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Subway Ridership Estimation at a Station-Level: Focus on the Impact of Bus Demand, Commercial Business Characteristics and Network Topology

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Abstract : The primary purpose of this study is to develop a methodological framework to predict daily subway ridership at a station-level and to examine the association between subway ridership and bus demand incorporating commercial business facility in the vicinity of each subway station. The socio-economic characteristics, land-use, and built environment as factors may have an impact on subway ridership. However, it should be considered not only the endogenous relationship between bus and subway demand but also the characteristics of commercial business within a subway station's sphere of influence, and integrated transit network topology. Regarding a statistical approach to estimate subway ridership at a station level, therefore it should be considered endogeneity and heteroscedastic issues which might have in the subway ridership prediction model. This study focused on both discovering the impacts of bus demand, commercial business characteristics, and network topology on subway ridership and developing more precise subway ridership estimation accounting for its statistical bias. The spatial scope of the study covers entire Seoul city in South Korea and includes 243 stations with the temporal scope set at twenty-four hours with one-hour interval time panels each. The data for subway and bus ridership was collected Seoul Smart Card data from 2015 and 2016. Three-Stage Least Square(3SLS) approach was applied to develop daily subway ridership model as capturing the endogeneity and heteroscedasticity between bus and subway demand. Independent variables incorporating in the modeling process were commercial business characteristics, social-economic characteristics, safety index, transit facility attributes, and dummies for seasons and time zone. As a result, it was found that bus ridership and subway ridership were endogenous each other and they had a significantly positive sign of coefficients which means one transit mode could increase another transportation mode's ridership. In other words, two transit modes of subway and bus have a mutual relationship instead of the competitive relationship. The commercial business characteristics are the most critical dimension among the independent variables. The variables of commercial business facility rate in the paper containing six types; medical, educational, recreational, financial, food service, and shopping. From the model result, a higher rate in medical, financial buildings, shopping, and food service facility lead to increment of subway ridership at a station, while recreational and educational facility shows lower subway ridership. The complex network theory was applied for estimating integrated network topology measures that cover the entire Seoul transit network system, and a framework for seeking an impact on subway ridership. The centrality measures were found to be significant and showed a positive sign indicating higher centrality led to more subway ridership at a station level. The results of model accuracy tests by out of samples provided that 3SLS model has less mean square error rather than OLS and showed the methodological approach for the 3SLS model was plausible to estimate more accurate subway ridership. Acknowledgement: This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Science and ICT (2017R1C1B2010175).
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