to the revenue passenger kilometer (RPK). They use a special methodology in Figure 2.3 to calculate index for each airlines and make safety ranking. Description of methodology is explained in German aviation magazine Aerointernational.

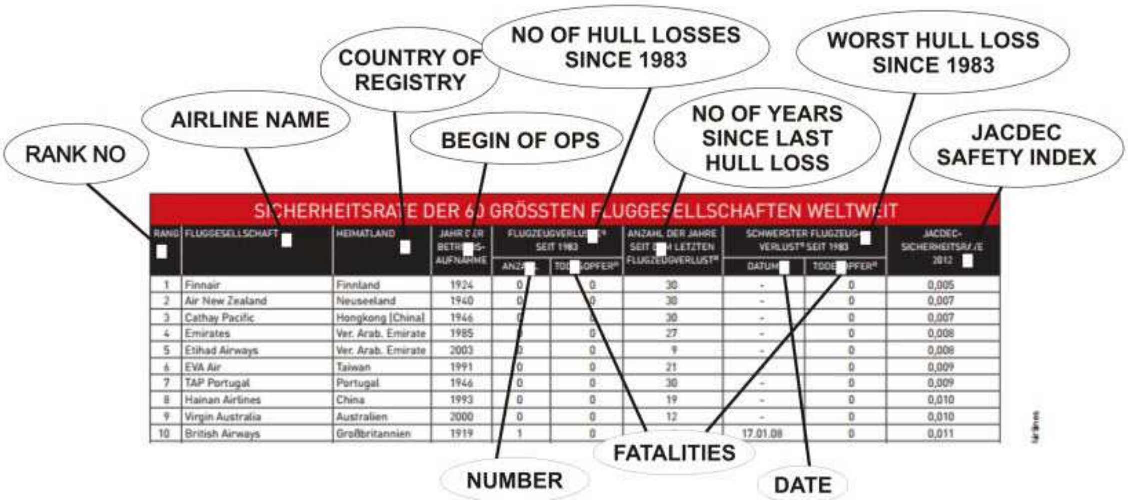


Figure 2.3 Methodology of airline safety evaluation

(Source: www.aerointernational.de)

JACDEC safety index is annually conducted by German Accident Investigation Bureau with eight components in Table 2.4 and formula to calculate airline safety index. Total sixty airlines were evaluated and ranked. Results of JACDEC safety ranking 2013 is showed in Table 2.5.

Table 2.4 JACDEC index methodology and definitions

1	Annual Revenue Passengers Kilometers (RPKs)	Flight performance of an airline by using the cumulative RPK's - 30 years back.
2	Fatalities	Deaths among all occupants on board commercial passenger flights of an airline - up to 30 years back.
3	Total losses	Accidents refer to operations where the aircraft is destroyed, or was no longer repairable.
4	Serious Incidents	Defined by international standards and referred to incidents where an accident was only narrowly avoided.
5	Accident-Free Years	The number of years without a total loss (hull loss) accident, backward from the current reference year to the most recent total loss of an airline.
6	IOSA Membership	IOSA (IATA Operational Safety Audit) is an unqualified certificate to determine a recognized program of the airline association IATA, to operational structures and quality management within an airline.
7	The Time Factor	Applying a time weighting factor to calculate the total accident history of an airline.
8	Country Transparency	Three levels of transparency of the controlling authority of Aircraft Accident Investigation.

(Source: http://www.jacdec.de/Airline-Rankings/Airline-Rankings.htm)

Table 2.5 JACDEC safety ranking 2013

	Safest	Index		Most Dangerous	Index
1	Air New Zealand	0.007	1	Lion Air	1.899
2	Cathay Pacific Airways	0.008	2	Vietnam Airlines	1.544
3	Finnair	0.010	3	China Airlines	1.130
4	Emirates	0.010	4	Air India	0.934
5	Eva Air	0.010	5	Tam Airlines	0.890
6	British Airways	0.011	6	Garuda Indonesia	0.802
7	Tap Portugal	0.012	7	Gol Transportes Aereos	0.689
8	Etihad Airways	0.012	8	Saudia	0.548
9	Air Canada	0.012	9	Korean Air	0.396
10	Qantas	0.013	10	Turkish Airlines	0.376

(Source: http://www.jacdec.de/)

- Air Transport Rating Agency (ATRA) (Switzerland)

ATRA's approach is based on aviation risk assessment and data analyses. ATRA holistic safety rating focuses on internal organizational factors, which contribute directly or indirectly to general safety and external factors such as environmental criteria are not taking into account. ATRA selects 15 organizational criteria in Table 2.6, which contribute to general safety.

Table 2.6 ATRA index methodology

Financial	Net financial result, maintenance expenses
Service	Passenger load factor, number of accidents during the last 10 years
Aircraft Operation	Total number of km flown, overall number of aircraft in service, average age aircraft in service, percentage of aircraft on order, homogeneous fleet of Airbus or Boeing, homogeneous type of aircraft, number of aircraft no longer in production, number of aircraft considered at risk
Human Management	Total number of employees, total number of pilots/copilots, total number of cabin crew employees

(Source: http://atra.aero/)

- Australian magazine (Askmen.com)

Information is taken from a survey by Australian magazine (Askmen.com) in 2012 and results are ranked on the basis of the number of flights since the last fatal accident in Table 2.7. Qantas is the only airline never suffered from a fatal accident until now, but due to the relatively small number of flights they operate compared to larger airlines, Qantas is only ranked number four on the list of safest airlines.

Table 2.7 Top 10 safe and dangerous airlines 2012

	Safest		Most Dangerous	Million Flights	Crash	Fatalities
1	British Airways	1	Cubana Airlines	0.32	8	404
2	Air Canada	2	China Airlines	0.91	6	763
3	All Nippon Airways	3	Iran Air	0.97	6	708
4	Qantas	4	Philippine Airlines	1.18	6	107
5	Finnair	5	Kenya Airways	0.45	2	283
6	Aer Lingus	6	Egypt Air	1.07	4	402
7	Air New Zealand	7	Pakistan International Airlines	1.43	5	440
8	Aerolineas Argentinas	8	Avianca	1.47	4	500
9	TAP Portugal	9	Thai Airways	1.98	4	352
10	Cathay Pacific	10	Garuda	2.00	4	431

(Source: http://www.askmen.com/top_10/travel/top-10-safest-airlines_1.html; http://www.squidoo.com/top-ten-most-dangerous-airlines)

- Airline Safety Assessment (AirlineRatings.com)

Airline safety assessment is conducted by AirlineRatings.com which adopts seven star safety assessment criteria in Table 2.8 for all airlines as follows: IOSA (IATA Operational Safety Audit) certification, EU blacklist, fatality free record for the past 10 years, FAA endorsement, eight ICAO safety parameters (legislation, organization, licensing, operations, airworthiness, accident investigation, air navigation service, and aerodromes), records of grounding of aircraft, and percentage of Russian built aircraft. It should be noted that most of the LCCs are not IOSA certified.

Table 2.8 Airline safety assessment 2016 in Asia

North East Asia		South Asia		East Asia	
Peach Air	5	AirAsia Malaysia	2	Spring Airlines	5
Vanilla Air	5	Scoot	5	Air China	7
Jeju Air	7	JetStar	7	China Eastern	7
JAL	7	Cebu Pacific	4	China Southern	7
ANA	7	Malaysia Airlines	5	China Airlines	7
Korean Air	7	Singapore Airlines	7	EVA Air	7
Asiana Airlines	6	Philippine Airlines	6	TransAsia Airways	5
		Garuda Indonesia	3	Cathay Pacific	7
		Thai Airways	4		

(Source: http://www.airlineratings.com/)

However, above airline safety rankings release annual assessment, but their methodologies vary and results are often different. Director of IATA's Global Safety Chris Glaeser said those airline safety rankings are partial and flawed. "It has been the view of the airline community that safety is not a competitive issue." (Gazette, 2013) Those methodologies may not be transparent, with possible issues concerning incomplete data, inconsistent definitions of accident types, and a bias in favor of younger airlines. Therefore, safety evaluation and airline safety ranking are only considered as references, and it does not mean well-evaluated airlines have less accidents in the future.

2.3 Safety Worries

In last section, various safety evaluation has been summarized. After accidents, safety is one of the most essential considerations that passengers require due to a fear of catastrophic disasters. Airline companies, the government, and international organizations have introduced diverse regulations and standards to ensure the full implementation of a safety management system to prevent these disastrous events. However, how to quantify people's subjective concerns and to analyze their behaviors are not yet studied. In the beginning, we would like to check cabin environment effects on air passengers.

2.3.1 Cabin Environment Effects

Passengers are eager for a comfortable space during their flights, but cabin air quality, humidity, seat design, aircraft noise and inflight entertainment may influence passengers' perception, resulting in flight anxiety. These factor may be related to airline service quality, but they can also help passengers stay calm.

Nagda and Koontz (2003) found dryness symptoms are attributable to low humidity (2 to 15%) and fatigue symptoms are associated with factors such as disruption of circadian rhythm. Practically all symptoms are exacerbated by longer flight durations. Studies citing problems of poor aircraft cabin air quality tend to be weak in design. Fai et al. (2007) focused on trunk drivers since they sit for long periods of time and feel more fatigue. Considering the long hours of hauling, it can be argued that one of the most important parts of the truck driver's working environment is the truck seat. Therefore, they found that seating comfort is a major concern, and main factors that affect seating comfort are seat-interface pressure distribution, whole-body vibration, muscle activity (ergonomics), thermal comfort as well as humidity comfort. Sittig et al. (2011) evaluated exposure of neonates and preterm newborns to noise during air medical transport (helicopters). They placed one dosimeter in the infant incubator, and recorded noise levels in various parts of the aircraft cabin. The results showed the incubator provided a 6-dBA (OSHA standard) decrease in noise exposure from that in the crew cabin. Because babies lack the physiologic abilities to handle stress, such as a noisy aircraft, they recommended to place an earmuff to relieve the noise harms. Lastly, Liu et al. (2008) developed a new entertainment adaptive framework for stress-free air travels basing on the passenger's current and target comfort states, user entertainment preferences to recommend a stress reduction entertainment to transfer passengers from the current state to the target comfort state. They indicated inflight entertainment can regulate the passenger's physical and psychological states to comfort states.

2.3.2 Adaptation

Adaptation is a tool to convert people's concerns into time scale. With time passing by, heals will be relieved. According to literature review, diverse definitions of adaptation are summarized in Table 2.9.

Table 2.9 Definition of adaptation

Literature	Description
Ronen and Yair (2013)	The process of adaptation can generally be described as a pattern of rapid improvement at the beginning followed by a much lower or even no further improvement as it reaches an apparent plateau.
Houlfort et al. (2015)	Psychological adjustment to retirement: they tested a model in which passion for work predicts psychological adjustment to retirement through the satisfaction of basic psychological needs.
United Nations (2016)	Adaptation is adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.
European Commission (2016)	Adaptation means anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause, or taking advantage of opportunities that may arise. It has been shown that well planned, early adaptation action saves money and lives later.

- Adaptation period in driving simulator

Ronen and Yair (2013) explored whether roads of different complexity and demand (curved, urban and straight) require different adaptation time, and examined the relationship between participants' subjective sensation of adaptation and objective driving performance measures. They used the exponential decay function to analyze adaptation (learning curves) in various driving performance measures. Experience and learning curve concepts can be used together to identify adapting drivers while they are driving practice sessions.

In the field of psychology the term forgetting curve in Figure 2.4 describes how the ability of the brain to retain information decreases in time. Ebbinghaus (1885/1974) performed a series of tests on himself over various time periods. He then analyzed all his recorded data to find the exact shape of the forgetting curve, and then confirmed that forgetting is exponential in nature. We can find that our safety worries have the similar trend as forgetting curve, because worries are also declined with time. Figure 2.5 shows memory retention for newly learned information. After first learned, memory will retain 80% after one day. Once the people review it, retention would return to 100% again. In the same way, memory will last longer and is not easily forgotten after repeated reviewing, which ensures learning efficiency. This situation is similar with TransAsia

Airways accidents. People's concerns were recalled again owing to repeated events, making people worry the airline repeatedly.

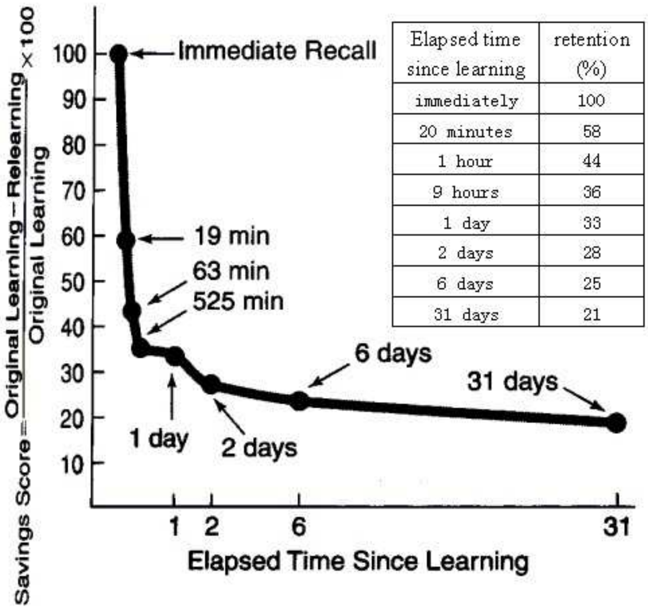


Figure 2.4 Forgetting curve
(Ebbinghaus, 1885/1974)

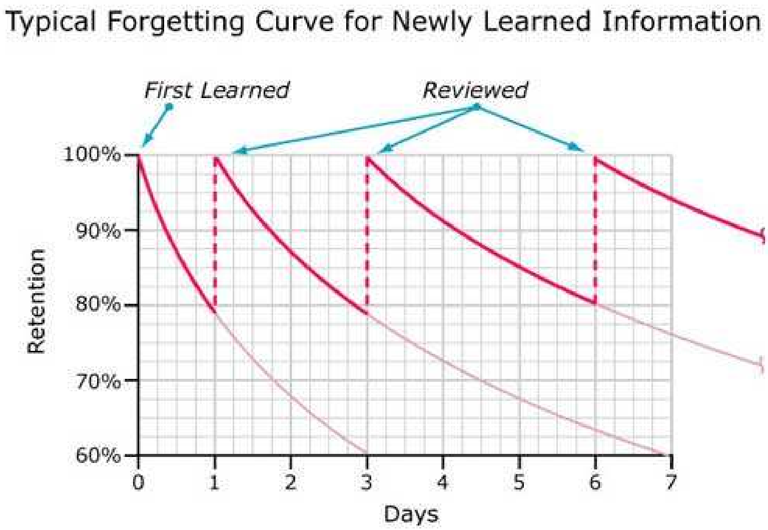


Figure 2.5 Learning process and memory retention
(Source: http://www.interskill.co.uk/business_results.html)

2.3.3 Factor Exploration of Safety Worries

For this reason, time to represent adaptation toward aviation accidents can be used as well. When an aviation accident occurs, people observe the news, arousing concerns regarding the involved airline's safety management. Passengers expect a safe and comfortable journey, but their negative experiences, such as knowledge of accident records, may have a stronger impact than positive experiences (Friman et al., 2001), influencing users and their willingness to purchase (Tarigan et al., 2010).

The determinants of airline safety concerns are derived from several psychological factors, such as air knowledge, cabin environment, airline operation performances, socio-economic information, and personality, among others. What lay people perceive differs from aviation industry experts' perspectives due to insufficient safety knowledge and experience. Moreover, cabin environment and design also affect people's visual feelings and consolation (van Oel and van den Berkhof, 2013). All passengers want to avoid risks, from take-off to landing, and desire a pleasant cabin space free from potential safety hazards, to reduce environmental stimuli that create negative consumer responses. Han (2013) used a confirmatory factor analysis and a structural equation model to discover the relationship among factors of ambient conditions, space function, cognitive and affective evaluations, satisfaction, and repurchase intentions, and concluded that air quality, temperature, layout, and equipment have an effect on people's emotion. Worries and safety perception can be determined by individuals and cultural variations (Lund and Rundmo, 2009).

To observe their worry performance to behaviors, Joewono and Kubota (2007) created a structural model construct with diverse factors, including income, trip expenses, trip frequency, car ownership, and trip purpose, to explore user satisfaction with paratransit service, and anticipate future transport modes for its motorized competition in Indonesia. Moreover, personality was also found to be dominant in influential behaviors. Nordfjærn and Rundmo (2015) measured personality by two constructs, sensation-seeking and normlessness, to observe the relationship among risk perception, safety motivation, and worry. Fyhri and Backer-Grøndahl (2012) defined an individual's enduring patterns of feelings, thoughts, and behaviors, and investigated the relationship between transportation risk perception and personality. These outcomes demonstrate that the more emotionally stable a person may be, the less that person considers the possibility of an accident. Thus, several factors were considered in this study to estimate accident influences, such as flight experiences, aviation safety knowledge, personality, and socio-economic information.

2.4 Components of Users' Behavioral Intention

People's selection criteria toward an airline is composed of different components which can be quantified statistically. Similar studies about airline loyalty have been extensively discussed until now. Oliver (1999) defined four levels of loyalty framework. The first phase is cognitive loyalty, which is based on available information or functional elements to customers such as airline impression, airfare, and service quality. The second phase of loyalty, affective loyalty, is linked to customers' feelings as satisfaction and trust toward the company. The next is conative loyalty indicating behavioral intention and willingness to use or to recommend. The real behavior is defined as action loyalty in the last phase (Forgas, 2010). Driving forces of airline loyalty were identified (Mikulic and Prebezac, 2011). For example, people select an air carrier based on price, service quality, operation efficiency, schedule, safety perception, and impression, etc. The duration of passengers to adopt a low cost carrier (LCC) and the factors that affect their loyalty toward the LCC were also explored (Chang and Huang, 2013). However, nowadays aviation accidents rarely happen (Chang and Yeh, 2004), but some people still perceive low cost carriers and airlines with previous bad records as unreliable (Chang and Huang, 2013) and refuse to use them.

In this study, a concept of airline selection behavioral intention will be built in Chapter 4 to describe the incentive covering cognitive, affective, and conative loyalty, and is expressed by influential and reflective factors, which is not achieved in previous studies. Influential factors of perception toward airlines including airline image, airfare acceptance, safety perception, and perceived quality, are considered to respectively contribute to people's airline choice behaviors. Meanwhile, behavioral intention can be reflected by their satisfaction, trust, and willingness as well. To identify the position of this research, diverse attributes to airline choices were summarized.

2.4.1 Influential Factors of Behavioral Intention

- Image

Image of the airline controls an important part in people's cognition. Image, service quality/service experience, and price/service value are main determinants of selecting airlines. Particularly, for full service carrier (FSC) passengers, service quality has a much stronger influence on airline image than price perception (Mikulic and Prebezac, 2011). Attributes of promotion and product in e-marketing factor can be considered as image (Elkhani et al., 2014). The factor of image was also adopted to clarify relationships and impacts with other factors (Hu et al., 2009; Dolnicar et al., 2011).

- Price

Some literature classified airfare as one of the attributes of perceived quality (Forgas et al., 2010; Lee et al., 2011; Forgas et al., 2012; Llach et al., 2013; Elkhani et al., 2014), while some studies considered price to be one independent factor (Dolnicar et al., 2011; Mikulic and Prebezac, 2011; Akamavi et al., 2015). However, low airfare is more attractive for passengers, but LCC passengers were more concerned about airline safety than about on-time performances, whereas FSC passengers had the opposite consideration. This is because LCCs over-emphasized cheap prices, which induced concerns about safety since customers may think the basic levels of service and safety standards are sacrificed in order to save costs (Mikulic and Prebezac, 2011).

- Safety perception

After an aviation accident, people’s anxiety and concerns about safety increase, resulting in decrease of usage. Safety is a consideration of passenger loyalty toward low cost carriers (Chang and Hung, 2013). Prior to the terrorist event in New York, safety is the first priority for passengers, followed by punctuality, promptness, and hospitality (Gilbert and Wong, 2003). In contrast, some researchers thought frequency of previous accidents is not the main reason of safety that influences safety because aviation accidents are extremely rare (Chang and Yeh, 2004). Slovic (1987) found concerns about safety are different for lay people and experts in some conditions, so for business travelers or frequent users, ticket price, schedule, flight frequency, and safety do not contribute to airline selection criteria much (Vlachos, 2014).

- Perceived service quality

Perceived service quality, also called service value, is ‘‘the consumer’s overall evaluation of the utility of a product based on perceptions of what is received and what is given’’ (Zeithaml, 1988). SERVQUAL was used to measure perceived service quality, which is a quality management framework defined as five aspects in aviation sector: tangibles, reliability, responsiveness, assurance, and empathy (Mosahab et al., 2010; Razavi et al., 2012). Some studies estimated perceived service value of using online booking (Mouakket and Al-hawari, 2012; Llach et al., 2013; Elkhani et al., 2014). There are also several studies using diverse attributes to represent service quality (Forgas et al., 2010; Suki, 2014) such as infrastructure tangibles and personnel service.

2.4.2 Reflective Factors of Behavioral Intention

- Satisfaction

The delivery of high-quality service to passengers is vital for the airline business (Suki, 2014). Most research connected perceived quality to satisfaction, or used multiple variables which attributed to hedonic value and utilitarian value to express satisfaction (Mouakket and Al-hawari, 2012). Satisfaction is one of the affective expressions. Airlines have to meet passenger expectations in order to achieve high level of satisfaction and consumer retention (Hu et al., 2009). As perceived quality improves, the satisfaction increases; as satisfaction becomes higher, repurchasing willingness rises as well (Lee et al., 2011).

- Trust and confidence

Trust is a belief of reliance on a company. Currently, research exists regarding safety confidence in vaccine and food issues (MacDonald et al., 2012), but this discussion is not equivalent in the aviation industry. Their results suggested that public concerns continue, despite increasing evidence that vaccines are safe and effective because beliefs can be more significant for the consumers than the fact. Airline safety is similar in that people tend to believe in their own opinion rather than risking an airline with an accident record. Therefore, as long as trust toward the airline is high, regardless of operation or safety management, people will be motivated to purchase the service. Trust was regarded as company values, employee attitudes, and customers' needs (Forgas et al., 2010; Akamavi et al., 2015). In case of e-trust when customers purchasing online tickets, website interface, exaggeration of website description, privacy protection, and fulfillment of commitment were considered (Harris and Goode, 2004; Lee et al., 2011; Forgas et al., 2012).

- Willingness to use and recommend

Positive word-of-mouth can be a factor other than customer satisfaction (Kim et al., 2001; Suki, 2014). Factors of intention to repurchase and intention to recommend followed by overall customer satisfaction is related to willingness as well (Han, 2013; Vlachos, 2014). According to past studies, a behavioral intention related to repurchase or to recommend will be considered (Chang and Huang, 2013).

2.4.3 Research Comparison

Table 2.10 summarized the reviewed studies and variables of key studies. There is not much discussion in effects of aviation accidents on people in previous literatures, most of them did not focus too much on safety perception, and a comprehensive model covering all factors is not yet built. Therefore, this research is going to determine the structure of public airline choice behaviors, and to emphasize the change on post-accident conditions.

Table 2.10 Key studies in aviation selection criteria attributes

Key studies	**Factors of the study**						
	Image	Price	Safety Perception	Perceived Quality	Satisfaction	Trust	Willingness
Kim et al. (2001)					•		•
Gilbert and Wong (2003)			•	•		•	
Chang and Yeh (2004)			•				
Harris and Goode (2004)				•	•	•	
Hu et al. (2009)	•			•	•		
Forgas et al. (2010)		-		•	•	•	
Mosahab et al. (2010)				•	•		
Mikulic and Prebezac (2011)	•	•		•			
Dolnicar et al. (2011)	•	•					
Lee and Wu (2011)		-		•	•	•	
Forgas et al. (2012)		-		•	•	•	
Razavi et al. (2012)				•	•		
Mouakket and Al-hawari (2012)				•	•		
Chang and Hung (2013)	•	•	•				•
Llach et al. (2013)		-		•			
Han (2013)				•	•		•
Suki (2014)				•	•		•
Elkhani et al. (2014)		-		•	•		
Vlachos and Lin (2014)	•	•	•	•	•		•
Akamavi et al. (2015)		•		•	•	•	

• Inclusion in the study; - Inclusion in factor of perceived quality.

2.5 Summary

This chapter firstly explains the difference between safety and safety perception. In previous literature, risk analysis was widely discussed, but we focus on public safety perception toward airlines and aviation accidents. Since everyone has their individual safety assessment toward safety, which is totally different from experts, so a general criteria to provide objective information is necessary. Therefore, accident causes and databases are summarized to provide details, and then diverse safety ranking criteria and results including JACDEC, ATRA, Australian magazine (Askmen.com), and airline safety assessment (AirlineRatings.com) are described. However, evaluation results vary, motivating us to deeply study people's subjective concerns. We reviewed cabin environment effects, adaptation, and dominant factors to quantify people's safety worries. Lastly, to analyze the interaction between their perception and behaviors, behavioral intention composing influential and reflective factors are explored. Furthermore, according to research comparison results, a comprehensive research consisting of overall variables is not yet built, making this dissertation innovative and meaningful.

Chapter 3

Negative Spillover Effects of Aviation Accidents

3.1 Introduction

Even with the advancements in aeronautical technology and weather forecasting, aviation accidents still cannot be avoided. We still hear news about aircraft crashes, loss of control and disappearance due to human errors (e.g. pilot and maintenance error), bad weather, mechanical failure or sabotage. According to Aviation Safety Network (ASN), a Netherlands-based online aviation database, the seriousness of aviation accidents can be classified into accident, hijack, incident, other occurrence, unfiled occurrence, write-off and hull-loss. Most aviation accidents are fatal, and involve other political problems, so it always causes huge public responses and concerns.

However, aircraft is proven to be the safest among all transport modes, but why do they always cause a big social panic and have an influence on economic performances? Even though they are also rare, crash events are nearly always catastrophic. Besides, the media tends to misrepresent the accident causes and usually lacks accurate safety knowledge, giving rise to negative spillover effects not only to air transport users but also to the society.

The purpose of this chapter is to make a structure to explore accident influences, and to clarify the degree to which accidents bring about consequences such as public perception change and social influences by collecting economic and news data. We selected TransAsia Airways GE222 Accident in Penghu, Taiwan, which occurred on July 23, 2014 as a study case and investigated on site to collect information. There are four airlines (i.e. UNI Air, Mandarin Airlines, TransAsia Airways and Far Eastern Air Transport) operating the routes from the two biggest airports in Taiwan mainland, Taipei Songshan Airport (TSA) and Kaohsiung International Airport (KHH), to Magong Airport (MGZ) in Penghu. The passenger demand as well as the load factor data from Civil Aeronautics Administration, MOTC in 2013 and 2014 are compared in Figure 3.1 to Figure 3.4.

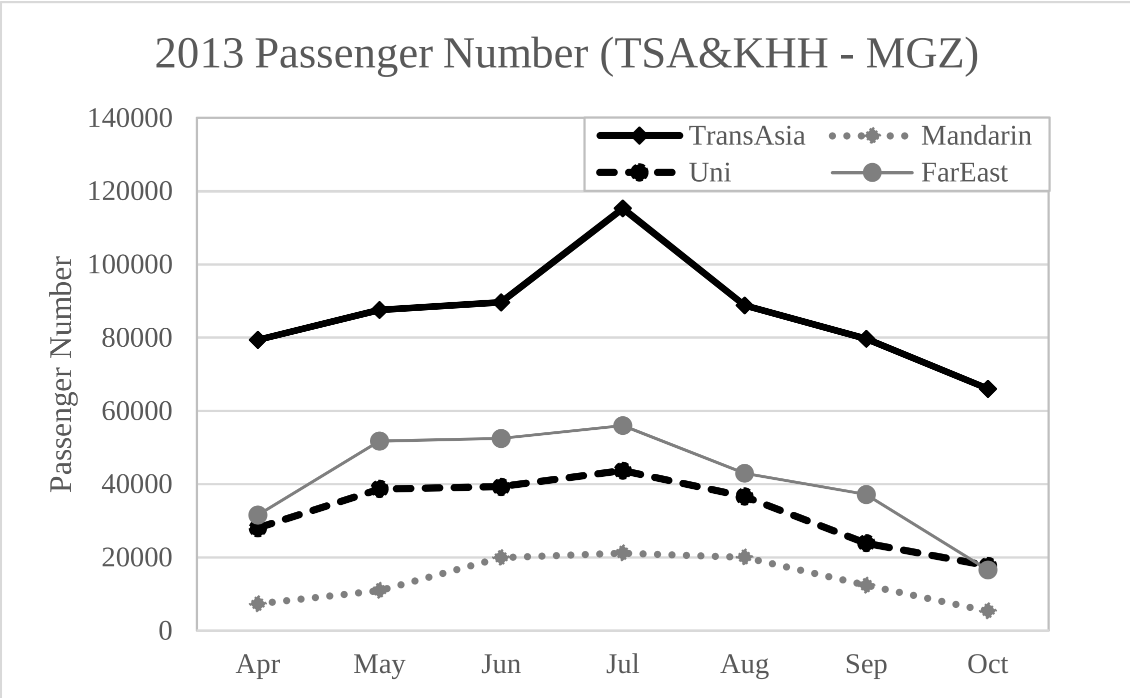


Figure 3.1 Passengers carried in 2013

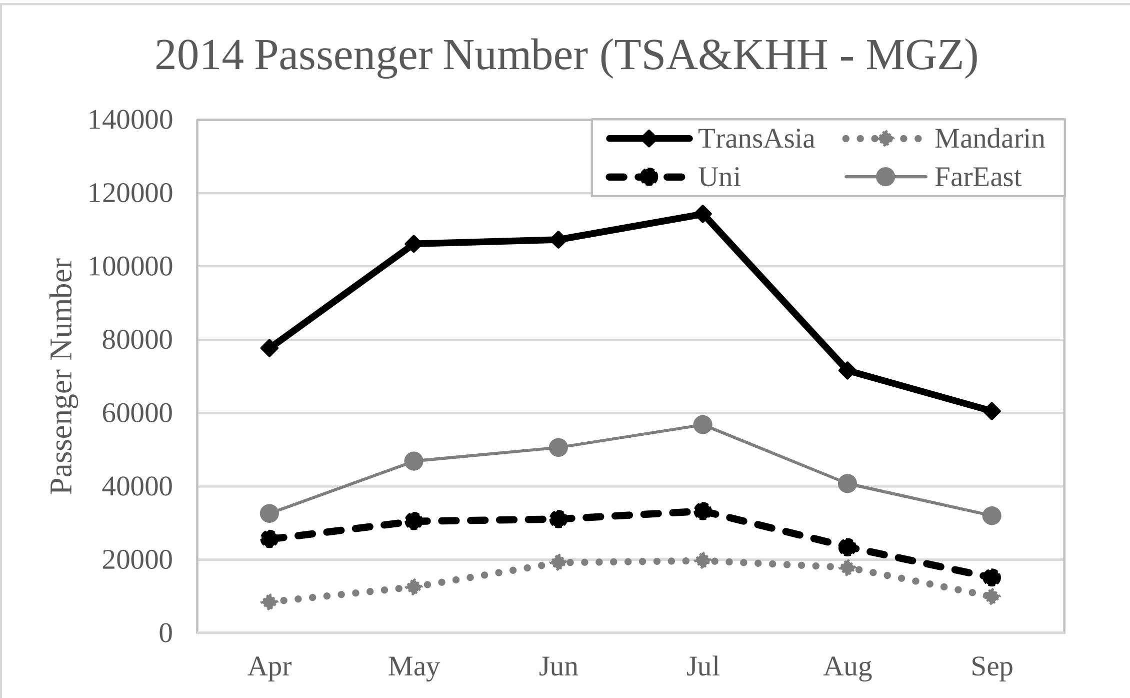


Figure 3.2 Passengers carried in 2014

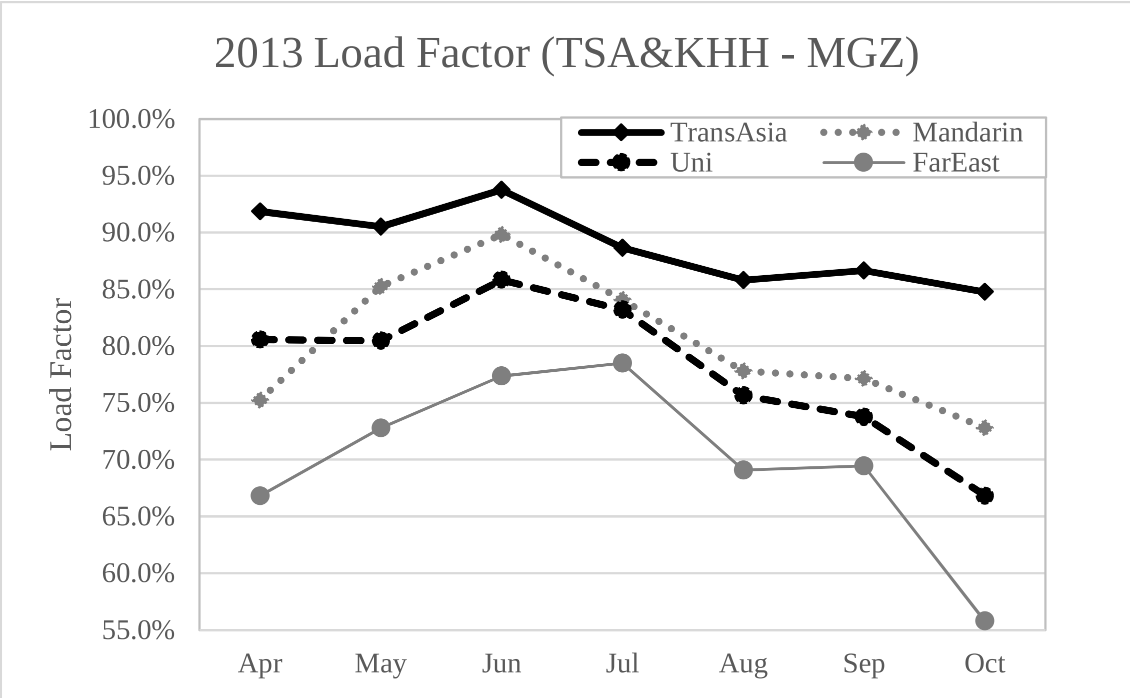


Figure 3.3 Load factor in 2013

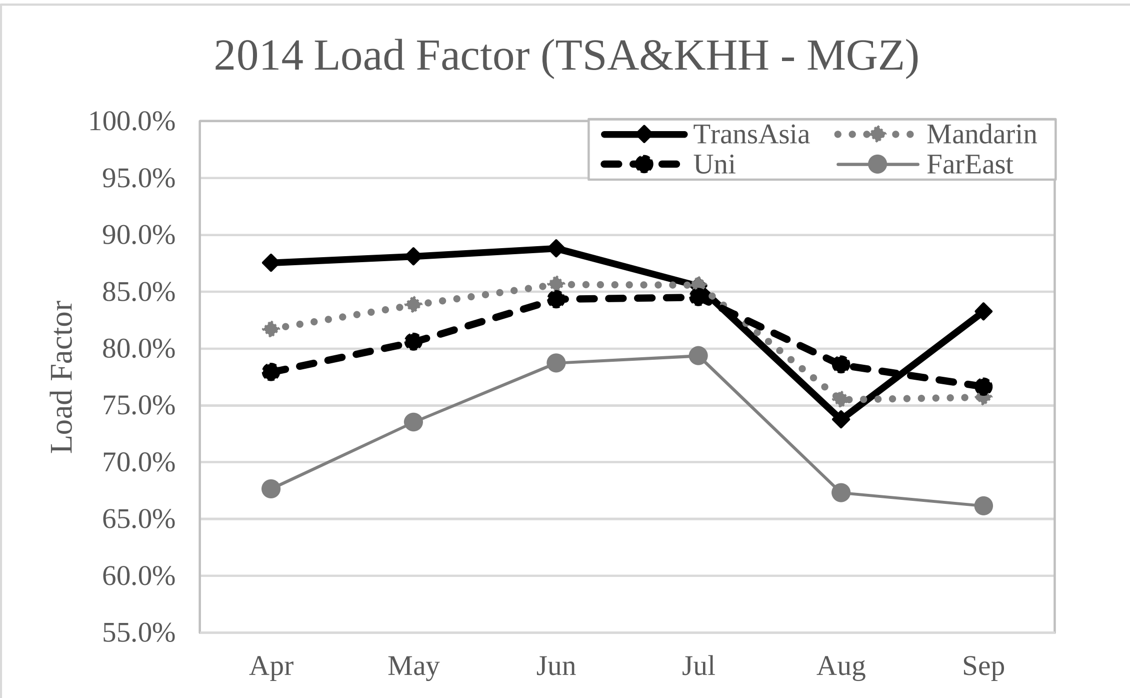


Figure 3.4 Load factor in 2014

For TransAsia Airways, the number of passengers carried and load factor (passenger/seat) in August 2014 abruptly decreased following the accident. People may have stopped using the airline because they mistrust it and have safety concerns about it, thus we would like to find to what degree they are influenced and to quantify the impact.

3.2 Social Influences of Aviation Accidents

Aviation accidents cannot be totally avoided, but it is possible to minimize the loss associated with accidents such as by reducing social panic. Aside from aviation disasters (Walker et al., 2005), terrorist attacks (Flouris and Walker, 2005a; Flouris and Walker, 2005b) and economic crisis (Goh et al., 2014) also affect aviation market performances.

The most direct and immediate effect that we can see after accident occurring is stock price fluctuation. Stock market reaction is a suitable connection to understand passenger choice behavior. Goh et al. (2014) used ESM (event study method) and CAPM (capital asset pricing market) model to realize investors' and market confidence after financial crisis. Flouris and Walker (2005a), Flouris and Walker (2005b) and Walker et al. (2005) also adopted ESM to examine economic influences by checking short- and long-term stock performance of airlines and aircraft manufactures after aviation disasters and terror attacks.

Crisis management is also used in other fields. MacDonald et al. (2012) used descriptive research method to establish what the government could do to increase public confidence in their vaccine system. Results indicated that despite the evidence showing vaccines are safe and effective, public concerns continue because beliefs rather than facts and evidence confirm the safety of vaccines. This is similar to airline safety. For an airline that has no recent disastrous incidents and has satisfied the lowest safety standards, people still tend to trust their safety perception and think otherwise. In the field of food safety, de Jonge et al. (2008) built a structural model to compare public food safety perception and consumer confidence in Canada and the Netherland. Seo et al. (2014) used ESM to develop an effective food crisis management strategies and to measure changes in stock prices, associated with the release of news. In other words, people tend to believe themselves rather than experts in issues such as aviation accidents, food crisis or vaccine confidence, and thus have a huge perception gap from experts. The only way to eliminate this gap is to educate people about risk through risk communication and risk management, and to help them overcome excessively high risk perception.

Liao (2014) pointed out that airlines especially do not want to arouse any fears or unpleasant feelings in their passengers because excellent service quality can increase levels of customer satisfaction, and retain consumers (Hu et al., 2009). Chang and Yeh (2004) indicated that the frequency of past accidents is not the primary factor that affects safety. However, to the best of our knowledge, previous studies, according to the reality that accidents are rare but disastrous, are unclear as to how people form their perceptions and concerns, then select an airline. This reason justifies the desire for passengers to use aircraft without anxiety, and to minimize the influences of accidents.

3.3 Influential Analysis

3.3.1 Structure of Aviation Accident Crisis

Aviation accidents may cause negative spillover effect to show influences on the airline, society, and economy. From the structure in Figure 3.5, we go from four sides, including user, society, airline, and government, to make a relationship among activities. Airlines and market/users are majorly affected. If customers keep not to use the airline, air transport resources are wasting, and airline itself may also face bankruptcy or M&A problems.

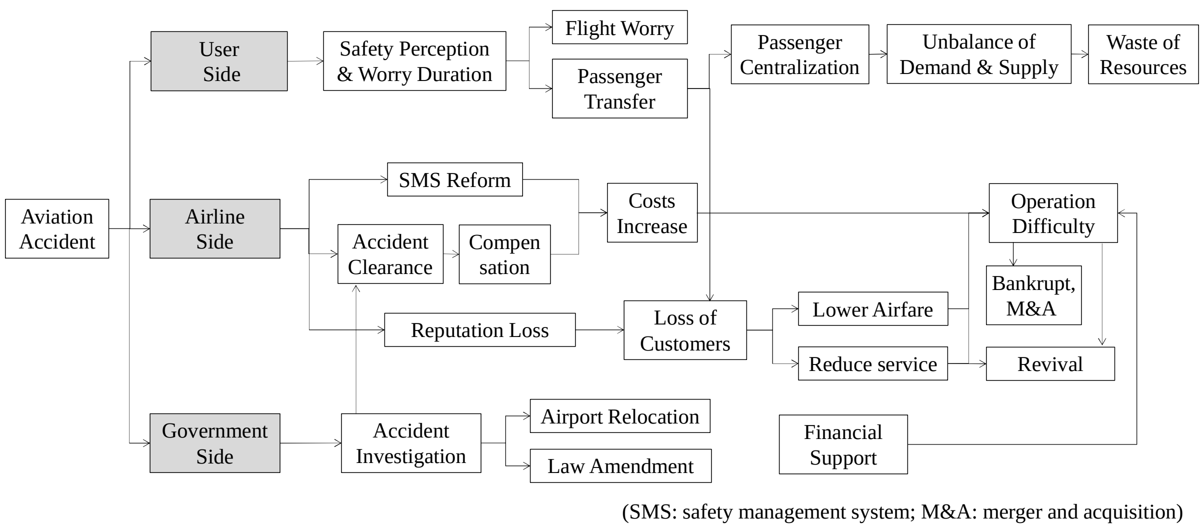


Figure 3.5 Negative spillover effects of aviation accidents

Accidents happen to FSCs/LCCs and financially state-supported or not, the influences also vary. Strategical management literature suggests that low cost based strategic management principles and operational processes enable low cost carriers to cope better during crisis period (Lawton, 2003). Averagely, estimated cost of a given crash to the insurance company calculated as $800,000 per death plus $300 million if the aircraft is lost (Kaplanski and Levy, 2010).

We can see from four stakeholders for post-accident influences. Because of public safety perception, customers' demand fluctuation and passenger decrease, and that results in financial crisis for airline companies. Wong and Yeh (2003) focused on the shift of passenger traffic following a flight accident, and said when the accident occurs during or just before an off-peak period, the traffic of involved airline would decrease. They employed X11 procedure of SAS/ETS software to adjust time fluctuation effects in demand, and estimated impact magnitude and duration of past 19 years accidents in Taiwan. According to their results, averagely accidents are associated with a 2.54 month effect and a 22.11% monthly traffic decline for the involved airline, but other airline also suffer a 5.62% monthly traffic loss because although they may gain from a switching effect, they may also lose some passengers due to the public fear of flying. Generally, the total externality effect is negative.

3.3.2 Minimization of Aviation Accident Influences

Aviation accidents have a strong influence (demand fluctuation and passenger decrease) on customers and the whole aviation market. Several measures to deal with post-accident situation such as law amendment, safety education improvement, airline crew training and even airport relocation issues can be adopted to eliminate accident influences and also reduce the possibility of repeated accidents. There are several methods to minimize the influences of aviation accidents such as law amendment, passenger safety education program, crew training, and airport relocation as follows.

- Law amendment

With air traffic increasing, accidents do happen despite the best efforts of previous regulators. Furthermore, nowadays investigating air accidents take new kinds of expertise and more resources than a decade ago, so the EU rules on investigating air accidents need to be updated to reflect the current realities of Europe's aviation market and the complexity of the global aviation industry. Valde´s and Comendador (2011) compared Chicago Convention of 1944 (Annex 13), EU Directive 94/56/EC, and EU

New Regulation to address contents/changes, to assess impacts and expected benefits.

- Passenger safety education program

Chang and Liao (2009) conducted a survey in two Taiwan airports to show that aviation safety education positively affects airline passenger cabin safety knowledge, attitude, and behavior (KAB). They suggested safety education should involve accurate instruction about emergency equipment procedures, situational awareness, emergency responses, and relevant cabin-safety regulations. Liao (2014) investigated the knowledge, attitude, and behavior intentions about airline cabin safety before and after for elementary school students. A safety education course (a lecture, a demonstration, and a film) were examined. The results showed a live instructor interacting with students by lecturing is more effective than presenting the information using only video media. They said students received most of their cabin safety information from TV, and then from the Internet, so these two sources should be utilized well in the future.

- Crew training

Chang and Yang (2010) selected SQ0006 Accidents to conduct an empirical study to find survival factors for occupants. According to 15 selected experts' questionnaire results, 47 critical survival factors were identified for developing and evaluating aviation safety programs. Particularly cockpit- and cabin-crew training and coordination are the decisive for accident survivability. Wang et al. (2013) said airlines that experience a higher accident rate, on average, tend to spend more funds on maintenance and training. As a result, airlines should also introduce new technology, improve plane maintenance, provide pilots and flight attendants with professional response training, and ensure compliance with safety inspections and standard operating procedures in order to provide a secure, enjoyable flight experience and build a safe, reliable brand image (Chen and Chao, 2015).

However, among several countermeasures, Cui and Li (2015) indicated that technology development is not the most important factor affecting the civil aviation safety efficiency of Chinese airlines. Instead, the most important factor is investments in training and developing aviation security staff and airline pilots. Wang et al., (2013) also proved that safety investment (by adding an airline's expenditures on maintenance and training, but did not include pilot skills) reduces accident propensity, while the reverse effect is also significant. Nevertheless, financial condition does not appear to affect safety investment or accident propensity.

- Airport relocation

Aviation accidents occurred around cities may arouse an issue of airport relocation. Several reasons should be considered such as benefits, necessity, tourism and suitable new airport location (to prevent bird strike). Whenever accidents occur, a call for airport relocation always appears, but difficulties and other limitation restrain this proposal. Several examples are summarized in Table 3.1.

Table 3.1 Examples of airport relocation issue

Airport	Situation
Eilat airport, Israel (Ergas and Felsenstein, 2012)	Currently located in the city center. Due to the constraints imposed by its limited runway length, terminal facilities and safety standards, international charter flights have increasingly been diverted to another airport.
La Aurora Airport, Guatemala, 1999 [1]	One Cuban national airline (Cubana de Aviacion) aircraft slammed into houses in the poor neighborhood after overrunning the airport runway. Several of those killed were on the ground. Also in 1993 and 1995, local residents around the airport were killed due to accidents. The crash in 1999 renewed calls for airport relocation for the safety of passengers and the residents of Guatemala City.
Moorabbin Airport, Australia, 2014 [2]	There were many aircraft flying over a built-up area, and many of the pilots are learners. The Australian Transport Safety Bureau statistics showed there were 745 reported accident and incidents in the past five years. But the flight school owner said, “There’s always going to be a bit of a risk with planes, but they’re safer than driving on the road.”
Santa Monica airport, USA, 2015 [3]	Harrison Ford plane crash becomes rallying cry from airport’s neighbors due to noise, traffic and occasional accidents. But, the airport a decent source of city revenue and a throwback to its history, which is attractive to the Hollywood elite because of its location.
Kotoka International Airport, Ghana, 2012 [4]	A recent crash of the Allied Air Cargo plane triggers calls for the relocation of the KIA airport. There was the need to think of a future relocation of the airport, but still no strong reason, citing the fact that other international airports were located in city centers, said by Minister of Transport.
Conway Airport , USA, 2007 [5]	The pilot of a Cessna Citation 500 was killed when his plane impacted a house near Conway Municipal Airport (CWS). The airport company owns several hundred acres of farmland for a new airport, although an

	environmental impact study on birds in the area has delayed further talk of placing a new airport.
Taipei Songshan Airport, Taiwan, 2015 (GE235 TransAsia Accident)	Plutocrat, politician, and real estate businessmen etc. are aiming the benefits of the land, so it is difficult for the government to control and share equally. Besides, current users also oppose airport relocation for their own convenience.

(Source:
[1]http://edition.cnn.com/1999/WORLD/americas/12/22/guatemala.crash.03/
[2]http://www.heraldsun.com.au/leader/south-east/amateur-plane-crash-death-in-chelsea-puts-microscope-on-moorabbin-airport/story-fngnvmhm-1227098632943
[3]http://www.theguardian.com/film/2015/mar/06/harrison-ford-plane-crash-rallying-cry-airport-neighbors
[4]https://www.modernghana.com/news/400763/1/allied-air-crash-would-not-affect-efforts-to-regai.html
[5]http://www.aero-news.net/EmailArticle.cfm?do=main.textpost&id=b9ad15d6-3162-46b7-90c2-6284c02a9f73)

3.4 Involved Stakeholder Analysis

The structure of multiple involved stakeholders of aviation accidents is drawn in Figure 3.6, which is a revised version of the original diagram by the Ministry of Transportation and Communications, ROC. Light lines connect the stakeholders in normal case, and dashed lines refer to coordination. In the figure, we focus on the route of post-accident, which is drawn by heavy lines, and highlight the important stakeholders such as airline, the media, the public, passenger, and economy and society. We can also find that these listed stakeholders are interactively related. When an accident happens, the media announces the news to the public, and then they become concerned about this issue.

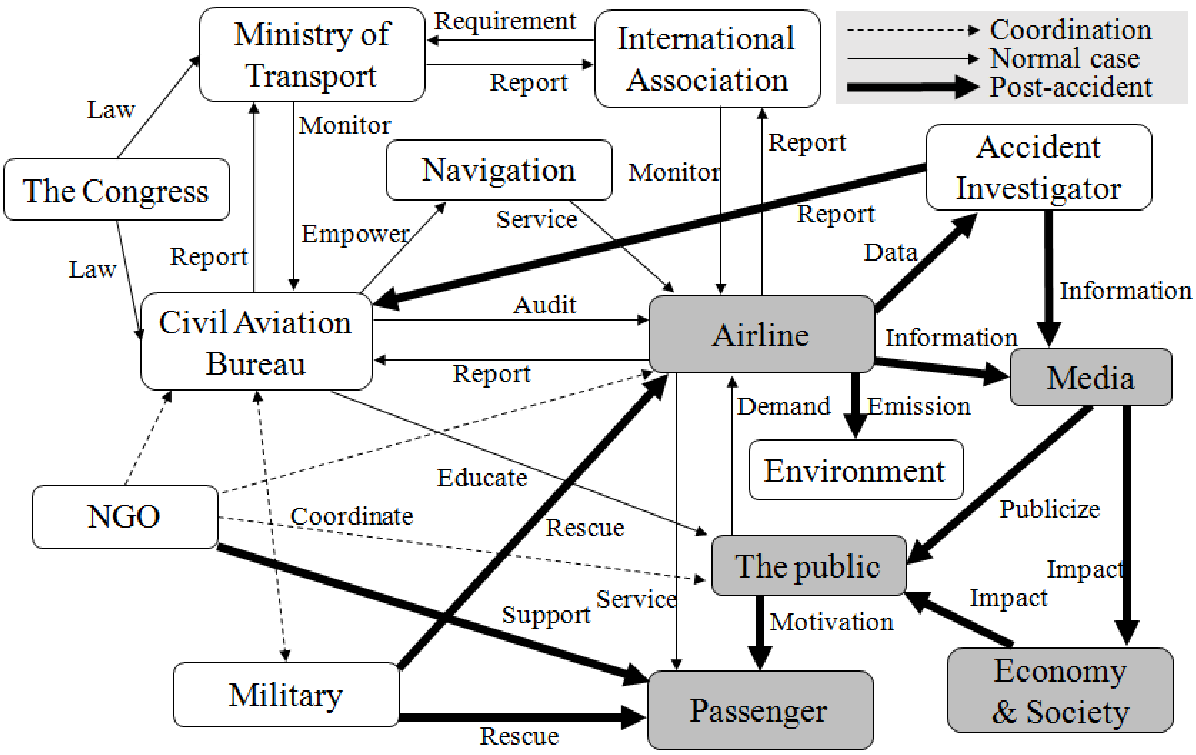


Figure 3.6 Involved stakeholders of aviation accidents

To investigate the impact of accidents, we selected one real accident for our case study, the GE222 Accident, which occurred at 19:06 on July 23, 2014. The operator was TransAsia Airways ATR 72-500, and the number of fatalities were 4 crew members and 44 passengers of total 58 occupants. The flight was from Kaohsiung International Airport (KHH) to Magong Airport (MZG), located in an isolated island in Taiwan Strait. The aircraft was out of flight path in en route phase before landing at Magong Airport because of bad weather. A sudden vertical wind shear caused the aircraft to lose lift force, which resulting the aircraft to be destroyed and crash onto local houses. Therefore, this research focuses on post-accident condition, airline, customers, economy and society will be research targets to analyze the interaction.

3.5 Stock Price Fluctuation

3.5.1 Social Influences of Aviation Accidents

The event study method (ESM) is a statistical technique to study stock price fluctuation caused by unexpected events, and can be used to quantify short-term impacts. Crisis management research has used ESM to explore the societal impacts of the release of new information or occurrence of unique events by measuring changes in stock prices (Seo et al., 2014; Walker et al., 2005). The assumption of the methodology is that the abnormal returns (ARs) are the result of the announcement and that no other event occurs on the same day.

$$R_{s,t} = \ln(\frac{P_{s,t}}{P_{s,t-1}}) \text{ or } R_{s,t} = \frac{P_{s,t} - P_{s,t-1}}{P_{s,t-1}}, \text{ for t=[-i,-1] and i} \in \mathbf{N}\text{-}\{1\} \quad (3.1)$$

where,

s	: stock,
t	: day,
$R_{s,t}$	: the returns of the stock s on day t,
$P_{s,t}$	: the closing price of stock s on day t.

Returns of the stock is computed as the difference between $P_{s,t}$ and $P_{s,t-1}$ in Equation 3.1 and Equation 3.2. The coefficients α and β are estimates of the parameters obtained via ordinary least squares (OLS) regression where $R_{m,t}$ represents for market return on day t given one period, t=[-i,-1]. The stock returns are regressed against the return of market index to remove overall market effects. The date of the event is denoted as t=0.

$$R_{s,t} = \alpha + \beta \times R_{m,t} + \varepsilon_t, \text{ for } t\text{=[-i,-1] and i} \in \mathbf{N}\text{-}\{1\} \quad (3.2)$$

$$ER_{s,t} = \hat{\alpha} + \beta \times R_{m,t}, \text{ for t=[1, j] and j} \in \mathbf{N}\text{-}\{1\} \quad (3.3)$$

where,

α, β : estimates,

m : market,

ε_t : error term,

$R_{m,t}$: the returns of the market on day t,

$ER_{s,t}$: expected return of stock s on day t.

Abnormal return on day t ($AR_{s,t}$) is the subduction of real stock return and expected return in Equation 3.3 and Equation 3.4. Note that abnormal returns are returns over and above the return predicted by general market trends on a given day. Finally we can accumulate abnormal returns within given event window to get cumulative abnormal return (CAR_s) in Equation 3.5.

$$AR_{s,t} = R_{s,t} - ER_{s,t}, \text{ for } t=[-i,j] \text{ and } i, j \in \mathbf{N}-\{1\} \quad (3.4)$$

$$CAR_s = \sum_t AR_{s,t}, \text{ for } t=[-i,j] \text{ and } i, j \in \mathbf{N}-\{1\} \quad (3.5)$$

where,

$AR_{s,t}$: abnormal return of stock s on day t,

CAR_s : cumulative abnormal return of stock s.

TransAsia Airways' closing price and market return were retrieved from homepage of Taiwan Stock Exchange Corporation (http://www.twse.com.tw/). The next trading day of TransAsia Airways aircraft crash is July 24, 2014 as t=0. We collected data for a period, t=[-61, -1], 60 trading days of pre-event data to determine the trend by using OLS, where t=-61 is April 25, t=-1 is July 22, 2014. To estimate the relationship between selected stock (TransAsia Airways) and whole Taiwan stock market performances, we can get β=0.0476, α=0.001, and $ER_t = 0.001 + 0.0476 \times R_{mt}$. Abnormal returns are the subtraction of expected returns for t=[-61, 47] and real returns as illustrated in Figure 3.7, where t=47 is September 30, 2014. As we can see, there is a big drop at t=0, indicating a big retreat on stock market. CAR_s is accumulation of AR_s, as seen in Figure 3.8. Before t=0, CAR_s had already been decreases, and the negative growth trend becomes more serious after the accident.

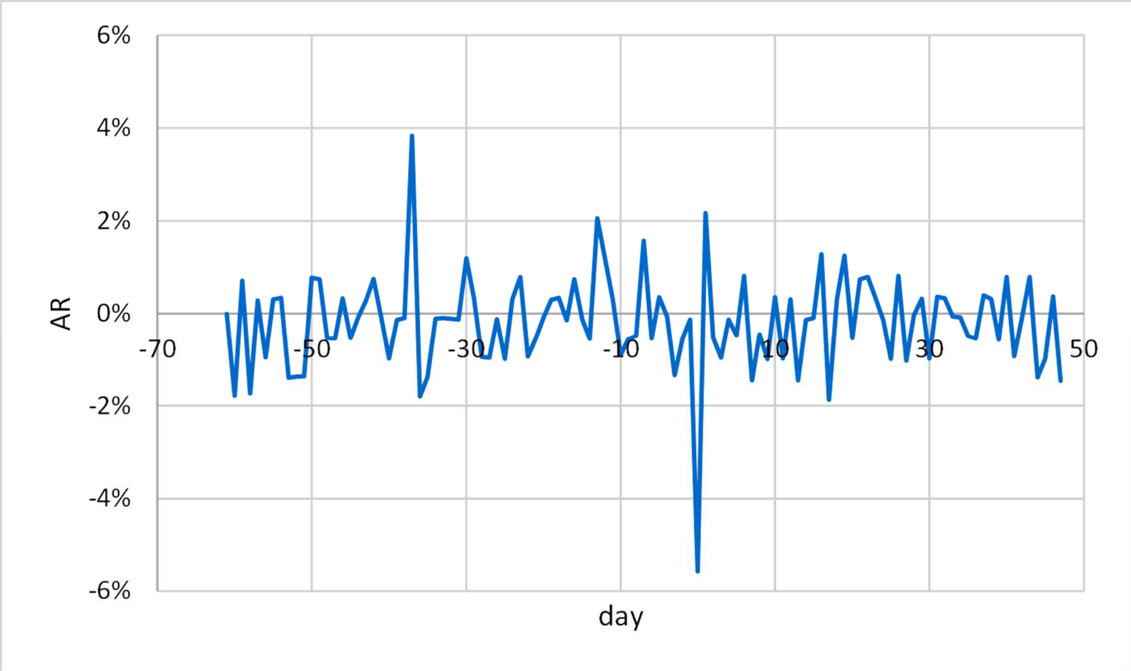


Figure 3.7 Abnormal Returns, t=[-61,47]

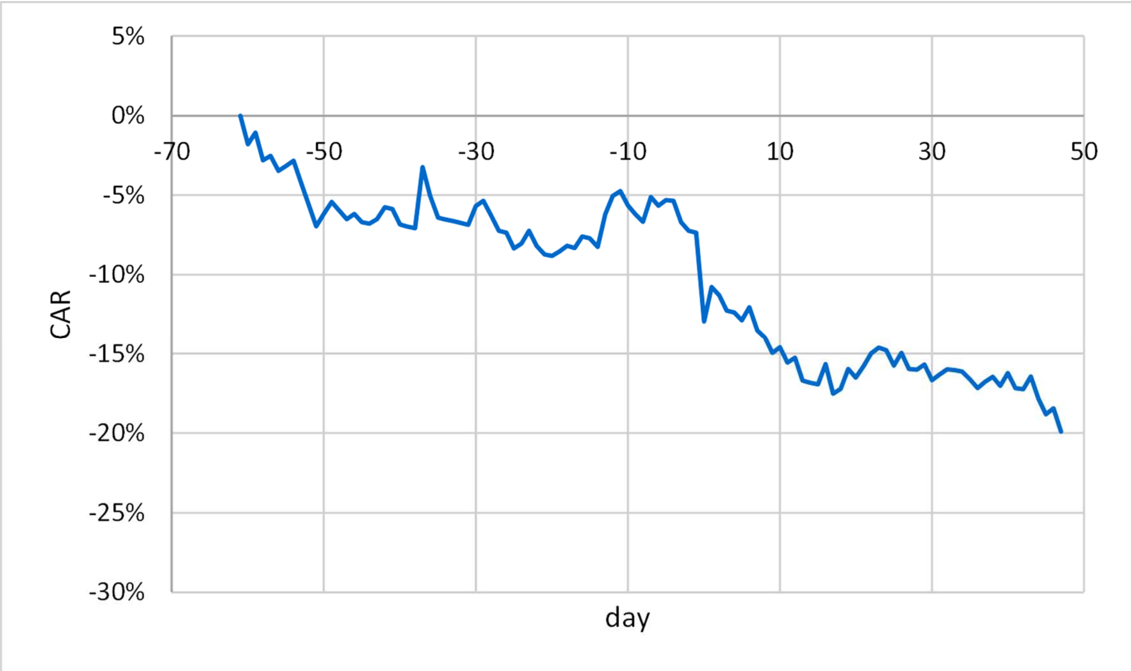


Figure 3.8 Cumulative ARs, t=[-61,47]

3.5.2 Relationship of Media Exaggeration and Social Impact

The media has a strong influence on consumers, such as in purchase behavior, perception, trust, and self-identification. For instance, Fang et al. (2012) found that during the avian influenza outbreak in Taiwan in 2004, the fear of chicken product consumption lowered risk tolerance and amplified public risk perception and anxiety through the repeated mass media transmission of information. To confirm aviation disaster causes, Walker et al. (2014) accessed various news services data source including Lexis/Nexis, Bloomberg and Reuters, and then determined what causes were reported in the initial news reports about the accident in order to ensure the direct influences to investors by using ESM. Yadavalli and Jones (2014) checked influences on consumer behaviors caused by positive media portrayal and negative media coverage about lean finely textured beef (LFTB) in the US. They found that consumers rely on news media to direct their food purchase decisions, and discussion of the LFTB controversy aroused curiosity in readers, causing them to seek further information on the topic. To quantify the media impact, a long-term tracing quality-adjusted approach to construct a weighted media index can be used. The media index is computed by summing the number of news articles across each news source per day and calculating an expected value based on percent of consumer readership per news source and the number of total news articles.

In this section, we accessed two news databases (udndata.com and KMW) and two newspaper official websites pertaining to the four biggest newspapers in Taiwan: United Daily News Series, China Times Series, Liberty Times, and Apple Daily. To observe short-term influences to society from news releases of the aircraft crash, we used the keywords “Penghu Aircraft Accident” and “TransAsia Airways” to collect all related news from July 23 to September 30, 2014 and made one database. All related news (920 articles) in Figure 3.9 were collected to get the number of news articles during the said period. According to Figure 3.10 which shows the media index of the GE222 Accident, we can understand that most news articles are focused on the first week and close to zero after one month. The peak occurs on July 24, 2014 (230 articles), which is the day after the accident, and we based on this day to standardize all data.

	日期	報紙	標題	內文
5	2014/7/23	蘋果日報	復航航空險 由國泰產承保	復興航空一架飛機在澎湖發生重摔起火，國泰產險今晚表示，復興航空的航空保險是由國泰產
6	2014/7/23	蘋果日報	網友畫面還原 復航迫降前風雨交加	澎湖今晚驚傳復興航空迫降意外。中央氣象局表示，從今天下午4時開始，麥德姆颱風的一條雨
7	2014/7/23	蘋果日報	澎湖空難 高市府明安排家屬專機	復興航空GE 222班機迫降澎湖造成重大傷亡，高雄市政府表示，目前市府觀光局正與復興航空
8	2014/7/23	蘋果日報	澎湖空難 網友目擊消防車輛趕往救災	澎湖空難造成47人罹難，警消出動大批人員前往救援，但救援途中風雨交加，飛機撞毀起火
9	2014/7/23	蘋果日報	澎湖空難 啟用大型機具搶救生還者	澎湖縣消防局表示，截至今晚10點45分為止，復興空難已造成26人死亡、12人送醫，另波及2戶
10	2014/7/23	蘋果日報	澎湖空難詐騙簡訊已現 請民眾多注意	今天晚間澎湖發生47人死亡、11人傷嚴重空難，沒想到有無良的詐騙集團利用民眾的關心，傳
11	2014/7/23	[中時]	麥德姆攪局 陸空交通大亂 國內航線、台鐵幾乎全停駛	[illegible]
12	2014/7/23	自由時報	復興空難》復航馬公降落失敗 澎湖消防局長：48人往生	〔本報訊〕復興航空一架從高雄飛往澎湖馬公的編號GE-222班機，今日傍晚因風勢過大降落失敗，準備重新降
13	2014/7/23	自由時報	復興空難》16名傷者名單公布 分送澎醫及三總	〔本報訊〕官方公布復興航空GE-222客機空難傷者名單，共16人，其中1男子蘇民華到院前死亡。 送往衛福部
14	2014/7/23	自由時報	復興空難》陳菊：儘速包機載家屬前往澎湖	〔本報訊〕復興航空由高雄飛馬公GE-222客機迫降失敗墜毀。高雄市長陳菊晚間在臉書表示，市府觀光局已取
15	2014/7/23	自由時報	復興空難》客機澎湖墜毀 全球媒體頭條報導	〔本報訊〕復興航空高雄飛往馬公的GE-222客機，今天（23）晚間在澎湖墜毀。國外各大媒體立即以快訊方式
16	2014/7/23	自由時報	復興空難》沒良心！澎湖空難出現詐騙簡訊	〔本報訊〕本日發生造成至少47死的澎湖空難，詐騙集團藉著民眾希望了解情形的心情，竟傳詐騙連結給民眾，
17	2014/7/23	自由時報	復興空難》澎湖血庫 目前不缺血	〔本報訊〕復興航空由高雄飛馬公GE-222客機迫降時墜毀，目前救出12人，送醫後11人仍有生命跡象，而對於
18	2014/7/23	自由時報	復興空難》航站痛哭媽媽 女兒送三總無生命危險	〔本報訊〕復興航空空難，GE222班機34歲乘客許瑀婕的媽媽，在得知復興航空的消息後痛哭坐地，經查明，許
19	2014/7/23	自由時報	復興空難》澎湖缺血 高雄捐血中心緊急支援200袋	〔本報訊〕復興航空由高雄飛馬公GE-222客機迫降時墜毀，目前救出12人，送醫後11人仍有生命跡象。高雄捐
20	2014/7/23	自由時報	復興空難》軍方人員一罹難一失蹤兩傷	〔記者蔡宗憲、王榮祥／連線報導〕復興航空空難，據了解，有4名軍方人員在班機上，澎湖憲兵隊中校隊長蔡
21	2014/7/23	自由時報	復興空難》馬總統悲慟：提供受難者家屬最大協助	〔記者王寓中／台北報導〕針對今）晚復興航空班機在澎湖馬公降落時發生重大飛安意外，多人不幸往生受傷。
22	2014/7/23	自由時報	復興空難》正駕駛李義良家屬接獲通知 明將趕往澎湖	〔記者黃文鍠／台南報導〕復興航空在澎湖墜機的正駕駛李義良，在復興服務將近二十年，已達退休標準，主要
23	2014/7/23	自由時報	復興空難》澎湖居民：飛機離跑道頭約1公里處栽下	〔本報訊〕復興航空GE-222客機疑似重飛不當發生墜機意外，根據住在澎湖消防總局附近的澎縣議員參選人郁
24	2014/7/23	自由時報	復興空難》澎湖血庫缺血 高市衛生局聯繫支援	〔記者王榮祥／高雄報導〕關於復興航空GE222意外，晚間傳出澎湖血庫缺血！ 高市衛生局已聯繫澎湖縣府，積
25	2014/7/23	自由時報	復興空難》陳菊指示全力協助 明早送家屬赴澎湖	〔記者王榮祥／高雄報導〕高雄市長陳菊關切復興航空意外，晚間指示相關單位積極協助； 民政局正向復興航空

Figure 3.9 Collected news articles

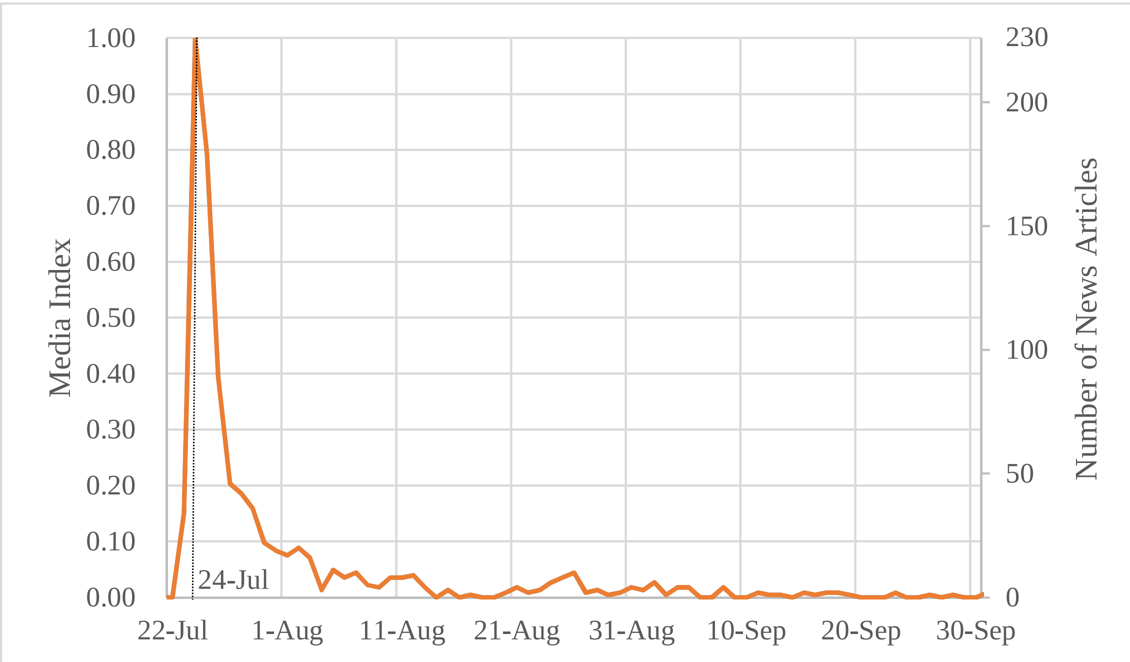


Figure 3.10 Media index and news article of the GE222 Accident

3.5.3 Hypotheses Development

In order to figure out the direct relationship between media influences and social impacts, we compared abnormal returns and news release. Abnormal returns in Figure 3.7 are similarly standardized using July 24, 2014 as the base, and then converted to absolute values, because absolute values can represent for stock price change regardless of positive or negative fluctuation. Figure 3.11 presents a graph that directly compares abnormal returns and number of news releases to represent the influences to the society from a combination of stock performances and the media. We found that they have similar trends especially in the first week, and it is almost corresponded. For this reason, we can judge that ESM, which is used to evaluate social panic, is related to media influences, and simultaneously we can say media exaggeration did affect the public cognition. As a result, we would also like to make hypotheses to clarify whether people are affected by aviation accidents, and that will be explained in next section.

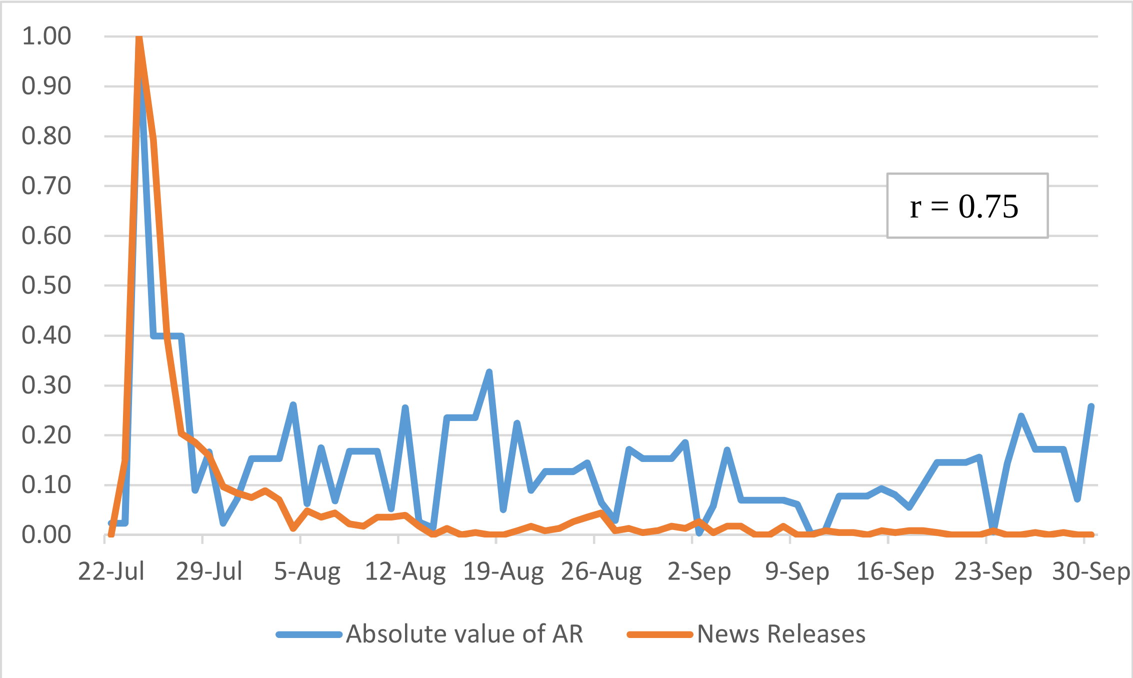


Figure 3.11 Comparison of media and stock performance

The findings can help the government and airlines to observe the effects on stock fluctuation, which is related to the release of news, so they could take some countermeasures to prevent getting worse.

3.6 GE222 Accident Field Survey

3.6.1 Field Survey Plan

To understand how the GE222 Accident impacted the local market, a field survey was conducted on September 18 to 19, 2014. The purposes are to investigate site situation and to interview with local residents and air passengers to familiarize with accident influences, and receive more feedbacks and details. Interview locations are Taichung and Penghu airports, inside aircraft, hostel, and shops as Figure 3.12 and Figure 3.13. Interviewee are passengers, airport staff, hostel staff, airline staff, and local residents. Interview contents include (i) age, travel purpose, flying experiences, airline; (ii) airline choice criteria; (iii) personal safety definition and judgment; (iv) safety perception to TransAsia Airways; (v) trend of tourist flow and any other impacts to local society.

Figure 3.12 Restaurant staff in Taichung Airport

Figure 3.13 Travel service in Penghu Airport

3.6.2 Summary of Interview Results

During the flight, passengers were firstly interviewed. Most of passengers are in group tour, and they did not select which airline to use, only followed travel agency arrangement. For other passengers, criteria of airline choices includes service (short distance: seat comfort), airfare (but almost the same among airlines), safety perception (no recent news release), aircraft type (prefer big jet), airline experiences, and schedule preference. Some passengers may not choose TransAsia Airways because of family's pressure and rumors, but some still kept positive attitudes to TransAsia Airways. From Taiwan to Penghu, people can choose aircraft or ferry, but most of them preferred easier and more convenient way. According to airport and airline staff, because September is going to be out of peak season, and also owing to the GE222 Accident, number of travelers to Penghu decreased around 20%, wherein almost all passengers are Taiwanese.

A site visit to local residents in Penghu, they though TransAsia Airways was just unlucky due to weird wind that let aircraft lose balance suddenly. Sometimes flight and seat supplies are limited, they cannot make airline choices but use the airline, and most of local residents take aircrafts to Taiwan (especially Kaohsiung) 1-2 times per year. Besides, they found Taiwanese people are forgetful. As long as there is no news about aviation accidents, then passengers will continue using TransAsia Airways. They guess recovery period would be six months. Lastly, to encourage local tourism, the Penghu local government planned to give each traveler to Penghu 500 NTD from October, 2014.

Figure 3.14 and Figure 3.15 show the three building destroyed by the aircraft, and there was not repaired yet after two months. However, residents living around the accident site behaved as usual and did not care about the accident anymore.

Figure 3.14 GE222 site investigation 1

Figure 3.15 GE222 site investigation 2

3.7 Summary

Because aviation accidents cannot be totally avoided, we consider to minimize the loss associated with accidents such as by reducing social panic. A structure of accident crisis covering user, society, airline, and government sides, has been drawn to show the potential consequences it may bring. Airlines, market and customers are majorly affected. Previously, to reduce the accident influences, several measures such as law amendment, passenger safety education program, crew training, and airport relocation have been implemented. Moreover, a structure of multiple involved stakeholders of aviation accidents shows these listed stakeholders are interactively related. When an accident happens, the media announces the news to the public, and then they become concerned about this issue. This research focuses on post-accident condition, airline, customers, economy and society are research targets to analyze the interaction. As a result, TransAsia Airways GE222 Accident is selected for a case study. We used event study method (ESM) to quantify short-term impacts, and to find the relationship with stock price fluctuation and news reports. The results showed they are correlated, implying strong accident influences on the society. Lastly, a site investigation to Penghu to survey the GE222 Accident was conducted to collect local and latest information.

Chapter 4

Analysis of Public Safety Perception

4.1 Introduction

After exploring the social and economic influences in Chapter 3, this chapter is going to discuss public perception toward aviation accidents. Four sub-sections including accident hypotheses testing, formation of safety perception, analysis of worry duration, and change of users' behavioral intention, compose diverse analysis of people's attitudes and perception. Propose, method, data collection and research target of each sub-section are summarized in Table 4.1.

Table 4.1 Analysis of public perception

	Purpose	Method	Data	Research Target
Accident Hypotheses Testing	・To prove a more recent accident has stronger effects on public perception than a less one	Hypothesis testing	Online survey	TransAsia Airways
Formation of Safety Perception	・To explore factors of safety perception ・To quantify the relationship with their behaviors	Regression analysis	Online survey	/
Analysis of Worry Duration	・To use worry duration quantifying concerns with time scale ・To explore factors dominating people's strength of worries	Cox proportional hazards model, Survival function	Online survey	Their frequent used or flavored airline
Change of Users' Behavioral Intention	・To build a SEM to describe people's behavioral intention ・To compare different SEM performances of two groups	EFA, SEM, Multi-group analysis	Online survey	Their frequent used or flavored airline

4.2 Research Instruments

4.2.1 Implementation of Online Survey

In order to explore people's perception, a comprehensive investigation covering people's diverse perception is needed. We adopted an online survey for Taiwanese citizens from January 27 to February 16, 2015. The GE222 Accident is a domestic route, so the four airlines operating in the domestic market are selected. The purpose is to realize what people consider about aviation accidents, and to clarify the degree to which people may perceive toward an airline that has recent accidents. It is feasible and reasonable to collect airline preference and evaluation data by online survey, because most of the people purchase air tickets through the Internet. Moreover, talking about aviation accidents to passengers in the airport is not morally allowed, so if we implement face-to-face questionnaire, it is highly possible to be rejected.

The questionnaire consists of five sections in Figure 4.1. Firstly, we used 4 items to investigate their previous flight experience for domestic and international routes, and preference and usage of four airlines in Taiwan, UNI Air, Mandarin Airlines, TransAsia Airways, Far Eastern Air Transport, and others. In the second section, we asked about their safety perception toward aviation accidents regarding to accident record impact, media impact, willingness to use the airline, confidence of safety knowledge, airline operation, financial, tangible and information-oriented concerns with a Likert 5-point scale to rate the level of agreement (i.e. 1: strongly disagree, 2: disagree, 3: neither agree nor disagree, 4: agree, 5: strongly agree). In section 3, criteria of airline loyalty and behavioral intention was obtained based on their most frequent or favored airline. Then we selected TransAsia Airways GE222 Accident in July 2014 as a case study target, and also asked people about their image and identity, safety perception, trust and willingness to use and recommend toward TransAsia Airways using a Likert 5-point scale (i.e. 1: very low, 2: low, 3: medium, 4: high, 5: very high). In the fourth section, there are two scenarios representing before and after the GE222 Accident. We would like to understand people's considerations toward TransAsia Airways before the accident, so we let them recall the previous situation and rate it as Scenario 1 in this study, while their considerations after half year of the GE222 accident were asked in Scenario 2. Lastly, socio-economic information including gender, age, monthly income, civil status and education level were retrieved in last section.

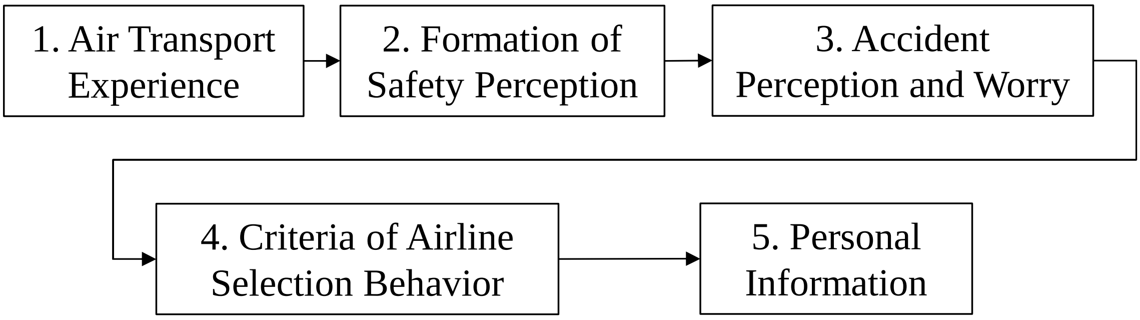


Figure 4.1 Contents of the survey

However, during the course of the survey, another TransAsia aircraft crash (GE235 accident) occurred in Taipei on February 4, 2015. Thus, respondents who participated in the survey after the second aircraft crash would have different feelings, perception and response due to the recent catastrophic accident and media exaggeration. Therefore, the respondents were separated into two groups according to answering period, which means before and after the GE235 Accident, as Group 1 and Group 2 respectively. Figure 4.2 shows the distribution diagram of respondents and accident period. Originally we only planned to implement survey for Group 1, but since the second accident occurred unexpectedly, we decided to continue collecting data. Accordingly, a total of 393 samples were divided into two groups, Group 1 and Group 2.

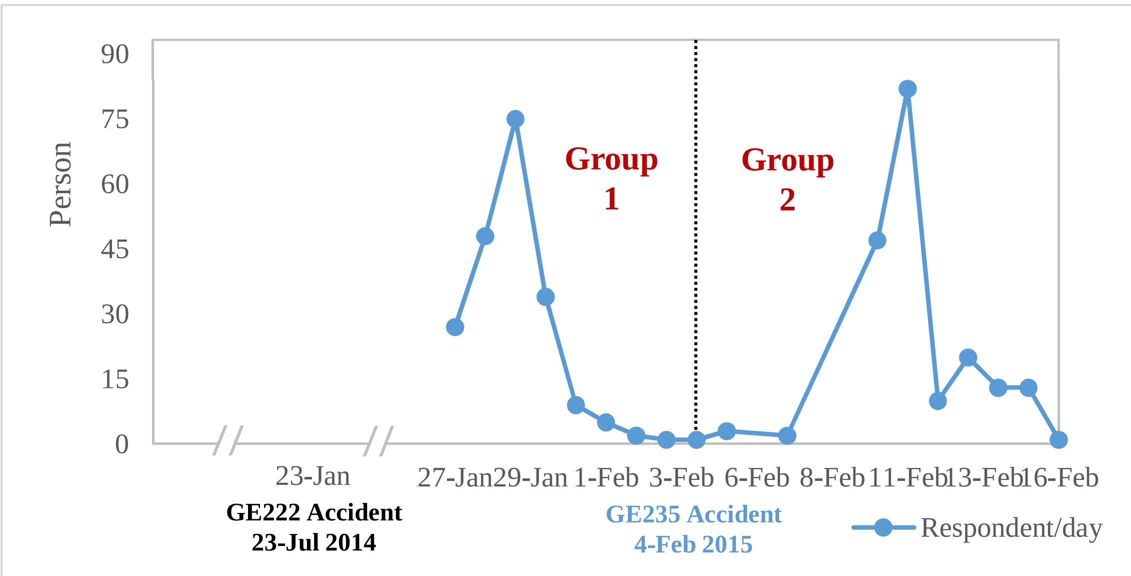


Figure 4.2 Distribution diagram of respondents and accidents

Table 4.2 Survey profile

Date	January 27 to February 16, 2015
Target	Taiwanese citizens who currently live in Taiwan
Type	Online investigation (google questionnaire)
Collected	393 samples (G1:202 / G2:191)
Screened	337 samples (G1:172 / G2:165)

A 3-week intensive online survey was conducted from January 27 to February 16, 2015 for Taiwanese citizens. We did not provide incentives for them to prevent double submission, and finally we received 393 effective samples for data analysis in Table 4.2. After data screening, 337 samples were remained. Owing to answering date, the respondents were divided into two groups according to their response date: (1) Group 1 refers to those who answered the survey before February 4 (the date of the GE235 accident), and comprises of 202 samples; and (2) Group 2 refers to those who answered after the said date, and is composed of 191 samples.

4.2.2 Descriptive Statistical Results

A demographic profile of total samples including gender, civil status, employment, monthly salary (NTD), age as well as education level are summarized in Table 4.3. Most respondents are young people (aged 21-30), single, unemployed, and highly educated with advance diplomas owing to the accessibility of the online survey. However, nowadays people purchase air tickets via airline websites, and airfares for domestic routes among airlines are slightly different but affordable. Although the aged people have more budget for airline choices, young people are considered to be future users, so their behaviors are important to understand potential market trend. Moreover, domestic flights mostly serve leisure purpose passengers instead of business trips, so majority of customers are young or mid-aged people, and socio-economic information does not have too many influences on their airline choices because of affordable and reasonable airfare among airlines.

Table 4.3 Demographic profile of respondents (screened data)

Category	Item	Group 1		Group 2		Category	Item	Group 1		Group 2	
		No.	%	No.	%			No.	%	No.	%
Gender	Male	98	57.0	105	63.6	Age	<21	1	0.6	3	1.8
	Female	74	43.0	60	36.4		21-30	100	58.1	123	74.5
Monthly salary (NTD)	<20,000	40	23.3	39	23.6		31-40	37	21.5	27	16.4
	20,000~39,999	47	27.3	51	30.9		41-50	20	11.6	3	1.8
	40,000~59,999	54	31.4	48	29.1		51-60	11	6.4	8	4.8
	60,000~79,999	17	9.9	13	7.9		>60	3	1.7	1	0.6
	>79,999	14	8.1	14	8.5	Education level	Junior	3	1.7	1	0.6
Civil status	Married	51	29.7	26	15.8		Senior	7	4.1	6	3.6
	Single	121	70.3	139	84.2		J. college	18	10.5	2	1.2
Employment	Yes	137	79.7	118	71.5		University	66	38.4	85	51.5
	No	35	20.3	47	28.5		Advance	78	45.3	71	43.0

The data of respondents' frequently used or favored airline, usage of the airline, annual flight frequency (both domestic and international flights), and frequency of use of TransAsia Airways are summarized in Table 4.4.

Table 4.4 Air travel itinerary of respondents (screened data)

Category	Item	Group 1		Group 2		Category	Item	Group 1		Group 2	
		No.	%	No.	%			No.	%	No.	%
Annual flight frequency[1] (domestic)	0	131	76.2	107	64.8	Frequently used or favored airline	UNI Air	109	63.4	117	70.9
	<1	29	16.9	38	23.0		Mandarin	27	15.7	16	9.7
	1-2	11	6.4	6	3.6		TransAsia	24	14.0	16	9.7
	2-3	0	0	5	3.0		Far Eastern	3	1.7	6	3.6
	3-4	0	0	5	3.0		others	9	5.2	10	6.1
	>4	1	0.6	4	2.4	Usage of the airline	Yes	41	23.8	58	35.2
Annual flight frequency[1]	0	19	11.0	13	7.9		No	131	76.2	107	64.8
	1	59	34.3	47	28.5	Total TransAsia usage[1]	0	96	55.8	95	57.6
	2	46	26.7	57	34.5		1-2	52	30.2	44	26.7
	3	19	11.0	18	10.9		3-4	13	7.6	6	3.6
	4	22	12.8	21	12.7		5-6	8	4.7	13	7.9
	5	7	4.1	9	5.5		>6	3	1.7	7	4.2

[1] Round trip is counted as 1.

Respondents largely prefer UNI Air, especially for those who do not fly frequently or have not used domestic flights before, because the other three airlines or their parent companies have bad safety records or financial crisis previously. After checking the usage data from Civil Aeronautics Administration, MOTC, the passenger carriage of airline distribution is different from our surveyed results. Market share for domestic routes of UNI Air, Mandarin, TransAsia, Far Eastern, and others are 37.2%, 14.5%, 28.0%, 17.6%, 2.7% in January, 2015, and 41.1%, 16.7%, 17.4%, 22.4%, 2.4% in February, 2015. The differences show that market share of UNI Air is lower in reality, suggesting that the young people have stronger intention to use UNI Air than the elderly. If the share for UNI is still higher after sample group balancing, we can infer that due to flight schedule or seat limitations they could not select what they want and use other airlines instead. Besides, Group 2 shows higher preference for UNI Air than Group 1, revealing that people tend to change the favored airline to UNI Air owing to the GE235 Accident influences. Some of the respondents do not have flight experience and even most of them have not yet used their favored airlines, but they still have their individual perception toward airline companies as potential customers, so these samples should be included.

4.3 Accident Hypotheses Testing

4.3.1 Hypothesis Description

As we described in previous section, in our investigation, we asked respondents their perception before the GE222 Accident (Scenario 1) and at the situation after the GE222 (Scenario 2). Nevertheless, the GE235 Accident occurred during our survey, making respondents divided into two groups as Group 1 and Group 2 in Figure 4.3. It is also necessary to compare the difference of respondents. The methodological approach used is hypotheses testing. We intended to testify whether aviation accidents have an impact on public perception toward airline companies for different groups under different scenarios. Two scenarios were created for evaluation. The current situation and an imaginary condition supposing that one fatal aircraft crash happens to the airline they selected were Scenarios 1 and 2, respectively. Therefore, the gap of perception can be compared to provide a perspective estimate of customers' behaviors after accidents. The only method is to design scenarios for respondents to imagine conditions and answer questionnaires, as it is not possible to forecast the occurrence of aircraft crashes.

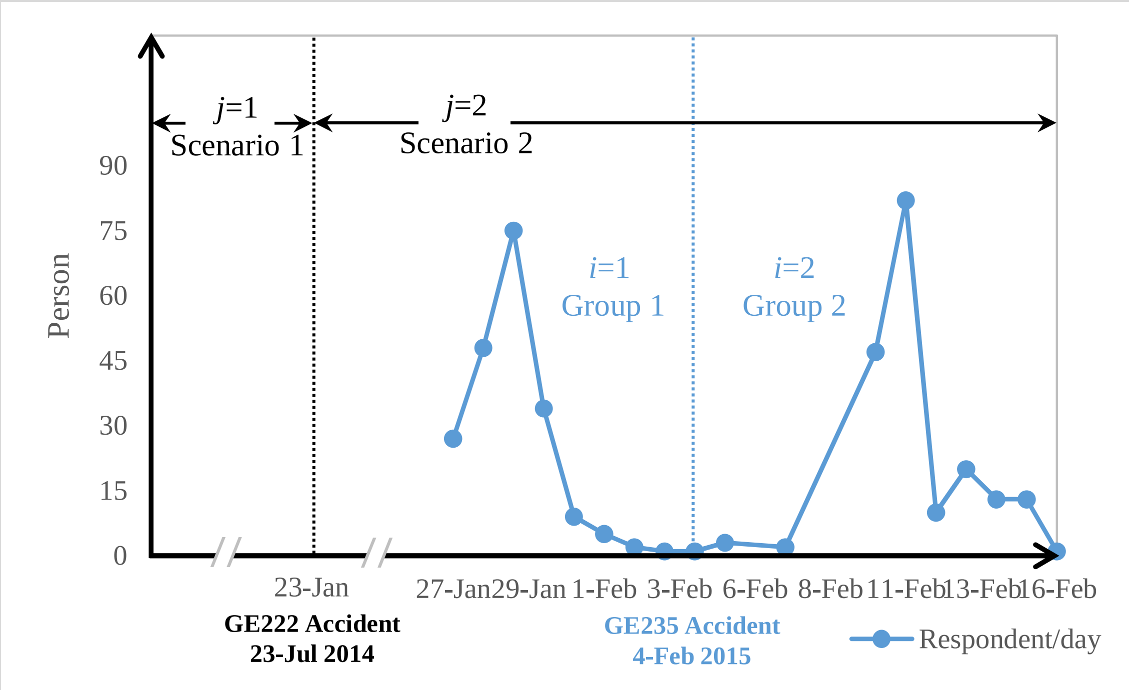


Figure 4.3 Distribution diagram of respondents, accidents and scenarios

Public attitudes toward the airline may change if an accident happens because its occurrence would decrease their product confidence, alter brand image and identity, and also let them re-evaluate the airline again. People may attribute the cause of accidents to operation and safety management, and arouse emotional distrust to the airline. Since the airline has a bad record once, people may be afraid of repeated occurrences again, thus their willingness to use and recommend the airline would be affected. Therefore, it is necessary to compare their perception change such as image (Mikulic and Prebezac, 2011; Elkhani et al., 2014; Hu et al., 2009; Dolnica et al., 2011), safety concern (Gilbert and Wong, 2003; Chang and Hung, 2013; Vlachos and Lin, 2014), trust (MacDonald et al., 2012) and purchasing willingness (MacDonald et al., 2012) between these two groups.

μ_{ijk} stands for mean of category k in scenario j for group i., for i= 1, 2 (G1 and G2 in brief), j=1, 2 (Scenario 1 and Scenario 2, S1 and S2 in brief) and k=1, 2, 3, 4 (image and identity, safety perception, trust, and willingness to use and recommend, as IMG, SAF, TRU, and WLN in short). The range of μ_{ijk} is from 1 (very low) to 5 (very high). μ_{ijk} is mean of people's 5-point rating (1:very low; 5: very high) toward TransAsia Airways as summarized in Table 4.5, and it should be no differences between G1 and G2 toward the same j, and k, if GE235 accident did not occur.

Table 4.5 Characteristics of hypothesis testing variable

i = 1, 2	(Group1, G1): respondents who answered before GE235 accident (Group2, G2): respondents who answered after GE235 accident
j = 1, 2	(Scenario 1, S1): situation before GE222 accident (Scenario 2, S2): current situation (6 months after GE222 accident)
k = 1, 2, 3, 4	(IMG): image and identity; (SAF): safety perception; (TRU): trust; (WLN): willingness to use and recommend

Therefore, the two hypotheses for Group 1 and Group 2 respectively are given below:

H1. An accident has a negative effect on the airline assessment from the viewpoint of public perception on the base of Group 1. ($\mu_{11k} > \mu_{12k}$)
H2. An accident has a negative effect on the airline assessment from the viewpoint of public perception on the base of Group 2. ($\mu_{21k} > \mu_{22k}$)

Regardless of groups, perception in Scenario 1 should be equal because there were no accidents before the GE222 Accident, so when respondents recall their previous consideration, they are supposed to judge TransAsia Airways in the same standard. However, another recent accident (the GE235 Accident) could have had an influence on Group 2 respondents, which implies that their criteria of perception could be biased and sentimental at that moment as Group 2 directly experience the seriousness of aircraft crash again through the media. In a similar way, the evaluation of TransAsia Airways after the GE222 Accident would be interfered with the GE235 Accident, we suppose that respondents may deepen their reactions and turn to be more pessimistic due to the recently happened accident. For these reasons, we assume that for Group 1 and Group 2, their perception in Scenario 1 and Scenario 2 are different due to the latest aviation accident involving the same airline.

H3. A more recent accident has a negative effect on the airline assessment from viewpoint of public perception on the base of Scenario 1. ($\mu_{11k} > \mu_{21k}$)
H4. A more recent accident has a negative effect on the airline assessment from viewpoint of public perception on the base of Scenario 2. ($\mu_{12k} > \mu_{22k}$)

When a tragic event breaks out, most of the people may be shocked and closely follow the news. Most of time, they would have an overwhelmed reaction upon hearing about it, then they would calm down gradually and adapt to the negative change until they can accept the truth. The period of adaptation to an aviation accident would vary across individuals and people would likely have additional influences from another recent accidents. In line with this, another hypothesis is proposed.

H5. A more recent accident has a stronger effect than a less recent accident on the airline assessment from viewpoint of public perception. ($\mu_{21k} > \mu_{12k}$)

To sum up **H1** to **H5**, the level of influence caused by aviation accidents for different groups under different scenarios can be specified.

H6. Both accidents have a negative effect on the airline assessment from viewpoint of public perception. ($\mu_{11k} > \mu_{21k} > \mu_{12k} > \mu_{22k}$)

Table 4.6 Summary of hypotheses

H1 ($\mu_{11k} > \mu_{12k}$), **H2** ($\mu_{21k} > \mu_{22k}$)	An accident has a negative effect on the airline assessment.
H3 ($\mu_{11k} > \mu_{21k}$), **H4** ($\mu_{12k} > \mu_{22k}$)	A more recent accident has a negative effect on the airline assessment.
H5 ($\mu_{21k} > \mu_{12k}$)	A more recent accident has a stronger effect than a less recent accident on the airline assessment.
H6 ($\mu_{11k} > \mu_{21k} > \mu_{12k} > \mu_{22k}$)	Both accidents have a negative effect on the airline assessment.

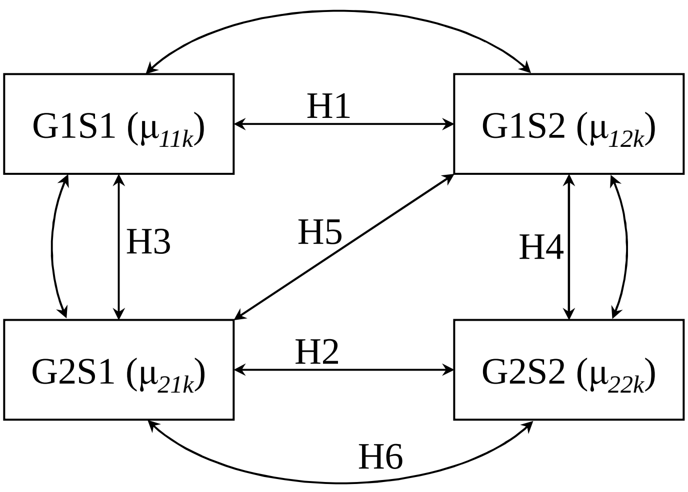


Figure 4.4 Configuration of six hypotheses

Hypotheses are summarized in Table 4.6. Structural model is shown in Figure 4.4. Then, we adopted a statistical method to prove the hypotheses. Null hypothesis (**H_0**) and alternative hypothesis (**H_A**) for **H1** to **H6** are listed in Table 4.7. It should be noted that we examined paired samples in **H1** and **H2** because we checked two variables given one group, while in **H3**, **H4** and **H5**, we had to compare the difference between two samples, Group 1 and Group 2. Moreover, we conducted *F*-test for **H3**, **H4** and **H5** in advance to check whether their variances are equal or not. In this study, after implementing one-tailed *t*-test, if *p*-value is smaller than level of significance, which normally uses 5%, null hypothesis can be rejected, and then we can accept alternative hypothesis.

Table 4.7 Hypotheses and statistical methodology

	H_0	**H_A**	Methodological approach
H1	$\mu_{11k} = \mu_{12k}$	$\mu_{11k} > \mu_{12k}$	*t*-test: paired two sample for means
H2	$\mu_{21k} = \mu_{22k}$	$\mu_{12k} > \mu_{22k}$	
H3	$\mu_{11k} = \mu_{21k}$	$\mu_{11k} > \mu_{21k}$	(1) *F*-test: two-sample for variances (2) *t*-test: two-sample assuming equal/unequal variances
H4	$\mu_{12k} = \mu_{22k}$	$\mu_{12k} > \mu_{22k}$	
H5	$\mu_{21k} = \mu_{12k}$	$\mu_{21k} > \mu_{12k}$	
H6	-	$\mu_{11k} > \mu_{21k} > \mu_{12k} > \mu_{22k}$	Combination of **H1** to **H5**

4.3.2 Difference of Two Groups

To understand public safety perception toward the air industry, we tested their agreement of the statements regarding aviation accidents, as shown in Table 4.8. This table compares Group 1 and Group 2, their consciousness regarding to accident record impact, media impact, willingness to use the airline, and confidence of safety knowledge. We adopted Likert 5-point scale to rate level of agreement (i.e. 1: strongly disagree, 2: disagree, 3: neither agree nor disagree, 4: agree, 5: strongly agree). From the results, we can find that Group 2 is more sensitive to aviation accidents than Group 1. They tend not to trust the airline especially if an accident occurs to the same company again, and further decrease their willingness to use it. Correlation test also reveals that safety perception is independent of age, income and education level for both Group 1 and Group 2. It means that no matter how different their socio-economic statuses are, all respondents have a common criteria for evaluating safety aviation consciousness. Besides, we also examined the correlations between aviation safety perception and age, income and education level in Table 4.8, eventually found there is no relationship. Thus, this survey has targeted general people, and can be used to understand their safety consciousness toward aviation industry regardless of their socio-economic statuses.

Table 4.8 Consciousness of aviation accidents of respondents (Group 1/Group 2)

Item description	Average	Standard deviation	Correlation		
			Age	Income	Education
(a) Accident record impact					
1. The safety level of airlines with accident records is the same as that of airlines without accident records.	2.40/2.26	0.99/1.01	0.00/-0.09	-0.04/0.05	-0.21/-0.15
2. An airline with a more recent accident is less reliable than an airline with a less recent one. (i.e. airline with accident 5 years ago is less reliable than airline with accident 6 years ago)	2.87/2.71	1.00/1.01	-0.04/0.03	0.00/-0.08	0.00/0.06
3. I am discouraged to purchase a flight ticket from an airline with more frequent accidents even it is cheap.	3.70/3.83	1.05/0.99	-0.05/-0.04	-0.02/-0.09	0.09/0.10
4. I don't care about flying with an airline that has had a number of casualties.	2.29/2.28	1.05/1.02	0.07/-0.03	-0.04/0.09	-0.21/-0.09
5. Even if an accident occurs, good company response and attitude make me feel that the airline involved is reliable.	4.07/3.90	0.70/0.78	-0.07/-0.02	-0.01/-0.06	0.07/0.10
(b) Media impact					
1. I feel dreadful when I watch the news coverage of aviation accidents on TV.	3.85/3.71	0.82/0.99	0.07/-0.02	-0.01/-0.02	-0.13/0.09
2. I believe the information and discussions regarding aviation accidents and airline safety rankings on the Internet.	3.60/3.25	0.73/0.87	-0.12/0.00	0.06/0.09	0.19/0.15
3. I am influenced by family members, relatives and friends to not use airlines with bad safety records to make them less worried.	3.79/3.78	0.90/0.87	-0.01/-0.04	-0.06/-0.03	-0.02/0.15
(c) Airline use willingness					
1. I do not want to buy or may sell (if owned) stock of an airline that I distrust.	3.65/3.72	0.80/0.87	0.20/0.13	0.05/0.09	-0.05/0.06
2. I will use the airline even my safety perception toward it is bad.	2.36/2.37	0.94/0.95	-0.11/-0.01	-0.01/0.09	0.03/0.05
3. I wouldn't recommend an airline that I distrust.	4.12/4.03	0.62/0.76	-0.05/-0.11	0.01/-0.09	0.09/0.05
(d) Confidence of safety knowledge					
1. I am familiar with airline safety management and know what to do in emergency.	3.02/2.88	0.93/0.95	0.01/-0.01	0.04/0.06	0.05/-0.08

4.3.3 Results of Hypothesis Testing

Table 4.9 shows the average and standard deviation of μ_{ijk} for i = 1, 2, j = 1, 2 and k = 1 to 4. Respondents used 5-point Likert scale to evaluate TransAsia Airways about image and identity, safety perception, trust, and willingness to use and recommend in two scenarios.

Table 4.9 Average and standard deviation in 2 scenarios for 2 groups

		Scenario 1				Scenario 2			
		IMG	SAF	TRU	WLN	IMG	SAF	TRU	WLN
Group 1 (202)	AVG	3.04	3.04	3.05	2.94	2.50	2.42	2.39	2.29
	STD	0.70	0.68	0.70	0.79	0.82	0.84	0.85	0.86
Group 2 (191)	AVG	2.90	2.87	2.86	2.82	1.97	1.84	1.85	1.79
	STD	0.72	0.74	0.74	0.77	0.80	0.81	0.79	0.82

Given that a rating of 1 is very low and 5 is very high, the range of each average number μ_{11k} is 2.94 to 3.05, μ_{12k} is 2.29 to 2.50, μ_{21k} is 2.82 to 2.90 and μ_{21k} is 1.79 to 1.97. There are significant differences among those data, so we tested the six hypotheses and examine the results. We adopted paired sample t-test for **H1** and **H2**. For **H3**, **H4** and **H5**, because they covered different samples, F-test was conducted at first respectively, and found variances of **H3** and **H4** were the same but variances of **H5** were unequal. After that, two-sample t-test assuming equal/unequal variances was implemented to examine the significance.

Table 4.10 Summary of hypotheses testing

	H_0	H_A	Significance			
			IMG (k=1)	SAF(k=2)	TRU(k=3)	WLN(k=4)
H1	$\mu_{11k}=\mu_{12k}$	$\mu_{11k}>\mu_{12k}$	**	**	**	**
H2	$\mu_{21k}=\mu_{22k}$	$\mu_{12k}>\mu_{22k}$	**	**	**	**
H3	$\mu_{11k}=\mu_{21k}$	$\mu_{11k}>\mu_{21k}$	*	**	**	0.075
H4	$\mu_{12k}=\mu_{22k}$	$\mu_{12k}>\mu_{22k}$	**	**	**	**
H5	$\mu_{21k}=\mu_{12k}$	$\mu_{21k}>\mu_{12k}$	**	**	**	**
H6	-	$\mu_{11k}>\mu_{21k}>\mu_{12k}>\mu_{22k}$	Confirmed	Confirmed	Confirmed	Partially confirmed

** Significant at 1% level; * Significant at 5% level.

Null hypothesis (**H_0**), alternative hypothesis (**H_A**) and *p*-value for **H1** to **H6** are listed as Table 4.10. After conducting one-tailed *t*-test for **H1** to **H5**, it was found that all *p*-values indicate greatly significant at 1% or 5% level, so null hypotheses can be rejected, and then accept alternative hypotheses. Examination result of WLN in **H3** is 0.075, which means there is no significant difference between μ_{114} and μ_{214} at 5% level, but it can be accepted at 10% level. That is to say, willingness to use TransAsia Airways is almost the same before the G222 Accident, but slightly affected by the G235 Accident. **H6** is the combination of **H1** to **H5**, and thus we can fully confirm the hypotheses for IMG, SAF and TRU, and partially confirm it for WLN.

The survey outcomes show that accidents significantly affected public perception toward TransAsia Airways, and that the more recent accident had stronger influences than the previous one, so for this reason, Group 2 could not fairly evaluate the airline at the same criteria as Group 1. Airline companies can also realize the consequences of repeated accidents will result in loss of customers, so they have to implement safety management at the highest level. Finally, results indicate that public perception is an important element in air transport management and dominates airline choice behavior, since their image and identity, safety perception, trust are low, willingness to use and recommend would be low as well.

4.3.4 Discussions of Hypothesis Testing

As time passes by, the worries are healed and gradually forgotten. This section investigated public perception change by assuming different cases for different groups of respondents. The purpose is to clarify the degree to which an accident would bring about consequences, e.g. public perception change and accident consciousness. Their general safety consciousness and evaluation to TransAsia Airways are totally different for Group 1 and Group 2 and in Scenario 1 and Scenario 2. This section has employed a hypothesis testing approach to quantify negative influence of aviation accidents to the public and revealed reasonable results. Aviation accidents cannot be predicted, so there is no research collecting similar data, which is a unique and exclusive point in our survey. The outcomes will be a typical research which analyzes the direct influence of just happened aviation accidents.

4.4 Formation of Safety Perception

4.4.1 Factor Exploration of Safety Perception

Various airlines and increasing air transport demands arouse a keen competition in the aviation market. Customers generally base on air fare, service quality, flight schedule, airline image and safety perception, etc. to select an airline. However, although aircraft is proved to be the safest transport mode, and aviation accidents rarely occur, some people still worry about the safety. The factors that cause their safety perception are not well summarized before at the best of our knowledge, so it is of importance to explore this phenomenon and help them reduce anxiety.

To summarize the problems we have observed, we would like to prove whether customers' safety perception have an effect on their behaviors. In order to improve safety, reduce accidents, and increase social benefits, we hope to explore the factors contributing to safety perception, and to drive airlines to improve safety so as to reduce the possibility of occurrence of accidents.

Diverse variables which may influence people's safety perception toward airlines were summarized, and a survey was conducted to collect data. According to literature review and our hypotheses, influential factors of safety perception in Table 4.11 can classified to five aspects: (a) aviation accidents (Gill and Shergill, 2004; Slovic, 1987), (b) financial (Suki, 2014; Mikulic and Prebezac, 2011), (c) tangible (Chang and Yeh, 2004; Han, 2013; van Oel and van den Berkhof, 2013; Suki, 2014; Mikulic and Prebezac, 2011), (d) airline operation (Suki, 2014; Chang and Yeh, 2004), and (e) information sources (Fang et al., 2012; Yadavalli and Jones, 2014; Suki, 2014; Chang and Yeh, 2004).

As a formation of the public's safety perception, subjective data was collected to convert qualitative variables into quantified data: 21 variables were measured with Likert 5 points (1: strongly disagree, 2: disagree, 3: neither agree nor disagree, 4: agree, 5: strongly agree), where high points suggest the indicator has strong effects on safety perception.

Table 4.11 Influential factors of safety perception toward airlines

	Indicator	Description
(a) Aviation Accidents: 4 variables		
AC1V	accident history	Safety of airlines with and without accident record are not the same.
AC2	accident free period	An airline with a more recent accident is less reliable than an airline with a less recent one.
AC3	accident frequency	I am discouraged to purchase a flight ticket from an airline with more frequent accidents even it is cheap.
AC4V	number of casualties	I care flying with an airline that has had a number of casualties in the past.
(b) Financial: 3 variables		
FN1V	airfare/insurance	I don't think the level of maintenance and accident insurance are well confirmed even air fare is low.
FN2	LCC	I think safety management of low cost carriers are less than full service airlines.
FN3	seat class	Economy class is less safe than business class.
(c) Tangible: 6 variables		
TA1	aircraft type	I feel that jets are steadier than turboprops.
TA2	cabin space/seat configuration	Cabin space and seat configuration (e.g. narrow-body aircraft with 1 aisle and wide-body aircraft with 2 aisles) contribute to my safety perception.
TA3	seat location/seat space	Seat space and location are important for me to stay calm.
TA4	noise	I am sensitive and may feel anxious to high engine noise.
TA5	safety video	I watch safety education video to increase my safety cognition.
TA6	entertainment/catering	In-flight entertainment and catering can distract my attention to flight condition.
(d) Airline Operation: 5 variables		
OP1	pilot	Pilot's skills in controlling aircrafts in different airlines are almost the same.
OP2	flight attendant	Bad flight attendants' guides and safety demonstration make me feel unsafe.
OP3V	in-flight announcement	I am not confident on safety management without in-flight announcements and signs.
OP4	flight cancellation/delay	I feel no problem in airline safety management if unusual flight cancellations or delays happen.
OP5	attitude	If an accident occurs, good airline's attitude and correspondent to accident arrangement still make me feel reliable on this airline.
(e) Information Sources: 3 variables		
IN1	TV	I feel dreadful when I watch the news coverage of aviation accidents on TV.
IN2	Internet news	I believe the information and discussions regarding aviation accidents and airline safety rankings on the Internet.
IN3	family/friends	I am influenced by family members, relatives and friends to not use airlines with bad safety records to make them less worried.

To test how these influential factors contribute to their behaviors, another three variables were collected to indicate safety perception-oriented behaviors in Table 4.12, such as stock holding (Seo et al., 2014; Walker et al., 2005), purchase willingness (Han, 2013), and word of mouth recommendation (Han, 2013; Suki, 2014).

Table 4.12 Variables of safety perception-oriented behavior

	Indicator	Description
(f) Safety Perception-oriented Behavior		
SP1	stock holding	I don't want to buy or may sell stock of airline (if owned) which I feel unsafe.
SP2V	purchase willingness	I will use the airline, which my safety perception toward is good.
SP3	word of mouth recommendation	I won't recommend the airline I distrust.

x_i^g stands for 5-point rating of 21 influential variables of safety perception, and y_j^g represents 5-point rating of safety perception-oriented three behavior variables with 5-point Likert points scale (1: strongly disagree, 2: disagree, 3: neither agree nor disagree, 4: agree, 5: strongly agree).

Regression analysis in Equation 4.1 was used to determine the contribution of each indicators x_i^g to their safety perception-oriented behaviors y_j^g. All data we have collected are subjective data, and we would like to observe the interaction among variables. x_i^g and y_j^g are subjective data, and interaction among variables can be clarified

$$y_j = \sum_i \beta_{ij} \cdot x_{ij} + d_j \quad \forall i \ ,j \qquad (4.1)$$

Because there was an accident occurred during investigation, samples were separated by two groups. 337 samples among total 393 samples were effective data after data screening, which include 172 and 165 respondents for Group 1 and Group 2, respectively. We want to use regression analysis to estimate whether customers' safety perception have an effect on their behaviors, characteristics of variables are summarized in Table 4.13.

Table 4.13 Characteristics of regression variables

g = 1, 2	(G1): samples who answered before GE235 accident (G2): samples who answered after GE235 accident
i = 1 to 21	**21 Influential Variables of Safety Perception** • Aviation accidents (4): accident history, accident free period, accident frequency, number of casualties • Financial (3): airfare/insurance, LCC, seat class • Tangible (6): aircraft type, cabin space/seat, configuration, seat location/seat space, noise, safety video, entertainment/catering • Airline operation (5): pilot, flight attendant, in-flight announcement, flight cancellation/delay, attitude • Information sources (3): TV, Internet news, family/friends
j = 1, 2, 3	**3 Safety Perception-oriented Behavior** (j1): stock holding; (j2): purchase willingness; (j3): word of mouth recommendation

4.4.2 Results of Regression Analysis

Because there are many variables included in the formula, two steps to eliminate insignificant variables were conducted firstly.

- Step 1: centralization examination

According to results of variables in Table 4.14 (x: 13 variables, y: 3 behaviors), higher score represents for stronger influences that the variable enforces. AC2 (accident free period), FN1V (airfare/insurance), FN2 (LCC) and FN3 (seat class) are not strong factors influencing safety perception, because many respondents had totally opposite recognition. Therefore, four variables were excluded from regression analysis.

Table 4.14 Results of variables

		Group 1 (172 samples) (%)					**Group 2** (165 samples) (%)				
		1	2	3	4	5	1	2	3	4	5
AC1V	accident history	3.5	14.5	11	58.7	12.2	1.2	17	6.7	55.8	19.4
AC2	accident free period	5.8	39.5	19.8	33.7	1.2	9.1	42.4	21.8	24.8	1.8
AC3	accident frequency	2.9	14	14.5	47.1	21.5	1.2	11.5	16.4	44.8	26.1
AC4V	number of casualties	1.7	16.3	9.9	51.7	20.3	1.8	16.4	13.3	46.1	22.4
FN1V	airfare/insurance	8.7	38.4	20.3	29.1	3.5	8.5	31.5	21.2	36.4	2.4
FN2	LCC	7.6	39.5	20.3	28.5	4.1	6.7	42.4	23	26.7	1.2
FN3	seat class	28.5	54.1	12.8	4.1	0.6	32.1	52.7	12.1	2.4	0.6
TA1	aircraft type	0.6	12.2	33.7	45.3	8.1	2.4	18.2	32.7	39.4	7.3
TA2	cabin space/seat configuration	5.2	23.8	23.3	43.6	4.1	4.8	26.7	21.8	38.8	7.9
TA3	seat location/seat space	2.3	9.3	14.5	61.6	12.2	5.5	12.7	18.8	54.5	8.5
TA4	noise	5.8	32	19.2	34.9	8.1	7.3	32.7	23.6	32.1	4.2
TA5	safety video	1.7	5.8	16.3	61	15.1	3	9.1	13.9	60	13.9
TA6	entertainment/catering	1.2	17.4	14.5	51.2	15.7	3	13.9	15.8	53.3	13.9
OP1	pilot	0.6	6.4	5.2	65.1	22.7	0	8.5	6.1	65.5	20
OP2	flight attendant	2.3	11.6	22.1	54.1	9.9	2.4	13.9	19.4	51.5	12.7
OP3V	in-flight announcement	2.9	16.9	15.7	52.9	11.6	3	15.2	13.9	57	10.9
OP4	flight cancellation/delay	2.3	20.3	14.5	52.3	10.5	2.4	21.8	15.2	53.3	7.3
OP5	attitude	0	3.5	8.1	62.8	25.6	0.6	6.1	11.5	63	18.8
IN1	TV	0.6	5.2	13.4	63.4	17.4	1.8	15.8	10.3	53.3	18.8
IN2	Internet news	0.6	9.9	25.6	60.5	3.5	3	15.2	35.2	44.2	2.4
IN3	family/friends	1.7	12.2	9.9	60.5	15.7	3	6.7	13.9	61.2	15.2
SP1	stock holding	1.2	6.4	27.9	54.1	10.5	1.8	7.3	23.6	50.3	17
SP2V	purchase willingness	1.7	14.5	12.2	57.6	14	1.2	14.5	17.6	52.7	13.9
SP3	word of mouth recommendation	0	1.7	9.3	62.8	26.2	1.2	1.8	11.5	61.2	24.2

- Step 2: Pearson correlation examination

Moreover, results of correlation coefficient are shown in Table 4.15, and four variables (TA1, TA6, OP2, OP4) were deleted due to low correlation.

Table 4.15 Results of Pearson correlation coefficient

		AC1V	AC3	AC4V	TA1	TA2	TA3	TA4	TA5	TA6	OP1	OP2	OP3V	OP4	OP5	IN1	IN2	IN3
SP1	r	0.06	0.30	0.14	0.04	0.18	0.09	0.23	0.15	0.08	0.13	0.08	0.08	0.06	0.11	0.27	0.03	0.30
	p	0.31	***	***	0.44	***	*	***	***	0.16	**	0.13	0.16	0.31	**	***	0.56	***
SP2V	r	0.28	0.40	0.35	0.01	0.08	0.03	0.13	0.00	-0.09	0.18	0.07	0.17	0.02	0.05	0.12	0.04	0.24
	p	***	***	***	0.79	0.17	0.59	**	0.96	0.10	***	0.19	***	0.73	0.37	**	0.47	***
SP3	r	0.20	0.28	0.20	0.06	0.21	0.07	0.02	0.07	0.03	0.12	0.08	0.02	-0.02	0.17	0.19	0.19	0.28
	p	***	***	***	0.24	***	0.22	0.78	0.23	0.57	**	0.14	0.73	0.67	***	***	***	***

***p<0.01, **p<0.05, *p<0.1

As a result, 13 variables were remained for regression analysis. Results for all samples are demonstrated in Table 4.16. β is standardized effect of each indicators toward safety perception-oriented behaviors. We can also say customers' safety perception dominates their behaviors.

Table 4.16 Results of regression analysis

Variable Description		SP1 (j=1) stock holding		SP2V (j=2) purchase willingness		SP3 (j=3) word of mouth recommendation	
		R^2=0.154		R^2=0.197		R^2=0.146	
		β	*p*	β	*p*	β	*p*
d	intercept	1.89	***	1.36	***	2.20	***
AC1V	accident history	-0.07	0.20	0.11	*	0.08	0.18
AC3	accident frequency	0.18	***	0.24	***	0.13	**
AC4V	number of casualties	0.02	0.74	0.16	***	0.05	0.43
TA2	cabin space/seat configuration	0.06	0.28	-0.05	0.37	0.11	**
TA3	seat location/seat space	-0.04	0.47	0.00	0.96	0.01	0.91
TA4	noise	0.11	*	0.00	0.93	-0.15	**
TA5	safety video	0.07	0.18	-0.07	0.17	-0.03	0.63
OP1	pilot	-0.11	*	0.08	0.18	-0.03	0.68
OP3V	in-flight announcement	0.03	0.56	0.10	**	0.00	0.94
OP5	attitude	0.08	0.12	0.04	0.39	0.13	***
IN1	TV	0.19	***	-0.03	0.60	0.08	0.18
IN2	Internet news	-0.09	*	-0.06	0.26	0.08	0.13
IN3	family/friends	0.15	**	0.09	0.14	0.16	***

***p<0.01, **p<0.05, *p<0.1

Results of regression analysis show low adjusted R^2 as 0.154, 0.197, and 0.146. For the goodness of regression analysis results, adjusted R^2 should be at least 0.5, and close to 1 as the optimal fit. Our results show low R^2 values, but ANOVA in Table 4.17 has good *p*-value, meaning these 13 variables are significantly different. The reasons why R^2 is low are considered to be exclusion of other relative behavior variables, and inclusion of some insignificant variables, e.g. which are insignificant for SP1 (stock holding) but significant for SP2 (purchase willingness) and SP3 (word of mouth recommendation). We understood this situation, and did not use the results for estimation.

Table 4.17 ANOVA results

Model	SS	df	MS	F value	*p*-value
Regression	44.675	13	3.437	5.708	0.000
Residual	194.452	323	0.602		
Total (Pivot table)	239.128	336			

4.4.3 Discussions of Regression Analysis

According to the results of regression analysis, we can understand that people who consider accident history, number of casualties, and in-flight announcement much are not willing to use personally (AC1V, AC4V, OP3V). Airlines with frequent accidents are totally not considered at all (AC3). Those who are picky to cabin space/seat configuration and noise may not use the airline personally, but possible to invest and recommend (TA2, TA4). People who think pilot skills are less important have high intention to invest the airline but do not encourage people to take (OP1). Airline good attitudes make people feel safe and willing to recommend (OP5). Therefore, airlines can improve service and provide reliable operation for people to stay calm.

Moreover, people who receive information from TV but do not believe in Internet information are possible to invest the company, but show less intention to use (IN1, IN2). Those who think family and friends' words are important for safety perception will not use the airline to avoid their worries (IN3). Consequently, the media should report correct and appropriate news to the public.

Financial indicators (LCC, airfare, seat class) and some tangible indicators (seat location/seat space, safety video) cannot demonstrate their behaviors. Moreover, multi-group comparison in Table 4.18 compares the differences between two groups.

Table 4.18 Multi-group comparison

	All						G1						G2					
	SP1 stock holding		SP2V purchase willingness		SP3 word of mouth		SP1 stock holding		SP2V purchase willingness		SP3 word of mouth		SP1 stock holding		SP2V purchase willingness		SP3 word of mouth	
	R^2=0.154		R^2=0.197		R^2=0.146		R^2=0.144		R^2=0.205		R^2=0.038		R^2=0.161		R^2=0.21		R^2=0.199	
	β	*p*	β	*p*	β	*p*	β	*p*	β	*p*	β	*p*	β	*p*	β	*p*	β	*p*
d	1.89	***	1.36	***	2.20	***	2.10	***	2.51	***	2.50	***	1.58	***	1.00	0.11	2.13	***
AC1V	-0.07	0.20	0.11	*	0.08	0.18	-0.09	0.26	0.12	0.14	0.10	0.27	-0.03	0.73	0.10	0.23	0.06	0.51
AC3	0.18	***	0.24	***	0.13	**	0.23	**	0.23	**	0.08	0.45	0.11	0.23	0.24	***	0.20	*
AC4V	0.02	0.74	0.16	***	0.05	0.43	0.00	0.97	0.09	0.33	0.07	0.49	0.03	0.72	0.23	***	0.02	0.84
TA2	0.06	0.28	-0.05	0.37	0.11	**	0.05	0.51	-0.12	0.14	0.08	0.34	0.05	0.57	0.02	0.80	0.15	*
TA3	-0.04	0.47	0.00	0.96	0.01	0.91	0.05	0.56	-0.07	0.36	0.01	0.91	-0.10	0.26	0.03	0.78	-0.01	0.90
TA4	0.11	*	0.00	0.93	-0.15	**	0.23	***	0.13	0.12	-0.08	0.39	-0.02	0.86	-0.12	0.14	-0.18	**
TA5	0.07	0.18	-0.07	0.17	-0.03	0.63	-0.01	0.86	-0.03	0.68	-0.02	0.84	0.15	**	-0.11	0.15	-0.05	0.52
OP1	-0.11	*	0.08	0.18	-0.03	0.68	-0.10	0.28	0.09	0.31	-0.01	0.90	-0.08	0.36	0.12	0.18	-0.01	0.90
OP3V	0.03	0.56	0.10	**	0.00	0.94	0.00	0.98	0.08	0.25	0.01	0.95	0.05	0.49	0.10	0.15	0.00	0.97
OP5	0.08	0.12	0.04	0.39	0.13	***	0.05	0.52	-0.07	0.37	0.16	**	0.14	*	0.11	0.15	0.07	0.34
IN1	0.19	***	-0.03	0.60	0.08	0.18	0.10	0.25	-0.14	*	-0.01	0.95	0.26	***	0.06	0.49	0.12	0.18
IN2	-0.09	*	-0.06	0.26	0.08	0.13	-0.02	0.80	-0.04	0.56	0.08	0.35	-0.14	*	-0.10	0.21	0.07	0.41
IN3	0.15	**	0.09	0.14	0.16	***	0.09	0.31	0.17	*	0.12	0.24	0.17	*	-0.02	0.85	0.21	**

***$p<0.01$, **$p<0.05$, *$p<0.1$

OP5 (airline attitude) is significant for Group 1, because people still believe in airlines if only one accident occurs, but case of repeated accidents may be different. After receiving information from IN1 (TV), Group 1 does not show difference, but Group 2 would like to sell stocks due to frequent accident records

The main contribution of this section is to provide a perspective for airlines to facilitate policy making and to decide which measures are effective for safety perception improvement and customer retention. We investigated people's safety perception formation, and results are meaningful for safety improvements.

4.5 Analysis of Worry Duration

4.5.1 Worry Duration: Cox Proportional Hazards Model

Passenger number may decrease after an accident due to their safety concerns, but worries may be decaying after a period, resulting in passenger return and discouraging airlines to improve safety management system. Wong and Yeh (2003) found that an accident occurs during or just before an off-peak period, accidents are associated with a 2.54 month effect and a 22.11% monthly traffic decline. This section focuses on people's concerns for, and perceptions of, safety in different airline companies before and after aviation accidents. Two aircraft crash events in Taiwan made it necessary and important for the government and airlines to understand what people are thinking and to quantify their concerns.

The mass media in Taiwan typically exaggerates the severity of aircraft crash events, then causes negative spill-over influences, but these may decrease over time. Points of interest in this study include consumers' acclimatization to an aviation accident and the exploration of factors that control their perception. Worry duration was used to specify and quantify this situation, and to describe the consumer's strength of concern toward an airline. Worry duration is a subjective concept and is defined as the period since an accident's occurrence until there is no individual retention of concern. The concept of worry duration is similar to the forgetting curve (Ebbinghaus, 1885/1974), hypothesized as the decline of memory retention over time. However, it is infeasible to trace people's worries by year; therefore, scenarios were created for respondents to imagine the conditions, and then a worry period for each person can be obtained. This study is meaningful for airlines and the government to estimate customers' behaviors toward the aviation market, and to facilitate decision making if aware of their worry period. To quantify strength of worries, worry duration is a subjective concept caused by one fatal accident toward the airline. The definition (def.) is a period since one fatal accident happened for individuals until there is no attempt to retain safety worries

The exploration of factors that control worry duration is also of importance. According to the literature review, causes of worry regarding aviation accidents include flight experiences, airline evaluation, safety knowledge, and socio-economic information, among others. Hazard-based survival analysis and the Cox proportional hazards model were utilized to observe participants' reactions (Washington et al., 2011). This method is primarily used for medical statistics, to express the probability of patients' survival statuses after therapy, and to examine the types of people that are suitable for treatment. However, this method is also suitable for this research, to find the factors that dominate worry duration, and forecast the declining period of worry after an accident.

The elimination of safety worries $F(t)$ was assumed in this study to be a cumulative distribution function, as noted in Equation 4.2,

$$F(t) = P(T < t) \tag{4.2}$$

where P is probability, T is the random time variable, and t is assigned time. Equation 4.2 indicates the possibility that people's concerns disappear. The survival function of worries $S(t)$ as in Equation 4.3, in contrast, denotes the possibility that people's concerns exist.

$$S(t) = 1 - F(t) = P(T > t) \tag{4.3}$$

The hazard function $h(t)$, or the conditional probability denoting that an event will occur between time t and $t + dt$, as demonstrated in Equation 4.4, is divided by the first derivative of the cumulative distribution with respect to time by the survival function. Here, elimination of worries represents the occurrence of an event.

$$h(t) = \frac{dF(t)/dt}{S(t)} = \frac{dF(t)/dt}{1 - F(t)} \tag{4.4}$$

This hazard-based model describes the probability of covariates' effects; therefore, the Cox proportional hazards approach, with covariates as illustrated in Equation 4.5, can be used to estimate the effects of factors (i.e., covariates in this model) that influence the duration analysis.

$$h(t \mid \chi) = h_0(t)\exp(\beta\chi) \tag{4.5}$$

$h(t|\chi)$ is the hazard function with covariate vector χ. χ is a vector of estimable parameters, such as flight experiences, aviation safety knowledge, and socio-economic information. $h_0(t)$ is the standard hazard, assuming all elements of covariate vector χ at zero, and β is a vector of estimable coefficients.

Limited studies exist regarding analysis of worry or adaptation by hazards-based functions. Chang and Hung (2013) used hazard function to discover the adoption of, and loyalty toward, low-cost carriers for Taiwan-Singapore passengers, and estimated coefficients for airline passengers' socio-economic characteristics. Nam and Mannering (2000) evaluated the duration and traffc congestion caused by highway vehicle incidents with hazard-based duration models, and focused on the clearance of hazards to statistically analyze the duration that traffic incidents detect, respond, and clear. Ronen and Yair (2013) used the exponential decay function psychologically, and explored whether roads of different complexity and demand require different adaptation time. They examined the relationship among respondents' subjective sensation of adaptation with learning curves and objective driving performance measures. Therefore, this study will use the Cox proportional hazards model to analyze individuals' worry duration and its corresponding factors. It should be noted that hazards were specified as hazards of existence of worries, termed "survival" (status: 0, censored data) in this study, and "death" (status: 1) means no worries to the airline. In other words, the higher hazards that exist, the less people worry.

4.5.2 Survey Design

According to literature review, several factors such as aviation knowledge (Gill and Shergill, 2004; Slovic, 1987), cabin environment (van Oel and van den Berkhof, 2013; Han, 2013), airline performances (Chang and Yeh, 2004), socio-economic and cultural variation (Lund and Rundmo, 2009; Joewono and Kubota, 2007), and personality (Nordfjærn and Rundmo, 2015; Fyhri and Backer-Grøndahl, 2012) have an effect on their safety concerns. Therefore, quantification of worry duration was collected in our survey which is designed for Taiwanese citizens who currently live in Taiwan. Domestic routes were the surveyed targets, as aviation accidents had recently occurred in Taiwan.

Firstly, a 5-point Likert scale (1: very concerned, 2: concerned, 3: neither concerned nor unconcerned, 4: unconcerned, 5: very unconcerned) at nine different periods (at the moment; 0-3, 3-6, 6-12, 12-24, 24-36, 36-60, 60-120, and over 120 months after one accident) was designed to inquire regarding worry duration toward aviation accidents in their preferred airline (such as UNI Air, Mandarin Airlines, TransAsia Airways, Far Eastern Air Transport and others). The last period in which their concerns exist (both in scale 1 and scale 2) represents the lifespan of concerns, and mean of these periods (0, 0.01, 1.5, 4.5, 9, 18, 30, 48, 90, or 120 months) is the individual's worry duration in Figure 4.5 and Figure 4.6. Worry duration, for those who were not concerned at all, is regarded as 0, while for those who were worried only at the moment, but not worried after 0 to 3 months, the worry duration is 0.01 to distinguish them from worry-free respondents. Those who were still worried after 10 years are censored samples; therefore, the duration is 120 months, but the status of worries is noted as a survival status. There were seven questions in the next section, with a 5-point Likert scale used to investigate aviation safety knowledge and a safety assessment of the airline. After a 3-week online survey, 393 effective samples were collected for data analysis. These include 202 and 191 respondents for Group 1 and Group 2, respectively.

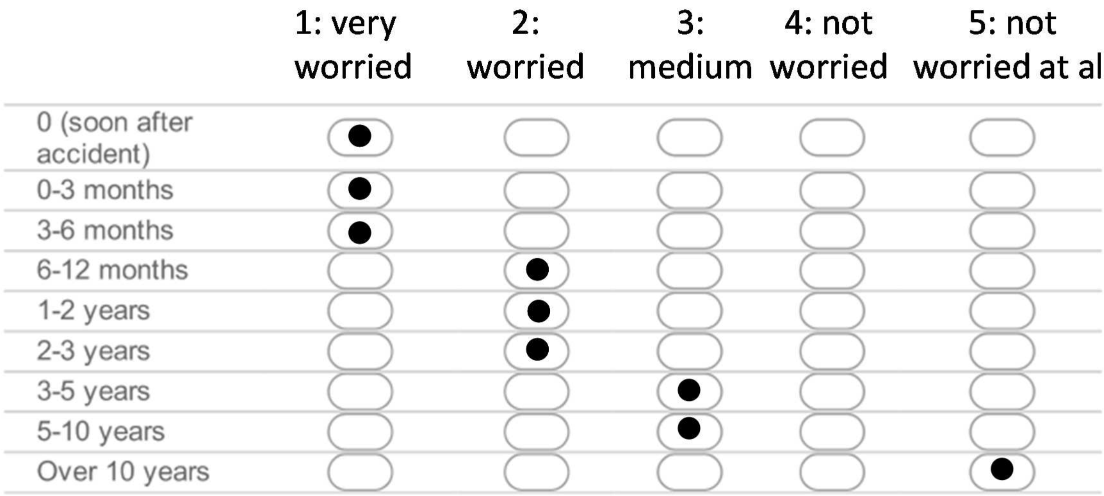


Figure 4.5 Duration form example 1 (duration: 60 months; status: death (1))

Figure 4.6 Duration form example 2 (duration: 120 months; status: survival (0))

4.5.3 Results of Worry Duration Analysis

Because a real accident occurred with TransAsia Airways, samples were divided into two groups. Worry duration toward four airlines, divided by two groups, is illustrated in Table 4.19. Approximate one quarter of samples have no concerns about safety, suggesting that they do not mind accident records. Half of them will alleviate their concerns in six months, and nearly ten percent still have safety concerns after ten years.

Table 4.19 Worry duration to airlines for Group 1 and Group 2

Worry duration (months)	UNI		Mandarin		TransAsia		Others		Total		
	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	All
0	17	37	7	7	8	3	6	7	38	54	92
0.01	18	6	1	1	1	1	1	1	21	9	30
1.5	9	5	2	1	4	3	4	2	19	11	30
4.5	11	14	5	0	2	1	0	1	18	16	34
9	24	13	6	3	7	2	5	3	42	21	63
18	15	16	4	4	1	1	0	1	20	22	42
30	7	15	3	4	0	1	1	4	11	24	35
48	5	6	0	1	1	0	1	1	7	8	15
90	4	2	0	0	0	0	0	0	4	2	6
120	15	13	1	3	2	4	4	4	22	24	46
Total	125	127	29	24	26	16	22	24	202	191	393

Variables for model estimation, with a 5-point Likert scale (1: strongly disagree, 2: disagree, 3: neither agree nor disagree, 4: agree, 5: strongly agree), are used to explore factors that influence worry duration, to rate aviation safety knowledge and assessment, are demonstrated in Table 4.20.

Table 4.20 Average of aviation knowledge and safety assessment

Description		Average	
Aviation safety knowledge		**G1**	**G2**
Q1	The safety level of airlines with accident records is the same as that of airline without accident records.	2.40	2.26
Q2	If an accident occurs, good company response and attitude still make me feel that the airline involved is reliable.	4.07	3.90
Q3	I am sensitive and may feel anxious to high engine noise.	3.04	2.92
Q4	In-flight entertainment and catering can distract my attention to flight condition.	3.63	3.58
Q5	I feel dreadful when I watch the news coverage of aviation accidents on TV.	3.85	3.71
Q6	I will use the airline even my safety perception toward it is bad.	2.36	2.37
Safety assessment toward the airline			
Q7	This airline implements safety management well.	3.68	3.66

Table 4.21 Relationship of coefficient, covariate, hazard function, survival function

β	χ	$h(t)$	$S(t)$
+	↑	↑	↓
-	↓	↓	↑

Relationship of coefficient, covariate, hazard function, and survival function are shown in Table 4.21. If β is positive, when covariate χ gets larger, worry may decay sooner, and vice versa. Therefore, we can base on this form to discuss outcomes. Table 4.22 illustrates the results of the Cox proportional hazards model, using IBM SPSS statistics at a 95% confidence interval to estimate an accident's worry duration, and to explore the relationships of flight experiences, airline assessment, and socio-economic information. We want to estimate the effects of covariates β that affecting worry duration, and to analyze how long people may accept an accident and reuse again.

Table 4.22 Estimation results of Cox proportional hazards model

	Group 1		Group 2	
	β	*p*-value	β	*p*-value
Q1 The safety level of airlines with accident records is the same as that of airline without accident records.	0.152	0.07*	0.156	0.07*
Q2 If an accident occurs, good company response and attitude still make me feel that the airline involved is reliable.	0.225	0.07*	0.207	0.08*
Q3 I am sensitive and may feel anxious to high engine noise.	-0.088	0.29	-0.227	0.01***
Q4 In-flight entertainment and catering can distract my attention to flight condition.	-0.036	0.68	-0.168	0.06*
Q5 I feel dreadful when I watch the news coverage of aviation accidents on TV.	-0.288	0.01***	-0.488	0.00***
Q6 I will use the airline even my safety perception toward it is bad.	0.236	0.01***	0.028	0.74
Q7 This airline implements safety management well.	0.284	0.04**	-0.043	0.72
Annual flight frequency	-0.102	0.13	-0.055	0.40
Usage of the airline (0: no, 1: yes)	0.037	0.82	-0.052	0.77
Age	0.006	0.64	-0.001	0.93
Gender (0: female, 1: male)	0.289	0.11	-0.078	0.68
Civil Status (0: single, 1: married)	0.093	0.68	-0.270	0.37
Employment (0: unemployed, 1: employed)	0.161	0.50	0.014	0.95
Income (1: lowest, 5: highest)	-0.049	0.58	0.206	0.04**
Education (1: lowest, 5: highest)	-0.113	0.31	-0.110	0.35
Number of observations	202		191	
Log-likelihood at zero	-654.311		-621.858	
Log-likelihood at convergence	-634.204		-588.731	
Chi square	38.910		71.257	
df	15		15	
Overall *p*-value	0.00***		0.00***	

* p<0.1, ** p<0.05, *** p<0.01 for one-tailed test.

Q1 and Q2 demonstrate similar results; therefore, those who believe all airlines have the same standard of safety management display a shorter worry duration, and airlines' moral attitudes and responses may increase their reliability. Q3 and Q4 regard tangible features, such as engine noise, in-flight entertainment, and catering, and these become more important for passengers to stay calm when using an airline with a poor safety record. People may become increasingly sensitive to safety after an accident event, and may require material satisfaction and comfort to divert their attention. In Q5, all people are apprehensive of the air crash news releases on television, and participants in Group 2 are more strongly influenced. Q6 and Q7 imply that people could tolerate an accident once, but were unacceptable for repeated accidents even if the airline provides good service and performs safety management. This indicates that people may trust airlines after a few mistakes, but if accidents repeatedly occur, a longer period is required to regain customer confidence. Socio-economic statuses and flight experiences are found to be insignificant for worry duration; instead, only subjective thinking and an evaluation of the airline's performance dominate their concerns.

Figure 4.7 to Figure 4.10 illustrate diagrams of worry's survival and hazard functions. Figure 4.7 and Figure 4.9 note a comparison of different airlines in Group 1's worry's survival and hazard functions, indicating people do not have specifically longer worry duration toward any particular airline. An approximate average 80% of people can relieve their concerns after two years. However, worries toward TransAsia Airways in Figure 4.8 and Figure 4.10 are separated from other airlines. Group 1 respondents who selected TransAsia Airways, or approximately 90%, can relieve their concerns after twenty months, but for Group 2, 25% still show concerns toward TransAsia Airways from thirty months until ten years, explaining that the GE235 accident did contribute to increased worry. The survival functions of worry also demonstrate different results. Curves overlap, with the exception of TransAsia Airways in Group 2, while the curves in Group 1 illustrate diverse trends due to their safety perception after an accident. Worry's survival for UNI Air and others (including Far Eastern Air Transport) for Group 1 in Figure 4.7 is maintained longer because they experience difficulty in clearly imagining the conditions of an accident that occurred six months prior, and this results in some errors.

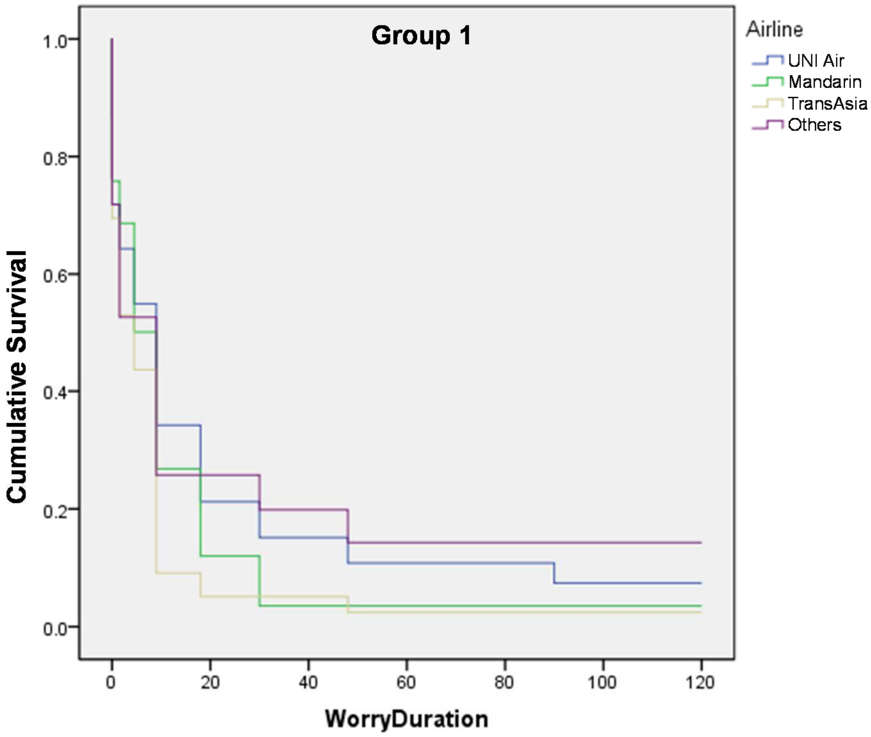


Figure 4.7 Comparison of worry's survival functions: airline (Group 1)

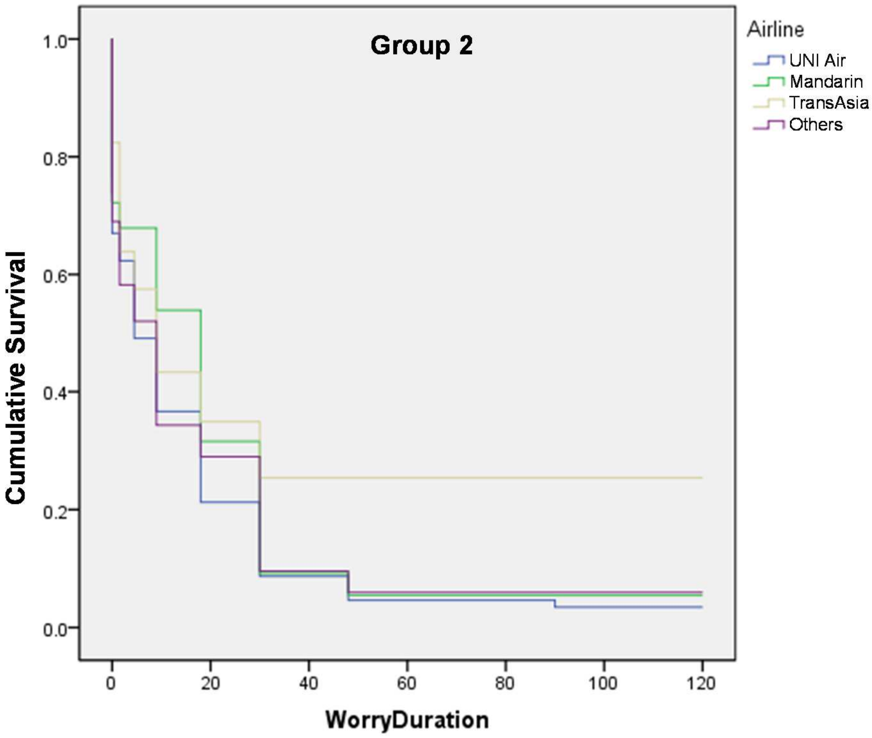


Figure 4.8 Comparison of worry's survival functions: airline (Group 2)

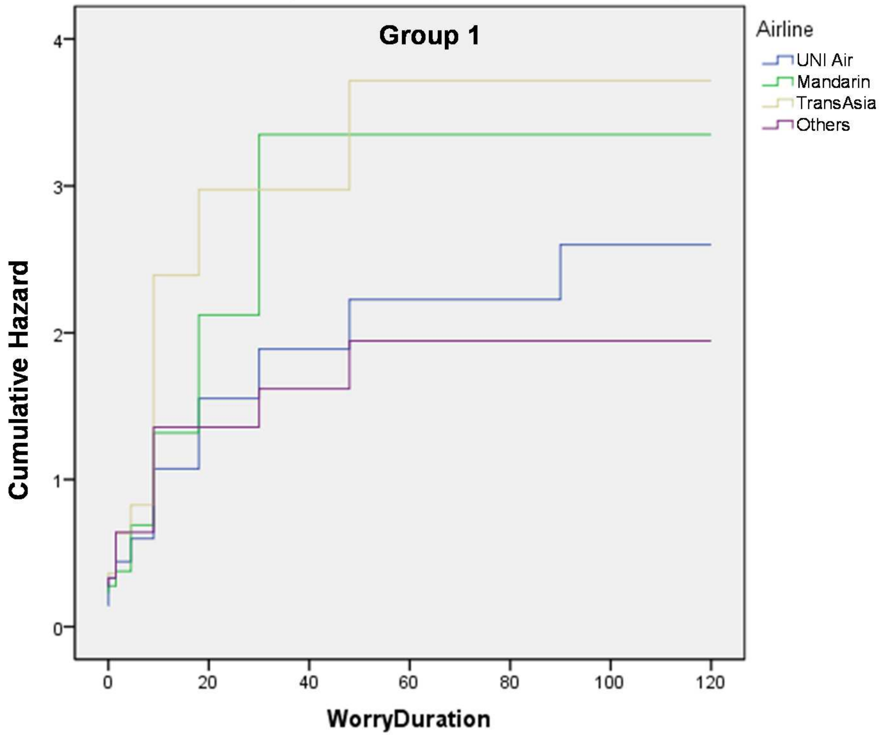


Figure 4.9 Comparison of worry's hazards function: airline (Group 1)

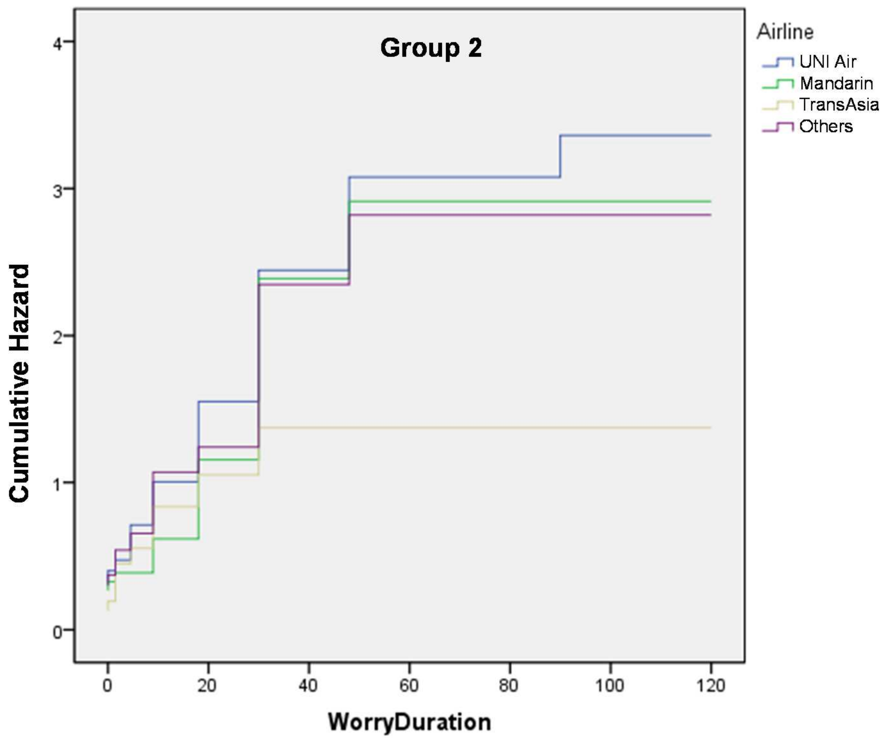


Figure 4.10 Comparison of worry's hazards function: airline (Group 2)

Lastly, a comparison of Groups 1 and 2 with different age intervals is shown in Figure 4.11 and Figure 4.12. The results indicate that perception changes among ages. Older people, particularly for 50s, can relieve their safety worries faster if only one accident occurs, but a repeated accident makes them concerned much more than others. This can be inferred that one accident is probably acceptable for unexpected mistake for aged people according to their longer air transport experience. Also, because case of two closely-happened accidents is rare, inducing them tend to avoid risk and keep conservative attitudes.

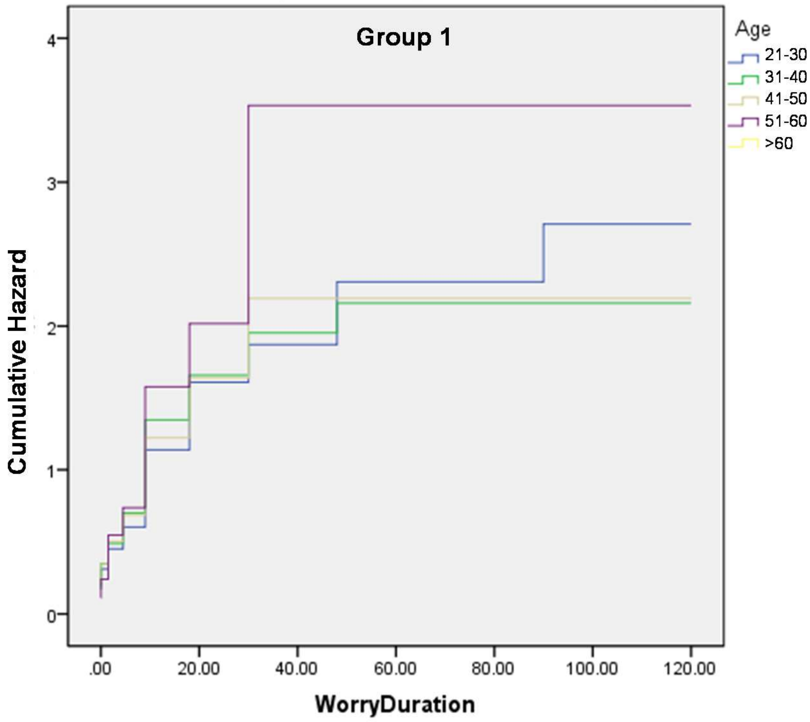


Figure 4.11 Comparison of worry's hazards function: age (Group 1)

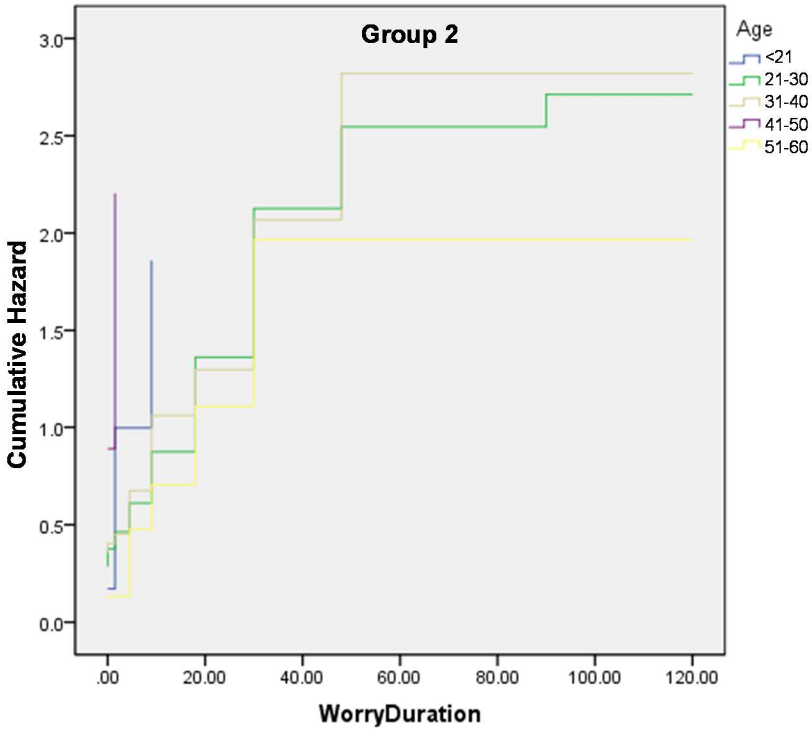


Figure 4.12 Comparison of worry's hazards function: age (Group 2)

4.5.4 Discussions of Worry Duration

This section provides an innovative concept to examine the influence of recently occurring accidents, and analyzes people's worry duration. Two recent air accidents in Taiwan were selected for the case study. An online survey was carried out to investigate public safety perception change. Samples were divided into two groups due to the recent accident, to implement a Cox proportional hazards model to estimate the variables of worry duration. The results noted socio-economic information and flight experiences do not contribute to concerns, but several subjective perceptions dominate, such as safety assessment toward the airline, aviation safety knowledge, news releases, and tangible factors. Moreover, 80% of people can relieve their concerns after two years, but it will take longer to alleviate worry if repeated accidents occur. The results indicate that accidents may cause a substantial impact on people, and they might refuse to take an airline with a poor company image, safety concerns, and public distrust; therefore, airlines should improve safety to avoid accidents.

Worry duration is the period from an airline accident's occurrence until the safety worries cease to exist. Therefore, to relieve safety worries and shorten the worry period, several countermeasures are addressed. First, the airline is certain to avoid repeated accidents. The media should avoid exaggerating the influences, and report accident news appropriately. Airlines should implement safety management thoroughly, improve service attitudes, and provide a comfortable cabin environment to maintain passengers' composure. Finally, people must receive aviation safety education, or risk believing information on the Internet and unconfirmed reports, which are generally incorrect.

This section was conducted from the perspective of lay people, which is significant for society, and innovative, to the best of our knowledge. The results could not only help airline companies understand customers' behaviors but also provide several suggestions for them to facilitate decision making and crisis management. However, while it is meaningful to reduce safety worries to help passengers use air transport without anxiety, if passengers still use an airline with recent accident occurrence, this may discourage the involved airline to improve their safety management system. Therefore, the government should carefully monitor airline performance to avoid this problem. This research provides a new concept to quantify social impacts of aviation accidents; nevertheless, many issues still exist. A tradeoff analysis of safety worries and airfare, and how safety worries affect choice behaviors, should also be considered, which will be discussed in Chapter 5. Subjective data was adopted for this study, but panel data collection is recommended to more precisely predict worry duration.

4.6 Change of Users' Behavioral Intention

4.6.1 Structural Equation Model of Users' Behavioral Intention

People change their perception toward airlines after accidents because of concerns with safety and fear of flying. Because customers have their own considerations about each airline, basing solely on their perception to use it for first time. If they feel satisfied and find the service reliable, then may show high incentive to the airline. Structural equation model (SEM) is a method to combine multiple latent factors and to observe mutual interactive influences among them. SEM and factor analysis are widely used in the field of transportation studies. Joewono and Kubota (2009) explored user satisfaction with paratransit service in Indonesia, which hypothesized how users measure paratransit's quality of service and loyalty. Suki (2014) examined the effects of the attributes of airline service quality to Malaysia Airlines and AirAsia. Kao et al. (2009) also used SEM to examine the relationship between safety culture and flight attendant safety performance for cabin crews in four major Taiwanese airlines.

According to literature review, four influential and three reflective factors are specified to express behavioral intention. Influential factors imply airline image and identity, airfare, safety perception and perceived service quality, while satisfaction, trust, and willingness can respectively represent people's intention. The proposed structure in Figure 4.13 provides a comprehensive model consisting of formative and reflective approaches to present behavioral intention with an instrument to measure multiple factors. This model includes diverse factors and can express two aspects of behavioral intention, which is innovative compared with models in previous studies.

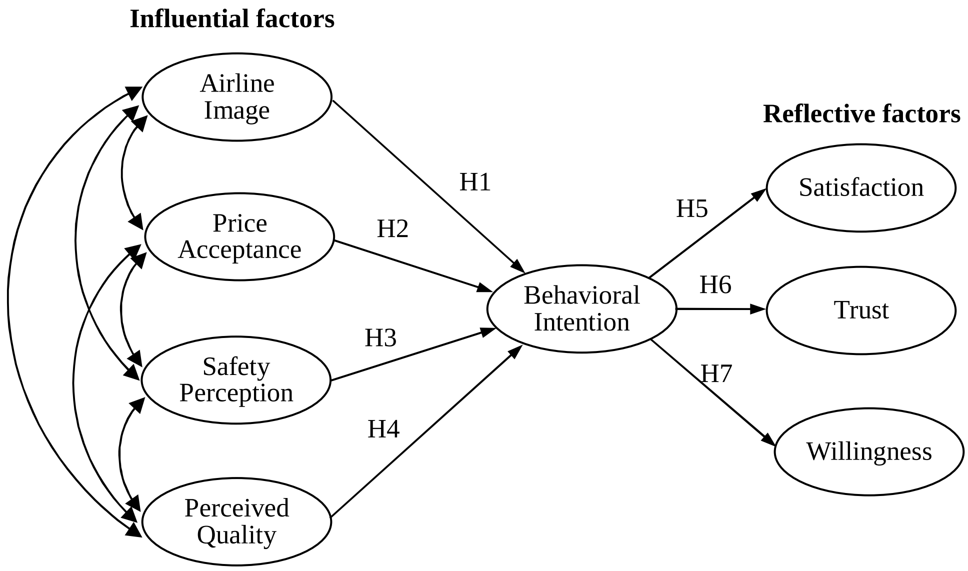


Figure 4.13 Conceptual structure for estimation of people's airline behavioral intention

Airline professional image is important to give a positive impression to the public, and most of customers want to spend reasonable costs and receive good service. Moreover, since air crash events are nearly fatal and normal people are not familiar with aviation safety mechanism compared with experts (Slovic, 1987), so safety perception may become a key element for airline choices. Accordingly, to examine the contribution of multiple factors to behavioral intention, four hypotheses are described as below.

H1. Airline image has a positive effect on behavioral intention.
H2. Price acceptance has a positive effect on behavioral intention.
H3. Safety perception has a positive effect on behavioral intention.
H4. Perceived service quality has a positive effect on behavioral intention.

These four formative factors are assumed independent, respectively contributing to behavioral intention. Meanwhile, it is also assumed as a second order factor, which is reflected by three latent variables such as satisfaction, trust, and willingness. After using the airline service, high satisfaction, trust, and willingness indicate their strong indeliberate motivation to reuse. Because these three factors are highly correlated, a second order factor analysis technique can be used to express the correlations among the first order factors to examine predictions (Bishop and Hertenstein, 2004; Mustapha and Bolaji, 2015). As a result, three hypotheses are listed as follows to reflect behavioral intention.

H5. Behavioral intention is positively reflected by satisfaction.
H6. Behavioral intention is positively reflected by trust.
H7. Behavioral intention is positively reflected by use willingness.

Liao (2014) indicated that airlines particularly do not want to induce any fears or unpleasant feelings onto their passengers. If an accident had just happened, due to the media exaggeration, customers may pay more attention to safety issues, even though they lack correct safety knowledge, they still tend to believe hearsay or their perception (Li et al., 2015b). Therefore, this phenomenon motivates us to build a behavioral intention model for customers to compare the differences under diverse accident situations to discover and to verify the influences before and after accidents.

Safety perception is regarded as one attribute of influential factors. Here, the situation was specified as the case wherein, after an aircraft accident happens, customers may change their perception toward airline companies, especially the increased concern of the people regarding safety which is closely related to their airline choice performances. Respective to the second accident, respondents were separated into two groups who joined the survey before and after the GE235 Accident to analyze whether the more recent accident had an effect on our results or not. The hypothesis to express aviation accident influences to their behavioral intention is described here.

H8. A recent aviation accident has an effect on the attributes of users' behavioral intention.

Table 4.23 Summary of SEM hypotheses

H1, H2, H3, H4	Airline image, price acceptance, safety perception, perceived service quality has a positive effect on behavioral intention.
H5, H6, H7	Behavioral intention is positively reflected by satisfaction, trust, and use willingness.
H8	A recent aviation accident has an effect on the attributes of people's behavioral intention.

Hypotheses for SEM is summarized in Table 4.23. To quantify influential and reflective factors to express people's behavioral intention, the mean and the standard deviation (S.D.) of twenty variables toward their frequently used or favored airline with Likert 5-point scale (1: strongly disagree, 2: disagree, 3: neither agree nor disagree, 4: agree, 5: strongly agree) are shown in Table 4.24. These variables were carefully designed according to previous literature and social situation in Taiwan to test the hypotheses. The range of surveyed results is from 3.12 to 3.82, where airfare and perceived quality variables are averagely low compared with the others.

Table 4.24 Variables for SEM estimation

Variable	Description	Mean	S.D.
image1	Commercial advertisement of the airline has a positive effect.	3.35	0.75
image2	The airline makes efforts to provide good air transport service.	3.76	0.67
image3	The image of the airline is professional and reliable.	3.82	0.70
price1	Airfare of the airline is reasonable.	3.39	0.71
price2	Airfare policy of the airline is flexible and with many discount campaigns.	3.12	0.69
price3	My rating of fare acceptance to this airline is high.	3.35	0.75
safety1	The airline implements safety management well.	3.72	0.65
safety2	Safety record of the airline is better than other airlines.	3.80	0.80
safety3	Pilots of the airline are well-trained.	3.56	0.65
safety4	The airline's measures to prevent accidents are good.	3.46	0.69
quality1	Service frequency and schedule of the airline are diverse and meeting my demands.	3.59	0.69
quality2	The airline's booking channel and cooperation with travel agency are good.	3.53	0.65
quality3	The airline inflight/ground service reaches my expectation.	3.57	0.65
quality4	The airline has a good on-time and low cancelation rate.	3.58	0.70
satisfaction1	My satisfaction with the airline increased after I used it.	3.65	0.61
satisfaction2	I have more positive impression and attitude toward the airline.	3.69	0.64
trust1	The airline is a reliable company.	3.72	0.63
trust2	The airline is responsible for providing a safe and sound trip.	3.72	0.63
willingness1	I will recommend the airline to other people.	3.57	0.71
willingness2	I will use the airline next time if possible.	3.78	0.66

4.6.2 Results of Structural Equation Model

- Factor analysis

Twenty variables were used for exploratory factor analysis (EFA) to express latent variables as shown in Table 4.25. Using maximum likelihood and promax (kappa=4) method, five EFA factors can explain 55.897% of the total variance. The χ^2 is 295.175 with 100 degrees of freedom, *p*-value is lower than 1%, so EFA reveals high goodness of fit. The second order factor, behavioral intention, which is reflected by willingness, satisfaction, and trust, shows good separation from other variables. Cronbach's Alpha (Leontitsis and Pagge, 2007) should be close to 1 to indicate data reliability. The research target is domestic routes in Taiwan, and airfare is not much different for these airlines, so it can be concluded that price is not the main consideration for airline choices. Most of factor loadings are over 0.5 except airfare acceptance factor, because airfare is affordable, and there are no other transport mode alternatives for passengers to choose from when using domestic routes in Taiwan.

Table 4.25 Results of exploratory factor analysis

	Factor				
	1	2	3	4	5
willingness1	0.757				
willingness2	0.840				
satisfaction1	0.750				
satisfaction2	0.813				
trust1	0.795				
trust2	0.797				
safety1		0.465			
safety2		0.532			
safety3		0.774			
safety4		0.958			
image1			0.606		
image2			0.718		
image3			0.848		
quality1				0.502	
quality2				0.438	
quality3				0.705	
quality4				0.709	
price1					0.471
price2					0.450
price3					0.351
Cronbach’s Alpha	0.916	0.843	0.779	0.757	0.501

- Analysis of SEM results

A structural equation model with twenty variables and eight factors using IBM SPSS AMOS 22 is illustrated in Figure 4.14. Twenty variables were used to express seven latent variables, and a second order factor was associated with three first order factors. The structure obtains both formative and reflective approaches, suggesting the second order factor is reflected by three first order factors, and is also contributed to by the other four factors, which is corresponding with EFA results in the previous section. The χ^2 of this model is 335.921 with 152 degrees of freedom. Goodness-of-fit index (GFI) and adjusted goodness-of-fit index (AGFI) are 0.903, 0.866, which are greater than their respective thresholds 0.9 and 0.8, and indicate the model specification is acceptable.

The root mean square error of approximation (RMSEA) is 0.063, which is lower than 0.08 as close fit. Normed fit index (NFI), Tucker-Lewis index (TLI), and the comparative fit index (CFI) are 0.903, 0.926 and 0.941, showing a good model fit as well (Hooper et al., 2008). The number on each path arrow indicates the standardized effects, where numbers in italic are fixed to one. The number attached to double arrow path is the coefficient of correlation between two factors. The bold number next to variables and factors is the R^2 value for each dependent or mediating variable, and the range in this model is from 0.11 to 0.96.

As for hypotheses **H1** to **H4**, airline image and safety perception were found to have effects on behavioral intention at 5% significant level, and criteria of safety perception is much higher. This suggests that air passengers still mainly consider safety. If the safety management of the airline is good, then professional image may increase as well. On the other hand, perceived quality has 10% *p*-value and airfare acceptance does not significantly contribute to airline selection criteria. The reason to infer this outcome is due to short flight distance and insignificant price differences among airlines. The scope of this study is domestic routes, where there is no business class and the longest flying time is from 50 to 70 minutes, so price and service quality do not dominate customers' criteria of selection as much. Moreover, a second order factor, behavioral intention, can be greatly reflected by satisfaction, trust, and willingness and according to our results showing 0.1% significance, proving **H5** to **H7**, the perception and attitude can reflect people's intention.

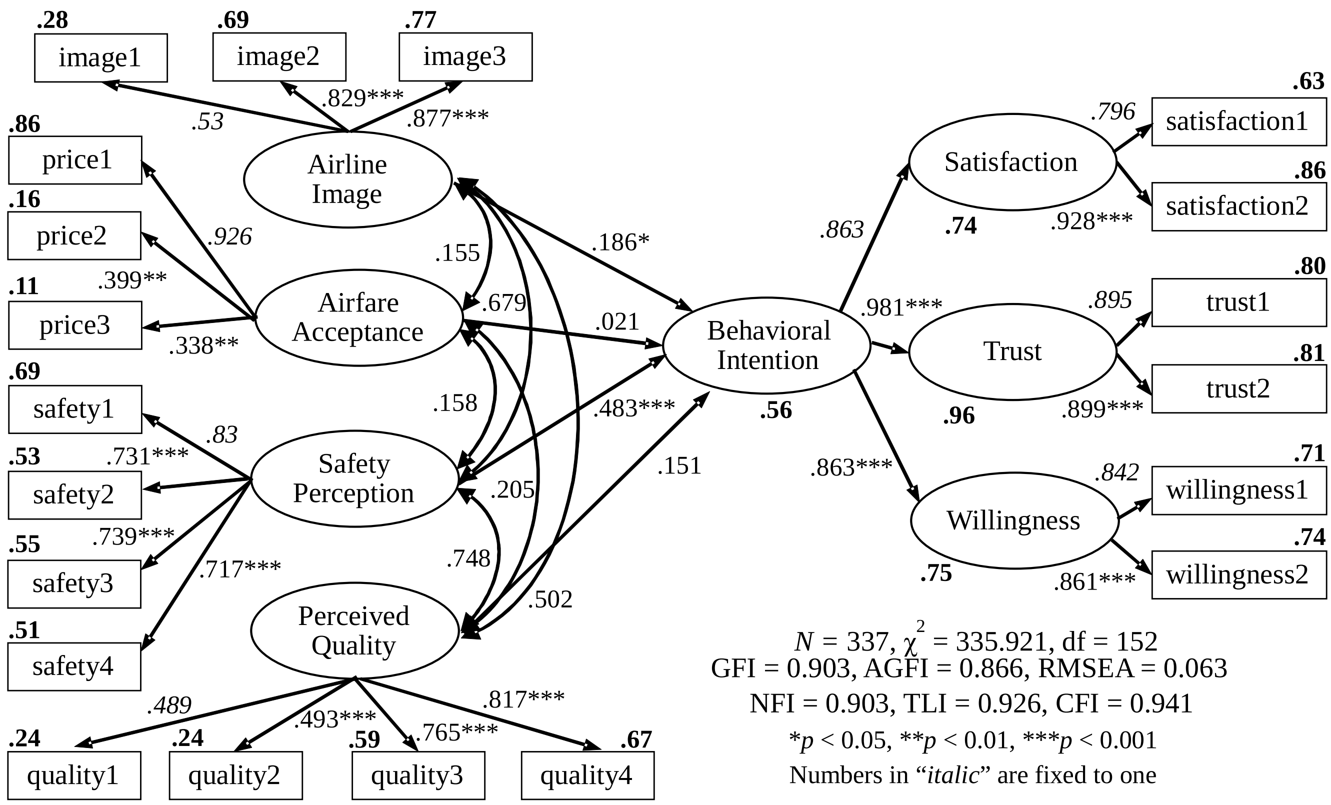


Figure 4.14 Results of proposed users' behavioral intention SEM.

- Multi-group comparison

The model in Figure 4.14 was run by whole data without division of Group 1 and Group 2. In order to compare the influences of the recent accident, samples were separated to illustrate standardized results respectively and to show the comparison in Table 4.26.

Observing the differences between Groups 1 and 2, the coefficients of the four attributes to the factor of perceived quality are smaller, and the coefficients of satisfaction, trust, and willingness variables to their respective factors are greater for Group 2. Four attributes of safety perception remains dominant for both Group 1 and Group 2 due to two recent accidents, which aroused their attention to safety issues. Airline image is getting stronger, while price acceptance and perceived quality are getting less sensitive. Therefore, it can be inferred that a repeated accident changes public perception and induces people to rely on mental relief instead of material needs, because safety perception and airline image create more solid effects than airfare acceptance and perceived quality.

Moreover, the contribution of seven factors to behavioral intention also shows discrepancy. Factors of airfare and perceived quality do not make a significant contribution, denoting price discounts and quality enhancement to retrieve passengers may not be useful. Airline image is only insignificant for Group 1, which means a recent and repeated accident has stronger influences than an accident that has occurred half a year ago, making users to value airline impression and to select a more reliable company. Lastly, safety perception to behavioral intention is higher for Group 1 but turns to be lower in Group 2, suggesting that people may be alert to safety issues and increase their concerns, but if there are repeated accidents, they may lose beliefs in airline safety management toward the whole aviation market, and their safety perception show to be less dominant for behavioral intention.

The findings also explain that people considered the first accident as an unexpected event and assumed all airlines have implemented safety measures to prevent risk, so they based on safety perception to select airlines after the first accident. However, a repeated accident happened in half a year, arousing a strong mistrust in safety management system and inducing people to evaluate on airline image. Also, the samples of the survey are composed of many young people, who have less air experience, so this time TransAsia Airways accidents hindered their preference and shifted them to other airlines, implying that airline impression dominates their behavioral intention as well. This phenomenon indicates that people lack comprehensive understanding toward aviation safety, so their selection criteria mainly base on individual safety perception. One accident is probably acceptable for unexpected mistake, but airlines with repeated accidents are not considered at all.

Table 4.26 Summary of SEM results

		Variable-to-Factor Factor-to-Factor Mutual Interaction	All		Sample Separation			
					Group 1		**Group 2**	
			β	*p*-value	β	*p*-value	β	*p*-value
image1	↔	Airline_Image	*0.530*		*0.513*		*0.543*	
image2	↔	Airline_Image	0.829	***	0.852	***	0.823	***
image3	↔	Airline_Image	0.877	***	0.804	***	0.938	***
price1	↔	Airfare_Acceptance	*0.926*		*0.945*		*0.766*	
price2	↔	Airfare_Acceptance	0.399	**	0.499	***	0.311	0.067
price3	↔	Airfare_Acceptance	0.338	**	0.330	**	0.412	0.059
safety1	↔	Safety_Perception	*0.830*		*0.783*		*0.869*	
safety2	↔	Safety_Perception	0.731	***	0.790	***	0.700	***
safety3	↔	Safety_Perception	0.739	***	0.774	***	0.701	***
safety4	↔	Safety_Perception	0.717	***	0.704	***	0.719	***
quality1	↔	Perceived_Quality	*0.489*		*0.558*		*0.407*	
quality2	↔	Perceived_Quality	0.493	***	0.622	***	0.358	***
quality3	↔	Perceived_Quality	0.765	***	0.810	***	0.732	***
quality4	↔	Perceived_Quality	0.817	***	0.818	***	0.803	***
satisfaction1	↔	Satisfaction	*0.796*		*0.767*		*0.818*	
satisfaction2	↔	Satisfaction	0.928	***	0.892	***	0.963	***
trust1	↔	Trust	0.895		0.844		0.938	
trust2	↔	Trust	0.899	***	0.889	***	0.908	***
willingness1	↔	Willingness	*0.842*		*0.802*		*0.867*	
willingness2	↔	Willingness	0.861	***	0.799	***	0.920	***
Behavioral_Intention	↔	Airline_Image	0.186	*	-0.012	0.938	0.179	*
Behavioral_Intention	↔	Airfare_Acceptance	0.021	0.663	0.070	0.317	-0.018	0.827
Behavioral_Intention	↔	Safety_Perception	0.483	***	0.751	***	0.366	*
Behavioral_Intention	↔	Perceived_Quality	0.151	0.102	0.073	0.509	0.250	0.132
Satisfaction	↔	Behavioral_Intention	*0.863*		*0.825*		*0.886*	
Trust	↔	Behavioral_Intention	0.981	***	0.992	***	0.977	***
Willingness	↔	Behavioral_Intention	0.863	***	0.948	***	0.798	***
		N	337		172		165	
		χ^2	335.921		581.815		581.815	
		df	152		304		304	

*Numbers in "italic" are fixed to one. *p<0.05, **p<0.01, ***p<0.001.*

A multi-group comparison analysis was conducted to test whether there is a significant difference between Groups 1 and 2. For unconstrained overall model, χ^2 is 581.815 with 304 degrees of freedom, and the number of groups is two. The χ^2 thresholds of multi-group differences at 90%, 95% and 99% confidence levels are 584.52, 585.66, and 588.45, respectively. After comparing whether Group 1 and Group 2 have differences with their perception in Table 4.27, illustrating that the safety perception as a criteria of selecting airlines is changed at 87% confidence level due to the GE235 Accident. In other words, the recent accident has a stronger influence on public perception than the GE222 Accident, and dominates their safety perception and behavioral intention toward airlines as to prove **H8**. Other factors show differences at 49% to 76% confidence levels between the two groups.

Table 4.27 Results of multi-group comparison analysis

Factor-Factor			χ^2	Confidence Level of Multi-Group Difference
Airline_Image	↔	Behavioral_Intention	583.027	72%
Airfare_ Acceptance	↔	Behavioral_Intention	582.264	49%
Safety_Perception	↔	Behavioral_Intention	584.197	87%
Percived_Quality	↔	Behavioral_Intention	583.215	76%
Satisfaction	↔	Behavioral_Intention	583.027	72%
Trust	↔	Behavioral_Intention	583.026	72%
Willingness	↔	Behavioral_Intention	582.631	63%

4.6.3 Discussions of Structural Equation Model

This section focuses on the change of airline choice criteria, and to explore the influences of accidents on public perception. Structural equation model is built to see how influential and reflective factors contribute to behavioral intention considering domestic flights in Taiwan, and to compare the influences of accidents on the model. The criteria for selecting an airline is also composed of multiple attributes. Taiwan was selected as the case study target due to two recent air crash events. Performing this research and making a model to describe this specific condition are important and timely. This is an innovative research discussing influences of aviation accidents on public perception, and explaining users' behavioral intention to express perception change after repeated accidents.

A 3-week online survey was conducted half a year after the GE222 Accident and covering the GE235 Accident in Taiwan, and the SEM results showed reasonable and good model fit. Influential factors were measured with formative approach, while reflective factors were expressed by three first order factors. Airline image and safety perception contribute to behavioral intention largely; but because of short flight distance and almost invariable airfare for domestic routes, price and perceived service quality do not show significant effects. Moreover, behavioral intention, as a second order factor, can be greatly reflected by satisfaction, trust and willingness, which helps estimate passenger choice behaviors to know dynamic market performances. Multi-group analysis indicated the recent accident altered people's criteria for selecting an airline, especially their safety perception which reveals differences at 87% confidence level.

Comparing the differences of customer perception caused by repeated accidents is novel in the aviation research field to the extent of our knowledge. The contribution is to use a second order factor analysis technique for building a behavioral intention model, and to compare the differences before and after a real accident. The findings reveal that customers considered the first accident as an unexpected event and assumed all airlines have implemented safety measures, so they selected an airline mainly according to safety perception after the GE222 Accident. However, people lost their confidence toward aviation safety and tended to value impression for airline choices after the GE235 Accident. Because most of the surveyed respondents are young people, who have few air experience, their favored airline may change to other airlines to replace TransAsia Airways. This phenomenon indicates that people lack aviation safety awareness (Slovic, 1987). According to an interview with TransAsia Airways on April 18, 2016, airline representatives clarified that safety measures had been conducted after the GE222 Accident, but people still based on individual safety perception to select an airline due to few news coverage of safety improvements, suggesting the necessity of a safety information sharing system between airlines and people.

Moreover, this research also brings up a problem that the level of safety may be affected by public perception change. If there are few rival airlines and limited flight alternatives, particularly for the domestic aviation market, customers have less airline choices but use it. Some who are not sensitive to safety issues are still willing to use it regardless of accident records. As long as the involved airline could maintain financial balance to pass impact duration of an accident, the airline may not spend extra expense for safety improvements after accidents if customers return after a period due to abating of worries or flight schedule limitation, resulting in safety problems. Aviation safety is a concept of risk, which is a combination of possibility and consequence. If airline companies can implement safety management thoroughly and continuously, the risk of accident occurrence would be lower, ensuring long-term safety for future air transport. Nevertheless, for small-scale or new airlines which have inadequate budget and cannot obtain the financial support from the government, a loss of passengers may lead to bankruptcy. Consequently, it is not socially beneficial for long-term aviation development.

It is meaningful for safety management system to avoid this problem and to improve overall safety standards. Therefore, the government and international organizations should legislate to ensure sustainable development of air transport, examine and monitor airline operations and management to lower risk of accidents. The change of people's perception is also an important driver for airlines to improve safety. People have to realize that their abating of worries, unawareness of aviation safety or continual usage may discourage airlines to enhance the level of safety, so they have to carefully make airline choices to avoid this problem.

4.7 Summary

This chapter conducted a questionnaire survey and selected TransAsia Airways GE222 and GE235 Accidents as case studies. Surveyed respondents were separated into two groups to make a hypothesis that the more recent accident had stronger effects on our results. We tested the results and showed significance. Besides, to explore people's cognitions, formation of safety perception was run by regression analysis to find dominant factors. To quantify people's safety concerns, worry duration was defined to specify the degree with time scale. Hazard-based survival analysis and the Cox proportional hazards model were utilized to observe participants' reactions. Diagrams of worry's survival and hazard functions were also drawn to provide a perspective to understand how long people keep worried. Finally, to observe how accidents change people's behavioral intention, the proposed SEM model provided formative and reflective approaches to present with four influential and three reflective factors. Airline image and identity, airfare, safety perception and perceived service quality contribute, while satisfaction, trust, and willingness can respectively represent people's intention. Factor analysis showed good separation of factors, and multi-group comparison indicated that the GE235 Accident made people lose their beliefs in safety management.

According to above public safety perception analysis, we found accident consequences, cabin environment, and airline operation, including pilot skills and airline attitude, etc., are common points for individuals' safety concerns. However, if there are repeated accidents, or respondents who joined right after the accident, these samples are more easily influenced by the recent event, and cannot evaluate the airline at the same criteria due to their safety beliefs. There are several ways to enhance passengers' safety perception. The most basic way is to educate people about correct aviation safety knowledge, or users may only base on their prejudice to have unprovoked concerns.

Chapter 5

Motivation for Airline Safety Improvements

5.1 Introduction

5.1.1 Problem Statements

We conducted a survey to explore people's perception toward accidents in previous chapter. Here airline's reaction will be the focus. This chapter brings up a problem that the level of safety may be affected by public perception change. If there are few rival airlines and limited flight alternatives, particularly for the domestic aviation market, customers have less airline choices but use it. Some who are not sensitive to safety issues are still willing to use it regardless of accident records. As long as the involved airline could maintain financial balance to pass impact duration of an accident, the airline may not spend extra expense for safety measures after accidents if customers return after a period due to abating of worries or flight schedule limitation, resulting in safety problems.

Aviation safety is a concept of risk, which is a combination of possibility and consequence. If airline companies can implement safety management thoroughly and continuously, the risk of accident occurrence would be lower, ensuring long-term safety for future air transport. Nevertheless, for small-scale or new airlines which have inadequate budget and cannot obtain the financial support from the government, a loss of passengers may lead to bankruptcy. Consequently, it is not socially beneficial for long-term aviation development.

Wong and Yeh (2003) based on the record of Civil Aeronautics Administration and Aviation Safety Council in Taiwan, where 26 accidents took place during the 19-year period, to estimate customer loss and influential period for airlines. According to their results, averagely, an accident occurs during or just before an off-peak period, accidents are averagely associated with a 2.54 month effect and a 22.11% monthly traffic decline for the involved airline, while other airlines may also lose 5.62% of passengers monthly because of public fear of flying. For the involved airlines, if there is no/less other airline rivals and if they have already met safety standard, they may not be motivated to spend extra expense for safety improvements, because customers still have to use air transport due to choice limitation and continual usage.

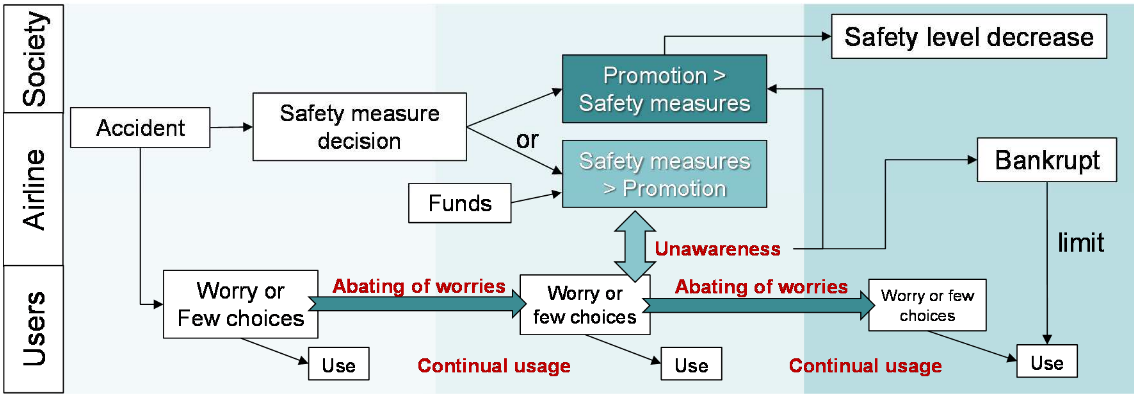


Figure 5.1 Problem process of airline's safety motivation.

Table 5.1 Airline's consideration for safety improvements.

	Decision Making	Consideration	Constraint	Hypothesized Consequence
Airline	Do more promotion than safety measures	Users' abating of worries, continual usage	capital turnover, few airline rivals	Safety level decrease
	Do more safety measures than promotion	Safety upgrade	People's unawareness (Slovic, 1987)	Bankruptcy

Figure 5.1 shows the process of airline's motivation for safety improvements, and Table 5.1 summarizes the consequences of two decisions. If the airline does not conduct safety measures after accidents, the level of safety will decrease, but if the budget of safety upgrade system cannot be reimbursed from customer recovery, it may face financial problem and then bankrupt. Hence, there is a problem for aviation safety and market performance that should be clarified.

This chapter is aimed to build a structure to demonstrate the interaction between customers and airline companies. Therefore, benefits for diverse stakeholders can be defined to find a solution to motivate airlines to upgrade safety management system after accidents for safe and sound development of aviation market, to help people better understand aviation safety knowledge, and to provide a scheme for airlines to implement safety measures.

The airline has two choices, while customers also have two choices based on uncertainty/risk to use or not to use. Because it is hard for airlines to precisely predict customers' behaviors, it may turn out to be nothing even putting a great amount cost in safety investment, making it possible to create a game to describe the tradeoff of safety and profits.

5.1.2 Application of Game Theory in Previous Studies

Game theory is widely used for decision making with different player's strategy and the utility. The players of the game are the main portion to make decisions, and they are involved to participate in a game for getting maximum benefits in a suitable action. The main elements in a game are players, information, strategy and payoff functions. Game theory provides a framework for interpreting the interaction among decision-makers for determining the outcome jointly. Game theory is to model conflict and cooperation among independent players, and is a powerful tool in understanding the relationships such as competition and cooperation.

In transport or administrative field, it was firstly used to model behavioral hypothesis for route choice, and after that diverse application has been addressed. Roumboutsos and Kapros (2008) extended game theory to the issue of integration within urban public transport networks provided by service operators. Wang and Yang (2005) used a game theoretical approach to model the strategic interactions between the operators in a deregulated bus market, taking into consideration competition over price and service frequency. Sun and Gao (2007) modeled passenger's choice of route and mode by applying game theory. Dong et al. (2010) found there are conflicts of the interest for cleaner production between a local government and a potentially polluting firm, and used game theory and add some policy variables to change the payoffs, which can improve the current policies. Talebpour et al. (2015) compared the difference for players with complete and incomplete information with an example of the Nash non-cooperative game. A full literature review of game theory applied to transport modeling has been summarized by Hollander and Prashker (2006).

5.1.3 Objectives of Game of Safety Improvements

After accidents, airlines are supposed to conduct safety measures to reduce risk. For their own safety, some of customers will select an airline according to their safety perception to reduce worries. However, people's worries will decline over time, making safety perception less dominant of airline choice criteria. Also, those who are not sensitive to safety issues or due to airline choice limitation, customers do not have other alternatives but use the airline. Therefore, the airline may not conduct costly safety measures to enhance level of safety, instead, they can give airfare discount and improve service to attract customers, because they assume passengers will return due to abating of worries over time.

This makes a tradeoff of safety and profit between the airline and customers, and can be expressed with a non-cooperative game. For sustainable and sound development of aviation industry, safety improvements are considered to be very important. Airlines are expected to improve safety after accidents. As a result, we would like to use this game to discuss to interaction between the airline and customers, and find the situation that is beneficial for both and the society.

Objectives to explore airlines' consideration and to find a solution is of importance.

- To identify gap of public safety awareness

Safety investment is necessary to improve safety management system, but how people think and perceive are different from the industry. Several reasons have been summarized as follows: (i) safety measures are not well explained and clearly demonstrated to people; (ii) many people are unwilling to use the involved airline because of their distrust toward this company and frequent accidents; (iii) people are not familiar with aviation safety, inducing their concerns and misunderstanding. Consequently, to specify this situation, information asymmetry should be described.

- To make a game to analyze the interaction between one airline and customers

If one airline does not try to implement safety measures or partially conduct, passengers may still return after a period because of abating of worries or limited choices of airlines. Customers' continual usage makes the airline not to invest money to improve safety, especially if there is no other airline competitors.

- To find the win-win for airlines and customers

We are not aimed to reduce people's worries such as provide safety education and improve cabin environment, but encourage airlines to conduct safety measures. For long-term and sustainable development of air transport, if airlines improve safety, people will start to trust the airline again, and their worries would decrease as well. This makes win-win for two stakeholders, and meanwhile level of safety can be enhanced.

- To summarize and evaluate safety measure performance

Several safety measures have be drafted by airline companies, but details and expected performances are not well propagandized to the public. Airlines may quantify the efficiency of safety measure with some methods, but how it defines and how it represents for the whole safety are also unknown. Factors of safety measure implementation include: cost, period, performance (expected results), priority, depreciable life, etc. of each measure. Therefore, to make an estimation considering diverse scenarios is necessary.

5.2 Game of Safety Improvements

Hypothesis of this game is both of the airline and customers have two strategies, making it possible to create a non-cooperative game to interpret the interaction among decision-makers for determining maximum benefit for individuals and the outcome jointly. We hope to find the win-win conditions for airlines, users, and social safety.

5.2.1 Game Formulation

A non-cooperative game theory composing 2 players with 2 strategies respectively in Table 5.2 is adopted to analyze the airline strategy and customer behaviors.

- Player A: the airline had one accident occurred (1 airlines)

In Chapter 5.1, we explained the most serious situation that if the airline does not do safety measures, safety level will decrease. Here we consider the airline will at lease do basic safety improvements, but will not invest additional expenses for extra safety measures. In order to attract passengers to use the airline again, Player A has strategies of active or passive action: (i) the airline can conduct safety measures to rebuild market confidence and to reduce accident risk; or (ii) assume passengers will return gradually, so provide airfare discount and improve service to attract customers. Airlines will also invest a huge amount of budget to do promotion to attract more customers.

- Player B: customers/potential passengers (N customers)

Customers are considering to (i) use the airline or (ii) not to use the airline. Furthermore, there are two kinds of people should be divided. People who are sensitive to safety issues are type I, while those who regard all airlines are safe and consider service as priority including price attraction, operation satisfaction, flight schedule preference, limitation of provided seats, airline choice, etc. belong to type II.

Table 5.2 Game formulation

<table>
<tr><th colspan="2">Player</th><th>Objective</th><th>Constraint</th><th>Strategy</th></tr>
<tr><td colspan="2" rowspan="2">Player A:
The airline</td><td rowspan="2">1. air transport service supply
2. maximum profits</td><td rowspan="2">1. budget
2. authority audit
3. do not know B
4. policy making timing</td><td>active action:
do more safety measures</td></tr>
<tr><td>passive action:
do more promotion</td></tr>
<tr><td colspan="2">Player B:
Customers</td><td rowspan="2">1. air transport demand
2.1 less worries
2.2 better service*</td><td rowspan="2">1. limited choices
2. know B's type, but do not know A</td><td>use the airline</td></tr>
<tr><td>[B type I]
Safety >
service</td><td>[B type II]
Service >
Safety</td><td>do not use the airline</td></tr>
</table>

5.2.2 Game Assumption

The problem is that airlines do not do safety measures, but customers are still using. Our target is to find the condition when airlines do safety measures and customers use the airline. To support the hypothesis, there are several conditions and assumptions for this game, and are summarized as follows.

- Developing country

This phenomenon may potentially happen in developing countries, where aviation safety law is not well equipped. These airlines consider safety improvement is much more expensive, even though affordable, than financial loss during impact period; also, if the government aviation authority is not strict on safety standards, as long as the airline satisfies the lowest requirement, there is no needs for them to expend expense for extra investment.

- Domestic routes

For domestic routes in one country, if airfare is not much different from airlines and also affordable, price will not be a dominant of airline choices. Besides, in most of cases, few airlines are operating in the same route, so for customers there are also few airline alternatives for them to select.

- Timing

TransAsia Airways faced a serious loss of passengers after two accidents. If the airline found there is no sign that passengers will return, they may change their strategies to conduct safety measures. Timing of implementation is an important factor for airline decision making, because customer confidence may still remain low even the airline has already made efforts, inducing a long-term challenge.

- Market performance

Airlines are also evaluating market conditions such as market share, airline rivals, flight frequency, if there are no other airlines operating the same route or targeting different customer groups, they may decrease motivation for safety improvement. At this situation, customers have no/less choices but still have to use them.

- Customers

What customers perceive is different for individuals. From our worry duration research, 25% of respondents are not worried about safety at all, and almost 80% of respondents can relieve their worries after two years. Moreover, some people are willing to take the airline even they feel unsafe due to limited flight choices and lower airfare. Therefore, these factors can be included into service perception, representing price attraction, limitation of provided seats, flight schedule preference, airline choice, etc. Tradeoff of worries and service can be two strategies for customers, while worries will decline with time as well.

- Budget

Airlines have to control budget and estimate the cost performance to get maximum profits for a long-term plan. For poor airlines, it is highly possible to avoid expensive safety measures due to budget limitation, if they did not receive supports from the government.

5.2.3 Game Setting

Lay people are not familiar with aviation safety so their perception are totally different from experts in some conditions (Slovic, 1987). Customers' continual usage regardless of accident records may make airlines not to improve safety, while their unawareness of aviation safety may let one airline lead to bankruptcy, resulting in an unbalanced aviation market. Therefore, it is possible to create a multi-players game, covering two players, the airline and customers, to explore the interaction.

Customers can be regarded as one group, because they have similar characteristics, and be divided into two types, becoming a two-player game. We are aimed to let customers, regardless type I or II, can use the airline, and the airline conducts safety measures. Several game setting are described in Table 5.3.

Table 5.3 Game setting

Two-person non-zero-sum game	二人非ゼロ和ゲーム	Nash equilibrium (ナッシュ均衡) exists
A game with imperfect information	完全情報もつゲームではない	Because the airline cannot predict customers' willingness, and customers normally are not familiar with safety measures, meaning two players make decisions at the same time (同時意思決定)
A game with incomplete information	情報不完備ゲーム	Airline cannot specify what customers consider such as preference for safety perception or airline service, so a random nature to divide groups into type I and type II is necessary. Information asymmetry problem (情報非対称性) may also happen.
Repeated game	繰り返しゲーム	It can be finitely (有限回) or infinitely, but using a discount factor δ can represent people's abating of worries with time passing and increase of demand, making the game continual.
Game with perfect recall	完全記憶	Both players A and B remember their previous decisions, and then make the next one.

5.2.4 Extensive Form

Extensive form (展開形ゲーム) can make it clear to observe decision making process as Figure 5.2.

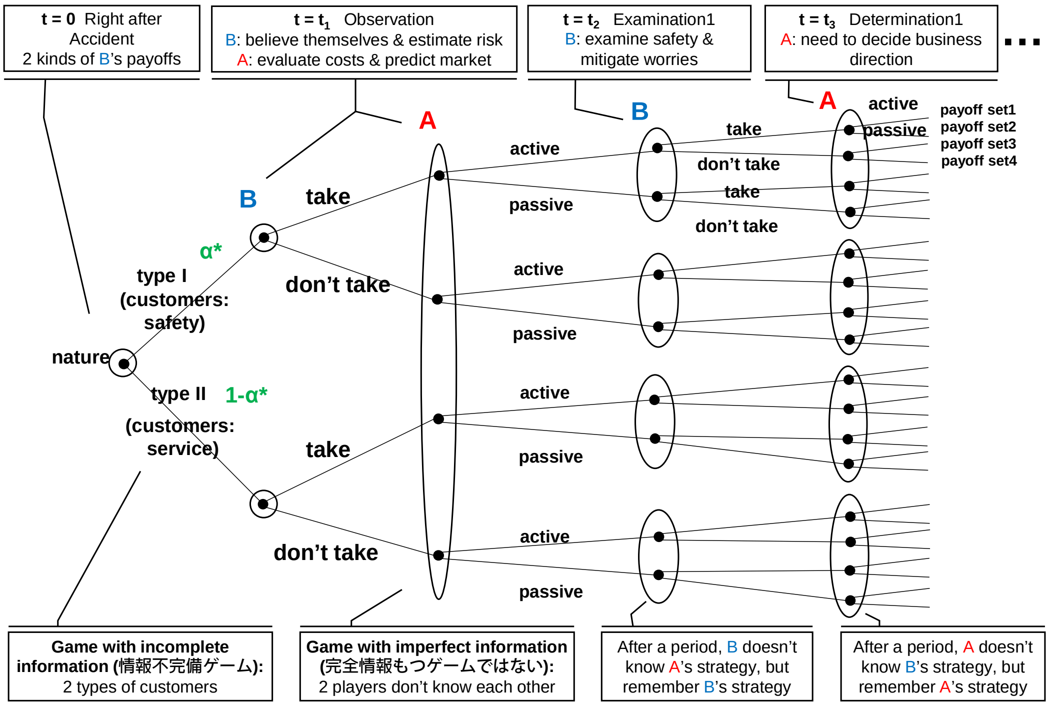


Figure 5.2 Extensive form of the game

5.2.5 Information Asymmetry

Because of information asymmetry (情報の非対称性), customers know which type they belong while the airline does not, resulting in adverse selection problem. In fact, there are two types of information asymmetry. Adverse selection (逆選択, 隠された情報) means one player knows information before game, while the other player does not know, making only high-quality goods from the market such as an example of second-hand car market (lemon market). Another is moral hazard (モラル・ハザード, 隠された行動), which indicates that a player with more information may do something bad to harm the other player and gain benefits for themselves after game such as an intended accident to get insurance compensation. Normally player with more information has more benefits, but player with more information may have less benefits two. In this study, game of safety improvements is similar to adverse selection, because airlines do not know customers' consideration before games.

- Comparison with lemon market

Akerlof (1970) firstly addressed in second-hand car market. Our game can be compared with lemon market in Table 5.4, because both examples are cases of information asymmetry. However, lemon market is one time game, but game of safety improvements can be a repeated game, and is presented as one time game here.

Table 5.4 Comparison of lemon market and game of safety improvements

<table>
<tr><th></th><th colspan="2">Player</th><th>Purpose</th><th>Information</th><th>Strategy</th></tr>
<tr><td rowspan="4">Lemon Market
(一回ゲーム)</td><td colspan="2">B: Car owner</td><td rowspan="2">Sell private car</td><td rowspan="2">Know car quality</td><td>Sell</td></tr>
<tr><td>[type I] (peach)
High-quality car</td><td>[type I] (peach)
High-quality car</td><td>Do not sell (withdraw)</td></tr>
<tr><td colspan="2" rowspan="2">A: Dealer</td><td rowspan="2">Buy second car</td><td rowspan="2">Do not know car quality</td><td>Buy with high price</td></tr>
<tr><td>Buy with low price</td></tr>
<tr><td rowspan="4">Game of Safety Improvements
(一回ゲームで示す繰り返しゲーム)</td><td colspan="2">B: Customers</td><td rowspan="2">Use air transport service (sell their usage 使用を売る)</td><td rowspan="2">Know customer type</td><td>Use the airline</td></tr>
<tr><td>[type I]
Safety perception
(high safety perception)</td><td>[type II]
Service quality
(less safety perception)</td><td>Do not use the airline</td></tr>
<tr><td colspan="2" rowspan="2">A: Airline</td><td rowspan="2">Provide air transport service (buy customer usage 使用を買う)</td><td rowspan="2">Do not know customer type</td><td>Active: improve safety (higher cost)</td></tr>
<tr><td>Passive: do not improve safety (airfare discount) (lower cost)</td></tr>
</table>

- Consequences of information asymmetry

In lemon market, car owners want to sell their cars to dealers, while the dealers do not know the quality of cars, so they are only willing to pay a fixed price (p_{avg}) to buy the car, which could be lemon (low-quality car) or peach (high-quality car). Car owners know the quality, and they will sell the car when they hold lemon ($p_{lemon} < p_{avg}$) or withdraw the deal when their car is peach ($p_{peach} > p_{avg}$). Adverse selection problem happens because of market mechanism and information asymmetry, making high-quality cars from the market. In the same way, the airline pays a fixed price (p_{avg}) to buy the customer's usage (type I or type II). Customers sell the usage when they are type II (service quality improved and airfare discount) or withdraw the deal when they are type I (they are only willing to use when the airline takes safety measures), making type I customers from the market. Consequently, airlines may not improve safety, and only type II customers are possible to use the airline, unless type I customers surrender to low safety perception airline. So, if airlines know customers' consideration, then we can estimate the consequences by comparing with lemon market example. To sum up, information asymmetry keeps lemons remain in the market, and only type II customers will be served in the aviation market.

- Countermeasures for information asymmetry: information sharing

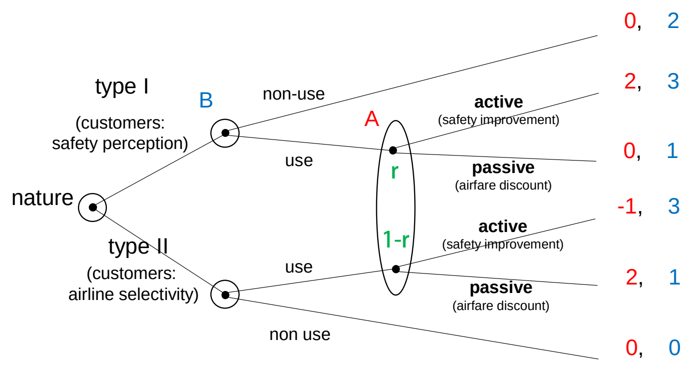
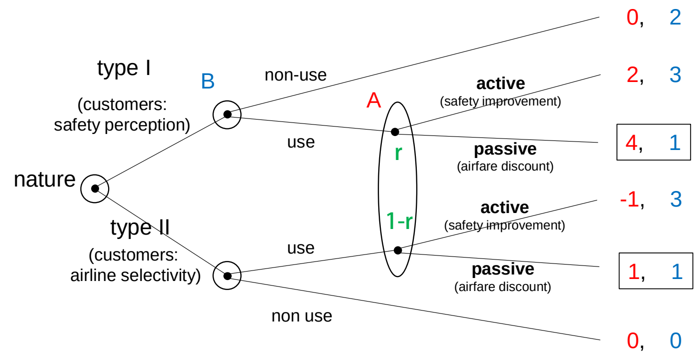
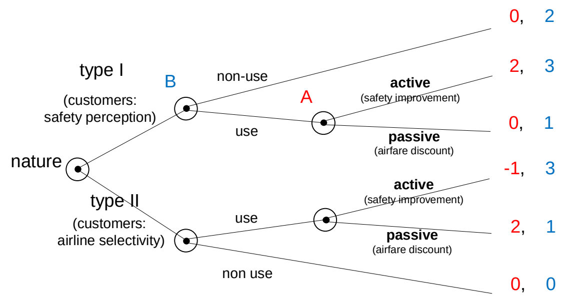
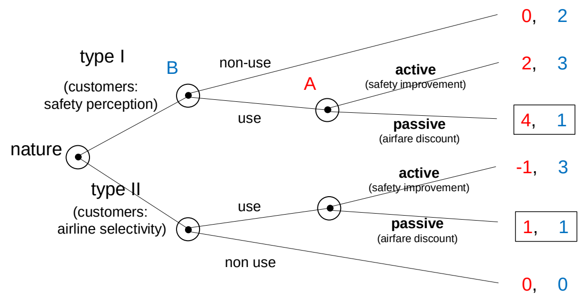
Both players do not know each other's strategy, making it hard for decision making. Each player only considers personal maximum benefits, turning it to be a non-cooperative game and resulting in Prisoner's Dilemma. We consider communication is necessary, so to create an information sharing system can avoid adverse selection and satisfy Pareto Optimality.

For lemon market, both players know car quality. If car owners do not want to sell peach with lower price, then both lemon and peach will remain in the market. But if car owners are willing to sell peach with lower price to get money, making peach from the market. Therefore, even both players have information, consequences may be different due to player B's consideration and limitation.

In the same way, if customers do not want to use the airline if there is no safety improvement, then both type I and type II customers will exist in the market. However, if customers cannot help but use the airline without safety improvements, it will make only type II customers remain in the market. Therefore, if customers have no other airline choices or they surrender to low safety-perceived airline, then airlines will not implement safety improvements as well because there will be no type I customers in the market.

To prevent this problem, because most of time player B owns more information, while player has less, two measures, signaling and screening, are suggested. Signaling means that player B provides information to player A, so customers can express their consideration thought the media. As for screening, player A can propose some methods to get information from player B, such that airlines conduct a survey to understand what customers are thinking. As a result, it is possible to make customers to one player to avoid adverse selection and to keep type I customers in the market. Comparison of information asymmetry and information sharing is shown in Table 5.5 to demonstrate the consequences.

Table 5.5 Comparison of information asymmetry and information sharing

	Normal case	Payoff changed case
Information asymmetry		
	A: passive; B (type I): non-use; B (type II): use → only Type II customers remain	A: passive; B (type I): non-use; B (type II): use → only Type II customers remain
Information sharing		
	A: active (if Type I) and passive (if Type II); B (type I): use; B (type II): use → Both Type I and Type II customers remain	A: passive (if Type I) and passive (if Type II); B (type I): non-use; B (type II): use → only Type II customers remain

5.3 Payoff Analysis

Payoff is a criteria for players to decide which strategy is more beneficial. In this section, payoff for two players is quantified via data collection and a case study, and the model will be illustrated with an extensive form. We use monetary unit to quantify airline's payoff and demand quantity to quantify customers' payoff. Diverse factors are included in Table 5.6 to express both players' considerations. Individual payoff analysis and results will be explained in following section.

We would like to use mathematic approach to model the interaction between airline and customers, and to examine the profitability for them. Players include the airline and customers (type I: safety-oriented, type II: service-oriented). The airline have active action (safety improvements) or passive action (service improvements: discount, promotion), while customers can select to use or not to use the airline.

Table 5.6 Factors of payoff for players

	+ positive		- minus	
	Quantitative	Qualitative	Quantitative	Qualitative
Airline	airfare revenue, tradeoff benefit	(airline image, customer loyalty)	fixed cost, variable cost, tradeoff cost: safety measures cost and promotion cost	
Customers	Demand function			
		Satisfaction, trust, safety perception, perceived quality, airline image impression	Airfare	

5.3.1 Customer Payoff

Two kinds of customers are considered here. Type I customers are safety-oriented, while type II customers are service-oriented. Here service covers price attraction, limitation of provided seats, flight schedule preference, limited airline choice, etc. Customers mainly consider trip satisfaction and trip itinerary, so we can conduct a questionnaire survey to get demand functions in different periods. Therefore, the demands can show how many users will use as to represent customers' payoff.

5.3.2 Airline Payoff

Airline companies (player A) most consider revenues and brand reputation as their most priority and symbol of business success. Because airline image and customer loyalty are infeasible to be quantified, here we only include quantitative variables. Besides, we separate airline's payoff in normal case and after accident case.

- Airline payoff variable in normal case

Profit and demand function variables for the airline are summarized in Table 5.7. Profit (**B**) is composed of revenue (**R**) and other costs, such as fixed cost (C_f) and variable cost (C_v*Q). Fixed cost will not change per flight which include maintenance, crew, airport facilities usage, landing fee, and depreciation, while variable cost bases on passenger number and varies. Revenue is multiplication of airfare (**P**) and passenger number (**Q**). The airline also as maximum supply of seats and fleets, indicating supply quantity (**S**), and total demand quantity cannot exceed airline supply ($Q \leqq S$). Therefore, profit (**B**) for the airline in normal case is $R - C_v*Q - C_f$, where **R** is made by **P***Q.

On the other hand, passengers' demand will change according to airfare. More customers will use it if price is getting cheaper. Besides, because worries toward accidents will decay over time (**T**), their willingness to use will increase as well. At this situation, we suppose that demand function may change over time (D_T) due to abating of worries, so demand for the same airfare will be getting higher. It suggests that passenger number (**Q**) is according to demand function ($Q=D_T(P)$), and the revenue ($R=P*Q=P*D_T(P)$) is also associated with it.

Table 5.7 Profit and demand function variables for the airline

Variable	Unit	Description	
D_T		Demand function	
T	Period	Time series	
R	Money	Revenue	$R=P*Q$
P	Money	Airfare	
Q	Person	Demand quantity	$Q=D_T(P)$
S	Person	Supply quantity	
C_v	Money	Variable cost per person	
C_f	Money	Fixed cost	
B	Money	Profit	$R - C_v*Q - C_f$

- Airline payoff variable after accident case

Here we consider a situation that if an accident occurs, variables for extra investment are summarized in Table 5.8. Given that the airline has one extra tradeoff budget (**C_e**) for active or passive actions, and can use it for safety measures (**C_s**) or promotion (**C_p**). The tradeoff budget can be proportional to airline profit, but if the accident scale is small, it can be regarded as one fixed amount, so we suppose the airline can use this budget for two purposes (**C_e** = **C_s** + **C_p** = constant). The coefficient (**$\alpha = C_s / C_e$**) is the decision making results for portion of safety measures budget.

Table 5.8 Tradeoff variables for the airline

Variable	Unit	Description	
C_e	Money	Extra tradeoff budget	
α		Coefficient of safety portion	
C_p	Money	Promotion budget	**$(1-\alpha)\ C_e$**
C_s	Money	Safety budget	**αC_e**
β	Money/person	Coefficient of promotion effect	
B_p	Money	Extra promotion profit	**$(C_p/\beta)*P - (C_p/\beta)*C_v$**
γ		Coefficient of safety effect	
B_s	Money	Extra safety measure profit	**$(\gamma-1)*Q*P - (\gamma'-1)*Q*C_v$**
Q'	Person	Total demand quantity	**$Q + C_p/\beta + (\gamma'-1)*Q$**
Payoff	Money	Payoff	**$B - C_e + B_p + B_s$**
Safety	Money/person	Extra the level of safety	**C_s/Q'**

Because customers will be attracted to use the airline after promotion, **β** is used to represent for promotion effect. The unit of **β** is money/person, suggesting the amount of money that the airline has to invest to increase one more passenger. As a result, extra promotion profit (**B_p**) is increased revenue but deduct variable costs (**$(C_p/\beta)*P - (C_p/\beta)*C_v$**). On the other hand, the airline may invest safety budget, and total customers (**Q**) may be more willing to use it due to awareness of safety measures, making them feel safe. Hence, **γ** denotes the increase of users, where the minimum is 1, and extra safety measure profit (**B_s**) is also increased passengers and deduct variable costs (**$(\gamma-1)*Q*P - (\gamma'-1)*Q*C_v$**). Accordingly, total passenger number (**Q'**) will change and have to consider tradeoff effects (**$Q + C_p/\beta + (\gamma'-1)*Q$**). Finally, we can get payoff after using tradeoff budget and include promotion and safety effects (**$B - C_e + B_p + B_s$**). To assess the level of safety after conducting safety measures, **C_s/Q'** expresses the additional safety amount for one passenger comparing to normal case without accident records.

5.3.3 Case Study of Payoff Analysis

A case study is using assumed data to analyze the payoff performances, and to see the interaction between the airline and customers.

- Demand function

Abating of worries and distribution of type I and type II have been already expressed in demand functions, which are supposed to be linear and will change over time. In reality, there are other airline competitors, making the demand function more complicated. However, to simplify the complexity, demand functions we use is the results after airline competition. Demand quantity bases on function of airfare in Table 5.9 and cannot exceed maximum supply quantity. $\mathbf{T_0}$ is the situation that there is no accident, and from $\mathbf{T_1}$ the airline is considering to use the tradeoff budget. Because the market will become steady gradually, we suppose $\mathbf{T_5}$ is equal to $\mathbf{T_0}$ as normal situation.

Table 5.9 Demand functions for T_0 to T_5

$\mathbf{D_T}$	Demand function
$\mathbf{D_{T0}}$	Q= -100P + 600
$\mathbf{D_{T1}}$	Q= -80P + 320
$\mathbf{D_{T2}}$	Q= -84.44P + 380
$\mathbf{D_{T3}}$	Q= -90P + 450
$\mathbf{D_{T4}}$	Q= -94.55P + 520
$\mathbf{D_{T5}}$	Q= -100P + 600

- Fixed cost and variable cost

To estimate fixed cost and variable cost, several coefficients are listed in Table 5.10. In most of cases, load factor should be 70% for airlines to make profits in normal situation ($\mathbf{T_0}$), so we use 0.7 for cost over revenue. Among the total costs, fixed costs account for 60%, while variable costs account for 40%. Average airfare is $2000. Therefore, we can get **Q** = 400,000 persons, **R** = $800,000,000, $\mathbf{C_f}$ is $336,000,000, and $\mathbf{C_v}$ is $560 per customer.

Table 5.10 Variables for cost estimation

Item	Number
Cost/Revenue	0.7
Fixed cost/Cost	0.6
Variable cost/Cost	0.4
Average airfare	$2000

- Payoff estimation

This non-cooperative game comprises two players with two strategies respectively. If an accidents happens, the airline can decide to conduct safety measures (active action) or to promote service (passive action), and customers can use or not use the airline.

Suppose Scenario 1 that the airline operating total domestic routes and can provide total 600,000 seats as supply quantity per period. Users have other airline alternatives but few. Average airfare for one round trip is $2,000, but an accident occurred to this airline, and they are considering whether to implement safety measures or increase level of service.

Payoff results comparison of $\mathbf{T_0}$ to $\mathbf{T_5}$ (Scenario 1) is demonstrated in Table 5.11. There is no tradeoff budget for $\mathbf{T_0}$, but after one accident, $400,000,000 ($\mathbf{C_e}$) will be used for accident arrangements. If the airline takes active action to conduct safety measures ($\boldsymbol{\alpha_a}$=1), but because the public are not awareness of aviation safety measures, there is no extra safety measure profit ($\boldsymbol{\gamma'}$=1). Considering passive action, in most of cases, the minimum amount for safety measures is necessary ($\boldsymbol{\alpha_p}$=0.1), and promotion effect is 2000 ($\boldsymbol{\beta}$).

Table 5.11 Payoff results comparison from T_0 to T_5 (Scenario 1)

Variable	Unit	T_0		T_1		T_2		T_3		T_4		T_5	
		active	passive	active	passive	active	passive	active	passive	active	passive	active	passive
P	10^3 $	2	2	2	2	2	2	2	2	2	2	2	2
Q	10^3 person	400	400	160	160	211	211	270	270	331	331	400	400
S	10^3 person	600	600	600	600	600	600	600	600	600	600	600	600
R	10^3 $	800000	800000	320000	320000	422222	422222	540000	540000	661818	661818	800000	800000
C_v*Q	10^3 $	224000	224000	89600	89600	118222	118222	151200	151200	185309	185309	224000	224000
C_f	10^3 $	336000	336000	336000	336000	336000	336000	336000	336000	336000	336000	336000	336000
LF		67%	67%	27%	27%	35%	35%	45%	45%	55%	55%	67%	67%
B	10^3 $	240000	240000	-105600	-105600	-32000	-32000	52800	52800	140509	140509	240000	240000
C_e	10^3 $	0	0	400000	400000	400000	400000	400000	400000	400000	400000	400000	400000
α		0.0	0.0	1.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1	1.0	0.1
C_p	10^3 $	0	0	0	360000	0	360000	0	360000	0	360000	0	360000
C_s	10^3 $	0	0	400000	40000	400000	40000	400000	40000	400000	40000	400000	40000
β		2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
B_p	10^3 $	0	0	0	259200	0	259200	0	259200	0	259200	0	259200
γ’		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
B_s	10^3 $	0	0	0	0	0	0	0	0	0	0	0	0
Q’	10^3 person	400	400	160	340	211	391	270	450	331	511	400	580
LF		67%	67%	27%	57%	35%	65%	45%	75%	55%	85%	67%	97%
Payoff	10^6 $	240	240	-506	-246	-432	-173	-347	-88	-259	0	-160	99
Safety	10^3 $/person	0.00	0.00	2.50	0.12	1.89	0.10	1.48	0.09	1.21	0.08	1.00	0.07

- Scenario comparison

Several scenarios are listed in Table 5.12 to compare the payoff changes. In Scenario 1, as base scenario, suggesting the worst situation, people do not know about safety measures, making the airline with active action in deficit in $\mathbf{T_5}$ in Figure 5.3. If safety information sharing is well conducted, people will be more willing to use it in Scenario 2, at least in $\mathbf{T_5}$, the active action can make profits in Figure 5.4. However, both in Scenario 1 and Scenario 2, passive action earns more profits than active action, and this could motivate the airline not to conduct safety measures. Although the level of safety may decrease, as long as there is no other accidents in the future, some airline companies may select this strategy, resulting in potential risk in the aviation market.

Table 5.12 Scenario setting

	Scenario 1 (base)	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
β	2000	2000	5000	2000	5000	5000
γ	1	1.3	1.3	1	1.3	1
$\mathbf{C_e}$	400000	400000	400000	200000	200000	400000

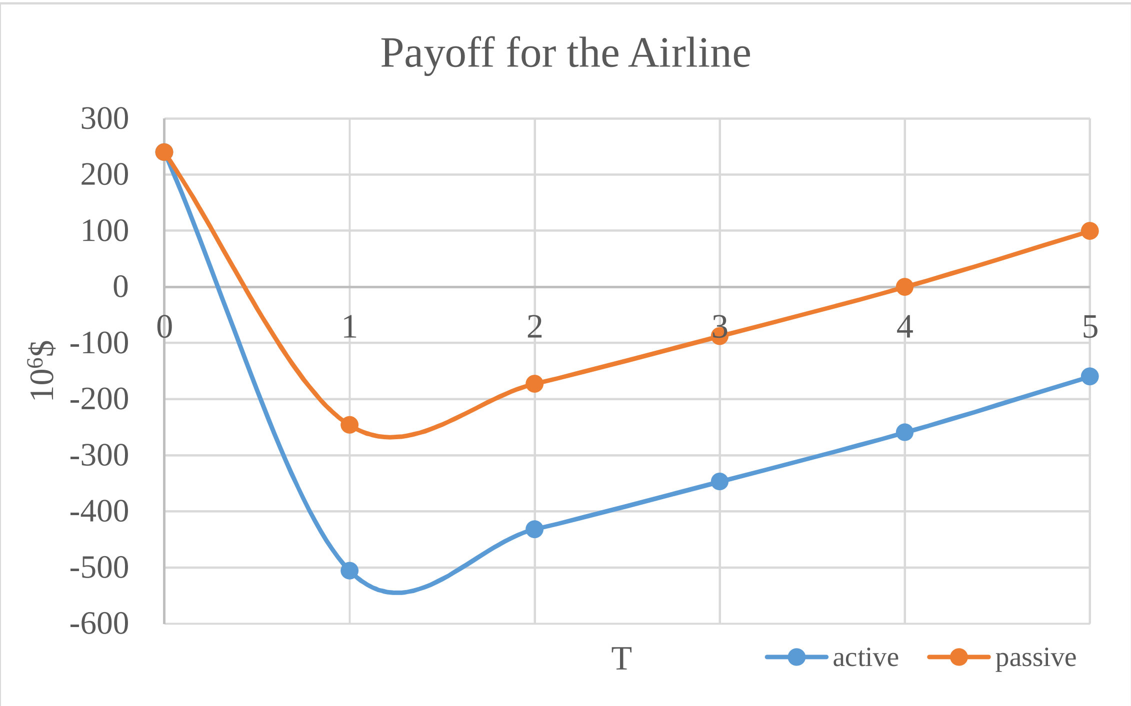


Figure 5.3 Payoff comparison in Scenario 1

β = 2000, γ = 1, C_e = 400000

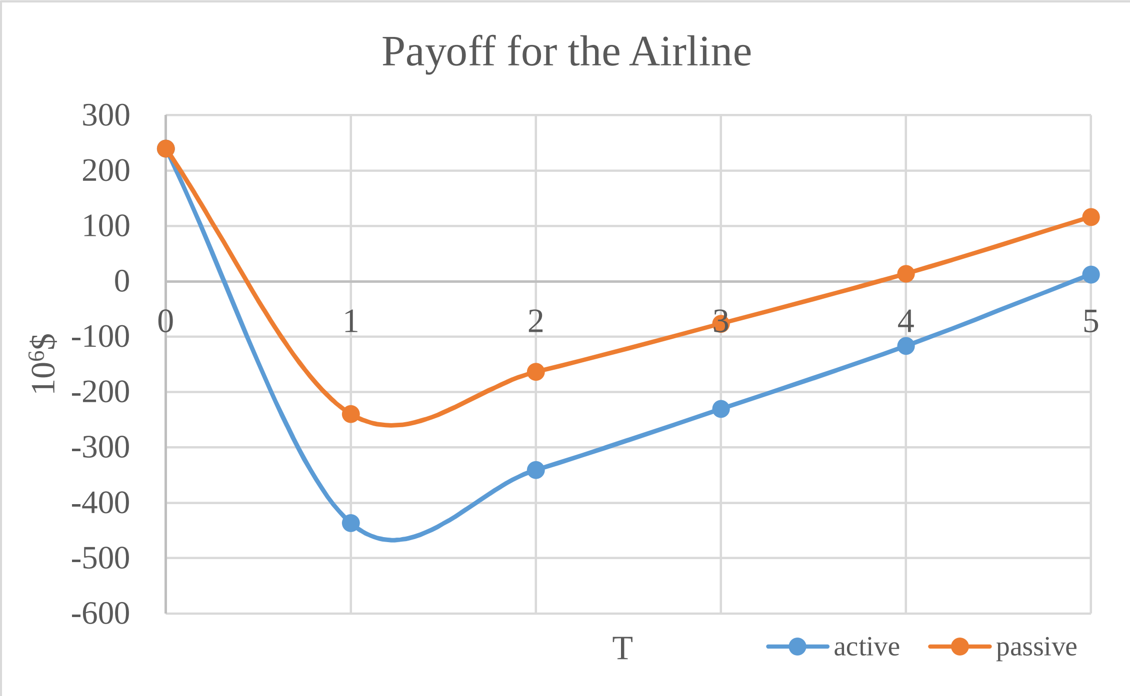


Figure 5.4 Payoff comparison in Scenario 2
β = 2000, γ = 1.3, Ce = 400000

Scenario 3 is the best solution in Figure 5.5. People cannot be easily attracted by promotion comparing to Scenario 2, suggesting **β** increases. Then, active action could loss more in initial stage, but for long-term steadiness, active action will earn more profits, and meanwhile extra safety investment for per passenger is higher too in Figure 5.6. Passive action could only have short-term benefits, but still in deficit in $\mathbf{T_5}$. This may cause financial problems, because safety information sharing makes people alert and select airlines carefully.

Besides, since people do not understand safety at all, the airline may cut the tradeoff budget in Scenario 4 in Figure 5.7. They also consider to remove budget in Scenario 5 in Figure 5.8 and Figure 5.9 comparing to Scenario 3. These two cases can let airline get profits faster, but extra safety investment to passengers will decrease as well, denoting higher risk. This analysis only assumes one accident occurrence. However, for those scenarios with lower safety investment, the possibility of repeated accidents would be higher, and at that situation it may result in enormous business loss.

Lastly, Scenario 1 is the worst situation that only passive action can earn profits, so if we change **β** to be higher in Figure 5.10, both strategies will be in deficit, suggesting that customers' willingness dominates airline decision making much.

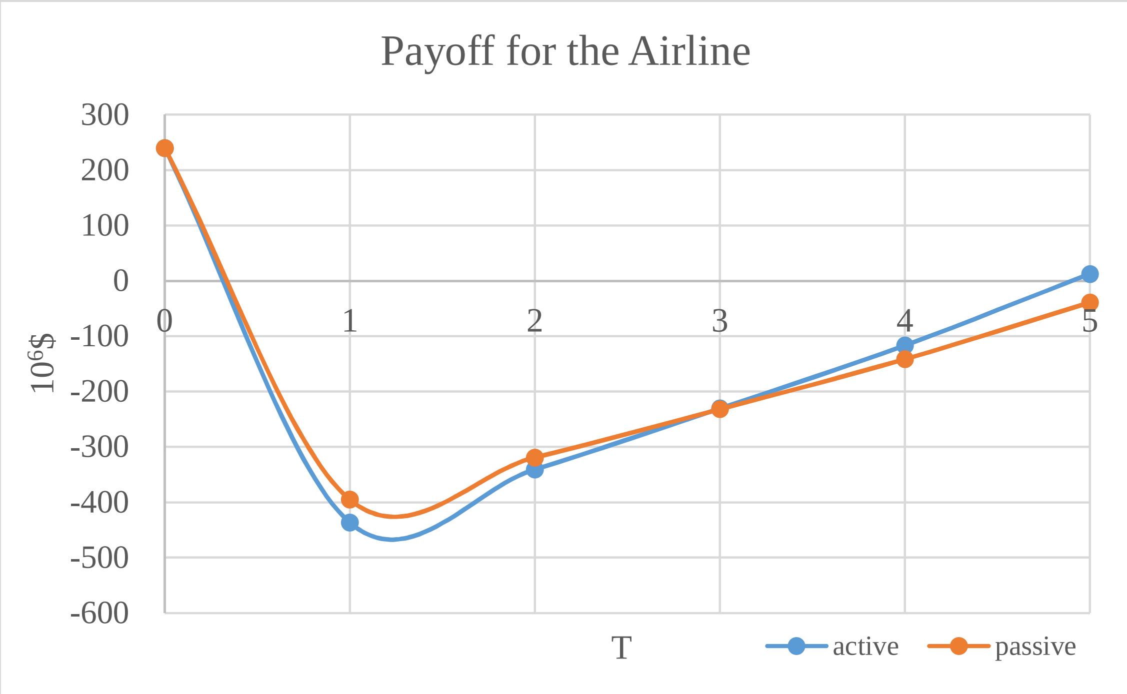
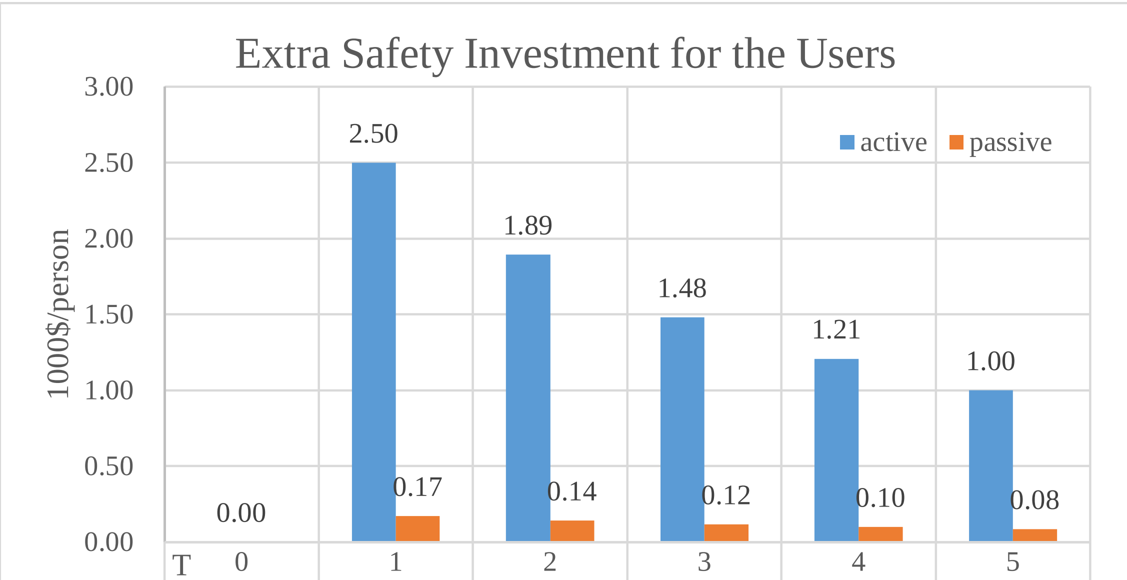


Figure 5.5 Payoff comparison in Scenario 3

β = 5000, γ = 1.3, Ce = 400000



T	0	1	2	3	4	5
active	0.00	2.50	1.89	1.48	1.21	1.00
passive	0.00	0.17	0.14	0.12	0.10	0.08

Figure 5.6 Extra safety investment comparison in Scenario 3

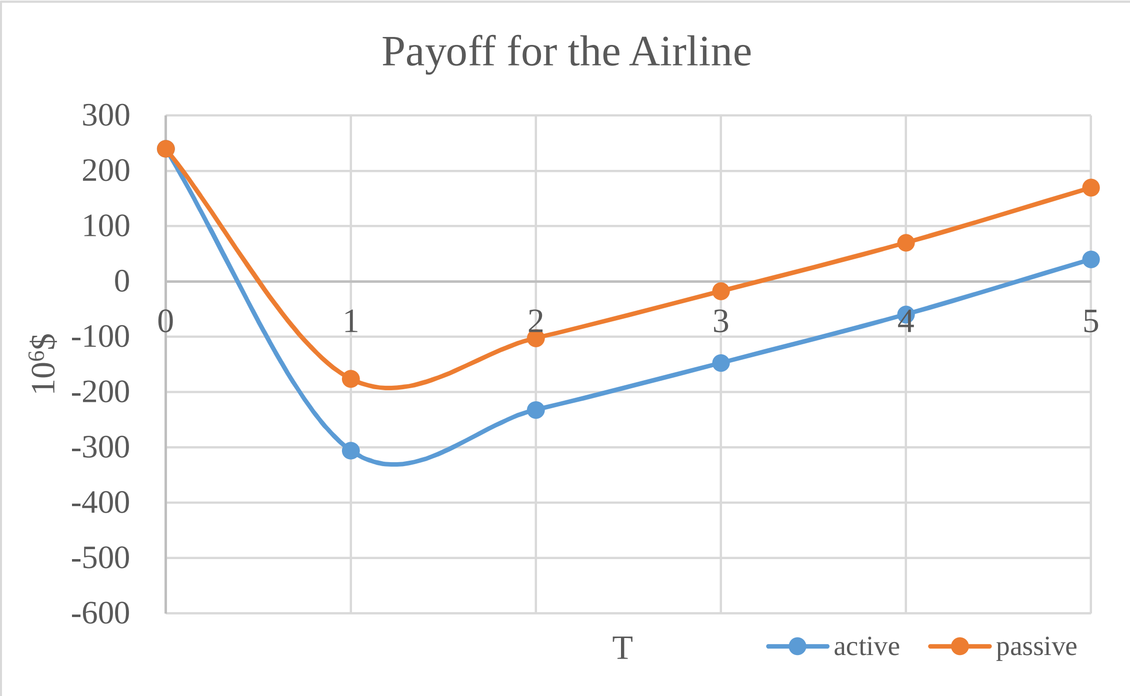


Figure 5.7 Payoff comparison in Scenario 4

β = 2000, γ = 1, Ce = 200000

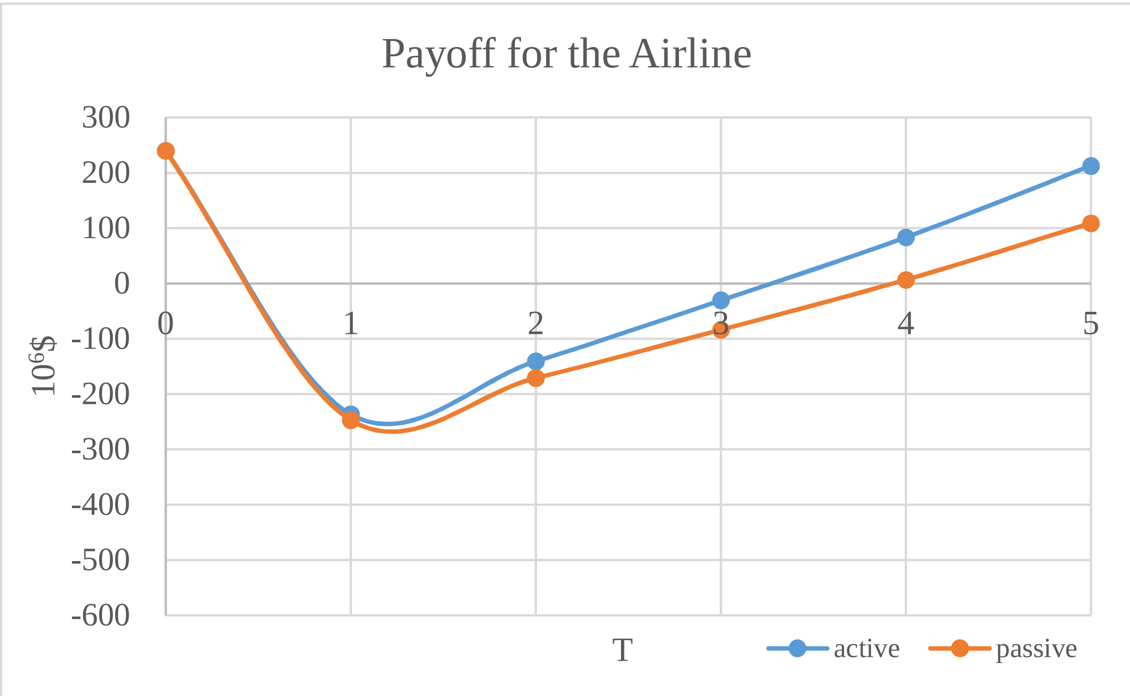
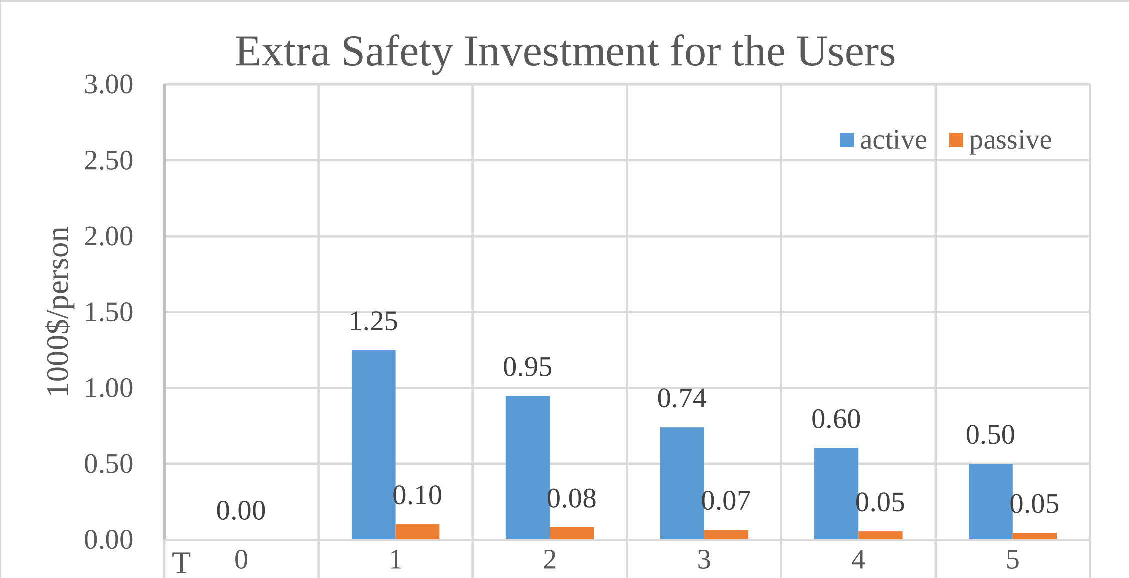


Figure 5.8 Payoff comparison in Scenario 5

β = 5000, γ = 1.3, Ce = 200000



T	0	1	2	3	4	5
active	0.00	1.25	0.95	0.74	0.60	0.50
passive	0.00	0.10	0.08	0.07	0.05	0.05

Figure 5.9 Extra safety investment comparison in Scenario 5

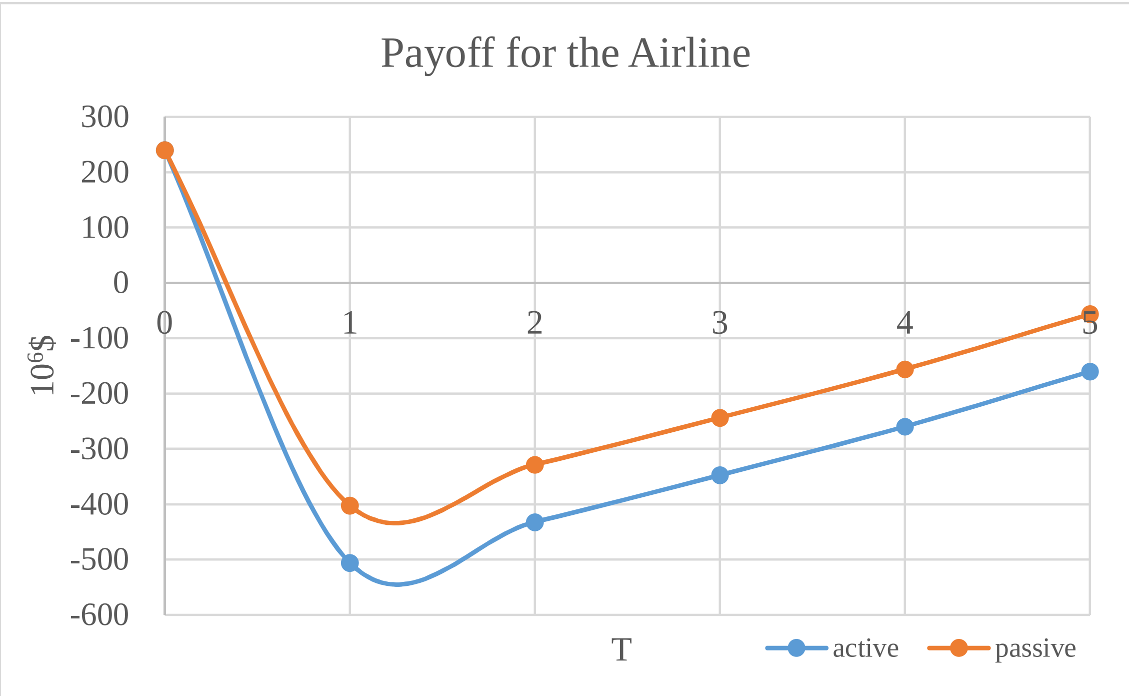


Figure 5.10 Payoff comparison in Scenario 6

β = 5000, γ = 1, Ce = 400000

From our analysis and figures above, we can understand **β** controls passive action while **γ** controls active action, because **β** suggests the amount of money that the airline has to invest to increase one more passenger, which is associated with promotion, while **γ** denotes the increase of users after implementation of safety measures, which is related to safety improvements.

We also based on the optimal condition, Scenario 3, to conduct sensitivity analysis to observe the differences. In Figure 5.11, **γ** and **Ce** are fixed to 1.3 and 400000, the results of **β** which suggests coefficient of promotion effect with unit of money over person show that if people are easily attracted by the promotion, the airline may tend to take passive action instead of implementing safety measures. Therefore, if aviation safety education is well spread to the public, and they will not be influenced by low airfares, making the airline with passive action in deficit.

β and **Ce** are fixed to 5000 and 400000 to examine how **γ** changes the airline's payoff for active action in Figure 5.12. **γ** stands for coefficient of safety measure effect, and passengers will increase with safety budget increasing. If airline safety program is well introduced to the public, they may have higher intention to use the airline, which helps airline companies recover from accident loss faster.

However, if the airline invests more tradeoff budget **Ce**, given **β** = 5000 and **γ** = 1.3, it will get harder to earn profits in Figure 5.13, even safety will approach the highest level, denoting the appropriate but not endless budget is necessary.

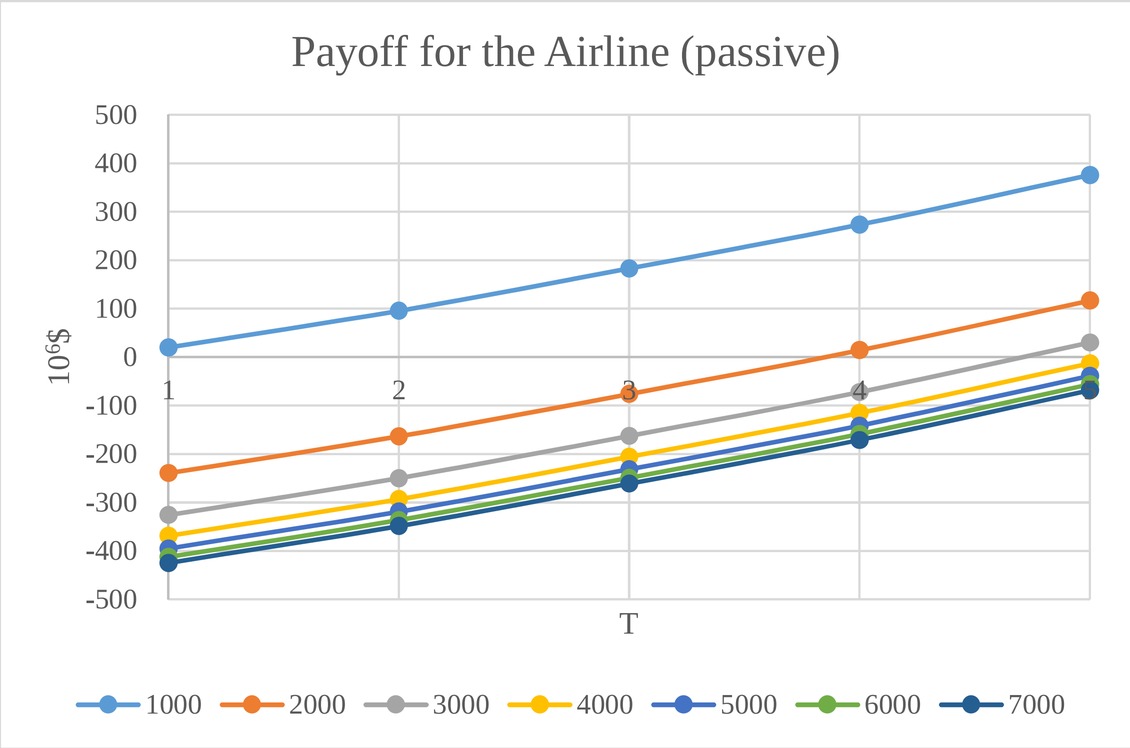


Figure 5.11 Sensitivity analysis of β in Scenario 3 (γ = 1.3, Ce = 400000)

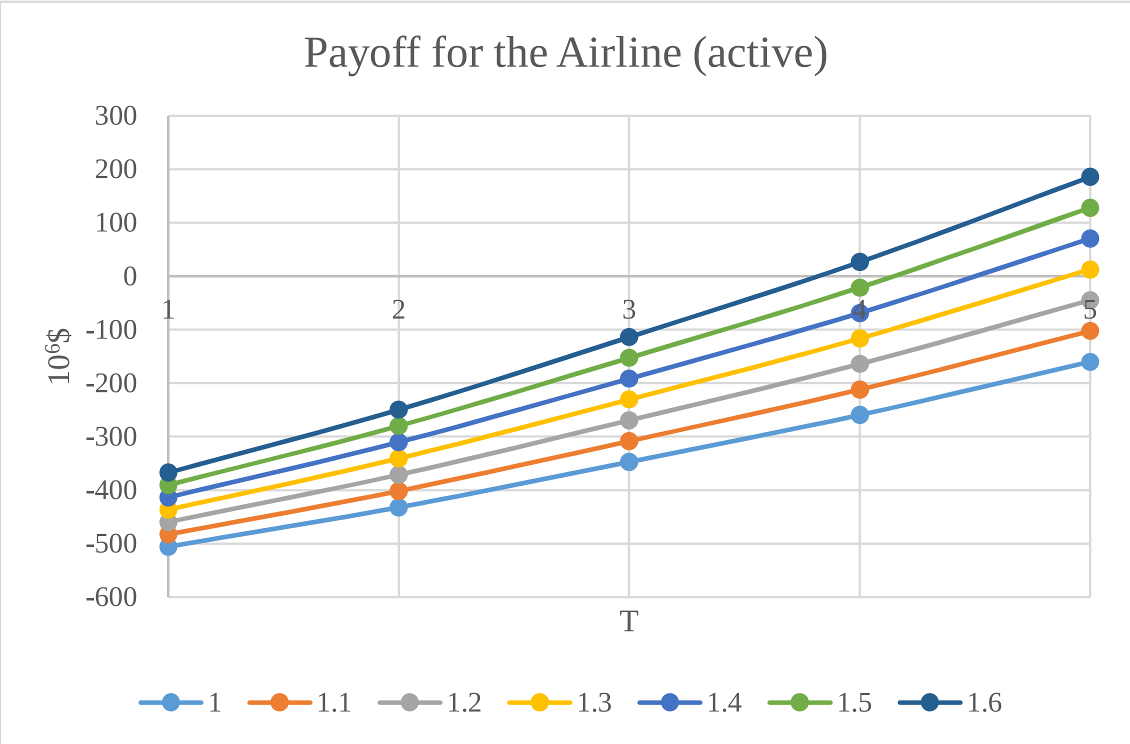


Figure 5.12 Sensitivity analysis of γ in Scenario 3 (β = 5000, Ce = 400000)

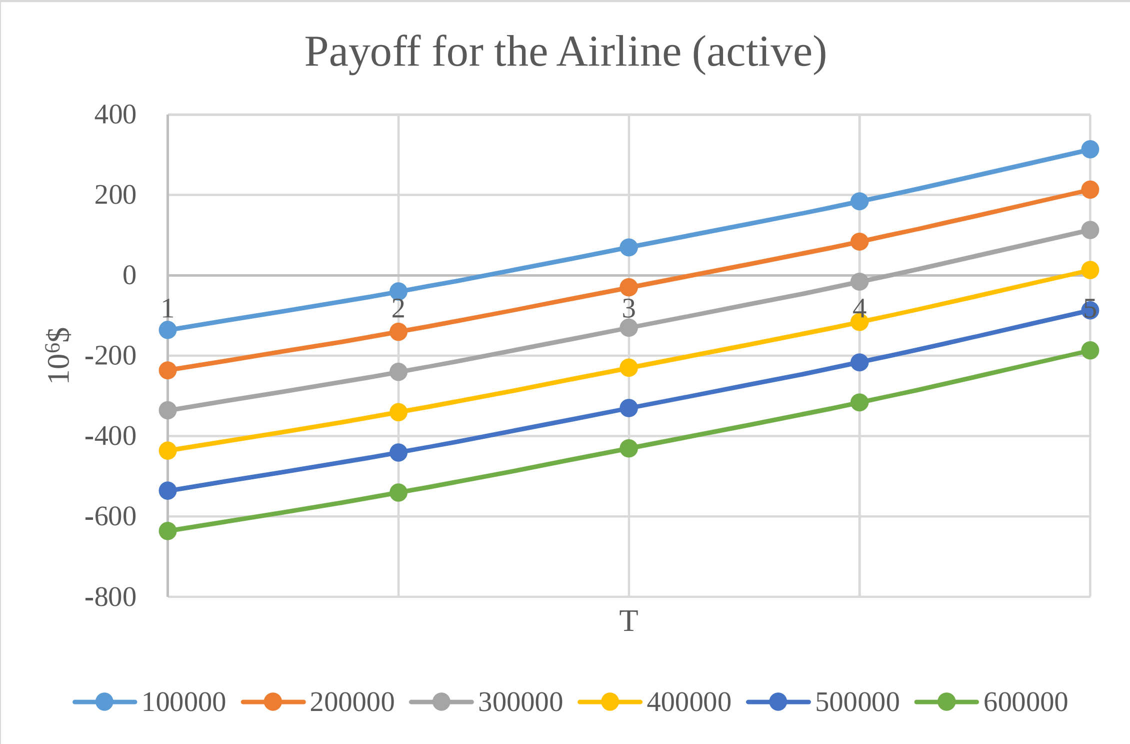


Figure 5.13 Sensitivity analysis of Ce in Scenario 3 (β = 5000, γ = 1.3)

- Discussion

The purpose of payoff simulation is to demonstrate diverse possibility for the airline decision making. Different scenarios were created to display payoff results. To find the condition for win-win, meaning the airline takes active action, earns more profits, and customers are also using it, people themselves have to understand their choices dominate the future level of safety. Nevertheless, the current situation is that safety information sharing is not well implemented, so those airlines with passive action may still remain in the market. In conclusion, even though information is limited, if people pay more attention to safety issues, and select an airline carefully, which will also ensure long-term steadiness and development of safety.

Lastly, game results in Scenario 3 are summarized in Table 5.13. We assumed demand functions to estimate demand quantity. The findings show that for customers, because there are limited airline alternatives for them and demand for air transport also exist, they still have to use the airline. Demand quantity will increase with time as well owing to abating of worry. Nevertheless, it is more profitable for the airline to take passive action in the beginning, but considering long-term business, implementing safety measures could be more beneficial. There are also other choices for the airline, such as using mixed strategy, and we can adjust coefficient of safety portion (**α**), to find the percentage for costs of safety measures and promotion, which creates maximum profits for them.

Table 5.13 Game results in Scenario 3

		T_1		T_2		T_3	
		Use	Non-use	Use	Non-use	Use	Non-use
Player A	Active	-436480, 208	-825600, 0	-340800, 274	-854222, 0	-230560, 351	-887200, 0
	Passive	-395008, 237	-825600, 0	-319200, 289	-854222, 0	-231856, 350	-887200, 0

		T_4		T_5	
		Use	Non-use	Use	Non-use
Player A	Active	-116538, 430	-921309, 0	12800, 520	-960000, 0
	Passive	-141516, 413	-921309, 0	-39040, 484	-960000, 0

5.4 Airline Interview

After accidents, TransAsia Airways had put many efforts to improve safety, but several questions have been drafted: What measures to do? How to do? How much it costs? How to evaluate the effects? Does the system really change? Because there was no big accidents for TransAsia Airways before, how did they manage crisis is worthy studying

5.4.1 Safety Investments

Firstly, we have to understand diverse definition of safety improvements. According to "State of Global Aviation Safety" (ICAO, 2013), aviation accidents continue to horrify till this day, yet safety has been the highest priority for the aviation industry over the past 100 years. Big improvements in technology, training and risk management have together resulted in laudable improvements. Airways News (2016) summarized top 5 modern improvements in aviation safety: CRM (crew resource management), RSWS (runway safety warning system), LLWAS (low level windshear alert system), EGPWS (enhanced ground proximity warning system), and TCAS (traffic collision avoidance system). Smith (2016) thought traditional safety management views the employees as the problem. Since the 1930's the philosophy of accident prevention has been based on the premise that "unsafe actions" of the worker cause 85% of accidents at work. Table 5.14 shows how the typical safety program shapes up.

Table 5.14 Safety programs

Management	• Management sets safety policies and procedures. • Supervisors watch workers or have them watch each other to prevent unsafe actions. • Managers set tough safety goals.
Staff training	• After employees are hired, they're trained on safe work practices. • Incentives are arranged to motivate employees to work safe and keep morale high.
Accident prevention	• Inspections find safety problems which are then corrected. • Every accident is thoroughly investigated with corrective actions following.

5.4.2 Interview Plan Results

We are analyzing motivation for airlines to implement safety measures, so exchanging with airlines to understand practical experience is meaningful. By providing our research results for airlines and expecting to receive feedbacks, we can find a win-win strategy for airline and customers, and help make a model for safety decision making. Interview details are listed in Table 5.15 and Figure 5.14.

Table 5.15 TransAsia Airways interview details

Time	14:00-17:00 April 18, 2016
Location	TransAsia Airways Headquarter (Taipei, Taiwan)
Interviewee	CEO: Peter Chen (陳欣德); Vice president: Chung-chi Liu (劉忠繼) (accident arrangement and media response); Assistant vice president: Yang-te Huang (黃揚德) (safety and security)

Figure 5.14 TransAsia Airways interview (Huang, Chen, Li)

After repeated accidents, TransAsia Airways followed their crisis management pattern. During that period, stock price was decreasing, meanwhile the airline had to investigate the accident with the government and also to provide air transport service. How airline companies arrange and respond to crisis is an important issue. We found that for TransAsia Airways, international routes were not affected obviously, only domestic routes lost passenger carriage. Therefore, they started to implement safety improvement program since March 2015. There are many measures to reduce risk, to motivate employees, and to increase customer confidence. However, before implementing, diverse factors are needed to be considered: passenger loss, passenger recovery trend, limited budget, current resources, government requirement, previous experience, accident report, etc. Hence, we would like to know how to make a correct decision considering all factors, and to help build a decision making process. After interview with TransAsia Airways, decision making process with various elements for safety measures can be defined as four phases in Table 5.16.

Table 5.16 Safety improvement decision making process

<table>
<tr><th>Phase 1</th><th>Phase 2</th><th>Phase 3</th><th>Phase 4</th></tr>
<tr><td rowspan="2">Accident
• Investigation
• Accident cause
• Severity
• Casualty
• Previous experience</td><td>Compensation
• Victims
• Families of victims</td><td>Budget/Revenue
• Undersell
• Passenger recovery</td><td rowspan="2">Employees
• Staff wastage</td></tr>
<tr><td>Government
• Safety audit requirement
• Financial support</td><td>Reputation
• Media report</td></tr>
<tr><td>Event analysis</td><td>Necessity and enforcement</td><td>Budget control and long-term effort</td><td>Short and long-term effort</td></tr>
</table>

Phase 1 (event occurrence) bases on accident situation and level of influences. In phase 2 (constraint), airlines are supposed to compensate for victims and meet government's requirement firstly, and then consider whether budget is enough and estimate how passengers will lose in phase 3 (outer balance). Lastly, phase 4 (inner steadiness) emphasizes on long-term steadiness. Because employees may quit after accidents, airlines have to cultivate safety culture to prevent a mass job quitting. In fact, aspects of safety culture are found in the shared attitudes of care and concern throughout the organization (Pidgeon and O'Leary, 1995), and in the visible commitment of senior management to safety (Droste, 1997). According to news release, TransAsia Airways compensated each victim for 14,900,000 NTD (4,970,000 USD) including 200,000 solatium, 1,200,000 grants and 13,500,000 settlements. For GE222 and GE235 Accidents compensation are the same, but some of victims' families were not satisfied and still negotiating with them.

After accidents in July 2014 and February 2015, TransAsia Airways has started flight safety improvement plan (飛安提升計畫) since March 2015. Several measures has been implemented and proposed as summarized in Table 5.17. TransAsia Airways interview results are summarized in Table 5.18.

Table 5.17 TransAisa Airways flight safety improvement plan

	Measures
Staff	• Experts: invited from Flight Safety Foundation, Airbus and other airlines • Development of Flight instructors: received ATR training and built new standard • Crew Resource Management (CRM): co-training system with flight attendant, operation dispatcher and pilot
Safety Audit	• Inner Audit: invited experts from aircraft manufacturer (ATR, Airbus), engine maker (PWC) to audit on site • Outer Audit: ATR and Airbus fleets passed CAA Audit • Secure Weather Standard: upgrade standard of runway visibility for domestic routes • SMS: FOQA (Flight Operation Quality Assurance) and LOFA (Line Operations Flight Audit) to ensure training and safety measure outcomes • SPI (Safety Performance Index), SPT (Safety Performance Target): quantify safety performance and improve management with data indicators • Conduct IOSA safety audit instruction, and prepare SMM (safety management manual)
Organiza tion	• TransAsia Flight Safety Committee: bi-weekly meeting • Product and Service Committee: provide service SOP • Salary Increment: 4-6% increase and talent promotion program • Safety Culture: "We put safety first" • Aviation Safety reporting System (AQD) • Aviation Safety Annual Meeting
Training	• Education Center: crew training, evacuation training • Flight Simulator: ATR72-600 and A320/A321
Fleet	• Fleet Age: control to 4 years • New Fleet: 6 fleets in 2015 (A321*2, A330*2, ATR72-600*2) and 6 fleets in 2016 (A321*2, ATR72-600*4) • Fleet Consistency: replace ATR72-500 with all ATR72-600 fleets

(Source: http://blog.uprofit-tw.com/?p=7506,
http://www.cna.com.tw/news/firstnews/201507020321-1.aspx,
http://www.chinatimes.com/newspapers/20151002000455-260106)

Table 5.18 Summary of TransAsia Airways interview

	Background	Purpose	Interview Results
Crisis Management Pattern	• Stock price decrease • Accident investigation • Provide air transport service	• To know how TransAsia Airways arranged and responded to crisis, and how to minimize loss	• Increase safety members: 6 persons -> 22 persons • Compensation: 2M NTD -> 14.9M NTD per person • Accident aftermath with local resident, ASC (Aviation Safety Council), CAA (Civil Aeronautics Administration), insurance company
Safety Improvement Decision Making Process	• Safety improvement program since March 2015 • Should consider diverse factors	• To understand how to make a correct decision considering all factors, and to help build a decision making process • To ask the decision making change after 1st and 2nd accidents	• Safety first: long term-plan to maintain strong intention and keep employees • Safety system reform: IATA verification audit after the GE222 Accident • Serious deficit: sold one building, catering and old aircrafts, No financial supports from the government • Wait for sunrise: expect to make ends meet in end of 2016
Evaluation of Safety Improvement Performances	• Input a huge resources in safety measures	• To evaluate safety measures • To quantify the effects of airline reputation, loyalty • To make an overall evaluating index	• Risk metrics: check safety improvements • Cannot quantify loyalty and airline image • Media entertainmentization: Not recommended to provide much information to the media, the reason why we cannot find details in TransAsia Airways annual reports

5.4.3 Evaluation of Safety Improvement Performances

According to GTAG10 (Global Technology Audit Guide) (2016) for BCM (business continuity management), CAE (chief audit executive) must understand the role of BCM as one of three elements of an Emergency Management Program. As Figure 5.15 shown, emergency response (ER) is the first action that focuses on avoiding, deterring, and preventing disasters and preparing the organization to respond to a disaster. The goal of ER is lifesaving, safety, and initial efforts to limit the impact to asset damage. Crisis management (CM) focuses on managing external (and in some companies, internal) communications and senior management activities during a disaster. Even in an environment where ER and CM are mature and effective, BCM may remain inadequately addressed. BCM capabilities are focused on the recovery of critical business processes to minimize the financial and other impacts to a business caused during a disaster or business disruption. BCM must be integrated with ER and CM but should be a separate program.

Figure 5.15 Emergency management program

The scale of aviation accidents can be longer and more influential. TransAsia Airways now is implementing a safety improvement program as part of BCM to rebuild market confidence and retrieve customers. However, the performances of each measure are unsure and hard to control. It is certain to input a huge amount of human power and resources in safety measures, but how to evaluate the effects and how airlines quantify the results, no matter airline image, reputation, or passenger number, it's possible to make an overall evaluation.

TransAsia Airways is also considering safety tradeoff, which is similar with our game of safety improvements. To find a balance between business and safety, a diagram (profit-safety guarantee) can be made in Figure 5.16. Airlines have to keep in safety operation interval to balance financial management and safety management.

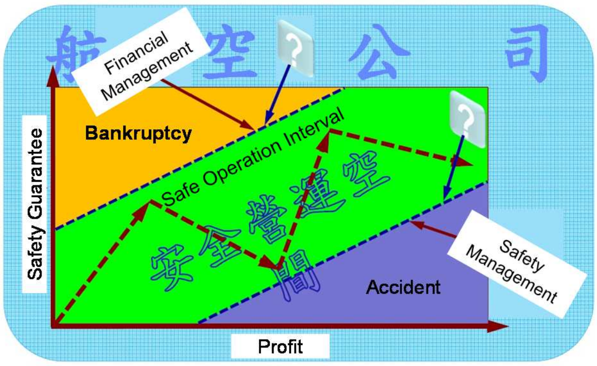


Figure 5.16 Tradeoff of safety and business

Airline companies take risk management procedures in Table 5.19 to prevent dangers, and deal with accident arrangements afterwards. Rather than safety measure performance quantification, TransAsia Airways is finding the likelihood of severity (risk assessment index) in Figure 5.17 to make a risk metric in Figure 5.18 after conducting safety measures, and they will know which item should be re-improved to reduce risk.

Table 5.19 Risk management procedures

Method	Risk management procedures
Predictive (予防)	FOQA report, flight pre-check (new route, airport risk assessment or safety management), safety information sharing
Proactive (先手)	Inner/outer audit, safety auditing, aviation safety reporting system
Reactive (後手)	CAA report, ASC report: accident, incident, occurrence, etc.

風險等級 Risk Level	風險指標 Risk Assessment Index	行動建議 Recommended Action	決策層級 Decision Level
高度風險 (不能接受) High Risk (Intolerable region)	12.1 and up	無法接受，需後續改進措施以消除相關危害，或管控可能導致更高風險發生之可能性或嚴重性因素，在確認完成風險降低/緩解措施至低度風險情況下才可恢復作業 Unacceptable under the existing circumstances. Further work would be required to designe and intervention to eliminate that associated hazard or to control the factor that lead to higher risk probability or severity.	總經理/副總經理級
中度風險 (有條件接受) Medium Risk (Tolerable region)	3.1-12	在確認完成風險降低/緩解措施至低度風險情況下可接受 Acceptable based on risk mitigation. It may require management decision.	協理/經理/副理/主任/副主任
低度風險 (可接受) Low Risk (Acceptable region)	1-3	可接受，無須採取任何行動 Acceptable.	一線主管督導/組長/工程師

Figure 5.17 Risk assessment index

Names	Levels
Acceptable	0.01 - 3.00
Undesirable	3.01 - 12.00
Unacceptable	12.01 - 25.00

Severity	Likelihood				
	1-Negligible	2-Minor	3-Major	4-Hazardous	5-Catastrophic
5-Frequent	5.00	10.00	15.00	20.00	25.00
4-Occasional	4.00	8.00	12.00	16.00	20.00
3-Remote	3.00	6.00	9.00	12.00	15.00
2-Improbable	2.00	4.00	6.00	8.00	10.00
1-Extremely Improbable	1.00	2.00	3.00	4.00	5.00

Acceptable　Undesirable　Unacceptable

Figure 5.18 Risk metric

Meanwhile, FOQA (flight operations quality assurance) with real flight data is used to analyze and track back whether pilots follow aircraft control SOP in Figure 5.19. Airphase software was installed to find potential problems to prevent accidents in advance. By doing so, pilots' performances can be examined and be improved gradually to ensure safety.

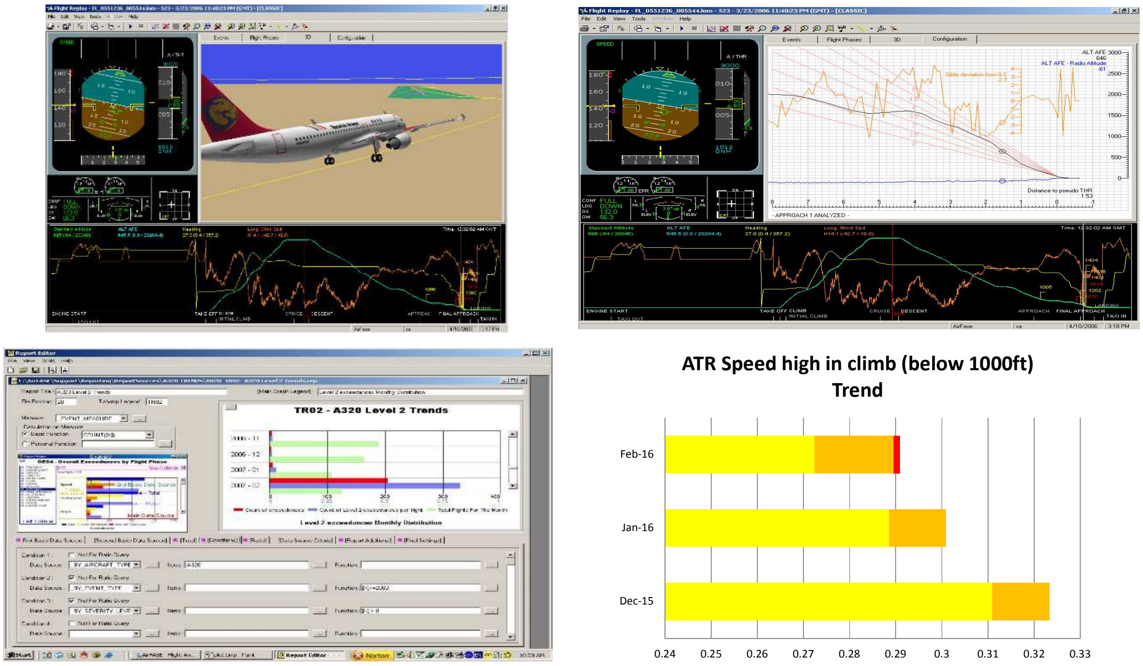


Figure 5.19 Demonstration of flight operations quality assurance

5.5 Summary

This chapter we found a problem that the airline may not conduct safety measures after accidents and tend to do promotion to attract more passengers, because of people's abating of worries and continual usage, resulting in safety and long-term aviation development problems. This makes a tradeoff of safety and profit between the airline and customers, and can be expressed with a non-cooperative game. The game of safety improvements is composing 2 players with 2 strategies respectively. The airline can take active action to improve safety or passive action to do promotion, while customers can decide to use or not to use. The game formulation, assumption and setting were described to study the interaction between two players. This game is similar with lemon market case because both are information asymmetry examples, and was compared to estimate market performances. Moreover, to quantify players' benefits, payoff analysis and sensitivity analysis were conducted. We can use demand functions to explore people's purchasing behaviors owing to airfare and worry decay. The airline is mainly considering profits, so we made a simulation for diverse scenarios to display different outcomes and find the win-win condition. The results showed customers' attitude control the airline's motivation, but since safety information sharing is not yet built, they do not know whether the airline conducted safety measures or not. We encourage airlines and the government to implement safety measures, and help passengers increase aviation cognition and understand safety measures. Lastly, a site visit outcomes to TransAsia Airways about practical safety affairs were summarized to support our theory.

Chapter 6

Conclusions and Recommendations

6.1 Conclusions

The problems we have stated including the social effects associated with aviation accidents, comparison of the influences of an accident on public perception, quantification of public perception, people's airline selection criteria and behavior, and the interaction between the airline and customers for safety measures. Our overall targets are to minimize impacts of accidents, and to enhance long-term aviation safety. This study is aimed to investigate the influences of repeated accidents on the society, people's perception and airline safety measures, and has produced fruitful results.

According to ICAO Annex 13, an accident is an occurrence associated with fatal or seriously injured persons, damaged aircrafts or structural failure, and missing aircraft, while an incident is defined as an event that could affect the safety of operations. When an accident happens, the media announces the news to the public, and then they become concerned about this issue. The mass media, in most cases, pays more attention to accidents because of fatalities, but repeated information heightened people's awareness of risks in Taiwan (Fang et al., 2012) and amplified their safety perception, so two real accident cases, TransAsia Airways GE222 and GE235 Accidents, that caused huge social panic in Taiwan were selected in this study.

In Chapter 3, to minimize the accident loss, a structure of accident crisis and a structure of multiple involved stakeholders of aviation accidents help us analyze influences of aviation accidents on the society. Because an accident happens, the media announces the news to the public, then airlines, market and customers will be majorly affected. Therefore, event study method (ESM) was used to quantify short-term impacts, and to find the correlation with stock price fluctuation and media effect. The results showed they are correlated, implying strong accident influences on the society.

Chapter 4 observed this from the perspective of lay people. A questionnaire survey was conducted to collect public perception, and separation of two groups owing to the recent accident showed significantly different. Through econometric skills to analyze formation of safety perception, worry duration, and people’s behavioral intention change, people’s perception can be quantified to observe their willingness to use the airline before and after an accident. Our study has explored diverse factors that control their perception, and clearly indicated people might gradually adapt to the accidents, and rebuild confidence toward the airline with time passing, but it will deteriorate again if an accident repeatedly occurs.

Chapter 5 was exploring the interaction between the airline and customers, and discussing the motivation for the airline to conduct safety measures, because people’s abating of worries and continual usage may discourage their intention, resulting in safety problem. This makes a tradeoff of safety and profit and is expressed with a non-cooperative game. The game of safety improvements is composing 2 players with 2 strategies respectively. We adopted several scenarios to analyze players’ payoff, made a simulation to display different outcomes for the win-win condition. The results showed customers’ attitude control the airline’s motivation, but information asymmetry hampers their decision making, so to create an information sharing mechanism to enhance the overall safety level is of importance.

Aviation accidents arouse a huge social panic and involve multiple stakeholders, so it is important to know and deal with the crisis. This is an overall research covering diverse stakeholders, the society, users, and the airline. Currently, there is no research to study multiple stakeholders’ performances after repeated accidents to the best of our knowledge, making results innovative. This study could serve as a constructive reference for the government and airline companies to deal with crisis management because the results have quantified the level of the seriousness and provided an estimation method to know the consequence of accidents. Airlines may also make more efforts to implement safety management in order to prevent accidents from happening. Media exaggeration about the accident could monitor airline safety performances but also might hamper the development of air transport market. Public perception toward accidents can be formulated to see the effects with their behaviors. Safety perception is one of the dominant that controls their willingness. Through our investigation, people’s concerns were collected and motivation for users to use can be estimated. Lastly, to enhance the level of safety, airline’s motivation for safety measures depends on customers, suggesting we air passengers also have responsibility for aviation safety.

6.2 Future Research Recommendations

This is a creative and useful research which greatly matches current needs. We can conclude that the decrease of air transport passengers and the airline's motivation after aviation accidents is attributed to public safety perception and information asymmetry, which may reduce the level of safety. Therefore, how change of public perception associates with safety is of importance. It is also rare that two accidents took place with the same airline and country within half a year, explaining the necessity of studying this situation.

For future research recommendation, we can apply the outcomes of this study to foresee the change of air market. The scope of the research can expand to international routes, so airfare, service quality, and socio-economic information may become more dominant. The survey was conducted online, so majority of samples are young and high-educated people. It is hard to represent general Taiwanese people's behaviors, but because demands for young travelers are increasing, the results can reveal the future trend of the aviation market. Worry duration is collected by two imaginary situations, a long-term panel data to trace their real safety concerns and to estimate how long the public may adapt to one accident by using duration analysis is more accurate. Implementing a stated preference survey to create a utility function and a discrete model, and analyzing how repeated accidents change their airline choice behaviors are of interest. This study collected subjective data covering only two timings: half a year after and immediately after an accident. Conducting a survey at different periods after an accident to check the relationship of social effects over time is recommended. Moreover, to quantify people's payoff for the game analysis, using assumed demand functions to estimate demand quantity has been achieved in this study, so to use a random dataset for running utility function or to conduct data collection for real demand functions could be considered for future work. Lastly, we only included one airline in the market in game of safety improvements, consideration of other airline competitors still need to be further discussed for clarifying the real market mechanism.

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