Statistical analysis of airline passengers' perceived accident risk

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Outline

1. Introduction
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Introduction (1/3)

- Air transportation has been recognized as a very safe transportation mode.
- However, aircraft accidents are often involved in explosion or high-speed crashes, the perceived survival rate was relatively low.
- Consequently, the general public may perceive that the majority of aviation accidents are not survivable.

Introduction (2/3)

- On the other hand, passengers usually pay a little attention to safety briefing.
- Take Naha accident for an example.
- It revealed that severity levels of aircraft accidents can be significantly reduced if appropriate safety procedures can be correctly applied.

Introduction (3/3)

- This study presents a survey of airline passengers' perceived risks of being involved in various aircraft accidents.
- Statistical comparisons are conducted to examine the differences between airline passengers' perceived risk and average actual survival rate.
- Additionally, this study conducted before-and-after comparisons to investigate the difference of time length that passengers focus on cabin safety information.

Data Collection (1/2)

- In order to compare the passenger's perceived risk and actual aircraft accident risks, two data need to be collected.
  - Aircraft accident records of passenger planes:
    - Source: Aviation Safety Network (ASN)
    - Date: between 1988 and 2007
    - Accident type:
      - Turbulence
      - Hijack
      - Bird strike
      - Fire
      - Engine failure

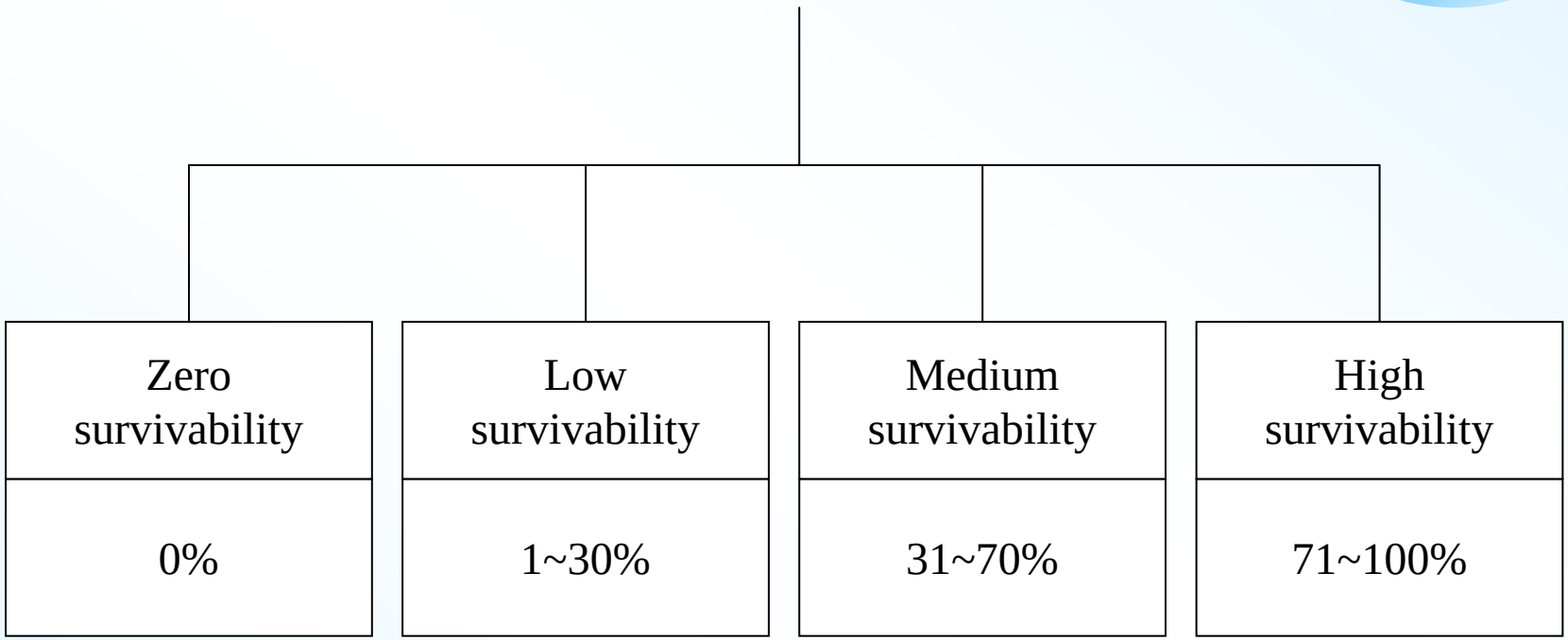
Data Collection (2/2)

- Questionnaire design:
  - Target: airline passengers who had ever travelled by airplane
  - Content:
    - Airline passengers' comprehension to cabin safety information
    - Airline passengers' perceived accident risk
    - Passengers' socio-economic characteristics
  - Approach: Internet
  - Date: between January 20, 2008 to January 26, 2008
  - Number of sample: 563 questionnaires were returned and 531 were available

Method (1/5)

- In this study, multinomial logit models were used to analyze the factors that influence passengers' perceived risks towards a specific type of accident.
- The perceived risk was ranked 11 by categories (i.e., 0%, 1-10%, 11-20%, … and 91-100%).
- To simplify the analysis, the perceived risk was rescaled to different categories.
- Rescaling to four categories can result in a better model fit as indicated by a higher likelihood ratio index.

Method (2/5)



Logit modeling structure for airline passengers' perceptions of survivability

Method (3/5)

- A statistical model can be derived to determine the probability of an aircraft accident having a specific perceived survivability level.

$$\Pr_n(i) = Pr(S_{in} \geq S_{In}) \quad \forall \ I \neq i \qquad (1)$$

∗ $\Pr_n(i)$ is the probability of airline passenger n having perceived survivability category i

∗ Pr denotes probability

∗ S_{in} is a function of attributes or variables that determine the probability of having perceived survivability likelihood i for the airline passenger n

∗ I is the set of possible perceived survivability categories

Method (4/5)

- A linear function of variables that determine the perceived survivability likelihood :

$$S_{in} = \beta_i X_n + \varepsilon_{in} \qquad (2)$$

∗ **X***n* is a vector of measurable characteristics that determine the airline passengers' perception of survivability

∗ βi is a vector of statistically estimable coefficients

∗ ε_{in} is an error term that accounts for unobserved factors influencing survivability

Method (5/5)

- Given equations 1 and 2, the equation 3 can be written:

$$\Pr_n(i) = \Pr(\beta_i X_n - \beta_{In} X_n \geq \varepsilon_{In} - \varepsilon_{in}) \quad \forall \quad I \neq i \qquad (3)$$

- if ε_{in} 's are assumed to be generalized extreme value distributed, then the probability of an airline passenger chooses four survivability categories is given by the standard multinomial logit model.

$$\Pr_n(i) = \exp[\beta_i X_n] / \sum_I \exp[\beta_I X_n] \qquad (4)$$

Analysis Results

- Descriptive statistics
- Model estimation results
- Comparison of airline passengers' perceptions of survivability with actual survival rate
- Before-and-after analysis for attention paid to cabin safety information

Descriptive statistics-

Airline passengers' comprehension to cabin safety information (1/2)

Variable (Symbol)	Category	Proportion	
		Before	After
Have respondents travelled by airplane before/after Naha accident. (BEXP/AEXP)	Yes	69.11 %	26.55%
	No	30.89 %	73.45%
Number of trips by airplane before/after Naha accident. (a round trip counted as two times) (BFREQ/AFREQ)	Mean	12.34	3.86
	Deviation	24.91	3.87
The proportion time of the length of the safety film would respondents spent on the plane before/after Naha accident. (BLGH/ALGH)	0%	10.90%	11.35%
	1~10%	12.26%	11.35%
	11~20%	13.90%	12.77%
	21~30%	9.54%	7.09%
	31~40%	11.71%	9.93%
	41~50%	9.54%	7.80%
	51~60%	4.63%	6.38%
	61~70%	3.54%	5.67%
	71~80%	4.09%	6.38%
	81~90%	4.09%	7.09%
	91~100%	15.80%	14.19%

Descriptive statistics-

Airline passengers' comprehension to cabin safety information (2/2)

Variable (Symbol)	Category	Proportion	
		Before	After
The understanding degree of the safety information after respondents saw the safety film on the plane before/after Naha accident. (BUND/AUND)	Misunderstand strongly	4.63%	5.67%
	Misunderstand	11.44%	10.64%
	Normal	49.87%	34.04%
	Understand	29.97%	45.39%
	Understand strongly	4.09%	4.26%
Does the Naha accident affect respondents' notice about safety information? (ATN)	Yes	72.32%	
	No	27.68%	
How to encourage respondents to pay attention to safety information. (multiple choice) (WAY)	The safety card shows by images and annotations	49.53%	
	The safety card shows by caricature	39.17%	
	Announced by the captain on public address system	18.83%	
	Announced by cabin crews on public address system	36.16%	
	Shows by animation film	57.82%	
	The safety film shoots by a celebrity	28.25%	
	Shows as a airhostess	51.60%	
	Advertises by airhostess gracious	58.57%	
	Other	0.94%	

Descriptive statistics-

Airline passengers' perceived accident risk (1/1)

Type	Category (%)										
	0 %	1 | 10 %	11 | 20 %	21 | 30 %	31 | 40 %	41 | 50 %	51 | 60 %	61 | 70 %	71 | 80 %	81 | 90 %	91 | 100 %
Hijack (HIJ)	1.88	3.39	4.71	3.95	4.90	19.40	11.30	10.73	16.38	15.07	8.29
Bird strike (BDS)	1.88	3.20	4.90	5.46	4.52	10.36	10.92	11.30	15.25	18.08	14.12
Turbulence (TBE)	0.75	1.13	0.75	1.32	1.88	3.58	2.07	5.65	12.24	28.44	42.18
Engine failure (EGF)	5.65	9.04	12.24	12.43	11.11	16.57	9.60	9.04	7.91	4.14	2.26
Fire (FRE)	4.33	12.05	12.43	13.18	12.05	16.95	11.30	7.72	5.27	3.77	0.94

Descriptive statistics-

Passengers' socio-economic characteristics (1/2)

Variable (Symbol)	Category	Proportion
Gender (GEN)	Male	61.77%
	Female	38.23%
Age (AGE)	Under 20	7.53%
	21~30	83.24%
	31~40	6.78%
	41~50	1.51%
	51+	0.94%
Occupation (OCC)	Industry	9.23%
	Business	9.23%
	Government employee	4.71%
	Service	13.75%
	Student	59.70%
	Other	3.39%

Descriptive statistics-

Passengers' socio-economic characteristics (2/2)

Variable (Symbol)	Category	Proportion
Individual income (monthly) (INC)	Under NTD20,000	61.96%
	NTD 20,000~39,999	25.05%
	NTD 40,000~59,999	9.04%
	NTD 60,000~79,999	1.88%
	Over NTD 80,000	2.07%
Education level (EDU)	High school	4.14%
	College/university	54.80%
	Post graduate	41.05%
Marital status (MRS)	Single	92.28%
	Married	7.72%

Model estimation results (1/7)

Variable	Estimated Coefficient (t-statistic)				
	Model HJK	**Model FRE**	**Model BDS**	**Model TBE**	**Model EGF**
Constant [L]	1.29(3.03)	2.11(5.73)	2.45(3.75)	1.15(2.00)	0.96(3.30)
Constant [M]	2.38(5.58)	2.91(4.94)	4.41(5.34)	2.34(3.97)	3.24(5.33)
Constant [H]	2.29(5.45)	2.12(3.34)	5.47(7.35)	4.57(8.09)	1.91(2.56)
Airline passengers' experience variables					
BEXP (1 if yes,0 otherwise) [Z, M]		0.53(2.67)			
BEXP (1 if yes,0 otherwise) [M, H]	0.55(1.95)				
BLGH (1 if average rate of watching the film is 0%) [Z]		0.73(2.10)	0.84(2.05)		
BLGH (1 if average rate of watching the film is 0%) [L]	0.96(2.14)	0.73(2.10)	0.84(2.05)		
BLGH (1 if average rate of watching the film is 0%) [H]			0.84(2.05)	2.09(2.57)	
BLGH (1 if average rate of watching the film is below 30%) [Z, L, M]					0.74(2.88)
BUND (1 if misunderstand) [L, M, H]		0.89(1.70)			
BUND (1 if understand strongly) [M, H]					1.48(2.03)

[Z] zero survivability, [L] low survivability, [M] medium survivability, [H] high survivability.

Model estimation results (2/7)

Variable	Estimated Coefficient (t-statistic)				
	Model HJK	**Model FRE**	**Model BDS**	**Model TBE**	**Model EGF**
Airline passengers' experience variables					
AEXP (1 if yes, 0 otherwise) [Z, L]			1.22(2.55)		
AEXP (1 if yes, 0 otherwise) [L, M]					0.45(1.65)
AEXP (1 if yes, 0 otherwise) [M, H]				2.28(2.20)	
AFREQ [Z, L]		1.21(2.37)			
AFREQ [L, M]			0.72(1.75)		1.62(2.84)
ALGH (1 if average rate of watching the film is 0%) [Z, L, M]				2.39(3.12)	
ALGH (1 if Average rate of watching the film is up to 71%) [Z, L]					1.03(2.88)
AUND (1 if misunderstand) [Z, L]			1.16(2.20)		
AUND (1 if understand strongly) [L, H]					2.63(2.26)
ATN (1 if yes, 0 otherwise) [L, H]					0.38(1.87)

Model estimation results (3/7)

Variable	Estimated Coefficient t-statistic)				
	Model HJK	**Model FRE**	**Model BDS**	**Model TBE**	**Model EGF**
Way variables					
WAY(1 if the safety card shows by images and annotations) [M, H]	0.56(2.06)				
WAY(1 if the safety card shows by caricature) [M, H]		0.34(1.84)		1.03(1.90)	
WAY(1 if announced by cabin crews on public address system) [Z, L]	0.76(2.76)				
WAY(1 if the safety information shows by animation film) [Z, L, M]			0.32(1.82)		
WAY(1 if the safety information shows by animation film) [L, M]		0.92(2.03)			
WAY(1 if the safety information shows by animation film) [H]	0.31(1.66)	0.92(2.03)			
WAY(1 if the safety film shoots by a celebrity) [Z, M]					0.35(1.76)
WAY(1 if the safety film shoots by a celebrity) [M, H]		0.43(2.05)			

Model estimation results (4/7)

Variable	Estimated Coefficient t-statistic)				
	Model HJK	**Model FRE**	**Model BDS**	**Model TBE**	**Model EGF**
Way variables					
WAY(1 if the safety information Shows as a airhostess) [Z, L, H]		0.30(1.65)			
WAY(1 if the safety information Shows as a airhostess) [L]	0.71(2.41)				
WAY(1 if the safety information was advertised by airhostess gracious) [Z]		0.92(3.03)	0.67(2.55)		
WAY(1 if the safety information was advertised by airhostess gracious) [L]		0.92(3.03)			0.69(3.07)
WAY(1 if the safety information was advertised by airhostess gracious) [M]	0.51(1.89)	0.92(3.03)	0.67(2.55)		0.69(3.07)
WAY(1 if the safety information was advertised by airhostess gracious) [H]	0.51(1.89)		0.67(2.55)		
WAY(1 if Other ways) [Z]			3.46(2.82)		

Model estimation results (5/7)

Variable	Estimated Coefficient t-statistic)				
	Model HJK	**Model FRE**	**Model BDS**	**Model TBE**	**Model EGF**
Airline passengers characteristics					
GEN (1 if respondent is female) [Z, M, H]	0.63(2.02)				
AGE (1 if respondent is at age of 20 or younger) [L]	1.42(3.47)				
AGE (1 if respondent is between 21 and 30 years old) [H]					0.78(1.83)
OCC (1 if the respondent is a worker) [Z]			2.39(3.42)	1.35(2.18)	
OCC (1 if the respondent is a worker) [L]				1.35(2.18)	
OCC (1 if respondent is a merchant) [Z, H]		0.69(1.93)			
OCC (1 if respondent is a merchant) [M, L]			1.05(1.86)		
OCC (1 if respondent is a public servant) [Z, L]				2.10(2.88)	
OCC (1 if respondent is a service industry) [Z, M, L]	1.46(1.97)			2.15(2.50)	
OCC (1 if respondent is a student) [L,M]	0.33(1.74)				
OCC (1 if respondent is engaged in other works) [Z, L]				2.15(2.50)	

Model estimation results (6/7)

Variable	Estimated Coefficient t-statistic)				
	Model HJK	**Model FRE**	**Model BDS**	**Model TBE**	**Model EGF**
Airline passengers characteristics					
INC (1 if individual monthly income is under NT $ 20,000) [L, M]				0.60(2.26)	
INC (1 if individual monthly income is between NT $ 40,000 and 59,999) [Z, L]			0.73(1.99)		
EDU (1 if the respondent has a Bachelor degree) [Z, M]		0.37(2.08)			
EDU (1 if respondent has a Master's degree or a Doctor) [L, H]					0.40(2.20)
MRS (1 if respondent is married) [L, M]	0.80(2.16)				
Number if observations	531	531	531	531	531
Log-likelihood at zero	-736.12	-736.12	-736.12	-736.12	-736.12
Log-likelihood at convergence	-531.62	-548.49	-544.03	-284.22	-548.49
ρ^2	0.28	0.26	0.26	0.61	0.20

Model estimation results-Model HJK (7/7)

Zero Survivability	Low Survivability	Medium Survivability	High Survivability
		had ever travelled by airplane before Naha accident	
	never watch the pre-recorded safety briefing before Naha accident		
		think the safety card shows by images and annotations	
think the cabin crews announce safety information			
		think the safety information shows by animation film	
think the safety information shows as a pretty airhostess			
		think the safety information was advertised by airhostess gracious	
female		female	
	under 20 years old		
service industries		service industries	
students			
	married		

Comparison of airline passengers' perceptions of survivability with actual survival rate (1/3)

- This table is 95% C.I of actual survivability data from ASN.

Accident type	Mean	Deviation	95%C.I	
			Low Bound	Upper Bound
Hijack	94.80	21.08	0.9081	0.9874
Bird strike	83.29	35.66	0.5347	1
Turbulence	73.93	45.70	0.3572	1
Engine failure	71.78	38.45	0.6250	0.8106
Fire	29.33	47.27	0	0.6314

Comparison of airline passengers' perceptions of survivability with actual survival rate (2/3)

- The actual survival rate for hijack is about 95% , which is classified as high survivability.
- On the other hand, there are 60% passengers thought the survival rate of hijack is under 70%.
- Apparently, passengers are pessimistic about the survivability of hijack.

Comparison of airline passengers' perceptions of survivability with actual survival rate (3/3)

- As for bird strike and turbulence accidents, the comparison results show that the passengers' perceived survivability and actual survival probability are fairly close.
- Turning to the perceived risk of engine failure and fire, the results show that about 40% passengers underestimated the actual survival rate of engine failure but 10% passengers overestimate the survivability of fire.

Before-and-after analysis for attention paid to cabin safety information (1/2)

- Method: Paired t test

$$\begin{cases} \mathrm{H}_0 : \ \mu_1 \geq \mu_2 \\ \mathrm{H}_1 : \ \mu_1 < \mu_2 \end{cases} \qquad (5)$$

- There are 121 respondents who had ever traveled by airplane both before and after Naha accident.
- The t test statistic is

$$t^* = \frac{\bar{d}}{\frac{s_d}{\sqrt{n}}} = -6.087 > t(120, 0.05) \ \Rightarrow \text{Reject } \mathrm{H}_0 \qquad (6)$$

Before-and-after analysis for attention paid to cabin safety information (2/2)

- Passenger's attention paid to cabin safety information after the event is significantly higher than those before the event.

Conclusion (1/2)

- Most of the passengers are aware of the risks of bird strike and turbulence.
- On the other hand, passengers tend to overestimate the risk by hijack and engine failure but underestimate the risk of plane fire.
- In addition, non-fatal Naha incident has a positive impact on passengers' attention toward the cabin safety information.

Conclusion (2/2)

- In terms of directions for future studies, how to make the cabin safety information more attractive to passengers might be useful.

Thank you for your attention!