Locationally Disaggregated Accessibility: Analyzing the Impact of Work Locations on Relative Accessibility Gains and Losses (#18-05150)

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1. Abstract

Accessibility is well studied in the literature capturing multiple locations, personal activity patterns and constraints. However, the contribution of accessibility realized relative to various locations in people's daily activity patterns is typically hidden focusing on the presentation of overall accessibility results. Knowing how much a places' accessibility contributes to a person's overall accessibility is important in light of social exclusion and equity concerns. The general question then becomes: what are the impacts of various locations on one's overall accessibility? This paper investigates the impact of various spatial anchor locations on accessibility and presents an empirical analysis of "place-based" locationally disaggregated accessibility. The goal is to explore variation by income groups of how home and work locations impact accessibility to non-work opportunities. Our empirical analysis uses 2014 data for the Minneapolis - St. Paul metropolitan area and compares home-based and work-based accessibility to explore the impact of work locations on the relative gains and losses in accessibility of different worker income groups.

2. Project background and overview

Measuring accessibility around multiple locations is important to understanding how the workplace and other locations influence people's accessibility experience and may mitigate or aggravate poor accessibility and thus social exclusion around home (1). Conventional indicators, such as cumulative opportunity or gravity-based models, are static because they typically compute accessibility around the home only focusing on a single trip such as to work, shopping or healthcare. Conversely, activity-based indicators, such as endogenous or exogenous activity-based models (2), are dynamic because they consider how people's daily mobility patterns between multiple mandatory activity locations (i.e. spatial anchors) shape their space-time feasibility of participating in other discretionary activities at dispersed locations. While activity-based indicators do consider multiple spatial anchors, they generally present an overall picture of accessibility mapped to the home location and thus miss the contribution of accessibility around each spatial anchor to overall or aggregate accessibility. While research has shown that accessibility varies by income, gender or other groups (3), there is no systematic analysis of how it varies for these groups by spatial anchor, or more generally, what may be thought of as a locationally disaggregate accessibility analysis. What has been shown is how space-time constraints affect gender differences in accessibility, demand for service, and supermarket accessibility.

Recent research has started to explore the impact of work locations on people experiencing social interaction, segregation and shopping accessibility. Home and work locations are used as the basis for measuring social interaction potential (SIP) allowing the decomposition of the regional or aggregate SIP indicator into localized specific residential and employment metrics (4). Maps show different patterns of SIP for home and work locations and that workers attain higher SIP at work than at home. In another example, segregation between whites and blacks using a SIP-based indicator is mapped to home and work locations (5). Their results show little difference between home-based and work-based segregation patterns, except for the latter's higher concentration around the downtown core and inner suburbs. A SIP-based indicator is also used to analyze supermarket accessibility (6). A ratio between a combined home- and work-based indicator and a home only indicator shows that more locations experience an improvement in supermarket accessibility when traveling by public transit than by automobile.

Past work has started to look at differences between home and work locations in terms of various socio-economic indicators. Only two studies have studied these differences in relation to accessibility, with both exclusively focusing on supermarkets. How locationally disaggregated accessibility varies for other non-work activities in general is unknown. No prior work systematically compares and contrasts home-based, work-based, and combined home and work accessibility. Moreover, none account for the local land-use mix, which is important because some people may choose to live in areas with little potential for social interaction or activity accessibility to enjoy safer and less trafficked areas. In this study, we advance the idea of locationally disaggregate accessibility. We calculate accessibility to a combination of 15 non-work activities around both home and work locations connected by people's commuting patterns. We then compare home-based and work-based accessibility for three income groups.

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3. Methods

a. Average zonal 20-minute population subgroup weighted share of metropolitan accessibility to non-work activities, A_{it}:

$$A_{it} = \frac{\sum_{j=1}^{n} O_j \times f(C_{ij})}{\sum_{j=1}^{n} O_j} \times \frac{P_{it}}{\sum_{i=1}^{n} P_i} = \frac{\sum_{j=1}^{n} O_j \times f(C_{ij}) \times P_{it}}{\sum_{j=1}^{n} O_j \times \sum_{i=1}^{n} P_{it}}$$

$$i = index\ of\ zones$$

$$t = index\ of\ population\ subgroups$$

$$j = index\ of\ activities$$

$$O_j = number\ of\ non-work\ activities$$

$$P_{it} = number\ of\ workers\ in\ zone\ i$$

$$f(C_{ij}) = \begin{cases} 1\ if\ C_{ij} \leq 20\ min \\ 0\ if\ C_{ij} > 20\ min \end{cases}$$

b. Ratio of zonal home-based to zonal work-based accessibility, AR_{it}:

$$AR_{it} = \frac{A_{it}^{H}}{A_{it}^{W}}$$

c. Locationally disaggregated accessibility gain or loss:
General:
if AR_{it} > 1 then worker has better access at home than at work
if AR_{it} = 1 then worker has the same access at home and at work
if AR_{it} < 1 then worker has better access at work than at home

Better access at home than at work:
if AR_{it} > 1 and < 2 then home access is 1-2 times better than at work
if AR_{it} ≥ 2 and < 4 then home access is 2-4 times better than at work
if AR_{it} ≥ 4 and < 10 then home access is 4-10 times better than at work
if AR_{it} ≥ 10 then home access is 10+ times better than at work

Better access at work than at home:
if AR_{it} > 0.5 and < 1 then work access is 1-2 times better than at home
if AR_{it} > 0.25 and ≤ 0.5 then work access is 2-4 times better than at home
if AR_{it} > 0.1 and ≤ 0.25 then work access is 4-10 times better than at home
if AR_{it} ≤ 0.1 then work access is 10+ times better than at home

4. Study area and data

Study area

The analysis is performed on commuting flows in the Minneapolis – St. Paul, Minnesota USA metropolitan area. The metro area is divided into 2314 traffic analysis zones and consists of 1,632,878 workers:

- Low income (< $1,250 per month): 372,868
- Medium income ($1,251-$3,332 per month): 444,089
- High income (> $3,333 per month): 815,921

Data

- Worker locations and commuting flows from U.S. Census Longitudinal Employer-Household Dynamics (LEHD)
- Non-work activities from Dun&Bradstreet business location dataset: banks, childcare facilities, convenience stores, dance and physical fitness, hospitals, libraries, medical clinics, religious organizations, restaurants, schools, automobile related services, personal grooming services, apparel shopping, appliances and other home shopping, and supermarkets
- Network free flow travel times used to calculate accessibility

5. Results

What is the share of each income group that has better or worse accessibility at work than at home?

Locationally specific accessibility relationship	% of Low Income	% of Medium Income	% of High Income
Work > Home	55.99%	58.28%	64.18%
Home = Work	2.48%	1.68%	0.87%
Home > Work	41.53%	40.04%	34.96%

5. Results

What is the share of each income group that has better or worse accessibility at work than at home by different factors?

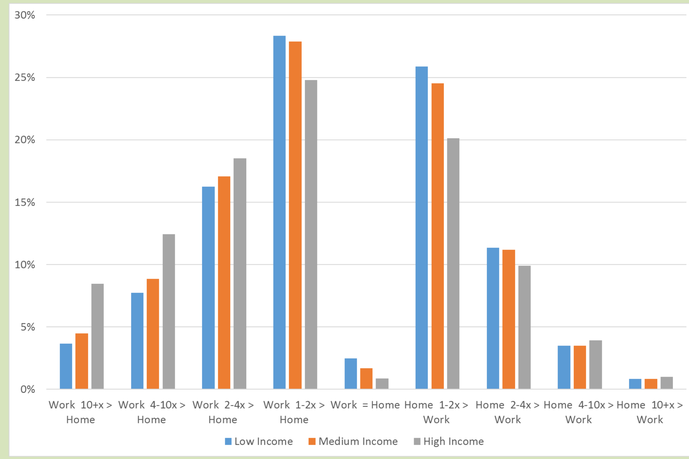

Figure 1. Share of population subgroup by factor of accessibility gain or loss

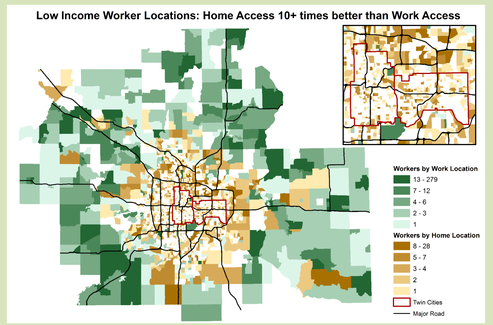

Figure 2. Home and work locations of low income workers whose home-based accessibility is 10x better than their work-based accessibility

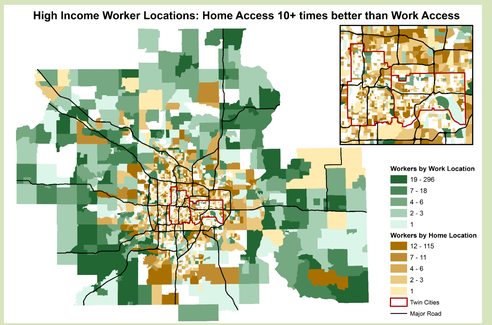

Figure 3. Home and work locations of high income workers whose home-based accessibility is 10x better than their work-based accessibility

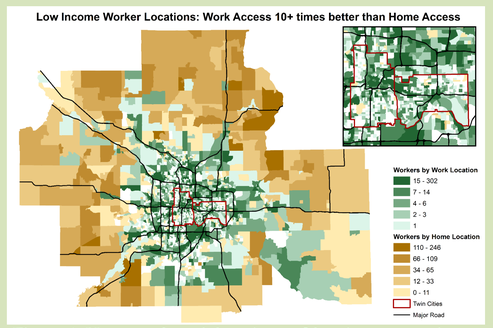

Figure 4. Home and work locations of low income workers whose work-based accessibility is 10x better than their home-based accessibility

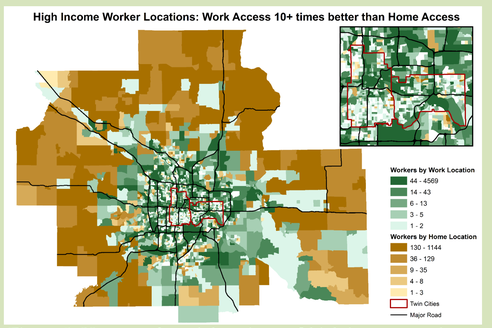

Figure 5. Home and work locations of high income workers whose work-based accessibility is 10x better than their home-based accessibility

6. Conclusions

The results show that a majority of low income workers (57%) live and work in areas where the ratio between between home and work accessibility is between 0.5 and 2. They seek out home and work locations with relatively balanced accessibility to non-work activities. A minority of low income workers (43%) live and work in areas with extreme accessibility imbalance. Comparatively, a minority of high income workers (46%) live and work in balanced areas, and majority (54%) in imbalanced areas. At the extremes fewer low income workers (28%) live and work in areas where work accessibility is more than twice as better than home accessibility compared to high income workers (39%).

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