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A multi-criteria approach for prioritizing advanced public transport modes (APTM) considering urban types in Korea

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ABSTRACT

This paper presents a multi-criteria decision analysis (MCDA) framework to prioritize advanced public transport modes (APTM) in Korea considering the urban types of new towns. In Korea, to overcome the shortcomings of conventional transportation modes such as buses and subways, the introduction of advanced public transit modes that deliver eco-friendly and cost efficient transport has become a critical issue in public transportation policy. Therefore, when a new town is designed, the adoption of APTM should be seriously considered as part of the municipal public transportation system. As part of efforts to provide basic and evidence-based information for the successful introduction of APTM in Korea, we explored which values an APTM initiative should pursue most extensively and investigated the option of APTM to best meet those values, considering the urban type in which the APTM will be operated. In this study, the decision criteria for evaluating the competitiveness of each APTM were suggested, and a hierarchical structure for the decision-making process was developed. Subsequently, dividing the types of new towns into the Metropolis type and the Small & medium-scale city type, relative weights of decision criteria are derived using MCDA, and the competitiveness of each APTM alternative is quantified in order to prioritize each mode for the type of city where the APTM will be introduced.

1. Introduction

In the 1980s, the Korean government instituted a policy of actively developing new towns to help manage problems caused by the rapid economic development and explosive population growth of the Seoul Metropolitan Area. As part of the first stage of this policy, five new towns near Seoul were constructed. These towns were completed and fully settled by the late 1990s. This policy has been considered a successful solution to the housing problems of the Seoul Metropolitan Area (Song and Lee, 1999). However, dramatic changes in population distribution related to the emergence of these large-scale new towns gave rise to many urban transportation issues such as serious traffic congestion, pollution, problems with commuters' safety and convenience, and low transport efficiency.

Previous authors have argued that the transportation problems of new towns of Korea are mainly due to the weakness of the public transportation systems. Specifically, in a survey completed by the residents of the five new towns (Song, 2002), 43.2% of respondents were not content with the overall public transportation system of the new towns, and 36.4% of respondents highlighted a lack of public transit modes as the most serious problem. Based on the experiences of these first-stage new town developments, the Korean government realized the necessity of creating an integrated transit plan that incorporates appropriate public transportation systems during new town development. As a result, public transportation system planning has become a significant element in the process of new town development.

Traditionally, Korean public transportation systems have relied heavily on conventional public transportation modes such as

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buses and subways. However, the competitiveness of these conventional public transportation modes has been reduced as Korean transportation policy has shifted to '*low-carbon green growth*' and '*sustainable development*' paradigms (Eom et al., 2009). To overcome the shortcomings of conventional transportation modes in the new paradigm, the introduction of advanced public transit modes (APTM) that deliver eco-friendly and cost efficient transport has become a critical issue in public transportation policy. When a new town is designed, the adoption of APTM should be seriously considered as part of the municipal public transportation system.

Advanced public transit modes are a broad category, including all types of public transportation beyond traditional modes like buses and subways. Conceptually, APTM ranges from incremental improvements in vehicle technology or operation techniques of existing modes to totally new concepts in public transportation modes (Sun and Park, 2009). Depending on the transport type, APTM can be divided into bus-type and railway-type modes (Luke and MacDonald, 2006). Bus rapid transit (BRT), one of the most well-known bus-type APTM, is an innovative bus system that uses dedicated bus lanes to improve passing speed and punctuality. Bus rapid transit has higher transport efficiency and better accessibility than conventional public transportation modes. The most representative railway-type APTM is light rail transit (LRT), which consists of a railway constructed at the same height as the road surface, allowing other vehicles to use the LRT tram rails as well. The main advantages of LRT include high reliability and ride quality, effective integration with new town developments, re-use of old tram lines, energy efficiency, and eco-friendliness. In addition to BRT and LRT, the Bimodal Tram mode is one of the most common APTM. Bimodal Tram (BT) is a dual mode of railway and bus, which can move in a tram-like manner on underground electro-magnetic laying track, but also on regular roads like a bus. Accordingly, BT can deliver the benefits of both bus and railway modes.

The characteristics of each type of APTM differ in terms of several important factors relevant to public transportation systems. These include necessary infrastructure, speed, transport capacity, and accessibility. For successful development planning of a new town, it is vital to select the optimal type of APTM for the unique needs and conditions of that municipality. It is also essential to adopt a systematic and effective evaluation framework to select the optimal choice among multiple promising APTM options.

Multiple-criteria decision analysis (MCDA) is increasingly used for decision-making in transport projects due to the complexity of the issues at stake and the inadequacies of conventional economic evaluation tools for public investment. These conventional tools, such as Cost Benefit Analysis (CBA) or Cost-Effectiveness Analysis (CEA), often fail to capture the full range of impacts of a transport policy or capital investment project (Browne and Ryan, 2011). The application of MCDA in the transport sector addresses various decision problems, such as mobility management, public transport, infrastructure decisions, and technology (Macharis and Bernardini, 2015).

Urban public transport decision-making is a suitable area for MCDA because multiple actors from both private and public sectors are involved in the design and operation of urban passenger transportation systems. Decision-making in public transit is thus a very complex task involving multiple economic, environmental, and socio-political issues (Perez et al., 2015). Recently, studies on urban public transport systems have begun to incorporate MCDA as a decision support tool for problems including development of criteria for evaluating projects (Yang, 2007; Jones et al., 2013; Barfod and Salling, 2015), evaluation of investment in transport system infrastructure (Ferrari, 2003; Caliskan, 2006; Tudela et al., 2006; Basbas and Papanikolaou, 2009; Schutte and Brits, 2012; Kumarage and Weerawardana, 2013), policies for decision-making in urban public passenger transport systems (Emberger et al., 2008; Arslan, 2009; Macharis et al., 2010; Hickman et al., 2012), choice of technologies or public transport modes (Yedla and Shrestha, 2003; Macharis et al., 2004; Li et al., 2011), and evaluation of service performance (Duleba et al., 2012; Hassan et al., 2013; Aydin et al., 2015; Aydin, 2017; Barbosa et al., 2017).

There is relatively little research applying MCDA to APTM-related problems. Multiple-criteria decision making has been used to address route or track selection for LRT, a characteristic problem facing APTMs (Gercek et al., 2004; Banai, 2006; Habtamu et al., 2013). Luke and MacDonald (2006) did address a similar problem to our work, namely the selection of a public transport mode among light rail and bus-based options. Their paper compared the advantages and disadvantages of both modes based on case studies in Europe, North America, and Australia and identified how particular modes were chosen. Although the theme is similar to our work, Luke and MacDonald (2006) applied a qualitative rather than a quantitative approach and did not harness the benefits of MCDA. Working within the urban districts of China and motivated by the urgent need to choose a public transport development mode as transit priorities are implemented, Hu and Guo (2014) examined the influence factors on public transit mode choice and established a new urban district public transit mode decision matrix. They considered four kinds of public transport modes including Normal Transit, Rapid Transit, LRT, and MRT and developed an evaluation index system comprised of three categories of influencing factors: transportation characteristics, urban area characteristics, and public transportation policy. Hu and Guo (2014) addressed the same problem as in our work and used a model based on the MCDA concept. However, the derivation of choice attributes and their scores was somewhat ad-hoc and not as rigorous as in a conventional and established MCDA approach, such as AHP.

The present study aimed to prioritize APTM in new towns of Korea using MCDA based on data gathered from transportation experts. In this study, the decision criteria for evaluating the competitiveness of each APTM were suggested, and a hierarchical structure for the decision-making process was systematically developed. Subsequently, relative weights of decision criteria were derived using MCDA, and the competitiveness of each APTM alternative was quantified in order to prioritize each mode for the type of city where the APTM will be introduced. We discuss the implications of our results for urban public transportation policy in Korea and present our conclusions.

The organization of this paper is as follows. The following section develops the hierarchical structure model of this study, with definitions of multiple decision criteria. In the third section, we present the results of the MCDA analysis prioritizing APTM for a new town. Subsequently, Section 4 discusses the implications of these results, and we present conclusions in the final section.