Integrate Economic Dimension into Spatial Mismatch Measure

Dong Liu [1,2], Mei-Po Kwan [1, 2, 3, 4]

1. Department of Geography and Geographic Information Science, University of Illinois at Urbana-Champaign; 2. Space-Time Analysis and Research Lab, University of Illinois at Urbana-Champaign

3. Department of Geography and Resource Management, The Chinese University of Hong Kong; 4. Institute of Space and Earth Information Science, The Chinese University of Hong Kong

Introduction

The spatial mismatch hypothesis (SMH) was formulated based on the mismatch between the socially vulnerable population concentrated in the inner cities and available job opportunities dispersed in the suburban areas.

It stated that many jobs were not available or accessible to inner-city socially vulnerable residents partly due to the lack of transit service to the suburbs.

Nevertheless, the mere presence of a transit system does not guarantee access to jobs as high travel costs, e.g., travel distance/time, transit fare, might discourage the full utilization of public transit for low-income people.

The few spatial mismatch studies that have examined spatial mismatch for transit-dependent population only considered the spatial dimension, i.e., travel distance/time as the travel cost and did not integrate the impact of the economic dimension, i.e., transit fare.

This study seeks to improve the assessment of spatial mismatch by integrating both spatial and economic dimensions into the measure.

Study area and data

The Chicago Metropolitan Area, the third largest metropolitan area in the U.S., is our study area.

The area includes seven counties (Cook, DuPage, Kane, Kendall, Lake, McHenry, and Will Counties) in northeastern Illinois.

The entire metropolitan area is served by the nation's second largest public transport system, which includes three transit operators, i.e., the Chicago Transit Authority (CTA), the Metra Commuter Rail (Metra) and the Pace Suburban Bus and Paratransit (Pace).

CTA serves the City of Chicago and the suburbs within the Cook County;

Pace connects the suburbs with the City of Chicago;

Metra serves the transit need of commuters living in the suburban counties of the metropolitan area.

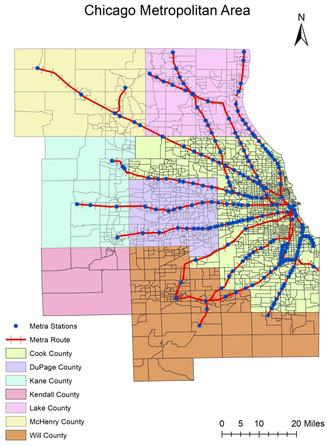

Fig.1 Chicago Metropolitan Area

The City of Chicago lies within the Cook County and is also the principal city of the Chicago Metropolitan Area (Fig.2).

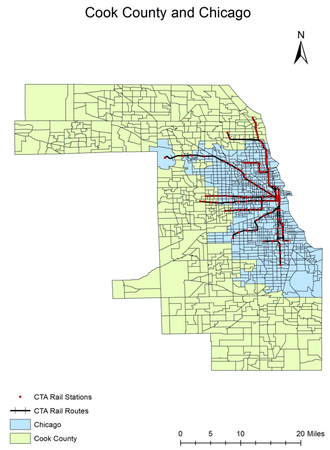

Fig.2 Cook County and the City of Chicago

The datasets used in this study are from the year of 2010 and include:

1) Census tract level demographic data from the U.S. Census Bureau;

2) Census tract level employment data from the Chicago Metropolitan Agency for Planning;

3) Transit-based travel time gathered through Google Maps Directions API;

4) Transit fare from the CTA, Pace and Metra.

Methodology

Cumulative-opportunity model is used to measure transit-accessible jobs. Based on the number of transit-accessible jobs and transit-dependent workers, dissimilarity index is used to measure the spatial mismatch conditions.

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

where A_i is the number of transit-accessible jobs, i.e., jobs within the time and transit fare threshold, from census tract i; O_j is the number of jobs in census tract j;

$$f(l_{ij}) = \begin{cases} 1 & if\ Tij \le \delta t \\ 0 & if\ Tij > \delta t \end{cases} \quad (2)$$

$f(l_{ij})$ is a weighting function with l_{ij} being transit time or transit fare from census tract i to census tract j. If only the travel time is considered, $f(l_{ij})$ is given by Equate (3), where T_{ij} is the travel time from census tract i to census tract j. δt is the travel-time threshold.

$$f(l_{ij}) = \begin{cases} 1 & if\ Tij \le \delta t\ and\ Cij \le \delta c \\ 0 & otherwise \end{cases} \quad (3)$$

If both travel time and transit fare are considered, $f(l_{ij})$ is given by Equation (4), where C_{ij} is the travel cost from census tract i to census tract j. δc is the transit-fare threshold. Only when travel time and transit cost are within the respective thresholds δt and δc are the jobs in a census tract considered transit-accessible jobs.

$$DI = \frac{1}{2}\sum_{i=1}^{n}\left|\frac{P_i}{P_{total}} - \frac{A_i}{A_{total}}\right| \quad (4)$$

where DI is the Dissimilarity Index for census tract i with higher DI value meaning severer spatial mismatch and vice versa; P_i is the transit-dependent workers in census tract i; P_{total} is the total number of transit-dependent population in the Chicago Metropolitan Area; A_i is the number of transit-accessible jobs, i.e., jobs within the time and transit fare threshold mentioned above, from census tract i; A_{total} is the summation of transit-accessible jobs from each census tract in the in the Chicago Metropolitan Area.

Results

This study

1) examines the spatial mismatch between low-income transit-dependent workers and transit-accessible jobs;

2) compares the spatial mismatch of all transit-dependent workers and low-income transit-dependent workers before and after considering both travel time and transit fare.

The geographic distributions of the transit-dependent workers and their income in the study area are shown in Fig. 3.

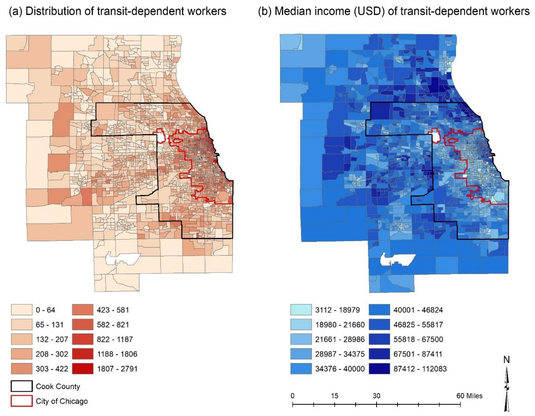

Fig.3 Distribution of transit-dependent workers (a) and median income (USD) of transit-dependent workers (b). travel time and one-way fare and (c) travel time and monthly fare

In Fig. 3 (a), Cook County had the most transit-dependent workers in the study area. In Cook County, the City of Chicago had the highest density of transit-dependent workers. Fig .2 (b) shows a majority of the transit-dependent workers residing in the west and south of the City of Chicago are low-income. Therefore, high transit fare can have more impact on their capability of reaching transit-accessible jobs as their income may restrict their travel budget.

The results of transit-accessible jobs based on travel time only are compared to the results of the transit-accessible jobs based on both travel time and transit fare as shown in Fig. 4 (a), (b) and (c).

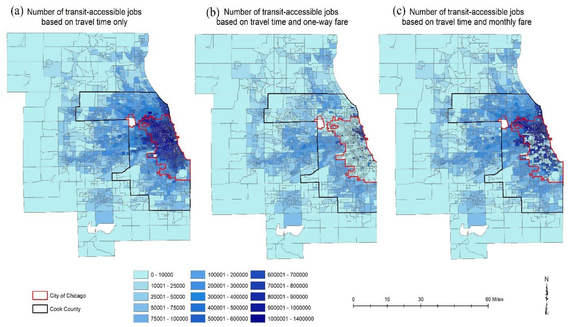

Fig. 4 The number of transit-accessible jobs based on (a) travel time only, (b) travel time and one-way fare and (c) travel time and monthly fare

As shown in Fig. 4 (a), when considering travel time only, census tracts with many transit-dependent workers across different income levels could reach many transit-accessible jobs, which indicates spatial mismatch is not serious in this region.

However, after adding transit fare to the measure, a large number of census tracts with many low-income transit-dependent workers as shown in Fig. 2 (b), (c) could reach much less transit-accessible jobs, which indicates that spatial mismatch is actually rather serious in the region for low-income transit-dependent workers.

Finally, Fig. 5 shows the comparative results of the DI values by considering 1) travel time only, 2) both one-way fare and travel time, and 3) both monthly ticket fare and travel time.

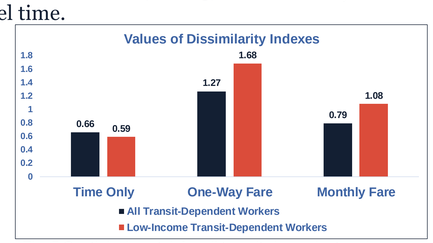

Fig. 5 Spatial mismatch for all transit-dependent workers vs. spatial mismatch for low-income transit-dependent workers

When considering travel time only, it shows that the level of spatial mismatch for all transit-dependent workers is slightly higher than that of low-income transit-dependent workers.

When transit fare is taken into consideration, it shows that the level of spatial mismatch for low-income transit-dependent workers is actually much higher than that of all transit-dependent workers.

The result indicates that although low-income transit-dependent workers live in places served by better transit service, they might not make full use of the transit service probably because of high transit fare.

Conclusion

This study improves the measurement of spatial mismatch by taking the economic dimension into consideration. It is proved in this study that spatial mismatch levels for transit-dependent workers are underestimated without considering the economic dimension, i.e., transit fare, of travel.

Besides, transit fare worsens spatial mismatch for all transit-dependent workers across different income levels in the study area. Nevertheless, transit fare has more impact on the spatial mismatch level of the low-income transit-dependent workers compared to that of all transit-dependent workers.

Finally, results of spatial mismatch measurement can be misleading for policymakers without considering transit fare

Ackonwledgements

I would like to offer my appreciation to the Chicago Metropolitan Agency for Planning for providing me with the employment data used for this study.

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