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Relationship between transit modal split and intra-city trip ratio by car for compact city planning of municipalities in the Seoul Metropolitan Area

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ABSTRACT

Compact-city planning factors are commonly applicable even to metropolitan areas. In most cases, however, planning policies based on theses factors fail to consider that travel patterns are not uniform in each metropolitan area. Furthermore, the travel pattern of inter- and intra-municipality that results from spatial interaction between a central city and its various sub-centres and suburbs in a metropolitan area has not been fully explored. A consideration of the specific urban system could therefore provide an answer to the question of why certain factors have different effects on the transit modal split and car travel distance between municipalities of a metropolitan area. The aim of this study was therefore to find an effective way to establish compact-city planning policies in municipalities of the Seoul Metropolitan Area (SMA). An investigation of the changed travel pattern in each municipality based on the changed relationship between transit modal split (TMS) and intra-city trip ratio by car (ITR) between 2006 and 2010 found that the SMA became more car-dependent: TMS and ITR of the municipalities declined together, and ITR decreased much more in the outskirts. Based on the relationship between the two factors, the effects of changes in land use and transportation were estimated using a combination of cluster and regression analysis. This revealed that, in municipalities of Seoul and its adjacent sub-centres, there is a need to promote transit-oriented development (TOD) by creating high-density areas within close proximity to city railroad stations. In contrast, it is necessary, in municipalities on the outskirts of the SMA, to restrict large-scale developments, such as large retail centres, and instead promote a mixture of self-sufficient land uses. In the intermediate municipalities that lie between these two, TMS and ITR can be increased through TOD near railroad stations, or ITR alone can be increased through a greater mix of land use. These findings could assist in implementing effective compact-city planning policies in each municipality of the SMA, and could also be applied to the other metropolitan areas in Korea or elsewhere in the world.

1. Introduction

There has been growing public awareness over the past few decades of the damaging impact that cars have on cities (Newman & Kenworthy, 2006) in terms of their noise, discomfort, psychological and physical insecurity, loss of amenity and social space, and atmospheric pollution (Council of Europe, 2002). Transport energy consumption and greenhouse gas emissions have also been linked to a dependency on cars in many cities, which is often the result of urban sprawl. The universal conviction that this sprawl increases travel distances, and therefore transport energy consumption (da Silva, Costa, & Brondino, 2007), provides a solid base to accept a more compact city as an appropriate solution. Indeed, Newman and Kenworthy's (1989) study of the relationship between density and energy use in an international sample of cities has been widely cited in support of compact city policies (Handy, 1996). However, despite this, the feasibility of compact cities, especially for metropolitan areas, has been called into question by the dominant trend of expanding urban development (Gordon & Richardson, 1989; Breheny, 1992, 1995; Wegener, 1996; Lee, 2001; OECD, 2012).

Most metropolitan areas in the world have become decentralized (Anas, Arnott, & Small, 1998; Aguilera, 2005; OECD, 2012), leading to a shift in the debate over the feasibility of compact cities to the relationship between decentralization and travel distance. Some studies (Gordon, Richardson, & Jun, 1991; Schwanen, Dieleman, & Dijst, 2001) have suggested that a decentralized distribution of employment and people shortens commuting distances. Most other studies (Aguilera, 2005; Casello, 2007), however, have found decentralization to be associated with increased commuting distances and a decrease in transit modal split. Despite these contradictory results, the compact city model has tended to be the core issue in studies relating to urban structure policies for reducing car dependency in metropolitan areas (Handy, 1996; Wegener, 1996; Cervero, 1996; Lee, 2001; Schwanen et al., 2001; Aguilera, 2005; Casello, 2007; Sung & Oh, 2011; OECD, 2012; Lee,

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Yi, & Hong, 2013), which have been based on the idea that a compact city is also applicable to the decentralized urban structure that is more common in today's urban context (OECD, 2012).

For many metropolitan areas throughout the world, the compact-city planning factors for increasing transit modal split and decreasing car travel distance have been examined in those studies, which confirmed the general findings of Newman and Kenworthy (1989). Indeed, findings from the empirical studies have been used to establish policies to reduce car use in many metropolitan areas (OECD, 2012). In most cases, it has, however, failed to consider that travel patterns and behaviour are not uniform in each metropolitan area. This means that different metropolitan areas should pursue different compact-city planning policies. Furthermore, the travel pattern of inter- and intra-municipality that results from spatial interaction between a central city and its various sub-centres and suburbs in a metropolitan area has not been fully explored. Considering a specific urban system (Parr, 2012) is therefore necessary to determine why certain planning factors have different effects on transit modal split and car travel distance not only between metropolitan areas but also between municipalities of a metropolitan area. This study focused on municipalities of a metropolitan area.

The total urban population grew universally during the 2000s, and in most countries, this increase followed a pattern of spatial dispersion of the urban population (Veneri, 2015). Urban development also occurred in the metropolitan areas of Asia (Anas et al., 1998; Newman & Kenworthy, 2006), including the rapidly changing Seoul Metropolitan Area (SMA) (Jun, 2012; Go & Choi, 2013; Yi & Lee, 2014), which represents one of the best examples of decentralized metropolitan areas in Asia. When compared to metropolitan areas in the US and Europe, the SMA has a central city with a much stronger centrality (Veneri, 2015: 8), a rapidly growing suburb owing to urban development (Jun, 2012; Go & Choi, 2013; Yi & Lee, 2014), and a public transportation network that operates mostly within the central city and limitedly to some major employment sub-centres (Lee et al., 2013). Because of these urban structural features, which accordingly affect the travel pattern across the set of municipalities that form Seoul's urban system (Parr, 2012), compact city policies should be based on an understanding of how such features influence the relationship between transit modal split and car travel distance in each municipality. This approach, which has not been pursued yet in other empirical studies, could lead to finding an effective combination of compact-city planning factors for each municipality of the SMA.

Based on this background, the purpose of this study is to suggest an effective approach for establishing compact-city planning policies in municipalities of the SMA. To this end, the changed travel patterns of the municipalities between two time periods (i.e. 2006 and 2010) were first investigated with regards to the relationship between transit modal split and car travel distance. The influence of the land use pattern and transportation system on these two indexes of the relationship was then assessed through cluster analysis and regression analysis. Finally, any variables identified as having an apparent influence on both indexes were suggested as factors influential to any policies aimed at compact cities in each cluster of the municipalities. The findings could inform the implementing of effective compact-city planning policies in each municipality of the SMA by taking into account their different urban features. This was intended to be of importance not only to the municipalities of the SMA, but also any one of the many newly rising nations that are experiencing issues with car-focused-traffic systems in their metropolitan areas, and which are seeking to expand city railroads to promote TOD.

2. Literature review

2.1. Compact city and metropolitan areas

Urban sprawl is a term commonly used to describe the uncontrolled expansion of urban development, which is characterised by low density, segregated land use, and an insufficient provision of infrastructure (OECD, 2012). This generally results in an increase in travel distance and a greater dependence on cars, thereby increasing transport energy consumption (da Silva et al., 2007) and providing a solid basis for establishing a compact city model like that suggested by Newman and Kenworthy (1989). This consists of a dense city centre and a commitment to mass transit (particularly rail) and other non-automotive means of transport, which has provided the motivation for empirical analysis of the relationship between urban structure and travel patterns in many international cities (Handy, 1996).

Going against physical planning policies aimed at reducing car travel distances and increasing transit modal split, Gordon and Richardson (1989) argued, however, against the adoption of monocentric compact cities in the U.S. from an econometric point of view. In addition to Gordon and Richardson's (1989) arguments, international studies relating to changes in the urban structure of metropolitan areas have found the monocentric compact city model to be infeasible owing to the dominant trend of expanding urban development (Breheny, 1992, 1995; Wegener, 1996; Lee, 2001; OECD, 2012).

In light of the current trend towards polycentric decentralization, there have been a number of empirical studies of the relationship between urban structure and travel patterns in metropolitan areas. Gordon et al. (1991) and Schwanen et al. (2001) have suggested that a polycentric distribution of employment and people shortens commuting distances, whereas Aguilera (2005) and Casello (2007) have found polycentricity to be associated with increased commuting distances and a decrease in transit modal split. Despite these contradictory results, the compact city model has tended to be the core issue in studies relating to urban structure policies for reducing car dependency in metropolitan areas (Handy, 1996; Wegener, 1996; Cervero, 1996; Lee, 2001; Schwanen et al., 2001; Aguilera, 2005; Casello, 2007; Sung & Oh, 2011; OECD, 2012; Lee et al., 2013), which have been based on the idea that a compact city is also applicable to the decentralized urban structure that is more common in today's urban context (OECD, 2012). In other words, when viewed on a metropolitan scale, a compact city need not presume any specific urban form (i.e., monocentric or polycentric). Consequently, the compact-city planning factors suggested by Newman and Kenworthy (1989) have been the focus of academic and political interest to find a solution to the high car dependency in metropolitan areas.

2.2. Compact-city planning factors

Newman and Kenworthy (1989) found that, in a number of large cities around the world, there is a clear negative relationship between the gasoline consumption per capita and the population and job densities. Further investigation of this negative correlation suggested that the urban structure within a city is fundamental to its overall gasoline consumption. Detailed land use policy factors used in this study included the strength of the city centre and the proportion of the population living in the inner city. In the case of the former, more jobs in the city centre generally mean that mass transit systems were more viable, whereas a significant negative correlation with the latter indicates that a greater mixture of residences and businesses exist in the core of the city (Anas et al., 1998). Transportation system factors such as modal split, provision of private cars, traffic speed, and the availability of roads and parking infrastructure also exhibit a strong correlation with gasoline use if they make car use preferable to other options (Newman & Kenworthy, 1989).

Breheny (1995) introduced a British study (ECOTEC, 1993) carried out for the Department of the Environment that provided evidence of a relationship between density and energy consumption, and which confirmed the general findings of Newman and Kenworthy (1989). It also demonstrated that there is an increase in average distance travelled with decreasing urban size; i.e. the lowest level of travel is in metropolitan areas owing to their higher urban densities, shorter travel