EFFECTS OF IMPROVEMENT OF HIGH MOBILITY NETWORKS ON PROGRESS IN SERVICE LEVEL AND CHANGE IN USER BENEFIT IN JAPAN

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ABSTRACT

In this study, first, progress in service level for all of Japan due to the improvement of high mobility transport networks from 1960 to 2000 is clarified quantitatively. In this analysis, we pay attention to efficiency and equality of improvement of transport networks over the whole country, and analyze regional difference in progress of service level. Second, change in user benefit due to improvement of high mobility networks is assessed. Finally, influence of improvement of high mobility networks on all of users in Japan is discussed. As a result of the first analysis, it was found that travel cost of air networks decreased greatly from 1960 to

1970. Travel time for every transport mode became less year by year. Second, user benefit of air networks increased from 1970 to 1980 and decreased from 1980 to 1990. The value of railway networks decreased from 1970 to 1980 and increased from 1980 to 1990. And, user benefit of road networks increased year by year. From these results, regarding the effect of improvement of transport networks changed over a 40-year period, valuable information was obtained.

Keywords: high mobility transport networks, travel cost, travel time, user benefit, Japan

INTRODUCTION

Japan is entering a time of rapid decrease in population and suffering with a declining birth rate as well as an aging population. In this situation, investment into infrastructure of transportation in national land is predicted to become less and less in the future. Therefore, it is necessary to change transport networks in consideration of their quality and efficiency which contribute to improve convenience and amenity for transportation users.

The Japanese Government announced the “National Land Sustainability Plan” issued by The Ministry of Land Infrastructure and Transport in 2008. This plan intends to change a national land structure in which excessive concentration of population and industry in the Tokyo Metropolitan areas and pacific belt zones is seen, and to promote the self-sustaining development in wide areas diversely over the national land. It is described in this plan that it is necessary to develop the distribution systems of international commodities and high mobility networks corresponding to wide economic activities. Also, it is noted in the plan that it is important to develop the quality of national transport networks by taking advantage of existing systems and promote efficient investment over the national land. In this situation, it is important as well as useful for designing transport networks and policies in the future in consideration of progress in service level and change in user benefit in the latter half of the 20th century. During this period of time, high mobility networks consisting of air, railway and expressways were developed remarkably.

In this study, first, progress in service level for all of Japan due to the improvement of high mobility transport networks from 1960 to 2000 is clarified quantitatively. As indexes to measure the service level, travel cost, time and generalized cost are used. The first express highway (expressway) was opened in 1963 and the Shinkansen (bullet train) began operation in 1964. In this analysis, we pay attention to efficiency and equality of improvement of transport networks over the whole country, and analyze regional difference in progress of service level. Second, change in user benefit due to improvement of high mobility networks is assessed. The efficiency and equality over the entire country are also considered. Finally, influence of improvement of high mobility networks on all of users in Japan is discussed related to the long term.

PREVIOUS STUDIES

There have been many studies concerned with analysis of development of road networks in Japan. For example, Abe et al. (2004) clarified the relationship between improvement of expressways and improvement of convenience of freight transportation in Japan from 1975 to 2000. They estimated the reduction of travel time between prefectures due to improvement of expressways, and analyzed the relationship between reduction of travel time and convenience of freight transportation. Kodama (1988) summarized influence of expansion of people's spheres of action due to reduction of travel time caused by improvement of expressways on aspects of recreation activities, daily life and business activities. Ando and Zheng (1999) defined economic effects of change in human exchanges due to improvement of road networks as “economy of road networks”. Then, they analyzed the relationship between industrial production of local municipality and travel time to major city. Kondo (1992), and Aoyama and Kondo (1993) analyzed the influence of improvement of expressways on trading area in a city. As a result, they clarified that the influence was significant, and trading area in a big city having a substantial attraction expands the scale. Also, they considered the direction of development of the Shikoku region in the future.

There are several studies which have contributed to the analysis of development of transport networks. For instance, Nakagawa et al. (1994) pointed out that the relationship between improvement of transport networks and development of regions had not been investigated in detail before, and discussed methodology to measure the possibility of interaction between regions by the development of transport networks. Moreover, they measured an extended possibility of interaction between regions from 1898 to 1990 using time that people can stay and accessibility time. Miura (2004) applied the Huff’s Model to the number of travellers in Japan, and proposed a method of analysis employing sensitivity analysis in order to estimate the influence of reduction of travel time due to development of transport facilities on the number of travellers who visit certain regions. Aoyama et al. (1996) proposed a migration model based on the Utility Maximization Theory in order to analyze the influence of transportation development on migration and applied it to Japan. Kondo et al. (1997) analyzed the change in development of high mobility networks based on users benefit from 1960 to 1990, and evaluated the service level of transport modes using the ratio of cost increase to reduced travel time. Following this, Yamaguchi et al. (1999) proposed a new method to evaluate the development of high mobility transportation networks more objectively based on the concept of generalized cost and applied it to Japan.

As described above, there have been a number of studies related to the theme of the development of transport networks. In this study we aim to further such studies as follows. , First, we clarify progress in service level for all of Japan due to improvement of high mobility transport networks consisting of air, railway and road from 1960 to 2000. In order to measure the service level, travel cost, time and generalized cost are used as indexes. Also, we clarify changes in user benefit per decade from 1960 to 2000.

OBJECT AND VIEWPOINT OF STUDY

Object of Study

Areas

46 prefectures with the exception of Okinawa prefecture in Japan are chosen as regions of analysis. Okinawa prefecture is relatively isolated and consists of many small lands that are not connected to the main islands of Japan by bridge. Therefore, this prefecture is not included in regions for analysis.

Period of Time

The analysis period of this study spans forty years from 1960 to 2000. During this period of time, high mobility networks developed rapidly in Japan. In particular, we analyze in the years of 1960, 1970, 1980, 1990 and 2000.

Transport Modes

The transport networks analyzed in this study consist of three transport modes. They are air, railway and road networks. With the exception of sea transportation, which accounts for a small percentage of the total, almost all trips by people in Japan use the above-mentioned three modes. Therefore, we choose these three networks as major modes. Figure 1 shows the change of the number of frights in air networks in Japan. Figure 2 shows development of the length of Shinkansen lines in railway networks, and Figure 3 shows development of the length of expressways in road networks.

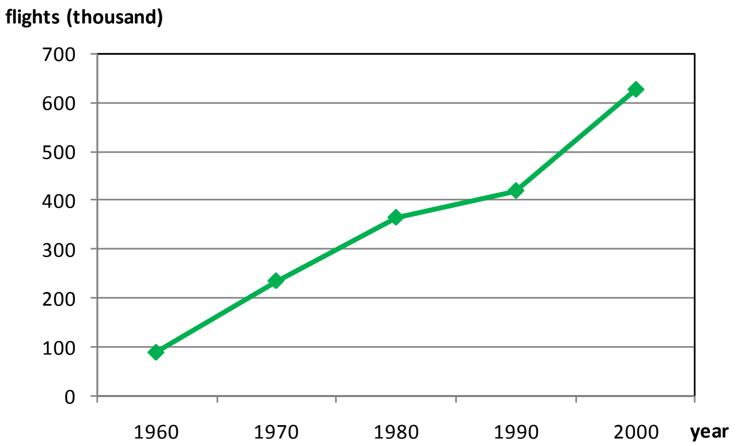

Figure 1— *Development of air networks (Number of flights)*

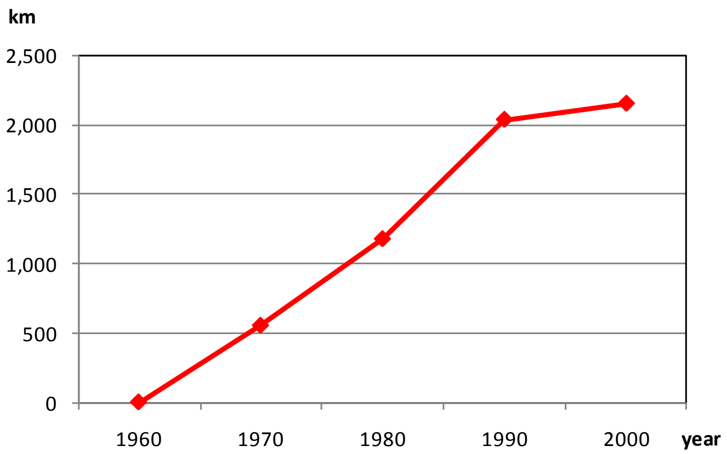

Figure 2—*Development of railway networks (Length of Shinkansen lines)*

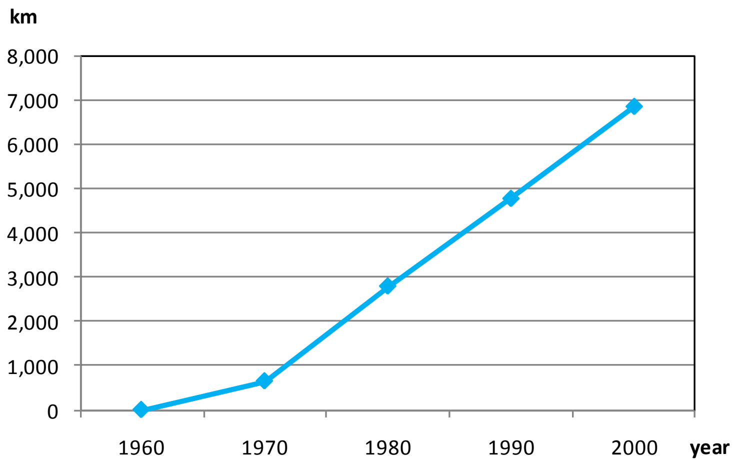

Figure 3— *Development of road networks (Length of expressways)*

As these figures show, transport networks improved remarkably in the latter half of the 20th Century. Improvement of expressways lagged a little behind the other two transportation networks from 1960 to 1970. All of the transportation facilities developed over time at the same pace from 1970 to 1990. The difference in improvement of each transport mode is seen from 1990 to 2000. Degree of improvement of air networks was most advanced of the three, the pace of improvement of railways dropped, and that of road remained constant.

Transport Networks

Travel time and travel cost between prefectures are measured along the shortest route in terms of travel time. Places of origin and destination to measure travel time between prefectures are those where their capital cities are located.

Air Network

Air networks consist of all of the domestic air routes, bus lines and railway routes. Bus lines and railway routes are regarded as access and egress transportation between prefectural capitals and airports. In addition, data of the railway networks are used instead of air networks between prefectures not having airports. Travel cost and time in air networks are measured using airline timetables. Travel cost and time needed for access from origin to airport and for egress from airport to the prefectural capitals are measured using road maps and train timetables. Travel time included 30 minutes to allow for the time waiting for departure in the airport lobby.

Railway Network

Railway networks consist of all the lines of Japan Railway Companies. Travel cost and time for railway networks are measured using train timetables. Travel cost was calculated in accordance from fares listed in timetables. Travel time included 15 minutes to change trains and waiting time on the platform.

Road Network

Road networks consist of all the expressways, major national roads, some regional roads and major ferry routes. Travel cost and time for road networks are measured using data from the NITAS and road timetables. Gasoline cost was calculated to be 13 yen per km based on average car size and gasoline price. The charge of ferries and expressways were assumed to that for an average passenger car of less than 5m in length.

Viewpoint of Study

In this study, changes in user benefit are analyzed and considered from viewpoints of regional difference. In consideration of regional difference and user benefit, we take two cases into account. In the first case, difference in 9 blocks of Japan is considered. And, for the second case, difference between populated areas and other areas is analyzed. This will enable us to identify regions where user convenience has been improved. We analyze the reasons of results obtained by considering various features of the regions. The final information is believed to be very valuable when we consider development of transportation facilities efficiently and in depth.

Total value of user benefit of Japan is defined as the sum of each user's benefit calculated between prefectures. Japan is divided into 9 blocks by reference to National Spatial Planning as shown in Figure 4 and Table 1. Concerning user benefits for the 9 blocks in Japan, we calculate value of user benefit for every prefecture included in each block and then sum them. Also, we compare data populated areas and rural areas. . The populated areas include prefectures having a city whose population is greater than one million in 2000. The populated areas consist of 10 prefectures which consist of Hokkaido, Saitama, Tokyo Kanagawa, Aichi, Kyoto, Osaka, Hyogo, Hiroshima, and Fukuoka. Other prefectures are assumed to be rural regions. The total population of the populated areas is 65,113,103 and that of the rural regions is 60,494,520 in 2000. Figure 5 shows regional division of the populated areas and rural regions.

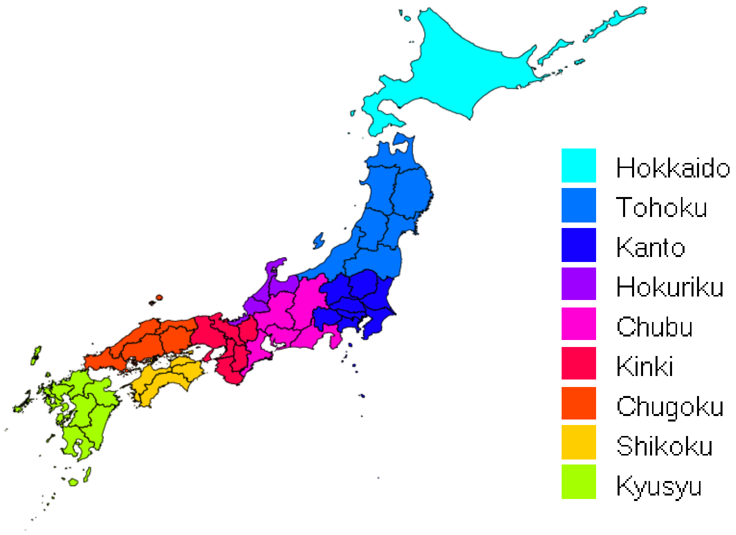

Figure 4 －Division of *9 blocks*

Table 1 －Division of 9 blocks and prefectures

Block	Prefectures	Population (2000)
Hokkaido	Hokkaido	5,683,062
Tohoku	Aomori, Iwate, Miyagi, Akita, Ymagata, Fukushima, Niigata	12,293,322
Kanto	Ibaragi, Tochigi, Gunma, Saitama, Chiba, Tokyo, Kanagawa, Yamanashi	41,321,883
Hokuriku	Toyama, Ishikawa, Fukui	3,130,772
Chubu	Nagano, Gifu, Shizuoka, Aichi, Mie	16,990,900
Kinki	Shiga, Kyoto, Osaka, Hyogo, Nara, Wakayama	20,855,585
Chugoku	Tottori, Shimane, Okayama, Hiroshima, Yamaguchi	7,732,499
Shikoku	Tokushima, Kagawa, Ehime, Kochi	4,154,039
Kyusyu	Fukuoka, Saga, Nagasaki, Kumamoto, Oita, Miyazaki, Kagoshima	13,445,561

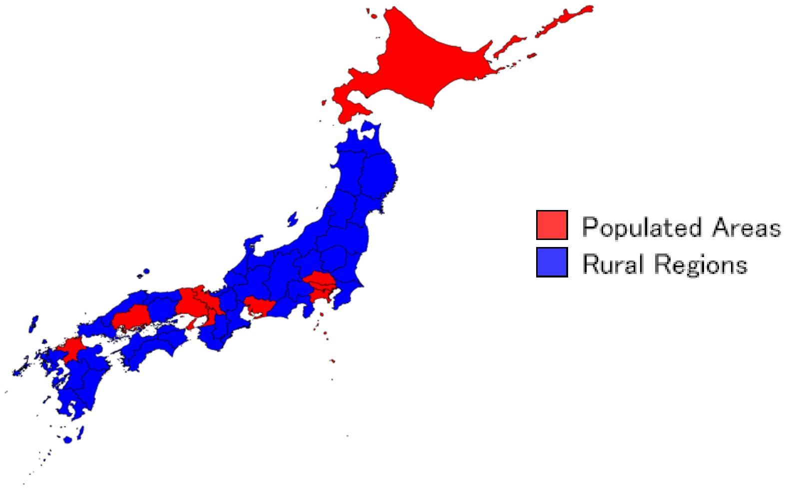

Figure 5－*Populated areas and rural region*

EFFECTS OF IMPROVEMENT ON PROGRESS IN SERVICE LEVEL

We analyze changes in service level for users by improvement of high mobility networks. Indexes to measure service level, travel cost, time and generalized cost are used in this study. It is assumed that all the people have an equal travel chance, and, therefore, value per capita is used. Also, travel cost, time and generalized cost are assumed the value for each unit distance.

Calculation Method

Travel cost and time between prefectures for the three transport modes are measured when one person living in each prefecture travels. We used indexes the travel cost, travel time and generalized cost of per unit distance here, as the purpose of this study is to analyze whether all of the persons who live in all prefectures have received the equal transport service. The further the travel distance becomes, the more the cost and time increase. When we calculate travel cost, travel time and the generalized cost simply, the values of prefectures located in the edge of Japan are big. In this study, we use the values of per unit distance to exclude the influence that the location of prefectures on travel cost, travel time and generalized cost. We assume two cases regarding ways of travel. It is supposed in [Case 1] that a person living in any prefecture visits all prefectures only one time. In [Case 2] the person visits all prefectures, and the number of visits is proportional to population of the prefectures the person visits. Travel cost and time per unit distance of these two cases are calculated from 1960 to 2000 by three transport modes using equations (1) ~ (4).

[Case1]

Travel Cost $c_{1i}^k = \sum_j c_{ij}^k / \sum_j d_{ij}$ (1)

Travel Time $t_{1i}^k = \sum_j t_{ij}^k / \sum_j d_{ij}$ (2)

[Case2]

Travel Cost $c_{2i}^k = (\sum_j P_j c_{ij}^k)/(\sum_j P_j d_{ij})$ (3)

Travel Time $t_{2i}^k = (\sum_j P_j t_{ij}^k)/(\sum_j P_j d_{ij})$ (4)

$c_{ij}{}^k$: Travel cost between prefectures i and j by transport mode k
$t_{ij}{}^k$: Travel time between prefectures i and j by transport mode k
P_j : Population of prefecture j
d_{ij} : Direct distance between prefectures i and j

Generalized cost of travel is defined as a compound function with travel cost and time being based on the value of time of people. Improvement of convenience in use of transportation for people in Japan is measured using generalized cost. Generalized cost is expressed by equations (5) and (6).

[Case1]

$$G_{1i}^k = c_{1i}^k + \mu_i t_{1i}^k \quad (5)$$

[Case2]

$$G_{2i}^k = c_{2i}^k + \mu_i t_{2i}^k \quad (6)$$

μ : Value of time

Travel cost and time of three transport modes are calculated using data of shortest route in terms of travel time between prefectural capitals for each of the transport modes. Travel cost in each fiscal year employs a value converted into the value of money in the year 2000. Distance between prefectures i and j uses the direct distance between prefectural capitals.

Value of Time

Many studies related to the value of time exist which we can use as references (for example: Bruzelius, (1979)). In the present study, the income method is applied when we estimate value of time. Average value of time is estimated using annual income and working time. Equation (7) is used for estimation of value of time. First, value of time is estimated for each prefecture. Then, average value of time for Japan is calculated. The estimation results of value of time for Japan are shown in Figures 6 and 7. Figure 6 shows change in nominal value of time. Figure 7 shows real value of time for the value of 2000 which is converted from the nominal value of time by a deflation index in the year 2000.

$$\mu_i = I_i / ((w_{mi} \times M_i + w_{fi} \times F_i) / P_i) \qquad (7)$$

I_i : Average annual income in prefecture i
w_{mi} : Work time of males in prefecture i
w_{fi} : Work time of females in prefecture i
M_i : Population of males in prefecture i
F_i : Population of females in prefecture i
P_i : Population of prefecture i

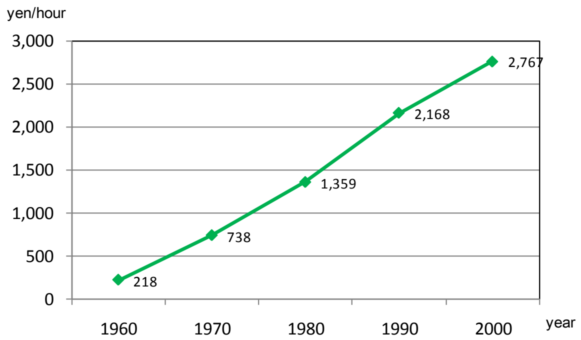

Figure 6— *Average value of time (Nominal)*

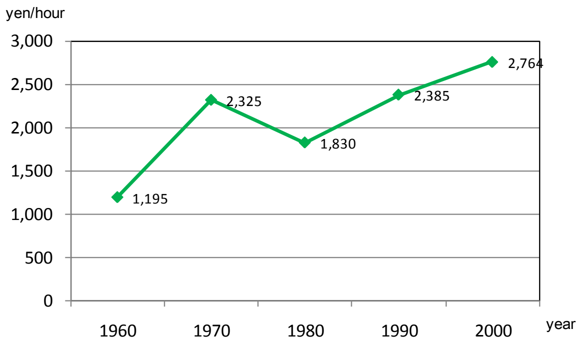

Figure 7— *Average value of time (Actual)*

Figure 6 shows that the nominal value of time has increased year by year. However, Figure 7 shows that the real value of time has been irregular. The real value of time has decreased from 1970 to 1980 and increased during other periods. In particular, the degree of increase from 1960 to 1970 is high. It is considered that this tendency is caused by change in working time which is comparatively small and annual income which is comparatively big. We calculate the generalized cost using the real value of time.

Results of Calculation

Changes in Travel Cost

Figures 8 and 9 show changes in travel cost of [Case 1] and [Case 2]. The value of travel cost of three transport modes in [Case 1] and [Case 2] are very similar, but those of [Case 1] are a little bigger than those of [Case 2]. Travel cost of air networks decreased remarkably from 1960 to 1970. This shows the immediate effect of high mobility networks especially improved in the 1960's. Travel cost of railways and road show little variation from 1960 to 2000, but that of railways increased slightly from 1980 to 1990. This is because of the privatization of Japan National Railways in 1987. When the travel cost of road networks is calculated, the number of passengers per car is assumed to be two people. When we look at this value, it is about 100 yen/km in 1960 and half a value in 2000 in air networks so degree of decrease is high. The value fluctuates up and down between 20 yen/km and 40 yen/km in railway and road networks.

Changes in Travel Time

Figures 10 and 11 show changes in travel time of [Case 1] and [Case 2]. The value of travel time of three transport modes in [Case 1] and [Case 2] are very similar, too. Travel time of every transport mode has become smaller year by year, and the difference in values of three transportation modes at time of analysis has become smaller. In particular, change of travel time in railway networks from 1960 to 1970 is remarkable. This shows the contribution of development of railway networks due to introduction of the Shinkansen trains. The cost of air networks is the highest of three modes every year, but the time of air travel is smallest of the three modes every year. In addition, travel time per unit distance in all periods is less than one minute/km.

Changes in Generalized Cost

Figures 12 and 13 show changes in generalized cost of three transport modes in [Case 1] and [Case 2]. Generalized cost of air networks has decreased year by year, but that of railway and road networks has fluctuated up and down from 1960 to 2000. Because the generalized cost of railways and roads is significantly influenced by value of time. Even if cost is reduced and time is shortened by development of transport networks every year, generalized cost will not necessarily decrease because it is influenced by value of time. When we look at the values in Figure 12 and 13, it can be seen that value of all transportation settles to about 80 yen/km in 2000 though the values differ in 1960.

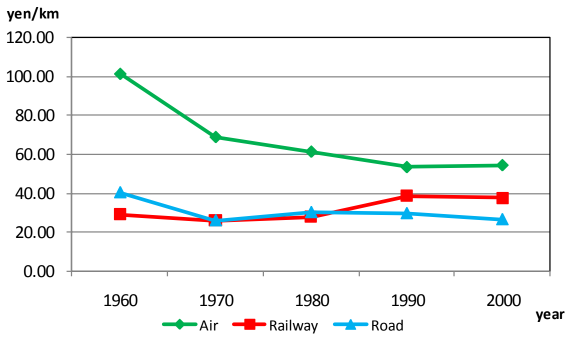

Figure 8—*Changes in travel cost [Case1]*

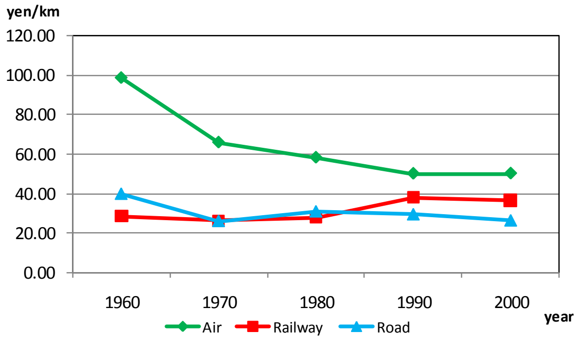

Figure 9— *Changes in travel cost [Case2]*

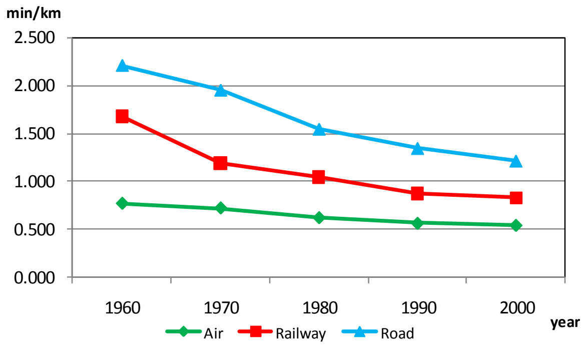

Figure 10— *Changes in travel time [Case1]*

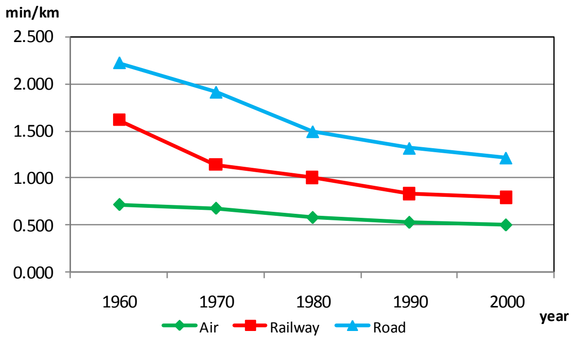

Figure 11— *Changes in travel time [Case2]*

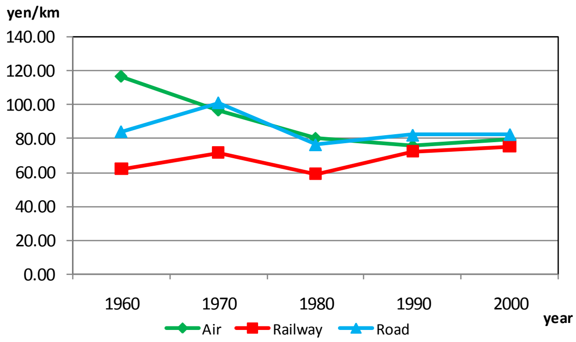

Figure 12— *Changes in generalized cost [Case1]*

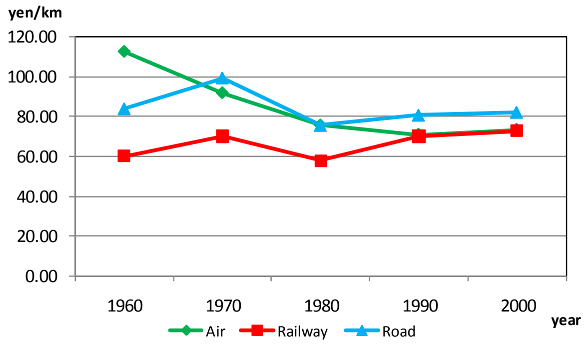

Figure 13— *Changes in generalized cost [Case2]*

We showed the change in service level for users by improvement of high mobility networks over a period of 40 years when one person travels using each mode of transportation. As indexes to measure service level, average travel cost, time and generalized cost are used in this study. The following is evident from the results. Travel cost of air has decreased remarkably year by year, that of railways increased from 1980 to 1990, and that of road has remained unchanged. Travel time of every transport mode has become shorter year by year.

In the next section, we analyze effects of improvement of high mobility networks on change in user benefit in consideration of regional difference.

EFFECTS OF IMPROVEMENT ON CHANGE IN USER BENEFIT

Method of Measuring Effects

We analyze change in user benefit by improvement of high mobility networks. In this analysis, as an index to measure user benefit, consumer surplus is used. In this study, first, the traffic demand function of each period of time is estimated for each of the transportation modes. Second, consumer surplus at 5 periods of time is calculated. Finally, changes in consumer surplus for every year from 1960 to 2000 are measured. Many studies related to the evaluation of transportation development using user benefit have been done which we can use as references (for example: Williams, (1977)).

Traffic Demand Function

The traffic demand function is estimated by application of the gravity model in this study. The traffic demand function of each transportation mode is assumed as shown in equations (8) ~ (10). 15 kinds of traffic demand functions can be obtained for each of the three transportation modes at five periods of time by estimating parameters of equations (8) ~ (10).
The traffic demand function of air networks is assumed as a function by introduction of ratio of travel time of railway and air networks as a variable. In addition, travel data of a distance shorter than 200km are excluded from the analysis in estimation of traffic demand function for air networks. The traffic demand function of road networks is assumed as a function in consideration of car ownership rate of departure place.

Air $$x_{ij} = k \frac{P_i^{\alpha} P_j^{\beta}}{G_{ij}^{\gamma}} \left(\frac{t_{ij}^{rail}}{t_{ij}^{air}} \right)^{\varphi} \qquad (8)$$

Railways $$x_{ij} = k \frac{P_i^{\alpha} P_j^{\beta}}{G_{ij}^{\gamma}} \qquad (9)$$

Road $$x_{ij} = k \frac{(\theta_i P_i)^{\alpha} P_j^{\beta}}{G_{ij}^{\gamma}} \qquad (10)$$

x_{ij} : Number of people travelling between prefectures i and j
G_{ij} : Generalized cost between prefectures i and j
P_i : Population of prefecture i
P_j : Population of prefecture j
t_{ij}^{rail} : Travel time between prefectures i and j by railways
t_{ij}^{air} : Travel time between prefectures i and j by air

θ_i : Car ownership ratio of prefecture i

$k, \alpha, \beta, \gamma, \varphi$: Parameters

In this study, in order to calculate user benefit between prefectures, traffic demand functions between prefectures are necessary. Therefore, next, traffic demand function between prefectures i and j is estimated based on traffic demand function intended for the whole country obtained previously. It is possible to estimate this function by substituting the population of prefectures i and j, travel time and car ownership for the traffic demand function for the whole country. These are expressed by equations (11) ~ (14).

$$x_{ij} = k_{ij} \frac{1}{G_{ij}^{\gamma}} \quad (11)$$

Air $$k_{ij} = k \times P_i^{\alpha} \times P_j^{\beta} \times \left(\frac{t_{ij}^{rail}}{t_{ij}^{air}} \right)^{\varphi} \quad (12)$$

Railways $$k_{ij} = k \times P_i^{\alpha} \times P_j^{\beta} \quad (13)$$

Road $$k_{ij} = k \times (\theta_i P_i)^{\alpha} \times P_j^{\beta} \quad (14)$$

Consumer Surplus

Consumer surplus between prefectures i and j in each period of time can be calculated using the traffic demand function between prefectures i and j. Consumer surplus between prefectures i and j is calculated by integration using equation (11). Figure 14 shows a concept of consumer surplus, and equation (15) shows calculation formula of consumer surplus at time 1.

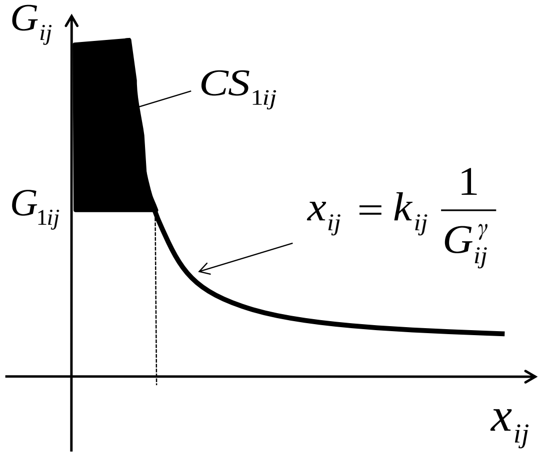

Figure 14－ *Concept of consumer surplus at time1*

$$CS_{1ij} = \int_{G_{1ij}}^{\infty} x_{ij} dG_{ij} = \frac{1}{1-\gamma} k_{ij} \left(\frac{1}{\infty^{\gamma-1}} - \frac{1}{G_{1ij}^{\gamma-1}} \right) \quad (15)$$

CS_{1ij} : Consumer surplus between prefectures i and j at time 1

Here, we assume a condition of $\gamma > 1$. Then consumer surplus between prefectures i and j at time 1 is shown as equation (16).

$$CS_{1ij} = \frac{1}{\gamma - 1} k_{ij} \frac{1}{G_{1ij}^{\gamma-1}} \qquad (16)$$

Consumer surplus between prefectures i and j can be estimated for three modes of transportation at five periods of time using equation (16) and changes in consumer surplus during a period of 10 years can be calculated using these results. We can analyze change in user benefit over a period of 40 years paying attention to regional difference.

Results of Traffic Demand Function

Parameters of traffic demand functions are estimated by the multiple linear regression method using equations (8) ~ (10). Results of estimation of parameters are shown in Table2. From Table 2, the condition of $\gamma > 1$ is satisfied for every transport mode. In particular, results of railways in the estimation are found to be highly accurate as coefficients of determination R^2 show.

Table 2 －*Results of parameter estimation of traffic demand function*

		1960		1970		1980		1990		2000	
Air	Coefficient of determination R^2	0.803		0.614		0.485		0.580		0.749	
	Conditioned coefficient of determination R^2	0.783		0.596		0.471		0.569		0.744	
	Number of sample	44		92		150		159		239	
	Variable	Parameter	T value	Parameter	T value	Parameter	T value	Parameter	T value	Parameter	T value
	logek	−25.163	−6.177	−10.243	−2.600	−12.209	−3.793	−16.493	−4.539	−19.469	−5.615
	α	1.802	10.012	1.611	10.532	1.234	10.704	1.668	12.880	1.661	20.227
	β	1.691	9.690	1.469	10.108	1.183	10.672	1.500	13.136	1.606	19.286
	φ	1.631	5.308	1.577	5.460	0.508	2.685	0.463	1.997	0.696	4.650
	γ	1.835	5.120	2.513	7.787	1.266	4.669	1.907	4.933	1.782	8.125
Railways	Coefficient of determination R^2	0.831		0.765		0.719		0.788		0.807	
	Conditioned coefficient of determination R^2	0.831		0.764		0.719		0.788		0.806	
	Number of sample	2068		2068		2070		1971		1816	
	Variable	Parameter	T value	Parameter	T value	Parameter	T value	Parameter	T value	Parameter	T value
	logek	−1.632	−1.874	−0.546	−0.572	−1.939	−1.953	−1.268	−1.379	4.676	5.176
	α	1.713	45.457	1.494	38.757	1.382	33.981	1.542	41.914	1.332	37.995
	β	1.417	37.623	1.261	32.566	1.197	29.307	1.250	33.779	1.156	32.925
	γ	3.346	82.559	2.861	61.331	2.570	54.665	2.903	64.058	3.066	67.578
Road	Coefficient of determination R^2	0.460		0.536		0.499		0.593		0.442	
	Conditioned coefficient of determination R^2	0.455		0.534		0.496		0.592		0.440	
	Number of sample	362		640		534		826		955	
	Variable	Parameter	T value	Parameter	T value	Parameter	T value	Parameter	T value	Parameter	T value
	logek	14.602	6.676	20.269	10.449	15.689	7.990	26.005	16.489	24.904	13.555
	α	0.542	6.369	0.726	8.945	0.824	8.398	0.738	9.727	0.494	5.655
	β	0.646	4.890	0.611	6.606	0.499	5.744	0.291	4.054	0.188	2.457
	γ	2.039	16.835	2.708	25.084	2.247	21.597	2.880	34.479	2.273	27.192

Calculation Results of User Benefit

Change in User Benefit

Figure 15 shows changes in total amount of user benefit in Japan. Figure 16 shows changes in amount of user benefit with the index to convert values in year of 1960 to 1. Figure 17 shows change in total amount of the number of passengers in Japan. And, Figure 18 shows changes in amount of the number of passengers with index to convert values in year of 1960 to1.

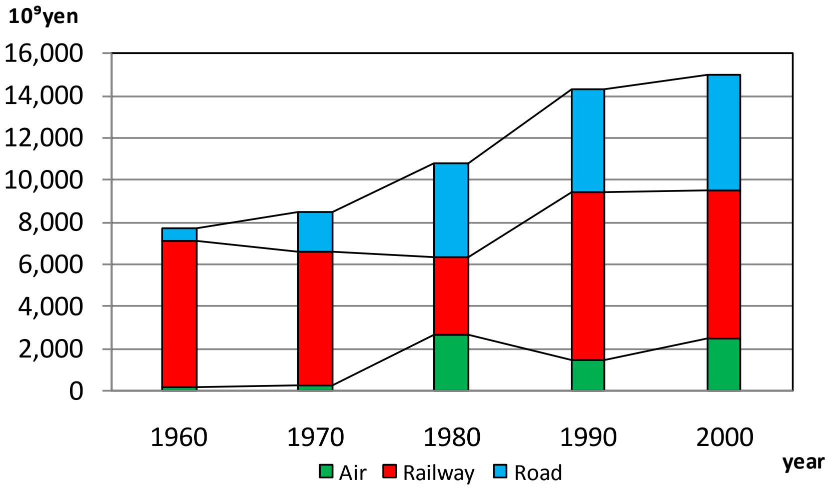

Figure 15－ *Changes in user benefit*

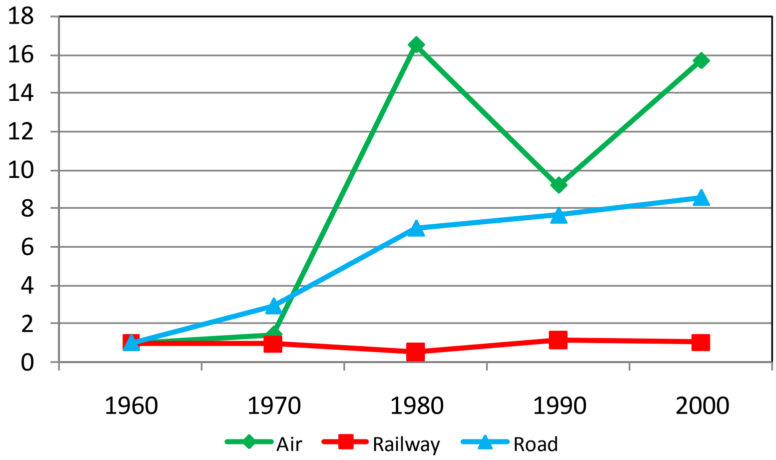

Figure 16 －*Changes in user benefit (Index)*

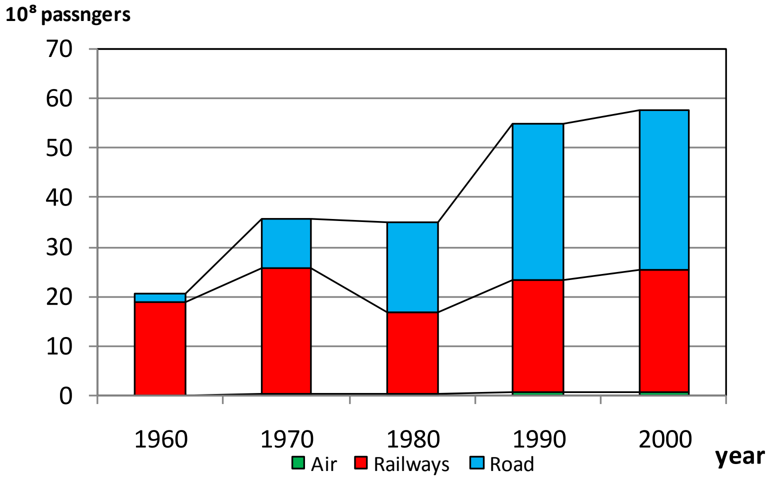

Figure 17— *Changes in the number of passengers*

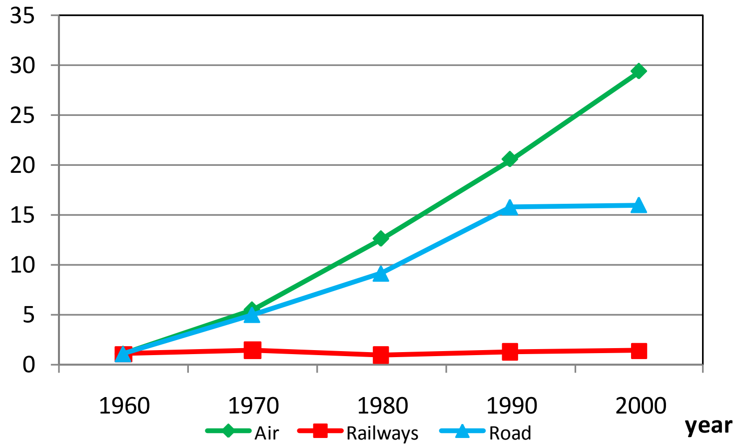

Figure 18— *Changes in the number of passengers (index)*

Figure 15 shows that total amount of user benefit has increased year by year. User benefit of road networks has become larger year by year, but those of air and railway networks have fluctuated from 1960 to 2000. Due to the delay in the popularization of air and cars, the main transportation was railways in the 1960s. The railways in high mobility networks were improved in the earliest of three transportations. For example, the Tokaido Shinkansen Line started the service between Tokyo and Osaka in 1964. A lot of people used the railway as the main transportation in this period of time. A number of interesting features can be seen in the change of user benefit of three transport modes from 1970 to1980. During this period of time, user benefit of air and road networks increased considerably, but that of railways decreased. In the development of airline networks, the first plan in improvement of domestic airline networks for five years was executed from 1967, and the second plan was executed from 1971. These plans enriched domestic airline networks by promoting construction of new airports in national land including local regions in order to respond the introduction of large-scale jet airplanes. The effect of these plans was seen in an increase in the number of passengers in 1970 which recorded 5.5 times as much as that in 1960. This result is considered to lead the increase in user benefit of these transportations. When it comes to railways, the railways fare often rose in the 1970s in order to resolve the problems of management. Especially, in 1976, the big rise in fare was executed railways. However, there was no rise of air fare from 1974 to 1980, as a result, they difference in fares between air and railways became small. Consequently, in the share in the number of passengers, that of air increased. The motorization made progress remarkably in the1970s. The appearance of the economy car due to a new industrial policy planed by Ministry of International Trade and Industry accelerated the motorization. These facts influenced the decrease in the number of railway users, and also the decrease in the user benefits in railways. About the road networks, economy cars became drastically popular in the 1970s. This is because that the price of cars was not considered to be expensive as the income of national nation increased very much. In addition, the road networks were developed, especially in expressways actively and rapidly in the 1970s. The length of construction in expressways in the 1970s recoded 3 times as long as that in the 1960s. These facts gave effects to the increase in the number of car users and their user benefit.

Figure 16 shows change in user benefit of air travel is most prominent of the three modes. In particular, change from 1970 to 1980 is remarkable. This indicates the immediate effect of development of air networks in the 1970's appeared. Amount of user benefit of railways is almost the same from 1960 to 2000, although it is evident that it increased a little from 1980 to 1990. Change in user benefit of road increased significantly from 1960 to 2000. In particular, the increase from 1970 to 1980 is large. One of the reasons for this is that amount of travellers using road networks increased as generalized cost of road-use decreased.

Change in User Benefit of 9 Blocks

We analyze change in user benefit in 9 blocks. The division of 9 blocks is as shown in Table 1. Results of calculation of change in user benefit of 9 blocks are shown Figures 19, 20, 21, and 22. Figure 19 shows changes in total amount of user benefit of three transport modes in the 9 blocks. Figure 20 shows changes in user benefit of air, Figure 21 shows that of railways, and Figure 22 shows that of road.

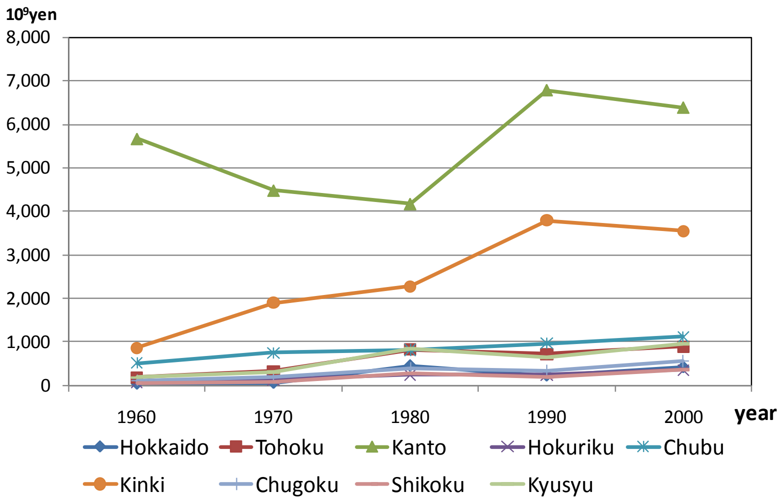

Figure 19 －*Changes in user benefit of 9 blocks*

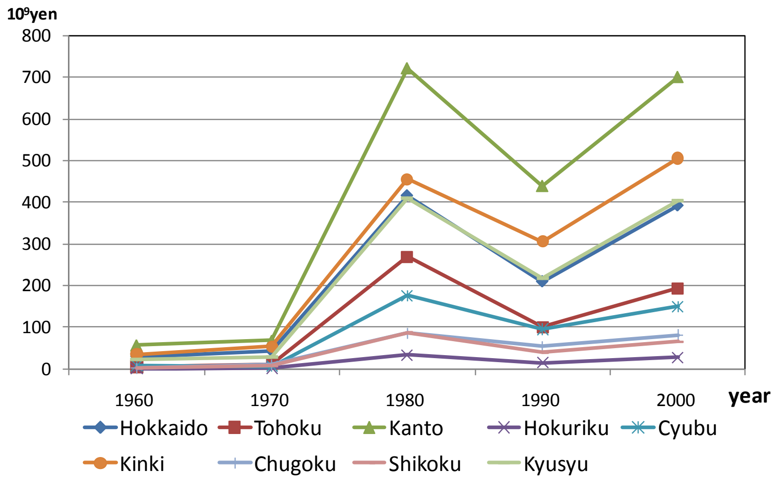

Figure 20－ *Changes in user benefit of 9 blocks (Air)*

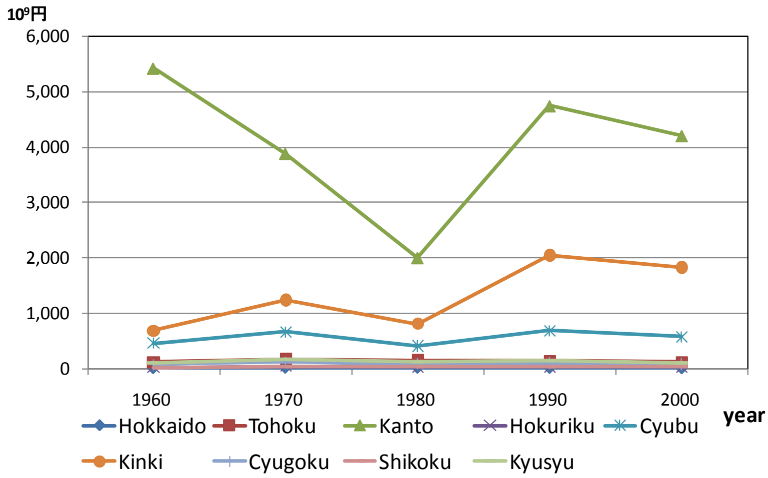

Figure 21－ *Changes in user benefit of 9 blocks (Railway)*

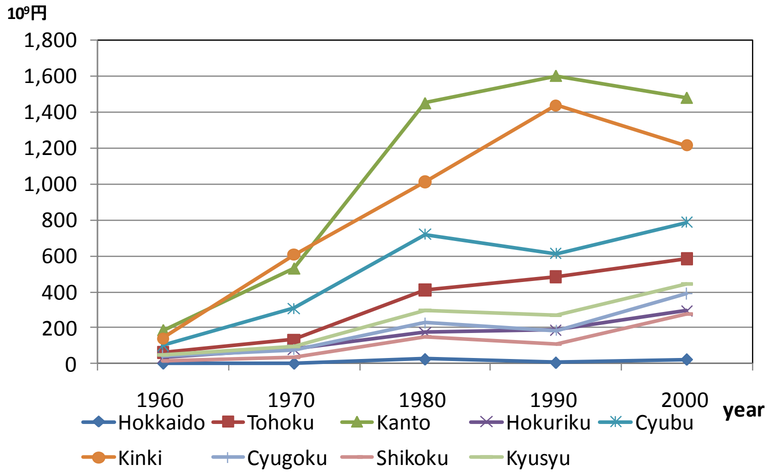

Figure 22—*Changes in user benefit of 9 blocks (Road)*

Figure 19 shows values of the Kanto and Kinki blocks are bigger than other blocks in total amount of user benefit. Changes from 1980 to 1990 are remarkable. The value decreased from 1960 to 1970 only in Kanto.

Figure 20 shows tendency of change in consumer surplus of air networks is similar in all blocks. The biggest increase is seen from 1970 to 1980, and biggest decrease is from 1980 to 1990. Increase from 1970 to 1980 is great in not only Kanto and Kinki blocks but also Kyushu and Hokkaido. Values in the blocks where air networks are developed have the same tendency to increase.

Figure 21 shows that changes of user benefit of 6 blocks except Kanto, Kinki, and Chubu blocks are very small in the case of railway networks. Kanto block has the biggest value of all blocks. Degree of decrease from 1960 to1980 and degree of increase from 1980 to 1990 are both significant in Kanto block. These changes differ from other blocks. In Kanto block, user benefit decreased from 1960 to 1980 because the volume of passengers using railway networks decreased significantly from 1960 to 1980. Volume of passengers of air and road networks increased during this period. It is assumed that railway users shifted to road and air in Kanto block. On the contrary, the value of Kanto block from 1980 to 1990 increased suddenly. The values of Kanto, Hokuriku and Chubu blocks from 1980 to 1990 improved very much because length of Shinkansen lines increased most from 1980 to 1990. Therefore, the volume of passengers using railways increased, and thus user benefit is considered to increase.

Figure 22 shows that user benefit increased greatly from 1970 to 1980 in all blocks. Especially, the value of Kanto is remarkable. This is because traffic volume of road networks increased significantly due to decreasing generalized cost from 1970 to 1980. Amount of increase of Chubu and Chugoku blocks from 1990 to 2000 are the biggest of all blocks. . The reason for this is convenience for users improves due to development of high mobility networks in countryside areas and, as a result, traffic volume increased.

Change in User Benefit of Populated Areas and Rural Regions

We analyze changes in user benefit of populated areas and rural regions and divided the national land of Japan into populated areas and rural regions as shown Figure5. Results of calculation are presented in Figures 23, 24, 25, and 26. Figure 23 shows change in total amount of user benefit of three transport modes in populated areas and rural regions. Figure 24 shows changes in user benefit of air travel. Figure 25 shows that of railway, and Figure 26 shows that of road.

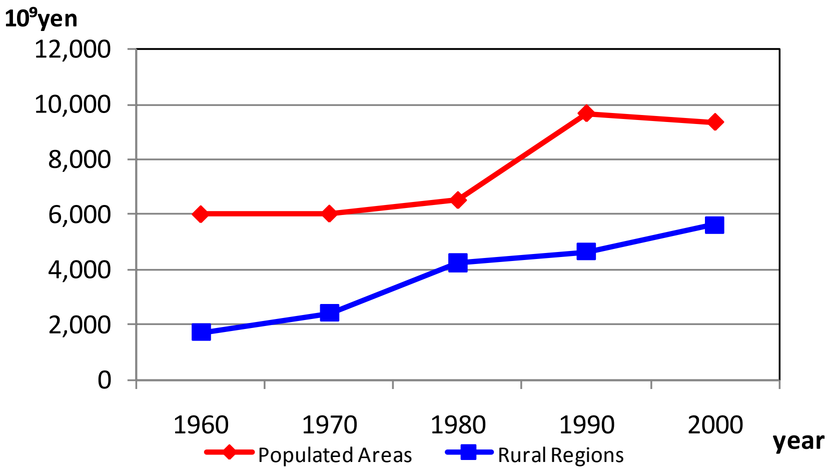

Figure 23— *Changes in user benefit of populated areas and rural regions*

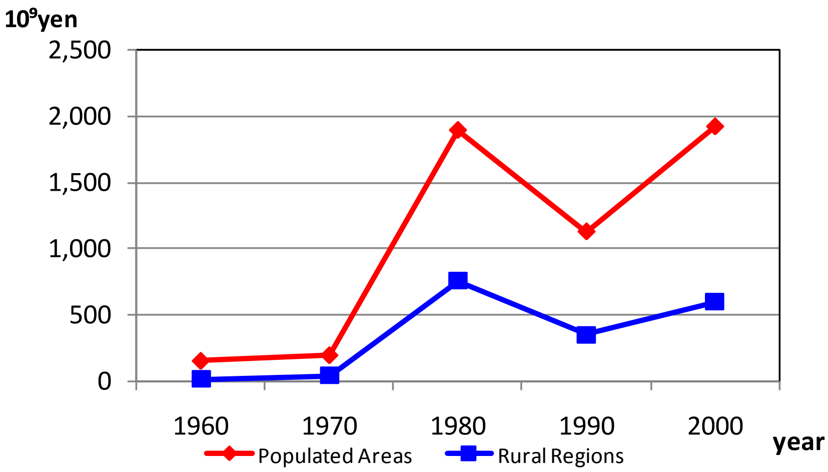

Figure 24— *Changes in user benefit of populated areas and rural regions (Air)*

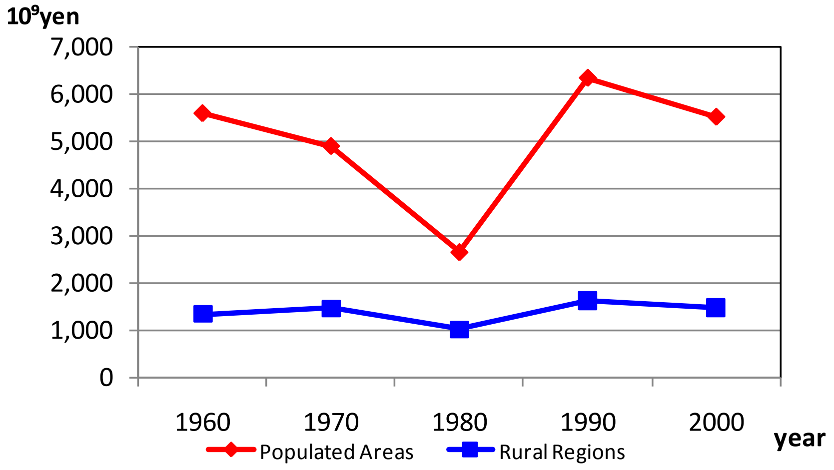

Figure 25— *Changes in user benefit of populated areas and rural regions (Railway)*

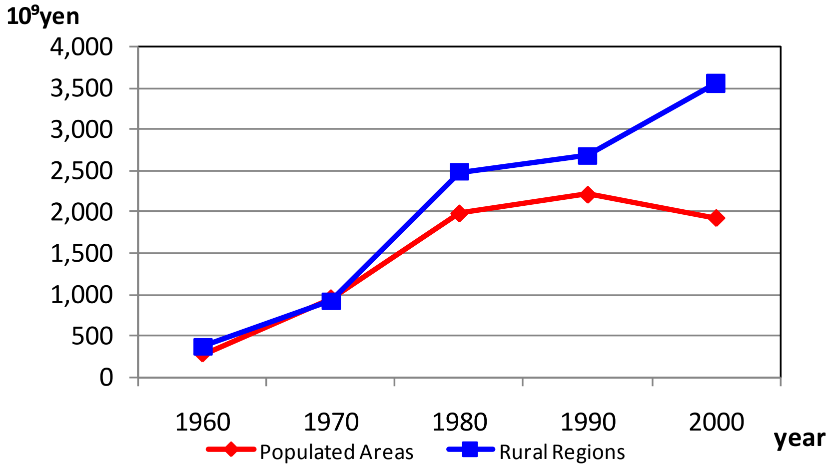

Figure 26— *Changes in user benefit of populated areas and rural regions (Road)*

Figure 23 shows that in almost all periods of time the user benefit of populated areas and rural regions increased year by year. However, that of populated areas decreased a little only from 1990 to 2000. Values for populated areas are larger than those of rural regions in all time periods.

As shown in Figure 24, little difference can be seen between populated areas and rural regions in 1960 and 1970. Since then, the values of populated areas are considerably larger than those of rural regions. Especially, the degree of increase in populated areas rapidly grows. The reason for this is thought to be because the immediate effect of improvement of air networks in populated areas is higher than that of rural regions in the 1970's

.

Figure 25 shows that values of rural regions are small and almost the same over a period of 40 years. On the contrary, values of populated areas vary extremely. In particular, a decrease from 1970 to 1980 and increase from 1980 to 1990 are great. It is considered that decrease in the value is caused by decrease in volume of passengers using railway networks in spite of decrease in generalized cost. In addition, it can be seen that generalized cost decreased during this period in all modes and traffic value of air and road networks increased. There is a possibility that some railway users shifted to road and air networks because of this. Regarding cause of increase in the 1980's, value of passengers increases greatly only in railways in the 1980's. The reason for this would be due to a shift of passengers from other modes of transportation to the railways.

Figure 26 shows that values are almost the same up until 1970. After that, values of rural regions grew more than those of populated areas. This trend was only present in the case of road networks. Values for populated areas decreased from 1990 to 2000. However, values of rural regions increased year by year. This is because there are a lot of people who use road networks in rural regions where expressways have been constructed at a faster rate than that of railway and air networks. In rural regions these tend to lag in comparison to more populated urban areas. Therefore, in rural regions, immediate effects appeared as a result of the development of road networks, especially expressways.

CONCLUSION

In this study, we analyzed and considered progress in service level and change in user benefit due to the improvement of high mobility transport networks consisting air, railway, and road networks from 1960 to 2000. From the analysis, we could verify how convenience of high mobility networks in Japan improved and also understand how user benefit generated over a period of 40 years. The results of this study can be summarized as follows.

(1) Travel cost of air networks decreased greatly from 1960 to 1970. This is considered to be an immediate effect of air networks in which were improved from the 1960's at a rapid rate. Travel time for every transport mode became less year by year. From this finding, it could be understood clearly that improvement of high mobility networks increased convenience for users with respect to time. The generalized cost of railway and road networks did not decrease though cost and time decreased as improvement of high mobility networks developed and convenience improved. This is because the value of generalized cost is influenced by value of time.

(2) Change in user benefit was analyzed and considered from viewpoints of regional difference. User benefit of air networks increased from 1970 to 1980 and decreased from 1980 to 1990. The value of railway networks decreased from 1970 to 1980 and increased from 1980 to 1990. From this, it could be seen that an opposite situation occurred. Also, the value of road networks increased year by year, in particular the change of value from 1970 to

1980 was significant. These changes are considered that changes in transport users of three networks varied year by year.

In this study, changes in service level and user benefit appeared as a result of the development of high mobility transport networks from 1960 to 2000 could be clarified. From analysis and consideration about how effects of improvement of transport networks changed over a 40-year period, valuable data was obtained. This data will be useful for designing efficient and effective improvement plans of transportation facilities in the future.

REFERENCES

Abe, H.; Taniguchi, M.; Shinke, T.; Kishida, K. (2004). Changes in the Inter-Prefectural Travel Time under the Construction of Highway Network and Their Impact on Commodity Flows. In: Studies in Regional Science, Vol.34, No.1, pp.185-202.

Ando, Y.; Zheng, X. P. (1999). An Empirical Study on the Relationship between Network Economies and Regional Economy - Evidence from the Japanese Network of Roads and Regional Industrial Productivities -. In: City planning review. Special issue, Papers on city planning, No.34, pp.235-240.

Aoyama, Y.; Kondo, A. (1993). The Impact of Major Raod Developments on the Spheres of Urban Influence of Japanese Cities. In: Transportation, Vol.20, No.8, pp.305-323.

Aoyama, Y.; Kondo, A.; Hirose, Y. (1996). Influence of Transportation Network Development on Domestic Migration in Japan. In: Selected Proceedings of 7th WCTR, Vol.2, pp.447-458.

Bruzelius, N. (1979). The Value of Travel Time. Croom Helm London.

Japan Travel Bureau Foundation. (1960, 1970, 1980, 1990, 2000). JTB Timetable, Japan Travel Bureau, Tokyo.

Kodama, M. (1988). The Effect of Expressway Network Construction on the Movement of People. In: Institute of Transportation Economics, Vol.48, No.3, 12-22.

Kondo, A. (1992). Impact of Development of Expressways on Trade Areas. In: Expressways and Automobiles, Vol.35, No.4, pp.20-27.

Kondo, A; Hirose, Y.; Yamaguchi, Y. (1997). Improvement of High Mobility Networks and its Evaluation based on Users' Value of Time in Japan. In: Proceedings of The Second Conference of Hong Kong Society for Transportation Studies, pp.67-72.

Ministry of Health, Labor and Welfare. (1960, 1970, 1980, 1990, 2000). Wages Structure Basic Statistical Investigation, Ministry of Health, Labor and Welfare, Tokyo.

Ministry of Internal Affairs and Communications. (1960, 1970, 1980, 1990, 2000). National Census, Ministry of Internal Affairs and Communications, Tokyo.

Ministry of Internal Affairs and Communications. (1958,1968,1971,1977,1982,1987,1992,1999). National Survey of Family Income and Expenditure, Ministry of Internal Affairs and Communications, Tokyo.

Ministry of Land, Infrastructure and Transport. (1960, 1970, 1980, 1990, 2000). Air Transportation Statistical Investigation, Ministry of Land, Infrastructure and Transport, Tokyo.

Ministry of Land, Infrastructure and Transport. (2001). National Integrated Transport Analysis System (NITAS) , Ministry of Land, Infrastructure and Transport, Tokyo.

Ministry of Land, Infrastructure and Transport. (1960, 1970, 1980, 1990, 2000). Report of Traveler Movement of between Regions, Ministry of Land, Infrastructure and Transport, Tokyo.

Ministry of Land, Infrastructure and Transport. (2007) White Paper on Land, Infrastructure and Transport, Ministry of Land, Infrastructure and Transport, Tokyo.

Miura, H. (2004). A Sensitivity Analysis of the Number of Visitors by Constructing Traffic Infrastructure – by Use of the Huff's Models- . In: Journal of the City Planning Institute of Japan, No.39-3, pp.673-678

Nakagawa, D.; Hatoko, M.; Kato, Y. (1994). A Study on the Changes of Possibility of Mutual Access by Improvement of Inter City Transportation. In: Journal of the Infrastructure Planning and Management, No.482 / IV-22, pp.47-56.

Yamaguchi, Y.; Kondo, A.; Hirose, Y.; Kawamoto, M. (1999), A proposition and application of an advanced set of generalized cost for high mobility networks. In: Transportation Science and Technology into the Next Millennium, pp.159--168,