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The impacts of an air-crash on students' transportation choice behaviour: An empirical study undertaken in Taiwan

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ABSTRACT

This research's objectives are to identify major factors influencing offshore student–commuters' transportation mode-choice and to develop simple Logit choice models prior and post a major air disaster. The total trip time, trip cost, ease of access to a transportation mode, student–commuters' household income, and the risk perceived by student–commuters using different transportation modes are found to have impacts on their mode-choice behaviour. Several logit model specifications were tested. The research reveals student–commuters' transportation mode-choice behaviour significantly changed post the May 2002 Penghu air accident. Reduction in airfares (which most airlines used to promote their services after the air-crash) was less attractive to passengers than convincing them that airline services were safe. Therefore, any post-disaster airline marketing campaign aimed at student–commuters should change from reduced fare promotion to service safety promotion.

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1. Introduction

Statistical data from the Civil Aeronautic Administration Taiwan (CAAC) suggests that the country's airline accident ratio is not that high when compared to the ICAO world record,¹ and the FAA ranks Taiwan in category 1 in its international aviation safety assessment programme,² however, the CAAC's "flag carrier accident rate" chart uses the criterion "numbers of accident/million block hours" and this cannot reflect the actual risk of a fatal air-crash. Passengers care most about fatality accidents than any other type of accident. According to Barnett and Higgins (1989), the primary safety measure should be "death risk per flight" which weights each fatal accident by the proportion of passengers killed.

In the final decade of the twentieth century, there were several major accidents involving China Airlines, a previous Taiwan flag carrier. This series of accidents caused large numbers of fatalities and only a few passengers survived. Therefore, the "death risk per flight" index for Taiwan should be relatively high compared to the industry average globally.

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¹ The average number in Taiwan was 2.043 fatality accidents/million block hours between 1992 and 2001, about 25% higher than the world average data in the same period. According to the FAA, fatal means any injury that results in death within 30 days of the accident (accessed <http://www.caa.gov.tw/factbook/19.JPG>, <http://www.nts.gov/publicntn/2002/ARC0202.pdf> and <http://www.boeing.com/news/techissues/pdf/statsum.pdf> on 22 January 2003).

² 'Category 1' means it complies with ICAO standards: a country's civil aviation authority has been assessed by FAA inspectors and has been found to licence and oversee air carriers in accordance with ICAO aviation safety standards. FAA assesses 97 countries/regions and 73 of them were ranked in category 1. Accessed <http://www1.faa.gov/avr/iasa/iasa50ws.xls> on 22 January 2003.

Table 1
Fares difference between airlines and ferry.

Type of fares	Timing	
	Before air-crash	Post air-crash
(A) Air fares (one way)	34–50 USD	30–42 USD
(B) Ferry fares (one way)	18–25 USD	18–25 USD
(C) Absolute fares difference (USD)	16–25 USD	12–17 USD
(D) Relative fares difference (%)	47–50	40

Note 1: (C) = (A) – (B), (D) = [(A)–(B)]/(A).

Note 2: Airfare between Taiwan mainland and Penghu Islands is sold at 10–15% discount.

Source: The airfare discount promotion data post the Penghu air-crash is provided by a senior manager of the Trans Asia Airways in Penghu. Similar data is also reported by Culpa (2003).

In terms of fatalities in a single accident in a country/area Taiwan ranked among the top-10 out of 202 countries/areas all over the world.³

According to the CAAC's records, three passenger-airline accidents happened near Penghu's Makung airport between 1970 and 2002. An accident in 1986 occurred on a direct flight from Taipei to Makung, the capital city of the Penghu County, resulting in the deaths of 13 people. The number of tourists visiting Makung declined immediately in that year (Shen, 2001). Although on two of the aforementioned occasions the destination airport was Hong Kong, not Makung airport, the crashes nevertheless had a devastating impact on Makung in the Penghu Islands (a national park in Taiwan), especially the 2002 airline catastrophe. Penghu County has two major industries: sightseeing and fisheries. When the airline disaster happened in May 2002, it was during the sightseeing high season. Some of the 225 victims' bodies were not found after the aeroplane disintegrated in midair near Penghu and therefore still lie somewhere on the sea bed. As a consequence no tourists will engage in offshore sports; before the accident one of the most popular tourist activities in Penghu. Moreover, the volume of tourists visiting the area declined more than 17.5% between June and December 2002 when compared to the same period in 2001.⁴

In a study conducted in New York in 2000, Siomkos found that only 3% of the survey subjects could remember a crash beyond 3 years into the past, but 89% were able to recall an airline crash in the last 3 years. Therefore, because frequent airline accidents could have a significant influence on their customers' transportation-selection behaviour, it becomes very important from the carriers' viewpoint to ascertain to what extent airline accidents have a negative impact on passengers' transportation mode-choice behaviour and how to minimise this negative impact through appropriate marketing strategy.

There are four airlines serving passengers between Taiwan and Penghu. In order to increase the passenger load factor, these airlines launched a price war campaign on this flight route after the 2002 airline tragedy. Penghu County's local government also endeavoured to promote the sightseeing industry by staging many cultural events. However, many superstitious people believed they would antagonise the spirits of dead airline victims missing in this area if they visited the offshore national park and therefore were unwilling to visit the County. Another important factor influencing tourists' decision not to visit this national park has been their worry about flight safety, Bergstrom and McCaul (2004) have studied the effects of 9/11 on college students' willingness to fly also found insecure air safety record reduced travellers' preference using air transportation. To try and boost the number of visitors to the area, the government of Taiwan has sought to encourage government employees to spend their annual-leave travel stipends domestically and outside their county of residency. Although this policy has been devised to promote the domestic tourist industry, it has not really helped Penghu National Park because tourists are more reluctant to visit areas where tragedies have occurred. Commuters are less sensitive to air accidents than tourists so an understanding of their travel decision-making behaviour becomes very important for a airlines' marketing campaigns after major air-crash.

Makung is the capital city of the offshore islands, the Penghu Archipelago. There is a national university in Makung, the National Penghu University (NPU). The NPU was established in 1992 and is the only school that offers bachelor degrees in Penghu County. There were 1682 students between 2001 and 2002, and about two-thirds were from Taiwan's mainland. Most students are aeroplane/ferry commuters about twice a month between Penghu Islands and Taiwan's mainland. Normally, one way flight time from Makung to the southern major cities on the Taiwan mainland is about 40 min, and the one way steaming time is around 2.5–4.5 h by ferry. Post an air-crash accident nearby the islands in 2002, the airlines offers 10–15% discount on the airfares for 6 months to attract commuters to use the air transport service. The fares and fares difference between airlines and ferry is summarised as below (see Table 1):

There is no bridge/tunnel connection between Penghu Islands and Taiwan's mainland. As a consequence, there are only two types of transportation modes, aeroplane and ferry boat, available to student-commuters travelling back and forth between Penghu and Taiwan's mainland. To analyse individual transportation mode-choice behaviour in detail, discrete choice theory (particularly probabilistic choice type) is most appropriate. It can be applied to assess an individual's probable selection of a feasible alternative and also provides a potentially powerful framework for analysing discrete choice situations. Dis-

³ Accessed <http://www.aviation-safety.net/statistics/worst-country.html> on 22 January 2003.

⁴ The air traffic high season for Makung airport is traditionally between April–September. July and August are the summer holidays for children when parents in Taiwan take their children to visit the Penghu Archipelago. Monthly passengers throughput via Makung Airport is usually slightly over 220,000 in these 2 months.

crete choice modelling is a standard method used to analyse individual choice behaviour and is an especially useful tool for transportation market demand analysis.

2. Literature review

There are many studies on transportation mode-choice (Duann, & Lu, 1998) and transportation risk management in the literature but none of the topics focuses on offshore archipelago areas close to Taiwan's mainland. Some studies have examined the competitive situation between aeroplane and cruise boat (Tien, 2000), but the research is mainly focused on the tourism industry and is quite different from this study, which analyses student-commuters' transportation mode-choice behaviour, particularly behaviour changes after a major air accident in the area nearby. Ho and Tien's (2002) study found the cruise vessel had advantage over the aeroplane in terms of social communication and travel comfort. The aeroplane had the advantage of high flexibility over the ferry boat. However, Ho and Tien's (2002) examination of passenger vessel service focused on tourists only and did not examine current offshore archipelago ferryboat practice in Taiwan.⁵

Rao, Sikdar, Krishna Rao, and Dhingra (1998) studied the choice of access mode to rail using the Artificial Neural Network (ANN) model and Multinomial Logit (MNL) model. The research found sex, age, household income, household size, travel allowance, wait time, travel time, and travel cost significantly influenced commuters' mode-choice behaviour. Lin (2000) investigated MRT/MCT (MRT: Mass Rapid Transit system, MCT: Medium Capacity Transit System) passenger arrival pattern difference between downtown and suburban passengers in the Taipei metropolitan area. In a multi-logit model research, Lin (2000) found 10 variables determined arrival passengers' preferred transportation mode-choice utility function for the rapid transit system in Taiwan. Of the 10 variables, four were generic i.e., travel time in the car; travel time outside the car; parking time; travel cost. The remaining six were socio-economic variables, namely, gender, age, profession, household income, number of cars in a household, and number of household members holding a driving licence. Chen (2002) explored inter-city passengers' transportation mode-choice behaviour, and found passengers' age, personal income, number of travel companions, in-vehicle time and cost, reliability of air transport, the comfort and safety of the railway, and the image of the inter-city coach influenced passengers' choice behaviour when long distance travel was considered.

Shailes, Senior, and Andrew (2001) used binary logit analysis to examine the manner in which tourists adjust travel behaviour in response to congestion. They found higher vehicle occupancy, a relatively large number of previous visits to the area and prioritising congestion avoidance in pre-trip planning significantly influenced congestion-avoiding travel behaviour. Cherchi and Ortúzar (2002) analysed the impact of a new train service in Cagliari (Italy) by both revealed preference (RP) and stated preference (SP) information. The RP data represented the choice between car, bus and train; the SP data considered the binary choice between a new train service (quicker, more frequent, with lower fares and more stations than the current one) and the alternative currently chosen by car and bus users. The authors found the quality of transportation mode services (such as comfort, punctuality) the most important variable influencing passengers' decision-making behaviour. Jovicic and Hansen (2003) devised a passenger travel demand model in Copenhagen mixing RP data and SP data from four different passenger segments in their logit models. Access/egress time, in-vehicle time, in-vehicle congestion time, parking time and parking cost were included in their mode-choice model estimation.

Abane (1993) studied city commuters' behaviour and found it was influenced by perceived service quality of the commercial commuter vehicles, gender, age, disposable income relative to travel cost as well as the reliability of schedules of the individual modes. Renn (1998) studied the role of risk perception for risk management and indicated people rather choose a risk that will kill a few people at a time than a risk that kills many people at once. Gigerenzer (2004) similarly indicated people tend to fear dread risk (low probability and high consequence events). After September 11, Gigerenzer (2004) indicated the US national revenue passenger miles decreased in October, November, and December 2001 by 20%, 17%, and 12%, respectively, compared with the same months in 2000. The monthly highway miles driven in 2001, compared with 2000, were on average 0.9% higher before September 2001, but 2.9% higher in October, November, and December 2001.

The work of Callahan, Hilsenroth, Yontai, and Waehler (2005) indicates both college students groups in Midwestern USA and NYC metropolitan area revealed substantial post-trauma stress responses 2 days after September 11, 2001, and the NYC group reporting slightly higher stress scores on the Impact of Event Scale (IES). A study by Walker, Thientham, and Lin (2005) examines 138 aviation disasters and the impact of aviation disasters on the short- and long-term performance of airline and airplane manufacturers. Walker et al. (2005) found disasters caused by criminal activity cause significantly large stock price drops in the days following the event. However, Walker et al.'s study is simply a comparative study on the performance of airlines before and after air disaster, it does not look into passengers' decision-making behaviour in response to air accidents which is the focus of this research.

3. Methodology

Probabilistic theory underlies different discrete choice models. In the discrete choice model, when the choice set has two alternatives, this situation is called the binary choice. Students faced with two feasible discrete alternatives can employ a

⁵ Currently, the ferryboat service between Taiwan's mainland and offshore small islands is both for tourists, commuters, and cargoes. All these ferryboat operators receive a subsidy from Taiwan's government. The Ministry of Transportation and Communication subsidised passenger ferry companies in remote areas NT\$ 217,230,000 between July 1999 and December 2000.

simple binary choice model (i.e., the logit model) to find the best alternative. The logit model assumes the distribution of the probability error item (ε) is Gumbel Distribution and the Probit Model assumes the ε item follows normal distribution. If there are two alternatives only in the decision maker's choice set, it becomes a binary logit model.⁶ The logit model⁷ is a useful statistical method for analysing and can help the decision maker solve a problem in a complex situation. The origin of logit model can be traced back to mathematical psychology (see [Thurston, 1927](#); [Tversky, 1972](#)). It is used in the present paper to more clearly understand student–commuters' decision-making behaviour in relation to travel to and from Taiwan's mainland and its offshore archipelago.

Let U represent the utility function, respondent i will choose the alternative that implies the highest utility (see Eq. (1))

$$U(X_{1i}, X_{2i}, \dots, X_{ki}) = \max[U(X_{1i}^A, X_{2i}^A, \dots, X_{ki}^A), U_i(X_{1i}^B, X_{2i}^B, \dots, X_{ki}^B)] \quad (1)$$

The alternatives are described by a number of attributes, X_1, X_2, \dots, X_k , and these attributes are different for each respondent and each alternative. The choice of the consumer reveals the consumer's preferences among the alternatives. When facing a binary discrete choice (alternative A and alternative B) situation, the consumer will choose the alternative with the higher utility.

A probability model is used in order to account for uncertainty (e.g., [Ben-Akiva & Lerman, 1985](#)). Specifically, the probabilistic model allows effects of unobserved variation among the respondents and takes pure random choices and errors due to measurement or incorrect information into account.

Letting U_{iA} represent the utility of alternative A perceived by decision maker i . The random utility of an alternative could be expressed as the sum of observable and unobservable components (see Eq. (2)):

$$U_{iA} = V(Z_{iA}, S_A) + \varepsilon(Z_{iA}, S_A) = V_{iA} + \varepsilon_{iA}, \quad (2)$$

where $V(Z_{iA}, S_A)$ is a systematic component, Z_{iA} the attribute values for alternative A as viewed by the decision maker i , and S_A is the vector of socio-economic characteristics of decision maker A, such as income, age and education. ε_{iA} (the unobservable components) is assumed to be a joint probability distribution and is iid (independently and identically distributed, i.e., the choice probability of alternative A is only a function of the difference between the utility of alternative A and that of alternative B).

Transportation choice models can be classified, according to the data characteristics, into two categories: aggregate model (AM) and disaggregate model (DM). The aggregate model is based on aggregated data, in particular, the demographic data such as average household income, average household car numbers, and total travel trips in a region, whereas the disaggregate model is based on each individual household data. The aggregate model focuses on the statistical data whereas the disaggregate data model focuses on behaviour analysis ([Lin, 2000](#)). Where behaviour analysis is concerned, disaggregate model (DM) has several advantages over aggregate model (AM): DM is based on the analysis of individual behaviour, it has better prediction power, it can accommodate more variables (including social economic and service level variables), and it can contribute to better policy decision-making. Since DM surveys are based on individuals or households, sufficient information can be collected to make pairwise comparison between different individuals. Moreover, DM survey and calculation costs are lower than those of AM when the same prediction accuracy is desired.

Transportation survey data can be divided into revealed preference (RP) and stated preference (SP). RP and SP data each have their own advantages and limitations with respect to estimation of behavioural parameters of interest ([Bhat & Castelar, 2002](#)). RP is obtained by recording actual decisions made by agents in an economic environment of interest. Historically used in the transportation research field to analyse travel demand, RP focuses on estimating how people value observable attributes of choice alternatives. SP observations are obtained by having respondents indicate their selections among possible alternatives in hypothetical choice situations ([Leitham, McQuaid, & Nelson, 2000](#)). SP has also been used to model respondents' choice behaviour with hypothetical alternatives ([Ben-Akiva & Lerman, 1985](#); [Brownstone, Bunch, & Train, 2000](#)). These two methods enable the analyst to extract invaluable, in-depth information from respondents.

The strength of modelling with RP data lies in the fact that the data is based upon the individual's actual market behaviour, and therefore reflects actual behaviour under actual conditions. However, the RP model cannot include respondents' perceptions in the questionnaire design ([Caldas & Black, 1997](#)). In contrast, it is possible to model respondents' choices with stated preference (SP) data, since choice set is under the control of the researcher, enabling analysts to extract respondents' preferences from multiple responses in different choice situations and reactions to combinations of attributes that are impossible to observe in the RP model. These features also make it possible to use the SP model for modelling new alternatives without having to make the assumptions that are required in the RP model ([Ben-Akiva & Lerman, 1985](#)). One major limitation, however, of the SP model is the fact that people often do not actually do what they say they would do under hypothetical circumstances. Moreover, the survey description of product attributes and purchase context may differ from that perceived in the actual market. Although the SP model does provide potentially valuable information to predict how people will actually act, it does incorporate sources of error in the prediction of behaviour.

⁶ Logit is a probability function and is used to forecast how a passenger will choose between alternative modes or routes. The simplest form is the Binomial Logit which considers only two choices.

⁷ The first application of the Logit model in transportation research was by [Warner \(1962\)](#) who used the Chicago survey data to set up a Binary Logit Model for work/non-work passenger trips.

The present study examines student–commuters' transportation mode-choice behaviour analysis before/after a major air accident in the Taiwan Strait near Penghu County in 2002. Disaggregate data are collected from each individual student through questionnaires surveys. Mode-choice questions in the first and third round questionnaire reveal students' actual commuting modes choice. Questions in the second round questionnaire immediately after the air-crash reflect students' hypothetical transportation mode-choice. Therefore, the disaggregate/RP binary logit model is employed to complete first and third rounds of this study.

4. Research design, questionnaire design, data sources and sample formation

Because this study intended to study student–commuters' change in their transportation mode-choices before and after a major air-crash through three rounds of questionnaires surveys, questionnaires distribution timing was critical to the success of this empirical research. The details of research design and timing are shown in Fig. 1.

Complicated questions would reduce the questionnaires' return rate; simple questions would reduce the possibility for further in-depth research analysis. How to find a balance between the two always challenges empirical researchers. Carefully

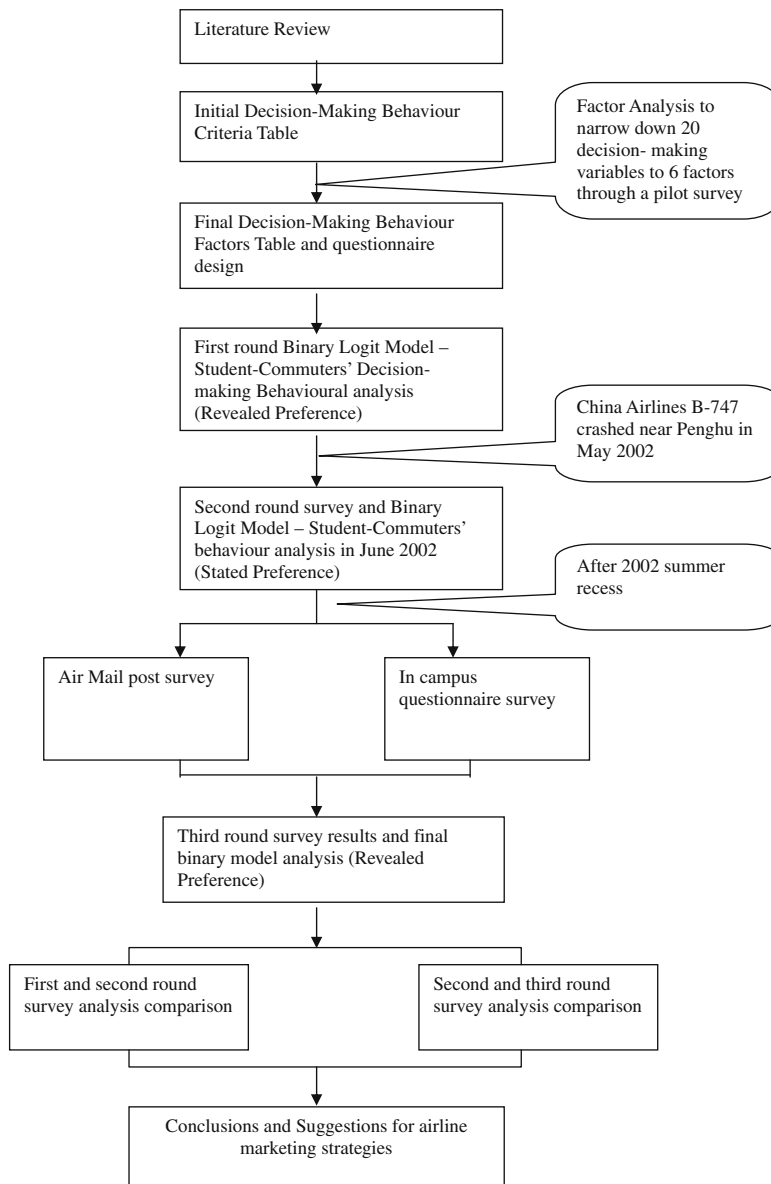


Fig. 1. Research design and questionnaire distribution timing.

Table 2

Importance of variables influencing 100 student–commuters' travel mode-choice in the Penghu Islands.

Before the CI 611 air-crash on 26 May 2002			After the CI 611 air-crash on 26 May 2002		
Ranking	Service variables	Mean	Ranking	Service variables	Mean
1	In-vehicle time	8.22	1	Residency location in Taiwan	7.88
2	Flexibility ^a	7.3	2	In-vehicle cost	7.63
3	Punctuality of vehicle	7.1	3	Travel safety	7.46
4	In-vehicle cost	6.6	4	In-vehicle time	7.06
5	Connecting transportation time	6.3	5	Flexibility ^a	6.66
6	Terminal service quality	6.11	6	Image of vehicle	6.09
7	In vehicle service quality	6.05	7	Terminal service quality	5.86
8	Travel safety	6.0	8	In vehicle service quality	5.77
9	Access/egress to airport/port	5.96	9	Ease of purchasing a ticket ^c	5.57
10	Out of vehicle cost	5.9	10	Punctuality of vehicle	5.54
11	Owner of a private vehicle	5.8	11	Student's disposable monthly living allowance	5.51
12	Image of vehicle providers	5.78	12	Out of vehicle cost	5.49
13	Residency location in Taiwan	5.56	13	Access/egress to airport/port	5.37
14	Student's disposable monthly living allowance	5.21	14	Connecting transportation time	5.31
15	Reliability of vehicle	5.2	15	Household income	5.17
16	Household income	5	16	Reliability of vehicle	5.09
17	Comfort of vehicle	4.69	17	Airport/port terminal waiting time	5.03
18	Ease of booking ^b	4.61	18	Comfort of vehicle	4.91
19	Airport/port terminal waiting time	4.49	19	Ease of booking ^b	4.74
20	Ease of purchasing a ticket ^c	4.36	20	Owner of a private vehicle	4.23

Note: Mean scores based on a nine-point scale of importance (9 = very important to 1 = very unimportant).

^a There are more than 50 daily flights (from 07:25 to 19:55) between the Penghu Islands and Taiwan's mainland, but only one passenger ferry departs daily between these two locations.

^b There is a strong monsoon between November and March in the Penghu Islands. April–September is the tourist high season, and commuters have to compete with the tourists when booking to secure a seat to go home. It can sometimes take more than 50 min to get through to make a telephone call to book a seat.

^c The passenger ferry does not have an on-line purchasing ticket service whereas some airlines do.

considered questionnaire design could reduce problems the researcher might face in the later writing up stages. A pilot study surveying 100 students was carried out, and the results were further refined by employing factor analysis to determine the final questionnaire (see below).

4.1. Questionnaire design

No literature analysing airline commuters' travel behaviour after an airline catastrophe had occurred was found, therefore, the variables needed for model specification could only be partly determined by referring to previous similar studies discussed in Section 2. Twenty variables were found to be relevant and they were used to set up the model after literature review and interviews with students. A five-member panel composed of academicians from the National Taiwan Ocean University (NTOU) and the National Penghu University (NPU) was formed to summarise and verify the 20 variables needed to specify the models (see Table 2).

Two very obvious changes after the 2002 Penghu air-crash were: (1) the travel safety variable moved from a ranking of 8 to a ranking of 3 and (2) image of vehicle providers moved from a ranking of 12 to a ranking of 6. The mean score of the travel safety variable increased from 6.0 before the crash to 7.46 after the air-crash. This was the largest mean score increase prior to and post the aircraft accident.

A pilot study of 100 NPU students was implemented and factor analysis with VARIMAX rotation was carried out to reduce the 20 variables to a smaller number of factors suitable for the student–commuters' transportation mode-choice questionnaire surveys. Six factors were found to have an eigenvalue greater than one in the analysis (see Fig. 2 and Table 3). Therefore, the 20 variables could be appropriately categorised into 6 factors (see Table 4), which were used in designing the final questionnaire. In order to find the decision-making behaviour difference before and after a major air catastrophe in the Penghu area, questionnaire content remained unchanged in the first, second and third rounds of the survey.

One of the major functions of factor analysis is to cluster similar variables into one factor; therefore there existed little correlation between the six factors, which is desired when applying binary logit analysis. Variance explained by each of the six factors is listed in Table 3 and is explained further below.

Factor 1: "General attributes of vehicle-related service quality" accounted for 40.46% of the total variance. There were six variables in this factor. Among them 'reliability of vehicle' and 'flexibility' had the highest factor loading on this factor.

Factor 2: "Income status of the student and his/her parents" was composed of three service variables. Of these, 'Disposable monthly allowance' of the students and his/her parents had the highest factor loading.

Factor 3: "Total trip cost" included in-vehicle cost and out of vehicle cost, for example, the air/ferry fare, and the taxi cost to an airport/port.

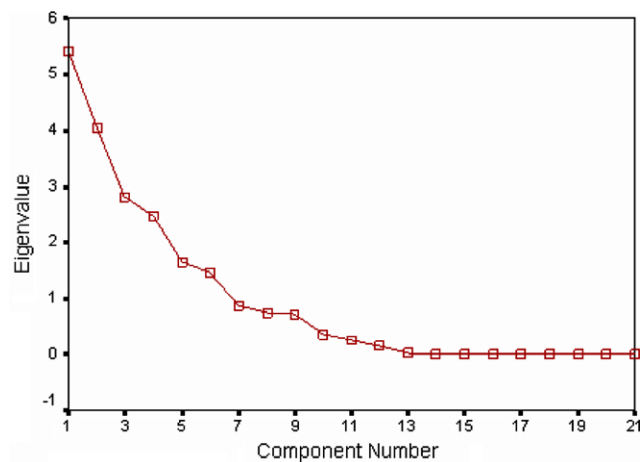


Fig. 2. Scree plot and factor analysis of transportation mode-choice criteria.

Table 3

Commuters' transportation mode-choice criteria.

Choice criteria	Factors					
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Reliability of vehicle	92 ^a	6	2	5	12	2
Flexibility	76 ^a	-11	-6	10	9	51
Terminal service quality	73 ^a	50	32	-16	18	-9
In vehicle service quality	71 ^a	44	-6	-29	22	-34
Comfort of vehicle	68 ^a	-4	58 ^a	13	7	8
Punctuality of vehicle	57 ^a	-37	33	-16	50	14
Students' monthly allowance	31	88 ^a	-26	-12	-7	-6
Household income	16	86 ^a	32	22	-7	4
Owner of a private vehicle	-17	79 ^a	-26	43	-2	22
In-vehicle cost	-9	-5	95 ^a	30	-6	7
Out of vehicle cost	11	-6	87 ^a	44	23	-15
Connecting transportation time	-20	7	11	94 ^a	-10	-2
Access/egress to airport/port	18	59 ^a	-16	69 ^a	-1	-21
Residency location in Taiwan	-50	-18	-15	62 ^a	26	-19
In-vehicle time	5	2	5	-33	90 ^a	4
Airport/port waiting time	34	16	24	4	70 ^a	-44
Ease of booking	3	-26	36	-58 ^a	59 ^a	20
Image of vehicle/service providers	42	22	19	-9	-12	80 ^a
Vehicle safety	-7	-27	15	42 ^a	-11	60 ^a
Variance explained by each factor	40.46	3.38	2.88	2.85	2.43	2.23

^a In a sample of 100 respondents, factor loadings of 0.55 and above are considered to be significant (Hair, Anderson, Tatham, & Black, 1995).

Table 4

Six factors summarised from 20 variables.

Factor 1	General attributes of vehicle-related service quality
Factor 2	Income status of the student and his/her parents
Factor 3	Total trip cost
Factor 4	Ease of access to other connecting transportation modes
Factor 5	Vehicle-related time (including booking time, ticket purchasing time, terminal waiting time, and in-vehicle time)
Factor 6	Safety images of transportation modes perceived by students

Factor 4: "Ease of access to other connecting transportation modes" comprised connecting transportation time, access/egress to airport/port, and residency in Taiwan.

Factor 5: "Vehicle related time" consisted of the time spent in the vehicle, airport/port waiting time, booking time and ticket purchasing time.

Factor 6: "Safety image of transportation modes perceived by students" included image of vehicle/service providers and vehicle's safety variables. Of these, image of commuting service providers had the highest loading factor. Factor 6 accounted for only 2.23% of the total variance.

4.2. Data sources and samples formation

Lin (2000) quotes Richards and Ben-Akiva (1974) who state that the prediction power of a logit model will attain a satisfactory standard if the sample size is more than 300. Stone and Rasp (1991) maintain that the logit model will achieve a satisfactory result with a sample size above 200 when compared with the linear regression model. More than 70% of NPU students travel between Taiwan's mainland and Penghu, and most of them travel at least four times or more by ferryboat or aeroplane each academic year. An initial study of students' travelling mode-choice focused on 300 undergraduate students randomly selected from six different academic departments in the NPU. Two hundred and sixty-six fully completed questionnaires were returned by students after distribution and collection by teachers. An initial research result report was completed in January 2002.

4.3. A three stages questionnaire survey⁸

An aeroplane catastrophe which happened near the Penghu region in May 2002 inspired the author to follow-up the previous research to check whether student-commuters' transportation mode-choice behaviour had changed or not. A fortnight after the Penghu air-crash, 266 questionnaires were sent to these same surveyees and 250 questionnaires were returned fully completed due to cooperation between teachers and students. However, only 220 questionnaires could be used for a comparison of student-commuters' behaviour before and after the crash because of incomplete data.

A third round survey was carried out after the 2002 summer recess to assess whether there were further changes in the student-commuters' actual travel decision behaviour. About 45% of previous respondents had been in their final year at the college and had graduated in the summer of 2002. It was therefore difficult personally contacting these students to undertake a further follow-up survey. Third round questionnaires were sent through the post to them. However, the return rate was below 10% for second-round respondents who had graduated in the summer of 2002. In total, 10 fully completed questionnaires were returned by post and 121 in-campus questionnaires were returned, 102 of them were fully completed.

5. Model specification and three step binary logit analysis

5.1. Three step binary logit analysis

Carrying out the questionnaire survey at different times could possibly result in different survey results. The second round survey, carried out immediately after the major air-crash accident, could only ascertain students' stated preference toward the transportation mode they would choose when they next went back to Taiwan's mainland. The first and third surveys were revealed preference surveys, since they indicated the actual transportation mode selected by students before and after the major Penghu air-crash in 2002.

5.2. Model specification

Model specification is a process of empirical model development which requires many intuitive model-building judgments (Ben-Akiva & Lerman, 1985). The most appropriate model specification should include the specification of relevant variables, estimation of utility function, and test of utility function.

Taking into account all the six factors influencing commuters' transportation mode-choice, the author set up the model specification as shown in Table 5.

Different combinations of the above seven variables were tested and the model specification in Table 5 shows the highest ρ^2 (=0.58); and 89.5% of the mode-choice is correctly predicted. Total trip cost has a significant influence on transportation mode-choice at the 10% significance level; household income has a positive influence on commuters' choice of the air transport mode at the 10% significance level. β_1 has a negative coefficient and is also significant at the 10% significance level (two tailed test), indicating that everything else being equal, commuters would choose the aeroplane instead of the ferry ship service.

6. Research findings

Before the 2002 air-crash near Penghu, student-commuters in the NPU showed a significant preference for an airline service (every other factor being equal), although the ferry ship service had a significant cost advantage over airlines for these commuters and higher household income had a significant positive impact on commuters' choice of the air transport mode (see Table 5).

A fortnight after the 2002 air-crash near Penghu, commuters who had never used the ferry service before began to consider using the surface transportation mode as an alternative commuting choice. Although they were aware of the great trip time difference between the two types of transportation mode (significant at the 5% significance level), they started to show

⁸ All the questionnaire surveys and data were implemented and collected by the author.

Table 5

Model specification 1 (before the 2002 Penghu air-crash accident).

Variables column	Alternative specific constant	Generic variables				Alternative-specific socioeconomic variables β_6 (household income)	Alternative specific constant (dummy) β_7
		β_1	β_2	β_3 (total trip cost)	β_4		
Aeroplane utility	0	Airline's related service quality level (max value is 5, 5 is best)	Airline's total round trip cost (NTD)	Ease of access to the connecting transportation modes to the aerodrome (max value is 5, 5 is the easiest)	Airline trip duration (Mins.) (time spent in booking/ticketing, terminal waiting, and in-vehicle time)	Income status (household income)	Worry about flight safety or not (1 if yes, 0 if no)
Ship utility	1	Ferry company's-related service quality level (max value is 5, 5 is best)	Ferry total round trip cost (NTD)	Ease of access to the connecting transportation modes to the port (max value is 5, 5 is the easiest)	Ferry trip duration (Mins.) (time spent in booking/ticketing, terminal waiting, and in-vehicle time)	0	0
Estimated coefficients	−15.55468	0.74251	5.05614e−003	5.54323e−002	3.03622e−003	2.36679e−004	−0.92946
t-Statistics	−3.12599*	1.13789	2.20237*	8.29865e−002	0.42968	2.78889*	−0.85639

NTD: New Taiwan Dollar (one-way fares for ferry and airlines are 18 USD and 39 USD, respectively, between Kaohsiung and Penghu).

Mins.: Minutes (one-way sailing time and flying time between Kaohsiung and Penghu are 270 min and 35 min, respectively).

Booking time: Time spent making a reservation.

Ticketing time: Time spent purchasing and picking-up a ticket.

Civil flight safety records are exhibited as the number of passenger deaths per million enplanement, the records are 0.11, 0.00, 0.00, 8.35, 0.00, 0.00, and 0.00 for year 1999, 200, 2001, 2002, 2003, and 2005, respectively (Source: http://www.asc.gov.tw/author_files/statistics96-05).

* Significant at the 0.10 level.

Table 6
Model specification 2 (A fortnight after the 2002 Penghu air-crash accident).

Variables column	Alternative specific constant	Generic variables				Alternative-specific socioeconomic variables	Alternative specific constant (dummy)
		β_2	β_3	β_4	β_5 (Total trip time)		
Mode	β_1	β_2	β_3	β_4	β_5 (Total trip time)	β_6	β_7
Aeroplane utility	0	Airline's related service quality level (max value is 5, 5 is best)	Airline's total round trip cost (NTD)	Ease of access to the connecting transportation modes to the aerodrome (max value is 5, 5 is the easiest)	Airline trip duration (Mins.) (time spent in booking/ticketing, terminal waiting, and in-vehicle time)	Income Status (household income)	Worry about flight safety or not (1 if yes, 0 if no)
Ship utility	1	Ferry company's lated service quality level (max value is 5, 5 is best)	Ferry total round trip cost (NTD)	Ease of access to the connecting transportation modes to the port (max value is 5, 5 is the easiest)	Ferry trip duration (Mins.) (time spent in booking/ticketing, terminal waiting, and in-vehicle time)	0	0
Estimated coefficients	–2.44192	–2.22004e–002	8.26279e–004	–0.24853	–5.88745e–003	5.18170e–005	–3.44965
t-Statistics	–1.09926	–6.34119e–002	0.76298	–0.65519	–1.88657**	1.96351*	–4.30021*

NTD: New Taiwan Dollar.

Mins.: Minutes.

Booking time: Time spent making a reservation.

Ticketing time: Time spent purchasing and picking-up a ticket.

* Significant at the 0.10 level.

** Significant at the 0.05 level.

Table 7

Model specification 3 (after four months, including a 2 months' summer recess, from the 2002 Penghu air-crash accident).

Variables column	Alternative specific constant	Generic variables				Alternative-specific socioeconomic variables β_6 (household income)	Alternative-specific constant (dummy) β_7 (worry about safety)
		β_2	β_3	β_4	β_5 (total trip time)		
Mode	β_1						
Aeroplane utility	0	Airline's related service quality level (max value is 5, 5 is best)	Airline's total round trip cost (NTD)	Ease of access to the connecting transportation modes to the aerodrome (max value is 5, 5 is the easiest)	Airline trip duration (Mins.) (time spent in booking/ticketing, terminal waiting, and in-vehicle time)	Income status (household income)	Worry about flight safety or not (1 if yes, 0 if no)
Ship utility	1	Ferry company's lated service quality level (max value is 5, 5 is best)	Ferry total round trip cost (NTD)	Ease of access to the connecting transportation modes to the port (max value is 5, 5 is the easiest)	Ferry trip duration (Mins.) (time spent in booking/ticketing, terminal waiting, and in-vehicle time)	0	0
Estimated coefficients	−2.45035	−0.20550	−5.84583e−004	−3.52225e−002	−5.01577e−003	8.05155e−005	−2.44228
t-Statistics	−1.11511	−0.57828	−0.60699	−9.28803e−002	−1.74356**	2.66349*	−2.63302*

NTD: New Taiwan Dollar.

Mins.: Minutes.

Booking Time: Time spent making a reservation.

Ticketing time: Time spent purchasing and picking-up a ticket.

* Significant at the 0.10 level.

** Significant at the 0.05 level.

more concern about the apparent danger of the air transport mode and some worried about flight safety (significant at the 10% significance level). Higher household income still had a positive influence on commuters' choice of the air transport mode (see Table 6). However, most student–commuters when they completed the second round of questionnaires surveys had not yet commuted between Taiwan's mainland and Penghu after the air-crash. Thus, they had only stated their preferred transportation mode-choice in the information that was subsequently collected and analysed.

Questionnaires with exactly the same content were distributed to the same student population a fortnight after a major air-crash near Penghu. Different combinations of the above seven variables were tested and the model specification in Table 6 shows the highest ρ^2 (=0.46), and 79.7% of the mode-choice is correctly predicted. Total trip time has a significant influence on the transportation mode-choice at the 5% significance level (two tailed test), and household income has a positive influence on student–commuters' selection of the air transport mode at the 10% significance level. β_7 has a negative coefficient and is also significant at the 10% significance level (two tailed test). Indicating that everything else being equal, 'worry about flight safety' has a negative impact on student–commuters' choice of aeroplane service.

Four months after the air-crash near Penghu (including a two months' summer recess), almost all students had had their first experience of commuting between Taiwan's mainland and Penghu. The follow-up questionnaires were distributed to the same student population. Some of the students had graduated and questionnaires were posted to them. The return rate of questionnaires from graduated students was low. Revealed preference information analysis indicates that β_5 (trip time), β_6 (household income), and β_7 (worry about flight safety) had the same pattern of influence as stated preference information immediately after the Penghu air-crash (see Table 7).

Different combinations of the above seven variables were tested, and the model specification in Table 7 shows the highest ρ^2 (=0.43), and 81.1% of the mode-choice is correctly predicted. Total trip time has a negative and significant influence on ferry mode-choice at the 5% significance level (two tailed test); and household income still has a positive influence on commuters' choice of the air transport mode at the 10% significance level. β_7 still has a negative value and is also significant at the 10% significance level, signalling that 'worry about flight safety' has a significant negative impact on commuters' choice of airline as a transportation mode.

The research findings confirms Borenstein and Zimmerman's (1988) arguments, they have indicated that consumers may interpret an recent air-crash as evidence that flying is generally more dangerous than previously they thought. Then industry-wide demand will be decreased and all airlines suffer from one carrier's accident, and all airlines may have common interest to enforce strict and common safety standards.

7. Conclusions

Airlines' marketing campaigns after a major air transport catastrophe traditionally focus on price competition due to weak passenger demand. However, NPU student–commuters indicated in the survey findings that trip time, household income and worry about flight safety had a significant influence on their preferred transportation mode-choice when surface and air transport modes were considered. The former two factors are beyond the control of the airlines but the last factor, flight safety, is not and should therefore be the focal point of airlines' marketing campaigns after an airline crash and not competitive pricing.

The quick and accurate finding of causes of airline accidents and an efficient response to prevent them happening again are common practices among airlines, and can help reduce passengers' worries about flight safety. A previous research by Boin, van Duin, and Heyse (2001) also indicated uncertainty and lack of adequate information of a disaster will strongly influence the fear afterwards and, as a consequence, the level of psychological stress. In addition, sponsorship of air transport education, seminars, and conferences can all have positive effects and help student–commuters to more accurately assess actual flight risk, especially since air transport has the lowest accident fatality rate among all kinds of transportation modes (Gigerenzer, 2004; Myers, 2001).

The two after-crash questionnaire surveys showed the same pattern of mode-choice. The stated preference of student–commuters could be utilised to predict their actual transportation choice behaviour in the future, and this finding could be useful for implementing relevant airline marketing strategies.

This research has only focused on regional student–commuters' responses to an air-crash within a short period of time. Long-term observation of the behaviour of non-student–commuters could have more effective marketing implications from the airlines' point of view.

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