CETRA 2016

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23-25 May 2016, Šibenik, Croatia

Road and Rail Infrastructure IV

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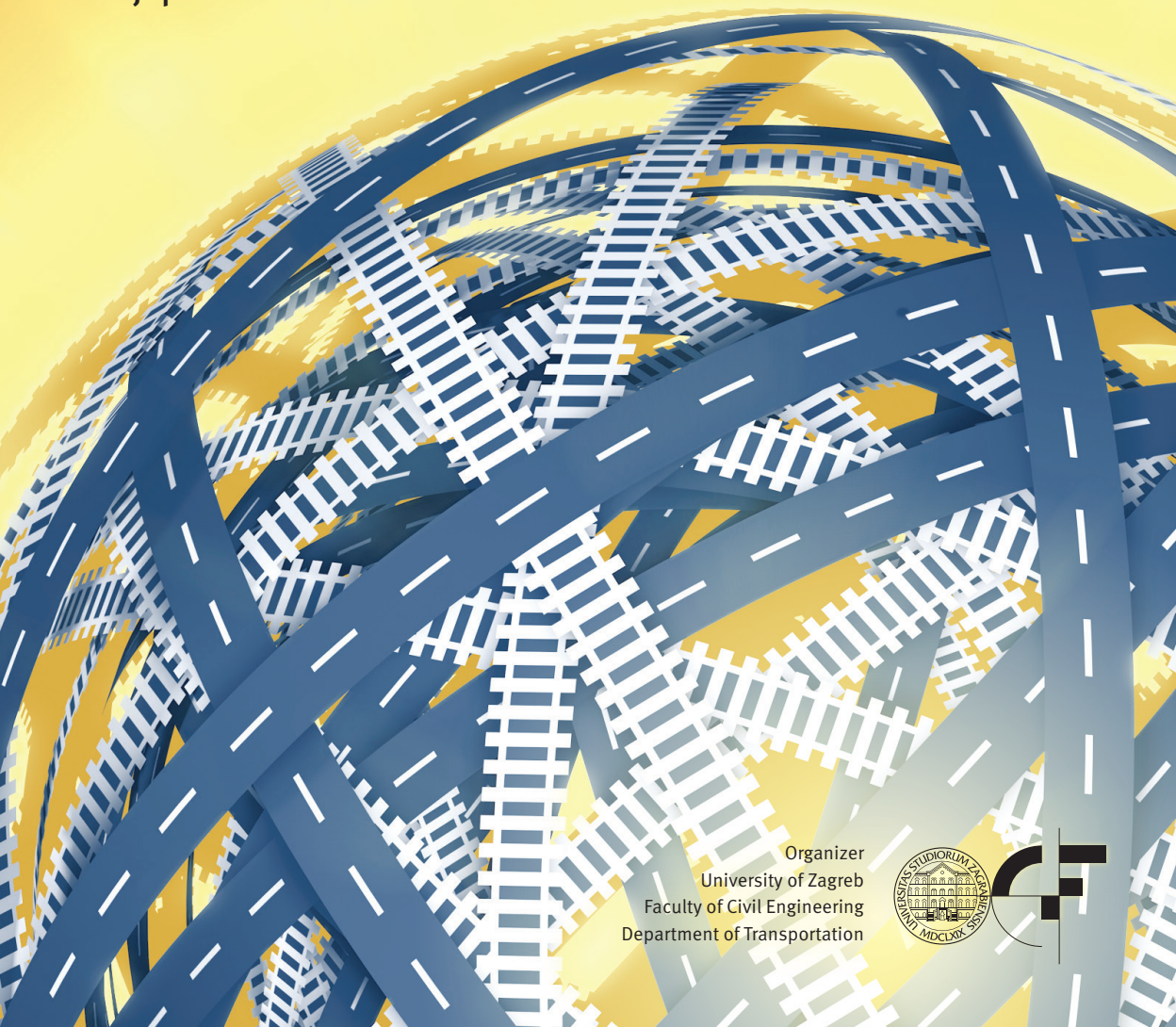

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Road and Rail Infrastructure IV

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STUDY ON USAGE BEHAVIOUR OF THE ARTERIAL TRAFFIC IN JAPAN

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Abstract

The arterial traffic network in Japan has been almost established because main points are connected by rail, air routes and expressway. The travel time is significantly reduced as compared to before due to speed up the arterial traffic in recent years. As a typical example of the arterial transportation include the Shinkansen, air plane and long-distance expressway bus. The Shinkansen and air plane is in the very competitive state in Japan. Because different preeminent transportation in the region in areas where both can be selected. On the other hand, long-distance expressway bus develops with the expansion of the expressway network. It has become a popular transportation around the student due to low fare compared with the Shinkansen and air plane. In this way the arterial traffic has changed with the development of the arterial traffic network. In addition, it is utilized by the personal attributes have influence on the easy to select transportation. The purpose of this study is to analyze how usage behavior changes by the development of the arterial traffic network, and creation of a transportation choice model considering the personal attributes. Behavior in Japan are analyzed using Inter-Regional Travel Survey in Japan and Air Passengers Observational Survey by Ministry of Land, Infrastructure, transport and tourism Government of Japan. As a result of this study, it become clear that person has a high annual income easy to select air plane, user has remained from sleeping limited express to the long-distance expressway bus, the boundary to select the Shinkansen or air plane.

Keywords: arterial traffic, behaviour, Shinkansen, expressway, Inter-Region Travel

1 Introduction

Arterial traffic network connecting between cities has continued to expand. This has led to major changes in human behaviour. In Japan, the Shinkansen network has been conducted since 1964 the Tokaido Shinkansen was opened. Today, the Shinkansen network has continued the expansion. In 2011, Kyusyu Shinkansen whole line, in 2015, Hokuriku Shinkansen between Nagano Kanazawa, in 2016, Hokkaido Shinkansen between Shinaomori Shinhakodate-Hokuto has opened. In addition, the highway is opened to traffic in the last year of Tokaido Shinkansen opening. It was only 71.7 km long at first, but current total extension of highway in Japan is 10685 km long. Ultimately aims to total length of 14000 km, the construction work is still progress.

In Japan, main points are linked by arterial traffic such as the Shinkansen, highway and air lines. Therefore this network would said to almost completed. These arterial traffic are in the very competitive state due to expansion of network. For example, the Shinkansen to airline and the Shinkansen to long-distance expressway bus (highway bus) are very good examples. In order to win such competitive state, each transportation working to improve level of service (LOS). Such as speed up, price cuts, and so on. Improvement of LOS is carried out for expan-

sion of passengers. But this case is concern that excessive service provision is offered. It is essential in order to provide the appropriate services to understand the user characteristics of each transport.
The purpose of this study is to analyze how usage behavior changes by the development of the arterial traffic network. In this study to target the arterial traffic network such as the Shinkansen, highway bus, and airline. Behavior in Japan are analyzed using three time points Inter-Regional Travel Survey in Japan by Ministry of Land, Infrastructure, transport and tourism Government of Japan. By using this data, it will be cleared about user characteristics and the influence and a change in the travel behavior when a new arterial traffic was opened to the existing OD pair.

2 Methods of analysis

2.1 Inter-Regional Travel Survey in Japan

Inter-Regional Travel Survey is carried out the arterial traffic user as a target by Ministry of Land, Infrastructure, transport and tourism Government of Japan. This is a national scale survey to investigate the trip from origin to destination beyond the prefecture by using arterial traffic. From the survey results, it is possible to grasp the reality of the trip such as, who, where to where, when, what purpose, what transportation, and so on. Table 1 shows corresponding investigation and arterial transportation. These survey results are integrated into one and to set magnification factor by a statistical method. In this study using three time point (2000, 2005, 2010) survey data. The number of trips of each transportation of each survey as shown in table 2.

Table 1 Corresponding survey and transportation (in Japanese)

transportation	survey(japanese)
airline	航空旅客動態調査
railway	幹線鉄道旅客流動実態調査
car	全国道路・街路交通情勢調査
ship	幹線フェリー・幹線旅客船旅客流動調査
highwaybus	幹線バス旅客流動調査

Table 2 Number of trip data

	number of data		
year	2000	2005	2010
air	152337	107586	95087
bus	34810	49247	28625
car	199446	228383	613122
rail	62415	72397	57967
ship	5499	4860	2807

2.2 Overview of analysis

Figure 1 shows a map of Japan segmented in 207 zone. In this study using a magnification factor set to this zoning based. To extract the required data by the screening. Then, remove the dummy data inserted for setting magnification factor and partitioning the trip by the representative transportation.

Figure 1 Japan segmented 207 zone

3 Basic analysis

3.1 Number of trips and Modal share

The number of trips shown in table 3 and 207 zone based modal share shown in table 4. The number of total trips has been decrease with each inning. Modal share has not a large difference. It can be seen that car is selected easily and demand of travel by car is increasing year by year. The railway share is high in the Tokyo metropolitan area and Keihanshin area. Car share had become higher in the surrounding area of major metropolitan area.

Table 3 Number of trips

year	trip					
	air	bus	car	rail	ship	total
2000	250411.1	71916.9	2467008.0	796307.0	23909.2	3609552.1
2005	169530.0	105872.8	2468794.5	769531.3	18417.6	3532146.1
2010	158459.2	66378.2	2526470.9	612822.2	9729.6	3373860.1

Table 4 Modal share (207 zone based)

year	share(%)				
	air	bus	car	rail	ship
2000	6.9	2.0	68.3	22.1	0.7
2005	4.8	3.0	69.9	21.8	0.5
2010	4.7	2.0	74.9	18.2	0.3

3.2 Attributes of the user

It is included personal attributes such as gender, travel purpose, age in survey data. In 2000 and 2005 survey are also included annual income of data. Table 5 through Table 8 shows that result of basic counting about personal attributes. Relationship between gender and transportation is that the proportion of men of air, car, rail is high. This is due to business trips. From the Table 6, bus is popular in young people and air is easy to use a layer of from

40s to 50s. Because bus is low price, it is popular with young people such as students. From the Table 7, air user it can be seen that the proportion of high-income earners is high. The average annual income of bus users is about 1.5 million yen, the user of the low income was shown to be dominant. The average of annual income of Japanese is 4.14 million yen. Car is likely to be selected for all purposes be seen from the Table 8.

Table 5 Relationship between gender and transportation

year		2000		2005		2010	
gender		male	female	male	female	male	female
mode	air	68.5%	31.5%	63.3%	36.7%	67.8%	32.2%
	bus	54.0%	46.0%	50.2%	49.8%	47.7%	52.3%
	car	77.3%	22.7%	76.2%	23.8%	76.9%	23.1%
	rail	73.4%	26.6%	67.9%	32.1%	71.9%	28.1%
	ship	62.3%	37.7%	59.7%	40.3%	55.0%	45.0%

Table 6 Relationship between age and transportation

year	2000					2005					2010				
mode	air	bus	car	rail	ship	air	bus	car	rail	ship	air	bus	car	rail	ship
age ～19	5.3%	2.9%	0.5%	1.2%	1.4%	6.7%	3.0%	0.3%	1.5%	3.3%	6.5%	1.9%	2.2%	0.7%	1.3%
20～29	12.7%	23.2%	12.7%	14.6%	19.8%	11.7%	22.1%	6.9%	11.8%	16.3%	9.6%	17.5%	10.6%	11.1%	12.8%
30～39	18.9%	15.5%	19.9%	22.1%	13.2%	21.7%	16.2%	15.5%	21.4%	16.9%	18.9%	14.6%	21.8%	21.4%	16.2%
40～49	20.9%	16.6%	22.3%	21.7%	13.0%	22.0%	16.6%	16.8%	23.1%	14.7%	24.1%	19.1%	22.8%	23.8%	17.0%
50～59	24.2%	21.2%	22.2%	24.0%	22.5%	22.3%	21.8%	21.7%	23.3%	20.5%	22.7%	21.6%	25.3%	21.7%	23.9%
60～	18.1%	20.6%	22.4%	16.3%	30.2%	15.6%	20.4%	38.9%	18.9%	28.2%	18.3%	25.3%	17.2%	21.5%	28.8%

Table 7 Relationship between annual income and transportation

year	2000				2005			
annual income(1000JPY	air	bus	rail	ship	air	bus	rail	ship
Nothing	14.17%	17.25%	9.49%	21.53%	17.05%	19.18%	11.25%	18.19%
～100	3.86%	8.21%	3.78%	9.32%	4.30%	10.52%	4.88%	9.57%
100～199	9.64%	19.76%	9.70%	18.20%	10.70%	21.12%	10.94%	21.00%
200～299	15.86%	17.98%	17.05%	22.05%	15.00%	18.57%	16.59%	22.42%
300～399	14.30%	11.58%	17.92%	10.92%	13.96%	12.06%	17.76%	12.88%
400～499	19.63%	14.77%	20.92%	10.10%	18.53%	11.81%	20.53%	9.45%
500～699	15.08%	7.94%	14.58%	5.03%	13.81%	5.17%	12.80%	4.56%
700～999	4.09%	1.38%	3.43%	0.86%	3.37%	0.83%	2.73%	0.90%
1000～1499	3.36%	1.13%	3.13%	2.00%	3.29%	0.72%	2.52%	1.02%

Table 8 Relationship between travel purpose and transportation

year	2000					2005					2010				
mode	air	bus	car	rail	ship	air	bus	car	rail	ship	air	bus	car	rail	ship
purpose business	54.7%	42.6%	28.6%	68.4%	27.6%	50.6%	40.5%	24.1%	65.7%	32.9%	57.7%	33.6%	26.2%	68.3%	37.1%
tourism	27.9%	15.4%	34.7%	12.9%	33.4%	33.5%	15.2%	30.6%	13.3%	27.0%	25.8%	23.9%	30.9%	13.6%	23.9%
private	9.8%	30.1%	11.9%	13.6%	26.3%	12.4%	33.0%	21.5%	15.7%	27.2%	14.2%	33.5%	22.3%	15.6%	26.9%
others	7.6%	11.9%	24.8%	5.2%	12.7%	3.5%	11.2%	23.7%	5.3%	12.8%	2.3%	9.0%	20.7%	2.6%	12.1%

4 Changes of arterial traffic network

Figure 2 shows the changes of the Shinkansen, highway and number of airports user. And Table 9 shows chronology of arterial traffic network.

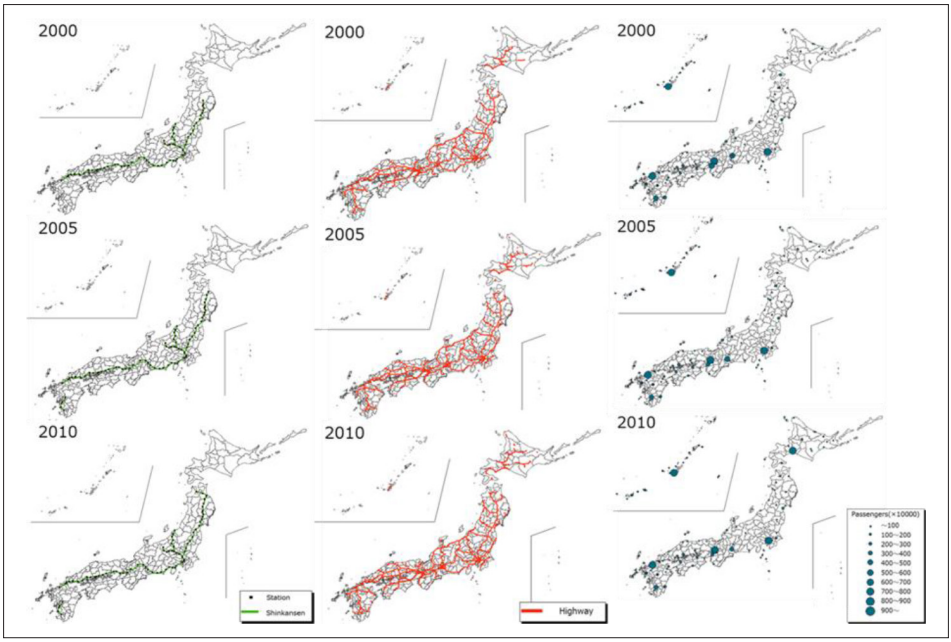

Figure 2 Changes of arterial traffic network (2000~2010)

Table 9 Chronology of arterial traffic network

	the Shinkansen	Highway	Aviation
1960s	Tokaido shinkansen (Tokyo-Osaka)	Metropolitan Expway Meishin Expway Tomei Expway	52 airports opened
1970s	Sanyo shinkansen (Osaka-Hakata)	Service extension is 2000km	Narita Airport opened 28 airports opened
1980s	Tohoku shinkansen (Morioka-Omiya) Joetsu shinkansen (Nigata-Omiya)	Chuo Expway Service extension is 4000km	12 airports opened
1990s	Tohoku shinkansen (Tokyo-Omiya) Nozomi start Nagano shinkansen (Nagano-Tokyo)	Tokyo-Gaikan Expway Kyusyu Expway Service extension is 6000km	Kansai Airport opened 16 airports opened New runway & 24 hour operation(Haneda Airport)
2000s	Tohoku shinkansen (Morioka-Hachinohe) Kyusyu shinkansen (Shinyatsushiro-Kagoshima) Tokyo-Osaka is 2 hours 25 minutes	Kita-Kanto Expway Tokai-Hokuriku Expway	Chubu Airport opened 12 airports opened
2010s	Tohoku shinkansen (Tokyo-ShinAomori) Kyusyu shinkansen (Hakata-Kagoshima) 320km/h operation (Hayabusa) Hokuriku shinkansen (Nagano-Kanazawa) Hokkaido shinkansen (ShinAomori-ShinHakodateHokuto)	Shin-Tomei Expway Joban Expway	3 airports opened

5 User characteristics

In this chapter, a more detailed analysis by cross tabulation of travel purpose and personal attributes. Table 10 shows the results of cross tabulation of purpose and gender. The majority of the business trip is a male. On the other hand, the majority of tourism trip using air, bus and railway is a female. Car user is almost male. From Table 11, it can be seen that the bus is mainly used by young people at homecoming and private. In addition, percentage of low income is higher.

Table 10 Cross tabulation of purpose and gender

		2000		2005		2010	
mode	purpose	male	female	male	female	male	female
air	business	90.7%	9.3%	87.7%	12.3%	87.3%	12.7%
	tourism	43.4%	56.6%	41.5%	58.5%	42.1%	57.9%
	private	40.6%	59.4%	39.4%	60.6%	39.2%	60.8%
	others	47.0%	53.0%	48.2%	51.8%	43.0%	57.0%
bus	business	84.2%	15.8%	78.6%	21.4%	78.0%	22.0%
	tourism	33.1%	66.9%	35.6%	64.4%	34.7%	65.3%
	private	30.0%	70.0%	29.5%	70.5%	30.5%	69.5%
	others	36.1%	63.9%	34.9%	65.1%	33.1%	66.9%
car	business	94.0%	6.0%	93.6%	6.4%	94.1%	5.9%
	tourism	75.8%	24.2%	79.5%	20.5%	81.4%	18.6%
	private	59.3%	40.7%	62.1%	37.9%	57.8%	42.2%
	others	75.2%	24.8%	73.2%	26.8%	73.2%	26.8%
rail	business	89.5%	10.5%	86.3%	13.7%	86.7%	13.3%
	tourism	39.0%	61.0%	34.6%	65.4%	38.5%	61.5%
	private	34.7%	65.3%	29.1%	70.9%	40.7%	59.3%
	others	43.4%	56.6%	36.0%	64.0%	44.2%	55.8%

Table 11 Cross tabulation of purpose and age

		2000						2005						2010					
mode	purpose	~19	20~29	30~39	40~49	50~59	60~	~19	20~29	30~39	40~49	50~59	60~	~19	20~29	30~39	40~49	50~59	60~
air	business	0.2%	10.2%	26.0%	28.4%	26.5%	8.7%	0.4%	7.7%	26.0%	31.9%	26.1%	7.9%	1.5%	6.4%	21.8%	32.7%	26.6%	11.0%
	tourism	8.7%	14.5%	10.8%	11.7%	22.2%	32.1%	15.8%	15.9%	18.9%	12.3%	16.0%	21.2%	16.7%	14.7%	15.1%	11.5%	14.6%	27.4%
	private	3.6%	22.8%	15.9%	16.0%	21.6%	20.1%	8.1%	17.2%	18.6%	13.4%	21.8%	21.0%	7.1%	13.0%	16.3%	14.1%	21.9%	27.6%
	others	28.8%	12.7%	8.6%	12.8%	18.4%	18.6%	8.6%	11.4%	12.0%	11.4%	24.7%	31.9%	14.7%	10.4%	7.9%	10.0%	19.6%	37.4%
bus	business	0.3%	13.4%	22.5%	26.3%	26.3%	11.3%	0.4%	11.8%	22.8%	26.0%	27.5%	11.4%	0.3%	8.8%	18.8%	29.0%	26.3%	16.8%
	tourism	2.5%	25.9%	9.1%	7.2%	17.8%	37.4%	3.1%	27.1%	13.4%	10.0%	16.1%	30.3%	3.0%	24.0%	16.1%	16.6%	13.8%	26.5%
	private	5.8%	35.2%	10.7%	10.5%	17.5%	20.3%	4.6%	29.1%	14.2%	11.5%	19.5%	21.1%	2.2%	21.7%	11.3%	13.0%	22.7%	29.1%
	others	6.0%	24.8%	10.8%	11.2%	18.9%	28.3%	5.5%	19.4%	8.4%	11.6%	18.2%	36.9%	3.7%	18.0%	7.1%	11.1%	20.3%	39.8%
car	business	0.0%	9.4%	25.2%	29.1%	26.7%	9.6%	0.0%	5.5%	18.1%	26.3%	25.0%	25.1%	0.0%	3.5%	22.9%	35.3%	27.2%	11.1%
	tourism	0.6%	13.5%	16.7%	18.7%	20.7%	29.8%	0.2%	5.7%	12.5%	12.0%	19.8%	49.9%	0.1%	4.5%	16.0%	18.5%	19.5%	41.4%
	private	0.6%	14.4%	19.9%	20.5%	18.2%	26.4%	0.3%	7.3%	17.4%	15.9%	19.8%	39.4%	0.1%	6.1%	15.9%	18.8%	22.5%	36.6%
	others	0.6%	13.7%	21.9%	24.0%	22.9%	17.0%	0.6%	9.9%	17.5%	18.7%	24.6%	28.7%	0.6%	9.2%	17.7%	23.8%	24.5%	24.2%
rail	business	0.2%	12.9%	26.5%	26.4%	25.9%	8.1%	0.2%	9.9%	26.0%	28.9%	25.3%	9.6%	0.1%	9.9%	25.0%	29.0%	23.4%	12.6%
	tourism	2.8%	14.4%	11.8%	9.6%	20.2%	41.2%	4.0%	13.5%	12.9%	11.4%	17.3%	40.9%	1.1%	14.2%	14.4%	12.5%	16.1%	41.6%
	private	2.8%	22.6%	14.8%	13.8%	20.0%	25.9%	2.9%	18.9%	14.4%	12.8%	20.6%	30.4%	1.9%	13.7%	13.7%	12.7%	19.1%	38.8%
	others	5.5%	20.1%	9.4%	12.2%	20.1%	32.7%	7.4%	11.7%	7.1%	11.6%	21.9%	40.3%	3.6%	10.2%	9.6%	10.9%	20.0%	45.7%

Table 12 Cross tabulation of purpose and annual income

		2000									2005								
mode	annualincome (1000JPY)	Nothing	~100	100~199	200~299	300~399	400~499	500~699	700~999	1000~1499	Nothing	~100	100~199	200~299	300~399	400~499	500~699	700~999	1000~1499
air	business	0.7%	0.5%	3.8%	13.7%	18.4%	28.7%	23.3%	6.3%	4.7%	1.1%	0.5%	3.8%	13.0%	18.6%	29.3%	23.2%	5.6%	5.0%
	tourism	27.2%	8.0%	18.0%	20.3%	10.0%	8.6%	4.7%	1.3%	1.8%	33.5%	7.4%	17.7%	17.7%	9.7%	7.4%	4.0%	1.1%	1.5%
	private	30.0%	7.9%	16.1%	17.6%	9.7%	9.7%	5.7%	1.8%	1.6%	32.7%	8.8%	16.5%	17.2%	9.3%	8.8%	4.8%	0.8%	1.1%
	others	41.8%	6.5%	11.2%	12.3%	8.2%	9.8%	6.4%	1.7%	2.1%	30.2%	8.8%	16.6%	16.3%	9.4%	8.7%	5.5%	1.5%	3.1%
bus	business	0.9%	1.8%	9.9%	19.8%	20.0%	28.0%	15.5%	2.7%	1.3%	1.5%	3.3%	11.9%	23.0%	22.5%	23.7%	11.4%	1.8%	0.9%
	tourism	23.2%	11.2%	31.8%	20.5%	5.2%	4.4%	2.3%	0.7%	0.6%	21.3%	14.0%	31.6%	19.5%	6.8%	4.2%	1.4%	0.4%	0.8%
	private	33.5%	13.8%	25.5%	14.8%	5.3%	4.5%	2.0%	0.3%	0.4%	32.9%	14.1%	26.5%	15.7%	5.7%	3.3%	1.1%	0.1%	0.6%
	others	28.6%	13.1%	25.9%	16.2%	5.5%	6.1%	2.7%	0.4%	1.4%	31.8%	14.1%	26.5%	15.3%	5.7%	4.7%	1.2%	0.5%	0.3%
rail	business	0.8%	1.0%	5.1%	16.5%	21.8%	27.5%	19.3%	4.3%	3.8%	1.0%	1.2%	5.5%	16.3%	22.3%	28.5%	18.0%	3.8%	3.3%
	tourism	25.3%	9.9%	21.2%	19.6%	9.7%	6.4%	4.0%	1.8%	2.1%	27.0%	11.3%	23.3%	18.2%	10.5%	5.1%	2.8%	0.7%	1.1%
	private	31.7%	9.7%	19.0%	17.0%	9.8%	6.6%	3.9%	1.3%	1.0%	32.8%	12.6%	19.9%	16.4%	8.7%	5.5%	2.8%	0.7%	0.7%
	others	27.1%	11.2%	18.0%	18.6%	8.8%	8.4%	4.6%	1.2%	2.1%	34.4%	11.1%	20.3%	16.5%	7.2%	5.5%	3.0%	0.6%	1.5%

6 Changes in modal share

Figure 3 shows the difference between modal shares of tourism of each survey. From Figure 3, it can be said the air and rail share has risen. The spread of mobile terminal is estimated to be a factor. It would be make easy to take a reservation for transportation. In addition, railway share is increased in trackside area when the shinkansen stretch opening. A similar trend is also seen in air share. The opening of Central Japan International Airport increased air share in Aichi prefecture. In this way, the development of arterial traffic network change the transportation mode of residents in the vicinity of that.

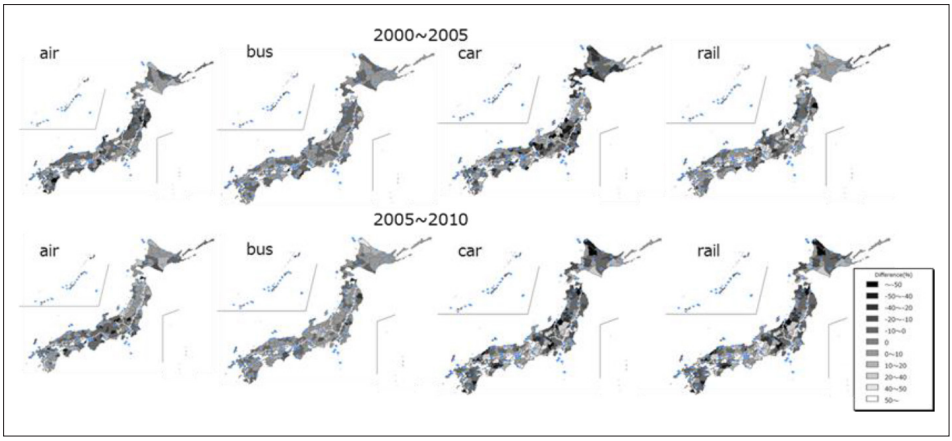

Figure 3 The difference between the share of 2000 to 2005, 2005 to 2010

7 Conclusions

It is suggested that the choice of transportation is different depending on annual income. For example, relatively air user has a high income but bus user has low income. It is estimated that has become popular around the student due to expanding the number of bus routes. From the analysis of difference of modal share, the conversion has been confirmed of the existing transportation by the development of new transportation. In the future, the construction of transportation choice model considering user characteristics and OD pair.

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