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The development and application of a land use diversity index for Oklahoma City, OK

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ABSTRACT

Characteristics of land use and land use diversity play an integral part in determining how a city develops, and also can influence the allocation of funds for urban redevelopment, crime prevention, and civic and transportation projects. With the rise of the sustainability movement and concern about environmental degradation, more cities are interested in optimizing transportation routes and utilizing their budgets to accommodate high-priority projects that benefit the most people. This paper develops a method for measuring land use diversity for Oklahoma City, Oklahoma, and explores the relationship between land use diversity and a suite of demographic variables. To accomplish this, a land use diversity index (LUDI) was developed to examine spatial patterns in diversity of land use. The analysis shows that areas with a higher LUDI are near interstates and main corridors while areas with a lower LUDI are located closer to where newer residential areas have been developed. A multivariate statistical approach was then used to identify those variables that might explain the specific spatial patterns of the LUDI in Oklahoma City. The results identify the relationship between the demographic variables and land use across the city, and illustrate the most interesting and significant spatial patterns. By coupling the land use diversity index and demographic data, Oklahoma City planners can apply the information to help make important decisions for the city, and it will provide quantifiable data to support their decisions.

Introduction

Land use is increasingly becoming an important aspect in urban planning. More specifically, larger cities are focusing on incorporating different land uses into the same area. For example, with the rise of the sustainability movement and concern about environmental degradation, more cities are interested in optimizing transportation routes and utilizing their budgets to accommodate high-priority projects benefiting the most people.

The built environment influences the movement of people and activity within and around a metropolitan area. Leccese and McCormick (2000) state that "in order to promote community, the built environment must be diverse in use and population, scaled for the pedestrian, and capable of supporting mass transit as well as the automobile." The foundational principles of the Congress for the New Urbanism (Leccese and McCormick, 2000) endorse healthy communities, and they recommend components such as mixed-use development, sustainable economies, and intact connectivity between communities to achieve a healthy community. One measure of the health of a community is its accessibility (Ashby & Pharr, 2012). A healthy community provides equal accessibility to "quality education, safe and healthy homes, adequate employment, transportation, physical activity, and nutrition, in addition to quality health care" for all citizens (Ashby & Pharr, 2012, 1).

In recent years, urban planning researchers have become more focused on better-planned cities and in measuring their efficiency. Many of the studies have concentrated on transportation planning and travel behavior (e.g., Ewing & Cervero, 2010, among many others), and some include land-use planning as well (Antipova, Wang, & Wilmot, 2011; Bartholomew & Ewing, 2008; Moudon, Sohn, Kavage, & Mabry, 2011). For example, if more diverse land uses are closer and more accessible to a broader range of people, then individuals will have more options when deciding how and when to get to their destinations. The breadth of studies on the relationship between transportation decisions, habits, and behavior and their effects is substantial; however, fewer studies

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have researched the relationship exclusively between land use and socio-demographics. One such study, Talen (2005, 2006), examined this relationship for two Illinois cities. Using census data and applying spatial analyses, Talen (2005, 2006) specifically investigated the relationship between zoning and human diversity. These previous efforts, including the work of the Congress for the New Urbanism, illustrate the qualities and benefits of mixed land use in urban areas, and these studies argue for the necessity of understanding land use diversity across a range of urban environments. Thus, the research outlined in this paper applies a similar method to the Talen (2005, 2006) efforts to investigate the relationship in Oklahoma City, Oklahoma.

Using land use parcel data and geospatial analysis and multivariate statistical analysis, this paper develops and applies a land use diversity index (LUDI) for each census tract in Oklahoma City, Oklahoma. After the land use diversity is determined for each tract, the study examines the relationship between land use diversity and a suite of demographics variables. The expectation is that the research will show that the more diverse areas are near the city's center and along main interstates and highways, while the less diverse areas are located along the urban fringe, where households will have higher incomes, more education, and where there will be fewer minorities. The areas with the highest land use diversity should show indications of households with lower incomes, less education, and more minorities. If the research does highlight these patterns, it might suggest that more consideration for planning and implementing funds for city improvements of services, such as schools, sidewalks, infrastructure, public transportation, and parks, will be needed for the areas with higher diversity. The application of a diversity index will be beneficial for planners, stakeholders, and city officials to use and help assess parts of the city that may be a higher priority than others. Optimizing the city's budget, the LUDI can help when deciding where improvements should be made, including, for example, sidewalks, schools, parks, streets, bus routes, etc.

Research context

Andres Duany, considered the father of New Urbanism, coined the term in the early 1980s when suburban sprawl was on the rise (Duany, Plater-Zyberk, & Shearer, 1992; Redmon, 2010). New Urbanism is a movement in the urban planning community that adopts pre-World War II neighborhood development practices. In her renowned book *The Death and Life of Great American Cities*, Jacobs (1961) harshly criticized the planning practices of the 1950s and 1960s and proposed new techniques to properly plan cities. Land use is one of the interconnecting pieces in implementing and adopting New Urbanism practices. More importantly, the spatial patterns of land use are a key component in effective urban planning. As expressed by Arrington (2000), land patterns should work well with transportation alternatives across a whole region. Only catering to the automobile is harmful when building a diverse and healthy community. He used Portland, OR, as an example of a city providing to all transportation needs – "walking, biking, transit, and yes, driving" (Arrington, 2000, 61). Within a region, the pattern and arrangement of the neighborhoods, districts, and corridors are crucial for optimal functionality. Plater-Zyberk (2000) stated that a one-quarter mile radius is the ideal size for a "neighborhood," and important daily activities, such as schooling, shopping, and work, should be along or within that radius. She also identified the necessity to serve all commuters equally (Plater-Zyberk, 2000, 81).

In addition to providing for all types of commuters – walkers, drivers, bikers, it is important to consider the demography of the residents, as pointed out by Kulash (2000) who described the importance of transportation planning for those residents who are incapable of driving an automobile. He also stressed the significance of minimizing walking distance and increasing interconnectivity to increase walkability, thus decreasing automobile traffic. Connecting transit and walking could expand the accessibility of the daily activities to more residents. The resounding and underlying theme these planners recognized was that the link between land use and transportation has deteriorated since the rise of the automobile and needs to be revitalized to build viable and healthy communities. Although many studies have focused on New Urbanist communities and their successes with adopting the new ideals, these same concepts can be applied to assess the land use practices and planning of a non-New Urbanist city. Although Oklahoma City is a well-established city, assessing the land use patterns as well as the demography of the city will help planners seek better planning practices for future developments and improvements for the city.

a) Measuring Land Use Diversity

Measuring diversity has been explored across disciplines with various methods, and there are multiple methods to measure diversity in a defined area. E. H. Simpson (1949, 688) developed a commonly used measure of diversity, called Simpson's index of diversity (also known as Simpson's index). This diversity index was initially developed as a way to calculate the richness of a particular species in an area, and is still widely used for that purpose. Simpson's index (D_1) can be written as:

$$D_1 = \sum \frac{n_i^2}{N^2} \tag{1}$$

where n' = total number of a particular species, N = total number of organisms of all species, and

$$0 \leq D_1 \leq 1$$

where 0 is maximum diversity and 1 is minimum diversity.

Efforts using Simpson's index in an urban and landscape setting include an analysis of the landscape structure of Kansas (Griffith, Martinko, & Price, 2000). Using a modified Simpson's index, they used land cover data at different resolutions to assess different landscape pattern metrics. Similarly, Zhang, York, Boone, and Shrestha (2013) analyzed the spatial patterns of land fragmentation in the Phoenix metropolitan area using a variation of Simpson's index. They chose to use Simpson's index, because evenness was "likely to be the major factor" in their analysis and this index is not sensitive to the presence of rare land fragment types (Zhang et al., 2013; 523). Byrne and Flaherty (2004) used Simpson's index, as well as other indices, to measure diversity of housing in Australia. Using the Australian Census data, they calculated diversities for dwelling types and occupancy types. Although they compared the different methods to measure diversity, they failed to map any of their results, which may have revealed more interesting information that could spatially explain the differences in the methods. Talen (2005) included maps in her study, showing diversity of land zoning and socioeconomics near two Illinois cities. Like the previous studies, Simpson's index equation was used to evaluate the zoning diversity at the parcel level.

b) Principal Components Analysis (PCA)

The next component in the examination of land use patterns in Oklahoma City is an approach to reduce collinearity in the analyzed variables. Principal components analysis is a method to reduce the number of variables or components in a statistical analysis. When there are many possible collinear variables in an analysis, a PCA can