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A study on possibility of commuting trip using private motorized modes in cities around the world: Application of multilevel model

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ABSTRACT

The focus of the current research was to evaluate how the individual's social characteristics and urban infrastructure impacts the usage of Private Motorized Modes (PMM). Based on individual and urban characteristics a multilevel analysis was conducted on the possibility of commuting trip by private motorized modes on the rush time of 78 cities around the world. Also the selected cities were classified through a principal component analysis, and based on the classification the impact of and urban variables on the possibility of commuting trips made by private motorized modes (PCTP) was verified. Results showed a diverse range of variables related to the usage of PMM, as well as the urban structure and railway lengths being an important variable in travel behavior.

Introduction

In recent years, the range of individual travel behavior is expanding with the advancement in motorization, alongside the economic development of cities around the world. The world is shifting toward faster and energy intensive modes of transportation (Schafer and Victor, 1999). In order to combat this issue, new city planning methods and management strategies for technical development that shift popularity from cars to public transit and reduce the dependence on private motorized modes are required. Many planning techniques and research projects since 1970 have focused on developing the urban structure based on the concept of sustainable development. In addition, it is recognized that the importance of developing sufficiently high quality alternatives that induce drivers away from their cars is increasing.

In particular, the heavy traffic demand during the commute hours is one of the factors that increase social costs, such as traffic congestion and delays. To cope with the increased social costs, congestion fees have been implemented in various cities to control traffic demand during peak commute hours (Suryo et al., 2007).

Recently, several studies were carried out to derive policy measures to reduce the overuse of Private Motorized Modes (PMM) from an urban structure and transport environment perspective. A study by Newman that examined 46 cities around the world provided strong evidence that high population density contributed to controlling PMM traffic demands (Newman and Kenworthy, 1989). Studies on the correlation between population density and transport characteristics have been carried out in other countries, and Asian counties with high population densities, including South Korea and Japan, have shown high interest in the subject (Morimoto and Koike, 1995). However, there are differences in vehicle usage among cities or

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zones with similar population densities, which indicates that while population density is strongly correlated with the usage of PMM, there are individual factors or regional factors causing traffic demands created by PMM. As such, it is necessary to analyze the details of the relationships among the factors at different levels.

The usage characteristics of PMM or factors expected to affect the usage characteristics can be examined based on a hierarchical structure. It could be considered that personal or household factors are in a lower hierarchy and zone, while factors of cities and countries are in a higher hierarchy. In general, social study data for a city or a country are strongly correlated with the features of the group in which the samples are included, and the individual samples are affected by the group's characteristics. Therefore, to explain the individual features of PMM usage in the city, it is necessary to consider the structural hierarchy of individual samples and the groups from which the samples were drawn. However research regarding both urban characteristics and the individuals social attributes, such as traffic patterns has been rarely conducted. Also, there has not been any research on the reliance of personal nodes on the basis of individual and urban factors. In terms of the conditions, this study focuses on how the structural and economical characters of urban districts, as well as the social characteristics of individuals, affect the dependence of personal transportation.

Based on this background, this research adopts a multi-level analysis method that enables us to understand the effects of hierarchical data on individual and urban level variables. Through the analysis on commuting trips of PMM, this research confirms the existence of significant variances in the possibility of commuting trips made by PMM (PCTP) among the cities, and the manner in which the variations and the relationship between dependent variables and independent variables at different levels are clarified.

To achieve this, for the current study a database of cities was built that considered individual factors and travel behavior of PMM reflecting travel behaviors described in the National Household Travel Survey (NHTS), which describes some of the factors associated with demographic information on the individual, concerning an individual's travel behavior in 78 cities in 14 countries.

In addition, this study checked the validity of hypotheses for factors at different levels of the hierarchy that affect the possibility of commuting trips made by PMM.

Literature review

Travel behaviors by urban structure, transport infrastructure and public transport

Previous studies on the relationship between urban environment factors and transport behaviors have generally utilized data collected at the city or sub-municipal level (namely ward), or at the zone level due to the constraints in defining spatial ranges for a certain study purpose in the urban environment. Crane and Crepeau (1998) studied the relationship between shapes of road network and transport behavior cities in the United States. Suzuki and Muromachi (2009) analyzed the relationships between accessibility to railway stations and usages of PMM. Also, Ewing and Cervero (2001) reviewed factors that affect usages of PMM by categorizing urban space according to zones.

On the other hand, an international survey study performed by Mackett and Sutcliffe (2003) reported several reasons for developing urban public transit systems, improving public transport, reducing traffic congestion, serving the city center better, improving the environment, and stimulating development.

In addition, reducing transportation energy consumption by mitigating traffic congestion is widely considered as one of the common reasons for building new transit systems. Rail has been well received as a transit mode that promotes transit-oriented development (TOD), which in the United States often translates into compact, mixed-use, and pedestrian-friendly development around transit stations, as an alternative to sprawl.

In this context, Winston and Langer (2006) indicated that congestion costs of PMM decrease in a city as rail transit mileage expands. In several US cities, traffic congestion growth rates declined after a Tram service was established. Baum-Snow and Kahn (2005) found significantly lower average commute travel times in areas near rail transit than in otherwise comparable locations that lacked rail service, due to rail's higher travel speeds compared with PMM or buses under the same conditions. In addition, Litman (2007) shows that per capita congestion delay is significantly lower in cities with high quality rail transit systems than in otherwise comparable cities with little or no rail service. Rail system expansion generally occurs in large and growing urban areas in response to increasing congestion. As a result, simplistic analysis often shows a negative correlation between rail transit and road congestion.

Kenworthy et al. (1999), as well as Kenworthy and Laube (1999), have also shown that the more intensive the land use, the shorter the travel distance, the greater the viability of transit, the higher the car occupancy of vehicles, the less the need for a car, and these patterns suggest that the urban density is fundamental to shaping travel behavior.

Giuliano and Dargay (2006) conducted an international comparative analysis of the relationships between car ownership, daily travel and urban structure. Using travel diary data for the US and Great Britain, they estimated models of car ownership and daily travel distance. Choi et al. (2011) also stated clearly that population density and number of vehicles have a negative correlation.

In terms of the effect of the transport infrastructure on travel behavior, it is confirmed that an increase in road density and extension of the railway infrastructure have positively contributed to road transport demand and transit oriented urban development.