Analysis of the Impact of Abandoned Direct Air Routes on Inter-regional Passenger Travel Flows in Japan

Yuto SHIRAISHI [a], Terumitsu HIRATA [b]

[a] *Graduate School of Engineering, Ibaraki University, Ibaraki, 316-8511, Japan*
[a] *E-mail:14nm810a@vc.ibaraki.ac.jp*
[b] *Ibaraki University, 4-12-1 Nakanarusawa, Hitachi, Ibaraki, 316-8511, Japan*
[b] *Email: hirata-t@mx.ibaraki.ac.jp*

Abstract: In Japan, the number of abandoned domestic air routes has been increased after the aviation market deregulation especially in regional air route with less passenger demand. Some of the local governments have started their own subsidy schemes and also the central government is now considering new support scheme for sustainable regional air network. As a fundamental study for considering the effect of maintain a direct regional air route and the criteria for the subsidy, this study examines the actual changes in inter-regional passenger volume and route choice behaviors after abandoning the direct domestic regional air route in Japan. By developing the air route choice model based on the aggregate logit model, the factors which affect passengers' air route choice behaviors and the relationship between the change in the generalized travel cost and the change in the inter-regional passenger volume are discussed.

Keywords: abandoned air route, inter-regional passenger volume, route choice behavior

1. INTRODUCTION

In Japan, domestic air market has grown by deregulation. The liberalization of airfare and new entry to air routes have encouraged competition of the Level of Service (LOS) especially in the trunk routes like the routes to/from Tokyo-Haneda (HND) airport (Kanda, et al. (2006)). On the other hand many unprofitable regional air routes have decreased the flight frequency or abolished.

Abolition of air routes might decrease the intercity travel demand and cause to the decline of the regional economy. Therefore some local governments in Japan have started their own subsidy schemes like load factor guarantee scheme. This scheme is a mutual agreement between the airline and the local government which operates the airport where the compensation are given to the airline from the government if the actual annual load factor are below the designated level or by contraries the incentive is given to the local government from the airline if it is over the designated level. Recently, the central government is considering the new support scheme for sustainable regional air networks like Essential Air Service (EAS) and Small Community Air Service Development Program (SCASDAP) in US or Public Service Obligation (PSO) in EU (Hashimoto (2013), Svein et al. (2012)). EAS and PSO have some criteria to select subsidized routes such as the distance to the hub-airport and the LOS of the alternative routes or transport. However the level of such a criteria might have been empirically determined and lack objective evidence. Also, Japan has some specialties such as a good ground transport system like High-Speed-Rail (HSR: Shinkansen) and a single large domestic hub-airport (HND).

With these research background, the purpose of this study is to analyze the actual change in intercity passenger volume and route choice behaviors after abandoning the direct domestic regional air route in Japan as a fundamental study for considering the effect of maintain a direct regional air route and the criteria for subsidized air routes. By developing the air route choice model based on the passengers' travel data between local regions, the factors which affect passengers' air route choice behaviors and the relationship between the change in transport LOS and the change in the intercity passenger volume are analyzed. For this analysis, the individual data of the inter-regional travel survey in Japan conducted in 2005 and 2010 are utilized.

Tansei et al. (2012) examined the factors to affect the air route abandoning in the domestic market in Japan, but did not see the impact if the abandoning air route on the inter-regional passenger demand. Yamaguchi, et al. analyzed the strategy for consolidating regional airports by developing the macroscopic intercity demand model, and clarified the airports to be consolidated because of the advantage of improving the accessibility to the nearby airport rather than improving the own airport in the region. Our focus is more on an individual air route not on an airport. Svein et al. (2012) surveyed widely about subsidy for remote airports and discussed about the factors that can be addressed to contribute to regional economic development in a more efficient way, but did not state it quantitatively. James et al. (2005) examined various schemes to attract air service in smaller markets including direct subsidies, guaranteed revenue approach and airline travel bank with a small experimental network simulation model, but did not examined what was actually occurred after abandoning direct air routes.

2. SCREENING OF THE TARGETTED ABANDONED DIRECT AIR ROUTES FROM 2005 TO 2010

The air routes which were abandoned between 2005 and 2010 are extracted by the following steps. Since Kansai airport (KIX) and Itami airport (ITM) are closely located, these two airports are treated as the same airports.

Step1: Extracting the air routes in which more than 50 flights per month were operated over more than 9 months in 2005.

Step2: Extracting the air routes from the Step1 routes in which there were no flights operated or not more than 50 flights per month were operated over more than 4 months in 2010.

From these steps, total 24 air routes are extracted as an abandoned air routes between 2005 and 2010 shown in Table 1 and Figure 1.

3. THE TRIP DATA AND THE FRAMEWORK OF THE ANALYSIS

3.1 Inter-Regional Travel Survey in Japan

The nation-wide large-scale intercity trip survey data are used in this study which are conducted in every 5 years in Japan. This survey are conducted in one weekday and one weekend in autumn. The sampling trip data can be converted to the annual total passenger numbers of every routes and every transportation mode (air, rail, sea, bus and car) between every 207 Origin-Destination (OD) zones with the annual number converting coefficient.

Table 1. The extracted abandoned air routes and its annual passenger volume in 2005

abandoned air routes	Annual passengers number in 2005	Frequency just before abandoning (flight/day)
New Chitose(CTS)－Naha(OKA)	189404	1
Memanbetsu(MMB)－Kansai(KIX)	150007	2
Hanamaki(HNA)－ChÙbu(NGO)	125509	3
New Chitose(CTS)－Okayama(OKJ)	112746	1
New Chitose(CTS)－Matsuyama(MYJ)	95542	1
Asahikawa(AKJ)－ Kansai(KIX)	81727	1
Okadama(OKD)－Nakashibetsu(SHB)	69095	3
Kushiro(KUH)－ ChÙbu(NGO)	64488	1
Fukushima(FKS)－ Naha(OKA)	52930	1
Oita(OIT)－ Naha(OKA)	43699	1
New Chitose(CTS)－Misawa(MSJ)	39253	1
Okadama(OKD) - Memanbetsu(MMB)	38261	2
Toyama(TOY)－Fukuoka(FKU)	37175	1
Fukushima (FKS)－ ChÙbu(NGO)	29833	2
Fukushima(FKS)－ Fukuoka(FKU)	29480	1
Shonai(SYO)－Osaka(ITM)	25520	1
Okadama(OKD) –Wakkanai(WKJ)	22033	1
KÕchi(KCZ)-Miyazaki(KMI)	15967	1
Matsumoto(MMJ)－Osaka(ITM)	15038	1
ChÙbu(NGO)－Tottori(TTJ)	14704	1
Matsuyama(MYJ)－Kumamoto(KMJ)	13391	1
Hakodate(HKD)－ Memanbetsu(MMB)	11693	1
Hakodate(HKD)－Obihiro(OBO)	9331	1
Asahikawa(AKJ)－Kushiro(KUH)	8627	1

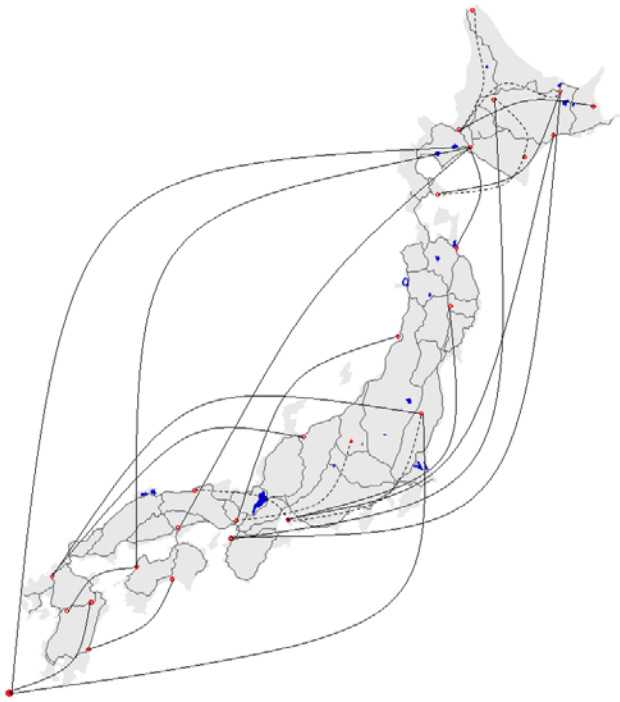

Figure 1. Map of the extracted abandoned air routes

3.2 Framework of the Analysis

The framework of the analysis is shown in Figure 2.

(a) Extracting the “major OD zones”

From the all OD zone pairs which had travel passengers between the zones who used the targeted air route in 2005 to be abandoned after 2005, the OD zones are extracted as “major OD zones” which had more than 1% passenger volume of total number of passengers of the targeted air routes and also had the access time to the targeted airport from the zone centroid of less than 120 minutes. Among “major OD zones”, the OD zone pair which had the largest number of passenger in the targeted air route are named “Representative OD zone”. The examples of these OD zones are shown in Figure. 3.

(b) Calculating the passenger volume of each route between major OD zones in 2005 and 2010

The travel routes are classified into 6; “Direct air route (self-airport - self-airport)”, “Connection route (self-airport - self-airport)”, “One other airport route (near) (self-airport – nearby airport”, “One other airport route (far) (self-airport – far airport)”, “Two other airport route” and “Ground route”. “Self-airport” means the airport located in the Origin or Destination zone, and “Other airport” means the airport other than self-airport and “near” means the airport which locates within 150km from the major OD zone centroid.

(c) Making the LOS data of each route

The LOS data are developed only for “representative OD zone” pair in order to simplify the analysis. Table.2 shows the summary of LOS data development. As for the connection service, the “effective connection frequency” is defined which takes lesser flight frequency among flight to and from connection airport and counts only connectable flights with the same airline (minimum connectable time is 30 minutes).

With these data, we analyze the changes in passenger volume and route choice behaviors after abandoning the direct air route, and evaluate the value of maintaining a direct air route with a simple procedure.

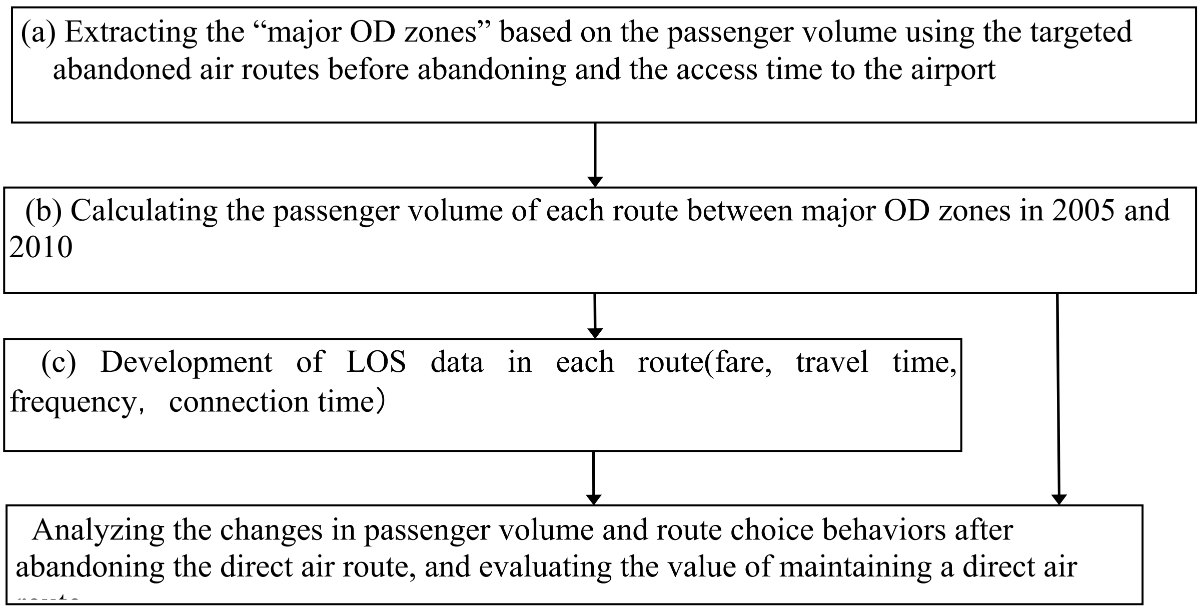

Figure 2. Framework of the analysis

Table 2. Details and data sources of LOS data in representative OD

Type of LOS	List of LOS	Reference	Notes
Frequency	Effective frequency	JTB timetable	"effective connection frequency" is defined which takes lesser flight frequency among flight to and from connection airport and counts only connectable flights with the same airline (minimum connectable time is 30 minutes).
Travel time	Flight connection time	JTB timetable	Minimum connection time among all of the connection (minimum is 30 minutes)
	Flight time	JTB timetable	Difference of departure and arrival time in the time-table
	Access time	Travel Route Search website [10]	The earliest travel time from the centroid of the zone to the airport by any mode (search on March 7, 2014)
	Egress time	Travel Route Search website	Same as above
	Connection time	Ministry of Land, Infrastructure, Transport and Tourism[11]	Assumption: ground transportation → aviation: 40 minutes, aviation → ground transportation: 15minutes
Cost	Access cost	Travel Route Search website	The cost of the earliest travel route
	Egress cost	Travel Route Search website	Same as above
	Airfare	JTB timetable Airlines' website	Normal airfare and normal discounted fare for the connection flight

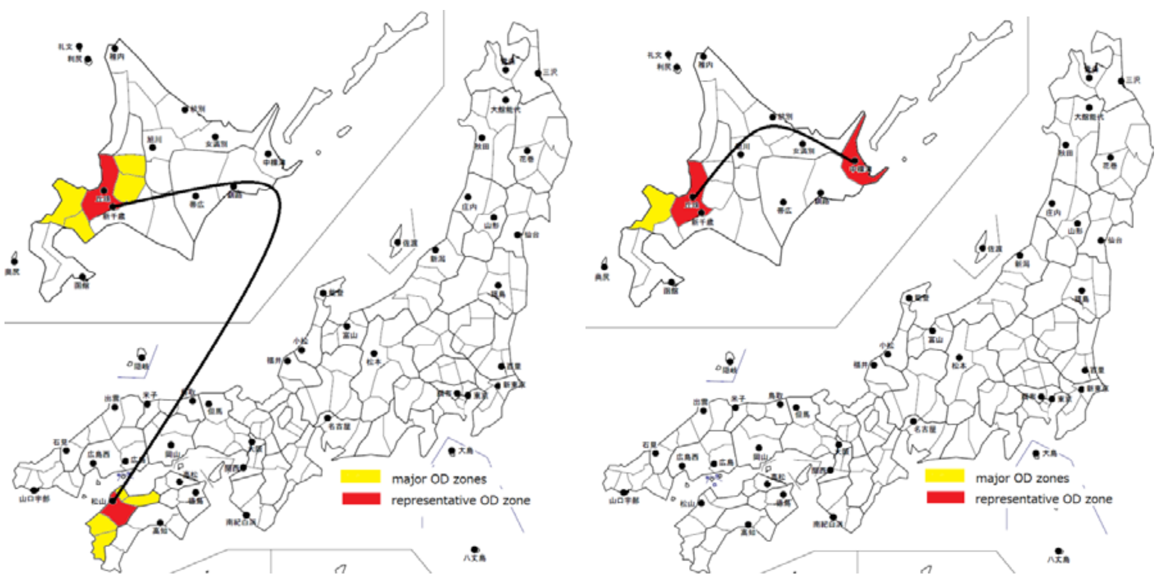

Figure 3. The example of extracting the representative OD and major OD zone pairs
(left: CTS-MYJ right: OKD-SHB)

4. ANALYSIS OF THE CHANGES ININTER-REGIONAL PASSENGER VOLUME AND ROUTE CHOICE BEHAVIOR

4.1 The changes in inter-regional passengers flow

Figure 4 and Figure 5 shows the actual changes in inter-regional passenger volume between "major OD zones" corresponding to the 24 abandoned air routes. Figure.3 shows the data for OD pairs which have the modal share of air transport to some extent (more than 20%), and Figure.4 shows the data with very low share of air transport in 2005 (7 routes). Our target year is 2005 and 2010, but the data of year 2000 is also shown as a reference to see the stability and reliability of the trip data because our target is lower demanded route and consequently the data sample size also tends to be lower. Our main target is the impact of the direct air route abandoning, therefore we analyze only the data shown in Figure.3. Details of each route and major OD zones are shown in Appendix 1 and 2.

The trend of the change in passenger volume is largely different among the different air routes. If we classify the data based on the rate of the change ((1) increase, (2) maintain (over 70% of 2005) and (3) decrease (less than 70%)), 3 routes are (1) increase, 5 routes are (2) maintain and remaining 9 routes are (3) decease as a result. In the next section, how the difference of transport LOS in the alternative routes has an impact on the passenger travel volume is discussed.

4.2 Comparison of the flight frequency and the fare of the alternative routes

We classified the targeted abandoned air routes in terms of the LOS of the alternative route which had the highest share of passengers including effective flight frequency, transfer or non-transfer (using other remote airport), discount fare for the connection and discount for normal fare (entry of a lower fare airline: Skymark Airline).

The result of the classification is shown in Table.3. The rate of the change in the passenger volume is indicated by asterisk (**: increase, *: maintain, no-mark: decrease). Even in the classification only by the frequency and fare, the rough trend of the change in passenger volume can be explained from this table. It is clearly indicated that the passenger volumes were maintained with the flight frequency of the alternative (air) route more than 7 flights per day. This implies the importance of the fright frequency of the alternative route after abandoning the direct air route with low frequency. Also, the discount fare for connection flight can be slightly increase the demand when the alternative route is a connection flight. With this table, the impact of lowering air fare by the entry of Skymark Airline (kind of LCC) cannot be clearly seen separately from that of flight frequency, but the demand always increased when Skymark entered to the alternative route with lower fare.

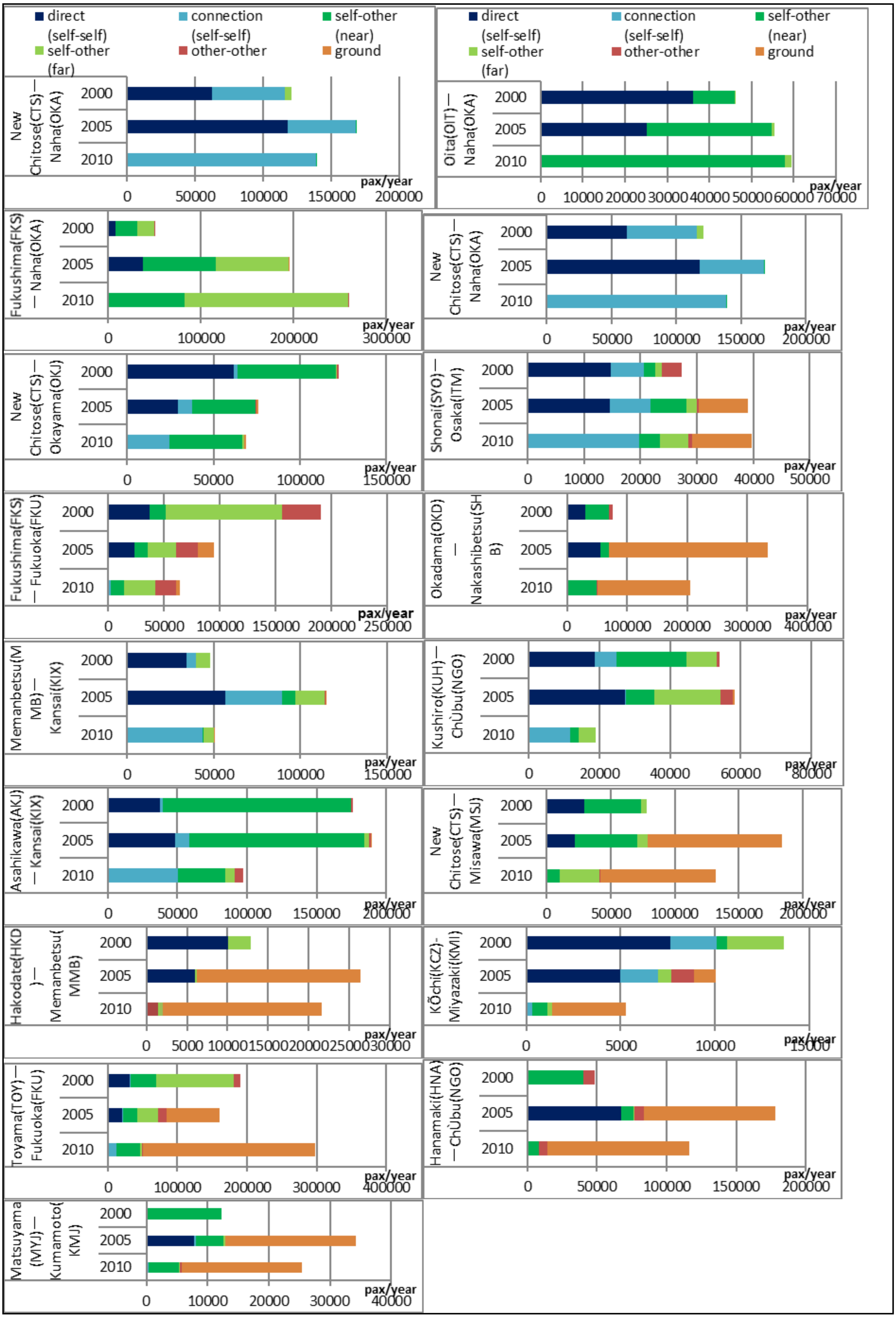

Figure 4. Changes in inter-regional passenger volume between major OD zones by each mode before and after abandoning the direct air route (share of the air is over 20%)

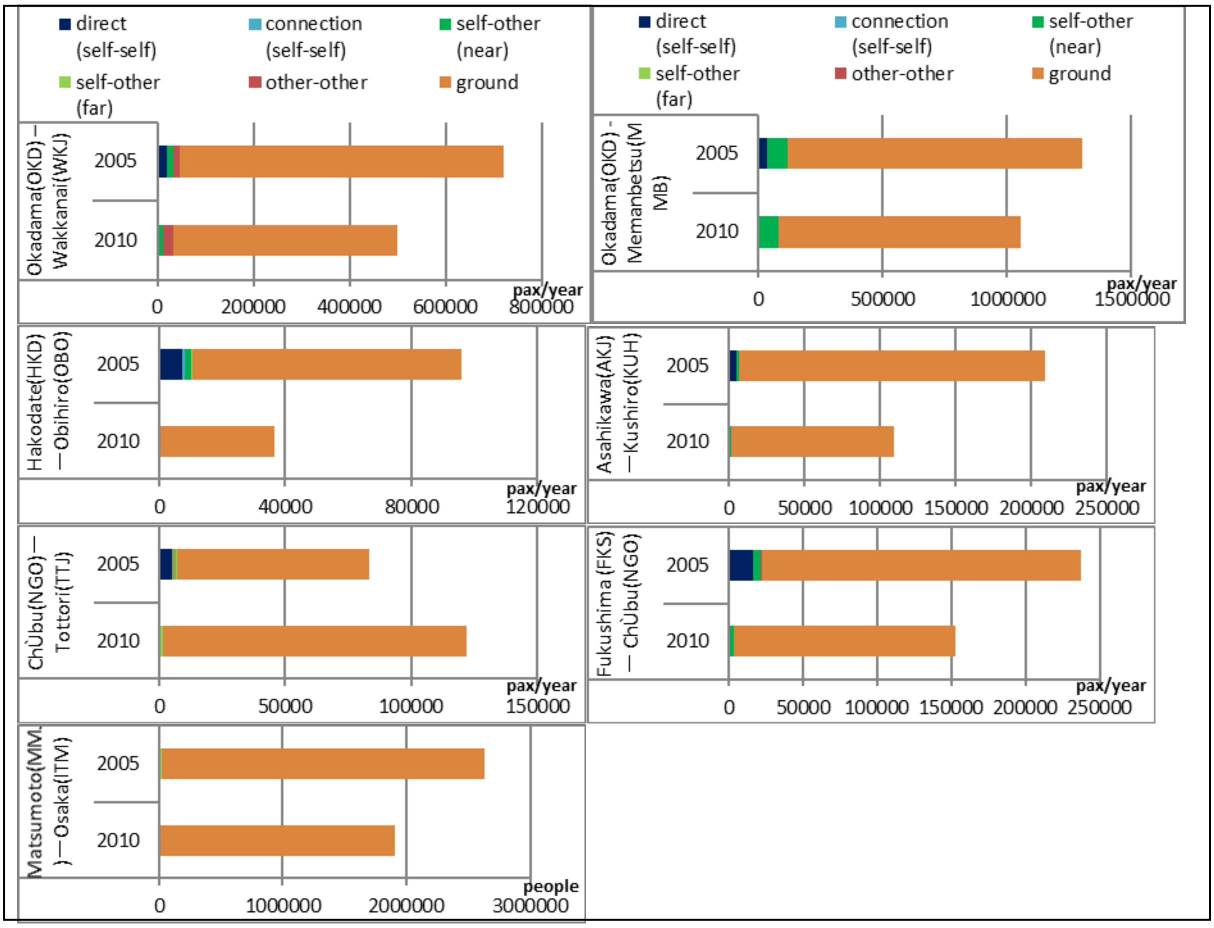

Figure 5. Changes in inter-regional passenger volume between major OD zones by each mode before and after abandoning the direct air route (share of the air is less than 20%)

Table 3. Effective flight frequency and fares of the representative alternative route and the change in passenger volume

connection or non-connection	**airfare**	**effective frequency 1-2**	**effective frequency 3-4**	**effective frequency 5-6**	**effective frequency >6**
Connection	discount fare for connection flight	KUH—NGO	MMB—KIX MMB—HKD		** (CTS)—MYJ * CTS—OKA * SYO—ITM
	no discount for connection flight		AKJ— KIX	KCZ—KMI	
Non-Connection	Skymark (LCC) entry				** FKS—OKA ** OIT—OKA * FKS—FKU
	No Skymark entry	CTS—MSJ TOY—FKU	* OKD—SHB	MYJ—KMJ HNA—NGO	* CTS—OKJ
routes shown in Figure 4 (ground transport is highly dominant)	* OKD –WKJ, OKD—MMB, AKJ—KUH, HKD —OBO, FKS—NGO, NGO—TTJ, MMJ—ITM				

-Rate of the passenger demand change: **: increase, *: maintain, no-mark: decrease

4.3 Estimation of the route choice model and calculation of generalized cost of inter-regional travel

The accessibility between two regions should be evaluated by considering multiple available routes comprehensively. In this study, the route choice model for the inter-regional transport with lower demand is estimated by using the aggregated air route choice probability between "representative OD zones". Then, the generalized travel cost are calculated by Logsum variables derived from the estimated route choice model.

The data for the estimation is the pooling data of the aggregated share of each air route between the 17 pairs of representative OD zones corresponding to each abandoned direct air route in 2005 and 2010. The parameters of the aggregate logit model shown in equation (1) and (2) are estimated by OLS.

$$P_i = \frac{\exp(V_i)}{\sum_{j=1}^{J}\exp(V_j)} \quad (1)$$

$$V_i = \sum_{k=1}^{K}\beta_k X_{ik} \quad (2)$$

P_i : choice probability of route i (share)
V_i : utility function of route i (utility)
β_k : The parameters for the variable k
X_{ik} : Explanatory variable k of route i

Table 4. The estimation results of the route choice model (aggregate logit)

Explanatory variable X_k	β_k	t-value	P-value
Total travel time (minute)	-5.42×10^{-3}	-1.84	0.073
Total cost (yen)	-4.90×10^{-5}	-1.80	0.079
Ln (effective frequency) (flight/day)	0.274	1.67	0.102
Dummy of direct flight (direct flight = 1)	1.11	2.15	0.037

Adjusted R^2=0.29, N=47

The estimation results are shown in Table 4. The total travel time and cost which include flight, ground access/egress and connection/waiting time are statistically significant as well as the dummy for direct flight. Flight frequency is not so highly statistically significant. However since this model are estimated by relatively small sample number, the estimated model are considered to be acceptable. The model can indicate that as is often considered the travel time, cost and frequency are the important factors for explaining route choice behavior.

Then, the inter-regional generalized travel cost are calculated by Logsum variables derived from the estimated route choice model which considers all of the important variables and multiple routes comprehensively shown in equation (3).

$$C_{ij} = \{ln \sum_k \exp(V_{ijk})\}/b \qquad (3)$$

C_{ij}: Generalized cost between zone i and j(yen)
V_{ijk}: utility of route k between zone i and j
b: Cost parameters in route choice model

Figure 6 shows the relationship between the rate of the change in inter-regional generalized cost and that in inter-regional passenger demand (sum of the demand between major OD zones). From this figure, there can be seen the trend that higher increase rate of the generalized cost leads to larger rate of demand decline although there are some variability. By using this generalized cost and demand change, the users' benefit of maintaining a direct air route can be also approximately calculated as consumer surplus shown in equation (4).

$$\Delta UB_{ij} = \frac{1}{2}\left(D_{ij}^0 - D_{ij}^1\right)\left(C_{ij}^0 - C_{ij}^1\right) \qquad (4)$$

ΔUB_{ij}: change of users' benefit (yen/year)
C_{ij}: Generalized cost between zone i and j(yen)
D_{ij}: Total passenger demand between zone i and j (pax/year)
0, 1: before (0) or after (1) abandoning direct air route

As just a trial case study, the actual changes of users' benefit by abandoning direct air routes targeted in this study are calculated as shown in Table 5. In this table, 3 cases are excluded in which the relationship between the change in the generalized cost and that in passenger demand is opposite. These changes of users' benefit can be one of the reference for considering or justifying the support from the government or other authorities such as a subsidy for maintaining a direct air route. If the relationship between the changes in inter-regional generalized cost and that in inter-regional passenger demand could be assumed like Figure 5, the uses' benefit (value) of maintaining a direct air route can be easily evaluated by the procedure shown in this study. The sophisticated large-scale demand forecasting model can be used for more precise evaluation, but the simpler procedure shown in this study might be also useful to the evaluation.

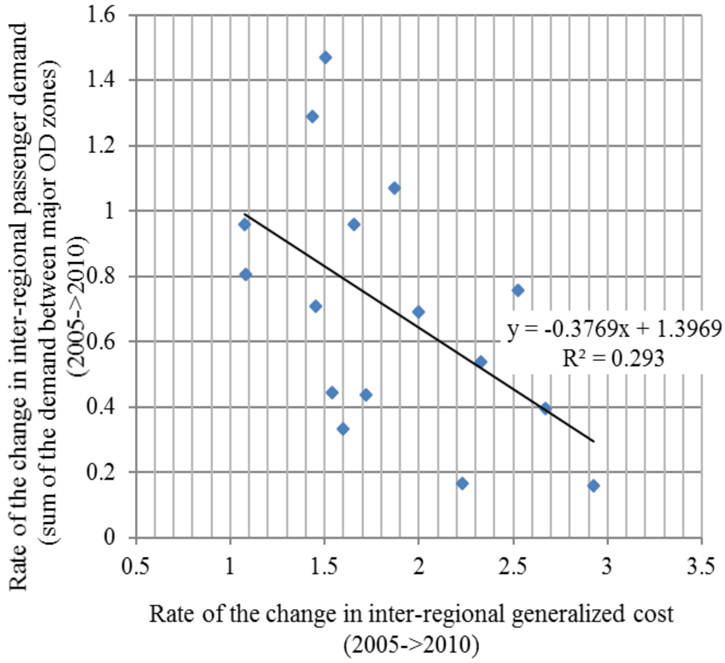

Figure 6. Relationship of generalized cost and flow volume of inter-regional

Table 5. Actual changes of users' benefit by abandoning direct air routes

Abandoned direct air route	Change of users' benefit (Million yen)
New Chitose(CTS)－Naha(OKA)	-4,113
Asahikawa(AKJ)－ Kansai(KIX)	-3,515
Memanbetsu(MMB)－Kansai(KIX)	-2,081
Okadama(OKD)－Nakashibetsu(SHB)	-1,709
Hanamaki(HNA)－ChÛbu(NGO)	-1,640
Toyama(TOY)－Fukuoka(FKU)	-1,291
New Chitose(CTS)－Misawa(MSJ)	-1,207
Fukushima(FKS)－ Fukuoka(FKU)	-1,116
Kushiro(KUH)－ Chubu(NGO)	-780
Shonai(SYO)－Osaka(ITM)	-486
Matsuyama(MYJ)－Kumamoto(KMJ)	-216
New Chitose(CTS)－Okayama(OKJ)	-194
Kochi(KCZ)-Miyazaki(KMI)	-165

5. CONCLUSION AND FUTURE WORKS

As a fundamental study for considering the effect of maintain a direct regional air route and the criteria for the subsidy, this study examines the actual changes in intercity passenger volume and route choice behaviors after abandoning the direct domestic regional air route in Japan and analyze the factors which affect the route choice and inter-regional passenger demand. By developing the route choice model for the inter-regional travel in less demand market, we try to evaluate the changes in generalized travel cost and inter-regional passenger demand, and finally evaluate the users' benefit (value) to maintaining a direct air route with a simple procedure.

For future works, the difference of route choice behaviors between local lines and trunk lines are to be analyzed, and more precise route choice model should be developed for evaluating the value of direct air route.

REFERENCE

Ekispert (Travel Route Search website), http://roote.ekispert.net/

Hashimoto, Y. (2013) Sustainability of Local Air Routes and Measures by National/Local Governments/Airlines, *Transport Policy Studies' Review*, Vol.16, No.2, 81-85 (in Japanese)

Tansei, K., Inoue, G., Yamada, Y. and Uchikado, M. , (2012) Analysis of the withdrawal/existence of Domestic Air Routes in Japan, *TECHNICAL NOTE of National Institute for Land and Infrastructure Managemen*t, No.697 (in Japanese)

Hiromichi YAMAGUCHI, Makoto OKUMURA, Huseyin TIRTOM and Jinyoung KIM (2013) Airport Reducing Policy considering Relationship Factor between Region and Airport, *proceedings of Infrastructure Planning*, Vol.48, CD-ROM (in Japanese)

James, N., Pamela, R. and John, R. (2005) Small Market Air Service and Regional Policy, *Journal of Transport Economics and Policy*, Vol. 39, Part. 3, pp.363-378.

Kanda, Y., Morichi, S. and Hibino, N. (2006) Impact Analysis of Airline Deregulation Policies in Japan, *Infrastructure Planning Review*, Vol.23, No.3, Japanese

Svein, B. and Nigel, H. (2012) Air Transport Service Provision and Management Strategies to Improve the Economic Benefit for Remote Regions, *Research in Transportation & Management*, Vol. 4, pp.3-12.

The Minister of Land, Infrastructure, Transport and Tourism, 1th~5th Inter-Regional Travel Survey in Japan, http://www.mlit.go.jp/sogoseisaku/soukou/sogoseisaku_soukou_fr_000016.html

Appendix 1. The lists representative OD and major OD zones

Abolition route	representative OD pair	Major OD zones
New Chitose(CTS)—Naha(OKA)	Sapporo・Naha	New Chitose (Tomakomai, Sapporo, Iwamizawa, Otaru・Kucchan, Muroran, Takigawa) Naha (Naha, Okinawa, Nago)
Memanbetsu(MMB)—Kansai(KIX)	North Abashiri・Kyoto	Memanbetsu (North Abashiri) Kansai (Sakai, Wakayama, Osaka, East Osaka, Amagasaki, Toyonaka, Kobe, Nara Harima, Kyoto, Uzi)
New Chitose(CTS)—Okayama(OKJ)	Sapporo・South Okayama	New Chitose (Tomakomai, Sapporo, Iwamizawa, Otaru・Kucchan, Muroran) Okayama(South Okayama, Bingo, West Kagawa, Okayama prefecture, East Kagawa, Tsuyama)
New Chitose(CTS)—Matsuyama(MYJ)	Sapporo・Matsuyama	New Chitose (Sapporo, Iwamizawa, Otaru・Kucchan, Muroran) Matsuyma (Matsuyama, Yawatahama ・Ozu, Niihama ・Saijo, Imabari, Uwazima, Ehime prefecture)
Asahikawa(AKJ)— Kansai(KIX)	Asahikawa・Sakai	Asahikawa (Asahikawa Hurano Nado) Kansai (Sakai, Wakayama, Osaka, East Osaka, Amagasaki, Toyonaka, Kobe, Nara, Osaka prefecture, Harima, Kyoto, Uzi)
Toyama(TOY)—Fukuoka(FKU)	Toyama・Fukuoka	Toyama (Toyama Shinkawa Takaoka, Tonami Kaga Toyama prefecture Zyoetsu) Fukuoka (Fukuoka, Kurume・Omuta Kitakyusyu Saga, Kumamoto, Chikuhou Tokuyama Yamaguchi, Fukuoka prefecture, Sasebo, Ube)
Fukushima(FKS)— Fukuoka(FKU)	Iwaki・Fukuoka	Fukushima (Koriyama, Shirakawa, Fukushima, Nasu, Aizu, Iwaki, Nikko) Fukuoka (Fukuoka, Kurume・Omuta Kitakyusyu Saga, Kumamoto, Hita・Kusu, Yamaguchi, Hiroshima)
Shonai(SYO)—Osaka(ITM)	Shonai・Osaka	Shonai (Shonai) Osaka (Sakai, Wakayama, Osaka, East Osaka, Amagasaki, Toyonaka, Kobe, Nara, Osaka prefecture, Kyoto, Uzi, Kameoka, South Shiga, Kyoto, Shigatohoku, North Kyoto, South Okayama)
Kushiro(KUH)— ChÙbu(NGO)	Kushiro・Toyota	Kushiro (Kushiro) ChÙbu (Nagoya, Toyota, West Shizuoka, North Mie, East Mikawa, Mietyunan, Tono, Shigatohoku, Iga, Iseshima, Gifu,)
Okadama(OKD)—Nakashibetsu(SHB)	Sapporo・Nemuro	Okadama (Sapporo, Otaru・Kucchan) Nakashibetsu (Nemuro)
Fukushima(FKS)— Naha(OKA)	Koriyama ・Naha	Fukushima (Koriyama, Shirakawa, Nasu, Fukushima, Aizu, Utsunomiya, Iwaki, Sendai, Souma, Fukushima prefecture) Naha (Naha, Okinawa, Nago)
Oita(OIT)— Naha(OKA)	Oita・Naha	Oita (Oita, Saeki) Naha (Naha, Okinawa, Nago)
New Chitose(CTS)—Misawa(MSJ)	Sapporo・South Aomori	New Chitose (Tomakomai, Sapporo, Iwamizawa, Otaru・Kucchan, Muroran) Miasawa (South Aomori, Hanamaki)
KÕchi(KCZ)-Miyazaki(KMI)	Kōchi・Miyazaki	Kōchi (Kōchi, Aki, Niihama ・Saijo) Miyazaki(Miyazaki, Miyakonojo・Kitamorokata, Nichinan Nobeoka Kuma)
Matsumoto(MMJ)—Osaka(ITM)	Matsumoto・Kobe	Matsumoto (Matsumoto Suwa・Ina, Nagano, Ueda YamanashiKuninaka) Osaka (Osaka (Sakai, Wakayama, Osaka, East Osaka, Amagasaki, Toyonaka, Kobe, Harima Nara, Osaka prefecture, Kyoto, Uzi)
Matsuyama(MYJ)—Kumamoto(KMJ)	Matsuyama・Kumamoto	Matsuyma (Matsuyama, Yawatahama ・Ozu, Niihama ・Saijo, Imabari) Kumamoto (Kumamoto, Yatsushiro・Ashikita)
Hakodate(HKD)— Memanbetsu(MMB)	Hakodate・South Abashiri	Hakodate(Hakodate) Memanbetsu (North Abashiri)
Hanamaki(HNA)—ChÙbu(NGO)	Hokyuzyou ChÙbu ・Toyota	Hanamaki (Hokuzyo・Hanamaki, Morioka, Akitananto Kamaishi) ChÙbu (Nagoya, Toyota, North Mie, Ise・Shima, Mietyunan)
Hakodate(HKD)—Obihiro(OBO)	Hakodate・Obihiro	Hakodate(Hakodate) Obihiro(Obihiro)
Asahikawa(AKJ)—Kushiro(KUH)	Asahikawa・Kushiro	Asahikawa (Asahikawa, Hurano) Kushiro (Kushiro)
Okadama(OKD) - Memanbetsu(MMB)	Sapporo・Abashiri	Okadama (Sapporo, Otaru・Kucchan) Memanbetsu (North Abashiri)
Okadama(OKD) -Wakkanai(WKJ)	Sapporo・Wakkanai	Wakkanai (Wakkanai) Okadama (Sapporo, Otaru・Kucchan, Tomakomai)
Fukushima (FKS)— ChÙbu(NGO)	Koriyama ・Nagoya	Fukushima (Koriyama, Shirakawa, Fukushima, Aizu, Iwaki) ChÙbu (Nagoya, Toyota, North Mie, Gifu, Mietyunan)
ChÙbu(NGO)—Tottori(TTJ)	Toyota・East Tottori	ChÙbu (Nagoya, Toyota, Gifu, West Shizuoka, North Mie, Ogaki, Kamo, East Mikawa, Aichi Prefecture, Mietyunan) Tottori (East Tottori, Center Tottori)

Appendix 2. The lists the LOS data for alternative routes

	LOS of alternative route		Type of alternative route			
Abolition route	**effective frequency**	**(connection or normal) fare**	**connection (self-self)**	**self airport-nearby airport (self-nearby)**	**self airport-remote airport (self-remote)**	**nearby airport-nearby airport nearby airport-remote**
New Chitose(CTS)—Naha(OKA)	18(6)	51200	**New Chitose-Haneda-Naha New Chitose-ChÙbu-Naha New Chitose-Shizuoka-Naha**			
Memanbetsu(MMB)—Kansai(KIX)	4(3)	41300	**Memanbetsu-Haneda-Kansai Memanbetsu-New Chitose-Kansai Memanbetsu-New Chitose-Osaka**		New Chitose-Osaka New Chitose-Kansai	
New Chitose(CTS)—Okayama(OKJ)	7(4)	30800	New Chitose-Haneda-Okayama	**New Chitose-Hiroshima New Chitose-Kobe**		
New Chitose(CTS)—Matsuyama(MYJ)	9(5)	43700	**New Chitose-Haneda-Matsuyama**	New Chitose-Osaka		
Asahikawa(AKJ)— Kansai(KIX)	3	52027	**Asahikawa-Haneda-Kansai**	New Chitose-Kansai New Chitose-Osaka New Chitose-Kobe		
Toyama(TOY)—Fukuoka(FKU)	2	38240	Toyama-Haneda-Fukuoka	**Komatsu-Fukuoka**	ChÙbu-Fukuoka	Osaka-Kumamoto
Fukushima(FKS)— Fukuoka(FKU)	47	32627	Fukushima-Osaka-Fukuoka	Sendai-Fukuoka	**Haneda-Fukuoka**	Haneda-Kitakyusyu
Shonai(SYO)—Osaka(ITM)	7(6)	29200	**Shonai-Haneda-Osaka**	Sendai-Osaka Niigata-Osaka	Shonai-Haneda	
Kushiro(KUH)— ChÙbu(NGO)	2(2)	39000	**Kushiro-New Chitose-ChÙbu**	Memanbetsu-ChÙbu	New Chitose-ChÙbu	New Chitose-Haneda
Okadama(OKD)—Nakashibetsu(SHB)	3	22100		**New Chitose-Nakashibetsu**		New Chitose--Kushiro
Fukushima(FKS)— Naha(OKA)	25	37264		Sendai-Naha	**Haneda-Naha**	
Oita(OIT)— Naha(OKA)	17	25888		**Fukuoka-Naha**	Kagoshima-Naha	
New Chitose(CTS)—Misawa(MSJ)	2	25300		New Chitose-Aomori	**New Chitose-Hanamaki New Chitose-Sendai**	
KÕchi(KCZ)-Miyazaki(KMI)	5	41000	**KÕchi-Fukuoka-Miyazaki**		Fukuoka-Kōchi	
Matsuyama(MYJ)—Kumamoto(KMJ)	5	20800		**Matsuyama-Fukuoka**		
Hakodate(HKD)— Memanbetsu(MMB)	3(2)	24000	**Hakodate-New Chitose-Memanbetsu**	Hakodate-Kushiro	New Chitose-Memanbetsu	
Hanamaki(HNA)—ChÙbu(NGO)	5	28400		**Sendai-ChÙbu**		Niigata-Komaki
Hakodate(HKD)—Obihiro(OBO)						
Asahikawa(AKJ)—Kushiro(KUH)						
Okadama(OKD) - Memanbetsu(MMB)						
Okadama(OKD) –Wakkanai(WKJ)						
Fukushima (FKS)— ChÙbu(NGO)						
ChÙbu(NGO)—Tottori(TTJ)						
Matsumoto(MMJ)—Osaka(ITM)						