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Exploring built environment correlates of walking distance of transit egress in the Twin Cities

Jueyu Wang[a,*], Xinyu Cao[b]

[a] Humphrey School of Public Affairs, University of Minnesota, Twin Cities., 301 19th Ave S, Minneapolis, MN 55455, United States
[b] Humphrey School of Public Affairs, University of Minnesota, Twin Cities., 301 19th Ave S, Minneapolis, MN 55455, United States

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ABSTRACT

Most studies on walking distance to transit stops either emphasize transit access or do not distinguish transit access and egress. Furthermore, environmental correlates of walking distance may differ by stop location. Using the 2010 Transit Onboard Survey in the Minneapolis and St. Paul Metropolitan Area, this study develops four models to compare the effects of the built environment around transit stops on walking distance of transit egress. Job density is negatively correlated with walking distance, consistent in all four models. Other built environment variables exhibit different impacts by stop location. Particularly, land use mix has positive impacts on walking distance for stops outside of downtown and suburban employment centers whereas job density is more important for suburban centers. Job accessibility and the number of intersections have significant effects on stops within downtown areas but have no significant impacts on stops outside of downtown areas. The number of transit stops has opposite impacts on walking distance for stops within and outside of downtown. Moreover, the built environment tends to have a larger impact on walking distance in downtown areas than non-downtown areas. We then discuss the implications for stop area land use planning and transit stop location choice.

1. Introduction

Public transportation plays an important role in providing access to diverse opportunities, activities, and services. It can also help reduce the growth of traffic congestion and improve air quality. To enjoy these benefits, it is important to enhance transit accessibility and encourage transit use. As a key access/egress mode, walking distance to/from transit stops/stations (called stops for simplicity) greatly influences individuals' use of transit services (Loutzenheiser, 1997; Zhao et al., 2003). The more close people live and/or work to transit stops, the more likely transit services are used (Murray et al., 1998). Furthermore, walking distance to transit stops is often used to define stop catchment areas, which are fundamental for evaluating land use impacts of transit infrastructure and designing policies for transit-oriented development (TOD). This study aims to offer researchers, transit planners, and policymakers a better understanding of built environment characteristics affecting walking distance of transit users at their destination-ends, and provide implications for stop area land use planning and the siting of transit stops.

A full transit trip consists of at least three segments: an access segment from origins to transit stops, an in-vehicle segment, and an egress segment from transit stops to final destinations. This study explores built environment correlates of walking distance of the egress segments between transit stops and non-home destinations. Using the 2010 Transit Onboard Survey in the Minneapolis-St. Paul Metropolitan area (Twin Cities), it aims to answer the following two questions: 1) how does the built environment around transit stops affect walking distance of transit egress? 2) Do these impacts differ between stops within and outside of downtown areas?

The paper extends the research on walking distance of transit users in two ways. First, previous studies on walking distance to/from transit stops either focus on the access from home to transit stops and overlook the egress from stops to destinations, or do not distinguish them in data analysis. Planning implications can be different between origin stops and destination stops. This study specifically examines transit egress at the non-home ends. Second, this study differentiates the impacts of built environment characteristics on walking distance to stops within and outside of downtown areas, which carries different policy implications for traditional downtown-oriented transit systems and multi-destination transit systems. Taken together, we aim to offer planning implications from the following two aspects. First, from the perspective of stop area planning, we want to identify built environment characteristics that are positively associated with the observed walking distance of transit users. This will inform land use planners how to

* Corresponding author.
E-mail addresses: wang5931@umn.edu (J. Wang), cao@umn.edu (X. Cao).

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encourage transit riders to walk longer. Second, from the perspective of stop location choice, we want to identify built environment characteristics that tend to shorten riders' walking distance. Accordingly, transit planners could locate transit stops in the places with these built environment attributes. Thus, stop area planning should encourage riders walking longer while stop location choice should minimize riders' walking distance.

This paper is organized as follows. The next section reviews the literature on walking behavior associated with transit trips. Section 3 describes study area, the data and methodology. Section 4 presents modeling results. The last section summarizes key findings and discusses policy implications.

2. Literature review

Previous studies have explored pedestrian access to transit stops extensively because walking is a primary access/egress mode of transit (e.g. Hsiao et al., 1997). Many studies investigated the correlates of the propensity of walking to transit stops. Demographic characteristics of transit users (such as gender, ethnicity, age, income, having a driver's license, and so on) affect walking mode choice (Loutzenheiser, 1997; Kim et al., 2007). From a planning perspective, access mode choice of transit users is influenced by stop-area built environment characteristics, including distance to transit stops (e.g. Chalermpong and Wibowo, 2007), employment and residential density (Loutzenheiser, 1997; Cervero, 2001), land use mix (Cervero, 2001), parking availability (Loutzenheiser, 1997; Cervero, 2001), sidewalk and street network (Maghelal, 2011), and pedestrian path characteristics such as the numbers of ascending steps, road crossings, and traffic conflicts (Olszewski and Wibowo, 2005). Furthermore, when transit users choose walking routes, they often prioritize walking time or distance to transit stops, as well as safety (Weinstein Agrawal et al., 2008).

Transit planners generally define transit catchment areas as a quarter-mile (400 m) for bus stops and half a mile (800 m) for rail stations (Hsiao et al., 1997; Zhao et al., 2003; Gutiérrez and García-Palomares, 2008). The catchment areas are often used for ridership prediction and economic impact assessment. A number of empirical studies have questioned the accuracy and appropriateness of these "rules of thumb" and incorporated various factors to explain the variation of walking distance to transit stops. They found that walking distance to transit stops is influenced by transit attributes, trip characteristics and demographics of transit users. For example, walking distance is positively associated with transit services with high frequency and short waiting time (O'Sullivan and Morrall, 1996; Alshalalfah and Shalaby, 2007). The number of transfers has a negative association with walking distance whereas total trip length is positively associated with walking distance (El-Geneidy et al., 2014). Transit users' demographic characteristics, such as gender, age, income, and the number of vehicles, are also important determinants of walking distance (Loutzenheiser, 1997; García-Palomares et al., 2013; El-Geneidy et al., 2014; Chia et al., 2016).

Some studies have examined the impacts of built environment characteristics around transit stops on walking distance because they are crucial for walking distance and transit use (Weinstein Agrawal et al., 2008). O'Sullivan and Morrall (1996) found that although the average walking distance to LRT stations in suburban areas of Calgary is 444 m, users of a suburban LRT station with a pedestrian-friendly environment walk 1.1 km to the station on average. Furthermore, walking distance is found to be positively associated with population density (El-Geneidy et al., 2014; Jiang et al., 2012), intersection density (El-Geneidy et al., 2014), and sidewalk density (Maghelal, 2011). Jiang et al. (2012) concluded that transit users walk longer to BRT stations in Jinan, China, when the route environment is highly walkable. Overall, these studies have shown the impacts of built environment attributes on walking distance of transit access from home to transit stops and offered important implications for stop area planning.

However, few studies have focused on transit egress from transit stops to final destinations and built environment correlates of transit egress. Egress travel of transit users at the destination-ends is very important for a transit trip. Given the hypothesis of travel time budget, egress travel distance/time to destinations plays an important role in determining the choice of transit (Loutzenheiser, 1997). Moreover, transit users often have multiple choices to access transit stops at the home-ends; they can park & ride, kiss & ride, bike, or walk to transit stops. However, at the destination-ends, walking is the only choice for most transit users. Therefore, any walking barriers for transit egress may deter transit users from taking transit. Understanding built environment correlates of transit egress is critical for the siting of transit stops and stop area planning at the destinations. Among few studies on transit egress, Townsend and Zacharias (2010) showed that the destination type, a proxy for land use and activity, is the only variable significantly correlated with walking distance of transit egress. After studying subway commuters' egress in Downtown Boston, Guo (2009) concluded that improved path environment increases the utility of walking and possibly increases transit riders' willingness to walk longer.

Walking distance to transit stops differs between downtown and non-downtown areas. O'Sullivan and Morrall (1996) found that the walking distance to CBD LRT stations is much shorter than that to suburban LRT stations. Presumably, built environment attributes in downtown and non-downtown areas contribute to the difference in walking distance. For example, destinations tend to be closer in downtown areas and hence walking distance is generally shorter. Alshalalfah and Shalaby (2007) also found that the dense transit network in Downtown Toronto, Canada, makes walking distance of access shorter, compared to other areas of the city. Furthermore, many metropolitan areas have experienced job suburbanization and multiple employment centers have emerged in suburban areas. Accordingly, transit planners are interested in the following two questions: How far do transit users walk from transit stops to non-downtown destinations, particularly destinations located within suburban employment centers? What factors influence the walking distance? These questions call for an investigation of the correlates of walking distance by differentiating stops within and outside of downtown areas. The answers also have implications for transit planning of grid transit systems. Traditional radial-line transit systems are oriented to serve the CBD, which is often characterized as pedestrian-friendly areas with high density, mixed land use, good sidewalks, and so on. However, some metropolitan areas (such as Phoenix and Las Vegas) without a strong CBD deploy a grid transit system to serve a dispersed array of travel destinations (Brown and Thompson, 2008), which vary greatly in pedestrian environments.

The study fills the two gaps in the literature and extends the stream of these studies by examining how built environment characteristics around destination-end transit stops influence walking distance of transit egress and comparing the influences between stops in downtown areas, and non-downtown areas.

3. Data and methdology

3.1. Study area

The Minneapolis-St. Paul (Twin Cities) metropolitan area consists of seven counties. The area includes two central cities, Minneapolis, the economic center, and Saint Paul, the political center. When defining downtown Minneapolis and Saint Paul, we used 20 jobs per acre as the minimum threshold to select continuous blocks. The suburban employment centers are defined using the criteria of 10,000 jobs as the minimum threshold of total number of jobs and seven jobs/acre as the minimum threshold of job density (Fig. 1).

3.2. Data and variables

This study used the 2010 Transit Onboard Survey administered by