Analyzing Airport and Access Mode Choice Behavior: Kyushu region case study

空港とアクセス手段の選択行動に関する研究
―九州地域を事例として―

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In this paper author attempts to model airport choice process in the Kyushu region of Japan. Data of 'Survey of international air travelers' dynamics' provided by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan is utilized to estimate disaggregate multinomial logit model for travelers visiting East Asia region from Kyushu. Author also attempts to estimate the effect of improvement of access facilities to the airport on the choice process. For this purpose two data sets from years 2005 and 2012 pooled to estimate this effect. It is established that it had statistically significant effect on probability to choose at least one airport in the region.

1. Introduction, motivation, and research questions

Recent decades witnessed fast and profound changes in the airline industry.

First, air traffic has grown substantially around the world. Several factors are responsible for this development. On one hand, rapid economic growth in Asia made air travel affordable to vast amounts of people. On the other hand, ongoing deregulation of airline industry in North America, Europe, and Japan led to emergence of numerous Low-Cost Carriers (LCCs). Competition of LCCs with legacy carriers resulted in reduction of airfares, which made air travel more affordable in developed nations as well.

Second, growth in air traffic has also been going hand in hand with changes in traditional airline business model. To cut costs LCCs prefer to use underutilized secondary airports, which led to redistribution of traffic from major hub airports to secondary airports in multi-airport regions (MARs). To remain competitive legacy carriers had to increase frequencies, which in turn resulted in higher congestion rates in major airports.

As a consequence customers today are often facing situation when available flights are spread among several airports, with some of them highly congested and not being able to offer very reliable service (hub airports), with the others not offering comfortable and fast access (local or secondary airports).

With this backdrop of rising congestion and distribution of flights among numerous airports understanding airport choice behavior by airline users becomes more important than ever. This research seeks to examine changes in airport choice behavior of airline users after major changes in airport accessibility.

Novelty of this research is mainly related to the object of the study and methodology. In this paper existing methodology is applied to a very large region, which includes several metropolitan areas, some of which are MARs in themselves. Influence of improvement in region transportation facilities on airport choice behavior is also estimated through pooling cross-sectional data.

The following is posed as a research question:

- Does airport choice behavior of airline users in the region with multiple airports change after improvement in accessibility to the region's major airport?

- If so, to what extent can it be attributed to that improvement?

The working hypothesis is the following: improved access to the Fukuoka Airport after opening of the final stage of Kyushu Shinkansen in 2011 led to changes in airport choice process of Kyushu residents.

2. Related Literature

While the research dedicated to the issue of airport choice emerged in the 70s it was not until 80s when necessary toolkit was developed. First attempts to investigate choice of airport were using aggregate modeling techniques.

However airport choice research field did not fully come of age until disaggregate modeling techniques were introduced to the field.

After over thirty years of research several factors most likely to influence travelers' choice were identified. These are attributes mostly related to either flight itself or airport.

Fare. Increase fare is expected to have negative effect on probability to choose given airport.

Frequency of flights[1)]. Flight frequency does not have one-way influence on choice process, as higher frequency of flights means more flexibility with departure times and availability of substitute flights in case of missing the flight, it also means higher congestion rates and more delays.

Airport access time[3)]. Access time is expected to have negative influence on choosing certain airport, as it increases disutility associated with being for long periods of time either in a car or in public transport.

Besides the factors mentioned above a plethora of other attributes, which could have an influence on choice process were examined as well. Airport related factors: c**ost of airport access** and **access distance**[2)], which are expected to have same influence as access time; **waiting time**, which naturally makes trip process less comfortable; **number of airlines serving airport**, which serves as a proxy for flight frequency. Trip related factors : **length of trip**; **in-flight time**; **loyalty program user**[3)], which lures passengers to airport served by certain airline; **early/late arrival**[3)]. Aircraft related factors: **aircraft type** and **seating capacity**, which are associated with travelling comfort. Demographic and social related factors: **income**[3)]; **age**[3)]; **gender**[3)].

3. Study area general information

The research subject is the Kyushu Island in its entirety and Yamaguchi Prefecture, which is located at the easternmost end of the Honshu Island. The reason to include Yamaguchi into the study scope is dependency of Yamaguchi on Kyushu airports, as there are no airports Yamaguchi that offer international service.

Kyushu is the third largest island of the Japanese archipelago located to the South West of the main island of Honshu. It spans over seven prefectures with combined population of 14.6 million people and area of 48,305 square kilometers (including smaller islands). Fukuoka is the most populated prefecture in the region with a population of over 5 mln people. With the exception of Saga, which has a population of only 849.8 thousand people in 2012 all other prefectures have population falling between 1.2 and 1.8 mln people. Population is not distributed evenly across the island. Cities with the population of over 200,000 people have a share of about 23% in 2010 and 22.7 in 2005. Fukuoka - Kitakyushu - Shimonoseki metropolitan area had a share of 9.8% of the total Kyushu population in 2010 and 9.6% in 2005.

4. Data and scope

For analysis the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan kindly provided data of 'Survey of international air travelers' dynamics'[*1]. Survey is targeting airline users travelling abroad (both Japanese and foreign citizens), as well as transit passengers. Survey usually takes place during months of August and October to account for influence of peak and off-peak season travel patterns. Each airport is visited at least two times, and at least once during weekend to account for weekend travel patterns. Survey covers all airports with international service in Japan. Survey questionnaire for Japanese passengers is organized into three large sections: respondents' socio-demographic characteristics, trip related questions (itinerary, purpose, etc.), and access related questions.

For the purpose of this study sample is limited to Japanese citizens only. Foreign and transit passengers are also excluded from the scope.

This study makes use of data of two surveys: 2005 and 2012. Year 2005 was selected as it was second year after first stage of Kyushu Shinkansen high-speed rail line between Kagoshima Chuo Station in Kagoshima and Yatsushiro Station in Yatsushiro was completed. Year 2012 was selected for the reason it was second full year after Shinkansen was completed in its entire length between Hakata Station in Fukuoka and Kagoshima Chuo Station. Preferring second year over first is based on assumption of inertia of travelers' choice process.

Observations from seven Kyushu prefectures and Yamaguchi were assembled into a sample. Total sample before

cleaning was 4569 observations (year 2005 – 1847, year 2012 – 2722). Distribution among destinations is summarized in Table 1.

Due to the overwhelming share of trips in East Asian direction as well as scarce availability of flights to other directions from Kyushu airports study sample is further limited to trips to East Asia only. Distribution of observations by prefecture is summarized in Table 2. Within East Asia direction flight distribution by destination country was: Korea – 61.2%; China – 28.7%; Taiwan – 10%. Direct flights made up 94.6% of all observations.

Table 1 Destinations distribution

Destination	2005		2012		Total	
	Obsv.	Share	Obsv.	Share	Obsv.	Share
East Asia (China, Korea, Taiwan, Mongolia)	1239	67.1%	2049	75.3%	3288	72%
South East Asia	239	12.9%	280	10.3%	519	11.4%
North and Latin America	148	8%	193	7.1%	341	7.5%
Oceania (incl. Guam, Saipan)	147	8%	75	2.8%	222	4.9%
Europe and Africa	74	4%	125	4.6%	199	4.4%
total	*1847*		*2722*		*4569*	

Table 2 Residence distribution, East Asia direction

Prefecture	2005		2012		Total	
	Obsv.	Share	Obsv.	Share	Obsv.	Share
Yamaguchi	101	8.1%	118	5.8%	219	6.7%
Fukuoka	349	28.2%	783	38.2%	1132	34.4 %
Saga	35	2.8%	83	4.1%	118	3.6%
Nagasaki	118	9.5%	174	8.5%	292	8.9%
Kumamoto	173	14%	248	12.1%	421	12.8 %
Oita	112	9%	173	8.4%	285	8.7%
Miyazaki	154	12.4%	170	8.3%	324	9.9%
Kagoshima	197	15.9%	300	14.6%	497	15.1 %
total	*1239*		*2049*		*3288*	

In 2012 females made up 58.1% of all travelers. In 2005 survey data on sex was not included. Among business travelers (19.3% of 2012 sample) females made up only 14.2%, while among leisure travelers (77.3% of 2012 sample) their share was 69.1%.

Age distribution is the following (total sample): ~20 years old – 6.6%; 21~30 – 20%; 31~40 – 20.7%; 41~50 – 19.4%; 51~60 – 19.2%; 61~70 – 12%; over 65 – 8%.

The airport of choice for travelers in 2012 was:

Fukuoka – 39.3%; Kitakyushu – 16.9%; Saga – 5.3%; Nagasaki – 4.6%; Kumamoto – 6.6%; Oita – 5%; Miyazaki – 7.3%; Kagoshima – 13.3%.

In 2005: Fukuoka – 55.5%; Kitakyushu – n/a; Saga – n/a; Nagasaki – 4.6%; Kumamoto – 7.2%; Oita – 4.3%; Miyazaki – 9.4%; Kagoshima – 14.7%.

5. Methodology

To estimate the effects of ground transportation improvement on the airport choice process disaggregate model of airport choice of the family of random utility family is estimated.

Random utility theory is assuming that users are rational decision makers, and want to achieve maximum possible utility. Several assumptions have to be made before constructing a model:

- Decision maker is considering several mutually exclusive alternatives, which make up a choice set;
- Each alternative is assigned utility level, and alternative which maximizes utility is selected;
- Assigned utility stems from a number of attributes characteristic of that alternative;
- Utility associated with alternative is unknown the researcher, hence random variable is used to represent it.

Probability to choose alternative k from choice set S can be represented as a possibility of utility of alternative k to be higher than any other alternative in the set:

$$p_k = Probability[U_k > U_n, n \neq k, n \forall S]$$

The utility of alternative *k* can be represented as the sum of observed V_k and unobserved ε_k components:

$$U_k = V_k + \varepsilon_k$$

Observed part of the utility can be represented as a sum of products of parameters and parameter coefficients:

$$V_k = \beta_0 + \beta_1 parameter_1 + \beta_2 parameter_2 + \cdots$$

This knowledge helps us to estimate disaggregate multinomial logit model (MNL):

$$p_k = \frac{\exp(V_k)}{\sum_{n \epsilon S} \exp(V_n)}$$

MNL model assumes that unobserved parts of alternatives' utilities are randomly and independently distributed (IID assumption) according to Gumbel distribution with a mean of *0*.

With this knowledge multinomial logit model of airport choice in Kyushu region in 2012 was estimated.

6. Estimation results

Two models were estimated to test the hypothesis that introduction of Kyushu Shinkansen had statistically significant influence on airport choice process of Kyushu residents. First, simple multinomial logit was estimated with 2012 data to provide fundamental understanding of airport choice process in Kyushu and test for significant variables. After data of 2005 and 2012 surveys were pooled to estimate effects of Shinkansen introduction in 2011. It was expected that at least some airports the effect was statistically significant. The direction of effect of effect of effect was expected to be negative, that is it was expected that after introduction of Shinkansen it some airports became less likely to be chosen.

Several utility function forms were tested. The following parameters were found to be significant: airport access time, airfare, and share of flight frequency. Variables were defined the following way:

access time	time from trip origin to the airport in minutes, as quoted by respondents in the survey;
airfare	price paid for the ticket as quoted by respondents in the survey;
flight frequency	share of flights per direction from given airport among all airports in the region, data was compiled using JTB Schedule.

Table 3 Model estimation results

Parameter	**Coefficient (t-value)**	
	Business	Leisure
Access time	**-1.694 (-4.853)**	**-1.444 (-9.755)**
Frequency	**14.331 (9.3399)**	**15.866 (24.934)**
Airfare	**-5.146 (-8.169)**	**-5.693 (-21.775)**
dummy Miyazaki	**6.560 (5.870)**	**8.961 (17.997)**
dummy Kumamoto	4.223 (3.308)	**7.454 (14.737)**
dummy Kagoshima	**6.928 (7.095)**	**8.961 (18.615)**
dummy Nagasaki	**5.535 (5.946)**	**7.441 (14.542)**
dummy Oita	-13.300 (-0.005)	**5.959 (11.4936)**
dummy Saga	**3.240 (2.912)**	**5.052 (10.349)**
dummy Kitakyushu	**0.877 (0.933)**	**3.493 (8.917)**
Observations		
R2 adjusted	0.545	0.580
Log-likelihood	-135.7	-130.2
	(Coefficients in bold significant at 0.05)	

Based on the distribution of preferred airports airport choice set for each prefecture was structured in the following manner (first column is prefecture, second column – airports):

Yamaguchi	Fukuoka, Kitakyushu;
Fukuoka	Fukuoka, Kitakyushu, Saga;
Saga	Saga, Fukuoka;
Nagasaki	Nagasaki, Fukuoka, Saga;
Kumamoto	Kumamoto, Fukuoka;
Oita	Oita, Fukuoka, Kitakyushu, Saga;
Miyazaki	Miyazaki, Fukuoka, Saga;
Kagoshima	Kagoshima, Fukuoka, Kumamoto.

The utility function is assumed to have the following form:

$$U_{airport} = \beta_0 + \beta_1(access\ time) + \beta_2(frequency) + \beta_3(airfare) + \varepsilon$$

Model was estimated both for business and leisure travelers.

As Fukuoka airport is the most popular airport in the region it was selected as the base level. This way probability of each to be chosen is:

$$U_{airport} = airport\ dummy + \beta_1(access\ time) + \beta_2(frequency) + \beta_3(airfare) + \varepsilon$$

Estimation results are presented in the Table 3. Models for both business and leisure segments had correct signs of all variables. They also have relatively high goodness of fit, as demonstrated by adjusted R^2 statistic. However, for business segment dummies for Kumamoto and Oita airports were not significant. This can be attributed to an overall lower number of observations.

To estimate effects of Shinkansen introduction on airport choice decision-making process the following steps had to be undertaken. First, data from 2012 survey was pooled with data from 2005 survey[*2]. Second, several dummies were introduced:

dummy2012	dummy indicating all observations (only year after treatment);
dummyTreatment	dummy indicating treatment group (both years) ;
dummyTreatment2012	dummy indicating treatment group (only year after treatment).

Here we assume treatment to be completion of Shinkansen in 2011, treatment group as observations originating in municipalities, which are located immediately to Shinkansen station, and thus benefit the most from improved access to Fukuoka airport (excluding Fukuoka city).

Utility function will thus assume the following form:

$$U_{airport} = \beta_0 + \beta_1(dummy2012\ ) + \beta_2(dummyTreatment) + \beta_3(dummyTreatment2012) + \beta_4(access\ time) + \beta_5(frequency) + \varepsilon^{*3}$$

This way the following can be assumed about the intercept of the utility function:

β_0	control group before treatment;
$\beta_0 + \beta_1$	control group after treatment;
β_1	control group difference (effect of treatment);
$\beta_0 + \beta_2$	treatment group before treatment;
$(\beta_0 + \beta_2) + (\beta_1 + \beta_3)$	treatment group after treatment;
$\beta_1 + \beta_3$	treatment group difference (effect of treatment).

Thus the effect of treatment is difference in difference:

$$(\beta_1 + \beta_3) - \beta_1 = \beta_3.$$

Furthermore these dummies will also be interacted with dummies indicating airports to estimate the probability of each airport to be selected. Essentially coefficient *dummyTreatment2012* interacted with airport dummy will be treatment effect, in this case effect of Shinkansen completion on probability to choose given airport.

Results of the estimation are summarized in エラー! 参照元が見つかりません。. As expected coefficients for access time, and flight frequency, as well as intercepts for each airport dummy were significant and had correct sign. However *dummyTreatment2012* group was only significant in case of Kagoshima airport. However it has positive sign, which runs contrary to the expectation that completion of Shinkansen decreased probability of other airports in Kyushu to be chosen.

Essentially this means that the effect of completion of Shinkansen was positive in case of Kagoshima Airport. This is most probably attributed to the unobserved factors that were not included in the utility function, such as airfare or else.

7. Conclusion

In this paper a multinomial logit model for airport choice in Kyushu region estimated. It was established in line with literature that access time, airfare, and flight frequency are significant variables in the airport choice process.

After that data from two different data sets from 2005 and 2012 were pooled to estimate effects of Shinkansen introduction in 2011.

It became clear that introduction of Shinkansen had statistically significant effect on probability to choose Kagoshima airport. This runs contrary original expectations that effect would be negative and probability to choose airports other than Fukuoka would decrease. This can be attributed to factors not captured in the observed part of the utility function.

This finding has very important policy implications. Although in this case Shinkansen was not designed specifically to serve as an access mode to Fukuoka airport, its high share as an access mode allows extrapolate findings of this analysis to cases where long distance access improvement is considered specifically for airports. Such improvement might not have expected results. It might be wiser to concentrate on improving attractiveness of the airport via other avenues.

Table 4 Model estimation results

Parameter	Coefficient (t-value)
Access time	**-1.831 (-21.517)**
Frequency	**10.094 (31.594)**
dummy Miyazaki	**3.624 (15.432)**
dummy Kumamoto	**2.909 (10.529)**
dummy Kagoshima	**4.357 (19.327)**
dummy Nagasaki	**4.156 (16.843)**
dummy Oita	**3.788 (14.994)**
dummy Miyazaki 2012	**1.469 (8.440)**
dummy Kumamoto 2012	**1.877 (8.106)**
dummy Kagoshima 2012	**1.085 (6.858)**
dummy Nagasaki 2012	**0.625 (3.160)**
dummy Oita 2012	**1.151 (5.336)**
dummy treatment Miyazaki	-18.891 (-0.004)
dummy treatment Kumamoto	**2.224 (6.193)**
dummy treatment Kagoshima	**0.318 (0.723)**
dummy treatment Nagasaki	-18.924 (-0.004)
dummy treatment Oita	-18.283 (-0.004)
dummy treatment Miyazaki 2012	0.847 (0.0000)
dummy treatment Kumamoto 2012	-0.520 (-0.856)
dummy treatment Kagoshima 2012	**1.978 (3.492)**
dummy treatment Nagasaki 2012	1.095 (0.000)
dummy treatment Oita 2012	0.699 (0.000)
R^2 adjusted	0.339
Log-likelihood	-2084
(Coefficients in bold significant at 0.05)	

Notes

*1 「国際旅客動態調査」'Kokusai ryokaku doutai chousa'

*2 Kitakyushu and Saga airports either did not exist or did not offer international services in 2005 and were excluded from the choice set.

*3 The attribute of airfare was excluded from the utility function, as data on fares were not collected in the 2005 survey.

References

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