A STUDY ON INTRODUCING ENVIRONMENTAL TAX IN INTERCITY-TRANSPORT SECTOR AND REDISTRIBUTION OF THE TAX REVENUE IN JAPAN

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1. INTRODUCTIONN

1.1 Background

The traffic demand in the world is in the trend of expansion through economic growth. Carbon-dioxide emissions from a traffic section are increasing along with that. However, it is necessary to execute measures to reduce carbon dioxide in the each section such as intercity-transportation, innercity-transportation and intercountry-transportation at early stage, considering the targeted reduction of the carbon dioxide will be made more severe in the future.

This study focuses on traveler traffic in intercity-transportation in Japan. The feature of the intercity transportation network in Japan is that there are 97 airports and 92 Shinkansen stations, because Japan is long and slender in length and is composed by five big islands (when 2010.1.1).

Carbon dioxide emissions from intercity transportation section have been increasing since 1990. The introduction of a competing principle helped the improvement of intercity transportation in which inefficiency had come to stand out. Concretely, the civilization of the National railway and deregulation of fixing aviation fare were done. Traffic demands have been increasing by these improvements that made fare down and service level up. Typical change of carbon dioxide emissions in intercity transportation sector was the share between airline, Shinkansen, the car. After deregulation of intercity transportation sector, the share of the car increased in the short distance movement, and the share of Airlines has increased in the long-range transport. lower price and shorting the time for spending trip was contributed to change ways of transportation from Shinkansen to aviation or cars. As a result, these changes will have invented the traffic system with a large negative environmental.

It will be necessary to achieve both the improvement of traffic convenience and the reduction of carbon dioxide emissions. There are two approaches to achieve the targeted carbon dioxide emissions in intercity transportation. The one way is supply side approach such as technological improvement. Top runner system challenge companies to develop new technology which is higher efficiency than current technology. The second way is demand side approach to prompt people to change transportation ways. Introducing new tax is one of the demand side approaches. Proposing the combination of policies that can use the advantage of these two approaches to its maximum becomes foundation induced to environmental friendly society.

A present environmental policy in Japan is delayed to introduce demand side policy such as environmental tax. Not equally traffic service in whole country delays the introduction of demand side policy, because the effect of introducing environmental tax into intercity transportation is different between big city and the province. It is necessary to propose how to use the revenue obtained from taxation to reduce the effect of introducing environmental tax in each region.

From these awareness of the issues, the objective of this study is to propose the environmental tax that is one of the demand side policy to achieve clear carbon dioxide reducing target and the re-distribution of tax revenue based on the viewpoint of a fairness. Furthermore, we develop new analyzing model to evaluate the effectiveness of two policies quantitatively. It clarifies the effect of introducing environmental tax ,for example how a traffic action will change in each region, how much carbon dioxide will decrease in each region, and how much the amount of re-distribution of tax revenue will necessary to ease the influence of the tax introduction.

1.2 Structure of this paper

This paper is composed by six chapters. In the chapter 1, it explains the background and the purpose of this research as an introduction. In the chapter 2, it introduces the European environmental taxation system and the difference point in intercity transportation in Japan. It also clarifies the standpoint of this study. In the chapter 3, it explains the economic thesis of the re-distribution of tax revenue and Baumol-Oates tax.

It also explains the back-casting approach which is based on Baumol-Oates tax. In the chapter 4, it develop new analyzing model to evaluate two policies quantitatively. In the chapter 5, to use the analytic model in the intercity transportation in Japan, the parameter is presumed. It also clarifies the effect by introducing environmental tax in each region. In the chapter 6, it explains the conclusion and the next issue which was not able to be clarified by this research.

2. THE PRIVIOUS RESEARCH

2.1 Examples of Environmental tax system in EU

In United Kingdom(UK), the government set the severe target that it decrease carbon dioxide emissions 20% compared with the level in 1990.To achieve this target, the government decided to introduce Fuel Duty Escalator system that raising hydrocarbon tax rate more than inflation rate from 1993 to 1999. A similar policy which raises oil tax rate gradually was introduced in Germany from 2000. The figure 2-1 shows changing of gasoline tax rate which make the level in 1980 100 from 1980 to 2008 in UK, France, Germany and Japan. In 2007, the tax rate had been increasing about 500 in UK and about 300 in Germany and France. Futamura(2000) said that the price elasticity had changed bigger from -0.06 to -0.26 by introducing new taxation. She also said the reasons why the price elasticity had changed were people bought more energy efficient products or used low mileage car. In Japan, on the other hand, the tax rate is uniform from 1980 to 2008.

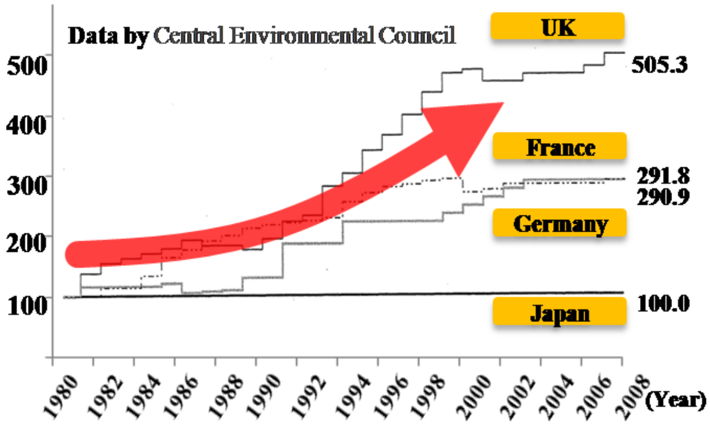

Figure2-1 : Variation of environmental tax rate

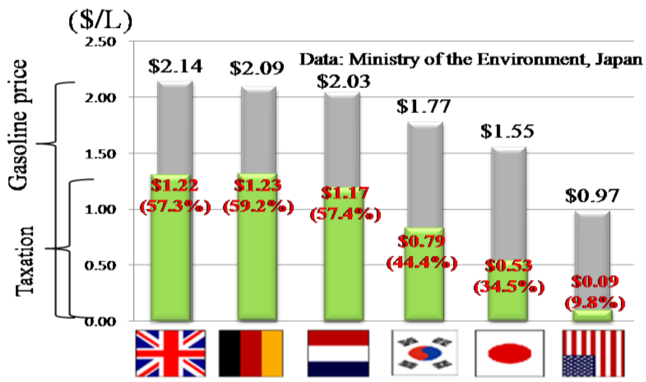

Figure2-2 : Comparison between each country tax rate in total gasoline price

Figure 2-2 shows difference of tax rate included in gasoline price in America, European country and Japan. It can be said possibility that it's initiative to change traffic performance to use more energy efficient ways, because UK, France and Germany paid about 1.7 times tax rate include in gasoline price.

2.2 The argument point about environmental tax system in Japan

The main point of argument about Japanese environmental tax system focuses on greening current tax system which make tax rate of low efficient cars higher and of high efficient cars lower. Especially, the taxation at using stage is late. Fuziwara, Hasuike, Kanemoto(2000) said that greening tax system at acquisition and possession will not be able to expect the effect of carbon dioxide reduction, but will increase social welfare. Tanishita and Kashima(2001) analyzed the change of elasticity about possess and use of car by reform the current tax system. These studies are previous studies about tax reform for greening tax system in car mode, but are not focused on other modes such as rail and aviation. It's also not focused on how to reduce the gap of taxation load between urban city and rural city. Therefore, it's necessary to evaluate how much re-distribution will need considering from the viewpoint of justice by introducing environmental tax.

3. ADVANTAGE AND DISADVANTAGE ABOUT BAUMOL-OATES TAX

3.1 A way of thinking about Back-casting approach

The way of thinking about Back-casting is thinking selection what means is necessary to achieve the target which was set clearly before to do something. Differences between this way of thinking and general that are the selection of things based on not what the situation is but the futures. Concrete means, using back-casting approach in intercity transportation to achieve the clear target, are like that economical approach such as taxation and emission trading, regulation approach such as top-runner policy.

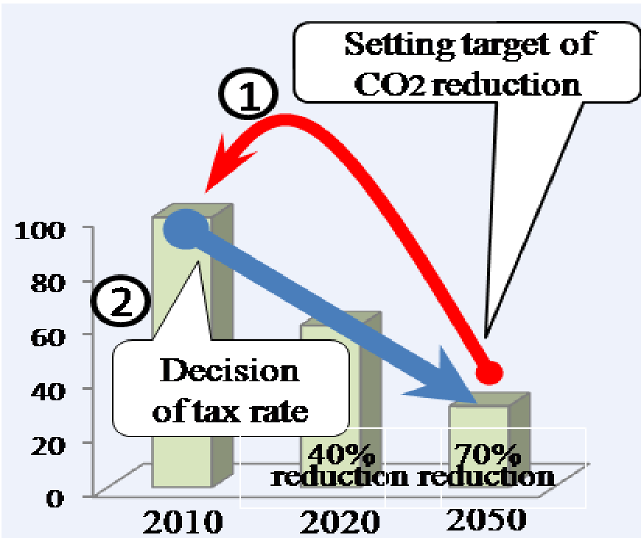

Figure 3-1 : Back-casting approach and BOT

Backcasting approach is used in many cases. For example, Geurs and Van Wee clear the difference between forecasting approach and backcasting approach. The OECD project on Environmentally Sustainable Transport (EST) is one of the most well known studies used backcasting approach. In the quantitative simulation, the EU-POSSUM project

(Banister et al,2000)was the first to assess European transport policies as to their consistency and feasibility, using a qualitative scenario-based approach based on backcasting approach. This study also uses backcasting approach. In the economic theory, taxation by using backcasting approach is named as Baumol-Oates tax(BOT).

3.2 Relation between Back-casting approach and Baumol-Oates tax

Environmental tax is defined as means to make it internal that is social cost generated by external diseconomies in the market. In other words, social welfare is maximized by taxation, because social welfare is not maximized in the present market transactions. Theoretical advantages of environmental tax are below. 1)It's possible to achieve the reduction target of carbon dioxide by minimum cost, 2) the effectiveness of price, 3) prompting improvement of technology, 4) double dividend which is the effect of environmental improvement by taxation into GHGs and the effect of efficiency improving distortion of existing tax system by using tax revenue.

The figure 3-1 shows the image of Baumol-Oates tax. Baumol-Oates tax is one of the environmental-tax, and is based on back-casting approach which means setting the clear reduction target of carbon dioxide in society. The taxation method is that a uniform tax rate is imposed on one unit of the pollution exhaust in the market. According to economic theory, the advantage of Baumol-Oates tax is to minimize total cost to reduce carbon dioxide for achieving the target by equalizing the marginal abatement cost. In this study, by taxing according to the carbon dioxide one ton generated from a traffic action make it possible to achieve the target by minimized cost.

The Baumol-Oates tax have disadvantage. Effects by introducing Baumol-Oates tax will differ between metropolitan and provinces because of difference of infrastructure level. More concretely, carbon-dioxide emissions are necessary to transport one person by one kilo because it depends on the car in each province. Otherwise, carbon-dioxide emissions transporting one person by one kilo-meter are less in metropolis than in province, because there are thick railway network in metropolis.

Thus, Baumol-Oates tax is very efficiency way to reduce CO2 emissions under setting clear CO2 reduction target, but it's necessary to consider how to fill a gap of tax load between urban city and rural city.

3.3 How to re-distribute tax revenue

As one of the means to cancel unfairness, the government re-distributes the tax revenue to keep effect uniform in each region by introducing environmental tax. There are some ways to use tax revenue such as constructing new railway or subsidies for purchasing new efficient products. In this study, the tax revenue is re-distributed for keep the change rate of utility steady in each province. As economical theory, social welfare function ordering the utility was needed before discussing the preferable change of the utility. However, we could not decide order of the utility because of difficulty for deciding social welfare function. Setting the standard of utility which is current consuming behavior under the budget constraint before introducing Baumol-Oates tax makes it possible to evaluate changing rate of the utility in each province.

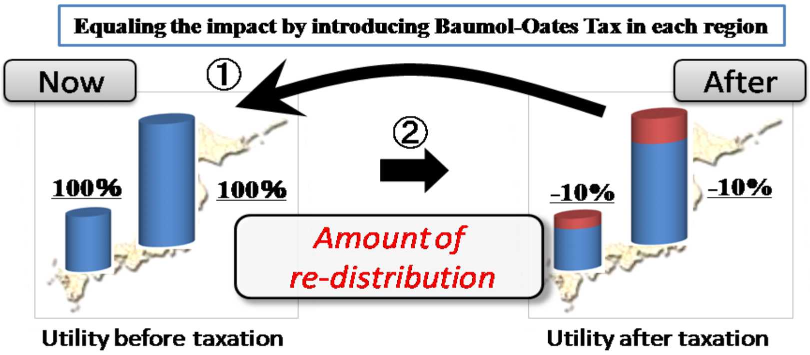

Figure 3-2 : Measures of re-distribution of tax revenue

3.4 A frame of evaluating the effect of these policies

There are three points to analysis quantitatively in this study.

1) To clarify the effect by introducing Baumol-Oates tax in each province, and how much traffic will change?
2) To clarify the effect by introducing Baumol-Oates tax in each province, and how much carbon-dioxide will reduce?
3) How much re-distribution will need to keep the effect of introducing Baumol-Oates tax in each province.

4. DEVELOPING A NEW ANALYTIC MODEL

4.1 Characteristics of this analytic model

In chapter 4, developing new analytic model make it possible to evaluate three particulars represented above headline. There are three points in this model.

1) It proposes a new technique of the anticipated traffic demands.

2) It proposes a new method of re-distribution of tax revenue.

3) Integrating two analytic models of taxation and re-distribution of tax revenue.

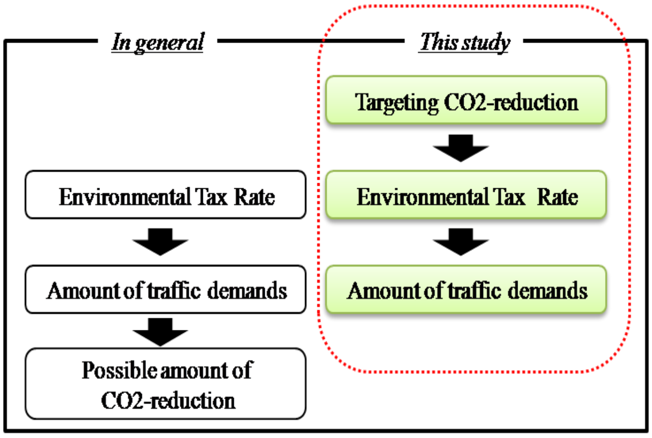

Figure 4-1 : Changing calculating method of transport demand in this study

First, proposing a new technique of the anticipated traffic demand means developing a model based on back-casting approach. It's said that the Backcasting approach was proposed by the Natural Step which is a non profit organization founded with the vision of creating a sustainable society in Sweden. In the Natural Step, the Backcastig approach is defined that a successful outcome is imaged in the future, followed by the below question: "what do we need to do today to reach that successful outcome?". From this concept, this study uses the baccasting approach into intercity transportation sector. Figure 4-1 shows difference of technique evaluating traffic demand between general technique and this study's it. In general technique, prices and times of transportation after introducing a policy decide traffic demands, and carbon dioxide emissions are outputted by traffic demands. In this study, however, it introduces Baumol-Oates tax to achieve clear targeted reduction set based on way of thinking of back-casting approach. The amount of the traffic demand in which the CO_2-reduction goal is achieved is decided.

Second, it decided the amount of re-distributions of tax revenue to become equal effect after that.

Third, it develops the integrated analytic model that is based on viewpoint of policy-mix. It is important to regard both by integrating it, because of the basis of the re-distribution of the tax that the government does is revenue by traffic behavior of the individual. This model is possible to calculate tax rate achieving the clear reduction target and the amount of the re-distributions becoming equal effect after re-distribution of tax revenue.

4.2 The terms and conditions using this analytic model

There are five points using this analytic model.

1) As a prerequisite condition using this model, it's necessary to definite researching scope. This analytic model is available using any regions to change parameters.
2) The scope of the research is made detailed further to express characteristic of transport behavior more clearly, for example that it means one unit is set to the size of the prefecture when the entire scope is made Japan.
3) One arrival and departure point that becomes a representative is set to the region made detailed at No.2. If Japan is made the entire object region and one unit was set as Aichi Prefecture, we set Nagoya station as arrival and departure point that becomes a representative in Aichi Prefecture. The reason to treat the prefecture as one unit in this study is the purpose of this study is to evaluate intercity transport behavior, not to evaluate detailed traffic behavior like inner city transportation.
4) Traffic service is being provided between the prefecture and the prefecture.
5) The traffic demand function is derived by calculating the theory of consumer behavior that follows economical thesis.

4.3 Setting variables used this model

It explains important variables used in the analytic model. There are five important variables in this model.

1) u_i : utility. 2) x_{ij}^k : traffic demand from region No.i to No.j by using way of transportation k. 3) c_{ij}^k : transportation cost from region No.i to No.j using way of transportation k. 4) t : the tax rate of Baumol-Oates tax. 5) e_{ij}^k : standard unit for carbon dioxide from region No.i to No.j using by way of transportation k.

U_i is used as a utility index of traffic demand behavior. People act to maximize the ui.

4.4 Definition of three function

4.4.1 CES type Utility function

In this study, utility function expresses utility of person for traffic. The figure 4-2 shows structures of CES type utility function. At first, u_i which is utility in region No.i is divided into two ways that is the traffic demand between regions i and region j(x_{ij}) and is the other consumer goods(x_i) which is the one to represent consuming ahead of all except traffic. In a word, it doesn't consider it excluding the market concerning the intercity transportation.

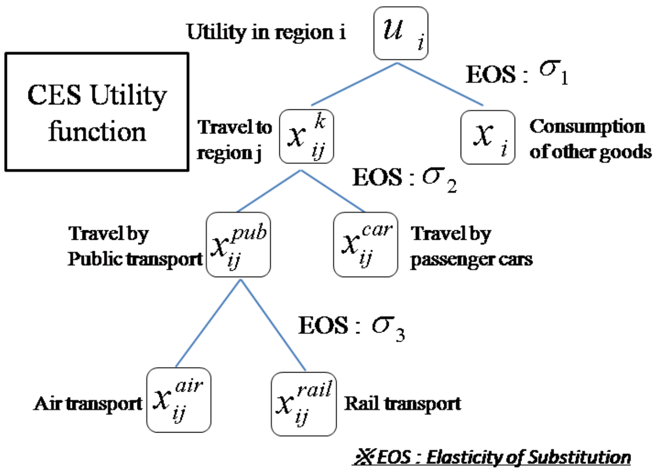

Figure 4-2 : CES type Utility Function

CES type utility function, CES type the other consuming function and CES type traffic function are wrote below.

$$u_i = \left\{ \sum_j \alpha_{ij}^{\frac{1}{\sigma_1}} x_{ij}^{\frac{\sigma_1 - 1}{\sigma_1}} + \alpha_i^{\frac{1}{\sigma_1}} x_i^{\frac{\sigma_1 - 1}{\sigma_1}} \right\}^{\frac{\sigma_1}{\sigma_1 - 1}} \tag{4-1}$$

$$x_{ij} = \left\{ \alpha_{ij}^{pub\,\frac{1}{\sigma_2}} x_{ij}^{pub\,\frac{\sigma_2 - 1}{\sigma_2}} + \alpha_{ij}^{car\,\frac{1}{\sigma_2}} x_{ij}^{car\,\frac{\sigma_2 - 1}{\sigma_2}} \right\}^{\frac{\sigma_2}{\sigma_2 - 1}} \tag{4-2}$$

$$x_{ij}^{pub} = \left\{ \alpha_{ij}^{air\,\frac{1}{\sigma_3}} x_{ij}^{air\,\frac{\sigma_3 - 1}{\sigma_3}} + \alpha_{ij}^{rail\,\frac{1}{\sigma_3}} x_{ij}^{rail\,\frac{\sigma_3 - 1}{\sigma_3}} \right\}^{\frac{\sigma_3}{\sigma_3 - 1}} \tag{4-3}$$

Here, $\alpha_{ij}, \alpha_i, \alpha_{ij}^{pub}, \alpha_{ij}^{rail}, \alpha_{ij}^{air}, \alpha_{ij}^{car}$ are the parameters of CES type function.

It divides into whether it is public traffic or the expense destination is car use when it is decided expense to traffic. In addition, public traffic is divided into the railway and airlines. In an important point, it's an alternative elasticity index (σ_i) to express the easiness of the change in transportation way when each branch diverges. An alternative elasticity index (σ_i) was decided by using existing traffic data.

4.4.2 The traffic generalized cost

Using traffic generalized cost by introducing time value makes it possible considering time value. The relational expression is as follows.

$$c_{ij}^k = w_{ij}t_{ij}^k + f_{ij}^k + te_{ij}^k \qquad (4\text{-}4)$$

Here, w_{ij}:time value, t_{ij}^k:traffic time, f_{ij}^k:cost other than time cost, t:environmental tax rate, e_{ij}^k: standard unit for carbon dioxide from region No.i to No.j using by way of transportation k. Traffic generalized cost is composed by three items. 1) The one considering time value. 2) The cost something like running cost of cars. 3) Payable taxes according to traffic. The reason why considering time value is that it becomes an important value standard when it's choosing the transportation way in the long-range transports such as the Shinkansen or airlines. For example, airline's fare is higher than Shinkansen, but airline is faster than Shinkansen.

The last member of the formula 4-4 is a member where the environment tax rate is considered. A unit of environmental tax is yen per ton. te_{ij}^k shows payable taxes generated by traffic. If the unit of carbon dioxide emissions per person and per 1 km is arranged from large one, it becomes it in order of cars, airlines, and railways. This formula is a mechanism that payable taxes increase as the unit of the emission source grows. Rising environmental tax rate higher contribute to change transportation ways, because the total cost requiring transportation is rose.

4.4.3 Budget constraint

It explains the budget constraint which will be base of consumer deciding transportation way. The budget constraint formula is as follows.

$$\sum_j \sum_k c_{ij}^k x_{ij}^k + c_i x_i \le I_i + Z_i \qquad (4\text{-}5)$$

Here, p_i: price of other consuming products, x_i: the amount of traffic demands, I_i: the income of consumer living in region i, Z_i:the amount of re-distribution of tax revenue.

First, this budget constrains formula means that the ratio of the capital spent on weather traffic or other consumer goods is decided in the budget constraint. Second, I_i wrote in right side in formula4-5 means total incomes living in region i. Considering total incomes by the size of prefecture satisfies supposition which consumer behavior does mainly at representative arrival and departure point in a prefecture. I_i is calculated by multiplying average incomes and population in region i. Third, it explains members of left side in formula 4-5. These members are sum by multiplying traffic generalized cost and traffic demands. Especially, representation of multiplying p_i and x_i is particular when it uses the theory of consumer behavior. p_i is standard price in this model, and is fixed to one.

4.5 Utility maximization

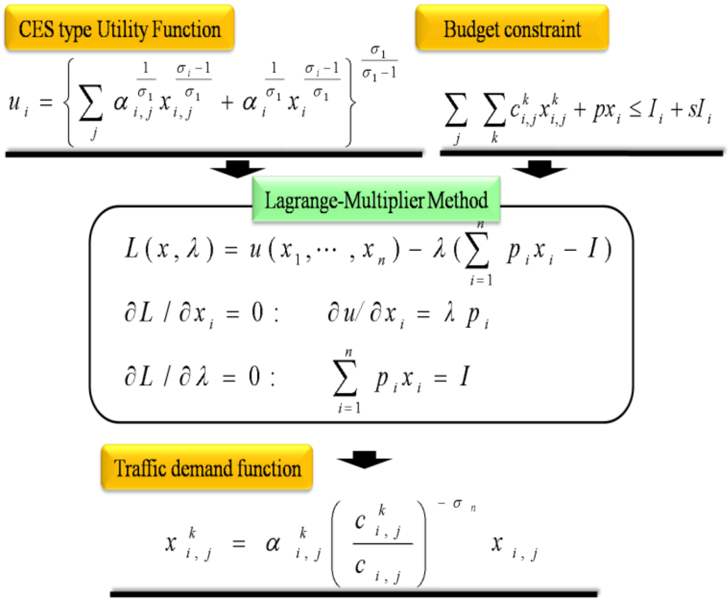

Figure 4-3 :The flow of calculating Utility maximization

It explains how to calculate traffic demand function by using CES type utility function under the budget constraint.
Figure 4-3 shows the entire flow of calculating traffic demand function. First, traffic demand person's behavior satisfies the hypothesis following the theory of consumer behavior which is equal to maximize the utility under the budget constraint. In a word, consumer living region i spend their money to maximize their utility under the total incomes in region i. More concretely, the traffic demand function is calculated by Lagrange-Multiplier Method. It's as follows.

$$x_{ij} = \alpha_{ij}\left(\frac{c_{ij}}{c_i}\right)^{-\sigma_1} \frac{I_i + t(1-r)\left(\sum_i \sum_j \sum_k e_{ij}^k \overline{x_{ij}^k}\right)}{c_i} \tag{4-6}$$

$$x_{ij}^{pub} = \alpha_{ij}^{pub}\left(\frac{c_{ij}^{pub}}{c_{ij}}\right)^{-\sigma_2} x_{ij} \tag{4-7}$$

$$x_{ij}^{car} = \alpha_{ij}^{car}\left(\frac{c_{ij}^{car}}{c_{ij}}\right)^{-\sigma_2} x_{ij} \tag{4-8}$$

$$x_{ij}^{air} = \alpha_{ij}^{air}\left(\frac{c_{ij}^{air}}{c_{ij}^{pub}}\right)^{-\sigma_3} x_{ij}^{pub} \tag{4-9}$$

$$x_{ij}^{rail} = \alpha_{ij}^{rail}\left(\frac{c_{ij}^{rail}}{c_{ij}^{pub}}\right)^{-\sigma_3} x_{ij}^{pub} \tag{4-10}$$

Furthermore, traffic generalized cost and indirect utility function are wrote as follows.

$$c_{ij}^{pub} = \left\{ \alpha_{ij}^{air}\left(c_{ij}^{air}\right)^{1-\sigma_3} + \alpha_{ij}^{rail}\left(c_{ij}^{rail}\right)^{1-\sigma_3} \right\}^{\frac{1}{1-\sigma_3}} \tag{4-11}$$

$$c_{ij} = \left\{ \alpha_{ij}^{pub} c_{ij}^{pub^{1-\sigma_2}} + \alpha_{ij}^{car}\left(c_{ij}^{car}\right)^{1-\sigma_2} \right\}^{\frac{1}{1-\sigma_2}} \tag{4-12}$$

$$c_i = \left\{ \alpha_{ij} c_{ij}^{1-\sigma_1} + \alpha_i p^{1-\sigma_1} \right\}^{\frac{1}{1-\sigma_1}} \tag{4-13}$$

p : numeraire

$$u_i = \frac{I_i + Z_i}{c_i} \tag{4-14}$$

4.6 Prerequisite conditions for calculating variables

4.6.1 Calculating transport demand and the tax rate

The formula is as follows.

$$\sum_i \sum_j \sum_k e_{ij}^k x_{ij}^k = (1-r)\left(\sum_i \sum_j \sum_k e_{ij}^k \overline{x_{ij}^k} \right) \tag{4-15}$$

Here, $\overline{x_{ij}^k}$: traffic demands before introducing environmental tax, x_{ij}^k: traffic demands after introducing environmental tax, r :CO_2-reduction target.
This chapter explains the relational formula that fills hypothesis of achieving the clear CO_2-reduction target. Setting clear CO_2-reduction target based on back-casting approach is important hypothesis in this study. The tax rate (t) is decided when the formula is satisfied. More concretely, the tax rate is calculated when former total CO_2-emissions multiplying traffic demands before introducing environmental tax and unit of CO_2-emissions is equal to sum multiplied former total CO_2-emission and (1-r) considering CO_2-reduction target.

4.6.2 The balance between the amount of tax revenue and total re-distributions on the government

This chapter explains the balance between tax revenue into government and total amount of re-distribution. The method of the re-distributing tax revenue that will be equal the variation rate of the effect by introducing environmental tax in each region is adopted to mitigate the impact different in each region by introducing uniform taxation in Japan. The formula is as follows.

$$\frac{\Delta u_i}{\overline{u_i}} = \frac{u_i - \overline{u_i}}{\overline{u_i}} = Const(C) \tag{4-16}$$

Here, u_i: the utility after re-distributing tax revenue to each region, $\overline{u_i}$: the utility before re-distributing tax revenue to each region, C: constant.
From the viewpoint on government, total tax revenue is equal to total amount of re-distribution. The formula to explain this relation is as follows.

$$t\left(\sum_i \sum_j \sum_k e_{ij}^k x_{ij}^k \right) = \sum_i Z_i \tag{4-17}$$

The left side in formula 4-17 means total tax revenue into government. It's calculated by multiplying tax rate of Baumol-Oates tax and sums which multiplying traffic demands and a unit of CO_2-emissions after introduced Baoumol-Oates tax. On the other hand, the right side of formula 4-17 means sums which re-distribute tax revenue to each region.

Therefore, it needs to decide three variables t, Z and C.

4.6.3 Integrated analytic model

This chapter explains specific calculation process to decide tax rate and amount of re-distribution to each region using formula 4-15, 4-16, 4-17. Integrated analytic model make it possible to decide that at one time. In chapter 4-4 and 4-5, it explains that consumer living region i spend their money to maximize their utility under the total incomes in region i. More concretely, the traffic demand function is calculated by Lagrange-Multiplier Method. The tax rate and amount of re-distribution is calculated using three formulas explained in 4-6. When three variables are assumed, the traffic generalization cost is redefined according to the tax rate. When traffic generalized cost calculated above are assumed, consumers re-decide the best traffic action to maximize their utility under budget constraint.

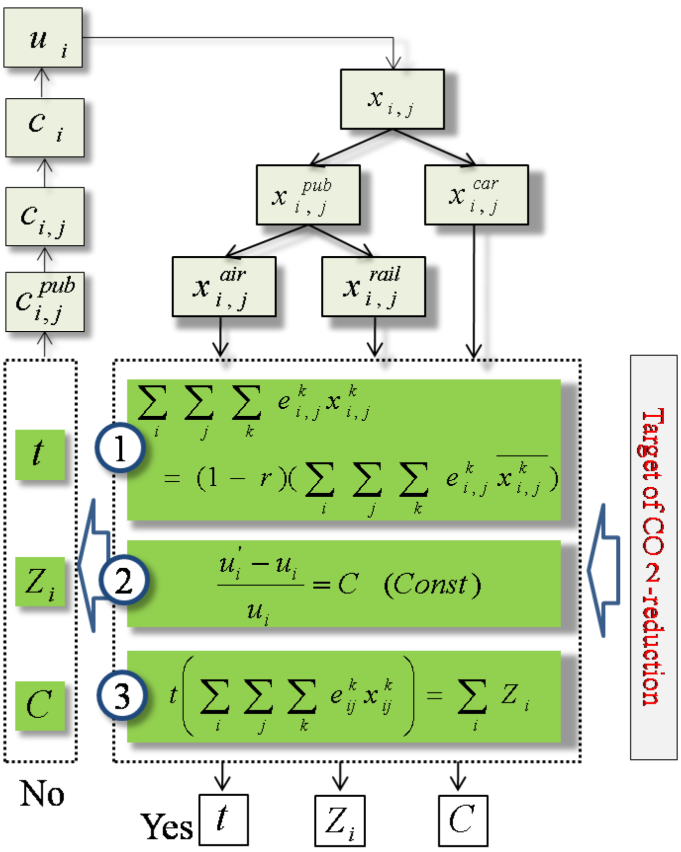

Figure 4-4 : Integrated analytic model

It confirms weather three variables decided by this flow fill three conditional formulas again. If three conditional formulas are not satisfied, re-calculating start until filling that repeatedly.

5. THE RESULTS OF ANALYSIS

5.1 Parameter estimation

5.1.1 The formulas for Parameter estimation

This chapter explains the formulas to estimate parameter to use integrated analytic model in the intercity-transportation sector in Japan. The formulas for estimating parameter are as follows.

$$\ln\frac{x_{ij}}{x_i} = \ln\frac{\alpha_{ij}}{\alpha_i} - \sigma_1 \ln\frac{c_{ij}}{c_i} \tag{5-1}$$

$$\ln\frac{x_{ij}^{car}}{x_{ij}^{pub}} = \ln\frac{\alpha_{ij}^{car}}{\alpha_{ij}^{pub}} - \sigma_2 \ln\frac{c_{ij}^{car}}{c_{ij}^{pub}} \tag{5-2}$$

$$\ln\frac{x_{ij}^{rail}}{x_{ij}^{air}} = \ln\frac{\alpha_{ij}^{rail}}{\alpha_{ij}^{air}} - \sigma_3 \ln\frac{c_{ij}^{rail}}{c_{ij}^{air}} \tag{5-3}$$

Table 5-1 : Unit of CO_2-reduction

	Unit of CO2-emissions (g-CO2/km・capita)	index
Railway	18.7	100
Aviation	110.7	592
Car	172.9	925

The estimating parameter is equal to estimate σ explained in chapter 4-4-1. The alternative elasticity variable between traffic and other consuming products is calculated in formula 5-1. The alternative elasticity variable between cars and public transportation is calculated in formula 5-2. The alternative elasticity variable also between railways and airlines is calculated in formula 5-3. The regression analysis makes it possible to evaluate the alternative elasticity variable using existing data with these formulas.

The method of parameter estimation is based on Okuda(2008). After setting the ratio for transporation demand between modes in horizontal axis and for transport costs in vertical line, the σ and α is decided by regression analysis. If you need more infromation about how to caluculate α and σ, I recommend for you to see the reference.

5.1.2 The results of parameter estimation

Table 5-2 : The results of parameter estimation

Coefficient(n) (A&B)	σ_1 Traffic & others	σ_2 Car & Public traffic	σ_3 Rail & Air
Alternative elasticity value	2.42(55.8)	3.42(41.9)	6.58(59.7)
Fixed number	16.9(35.1)	2.48(60.7)	2.92(49.1)
Coefficients of determination	0.699	0.513	0.702
Multiple correlation coefficient	0.836	0.716	0.838

This chapter explains the results of parameter estimation using formulas 5-1, 5-2, 5-3. The table 5-1 expresses a unit of CO_2-emissions used in calculating process for parameter estimation. The Table 5-2 expresses the results of parameter estimation.

First, the data about traffic demands and traffic generalized cost is needed to estimate parameter. In this study, the data about traffic demands derived by 1990 Inter-regional Travel Survey, and the data about traffic generalized cost derived by JTB time-table in 1990 and road network in 1990. The number of total sample is 2,231. This sample is aggregate data that is OD trips between 50 regions, but it doesn't include some data such as inner-city transport demand and between each prefecture in metropolitan.

First, the result of an alternative elasticity variable between traffic and other consuming products is 2.42. The R-squared is 0.7 and the multiple correlation coefficients are 0.836.

Second, the result of an alternative elasticity variable between cars and public transportation is 3.42. The R-squared is 0.52 and the multiple correlation coefficients are 0.716. The t-value is 41.9 and 60.7.Acctualy, R-squared is low in this case, so this is the future task.

Third, the result of an alternative elasticity variable between railways and airlines is 6.58. The R-squared is 0.70 and the multiple correlation coefficients are 0.838. σ_3 is twice σ_2. This means the substitution of transportation happens easily with Airlines in the railways for the same transportation.

5.2 Effects of estimating effect by introducing environmental tax

5.2.1 Changing transport demand and shifting transport mode

In this study, we set clear CO_2-reduction target (r) to 5%. It explains the effect of introducing Baumol-Oates tax and re-distributing tax revenue to each region in Tokyo as a representative example of arrival and departure point. When the price that the environment tax pushes up is converted into the gas price, it is 62 JPY per 1L of gasoline.

The figure 5-1 shows the amount of decrease of departure traffic demands from Tokyo, and the figure 5-2 shows the variation rate of departure traffic demands from Tokyo.

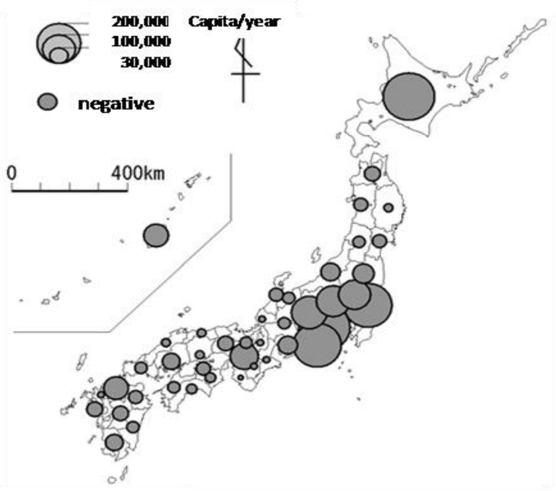

Figure 5-1 : Change in trip volumes originated from Tokyo metropolitan area

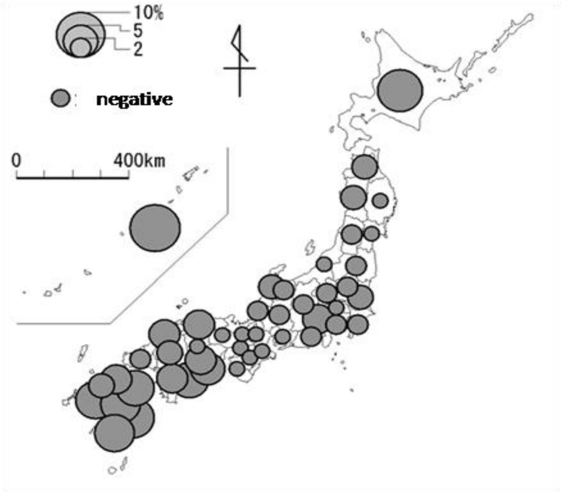

Figure 5-2 Ratios for the changes in trips originated from Tokyo metropolitan area

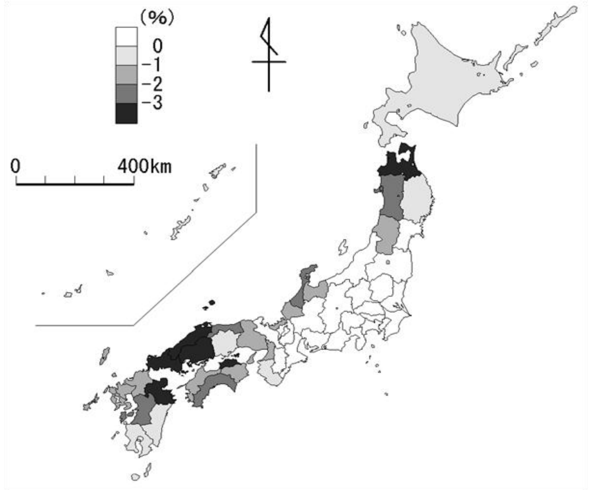

Figure 5-3 Air transport mode share changes(Tokyo originated)

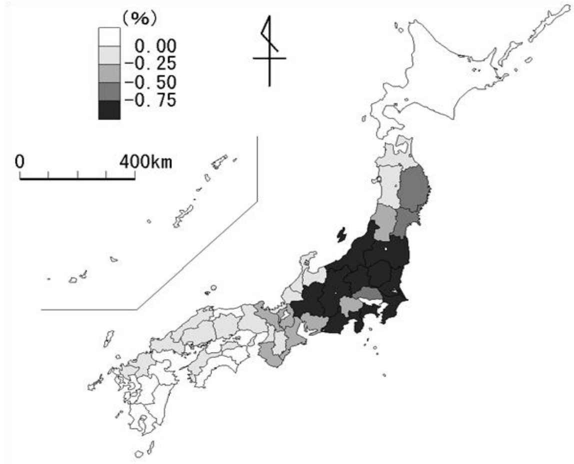

Figure 5-4 Passenger car mode share changes (Tokyo originated)

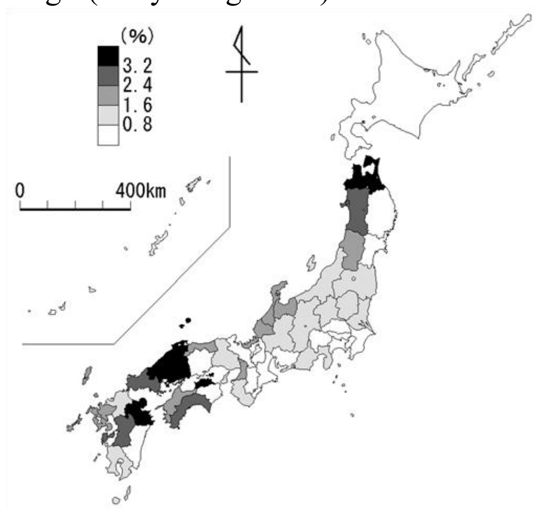

Figure 5-5 Rail transport mode share changes (Tokyo originated)

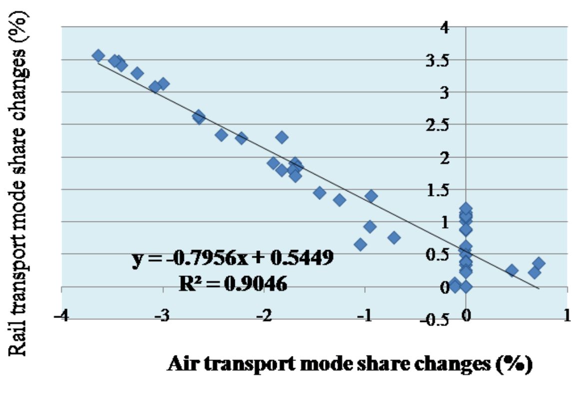

Figure 5-6 The relation between air and rail transport mode share changes

The figure 5-1 is total amount of decrease of traffic demands which include three the way of transportation such as cars, railways and airlines. There are a lot of decreases in the amount of the traffic demand to Tokyo outskirts from Tokyo. More correctly, Yamanashi Prefecture is decreased 280,000 people per year, Ibaragi Prefecture 240,000 people per year and Shizuoka Prefecture 240,000 people per year. The reasons why these prefectures is decreased traffic demands such as amount of traffic demands are that the share of car is high , for example, from Tokyo to Yamanashi Prefecture is 92%, to Ibaragi Prefecture is 75% and to Shizuoka Prefecture is 56%. The impact by taxation is biggest to people using cars for transportation from Tokyo, because a unit of CO_2-emissions from car is the highest in the car, railways and airlines.

Hokkaido Prefecture is also decreased traffic demands about 240,000 people per year. It corresponds to decrease total traffic demands 8% per year from Tokyo to Hokkaido. The substitution from airlines to railways is difficult, because there are no express-railways between Tokyo and Hokkaido. Shikoku region and Kyushu region are also decreased in traffic demands on 7% average. The feature of these regions is the share of airlines between Tokyo and Shikoku or Kyushu region is on 80% average. No alternative transportation lead to decrease traffic demands in these regions.

The figure 5-3 shows variation rate of share on airlines between Tokyo and each prefecture. Aomori prefecture and Chugoku regions are decreased in aviation share on 3% average.

The figure 5-4 shows variation rate of share on cars between Tokyo and each prefecture. The car share rate is decreased about 1% average in Prefecture located from Tokyo to 200~300km.

The figure 5-5 shows variation rate of share on railways between Tokyo and each prefecture. The railways share increases 3% average in Tohoku, Chugoku and Kyusyu regions where the aviations share is decreased on 3% average. Considering a decrease of traffic demands in Aomori Prefecture, passenger change transportation way from aviation or cars to railways about 7,800 people which is correspond to 25% of a decrease of traffic demands between Tokyo and Aomori prefecture, and about 8,160 people which is correspond to 68% of a decrease of traffic demands between Tokyo and Yamaguchi Prefecture.

The figure 5-6 shows the relation increasing railways share in proportion to decrease aviation share. However, there is no relation increasing railways share in proportion to decrease cars share. The condition that the alternative elasticity variable between railways and aviation is higher than it between railways and cars causes this effect like expression in figure 5-6 by pushing up the total cost by taxation.

5.2.2 Reducing CO2 emissions

In this study, the targeted CO_2-reduciton was set as 5%. This chapter explains the amount of the CO_2-reduction and the change rate of it by introducing Boumol-Oates tax into the intercity-transportation in Japan.

The figure 5-7 shows the amount of CO_2-reduction. This result is an amount of the reduction based on departure place. Total amount of CO_2-redution from the intercity-transportation is

2.42 million ton. Regions where the amount of the reduction is especially large are as follows, Hokkaido is 230,000 ton, Tokyo is 290,000 ton, Osaka Prefecture is 110,000 ton, Fukuoka Prefecture is 120,000 ton and Okinawa Prefecture is 160,000ton.

The figure 5-8 shows rate of CO_2-redution. Regions where the rate of CO_2-reduction is especially large are as follows, Hokkaido is 9%, Tokyo is 6%, Osaka is 6% and Okinawa is 10%. The reason why the amount of CO_2-reduction in Hokkaido is large is the traffic demands using aviation are reduced about 70% by taxation. The traffic to Hokkaido depends on 80% of using airlines and the scarcity an alternative transportation enlarges the amount of the reduction.

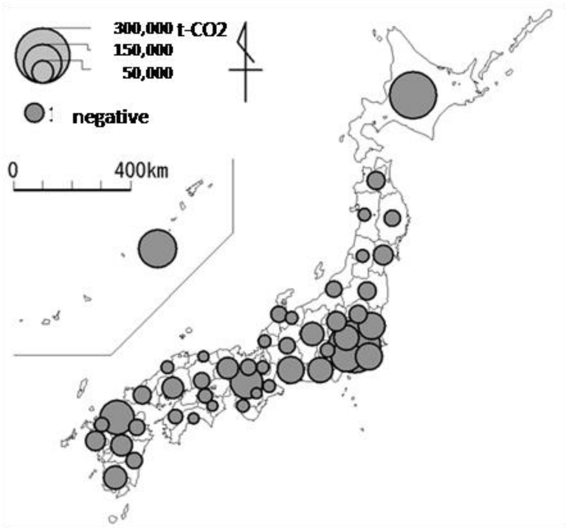

Figure 5-7 Amount of reduced CO_2 emissions based on original area

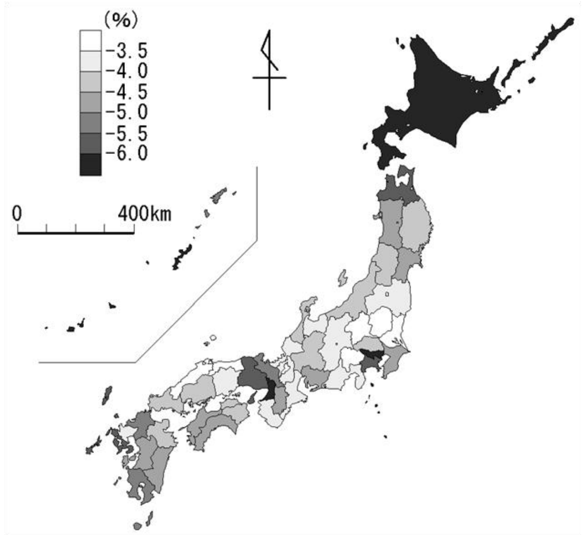

Figure 5-8 Ratios for CO_2 emissions reductions based on original area

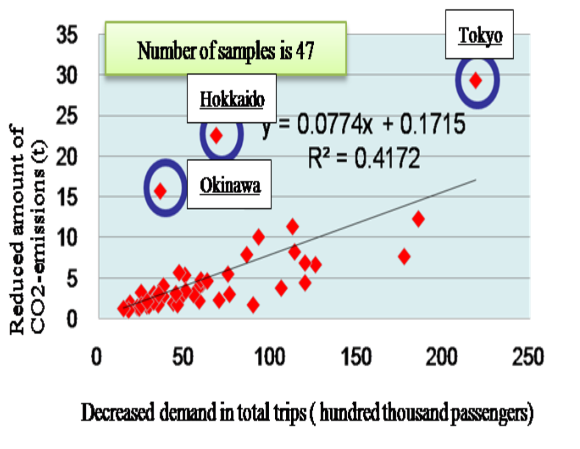

Figure 5-9 Relationship between total trip demand decline and CO_2 emissions reductions

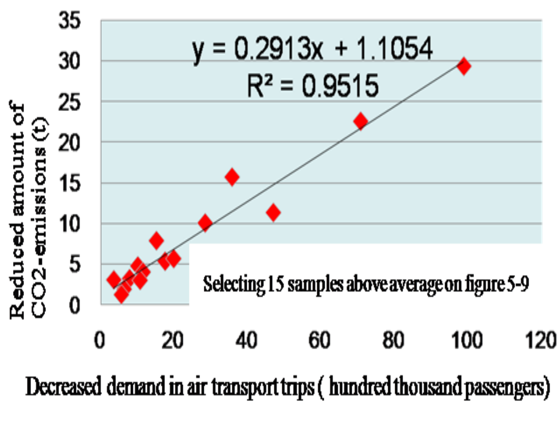

Figure 5-10 Relationship between air transport demand decline and CO_2 emissions reductions

The figure 5-9 shows relationship between the amount of a traffic demand decrease and the amount of the carbon dioxide reduction. In general, there is a proportion in the amount of a traffic demand decrease and the amount of the reduction of carbon dioxide. However, the

amount of the carbon dioxide reduction to a traffic demand decrease is five times as large as that of the average in Hokkaido and is 1.6 times in Tokyo.
The figure 5-10 shows the relationship between the amount of traffic demands of aviation and the amount of the CO_2-redcution. The common feature in the region where the amount of the CO_2-reduction to the amount of a total traffic demand decrease is large is that there is a strong proportion in the amount of an airlines demand decrease and the amount of the CO_2-reduction. Tokyo, Osaka and Fukuoka are central city in the intercity-transportation in the surrounding area where the traffic convenience is very good. The amount of the CO_2- reduction is large in these areas, because there are quite a lot of traffic demands which leave these areas. Especially in Tokyo, it is thought that the amount of the CO_2 reduction increases because it substituted transportation from Airlines to the railway after it taxes. This is a feature of intercity-transportation in Japan that many intercity-transportation networks are constructed to maintain the network with Tokyo.

5.2.3 The Relation between payable taxes and amount of re-distribution

This chapter explains relations between payable taxes and amount of re-distribution in each region.
The figure 5-11 shows amount of payable taxes in each region when targeted CO_2-reducion is set on 5%. The amount of payable taxes of each region is as follows, Tokyo is 24.2 billion yen, Hokkaido-Osaka-Fukuoka and Okinawa is about 10 billion yen. Total tax revenue into government is 260 billion yen.
The figure 5-13 shows proportion between amounts of total traffic demands from each region and payable taxes. The amount of payment of taxes is calculated by multiplying total traffic demands and CO_2-emissions per capita between origin and destination. It is larger than the average that total payments of tax in Tokyo, Hokkaido and Okinawa prefecture. The common feature in these regions is depending on aviation for intercity-transportation.
The figure 5-12 shows total amount of re-distribution of tax revenue to each region according to the rule to equate the decrease rate of the influence by introducing environmental tax. The amount of re-distribution to each region is as follows, Tokyo is 24.2 billion yen, Hokkaido-Osaka-Fukuoka and Okinawa Prefecture is about 10 billion yen. The amount of re-distribution to each region is nearly equal to the amount of payments of tax, because setting the rule to equate the decrease rate of influence by introducing environmental tax.
Based on above-mentioned content, it inspects the unbalance of amount of payments of tax and re-distribution by subtracting amount of payments of tax from amount of re-distribution of tax revenue in each region.

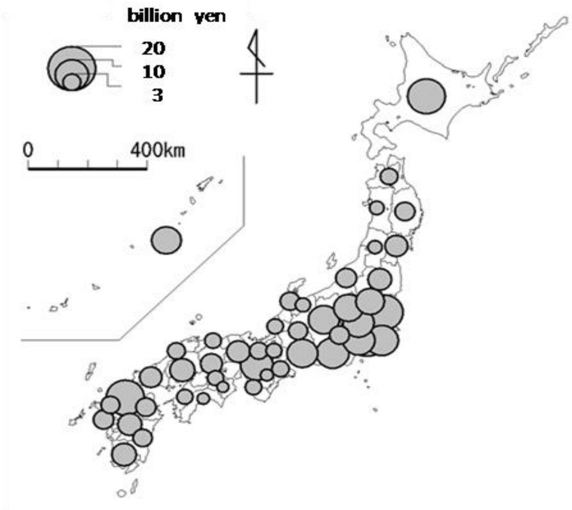

Figure 5-11 Collected tax amount in regions

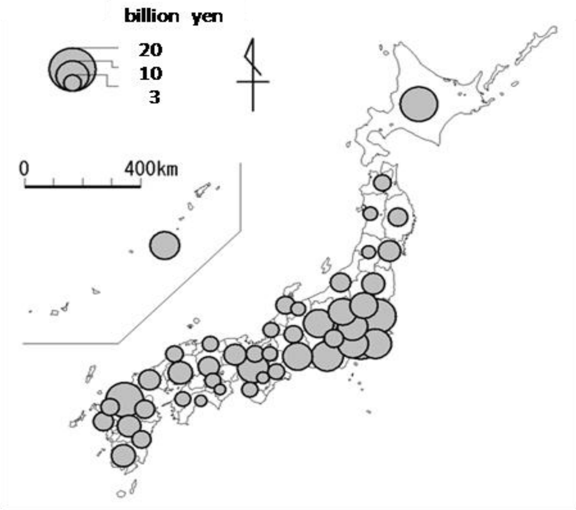

Figure 5-12 Amount of taxes re-allocated to regions

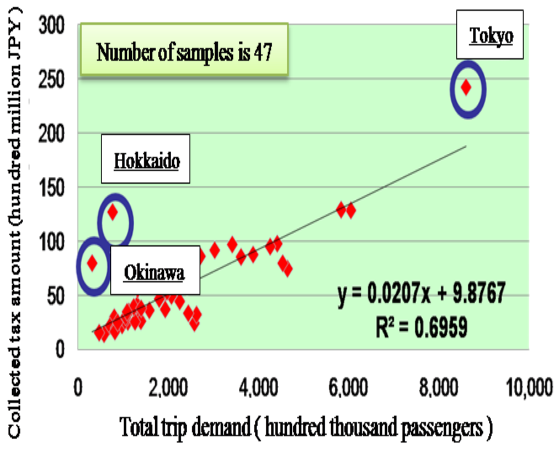

Figure 5-13 Relationship between total trip demand and collected tax amount

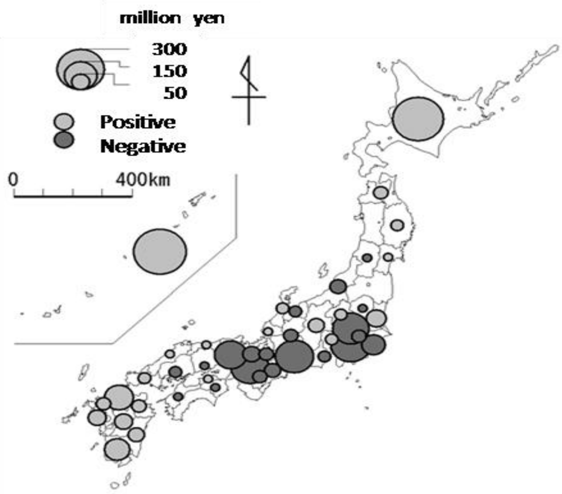

Figure 5-14 Differences of levied returned tax sums(by subtracting collected amount from the re-allocated amount)

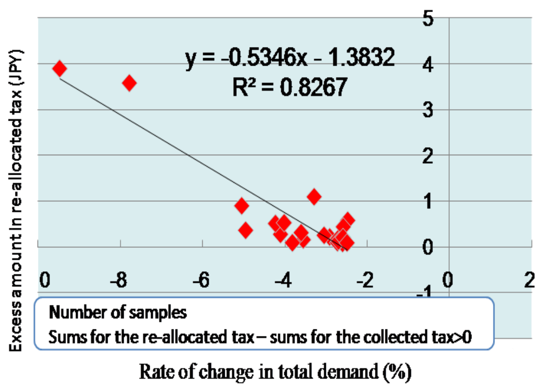

Figure 5-15 Relationship between the rate of change in total trip demand and the excess amount in re-allocated tax

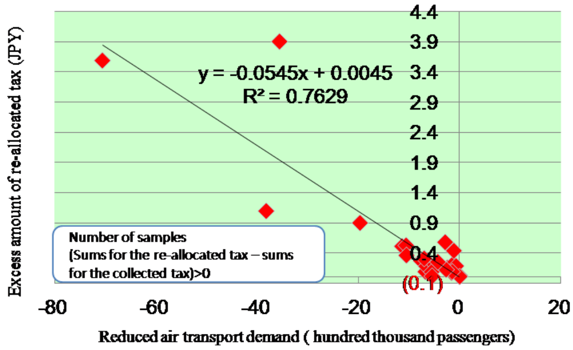

Figure 5-16 Relationship between the reduced air transport demand and the excess amount in re-allocated tax

The figure 5-14 shows the result of calculating above issue. There are some regions where the amount of re-distribution of tax revenue exceeds the amount of payments of tax such as Hokkaido prefecture and Okinawa prefecture. This means the big re-distribution should be done to Hokkaido and Okinawa prefecture to fill the assumptions that makes the change rate of utility in each region constant by taxation. Hokkaido and Okinawa Prefecture exceed 370 million yen, Fukuoka and Kagoshima Prefecture exceed 100 million yen. The figure 5-15 shows proportion between variation rate of total traffic demands and
The common feature where amount of re-distribution of tax revenue exceed amount of payments of tax is that there is proportion between variation rate of total traffic demands from each region and exceeding amount of subtracting amount of re-distribution from payments of tax(refer to figure 5-15). Furthermore, there is proportion between amount of decreasing traffic demands of aviation and exceeding amount of subtracting amount of re-distribution from payments of tax(refer to figure 5-16).
On the other hand, there are some regions where amount of payments of tax exceed amount of re-distribution of tax revenue like Kanagawa, Saitama, Aichi, Osaka and Hyogo Prefecture about 180 million yen. Kanagawa, Aichi, Osaka and Hyogo Prefecture are included in eight high-ranking prefectures at the railway allotment rate. The reason that Saitama Prefecture becomes payment of taxes excess was uncertain.

6. CONCLUTION

6.1 The result of this study

This study is to propose the environmental tax that is one of the demand side policy to achieve clear carbon dioxide reducing target and the re-distribution of tax revenue based on the viewpoint of a fairness. Furthermore, we develop new analyzing model to evaluate the effectiveness of two policies quantitatively.
The characters of this study are as follows. 1) Proposing Baumol-Oates tax which is most effectiveness measure to achieve CO_2-reduction target. 2) Developing new analytic model to evaluate policy proposed in this study. 3) Evaluating the effect of introducing environmental tax and re-distribution of tax revenue in each region.
The results of this study are shown as follows.

1) Taxing environmental tax affects differently whether the presence of substitution of transportation or not. Correctly, Hokkaido and Okinawa Prefecture decrease traffic demands about 8.5% not having alternative transportation. The regions where the railway is constructed are avoided to reduce much of traffic demands by changing the way of transportation. There is proportion between decreasing the share of aviation and increasing it of railway, because the alternative elasticity rate between aviation and

railway is higher than it between car and railway. That means to happen easily to substitute transportation from aviation to railway.

2) The amount of CO_2-reduction in Hokkaido and Okinawa Prefecture is about 4.5 times as large as that of the average. The amount of CO_2-reduction in these regions are large than other region, because it depends on aviation for transportation.
Tokyo, Osaka and Fukuoka are central city in the intercity-transportation in the surrounding area where the traffic convenience is very good. The amount of the CO_2-reduction is large in these areas, because there are quite a lot of traffic demands which leave these areas. Especially in Tokyo, it is thought that the amount of the CO_2 reduction increases because it substituted transportation from Airlines to the railway after it taxes. This is a feature of intercity-transportation in Japan that many intercity-transportation networks are constructed to maintain the network with Tokyo.

3) The amount of payable taxes of each region is as follows, Tokyo is 24.2 billion yen, Hokkaido-Osaka-Fukuoka and Okinawa is about 10 billion yen. Total tax revenue into government is 260 billion yen. The common feature in these regions is depending on aviation for intercity-transportation.
The region where the amount of re-distribution of tax revenue exceeds is as follows, Hokkaido and Okinawa Prefecture exceed 370 million yen, Fukuoka and Kagoshima Prefecture exceed 100 million yen. There is proportion between amount of decreasing traffic demands of aviation and exceeding amount of subtracting amount of re-distribution from payments of tax.

6.2 Issues on further analysis

Adding three viewpoints make it possible to evaluate more correctly.
First, it's developing analytic model including the influence into other market. The taxation rise traffic generalized cost, and its spread other market like rising cost in factory. Considering the influence between each industry market and transportation market gives more corrective tax rate into transportation market.
Second, it's developing new analytic model which have time span to evaluate the influence occurring in the future. It means evaluating appropriate tax rate which considering future influence. It is equal to include the future population, the economic growth rate or the level of infrastructure into analytic model.
Third, this study uses the old data in1990, because it's mainly focused on to developing new model and policy evaluation. But, update date should be used to evaluate more correctly. In addition to these issues, improving parameter estimation method is needed to evaluate accuracy of consumer behaviour.

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