CHANGES IN POPULATION DENSITY IN COLUMBIA, SOUTH CAROLINA

Steven D. Lang, Department of Economics and Business,
Randolph-Macon-College, Ashland, VA 23005, slang@rmc.edu

INTRODUCTION

This proposal describes a research plan to analyze changes in population density patterns for the Columbia, SC metropolitan area. The study will utilize U.S. Census data to estimate population density gradients for the metropolitan area for 1990, 2000, and 2010. The resulting gradients will be compared, with the a priori expectation that the gradients have declined over time, indicating a more dispersed population.

BACKGROUND

Population Density Patterns

The generalization that population density declines at a decreasing rate as distance from the center city increases is consistent with intuition, economic theory, and careful empirical analysis. Imagine a view of a city skyline. It declines in a manner that could be described by a negative exponential function. Correspondingly, intuition would lead one to expect population density to follow this same pattern. Economic theory predicts this pattern partly because of the factor substitution that is evident in that skyline, but also due to substitution by consumers of housing space.

The Monocentric City Model

Our understanding of urban land use patterns is rooted in the *monocentric city model* (Alonso, 1964; Muth, 1969; Mills, 1967). This model generates the equilibrium result that utility-maximizing households would require lower housing prices as distance from the city center increases to compensate for the higher commuting costs they incur. In response to lower prices per unit of housing space, households would consume more housing space and substitute away from other goods. All else equal, households would be more dispersed at more distant locations since they live in larger dwellings.

Of course, all else would not be equal. Specifically, this decreased willingness on the part of consumers to pay for a unit of housing space reduces the amount that profit-maximizing developers are willing to pay for a unit of land as distance from the city center decreases. Thus, the equilibrium price of a unit of land falls as distance from the city center increases. Consequently, builders use more land and less capital per household dwelling as distance from the city center increases.

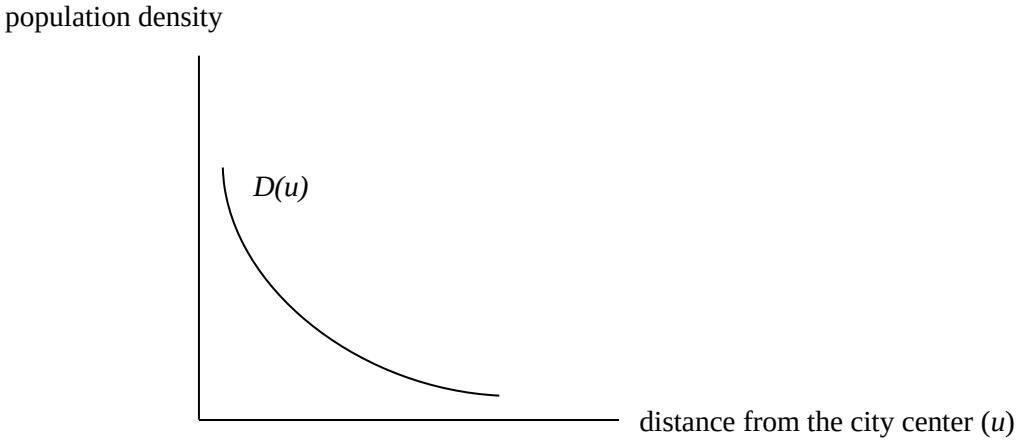
It is easier to deduce the effects of consumer and producer substitution if we start at the edge of development and move towards the city center. Households facing higher unit prices of housing would live in smaller dwellings, meaning they would consume fewer square feet of housing space. Developers would respond to higher land rents by using less land and more capital per household dwelling. They would accomplish this substitution by building taller residential structures. So each household would live in smaller dwellings and each dwelling would use less land as distance to the city center decreases. The result, as illustrated in the figure below, is that population density increases exponentially as we move closer to the city center.

Population Density Gradients

The population density pattern in the figure below can be approximated by the function

$$D(u) = D_0 e^{-gu}, \quad (1)$$

where u is distance from the city center and D_0 is population density at the city center (u=0). The parameter g, which measures the rate at which population density falls as u increases, is referred to as the *density gradient*.



The density function above can be transformed to

$$ln\ D(u) = ln\ D_0 - g\ u. \quad (2)$$

Using observations of population density at various distances from the city center, regression analysis can be used to estimate g. So if u measures distance from the center in miles and g = 0.50, then population density is estimated to decline at 50% per mile.

Empirical Evidence

Early estimates of population gradients using 1950 Census Data show that for a sample of U.S. cities the density gradient averaged 41% per mile (Muth, 1969). More recent studies show that density gradients in the U.S. (Mills, 1972) and abroad (Anas, Arnott, and Small, 1998) have fallen over time as cities have become more decentralized.[1]

DATA AND METHOD

The data requirements for this project are minimal. The U.S. Census Bureau publishes data on population and land area by census tract. These data will be collected and population density will be calculated for 1990, 2000, and 2010 for each of the tracts in the Columbia, South Carolina Metropolitan Statistical Area (MSA). This MSA includes six counties: Calhoun, Fairfield, Kershaw, Lexington, Richland, and Saluda. There are 251 census tracts distributed across these counties and the principal city of Columbia is located in Richland County.

[1] The paper will include a more complete review of the evidence.

Census data also include the centroid for each census tract. GIS technology will be used to calculate the distance between the centroid of each tract and the centroid of the tract that contains the geographical center of the Columbia Central Business District (CBD).

Since the transformed density function (2) is linear, OLS regression estimates of the density gradients can be obtained for 1990, 2000, and 2010. Standard statistical tests will be used to determine if any differences in these estimates are statistically significant.

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