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Assessing Environmental Impacts of Transport and Land-Use Policies in the Tokyo Metropolitan Area

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1. INTRODUCTION

ECMT and OECD give “Sustainability” in term of environment, the definition that we enjoy benefits through socioeconomic activities without depletion of quality of environment, health and safety, and at the organizations, it is focus on coexistence of environment and socioeconomic activities related to transport. Though the automobiles especially, in transport sector, give much benefit to our everyday life, they have caused environmental problems like as air pollutions, global warming, noisy and traffic accidents. For “Sustainability” on field of transport, the prudent and immediate measures are required.

ECMT and OECD also show some policy options for environmental problems, those are regulation, pricing and promotion of public transport and so on. Though implement of those policies is very effective to environmental improvement, those have concerns that the welfare loss is generated. In this paper, we measure how much socioeconomic activities are reduced and utility is down by mathematical economic approach, when those policies are implemented, and put the final purpose on proposing most efficient policy, in the meaning to achieve environmental improvements without depletion of the utility. In this research, we have argued effective policies for national wide, Tokyo metropolitan area and Okayama local area. After showing the abstract for whole evaluation on each study, we show the result on Tokyo metropolitan area in detail.

2. Policy evaluation for national wide, Tokyo metropolitan and Okayama regional area

2.1 Outline of each evaluation

In whole study, we adopt the mathematical economic approach, which consists on the economic agents’ behaviours formulated by micro economic principle, those are households’ utility maximizing or firms’ profit maximizing behaviour, and market mechanism where each agent’s behaviour is adjusted through price function and the market converges to the equilibrium. Hence those models allow us to grasp the change of agents’ behaviours due to implement the policies, and measure the damage given to household’s utility and firm’s profit. From the result, we may indicate the most efficient policy for “Sustainability”.

2.2 Result of policy evaluation

Next, we will show the policy options picked up in each study.

Nationalwide model: 1) Fuel mileage regulatory policy by Top Runner method 2) Changing policy of automobile related tax to green system 3) Carbon tax related to only automobiles.

Tokyo metropolitan area model: 1) Road investments 2) Road pricing 3) Railway investments 4) Reduction of railway fares [3 pattern] 5) Relaxation of floor capacity limits 6) Package project [2 pattern].

Okayama local model: 1) Bypass roads 2) HOV lanes and Bus lanes 3) Streetcar 4) Transit mall (Car free zone) 5) Park & Ride.

The results of policy evaluation are expressed as below,

Nationalwide model: 1) Fuel mileage regulatory policy and 2) Green tax are expected to decrease some environmental pollutions, but those unfortunately may not reach the target of COP3 with moving in a current policy level. So, it is implicated that the policy like as carbon tax is requested, that is efficient in the point of being levied directly to automobile user.
Tokyo metropolitan area model: Road investments are brought much benefit to socioeconomy through drastic reduction of automobile required time, but increase environmental pollutions through increasing automobile use or extending drive length with being suburban of urban area. For this result, railway investments are expected to decrease environmental pollutions with current utility level, because the mobility remains to be secured by hastening a conversion from automobile to railway. By adding the reduction policy of railway fares on railway investments, environmental pollutions are shown to be reduced more. The results for this case are explained again in the later half.

Okayama local model: At all policies, environmental pollutions are reduced, at especially, the reduced rate by implementing transit mall is most large. However, transit mall project also deplete the utility of people. For this result, the package project combined transit mall with Park & Ride became the result of reducing environmental pollutions with keeping high utility level, and this can be said that it is exactly “Sustainability”.

3. Detail results of Policy evaluation at Tokyo metropolitan area

Here, we show the model and the result of policy evaluation of Tokyo metropolitan area in detail. This model is based on the mathematical economic model same to other evaluation model, in addition, is considered location and traffic equilibrium, those have been developed on the field of land-use and transport modeling. We prefer to call the model “CUE (computable urban economic) model” and have continued researches related to its model.

3.1 Structure of CUE model

The key study on CUE model is the one by Anas (1984). Anas formulated the agents’ economic behaviour for the urban area that is divided in some zone, by framework of general equilibrium. The characteristic of his model is the point of being taken even traffic equilibrium in model for the agents’ transport behaviour. In the other hand, the CUE model is based on the framework of the multi-market equilibrium in which the land markets are focused. Though we don’t adopt the general equilibrium model like Anas’ one, the CUE model became easy to apply to the actual projects and has be possible to compute impacts of projects or policies at Tokyo Metropolitan area where huge data is required.

On the case study, we set target to Tokyo metropolitan area that is divided in 169 zones. There are households, composite goods firm, which is considered as an employee, and absentee landowner in the each zone (See Fig.1). Household and firm behave so as to maximize utility and profit, respectively, and they are
supposed to be allowed to relocate the zone, where utility or profit obtained as the result are higher. And an absentee landowner supplies land so as to maximize its revenue gained from land rent.

From this modeling, when implementing projects or policies, the follow as below is indicated. Each agent will relocate the zone where the utility or profit is improved by the road investment projects for instance. This location change will cause two phenomenons, which are the increases of land demand to concerned zone and traffic generation from concerned zone. For former land demand increase, though an absentee landowner receives it to some extent by increasing land supply, when being raised the land demand any more, it causes to raise land rent. And, through the adjustment of land rent, the relocation behaviour of agent is converging to equilibrium. For later traffic generation increase, it causes to rise required traffic time on the roads postponed from concerned zone due to the constraint of traffic capacity. And, through the adjustment of changing the path or controlling traffic generation by road user, the traffic equilibrium is achieved that means required traffic times of all paths become to equal.

3.2 Summary of projects or policies

The projects and policies considered here are already shown at section 2.2. In those, 4) Reduction of railway fares is considered three patterns, that is the reduction in railway fares by 50%, by adopting the lowest fare rate among various operators and by not requiring additional charges for transfer between different operators. And package project consists of two patterns that is the case on implementing the projects and policies from 2) to 5) simultaneously, and carrying out also the road investment projects in addition on those projects.

In this simulation, we set benchmark year at 2000, and calculate the equilibrium by giving the total population and employee at intervals of five years, and consider seven periods until 2030.

3.3 Results of evaluation

We show the change rate of CO2 emissions and GRP (Gross Regional Products) with each project or policy compared to BAU (Business as Usual) case in Fig.2. From those results, road investment projects and Package 2, which include road investments, increase GRP, but increase also CO2 emissions. Because the road required time is reduced drastically by the road investments, economic activities become to be activated and GRP is pushed up. The reduction of road required time, however, increases automobile use. In addition, the road investments cause extension to suburban of urban area (see Fig.3), so driving length of each automobile is expanded, and it is thought CO2 emissions are increased so much.

Against this, railway investments reduce CO2 emissions and increase GRP. In especially, Package 1 (projects and policies from 2) to 5)) reduces CO2 emissions most, though some GRP falls compared with the only railway investments case. This reason is considered that Package 1 has decreased automobile use by accumulating location of households and firms to around the railway construction district (See Fig.4). And railway investments to around the center of Tokyo lead to expansion of high productivity area, so more firms enjoy the effects by being improved productivity.

Road pricing and Relaxation of floor capacity limits are results in which not changing to BAU case.
REFERENCE


Fig. 2 The change rate of CO2 emissions and GRP with each project/policy compared to BAU case

Fig. 3 The changes in population and employee with Road investments compared to BAU case

Fig. 4 The changes in population and employee with Package 1 compared to BAU case