

VARIOUS FACTORS AFFECTING MODAL CHOICE BEHAVIOR OF THE INTER-CITY PASSENGER BETWEEN KEIHANSHIN AND FUKUOKA

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Abstract: Comparison of passengers volume who traveled by the airline and high-speed railway, Shinkansen, show that airline passengers are increasing by various discounted fares were introduced after airfare deregulation in 1997. The questionnaire survey by the Internet was carried out about the person who moves between Keihanshin and Fukuoka in Japan. Most passengers were found to value the various factors by aggregating and analyzing valid response. In addition, the binary choice model was estimated so that we can consider the relationship on modal choice behavior and the factors passengers pay attention. From the result of this model, the factor is expected to the following; "line haul cost", "time out-of-vehicle" and "number of transfer". The hit ratio of this model which contains these factors is about 70 percent. Therefore, it is reasonable to say that this model is the best for explaining passengers' behavior.

Key Words: Intercity Passengers Travel, Logit Model

1. INTRODUCTION

1.1 Background

Most passengers who traveled between major cities in Japan use either airplane or high speed train (Shinkansen from now on). When we compare both of them, passengers demand for airplanes is being extended by having introduced various discounted fares such as tokuwari (special discounted fare) after the aviation deregulation in 1997 (Figure 1). On the other hand, the high speed train companies tended to introduce the new train service such as "Hikari rail star" in March, 2000 so as to attract more passengers. That is, although the various kinds of ticket is for airplanes, it may be said that there is nothing to the high speed train. Then, we considered that it is desirable for passengers to be able to choose various discounted fares.

1.2 Purposes of research

Purposes of this research are as follows;

(a) Analysis of factors affecting modal choice

It is important to consider why passengers choose the mode. Therefore, we clarify the factors affecting modal choice.

(b) The proposal of the new discount ticket in the high speed train

As the background of research also described, the high speed train does not have a discounted fare corresponding to a user's needs like an airplane. Therefore, we assume that a discounted ticket is temporarily introduced into the high speed train, and investigate the effect of introduction (market share change). Especially we focus on the change of demand and profit. Our case study is carried out for intercity travel between Keihanshin and Fukuoka. Keihanshin means metropolitan area of Osaka, which is second largest city in Japan. Fukuoka is the main city in Kyusyu islands and 4th largest city in Japan.

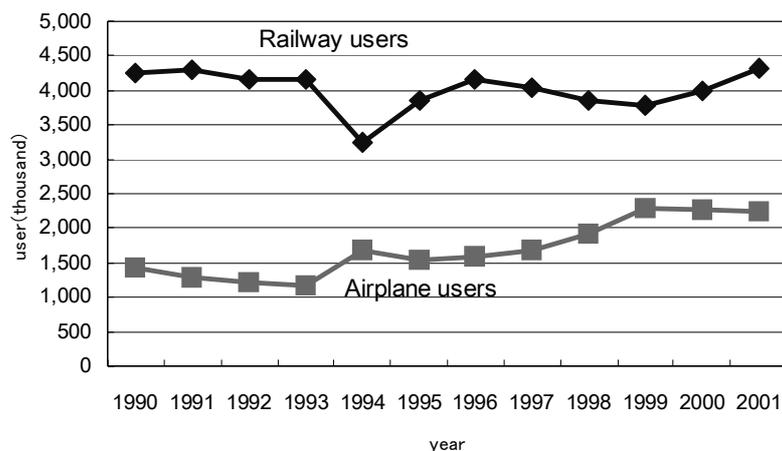


Figure 1. Number of Passengers between Keihanshin and Fukuoka

1.3 Contents of research

1. Introduction
2. Building hypothesis
3. Behavioral Survey
4. Result of survey, and hypothetical test
5. Analysis of factors for mode choice
6. Modeling passengers behavior by the Logit model
7. Forecasting demand
8. Conclusion

2. BUILDING HYPOTHESIS

The present fare and travel time required by the airplane and the high speed train are shown in Table 1. Hypothesizes from present condition analysis are as follows.

(Hypothesis A) Passengers concern more for egress than access. Both airplane travel and high speed train travel between Keihanshin and Fukuoka turn into prolonged one. Therefore, passengers concern more on egress than access when they consider modal choice. Because, travel after a passenger arrives at the airport or station is considerably accompanied by the feeling of fatigue, it is thought that the mode near the destination is chosen from an origin.

(Hypothesis B) Passengers who value shorter waiting time choose high speed train. Those who think the importance of waiting time expect shorter time required for waiting the high speed train. Therefore, they prefer high speed train even if it takes longer time for line-haul. There is difference on value of time.

(Hypothesis C) Purpose of travel affects modal choice

It is thought that the mode is different based on the purpose of travel.

(Hypothesis D) Business traveler prefers airplane.

Since the passenger whose purpose is business is more influenced by time than the people who have other purposes, he or she may prefer high speed train with high frequency of operation. The hypothesis results are shown in section 4.

Table 1. Characteristics of Modes for Case Study

Item	Airplane(Fukuoka-Osaka/Itami)	Shinkansen(Hakata-ShinOsaka)
Fare	18300yen Full fare	14890yen (Reserved seat)
	12800yen Tokuwari1	14590yen (Non-Reserved seat)
	16200yen Webwari	26600yen (Shinkansen Kyoto discount ticket)
		26200yen (Shinkansen Osaka discount ticket)
Line haul time	55minutes	150 minutes (Nozomi)
		165 minutes (Hikari Rail Star)
Frequency	15-240 minute interval (ANA/JAL)	8-40 minute interval
Access cost	250yen Fukuoka subway (Tenjin-Fukuoka airport)	200yen Fukuoka subway (Tenjin-Hakata)
Access time	About 10 minutes	About 5 minutes
Egress cost	490yen Airport Limousine bus (Osaka airport-ShinOsaka)	230yen Osaka city subway (ShinOsaka-Tanimachi4)
	230yen Osaka city subway (ShinOsaka-Tanimachi4)	
Egress time	(Osaka airport-ShinOsaka) About 25minutes (ShinOsaka-Tanimachi4) About 15minutes	(ShinOsaka-Tanimachi4) About 15minutes
Time outside vehicle	About 55 minutes	About 30 minutes
All time	About 160 minutes	About 205 minutes
Number of transfer	4	3

3. BEHAVIORAL SURVEY

The investigation was performed by web survey. Respondents -who are residents of Kyoto, Osaka, Hyogo Prefecture, and Fukuoka Prefecture- are passengers who traveled between Keihanshin and Fukuoka within the past one year. The O-Ds of Shinkansen which were included in this survey were the route between Kyoto, Shin-Osaka, Shin-Kobe, Nishi-Akashi, or Himeji station, and Kokura or Hakata station. About airplane users, we consider as the person using between Osaka / Itami or Osaka / Kansai, and the Fukuoka airport or Saga airport. In addition, it is an investigation was conducted in March, 2004.

4. RESULT OF SURVEY, AND HYPOTHETICAL TEST

4.1 Result of Survey

Although the total number of samples at the time of the number of replies of a questionnaire investigating was 513, the number of the valid samples for analysis of them is 332. The attribute of the respondent set as the analysis object of investigation is shown in Figure 2.

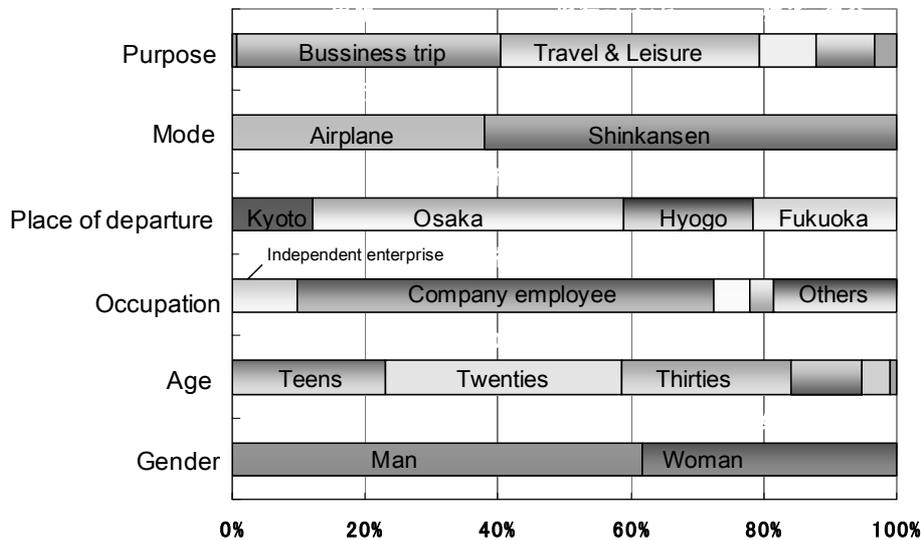


Figure 2 Respondent's Attribute

The modes of transportation used as compared with data more nearly actual than Figure 2 inclines toward the airplane a little by results of an investigation now. Moreover, also in the age group, from teens to 40's occupy most, and incline toward the younger age group. Since the investigation method was the Internet, although it became the attribute which deviation can see a little in this way, it analyzes this time using this result.

4.2 Consideration According to Each Question Item

(a) Trip purpose

The purpose-oriented trip number rate is shown in Figure 3.

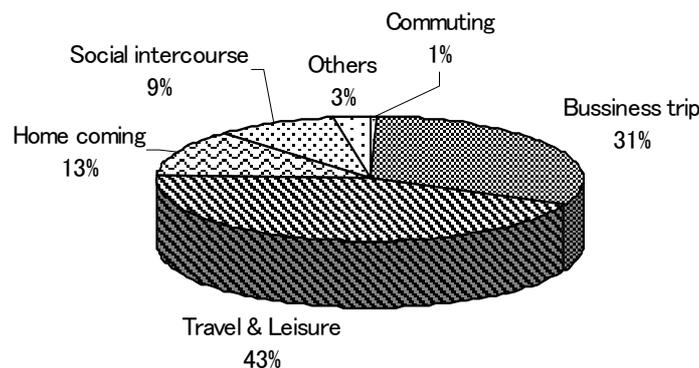


Figure 3. Trip Purpose

From Figure 3, the person who traveled as business trip and leisure trip were about 70%. Moreover, although the person who traveled in order to call it homecoming were about 13%, it is expected that the number of people who answered homecoming may increase at the end and beginning of the year. In addition, the person who answered commuting is considered as

mistake reply.

(b) Model share

The result according to used modes of transportation is shown in Figure 4.

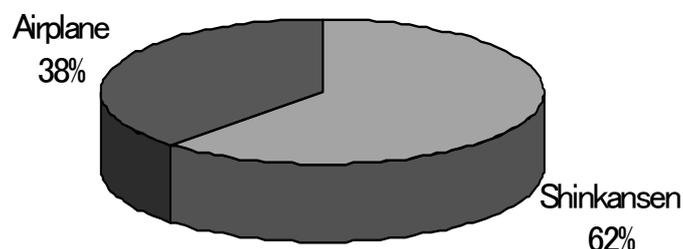


Figure 4. Modal Share

Airlines and the Shinkansen are main transportation modes between Keihanshin-Fukuoka. Even though the share of Shinkansen was about 20% higher than airlines, they were considered as competitors. It is possible that choosing Shinkansen or airlines depends on some trip purposes, tastes and some factors.

4.3 Hypothetical test

(a) Test for Hypothesis A

Shinkansen passenger share of figure 4 is higher than figure 1. However, figure 1 showed that airline passengers increased since 1997.

(b) Test for Hypothesis B

According to reasons of transportation mode selection, it can be seen that high percentages of passengers select Shinkansen because the destination was near the alighting Shinkansen station.

(c) Test for Hypothesis C

About the hypothesis C, since it did not ask directly, the thing in a choice item was used, and χ^2 official approval was caused and it analyzed. An official approval result is shown in Table 2.

Table 2 Total Result of Person of Actual-Working-Hours Serious Consideration

		Compulsary working hours are short		Total
		0	1	
Transportation	Airplane	118	32	150
	Shinkansen	208	6	214
total		326	38	364

Chi-sq = 32.38

From Table 2, since it is smaller than the significant level 0.05, it is rejected. Those who the selected modes of transportation serves as an airplane, and think the time which has got on as important obtained the analysis result of choosing an airplane. However, since the hypothesis has asked waiting time, if it serves as a judgment of this hypothesis, it is impossible only at this result.

(d) Test for Hypothesis D

Although it was "a travel and leisure" that there were for the move purpose than Figure 3, it turns out that the move purpose occupies most on "a business trip" and "a travel and leisure".

5. ANALYSIS OF FACTORS FOR MODE CHOICE

The modes-of-transportation selection factor analyzed by whether a difference is in the number which chose an airplane and the high speed train by χ^2 test approval about the selection result and the relation of a factor of a modes of transportation. The selection result and factor of the modes of transportation are shown in Table 3.

Here, the view of Table 3 is explained. First, it classifies into the item about traffic with "concrete" the time required, a fare, a change, etc., the item about "service", and the item of a "mental factor" further. And selection factors are enumerated and the modes of transportation which attaches O mark can say intentionally that a difference is by χ^2 test approval. In addition, that to which x mark attaches an airplane and the high speed train is the selection factor which was not judged as there being a difference intentionally as a result of χ^2 test approval.

6. MODELING PASSENGERS BEHAVIOR BY THE LOGIT MODEL

Based on the analysis result of the modal choice factor performed in this questionnaire result and Section 5, it investigates concretely what influence these factors have on modes-of-transportation choice behavior. The explanation variables used for this model is shown below.

- The fare of a line hole (an airplane and high speed train)
- The time required of a line hole (an airplane and high speed train)
- The access time required to an airport and a high speed train station
- Access expense to an airport and a high speed train station
- The egress time required from an airport and a high speed train station
- Egress expense from an airport and a high speed train station
- Time outside of the vehicle
- The number of times of a change

The model was made using eight explanation variables and parameter presumption was performed. 44 models are created in all, among those the parameter of the model of nine high models of explanation power, the likelihood ratio, the hit ratio, etc. are shown in Table 4. In the case of model creation, the problem of coliniality occurs, multiplex is surely carried out, and cannot say that explanation power and reliability are high, either. However, the model was made after this problem refused for there to be this time.

When the model result of Table 4 was compared, multiplex also took the problem of colinarity into consideration to some extent, and model 9 was judged to be a model with the highest explanation power. Therefore, change of the demand at the time of fluctuating a line hole fare this time using model 9 is predicted.

Table 3. The Relationship between Modal Choice and Various Factors

	Selection factor	Airplane	Shinkansen
Time and Cost etc.	Getting on time is short	O	
	The time require from the place of departure to the destination is short	O	
	The transfer and the change are convenient		O
	The fare is cheap	O	
	It moves to the airport and the station by bus	O	
	Transportation from the airport and the station	O	
	Delay		O
	The distance from the plance of departure to the airport and the station is short		O
	The transportation to the airport and the station is a railway		O
Service	station is a railway		O
	It is possible to reserve it by the internet	O	
	The credit car can be used	O	
	The ticket can be bought without reservation		O
Psychological factor	The service inside vehicle is good	O	
	Not become tired	O	
	Comfort		O
	Sex distinction	x	x
	Occupation	x	x
	Age	x	x
	Hapiness of getting onb to transportation	x	x
	Fear to transportation	x	x

Table 4 Estimation Result of Various Models

Model number	model 1	model 2	model 3	model 4	model 5	model 6	model 7	model 8	model 9
Line haul fare	-	-0.16 (-2.60)	-0.14 (-2.32)	-0.21 (-3.62)	-	-0.21 (-3.69)	-	-	-0.10 (-2.10)
Line haul time	-	-	-0.14 (-4.00)	-	-	-	-	-	-
Waiting time	-	-0.75 (-6.47)	-0.69 (-6.35)	-0.26 (-4.62)	-0.19 (-3.79)	-0.33 (-7.50)	-0.18 (-3.66)	-0.72 (-6.46)	-
Number of change	-0.33 (-2.59)	-	-	-0.22 (-1.71)	-0.23 (-1.84)	-	-0.24 (-1.88)	-	-0.65 (-6.54)
Access + Egress cost	-	-	-	-	-	-	-	-	-
Access + Egress time	-	-	-	-	-	-	-	-	-
Airplane dummy	-0.69 (-2.74)	1.62 4.30	-	-	-	-	-	1.74 4.76	-
Total time	-0.10 (-2.83)	-	-	-	-	-	-	-	-
Riding time	-	-	-	-	-	-	-	-	-
Total cost	-	-	-	-	-0.06 (-1.39)	-	-	-	-
Likelihood ratio	0.12	0.21	0.20	0.16	0.14	0.16	0.13	0.14	0.12

7. FORECASTING DEMAND

In this section, we will forecast demand of both airlines and Shinkansen, by using model 9 of section 6, that changes when the average fare of each mode decrease. The real of market share was shown in figure 4 as 62%:38% (Shinkansen:Airlines). The expected market share when airlines reduce ticket fare was forecasted in table 5 and figure 5, and expected market share

when Shinkansen reduce ticket fare was shown in table 6 and figure 6. The market share of each mode increase when its fare decreases.

In addition to figure 6 and table 6, we chose discount rate 14%, 23% and 39% by the following reasons: 14% discount rate is equal to 1day-advance purchase ticket of airlines (12,800yen), 23% discount rate is equal to special discount ticket of Shinkansen (11,500yen), and 39 % discount rate is equal to super discount air ticket (9,000yen). All these discount rate are calculated by comparing with full fare of Shinkansen reserved seat between Shin-Osaka station and Hakata station (14,890yen). According to figure 6, 3% of Shinkansen passenger share may increase if the average fares of Shinkansen decrease about 10%. Moreover, if the average fares of Shinkansen decrease to Bargain fare, the share of Shinkansen may increase 10%.

Table 5. Market Share Change after Reducing the Price of Airlines Fare

Average discount rate	Shinkansen	Airlines
0%	62%	38%
2%	61%	39%
5%	60%	40%
10%	58%	42%
20%	54%	45%

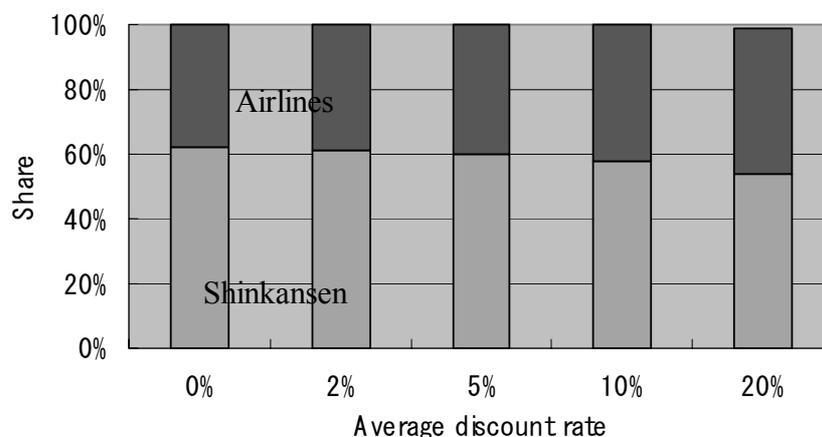


Figure 5. Market Share Change after Reducing the Price of Airlines Fare

Table 6. Market Share Change after Reducing the Price of Shinkansen Fare

Average discount rate	Shinkansen	Airlines
0%	59%	41%
2%	59%	41%
14%	63%	37%
23%	66%	34%
39%	70%	30%

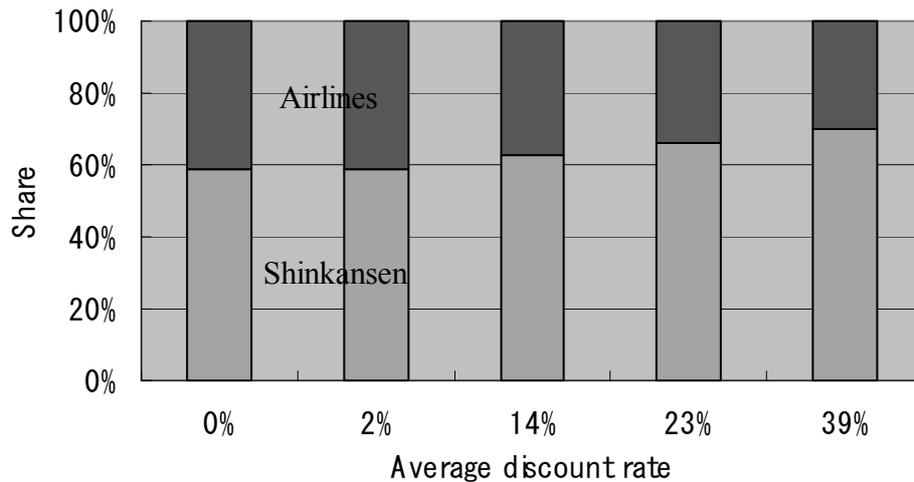


Figure 6. Market Share Change after Reducing the Price of Shinkansen Fare

Refer to table 3, airline passengers considered that air ticket was cheaper than Shinkansen tickets. Therefore, it may be beneficial to Shinkansen if its ticket price is reduced. We showed the expected annual revenues of Shinkansen if the average revenue is reduced with different percents. In addition, the expected annual revenues were obtained from expanded travel demand (The base travel demand was shown in figure 1.).

The expected annual revenues were calculated from fare and expected annual travel demands, and the expected annual travel demands were obtained from base expected travel demand (modal share times total passenger volume) plus expanded travel demand (e.g, passenger who travel by Shinkansen more often because it is cheaper). The expanded travel demands were computed from *gravity model* by using time series data of ticket fare, residents' income, inflator, annual passenger volume in last 25 years. Finally, the elasticity of ticket fare was obtained for expanded travel demand calculation. The expected annual revenue increased as the discount rate increase up to 23% discount rate, but at the discount rate 39%, revenue was less than base situation.

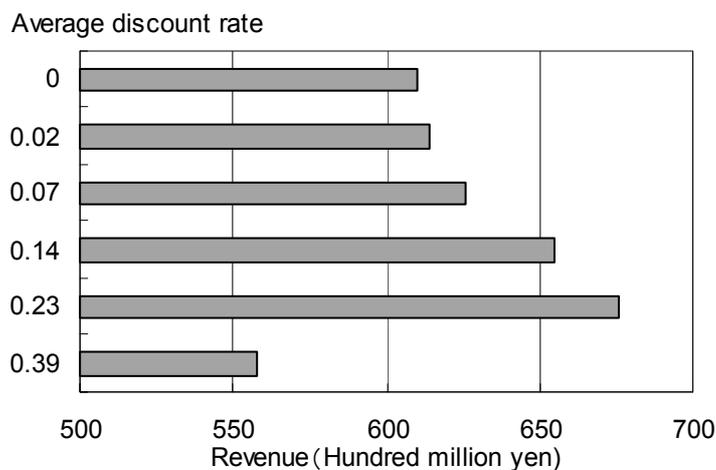


Figure 7. Revenue Change after Shinkansen Fare Discount

8. CONCLUSION

Although the actual modal share between Keihanshin-Fukuoka was a result from behaviors by many railroad users, the demand of airlines passengers was increased after aviation deregulations. The railway company introduced new train, which called "Hikari Rail Star", in order to provide passengers more luxury service. Airline companies tend to rely on various discounted fares because they can not introduce new airplanes. So competition on fare levels will be important for the railway company.

We analyzed modal choice (airlines and Shinkansen) on inter-city passenger travel and its affecting factors. The result showed that "the fare is cheap" is one of the factors for choosing airline and people start to consider the airline travel is no longer expensive. And based on this analysis, the modal choice model was built using the disaggregate model. Consequently, although the logit model which used the explanation variable a "line haul fare" and "the number of transfer" were built and we consider it is best under our available data, the problem on co-linearity remains as a future works. Finally, the expected change of modal share was shown and revenue for the railway company after reducing the price of a Shinkansen fare was calculated. We can conclude that the railway company should consider optimal level of fare which achieves not only revenue maximization but also passengers' satisfaction.

REFERENCES

- Algers, S. (1993) An integrated structure of long distance travel behavior models in Sweden, **Transportation Research Record 1413**.
- Algers, S. (2001) Long distance trips and class/departure time choice, **9th World Conference on Transportation Research**.
- Muto, M. (2001) A study on method of survey and analysis for modal choice characteristics of inter-regional railway passengers, Railway Technical Research Institute Report, Special No. 49, 2001 (in Japanese)
- Muto, M., Uchiyama, H. (2001) An outlook of the domestic intercity passenger transportation focusing on days of competition between Shinkansen and airline, *Transport Policy Studies' Review*, Vol.4, No.1, pp.745-750 (in Japanese)
- Vuuren, D.V. (2002) Optimal pricing in railway passenger transport: theory and practice in the Netherlands, **Transport Policy 9**, pp.95-96.