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Paired-line hybrid transit design considering spatial heterogeneity ☆

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ABSTRACT

This study attempts to incorporate spatial heterogeneity into the optimal design of paired-line hybrid transit systems, which aims to strike a better balance between accessibility and efficiency by leveraging the flexibility of a demand adaptive service. A simple trip production and distribution model is introduced to differentiate the central business district (CBD) of a city from its periphery. To cope with the heterogeneous demand pattern, the transit system is also configured differently inside and outside the CBD, for both its fixed route and demand adaptive services. Allowing the supply heterogeneity complicates transit users' route choice modeling considerably. As a result, user costs must be estimated separately for six subregions that constitute the feasible set of the fixed route headway. Each subregion corresponds to a unique route choice behavior, hence leading to a distinctive design model that is formulated as a mixed integer program and solved by a commercial solver. Results of numerical experiments show that concentrating demand in the CBD significantly reduces the average system cost, and this benefit increases as the average demand density becomes larger. Also, recognizing demand heterogeneity and responding to it with a tailored design can be highly beneficial. However, this benefit diminishes as the average demand density increases.

1. Introduction

Traffic congestion is a disruptive force in our daily life. It makes our travel on road longer, unhealthier (https://www.philstar.com/lifestyle/health-and-family/2015/09/16/1500827/science-says-traffic-congestion-can-kill-you), more dangerous (Quddus et al., 2009) and stressful (Hennessy and Wiesenthal, 1999), and less comfortable (Harriet et al., 2013). Traffic congestion also causes an excessive drain on the resources worldwide, wasting more than $150 billion a year in the U.S. alone (Schrank et al., 2015). Of the many solutions proposed to tackle the congestion problem, developing an efficient and convenient mass transport system as an alternative to driving is widely embraced (Ceder, 2007). Traditional transit services running on fixed routes and schedules, however, do not always offer a viable alternative to driving. They tend to thrive where the population density is sufficiently high to justify the provision of a dense network running on short headways. Operating such services efficiently in large metropolitan areas is always a challenge, unless the urban sprawl is

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