Longitudinal Analysis on Inter-regional Business Trips and Office Network

Makoto TSUKAI[1] and Makoto OKUMURA[2]

[1]*Graduate School of Engineering, Hiroshima University, 1-4-1, Kagamiyama, Hiroshima, Japan*
[2]*International Research Institute of Disaster Science, Tohoku University, 6-6-4, Aramaki-aza-aoba, Miyagi, Japan*
mtukai@hiroshima-u.ac.jp, mokmur@m.tohoku.ac.jp

ABSTRACT

Since HSR enables to expand a round-trip area within a day, an introduction of HSR would potentially influence on inter-regional office network to concentrate the headquarter or branch office of firms on the limited number of mega-cities. Such the change is caused by the sustainability between business trips and branch office location to the destination city, so then a simultaneous analysis between the branch office location and inter-regional trips will shed light on this phenomena. This study purpose an itegrated model to clarify the longitudinal change of inter-regional business trips and office network system in Japan. As the result of analysis, improvement of inter-regional public t ransport will differently influence on the business network, depending on the geographic location and a hierarchical function of each city. We could found that the Kanto (Tokyo) metropolitan area keeps th e grobal interaction, while the Chubu (Nagoya) metropolitan area becomes to decrease the passeng er interaction. On the orher hand Kansai (Osaka) metropolitan area is also decrease the passenger demand, which indicate the relative shrink of economic activity in Kansai area.

1. INTRODUCTION

Business activities in Japan have been changed to utilize the high speed inter-regional tran sportation service, since 1990's. The improvement of transportation service will increase the sh ares of cooperated business activities among the different cities. In other words, firms may fro m a novel hierarchical business system connecting the major cities.

This study estimate the integrated model in administrative relation with passenger trip dem and in domestic Japan for multiple cross-sections, following the conventional study of Tsukai and Okumura (2004). An empirical study is conducted by using multiple cross section data, in order to clarify the influence of transportation cost decreasing on the inter-regional business t raffic and the business administrative network in Japan.

2. CONVENTIONAL STUDIES

Fujii (2006) pointed out the benefits coming from inter-regional passenger transportation im provement to the local cities are the reduction of transportation cost and an attraction of the f irms making a business in a whole domestic Japan, respectively. Such the firms are called in this paper as "global firm", while the firms to have a business in local area is called as "loc al firm". Note that some of local cities are not enjoy the benefit because the withdrawal of b ranch office may occur by transportation service improvement. Hino (2001) pointed out that th e requirements as a branch office location in local cities are higher accessibilities not only for the headquarter office, but also the administrative areas from the branch. In this study, Hino mentioned that the location to minimize the transportation cost is preferred as the location of branch office, since the branch office cost is mainly occupied by the transportation cost for b usiness activities.

Tsukai and Okumura (2001) proposed a branch office location model to minimize a sum o f location cost of the city and transportation cost to headquarter and to the administrative area. In this study, optimal headquarter-branch office networks are regressed on the actual branch office administrative network data, then the weights of each office network are statistically esti mated. Tsukai and Okumura (2004) expanded the proposed model to integrate the observed pa ssenger traffic data. While the hierarchical business network is assumed to be three levels in Tsukai and Okumura (2001 & 2004), Takata *et. al* (2009) assumed to multiple levels for the branch office network in order to confirm the rank-size rule of population distribution, by co mparing with the customer distribution in the branch office network with multiple level. This study clarified that the higher a function of branch office is, the more staggered the distributi on of population appear.

This study applies the model proposed in Tsukai and Okumura (2004) for different cross-s ectional data, in order to clarify the longitudinal influence of transportation service on busines s network structure and passenger traffic.

3. BUSINESS NETWORK MODEL

Following data are used in this study. Business passenger travel data is the OD data of pa ssenger's address to destination in the net passenger traffic survey conducted by the ministry of Land, Infrastructure, Transport and Tourism. The missing data in this survey (i.e. the traffic in intra metropolitan area as Kanto, Cyubu and Kansai) is imputed by the gravity model esti mated from inter-prefectural data except Okinawa. Business network data is headquarter-branch office linkage and the employer's dataset in the national statistics in office and firm conducte d by the ministry of public management. Inter-regional LOS data is airline, railway and car o n each transportation network, made in Hazemoto's study (2003).

3.1 DEFINITION OF HEADQUARTER AND BRANCH OFFICE SYSTEM

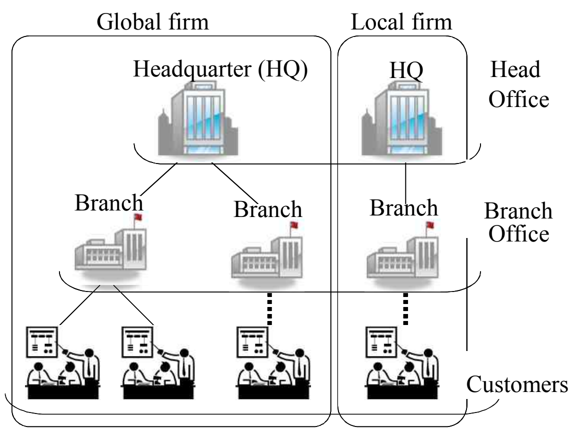

Fig. 1. Hierarchical office network system

In this study, we assume the following two types of firms referred as "global" and "local" firm, respectively. The former firm administrates all the domestic Japan, while the latter firm mainly administrates the geographically closer areas such as the local monopolistic firm, for example, the local electric firms in Japan. Further, the global firms can be classified into following sub-classes; the global firm to locate the branches to the limited number of cities, and the global firm to locate the branches for all the major cities. Hereafter, the both of headquarters offices in the global and local firm are called "head-office". The head-office has several branches. As we discussed above, branches are classified into the one to have many administrative areas and the other to have the one administrative area of the branch located. Both type of branches are called "branch-office", in the following analysis. Fig.1 shows an example of a hierarchical office network system.

3.2 BRANCH OFFICE LOCATION MODEL

Branch office location model gives an optimal set of branch office locations to minimize the administrative / location cost under the given headquarter location. In this study, the target area in Japan is 46 prefectures. Since the branch office data is only available at the prefecture level, each of the prefecture capital is dealt with a representative city, and Okinawa prefecture is excluded in the model system due to its distant location, i.e., always a branch office located in Okinawa. Global firm have a hierarchical office system with three layers shown in fig. 1, and they fulfill the following four conditions.

1) Each of global office locates several branches as to cover all the customers in Japan. A customer in each city is not doubly administrated in each network, shown in fig. 1.
2) A headquarter in global firm administrates their branch, and a branch administrates their customers. Therefore, a headquarters cannot directly administrate the customer. One headquarters and one branch are allowed to be located at one city, in each network.
3) The passenger traffic between headquarter and branch is proportionally generated to the traffic between branch and sum of customers in the administrative area of the branch.
4) A fixed location cost is required to locate branch, for each city.

In case of a branch is located to the identical city with its headquarters, which would be caused by condition 2), it indicates that a headquarters administrate the customers in the branch office administrative area. From the condition 3), we can define an index of branch performance R_l as a ratio between headquarter to branch traffic r_{jk} and the sum of branch to its customer traffic r_{ij} as eq.(1).

$$R_l = \frac{r_{jk}}{\sum_i r_{ij}} \tag{1}$$

Eq.(1) indicates that a branch deal with the business requests coming from the customer, then the requests are compressed to transmit to the headquarters. Therefore, the higher the branch office performance is, the lower the value of R_l is. Considering the branch office efficiency and the existence of linkage between headquarters and branch, R_l lies in $0 < R_l < 1$.

Let a dummy variable y_j indicate the location of branch, and a dummy variable x_{ij} indicate the administrative areas of the branch in *j*. The proposed model gives an optimal branch office location y_j and their administrative area x_{ij}, as to minimize total cost z^{kl}.

$$\min_{y_j, x_{ij}} z^{kl} = \min_{y_j, x_{ij}} \left(\sum_{i \in I} \sum_{j \in J} W_i C_{ij}^{BC} x_{ij}^{kl} + R_l \sum_{j \in J} C_{jk}^{HB} \sum_{i \in I} W_i x_{ij}^{kl} + \sum_{j \in J} F_j y_j^{kl} + D_k \right) \tag{2}$$

where, W_i is customer transportation demand in i, C_{ij}^{BC} and C_{jk}^{HB} are a generalized transportation cost between ij and jk, respectively. F_j and D_k are the location cost of branch office in j and headquarters in k, respectively. Note that in eq.(2), the location of headquarters k and branch office performance index R_l are to be exogenously set.

3.3 RESULTS IN OPTIMAL BRANCH OFFICE LOCATION

The optimal set of branch office locations is obtained for each headquarters location and the branch office performance index. Table 1 to 3 show the branch office location in Tokyo headquarters case for each R_l from 0.1 to 0.9, increased by 0.1, in 1995, 2000 and 2005. When R_l is close to 0.9, number of branch office is small, and vice versa. Comparing the result with different cross-sections, branch office tends to locate at the megacity or the local primal cities, nothing to do with the value of R_l.

Fig.2 and 3 show the location of branch and its administrative area. Irrelevant to R_l, branch office is located in Hokkaido and Kyusyu. The branch is not located in Shikoku area, and

Tab. 1. Branch office location of Tokyo HQ, in 1995

R_l																	
0.1	○	○			○	○			○		○			○	○		
0.2	○	○			○				○		○			○	○		
0.3	○	○			○				○		○			○	○		
0.4	○	○			○				○		○			○	○		
0.5	○				○				○	○	○				○		
0.6	○				○				○	○	○				○		
0.7	○				○				○		○				○		
0.8					○					○					○		
0.9					○												

Tab. 2. Branch office location of Tokyo HQ, in 2000

R_l																	
0.1	○	○			○	○			○	○			○	○	○		○
0.2	○	○		○	○				○	○			○		○		○
0.3	○	○		○	○				○	○			○		○		○
0.4	○	○		○	○				○	○			○		○		○
0.5	○		○		○				○	○			○		○		
0.6	○		○		○				○	○					○		
0.7	○				○				○	○					○		
0.8	○				○					○					○		
0.9					○					○							

Tab. 3. Branch office location of Tokyo HQ, in 2005

R_l																	
0.1	○	○		○	○				○		○		○	○	○		
0.2	○	○			○				○		○		○	○	○		○
0.3	○	○			○				○		○		○	○	○		
0.4	○	○			○				○	○			○		○		
0.5	○		○		○				○	○			○		○		
0.6	○		○		○				○	○					○		
0.7	○				○				○	○					○		
0.8	○				○					○					○		
0.9					○					○							

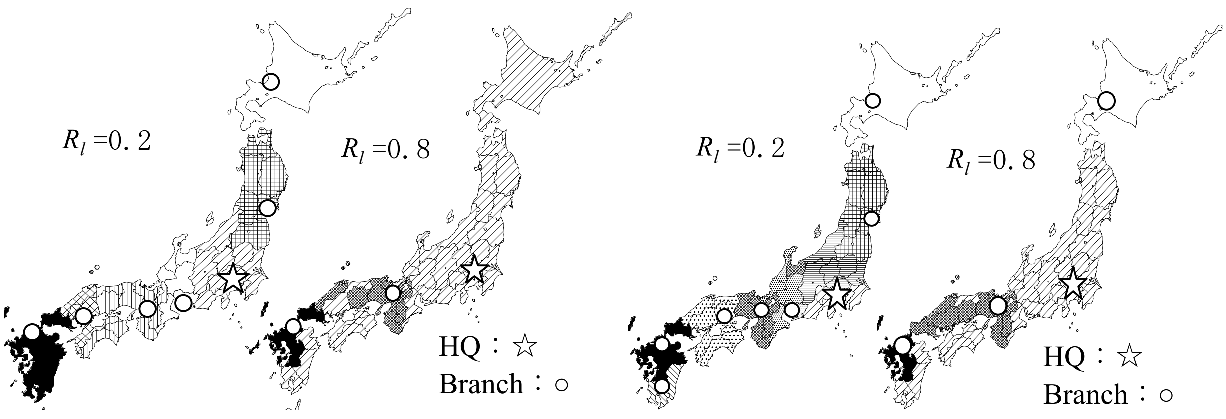

Fig. 2. Administrative area of branch office; Tokyo HQ in 1995 (left) and in 2000 (right)

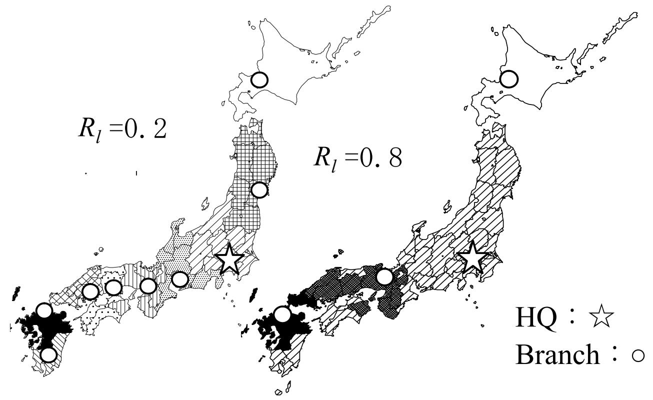

Fig. 3. Administrative area of branch office of Tokyo HQ in 2005

the Shikoku area is administrated by the branch in other region. The reasons to attract the branch to megacity or local principal city can be considered that they have many customers within the city and that the accessibility to the surrounding area is better than the neighbors.

4. AN INTEGRATED MODEL WITH BUSINESS ADMINISTRATION AND TRAFFIC

In this section, we formulate the integrated model with business administration and passenger traffic. In the following model, we considered not only the administrative relation obtained in the branch office location model, but also the administrative relations between headquarters to other 46 cities of the global firm, and also that of local firm. These three types of administrative relations are used to be explanatory variables for the observed inter-regional headquarter and branch linkage, and for the business passenger traffic.

The administrative relations in global firm with several branches are formulated in eq.(3).

$$N_j^{kl} = \beta^{kl} R_l \sum_i W_i x_{ij}^{kl} \tag{3}$$

where, N_j^{kl} is a number of administrative relation obtained from the branch office location, and x_{ij} is an administrative relation of headquarters k and R_l . β^{kl} is a parameter to give a weight of such the relation.

The administrative relations in global firm with 46 branches are formulated in eq.(4).

$$M_{kj} = \gamma_k W_j \tag{4}$$

where, M_{kj} is a number of administrative relation between headquarters in k to branch in j. γ_k is a parameter to give a weight of such the relation.

The administrative relations in local is formulated in eq.(5).

$$L_{kj} = A P_k^{\alpha_1} P_j^{\alpha_2} C_{kj}^{\phi} \tag{5}$$

where, L_{kj} is a number of administrative relation of local firm between k and j. P_k, P_j are number of employee in k and j, respectively, and C_{kj} is a generalized transportation cost from k to j. $\alpha_1, \alpha_2, \psi, A$ are parameters.

Eq.(3) and (4) indicate that the number of linkage between headquarter and branch is proportional to the sum of customers in each administrative area. As shown in eq.(5), the number of administrative linkage of local firm is formulated by gravity model. Note that the administrative linkage within a prefecture is not considered in our model because of lack in traffic data.

By using eq.(3) to (5), the administrative model and passenger traffic model are formulate in eq.(6) and in (7), respectively.

$$S_{kj} = \sum_{l} N_{kj}^{kl} + M_{kj} + L_{kj} + \varepsilon_{kj} \tag{6}$$

$$T_{pq} = \sum_{k} \sum_{l} \varphi^{kl} (N_{pq}^{kl} + W_p x_{pq}^{kl}) + \sum_{k} \lambda_k M_{pq} + L_{pq} + \varepsilon_{pq} \tag{7}$$

where, T_{pq} is the observed passenger traffic between p and q, S_{kj} is the observed administrative linkage between headquarters in k and branch in j, and $W_p x_{pq}^{kl}$ is the passenger traffic between branch and customers of global firm. φ^{kl}, λ_k are parameters, respectively, ε_{kj} and ε_{pq} are error terms, respectively.

T_{pq} is obtained from the net passenger travel survey. In this data, the travel direction can be distinguished by referring to the address of passenger. However, the direction of transportation and the direction of business interaction would not always be identical. Therefore, we use non-directed business trip data, by summing up the passenger traffic from p to q and from q to p.

5. RESULTS OF PARAMETER ESTIMATION OF THE INTEGRATED MODEL

For the calculation of the integrated model, the candidate of administrative network of global firm is prepared for 108 (i.e. 9 different R_l from 0.1 to 0.9, and 12 different headquarters such as Miyagi, Saitama, Chiba, Tokyo, Kanagawa, Shizuoka, Aichi, Kyoto, Osaka, Hyogo, Hiroshima and Fukuoka). The combination of these candidates is sought by trials and errors. The estimated model is shown in tab.4. The determinant coefficients of administrative model for three cross sections as 1995, 2000 and 2005 are over 0.7, and that of passenger traffic model are over 0.8, hence the model fit is fairly good. The global firms with headquarters in Miyagi and in Kyoto were not significant, so that these networks are not set as explanatory variables. All the parameters included in the table are significant, and the signs of parameters are matched to be expected. Looking on the weight parameter β_l, the shares of headquarters in Saitama, Chiba and Kanagawa are relatively high.

The negative parameter estimates are obtained for generalized transportation cost, and the number of employee at the branch city. While it is acceptable for negative parameter appearing in cost variable, the negative parameter for employee is rather difficult to understand. It can be considered that the city with large number of employee tends to locate the local firm, so then the global firms have some difficulty to locate their branch.

The branch performance index R_l appearing in tab. 4 indicates that the high branch performance indices are seen for Tokyo, Aichi, and Osaka headquarters, while it is considerably low at Saitama, Chiba and Kanagawa headquarters. Such the results would show that the global firm with headquarters in megacities forms the business network with higher business performance in branch office. In other words, the improved accessibility provided by inter-regional airline or high speed railway enables such the staggered (horizontal) business network. The comparison between the different cross sections shows that the branch performance is increased for the network with headquarters in Tokyo or Osaka, while it is decreased in Shizuoka and Hiroshima. The longitudinal change of business network implies that the improving domestic LOS

Tab.4. Result of parameter estimation in the integrated model

	predictor variable	R_l	in 1995 estimated value		t value	share	in 2000 estimated value		t value	share	in 2005 estimated value		t value	share
Grobal firm β_k	Saitama	0.9	27.626	**	28.35	4.03%	16.694	**	33.03	4.54%	26.596	**	32.76	4.47%
	Chiba	0.9	18.751	**	22.26	3.23%	23.402	**	23.73	3.24%	21.253	**	25.31	3.44%
	Tokyo	0.1	-		-	-	44.812	**	4.90	1.28%	35.341	**	4.48	1.04%
		0.3	37.564	**	14.14	2.95%	-		-	-	-		-	-
	Kanagawa	0.9	27.553	**	29.26	4.23%	12.489	**	27.76	5.26%	24.667	**	35.38	4.92%
	Shizuoka	0.1	42.662		5.32	1.88%	-		-	-	-		-	-
		0.7	-		-	-	6.729	**	9.80	1.90%	-		-	-
		0.9	-		-	-	-		-	-	2.237	**	4.16	0.69%
	Aichi	0.2	46.669	**	16.30	3.43%	-		-	-	7.652	**	1.70	0.60%
		0.7	-		-	-	17.782	**	18.99	2.27%	18.307	**	12.78	2.47%
	Osaka	0.1	-		-	-	132.520	**	24.25	6.25%	57.237	**	28.09	5.88%
		0.5	37.348	**	28.75	4.66%	-		-	-	-		-	-
	Hyogo	0.8	-		-	-	10.822	**	14.81	2.49%	12.250	**	16.55	2.73%
	Hiroshima	0.2	21.785	**	7.67	1.76%	-		-	-	-		-	-
		0.3	-			-	13.593	**	7.28	1.77%	14.088	**	7.61	1.82%
	Fukuoka	0.1	76.892	**	14.63	3.39%	-		-	-	80.659	**	15.08	3.77%
		0.7	-		-	-	13.718	**	16.44	3.60%	-		-	-
Grobal firm γ_k	Saitama		5.497	**	3.75	2.32%	4.466	**	2.97	1.99%	5.506	**	3.68	2.43%
	Chiba		3.625	*	2.48	1.54%	4.471	**	3.03	2.01%	4.502	**	3.06	2.00%
	Kanagawa		4.197	**	2.78	1.75%	5.662	**	3.60	2.49%	4.380	**	2.84	1.91%
	Shizuoka		4.523		2.79	1.93%	-		-	-	-		-	-
	Hyogo		13.157	**	11.86	5.57%	-		-	-	-		-	-
local firm L_{kj}	generalized cost φ		-0.957	**	-16.08	57.32%	-0.946	**	-16.11	60.90%	-0.982	**	-17.25	61.81%
	emploees (head office) α_1		0.673	**	9.28		0.746	**	7.55		0.713	**	7.84	
	emploees (branch) α_2		-0.711	**	-8.71		-0.849	**	-7.81		-0.818	**	-8.17	
	constant term A		14.382	**	29.20		15.132	**	30.10		15.497	**	32.05	
	coefficient of determinatioı													
	(jurisdiction model)			0.769				0.729				0.771		
	olume of business traffic ı			0.832				0.871				0.874		
	number of samples			2070				2070				2070		

**:significant at 99% level *:significant at 95% level

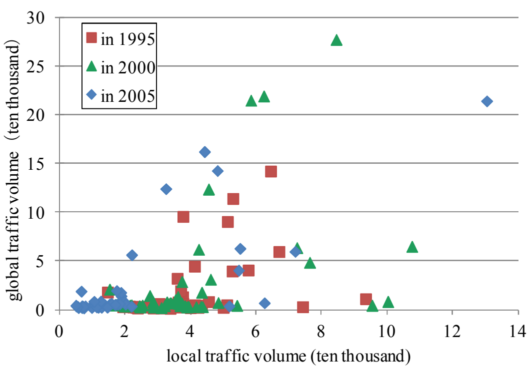

Fig. 5 Global and local traffic (origin)

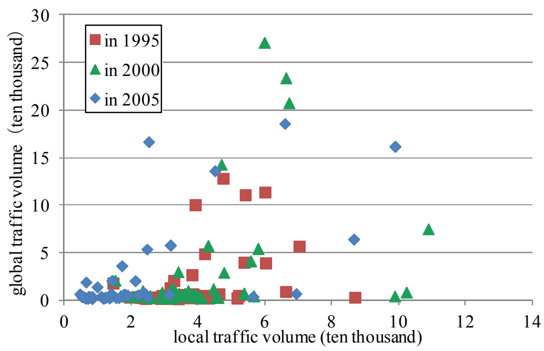

Fig. 6 Global and local traffic (destination)

will result in the integration of business activities into a few megacities, instead of the deterio ration of local primal cities.

In order to clarify the longitudinal change in inter-regional passenger demand, we decompo sed the passenger traffic into global firm and local firm, for both trip generation and trip attra ction. The change in global and local traffic is shown in fig. 5 and 6. The total demand of g lobal and local traffic is increased from 1995 to 2000, while it is decreased from 2000 to 20 05. For looking these tendencies much closer, we aggregated the data for each headquarters ci ty. Fig.7 shows the aggregation for trip generated cities from 1995 to 2000. In this figure, bot h of traffic on global and local firms is increased in Tokyo, Kanagawa and Saitama, and the remarkable increase is occurred in global traffic. On the other hand, local traffic is much incr

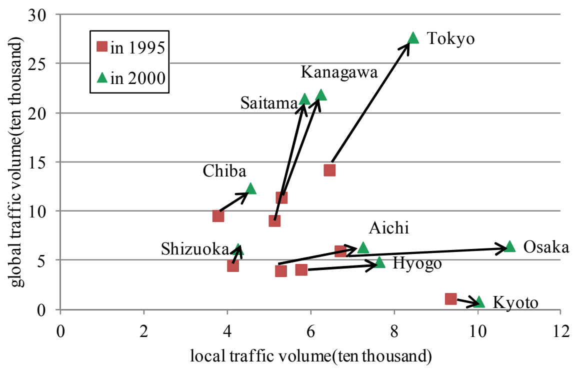

Fig. 7 Changes in trip generation (1995/2000)

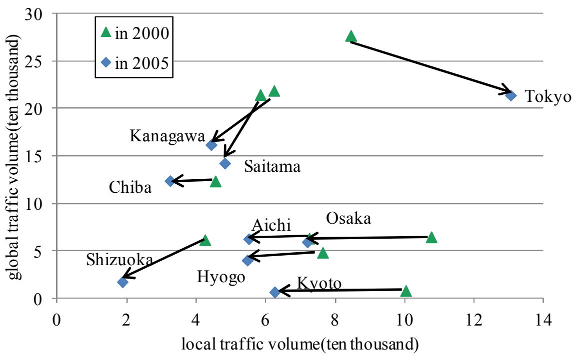

Fig. 8 Changes in trip generation (2000/2005)

eased in headquarters in Aichi, Osaka and Hyogo. Such the change would imply the cities in Kanto area enjoy the benefit of domestic-wide improvement of transportation service, while t he local principal cities tend to strengthen the business linkage with the surrounding area.

Fig. 8 shows the aggregation for trip generated cities from 2000 to 2005. In this figure, b oth of traffic by global and local firm is decreased, while the local traffic is increased in Kan agawa and in Saitama. The reason why these cities increase the local traffic seems an increas e of business attractiveness in these cities.

6. SUMMARY

In this study, we proposed a normative branch office location model and an integrated mo del with branch office location and inter-regional passenger traffic, in order to clarify the influ ence of LOS improvement of inter-regional traffic on headquarters and branch office linkage, and the passenger travel demand. The branch office location model showed that if the perform ance of branch office is higher, the number of branch office on the optimal business network is increased. Therefore, other factors are to be equal, the LOS improvement will result in the increase of branch office.

On the other hand, the empirical regression model for observed administrative linkage and passenger traffic showed that the increase in the higher performance branch office and the lo wer performance branch office simultaneously occur from 1995 to 2005. Moreover, the share of local traffic is increased from 2000 to 2005. Such the trends are completely different betw een the megacities and other local primal cities. Therefore, we should carefully observe the re gional characteristics and propose a regional policy to activate the local economy.

The remaining issues are follows. In order to clarify the progress of business IT usage, th e proposed model should be applied for 2010's passenger traffic data. The accessibility to the Asian countries would be influence on the branch office location, since the economic activiti es become global in the world.

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