Segregated by Design? The Effect of Street Network Topological Structure on the Measurement of Urban Segregation*

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Racial residential segregation is a longstanding topic of focus across the disciplines of urban social science. Classically, segregation indices are calculated based on areal groupings (e.g. counties or census tracts), with more recent research exploring ways that spatial relationships can enter the equation. Spatial segregation measures embody the notion that proximity to one's neighbors is a better specification of residential segregation than simply who resides together inside the same arbitrarily-drawn polygon. Thus, they expand the notion of "who is nearby" to include those who are geographically close to each polygon rather than a binary inside/outside distinction. Yet spatial segregation measures often resort to crude measurements of proximity, such as the euclidean distance between observations, given the complexity and data requirements of calculating more theoretically-appropriate measures, such as distance along the pedestrian travel network. In this paper, we examine the ramifications of such decisions. For each metropolitan region in the U.S., we compute both Euclidean and network-based spatial segregation indices. We use a novel inferential framework to examine the statistical significance of the difference between the two measures and following, we use features of the network topology (e.g. connectivity, circuity, throughput) to explain this difference using a series of regression models. We show that there is often a large difference between segregation indices when measured by these two strategies (which is frequently significant). Further, we explain which topology measures reduce the observed gap and discuss implications for urban planning and design paradigms

Keywords: segregation, neighborhoods, spatial analysis, network analysis, spatial weights

INTRODUCTION

An exceedingly common abstraction in applied spatial analysis is the use of euclidean distance as a proxy measure for geographic proximity (which is, itself, often a proxy for the frequency of social interaction). It's the geographic equivalent of the spherical cow, save that scientists of many different disciplines often fail to realize how simplified it is. While, in general, simple proximity is a reasonable heuristic for understanding Tobler's Law, the behavioral realities of movement and social interaction in complex urban environments often require a more thoughtful model.

this project examines the relationship between pedestrian network characteristics and the measurement of metropolitan segregation. It examines three questions:

1. How large is the difference between euclidean-based and network-based measures of spatial segregation?
    - how often
    - where?
2. Are the differences between euclidean and network measures significantly different from random realizations of the same data?
    - how often
    - where

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3. what characteristics of the pedestrian network explain the observed difference in measurement?

really quick overview of normative concepts of community and urban design… Daniel Burnham, Le Corbusier, Ebenezeer Howard, James Rouse, and… Emily Talen

how do we represent space in social science research?

classics: - sociology uses groups. Neighborhoods or cities are discrete containers that condition social behaviors (Park, Burgess, McKenzie) - econ and regional science use distance from the city center - ultimately about transport of goods (von thunen was based on an *agricultural economy* and moving crops from the ag hinterlands into the marketplace where people actually lived). - Transport connectivity is implicit, but models are high-level in the 1950s, and the abstraction works conceptually. Neither the theory or computational power exist yet to examine the role of better measurements of W_{ij}

recents: - GIS, geography, and spatial econometrics concepts of spatial weights - multiscale and/or bespoke neighborhoods in geography and sociology (HIPP & BOESSEN (2013), van Ham,) - street networks in empirical work - grannis shows social interactions are more frequent inside T-communities defined by street networks - Roberto uses street networks to measure segregation in a small-scale case study.

Now we have both the tools and the logic to test these assumptions and understand the role of abstractions such as euclidean distance-based measures in our assessment of critical social processes such as residential segregation. Fast graph algorithms allow us to construct more realistic concepts of spatial weights matrices, and computational statistics allow us to construct and test realistic null hypotheses about the allocation of urban population groups. Here, we examine the role of street network topology in the appropriate measurement of urban segregation. Our goals are twofold. First, we aim to understand the implications of simple Euclidean distance- based abstractions when conducting formal spatial analyses; that is, do we find substantive differences in results when more realistic concepts of spatial relationships (e.g. network connectivity) are considered? Second, we aim to explore the elements of urban design (particularly the street network configuration) in widening the gap between analytical abstraction and empirical reality. More simply, we aim to understand whether certain elements of the street network are associated with a greater difference in measured segregation. With this knowledge, urban designers and planners can begin with more inclusive communities from the beginning.

URBAN INFRASTRUCTURE AND SOCIAL INTERACTIONS

Classically, space is treated as a discrete concept, by membership in a group (i.e. a school, classroom, neighborhood, or city), where any of these groupings is defined exogenously.

The Role of Space in Segregation Measurement

Making Space Explicit

Reardon & O'Sullivan (2004) Reardon et al. (2009) Wong (1997) Bailey (2012) Rey & Folch (2011) O'Sullivan & Wong (2007) Wong (2004) Dawkins (2004)

Interrogating Spatial Scale

Lee et al. (2008) Reardon et al. (2008) Bézenac et al. (2022) Olteanu et al. (2019) Östh et al. (2015) Clark et al. (2015)

Homogenous Communities and Urban Design

Grannis (1998) Grannis (2005) Roberto (2018)

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