別紙様式２

学位論文要旨

ヤンホン　イン
氏　名　Yanhong　Yin

論文題名

An Evaluation Method of Compact City based on Individual Energy Consumption Behavior

（効用水準とエネルギー消費の視点から見た都市のコンパクト性評価手法）

要　旨

Different built environments may induce to diverse social, ecological, and environmental consequences. Many studies discuss the urban forms that may give rise to sustainable urban development, such as the compact city. Reducing pollution and minimizing the loss of open countryside are believed as two main benefits of compaction. How to analyze the effect of compact city and give suggestions to policy making, implications of these discussions are important in the task of urban sustainable development. The amount of energy consumption is a very important and effective index to assess compact city policy from sustainability viewpoint. Growing concerns about surging oil prices and the greenhouse gases produced by burning fossil fuels require that urban development not only minimize the use of resources and the spatial displacement of environments, and also improve energy efficiency.

This thesis mainly aims to establish a methodology framework to analyze the compact city from veracity, feasibility aspects and give suggestions for compact city policy based on energy consumption analysis. The dissertation addresses the concern by assessing the compact level of cities by energy consumption efficiency and undertaking a collection of analysis on issues surrounding the energy consumption estimation allowing for complexity and heterogeneity in individual consumption behaviors. Several endeavors are taken: 1) the development of a method to estimate the individual energy consumption on present level of quality of life; 2) the construction of a model to estimate the minimum energy consumption for the present utility; 3) effect analysis of transport

pricing policy and density policy; 4) relationship between built environment characteristics of compact city and energy consumption.

Our study firstly show a microeconomic based quantitative analysis scheme to estimate the energy consumption by considering 1) a consistency relationship between the level of quality of life and utility; 2) the utility theory based on personal consumption behavior; 3) the conflict between traffic congestion and energy consumption. The quality of life is represented by utility in purely economic term, which can be quantified by goods consumption. As resident is assumed to consume two kinds of goods: composite goods and mobility goods, utility is explained by a two order CES (Constant Elasticity of Substitution) function. People are assumed to maximize their utility by consumption of composite goods and mobility goods constrained by income. The individual energy consumption can be estimated based on his consumption behaviors explained by the demand of each kind of goods on the maximum utility. Consider the influence of the traffic congestion, trip time is introduced into the estimation function. Energy consumption efficiency, ratio of utility to energy consumption, is developed as an index to evaluate the compact level. Estimated actual and optimal energy consumption was calculated in this thesis based on different applications.

We applied the methodology to Kumamoto region to test the veracity of compact city. The relationship between built environmental characteristics of zone and energy consumption efficiency was analyzed by a regression model. We chose the estimated actual energy consumption efficiency as the dependent variable. Nine independent variables represent built environment characteristics of zone from density, diversity and accessibility aspects. The model shows strong explanatory power. Population density, ratio of retail jobs to population (land use diversity) and transit fare are found influence energy consumption efficiency strongly.

Based on the result of veracity test, we proceed with the second application of feasibility. Effect of policy on energy consumption is checked by simulating policy scenarios. Two kinds of policies are assumed to introduce in the Kumamoto region: transport pricing policy and density policy. Eight policy scenarios are simulated based on four transport pricing strategies: adding gasoline tax by 20 yen/liter or 40 yen/liter and reducing mass transit fare by 20% or 40%. Results show gasoline tax adding is effective to reduce car trips thus less energy consumption. Mass transit fare reduction does increase mass transit trips, but the effect is offset by unchanged car trips. Scenarios with mass transit

fare reduction alone show little decrease of energy consumption. Three density policy scenarios are set, unchanged population (100% of population), reduced population (90% of population), 90% population and all concentrated in Kumamoto city. Similar results of energy consumption efficiency are shown in the scenarios of 100% population and 90% population. The highest energy consumption efficiency is shown in the result of scenario that 90% population and all concentrated in the Kumamoto city. In order to reduce energy consumption, increasing the population density of the Kumamoto city is much more effective than improving the population density of the Kumamoto region.

We discuss the most suitable compact level by the optimal energy consumption efficiency, which is the ratio of present utility and minimum energy consumption. A model is developed to estimate the minimum energy consumption on the present utility. We applied the model into Kumamoto and Nagasaki region. High population density is in Nagasaki, which is assumed to be more compact. Nagasaki shows higher estimated actual energy consumption efficiency, which means high compact level in this region. It is same as expected. However, bigger estimated optimal energy consumption efficiency is found in Kumamoto. The difference between the estimated actual and optimal energy consumption efficiency is larger in Kumamoto region. It means there is more improvement room in Kumamoto. Compared the estimated actual energy consumption, less car trips but more mass transit trips and composite goods consumption is found for the minimum energy consumption in both regions. Zones with higher energy consumption efficiency are mainly located in the city center and along mass transit lines in both regions. Result suggests that reducing the energy for car trips instead of more mass transit usage and composite goods consumption leads to less energy consumption. However, more money is also needed. Averaged 401 yen of additional cost is needed for one person to change his consumption behaviors to the ideal one for the minimum energy consumption in the Kumamoto region.

In conclusion, this study developed a methodology framework to analyze the compact city from veracity, feasibility and most suitable compact level by energy consumption analysis. The methodology of this paper is very important since it estimates the individual energy consumption through personal consumption behaviors from a microeconomic perspective. It verified that energy consumption efficiency is effective to evaluate the compactness of cities. Our model for minimum energy consumption on present utility is very suggestive for compact level policy making. Policy simulation and relationship analysis give us more implications for compact city planning. The findings

in this paper suggest six implications for compact city policy: 1) More suitable compact level leads to higher energy consumption efficiency; 2). The consumption pattern is recommended for fewer car trips, greater mass transit usage and more composite goods consumption; 3) Gasoline tax is effective to reduce energy consumption; 4) Concentrating the population in center city is an effective strategy to less energy consumption; 5) High population density, high land use diversity is recommended for compact city development.