Cities 60 (2017) 124–138

Contents lists available at ScienceDirect

Cities

journal homepage: www.elsevier.com/locate/cities

The City is flatter: Changing patterns of job and labor access

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ARTICLE INFO

Article history:
Received 13 March 2016
Received in revised form 18 July 2016
Accepted 1 August 2016
Available online xxxx

Keywords:
Accessibility
Land use
Travel time
Travel behavior
Minneapolis
St. Paul

ABSTRACT

This study measures accessibility by automobile for the Minneapolis - Saint Paul (Twin Cities) region from 1995 to 2005. In contrast to most previous analyses of accessibility, this study uses travel time estimates derived, to the extent possible, from actual observations of network performance by time of day. A set of cumulative opportunity measures are computed with transport analysis zones (TAZs) as the unit of analysis for 1995 and 2005. Analysis of the changes in accessibility by location over the period of study reveals that, for the majority of locations in the region, accessibility increased over this period, though the increases were not uniform. A "flattening" or convergence of levels of accessibility across locations was observed over time, with faster-growing suburban locations gaining the most in terms of employment accessibility. An effort to decompose the causes of changes in accessibility into components related to transport network structure and land use (opportunity location) reveals that both causes make a contribution to increasing accessibility, though the effects of changes to the transportation network tend to be more location-specific. Overall, the results of the study demonstrate the feasibility and relevance of using accessibility as a key performance measure to describe the regional transport system.

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1. Introduction

The coevolution of transport and land use has been established historically in a variety of contexts (Levinson, 2008; Xie & Levinson, 2009b; Kasraian et al., 2016). But coevolution is not just an historical phenomenon, it is something we see everyday as households and firms relocate to improve their condition in a changing economic landscape, and as transport providers restructure and extend transport networks to better serve their customers. Locators select metropolitan regions to be near activities, things, organizations, and people that are important to them, and they select locations within metropolitan areas for similar reasons, trading off benefits and costs of those locations.

In cities, firms aim to achieve economies of agglomeration and improve productivity and output by locating near customers (other firms and/or households depending on the nature of the firm), suppliers (including their labor force), and even competitors – creating a centripetal force in cities, while trying to reduce costs of land and congestion (which is a centrifugal force). Households aim to achieve proximity to their work, shops, and other activities and amenities (also a centripetal force) while simultaneously obtaining more house and lot for the money, producing a centrifugal force on urban regions. This tension between centripetal and centrifugal forces keeps the city from achieving either a maximal density (all activities on a single point) or a minimal density (all activities spread out evenly across space). However the balance between these two forces changes over time with exogenous changes in other technologies (e.g. vehicles, communication, finance), demographics (e.g. the relative demand for living space varies by lifecycle), socio-economics (e.g. the income or wealth of consumers), and other preferences (e.g. willingness to commute, time scarcity).

The concept of accessibility allows us to measure the efficiency of the city in its primary role, enabling people to reach other people, places, and things. Accessibility is by definition a very complex matter, which also, for example, includes individual capabilities, needs, and wishes, as well as competition. The concept has been well-described in the literature (Handy & Niemeier, 1997; Kwan & Weber, 2003; Geurs & Van Wee, 2004; Scott & Horner, 2008; Ottensmann & Lindsey, 2008; van Wee & Geurs, 2016), and is applied here in a new empirical context.

Accessibility as used here is a concept of potential associated with places, not realized or actual travel conducted by individual persons at a given time. While the two are correlated, the relationship is far from perfect (Niedzielski & Boschmann, 2014). Some European literature discusses the concept of territorial cohesion, which may be formulated as a normative accessibility goal aiming to ensure "citizens have equal access to facilities services and knowledge" (Mirwaldt et al., 2009). We treat accessibility here as a positive rather than a normative concept, we are simply trying to measure the change in opportunities, without passing value judgment or establishing standards (Páez et al., 2012).

This study *measures* access to jobs and to labor by automobile. It thus differs from previous research in one important aspect, we use measured rather than modeled accessibility. This means the inputs to the maps presented here are the results of direct measurements of travel times and delay (supplemented by carefully calibrated direct travel time models

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http://dx.doi.org/10.1016/j.cities.2016.08.002
0264-2751/Published by Elsevier Ltd.

where flows are available and speeds are not) rather than the outputs of a regional transportation planning/forecasting model or based on assumptions of travel speeds based on road classification.

This study further examines the change in the makeup of accessibility in the Minneapolis-Saint Paul, Minnesota (Twin Cities) metropolitan area between 1995 and 2005 and tests whether, playing off the title of Thomas Friedman's book *The World is Flat* (Friedman, 2007), *The City is Flatter* than it used to be. Other studies have looked at the evolution of US cities, e.g. (Giuliano et al., 2007) illustrates the emergence of regional subcenters in the Los Angeles area, and (Giuliano et al., 2012) shows that growth depends on accessibility. In contrast, (Helling, 1998) found declining accessibility in Atlanta through the 1980s.

Minneapolis and Saint Paul arose like many cities in the late 19th and early 20th centuries around the streetcar (Xie & Levinson, 2009a), but ultimately adopted the automobile highway system as the primary means of transport (Iacono & Levinson, 2009). This study focuses on auto accessibility, as automobile is the dominant mode of travel for longer trips. Other studies by the authors examine transit accessibility in the region (Owen & Levinson, 2015), and related studies look at access to non-work destinations (Iacono et al., 2010).

The period between 1995 and 2005 saw a number of changes in the Twin Cities. Population and employment rose on the order of 1% annually, the economy went through one recession associated with the Dot Com bubble, decline in the stock market, and 9/11, and toward the end of the period fuel prices began their rise (ultimately peaking (to date) in 2008). However this is also a period of relative stability in the transport network. The Twin Cities Interstate system was essentially complete in 1994, and though roads have widened some and new non-freeway links built, these have been relatively minor. There was a relatively sharp increase in traffic in the first part of this period, before a leveling off in the later years. Between 1995 and 2005 we see a larger increase in growth in both jobs and workers in the suburbs than the central cities of Minneapolis and St. Paul. This notion of the flattening of the city has been measured in various ways, including e.g. land value (Heikkila et al., 1989), travel times (Gordon et al., 1989; Levinson & Kumar, 1994), and analysis of subcenters (McMillen & McDonald, 1998).

The next section describes methodology on accessibility. This is followed by the data used in this study for both land use and travel times. A travel time matrix is developed and applied to determine the cumulative number of jobs or workers accessible in a given time band. The results highlight maps and numeric analyses underlying those maps. We focus on trends from a series of maps within fewer time bands to examine shifts in accessibility more deeply. Specifically, we will look at key commute times including 15, 20, 25, and 30 min commute-time thresholds. Later, we will narrow the focus to accessibility in years 1995 and 2005 at the 20 min commute in an attempt to disentangle those aspects of accessibility associated with different accessibility impacts that may be attributed to land use changes or with changes in the transport system. The paper concludes with implications for policy and the potential for future research in this arena.

2. Methodology

Taken by itself, the travel time matrix measures *mobility*. The information it contains, along with the network topology, is enough to determine the speed at which network users can travel from any zone to any other. However, transport is often described as a derived demand, which means that mobility is not an end in itself, but is necessary due to the spatial separation of other activities or objectives (Wachs & Kumagai, 1973). As long as travel is occurring for reasons other than pleasure, the proximity of demanded destinations must be considered along with mobility in order to evaluate the benefits of network performance to the user. In short, the possibility of high-speed travel is of limited use if the distance between origins and destinations is great. Weighting *mobility* by the number of opportunities it presents to arrive at *accessibility* can help direct investment in network improvements not merely toward where speed will be increased the most, but to where the increased speed will provide the greatest improvement in terms of access to desired destinations. Where mobility improvements respond to a derived demand, increased accessibility addresses a more basic need.

Accessibility can be thought of as the potential opportunity for interaction (Hansen, 1959). In this analysis, cumulative opportunity measures are calculated as total numbers of jobs, residents and workers reachable from each point in a given time period. This measure was chosen because it is spatially continuous and suitable for creating maps to compare changes in accessibility across the region. Maps showing extents of equal accessibility can also be created, similar to topographic contour maps showing lines of equal elevation. Alternative measures could be either gravity- or utility-based. Gravity measures introduce an additional complication in that an appropriate function of distance must be chosen. Utility is a difficult concept to quantify, because individual residents place widely varying value on access to different things.

The Hansen accessibility measure is traditionally defined as:

$$A_i = \sum_{j=1}^{n} O_j f(C_{ij})$$

where:

A_i = accessibility from a zone (i) to the considered type of opportunities (j)
O_j = opportunities of the considered type in zone j (e.g., employment, shopping, etc.)
C_{ij} = generalized (or real) time or cost from i to j
$f(C_{ij})$ = Impedance function (exponential or power functions are most often used).

The specific weighting function $f(C_{ij})$ used has a strong impact on the resulting accessibility values, and the best-performing functions and parameters are generally estimated independently in each study or study area (Ingram, 1971). This makes comparisons between modes, times, and study areas challenging. (Levine et al., 2012) discuss these challenges in depth during an inter-metropolitan comparison of accessibility; they find it necessary to estimate weighting parameters separately for each metropolitan area and then implement a second model to estimate a single shared parameter from the populations of each. (Geurs & Van Wee, 2004) also note the increased complexity introduced by the cost weighting parameter.

Perhaps the most straightforward approach to expressing accessibility is discussed by (Ingram, 1971) as well as (Morris et al., 1979). *Cumulative opportunity* measures of accessibility employ a binary weighting function, which defines $f(C_{ij}) = 1$ if $C_{ij} < T$ and 0 otherwise, where T is a selected travel time threshold. Accessibility is calculated for specific time thresholds and the result is a simple count of destinations that are reachable within each threshold. Both calculation and interpretation of the accessibility measure are dramatically simplified, which (El-Geneidy & Levinson, 2006) note is of particular benefit when accessibility metrics are used in a planning context. Also, accessibility based on cumulative opportunities is directly comparable across space. Because the cumulative opportunities measure is a simple count of destinations reachable in a given travel time threshold, its value corresponds directly to the numer of destinations. Comparisons based on weighted opportunities measures of accessibility are less intuitive. A weighted opportunities measure is based on

Table 1
Regional totals of cumulative opportunity measures in each analysis year.

Year	Population	Employment	Labor
1995	2,465,389	1,449,268	1,199,732
2000	2,642,056	1,603,295	1,422,079
2005	2,663,303	1,554,369	1,408,238