RETROSPECTIVE ASSESSMENT OF INTER-REGIONAL TRANSPORTATION SERVICE -- NETWORK EXTERNALITY IN LOS IMPROVEMENT --

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Abstract: In Japan, rapid railway lines have been installed and expanded in order to connect regional prime cities to Tokyo, while airlines began to enhance their domestic service after the deregulation of airlines in 1986. In longer term, the influence of competition between railway and airline become more complex, because of network externalities of LOS improvement on networks. This study makes a retrospective assessment of inter-regional transportation services in ODs with their demand by using the Japanese longitudinal data in 1970, and 1995. The inter-regional net passenger traffic, average speed, fare per distance, and least frequency of the link in line-haul route are compared to find the characteristics of inter-regional LOS. Through the analyses, three kinds of inter-regional transportation markets were identified, and the characteristics of those were summarized. The network externality in LOS strongly appeared in railway service and demand. Such modal characteristics should be carefully considered in inter-regional network planning.

Key Words: Net passenger traffic, railway and airline network, network externality in LOS

1. INTRODUCTION

In south-eastern Asia, many countries step into the stage to facilitate the domestic transportation network. In Japan, since the first 'Shinkansen' line between Tokyo and Osaka opened in 1964, rapid railway lines have been installed and expanded in order to connect regional prime cities to Tokyo. At present, 'Shinkansen' and other inter-regional railway lines shape an intensive network that cover almost all large cities. On the other hand, airlines began to enhance their domestic service substantially after the deregulation of airlines in 1986. In the middle distant inter-regional travel markets, where both railway and airline services are provided, fierce competitions started in '90s. In short term, such competitions are simple, then, both airline and railway may try to improve LOS in order to increase their market share in the target line. However, in longer term, such competitions become more complex, because of "network externalities of LOS improvement".

Suppose the case that new railway service between the two large cities is started, the truck must be continuously constructed between the two large cities, and then the constructed truck passes some smaller cities between the two large cities. By adding some stations at the smaller cities, LOS improvements can be enjoyed for all the passengers traveling along the truck. When the truck is expanded to another city, all the LOS between the newly connected city and all other cities conventionally located on the network will be simultaneously improved. As discussed above, the LOS improvement of a single link potentially increase

LOS for many OD demands on the network, then it actually causes some changes in modal choice or route choice in some ODs. Since such the changes depend on both network shape and the location of improved link(s), we call the inevitable change in LOS as "network externality (in LOS improvement)". In Japan, huge amount of travel demand in middle distance ODs has been economically cultivated after the opening of major railway trunk lines. Railway service has strong network externalities in LOS improvement. On the other hand, network externality is rarely observed in airline network. Flight service improvement between two cities only favors travelers between those cities. If the new flight is added, LOS improvements are limited in that OD pairs, or in origin and destination cities.

Network externalities between different transport service suppliers would be a source of cooperation. Recently, some Japanese railway companies have altered conventional competition strategy into the one positively utilizing network externalities. Once airline gained enough share in the inter-regional passenger transport market between large cities with long distance, the complement strategy can make more profits for railway companies, rather than competing strategy. Therefore, they began to cooperate with the airlines by improving middle distant LOS to connect to major airports. Such complement strategy between railway and airline companies may change the structure of LOS on inter-regional transportation network into new one.

2. MULTIMODAL POLICIES AND THE REMAINNING ISSUES

2.1 Summaries in Conventional Studies

Cooperation among transport service suppliers was originally conceptualized in the logistics strategy called SCM(Supply Chain Management system), in late '90. SCM strategy aims to totally coordinate material and goods freight including virgin material flows, intermediate-inputs flows, and retail good flows (Alvarado, 2001). SCM utilizes information technology to handle the various kinds of information required to meet the goods demand with minimizing the stock-off, and without extra production activities or logistics. SCM activities increase the information cost of supplier side in expense to the demand side transaction cost, therefore the goods supplier could take an advantage to internalize the logistics activity with production and marketing sectors, or to make an alliance to logistics suppliers (Panaydes, 2002). SCM may change the freight center location because the logistics cost under the alliance of transport service supplier is decreased. Racuina and Wynter (2004) proposed optimal freight hub location model based on facility location model in order to enjoy the scale economy in trunk lines of integrated freight network.

Cooperation of different kind of passenger transport service suppliers is called multimodal, or integrated transportation policy. The importance of integrated transportation policy has already recognized in intra-city public transportation planning (Chowdhury and Chien, 2002), since the globalization of passenger transportation in recent years notified that the common problem structure lied in inter-regional level. For example, a seamless inter-regional public transportation system in EU countries is an important goal transportation policy of EU government (Sichelschmidt, 1999). O'Sullivan and Patel (2004) studied the ease of intermodal transfer, then found that the fragmentations of transport operation occurred by privatization made the seamless inter-regional transportation in EU difficult. They proposed that appropriate inter-ticketing service would be a solution for this problem. As a study for multimodal transportation system operation, Chang, Yeh, and Shen (2000) developed a model in order to design the optimal allocation of inter-regional passenger train services. Under the

given demand, their model could find the best-compromised operating plan between operational cost of supplier side, and waiting time cost of passenger side, then output stop-schedule plan, service frequencies, and fleet size.

Concerning to the demand characteristics, Krygsman, Dijst, and Arentze (2004) pointed out the importance of access and egress improvement in inter-regional travel through the calculation of shares of them in line-haul travel time. Lythgoe and Wardman (2002) estimated the access and egress demand function between rail station to airport using disaggregated data. Their study clarified that the direction of journey, such that in-way, or out-way was also an important factor to influence the demand function because of the difference in time value for each direction. Cascetta and Papola (2003) simultaneously modeled the intra-city and inter-regional modal choice behavior applying Nested-Logit, and Cross-Nested model to disaggregated data. In this study, timetables of railways and airways were used to measure the effect of early and late arrival penalties that inter-regional passengers actually faced, then those penalties significantly influenced on the modal choice. A cumbersome problem in demand side approach, however, is that the huge amount of Level of Service (LOS) information is required to describe the detailed situation of individual journey. Detailed LOS information is available not only by questionnaire, but also by simulation analysis using detailed spatial and temporal information. Horn (2003) proposed a journey-planning model based on Dijkstra path-searching method. Lo, Yip, and Wan (2003) claimed that non-linear fare structure caused by intermodal transfers was neglected in conventional studies, and then proposed a new network construction method which enabled to consider the non-linearity of fare structure.

Comparing to the rich accumulation of studies in applied and operational issues, fundamental approach to choose the appropriate transportation modes for integrated transportation system are scarce. One of the earliest concepts was indicated in the speed-distance figure on which the provided transportation services by each modes were plotted (Boulandon, 1970). This figure was made to show the existence of some of missing spots among the speed-distance characteristics and transportation modes. Such spots were called transportation modal gaps, and referred to be facilitated in the future. Jorgenson and Pederson (2004) formulated the supplier's objective function considering the difference in demands that corresponds to the travel distance. Unfortunately, this study did not give a clear-cut relation between transportation mode and travel distance, however. As a empirical approach, Coto-Millan, Banos-Pino, and Ingrada (1997) studied longitudinal inter-regional passenger transport data from 1980 to 1992 in Spain, using co-integration techniques developed in time series analysis. In their study, direct or indirect (cross-modal) price elasticity was estimated. The result of this study showed that no significant cross-elasticity was found between rail and air demand in this duration.

2.2 Purpose of the Study
In inter-regional transportation planning, the importance of seamless intermodal transportation policy has been conventionally often referred, but it is impossible to coordinate the individual planning scheme for facility or operation of each modes (Ham, Kim and Boyce, 2005). One of difficulties for such coordination comes from the lack of fundamental information about the characteristics of speed, fare, and demand for inter-regional public transportation based on actual LOS and demand. Such information has not yet formally reviewed, especially from a retrospective viewpoint. Even this study uses the domestic data in Japan, our analysis would provide important information especially for Asian developing countries that are on the way to national transportation network construction.

This study purposes to make a retrospective assessment of inter-regional transportation services in ODs with their demand by using the Japanese longitudinal data in 1970, and 1995. In conventional studies, gross passenger traffic is used, but gross passenger traffic data is made by aggregating the ticket sales data. Therefore, a multimodal journey using both railway as an access link and airway as a trunk link is separately counted for each link because the passenger uses two tickets. In other words, the data ignores transfers. On the other hand, net passenger traffic data records the initial and the last node of a journey. For the analysis of multimodal journey, the line-haul information about fare, speed, and demand should be used. In Japan, net passenger traffic had not been surveyed until 1990, but gross passenger traffic survey was started in 1970. In order to make comparisons based on the line-haul information of journeys, we estimate the net passenger traffic based on the gross passenger traffic data. Using the estimated demand, average speed, fare, and frequency, we investigate the characteristics of inter-regional LOS and demand. Based on the comparison of growth of LOS and demand of each inter-region, we try to summarize the characteristics of inter-city transportation markets, and to find the network externalities of railway market. Finally, remarks and conclusions are made as to suggest some useful findings for the countries where the domestic network are rapidly evolving.

The following sections in this paper are organized as follows; **Sec.3** shows the procedure to estimate the net passenger traffic, developed by Hazemoto, Okumura, and Tsukai (2004). In **sec.4,** scatter plot analysis between LOS for each link and the estimated demand, or both of growths are done to find the characteristics, then discussions are made. Finally, concluding remarks and remaining issues are shown in **sec.5**.

3. ESTIMATION OF NET PASSENGER TRAFFIC

3.1 The Procedure
Between the gross passenger traffic and the net passenger traffic, a relation shown in eq.(1) is hold.

$$y_S = \sum_{OD} \mu_S^{OD} T_{OD} \tag{1}$$

here, y_S, μ_S^{OD}, and T^{OD} are gross passenger traffic, link usage rates of each link S in an OD, and net passenger traffic in the OD, respectively. Similar to eq.(1), a relation between estimated gross passenger traffic and the estimated net passenger traffic is formulated in eq.(2). The variables with *hat* are estimated values.

$$\hat{y}_S = \sum_{OD} \hat{\mu}_S^{OD} \hat{T}_{OD} \tag{2}$$

If the observation error $y_S - \hat{y}_S$ follows a log-normal distribution, simultaneous probability density function in terms of all the observations of gross passenger traffic is given as eq.(3). Note that $\hat{T}^{OD}$ is parameterized by unrestricted gravity type model shown in eq.(4). Now return to eq.(3), let σ denotes the variance of the observation errors.

$$L = \prod_S \frac{1}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{1}{2}\frac{\{\ln(y_S) - \ln(\hat{y}_S)\}^2}{\sigma^2}\right) \tag{3}$$

Maximizing eq.(3) in terms of the parameters in $\hat{T}^{OD}$ would bring the estimates of net passenger traffic $\hat{y}_S$, if $\hat{\mu}_S^{OD}$ is obtained.

$\hat{T}^{OD}$ is formulated in eq.(4), and eq.(5).

$$\hat{T}_{OD} = (N_1)^{\alpha_1} (N_2)^{\alpha_2} (d_{OD})^{\gamma} \prod_n (LOS_{OD})^{\delta_n^{OD} \phi_n} \prod_m \exp(\varepsilon_m^{OD} \kappa_m) \tag{4}$$

$$LOS_{OD} = \sum_p \exp(V_p) \tag{5}$$

here, N_1 and N_2 are larger and smaller population of the OD zones, respectively. d_{OD} is the distance, LOS_{OD} is the index of provided level of service, and V_p is the utilities of mode p. δ_n^{OD} and ε_m^{OD} are distance class dummies and OD pair dummies, respectively. $\alpha_1, \alpha_2, \gamma, \phi_n$, and κ_m are parameters to be estimated.

$\hat{\mu}_S^{OD}$, link usage rates of each link S in an OD, is estimated by the following procedure.

$$\hat{\mu}_S^{OD} = \sum_{l \in L_{OD}} \hat{P}_l^{OD} \rho_{S,l}^{OD} \tag{6}$$

$$\rho_{S,l}^{OD} \begin{cases} 1 & (l \in L_{OD}, s \in l) \\ 0 & (l \notin L_{OD}, s \notin l) \end{cases} \tag{7}$$

Here, $\hat{P}_l^{OD}$ is a route split ratio of each route l in an OD. $\rho_{s,l}^{OD}$ defined in eq.(7) is a dummy variable to indicate whether the route l contains link s, or not. L_{OD} denotes the route alternative set of an OD for each representative modes (i.e. if the route includes railway links as access and egress links, and an airline link with the longest distance in this route, the representative mode is defined as airline). The routes are efficiently generated by the K-th shortest path searching algorithm. Route enumeration starts from the shortest time, and stops when the line-haul travel time of the additional route exceeds the 1.5 times of the prime route. Based on L_{OD}, $\rho_{s,l}^{OD}$ is obtained. $\hat{P}_l^{OD}$ is defined by a logit type model, whose parameters are estimated using net passenger traffic data in 1995. For example, in order to calculate $\hat{P}_l^{OD}$ in 1970, we assumed that the route split parameters of $\hat{P}_l^{OD}$ obtained for 1995 can be applied for 1970. Given $\hat{P}_l^{OD}$ and $\rho_{s,l}^{OD}$, $\hat{\mu}_S^{OD}$ are obtained on eq.(6), then $\hat{T}^{OD}$ in 1970 (unobserved net passenger traffic) can be estimated by using y_S (observed gross passenger traffic) through the maximization of eq.(3). Details of the enumeration procedure are shown in Hazemoto, Tsukai, and Okumura (2003), or Hazemoto, Okumura, and Tsukai (2004).

**3.2 Performance of the Proposed Procedure**
In this reproduction procedure, OD nodes are set for each of 46 prefectures except Okinawa. Since the inter-regional passenger traffic by car and ferry is not so intensive in Japan, railway and airlines are considered as representative inter-regional transportation modes, hereafter. LOS of both modes is calculated by Navinet system provided by the Ministry of Land and Transportation, and the source of population data is the National Population Census. Inter-regional distance is the Euclid distance between the capital cities of each prefecture. At estimation, eq.(4) is transformed in log-linear function.

Table 1 shows the results in three columns. In order to compare the performance of the proposed procedure, we estimated a normal gravity model (same as eq.(4), log-transformed at model estimation) using net passenger traffic data in 1995 in the left column as the reference model to directly reproduce the net passenger traffic. Reproduction of a gravity model using gross passenger traffic in 1995, based on the proposed procedure is shown in the middle column. Comparing with the estimates of both models, those values are slightly different, but estimates of the proposed model are significant with expected signs. R-squared index of the reproduction model for net passenger traffic is slightly lower than that of the normal gravity

Table 1 Estimates of Reproduction Model

Explanatory variables		1995		1970
		Gravity	Rep.G.	Rep.G.
Population (large)		1.334 **	1.763 **	1.522 **
Population (small)		1.139 **	1.202 **	1.151 **
Distance	(km)	-0.165 *	-0.683 **	-0.970 **
LOS Dummies	0-300	0.363 **	0.581 **	0.307 **
	300-600	0.319 **	0.350 **	0.171 **
	600-900	0.248 **	0.167 **	0.084 **
	900-	0.256 **	0.074	0.009
Regional Dummies	N to N	-1.123 **	0.376	3.288 **
	N to Mid	-2.162 **	-0.896	2.088 **
	N to W	-2.100 **	-1.279 *	0.985
	Mid to Mid	-2.387 **	-1.816 **	1.610 *
	Mid to W	-2.289 **	-1.592 *	2.296 **
	W to W	-1.675 **	-0.503	2.935 **
Variance	σ^2	-	1.126 **	2.128 **
R squared for gross flow		-	0.801	0.602
R squared for net flow		0.817	0.788	-
Number of samples		1020	1056	1085

* : significant in 5%, **: significant in 1%
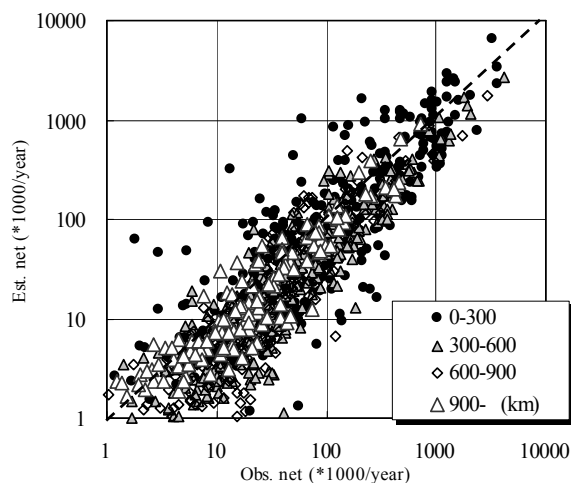
Figure 1 Observed / Estimated Net Passenger Traffic in 1995
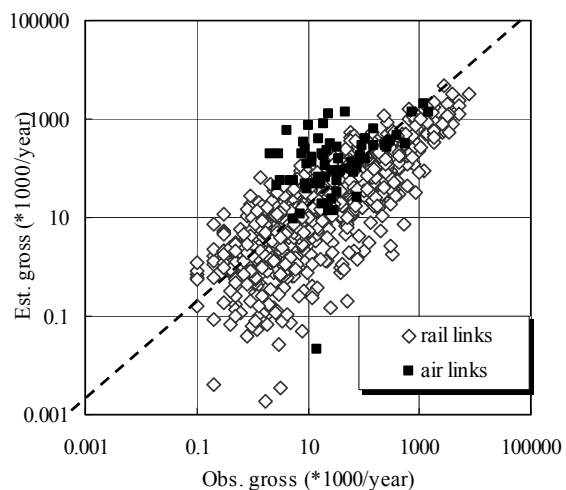
Figure 2 Observed / Estimated Gross Passenger Traffic in 1970

model, but still high, and the index for gross passenger traffic is also high. Therefore, the performance seems good. **Fig. 1** shows a scatter plot of the observed and the estimated values of the net passenger traffic, marked for representative modes. Reproduction performance does not differ between representative modes.

The right column in **Table 1** shows the estimates of the reproduction model using gross passenger traffic in 1970. Parameters are estimated with expected signs, but the values are different from the estimates in 1990. For example, parameters in population are considerably small in 1970, indicating the lower level in inter-regional trip generation. R squared index is not quite low, but not so high. **Fig. 2** shows a scatter plot of the observed and the estimated gross passenger traffic, marked for each line-haul distance segment (gross passenger traffic is obtained by converting the reproduced net passenger traffic with route split ratio $\hat{P}_l^{OD}$).

Comparing with the difference of the reproduction performance between the categories, plots for 0 to 300 km are widely apart from the observations. Such tendency means the necessity to add much information to improve the reproduction performance in this category, by means of reassessment of the route split model exogenously given in this procedure, for example. However in this study, we progress the analysis into the retrospective assessment of inter-regional transportation services, based on the estimated net passenger traffic.

4. CHARACTERISTICS OF INTER-REGIONAL TRANSPORTATION

4.1 Net Passenger Traffic
The performance of the proposed reproduction procedure in sec.3.2 indicates that the reliabilities of each estimation are not so high. Therefore, in order to avoid a nuisance fluctuation caused by instable samples, we divided the OD samples into 9 segments based on line-haul distance. **Table 2** shows the definition of segments.

Table 2 Definition of Distance Segments, and Number of Observations

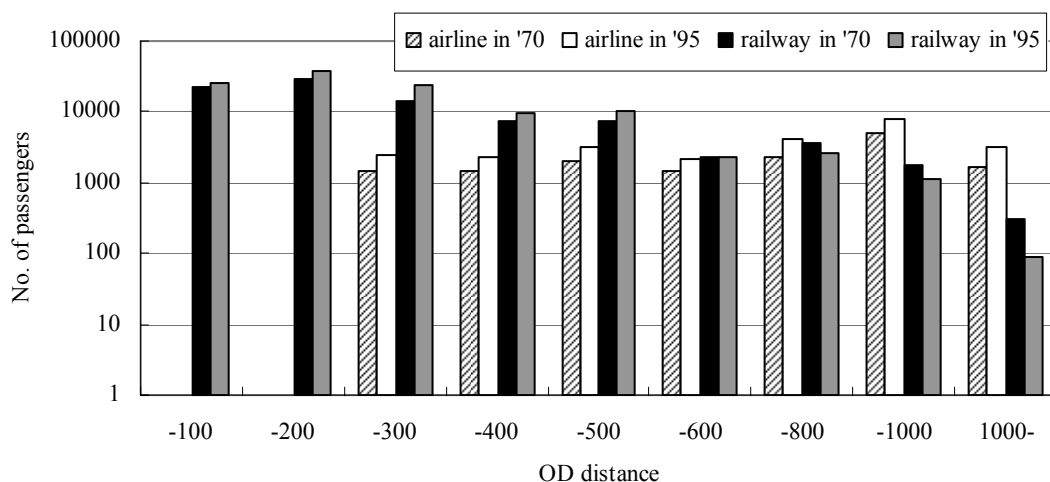| OD distance	-100	-200	-300	-400	-500	-600	-800	-1000	1000-
No. of ODs	52	138	148	123	119	105	149	107	79

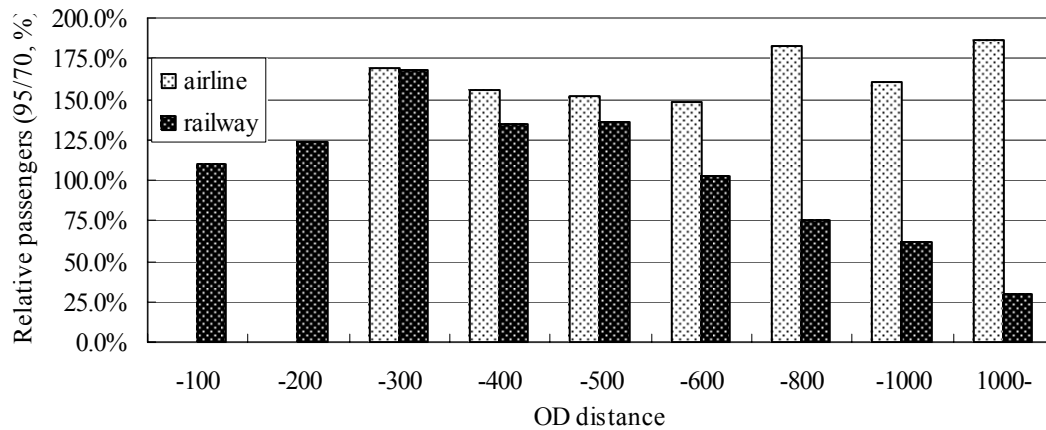**Figure 3 Number of Inter-regional Net Passengers in 1970, and 1995**

Figure 4 Relative Number of Passengers in 1995, Compared to 1970

Fig. 3 shows the aggregated demand for each category in 1970, and 1995. Since airline passengers in the 0 to 100 km segment, and in 101 to 200 km segment are very few, we dropped them from the figure. Concerning airline, the number of passengers increases in all segments. The number of railway passengers increases in five segments less than 600 km, but it decreases in three segments over 601 km. In the 601 km to 800km segment, the number of airline passengers is fewer than that of railway in 1970, but it exceeds the number of railway passengers in 1995. This result suggests that intensive competition between airline and railway companies occurred in this segment. **Fig. 4** shows the relative number of passengers in 1995, standardized by 1970's passengers. In the segments over 801 km, a drastic growth of airline passengers (over 150%) occurred, instead of a steep decrease of railway passengers. The sum of passengers of both modes increases from 14,600 to 19,300, which is about 30 % growth. In the 201 to 300 km segment, passengers of both modes increased.

4.2 LINE-HAUL SERVICE LEVEL OF AIRLINE AND RAILWAY
In the Boulandon's scatter plot, transportation modes were plotted on the axis of distance, speed, unit fare, or (gross) traffic demand. Hence, the scatter plots show the LOS provided by transport service supplier at that time, which are not identical to the representative LOS that the average passengers experienced. In order to make a retrospective assessment of inter-regional transportation service, we slightly modified the original Boulandon's approach to calculate the representative LOS for each segment. In the following figures, we calculated the LOS of airline and railway weighted by the number of passengers $\bar{S}^m$, as in eq.(5).

$$\bar{S}^m = \frac{\sum_{OD} \hat{T}^m_{OD} S^m_{OD}}{\hat{T}^m_{OD}} \tag{5}$$

Fig. 5 shows the velocities of airline and railway for each distance segment. Note that velocities of airline below the 200 km segments are dropped, because of the instable estimates of passengers. The velocity of airline increases in larger distance segments, but the velocity of railway is stable after the segments longer than 201 km line-haul distance. **Fig. 6** shows the relative velocities of two modes in 1995, standardized by 1970's. The growth of airline velocity is very small in all segments, but railway velocities considerably increase in all segment. The velocity growth of railway clearly indicates the existence of the network externality in LOS, by the continuous inter-regional railway improvement in Japan. On the other hand, since the airline in Japan does not shape the clear hub-and spoke network and then provide point to point linkages. Line-haul velocity of airline is strongly affected by the velocities of access and egress links, therefore, not easy to be improved.
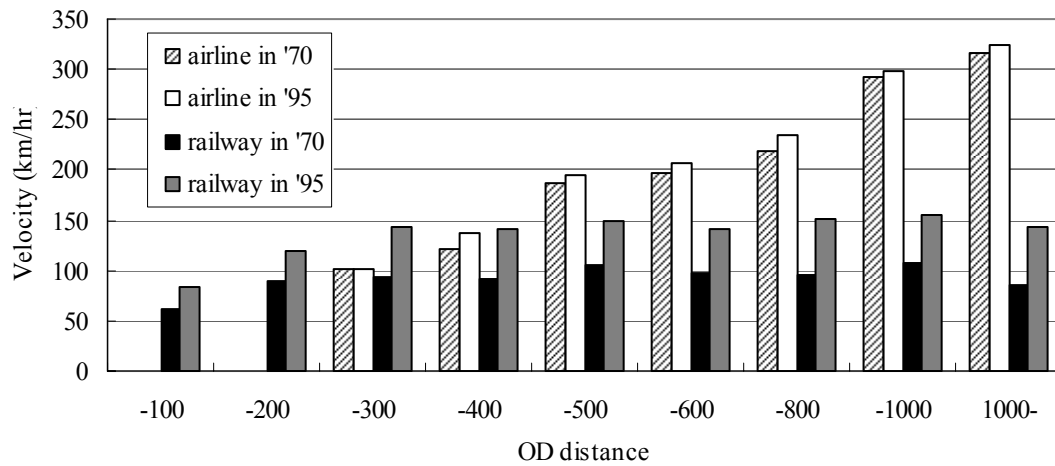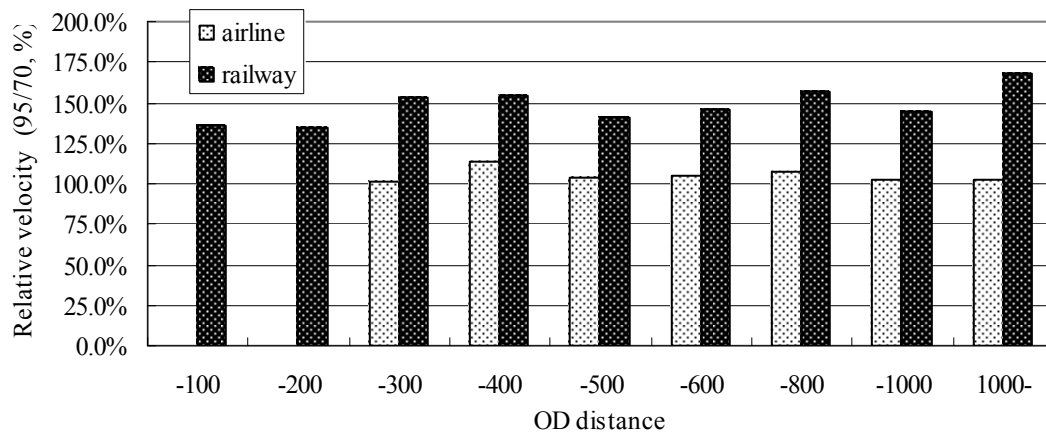
Figure 5 Modal Velocities in 1970 and 1995

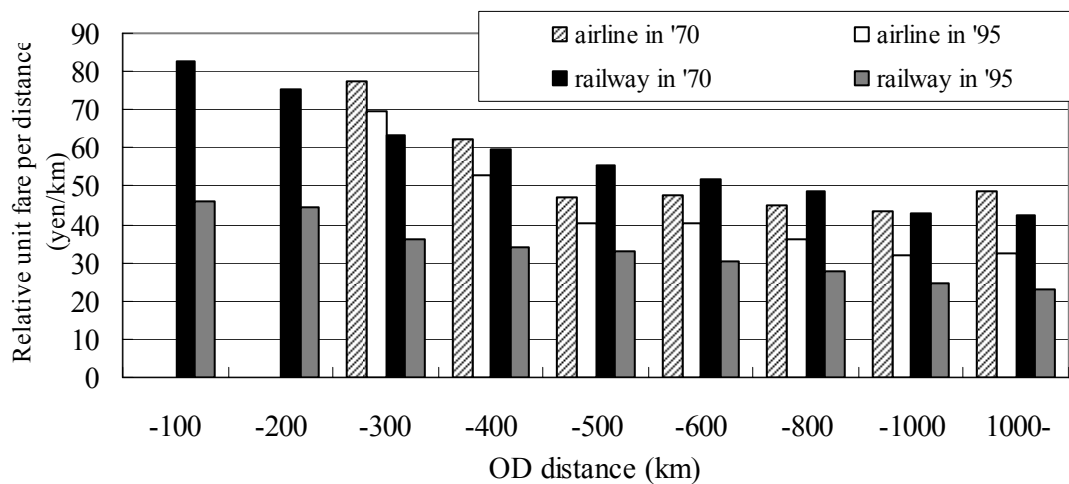**Figure 6 Relative Velocities of Two Modes in 1995, Compared to 1970**

Figure 7 Unit Fares per Distance in 1970 and 1995

Fig. 7 shows unit fares per distance of each mode. The monetary term of fare is deflated in 1995 price. Except the segment of airline over 1000km, unit fares decreases along the increase of distance. In 201 to 300 km segment and 301 to 400 km segment, unit fare of airline is higher than railway fare in both cross-sections. However in 401 to 500 km, 501 to
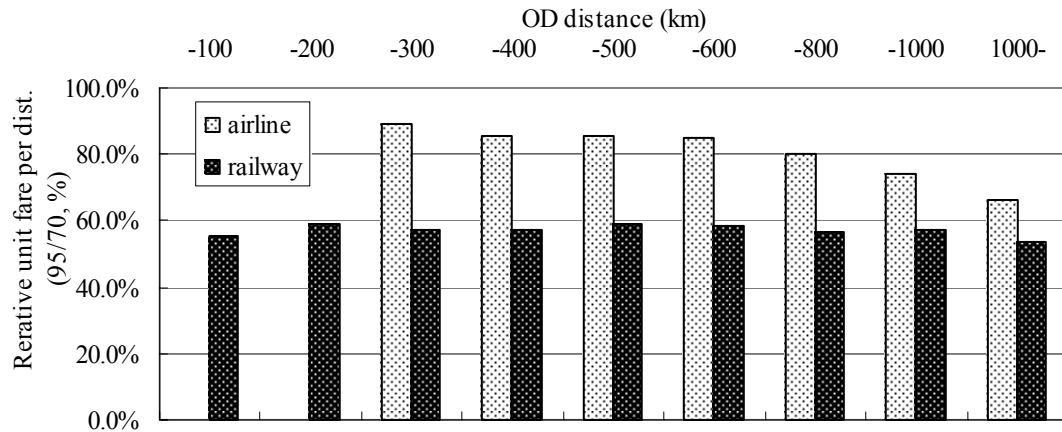
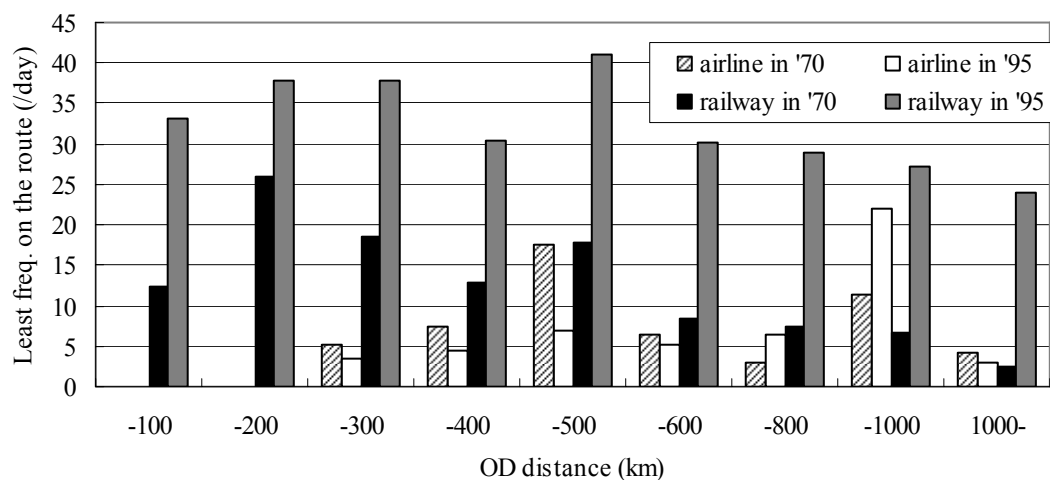**Figure 8 Relative Unit Fare per Distance in 1995, Compared to 1970**

Figure 9 Least Frequencies on the Routes in 1970 and 1995
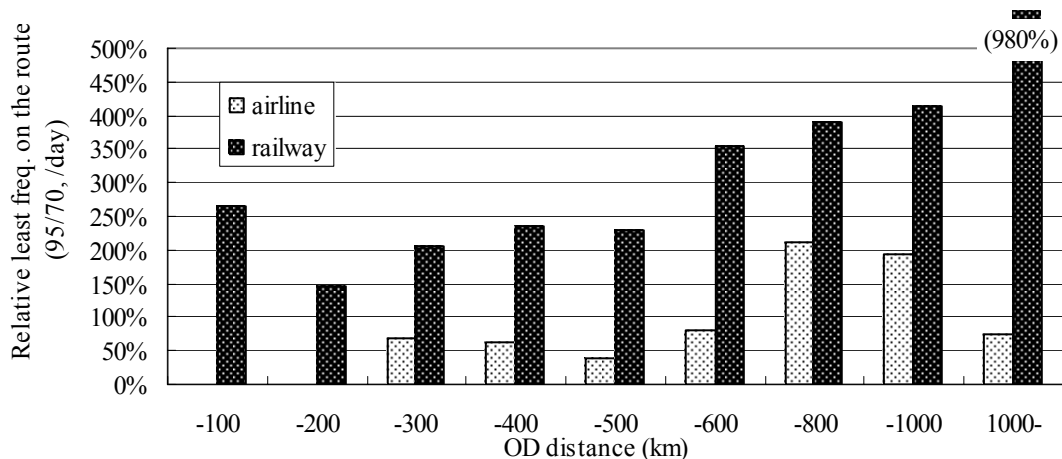

Figure 10 Relative Least Frequencies on the Route in 1995, Compared to 1970

600 km, and 601 to 800 km segments, the unit fares of airline are lower than railway in 1970, but the opposite relation is seen in 1995. **Fig. 8** shows the relative unit fare per distance in 1995, standardized by 1970's. The decrease in fare per distance of railway uniformly occurs in all the segments about 60 % of 1970's price, but the decrease of airline is not uniform, especially remarkable in the 801 to 1000 and over 1000 km segments.

Fig.9 shows the least link frequencies on the route (called least-frequency, in the following sentences). Concerning to airline in 1970, the higher least-frequencies appear in 401 to 500 km segment, while the outstanding peak appears in 801 to 1000 km segment. The segment of highest least-frequency of airline shifts from 401 to 500 km, to 801 to 1000 km. Least-frequencies of railway in the segments longer than 501 km in 1970 are significantly smaller than the shorter segments, but such difference is disappeared in 1995, by overall increase of the frequencies in all distance segments. The segment of highest least-frequency of railway also shifts from 101 to 200 km, to 401 to 500 km. **Fig.10** shows relative least frequencies on the route in 1995, compared to 1970. The increase of least-frequency of airline about 200 % occurs in two segments as 601 to 800 km, and 801 to 1000 km, but they decrease in all the other segments. The least frequencies of railway increase in all the segments. Especially in the segments longer than 501 km, over 300 % growths occured.

4.3 Discussions
The change of modal split of net passenger traffic shown in fig.3 would directly correspond to the change of the required quality of inter-regional transportation. In 1970, there are three different markets in inter-regional transportation. First market is the segment of less than 500 km line-haul distance. This segment is monopolized by railway. Velocity of railway and fare per distance are competitive to airline. However in 401 to 500 km segment, even railway loses the advantages in velocity and fare per distance, the market share is still almost monopolized by railway, because of the shortage in the frequency of airline service. Second markets are 501 to 600 km, and 601 to 800 km segments. In those segments, share of railway are still high, but airline can get the substantial share, because velocity and least frequency of airline is competitive to railway. Therefore, the low market share of airline would be caused by insufficient service supply. The last market, over 801 km segments, market was monopolized by airlines due to the large advantage of velocity.

In 1995, there are also three different markets, but the boundaries of the markets are pressured by the rapid improvement of airline service. The boundary of the first and the second market still remains at around 500 km, but the growth of airline passenger is larger than railway. Interestingly in 401 to 500 km segment, the advantage of airline LOS is only of velocity, but the advantage of least-frequency is lost. Such trend means that airline service supplier can attract the passengers by taking the advantage of velocity, due to the relatively longer distance. The characteristic of the second market was fierce competition of both modes in 1970. Because the railway passengers in 601 to 800 km segment considerably decrease in spite of increase of airline passenger, the share of both modes becomes almost even. Note that in the remained 501 to 600 km segment; almost all the passengers newly increased in this segment from 1970 to 1995 are obtained by airline. The third market of longer distance is characterized by the monopoly of airline that is strengthened in 1995. Such trends are brought by significant advantage of velocity of airline, and caused by the significant increase of airline service supply due to the deregulation of airline in 1985.

While above discussions impress the "serious decline of railway transportation in Japan", the share of railway transportation in 1995 is about 83 %, and the share of railway passengers in the first market, less than 500 km segments, still occupies about 71% to the total inter-regional passengers in 1995. Therefore, these results can be understood that modal split of inter-regional passenger transportation in Japan steps into new stage. For example, in the first market, the growth of 201 to 300 km segment is very high for both modes, but share of passengers in this segment is almost monopolized by railway (about 90 %). Since airline is not competitive to railway in LOS in this segment, we can conclude that railway and airline

are not competing.

In terms of network externality in LOS, the obvious difference is observed between railway and airline. The figures in relative comparison of LOS (in **fig.6**, **fig,8**, and **fig.10**) showed that the considerably large improvement of railway LOS simultaneously occurs in all distance segments. On the network, only a few improvements of links cause many improvements of LOS for all the ODs using the improved links. Since the expansion of "Shinkansen" required many improvements of inter-regional links, the improvement of LOS appeared from short distant ODs to long distant ODs, resulting in the simultaneous improvement of all distance segments. Owing to such improvement, railway can attract more passengers in shorter distance, unless the competition to automobile is fierce. Such case is shown in **fig.4** between 201 km to 500 km segments. However, an improvement of airline LOS of the specific link hardly influences on the other ODs. Because airline services in Japan does not shape a hub and spoke network, an install of an airline link can only provide point to point connection. Based on the advantages of each mode, airline service suppliers provide the point to point service to the small or niche sub-market, while railway service suppliers induce the new passengers by enforcing the network externality supported by the significant improvement of LOS.

5. REMARKS AND REMAINING ISSUES

This study made a retrospective assessment of inter-regional transportation services in ODs with their demand by using the Japanese longitudinal data in 1970, and 1995. The estimated demand, average speed, fare per distance, and least frequency of links in the line-haul route were compared to find the characteristics of inter-regional LOS and demand in longitudinal viewpoint. From those analyses, three kinds of inter-regional transportation markets were identified, and the characteristics of those were summarized. The network externality in LOS strongly appeared in railway service and demand, but it did not appear in airline service and demand. Therefore, such difference in modal characteristics should be carefully considered in future inter-regional network planning. Note that the LOS of multimodal trip is strongly affected by the cooperation between railway and airline service. In case of Japanese inter-regional transportation, intensive railway network is the dominant factor of LOS. In such country, the roll of airlines is to compensate the niche market, and the cooperation of service supplier should be made, based on the above situation. On the other hand, airline oriented inter-regional transportation system can be constructed, as the case of U.S. The difference of inter-regional transportation network also stems from the geographical location of large cities. The inter-regional network planner should also take care for the spatial demand distribution in the present state, and in the future.

Remaining issues of this study are as follows. The obtained results strongly depend on the geographical characteristics of Japan. Further study in other countries where the characteristics of spatial distribution of population, and of present network are different from Japan should be continued. The competition to automobile transport ignored in this study is required in the planning of short distance ranges. The growth of LOS and demand of each inter-region should be compared to the regional growth, in order to find the existence of network externalities of LOS among the connected cities.

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