



# Perceived accessibility, mobility, and connectivity of public transportation systems



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## ARTICLE INFO

### Article history:

Received 11 September 2014  
Received in revised form 28 April 2015  
Accepted 4 May 2015  
Available online 27 May 2015

### Keywords:

Public transportation  
Accessibility  
Mobility  
Seamless connectivity  
Multidimensional Rasch model

## ABSTRACT

Although public transportation is considered effective at reducing the external cost of driving private vehicles, many urbanites do not use public transportation. This study develops measures employing accessibility, mobility, and seamless connectivity for an entire public transportation service chain as indicators for evaluating public transport services, prioritizes underperforming scenarios from the perspective of urban travelers, and derives various market segmentation strategies that consider different socio-demographic characteristics. A conceptual model is set up herein to assess these latent constructs that describe unobservable and immeasurable characteristics. As a Likert ordinal scale can generate misleading statistical inferences, the Rasch model is used to eliminate bias generated by an ordinal scale when measuring these three latent constructs separately. The Rasch model compares person parameters with item parameters, which are then subjected to logarithmic transformation along a logit scale so as to recognize specific difficulties of service scenarios that cannot be easily eliminated by certain urban travelers. The multidimensional Rasch model also measures the perceptions of urban travelers in terms of the interactions between accessibility, mobility, and seamless connectivity of this public transportation system. While comparing urban travelers of two large cities in Taiwan, Taipei and Kaohsiung, the empirical results demonstrate that perceived accessibility, mobility, and seamless connectivity differ based on travelers' age, frequency of weekly sports activities, and environmental awareness. This paper also advances appropriate improvement strategies and provides policy suggestions for urban planners, public transportation service operation agencies, and policy makers when they seek to create user-friendly public transportation services. The proposed approach can be generalized in other cities by considering their local context uniqueness and further evaluating their public transport services.

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## 1. Introduction

Sustainable transportation systems should move people and goods and help promote social inclusion and balanced urban development (Gudmundsson, 2004; Elias and Shiftan, 2012; Miranda and Rodrigues da Silva, 2012). As public transportation is regarded as a solution to problems related to difficult mobility in cities, a user-friendly public transportation system should consider the accessibility to public transportation stations, the mobility of the public transportation system, and

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seamless connectivity with various other transportation systems (e.g., railways, metros, local light rail transit, and buses) (Mishra et al., 2012). Although public transportation is an effective means for promoting transportation sustainability, many urban travelers do not use it (Gabrielli et al., 2014), as inappropriate planning in terms of accessibility, public transport mobility, and seamless connectivity can reduce ridership and increase the dependence of urban travelers on private vehicles (Welch and Mishra, 2013).

Accessibility can be measured by the distance between households and public transport stops or by the length of a journey from one's house to work via public transportation (Handy and Niemeier, 1997; Weber, 2003), yet research on accessibility of public transportation is limited (Mavoa et al., 2012; Martin et al., 2002). Captive riders, including youth and the elderly, need a reasonable level of accessibility to reach their destinations (Martin et al., 2008). Urban travelers are also concerned with the mobility of public transportation services, whereby mobility is defined as the ability to travel. The most common method of measuring mobility is to evaluate the frequency of a service at a particular node (Sanchez et al., 2004). Although intermodal transfers are often necessary (Vuchic, 2006), inconvenient transfers can reduce user satisfaction, discourage potential riders, and diminish a system's competitiveness (Wardman et al., 2001). Seamless connectivity helps expand performance to meet the demands of multimodal transportation systems (Hadas and Ranjitkar, 2012). Although connectivity measures are often studied, their application to public transportation is rare (Mishra et al., 2012).

Previous studies measuring accessibility, mobility, and connectivity focused mainly on Geographic Information System (GIS)-based public transit networks (O'Sullivan et al., 2000; Tribby and Zandbergen, 2012; Mavoa et al., 2012). Comprehensive measurement indicators have been rarely developed in the literature to assess accessibility, mobility, and connectivity of an entire public transportation service chain from the perspective of urban travelers. This paper's proposed measurement approach is a tool that urban planners and policy makers can deploy to evaluate the perceptions of urban travelers regarding accessibility, mobility, and connectivity so as to prioritize underperforming scenarios. This study also considers the heterogeneity of passenger behavior.

The work contributes to the literature by measuring the latent traits of urban travelers, including their perception of accessibility, mobility, and connectivity, and using the Rasch method, a psychometric approach, to avoid bias generated by an ordinal scale via a logistic linear transformation. The Rasch model is advantageous in its capacity to compare person parameters with item parameters, which can then be subjected to a logarithmic transformation along a logit scale to clearly identify difficulties in service scenarios that cannot be overcome easily by certain urban travelers. This study also looks at the effects of differences in the socio-economic characteristics of urban travelers on their perceptions of accessibility, mobility, and connectivity. An effective strategy is then derived to alleviate the perceived travel difficulties for segmented urban travelers. Analytical results by the Rasch model generate several managerial implications and serve as reference for transportation agencies, urban planners, and policy makers who seek to improve public transportation services by addressing the needs of various groups of passengers.

This study has six sections. The introduction identifies key research issues. Section 2 characterizes the two public transportation systems in metropolitan Taipei and Kaohsiung. Section 3 elucidates the conceptual model for measuring accessibility, mobility, and connectivity as perceived by urban travelers. Section 4 describes the Rasch model and its application for measuring perceived accessibility, mobility, and connectivity. Section 5 describes the procedure for data collection and Rasch analytical results. Section 6 presents research findings, policy implications, conclusions, and recommendations for future research.

## 2. Public transportation services in Taipei and Kaohsiung

Taipei, Taiwan's capital city, is the country's economic and political center and is located in the north of the island. The city has experienced rapid growth in both population and number of vehicles, generating countless traffic congestion issues. Taipei's city government has implemented several transportation policies aimed at slowing increases in the number of private vehicles and to improve the percentage of people using transportation. The Taipei metro currently has 11 lines and a ridership of 1.9 million passengers daily. Moreover, Taipei buses serve 385 lines and 1.8 million passengers daily.

Taipei's city government has established the Public Bike Sharing System (PBSS) and has created a network of urban bike lanes with bike station services to encourage residents to take advantage of PBSS for short distances and to reduce the use of and to replace personal motor vehicles, resulting in reductions in traffic congestion and environmental pollution. This bike system offers a 24-h unmanned automated kiosk system service. Taipei's PBSS is called YouBike, and the city government has delegated its service operations to Giant, which is Taiwan's number one global bicycle manufacturer. Passengers can take a bicycle from a station and return it to any station. Although Taipei has 1.8 million daily bus riders and 1.9 million daily metro riders, only 2775 daily urban travelers used PBSS in 2012.

Kaohsiung, Taiwan's second largest city, is located in southwest Taiwan and is the only other city with a metro system, yet the percentage of private cars and motorcycles there is higher than in Taipei. Consequently, its city government is also promoting the use of public transportation. Currently, the Kaohsiung metro has two MRT lines serving 160,000 passengers every day. To improve usage rates for public transportation (9.59%), the city government has favored a light-rail system. Construction of the north-south and east-west loop networks with light-rail transit lines around the perimeter is predicted to increase overall performance of the public transportation system. Kaohsiung also launched free bus services in 2014. Various public transportation services are increasingly being offered to enhance ridership.

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