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Essays on Urban Sprawl, Race, and Ethnicity

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ESSAYS ON URBAN SPRAWL, RACE, AND ETHNICITY

A Dissertation Presented

by

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DEDICATION

For my parents and grandparents.

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ABSTRACT

ESSAYS ON URBAN SPRAWL, RACE, AND ETHNICITY

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This dissertation investigates the economic consequences of urban sprawl for US minorities. Each essay focuses on a key empirical debate related to that relationship. The first essay establishes a set of attributes and empirical measures of sprawl based upon a comprehensive review of the literature. I define sprawl as a multi-faceted pattern of three land-use attributes: low density, deconcentration, and decentralization. I then resolve several methodological inconsistencies in the measurement of sprawl. Extensive analysis of spatial and economic data finds that metropolitan areas do not commonly exhibit high-sprawl (or low-sprawl) features across multiple measures. Instead, they often exhibit unique combinations of low-sprawl and high-sprawl attributes. The second essay examines the effect of sprawl on minority housing consumption gaps since the housing bust. I make two contributions to the literature. First, I reveal a facet of the relationship between sprawl and the Black-White housing gap not examined by previous econometric studies: Sprawl only contributes to reducing that gap once a metropolitan area reaches a critical threshold level of sprawl, typically at high levels of sprawl. Below a threshold, sprawl facilitates an expansion of the Black-White housing gap. Second, I compare results for Blacks, Asians, and Hispanics using recent data. For Blacks, the benefits from sprawl occur above an even higher threshold, as compared to preceding studies using 1990's data. For Asians, sprawl yields significant gains in housing consumption relative to Whites. As such, arguments that anti-sprawl policies reduce minority gains in housing should be treated with considerable skepticism in the post-Great Recession economy. The third essay explores the relationship between sprawl and racial and ethnic segregation. This econometric study advances the understanding of that relationship in two ways. First, I examine the effect of countervailing patterns of multiple land-use attributes, i.e. unique combinations of low-sprawl and high-sprawl attributes, on all five of the dimensions of segregation. Second, I compare outcomes for Blacks, Hispanics, and Asians. The study analyzes the contribution and transmission of countervailing spatial patterns of land use to increasing (or decreasing) segregation. These complex effects bring new precision and insights to the analysis of racial and ethnic inequality in an age of rapid demographic change.

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CHAPTER 1

INTRODUCTION

1.1 Motivations and Research Objectives

The term 'urban sprawl' stirs no shortage of debate, controversy, and intrigue.[1] In the United States, sprawl is both a celebrated and denounced spatial pattern of land use. For the economics discipline, the nature, causes, and consequences of sprawl are key topics of interest. Many of the classic debates in economics lie at the center of the debate over sprawl, such as the role of market forces, the motives and consequences of government regulation, as well as the sources of inequality and social mobility. This dissertation contributes to those debates by deepening the understanding of sprawl as an economic process, critiquing prevailing policy conclusions, integrating new approaches to understanding the consequences of sprawl for minorities, and finally, by posing new questions for future scholarship.

For its defenders, sprawl contributes to an array of positive economic and social outcomes.[2] One argument is that sprawl increases housing affordability by expanding the supply of land available for residential development. This production of space also permits greater housing consumption in the form of newer homes with more living space. In metropolitan areas with historically intensive or compact land-use patterns, sprawl contributes to expanding access to homeownership and the amenities of suburban life.

Scholars have used race as a lens to understand and defend these arguments in favor of sprawl. Prior to the housing bust, the contention was that the positive effects of

[1] For an introduction to the contemporary sprawl debate, the reader is referred to the symposium on sprawl featured in the Brookings-Wharton Papers on Urban Affairs (Gale & Pack, 2001), as well as the special issue on sprawl in the Brookings Review (Szitta, Katz, & Downs, 1998).

[2] See Bruegmann (2005), Downs (1999), Gordon and Richardson (1997), and Kahn (2001).

sprawl are particularly favorable for minorities and low-income groups, given the history of segregation and other barriers that they have faced in housing markets. That perspective was also used to formulate a key policy conclusion. Local or regional growth regulations could limit minority progress, especially in metropolitan areas where sprawl-like land-use patterns are associated with smaller racial disparities in housing, or less racial segregation.

For its detractors, sprawl is costly and wasteful for a number of reasons.[3] From a public finance perspective, critics allege that sprawl reduces the ability to realize economies of scale in public services provision and infrastructure maintenance. Furthermore, they assert that sprawl leads to the erosion of the central city tax base, which exacerbates inner-city decay. Environmentalists denounce sprawl for its negative consequences for the availability of open spaces and scarce agricultural resources. Public health advocates denounce sprawl for its association with greater automobile dependency, which contributes to more air pollution and less physical activity. Critiques against sprawl are also levied from a labor and employment perspective. Researchers often cite the increase in transportation and commuting costs that result from the rapid expansion of metropolitan areas, which they contend leads to spatial mismatch problems and structural unemployment in local labor markets. Finally, critics argue that sprawl reduces the likelihood of community building, which could increase segregation.

The recent literature on the consequences of urban sprawl for minorities lies at an intersection of economics, urban planning, geography, and sociology. Between the late 1990's and early 2000's, three major empirical debates or 'currents' emerged within this literature. The first current engages the dual challenges of defining and measuring urban

[3] See Burchell et al. (1998), Ewing (1997), and Ewing, Pendall, and Chen (2002).

sprawl. These challenges are crucial to understanding the economic effects of sprawl, as those effects, and their theoretical connections to sprawl, are critically sensitive to the definition and measurement of sprawl itself. The second current investigates the relationship between urban sprawl and racial inequalities in housing consumption. Research using 1990's data finds a positive contribution of sprawl to the long-term reduction in the Black-White housing consumption gap. Scholars conclude that anti-sprawl government policies would therefore reverse the gains in housing consumption achieved by minorities during the 1990's. The third current examines the consequences of urban sprawl for racial segregation. Several studies, using various conceptual definitions and measures of both sprawl and segregation, largely find a positive contribution of sprawl to the decline in Black segregation.

Recent economic, structural, and demographic changes in the United States provide the motivation for this dissertation. Since the period between the late 1990's and early 2000's, several factors have transformed the economic position of racial and ethnic and minorities; namely, the housing bubble and subprime mortgage meltdown; ongoing job losses in the manufacturing and public sectors; growing concerns over budget deficits; rising costs of energy, food, and healthcare; and finally, the rapid population growth of Asians and Hispanics. These factors necessitate not only a reexamination of the predominant arguments in the literature, but also the integration of new perspectives on the economic effects of sprawl on minorities. Accounting for such changes also demands reconsideration of the prevailing policy conclusions in the literature.

This dissertation therefore has four primary research objectives: first, to reappraise previous empirical models through the process of critical replication; second,

to update those models with recent data, in order to assess their relevance for the post-housing-bust economy; third, to extend the analysis to include 'new minorities;' and fourth; to introduce new approaches to understanding the consequences of sprawl for racial and ethnic minorities.[4]

1.2 Plan of the Dissertation

Following this introduction, the remainder of the dissertation is divided into four chapters.

Chapter two has dual objectives. The first objective is to rigorously define and analyze a set of alternative attributes of urban sprawl. This chapter defines sprawl as a multi-dimensional spatial pattern of three primary land-use attributes: low density (frequency of economic development per square mile), deconcentration (degree to which economic development takes place in relatively few places), and decentralization (degree to which economic development takes place beyond the historical central business district). The second objective is to resolve methodological inconsistencies in the empirical measurement of urban sprawl. Previous contributions in the literature often feature small samples, outmoded data, and/or incomplete operational specifications of economic development. This chapter employs recent data in the context of a national dataset, and comprehensively compares both employment-based and residential housing-based measures of sprawl. The study finds that metropolitan areas do not consistently feature high-sprawl characteristics across multiple measures of land use. Instead, they often exhibit a combination, or 'configuration,' of both high-sprawl and low-sprawl

[4] The term 'new minority' generally refers to Hispanics, Asians, and persons of mixed-race. Analysis of new minorities in this dissertation will focus exclusively on Hispanics and Asians.

attributes.

Chapter three explores the relationship between urban sprawl and minority housing consumption gaps, and compares that relationship between 1997 (a period marked by a housing boom) and 2009 (a period marked by a housing bust). Several contributions of this study increase skepticism concerning arguments that anti-sprawl regulations limit minority progress in housing markets. First, the chapter introduces a new method of understanding the relationship between sprawl and the Black-White housing consumption gap. Through the process of critical replication, the chapter documents the presence of a 'threshold' effect, whereby sprawl only contributes to reducing the Black-White housing gap once a metropolitan area surpasses a high level of sprawl. In the substantial number of metropolitan areas below this critical threshold, sprawl contributes to expanding that gap. Second, the chapter moves beyond the traditional Black-White framework by integrating and comparing results for Asians and Hispanics. Although the models do not yield statistically significant results for Hispanics relative to Whites, the models predict extensive relative gains in Asian housing consumption from sprawl. Third, the study utilizes post-housing bust data to reappraise the nature of the relationship between sprawl and minority housing consumption gaps. The study finds that, as compared to the 1990's, the positive contributions from sprawl for Black housing consumption occur above much higher thresholds. This implies that the benefits of sprawl are limited to an even smaller number of high-sprawl metropolitan areas.

Chapter four examines the effects of urban sprawl on racial and ethnic segregation. This chapter advances the understanding of those effects in three principal

ways. First, with respect to the independent variable in question, the study accounts for the possibility of countervailing patterns of multiple land-use attributes, i.e. unique combinations of both high-sprawl and low-sprawl attributes. A considerable amount of work in the literature specifies density as the causal variable of interest. A limited amount of work specifies sprawl as a multi-dimensional phenomenon. Informed by the data and analysis featured in chapter two, this study defines five alternative configurations of land use. The introduction of countervailing patterns of land use, as a determinant of racial and ethnic segregation, is a key contribution of this chapter. Second, as in chapter three, this study comprehensively analyzes segregation outcomes for Blacks, Hispanics, and Asians. Previous studies focused primarily on Black segregation. Although a few scholars explored the consequences of land-use policies for new minority segregation, none have explored the consequences of sprawl for new minority segregation. Third, with respect to the dependent variable in question, the chapter examines all of the five dimensions of racial and ethnic segregation in the literature. This is an important consideration, as many of the unexamined dimensions are key descriptors of Asian and Hispanic segregation. The study expands the understanding of this relationship by comparing metropolitan areas with combinations of low-sprawl and high-sprawl attributes to those with uniformly high-sprawl (or low-sprawl attributes), by examining how the configuration of land use contributes to the rise (or decline) in segregation of a particular minority group, and by exploring the similarities and differences in those outcomes across all three minority groups.

Chapter five concludes the dissertation with final thoughts and reflections, and suggests several courses for future research.

CHAPTER 2

ALTERNATIVE MEASURES OF URBAN SPRAWL: ATTRIBUTES AND EMPIRICAL EVIDENCE FROM 2000

2.1 Introduction

The only agreement about the definition of urban sprawl is that there is no agreement about the definition of urban sprawl. In a literature with both academic and popular roots, urban sprawl has been defined as a process of development over time, a condition of land use, a consequence of planned or unplanned decision-making, a cause of undesirable economic outcomes, an aesthetic judgment of the urban environment, and finally, by way of notable examples of sprawl itself (Galster et al., 2001). In the early 2000's, however, a new research agenda emerged that focused on quantitative attributes and measures of urban sprawl. This direction has allowed for more rigorous empirical debates over the relationship between urban sprawl and its aforementioned contexts.

The economics discipline is a crucial setting for interest and controversy in this dialogue. Although the precise definition and measurement of sprawl remains rightfully contested, one fundamental stylized observation is clear: Urban sprawl is a predominant spatial pattern of housing and labor markets in US metro areas. Economists of both mainstream and radical persuasion now have the opportunity to use sprawl as an empirically rigorous conduit to understand urban economic processes.

The purpose of this chapter is to establish the relationship between the empirical measurement of urban sprawl and the economic vision of this dissertation. Section 2.2 begins with a short survey of the literature. Section 2.3 then identifies a set of distinct attributes and empirical measures of sprawl. Section 2.4 explains the choice of data and sample size. Section 2.5 follows with a lengthy discussion of results using summary

statistics, regional analysis, and correlation analysis. Section 2.6 concludes the chapter with an overview of its findings.

2.2 Literature Survey

The literature on the measurement of urban sprawl took form in the late 1990's and early 2000's. Empirical studies of urban sprawl fall into two primary categories: those that measure a specific attribute of sprawl, and those that measure sprawl as a multi-dimensional phenomenon. The literature also varies by empirical specifications of the attributes of urban sprawl, operational definitions of economic development, boundary definitions of the metro area, as well as disaggregated areal units.

For example, the Fulton, Pendall, Nguyen, and Harrison (2001) study specifies urban sprawl as a density-driven phenomenon. The study measures sprawl as the ratio of, and percent change in, population to urbanized land in 281 metropolitan statistical areas.[5] In this case, urban sprawl is an adjective used to describe land use. A 'sprawling' metro area exhibits low rates of population growth relative to urbanized land, or low-density land consumption. A 'densifying' metro area exhibits high rates of population growth relative to urbanized land, or high-density land consumption.

The Nasser and Overberg (2001) piece in USA Today is also a notable, albeit over-simplified, specification of density-driven urban sprawl. This study ranks 271 urbanized areas by two measures: population density in 2000, and the change in population density over the 1990's.[6] The index is the combined ranking of the two

[5] Urbanized land is the consumption of all land resources for urbanization according to the Department of Agriculture's National Resources Inventory surveys.

[6] Urbanized areas (UA) are densely-settled areas with a total population of at least 50,000 people. The UA

factors. Lower values constitute higher densities, and lower sprawl.

Concentration is also a measurable attribute of urban sprawl. The Lopez and Hynes (2003) study is a widely-cited analysis of concentration-driven sprawl. Concentration refers to the degree of variation in density across the physical space of a metro area. This index measures the difference between the proportion of metro population in low-density census tracts and the proportion living in high-density tracts for 330 metropolitan statistical areas. Higher index values indicate a higher percentage of population in low-density tracts, or a higher degree of sprawl. Lower index values indicate a lower share of population in low-density tracts, or a lower degree of sprawl.

Several studies define and measure urban sprawl as the extent of employment decentralization. In general, the 'Job Sprawl' method measures the share of metropolitan employment outside of a traditional central business district. There are multiple articles of note in this literature, each of which features variations on method, and in the context of economic analysis. In their original article, Glaeser and Kahn (2001) divide 335 metropolitan areas into three 'rings': the first ring is the immediate area within three miles of a central business district; the second ring is the area between three and ten miles; the third ring is the area between ten and thirty-five miles. The analysis focuses on the relationship between job sprawl and sectoral specialization, education and skills attainment, labor force preferences for suburbanization, as well as metropolitan tax and redistribution policies. In Glaeser, Kahn, and Chu (2001), the authors define differing patterns of both 'low-' and 'high-job sprawl' phenomenon, and examine regional and age effects in the one-hundred largest metropolitan statistical areas. Kahn (2001) measures job sprawl as the share of employment in the outermost ring, while Stoll (2005, 2007)

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is a more explicit distinction between urban and rural territory. It is defined by the Census Bureau.

uses the share of employment outside of a five-mile radius from a central business district. The former uses the methodology to examine the relationship between sprawl and the Black-White housing consumption gap, while the latter explores the relationship between sprawl and spatial mismatch. Kneebone's (2009) article revisits and updates this approach by examining changes in employment decentralization between 1998 and 2006 in the ninety-eight largest metropolitan areas.

Although the 'Job Sprawl' measures occupy a significant position in the centrality literature, they do not hold an exclusive monopoly. The Song (1996) piece, for example, reviews a number of gravity-based measures of centrality using population data. Gravity measures are distinct from traditional centrality-based approaches because they are not based upon the location of a central business district.

Several works have shifted the empirical analysis of urban sprawl towards a multi-dimensional analysis, not unlike what transpired within the racial and ethnic segregation literature during the 1980's.[7] The research of the 'Galster Group' is arguably the most prominent in this regard. The original article by Galster et al. (2001) defines urban sprawl as a static land-use condition based upon eight distinct attributes, drawn from their extensive review of the literature: density, continuity, concentration, clustering, centrality, nuclearity, mixed land use, and proximity. Lower values imply higher levels of sprawl, while higher values imply lower levels of sprawl. Geographic information systems (GIS) software is used to divide thirteen urbanized areas into one-square mile and one-half-square mile grids. Due to the associated time and resource restrictions of those calculations, their empirical analysis is limited to six of the suggested attributes using population data only. Wolman et al. (2005) make two major adjustments to this

[7] See Massey and Denton (1988).

approach: first, they exclude land that is unavailable for development using the US Geological Survey's National Land Cover Database; second, they define an "extended urban area" as an alternative operational boundary, based upon density and commuting patterns beyond the borders of the urbanized area definition. Incorporating those adjustments, Cutsinger, Galster, Wolman, Hanson, and Towns (2005) conduct rigorous factor and correlation analysis on multiple attributes of urban sprawl, using both housing and employment data in fifty extended urban areas. Cutsinger and Galster (2006) extend this methodology further by defining several typologies of (sometimes countervailing) urban sprawl patterns.

In addition to the 'Galster Group' studies, a number of other works expand the empirical analysis of urban sprawl from a multi-dimensional perspective. For example, the two pieces by Malpezzi (1999) and Malpezzi and Guo (2001) are quite useful. They test several alternative empirical measures of density, dispersion, density gradients, discontiguity, spatial autocorrelation, and compactness using population data in 330 metropolitan areas. Ewing, Pendall, and Chen (2002) of Smart Growth America also developed a four-factor sprawl index based upon residential density, the neighborhood mix of housing, employment and services, the strength of central city activity, as well as street network accessibility. The authors construct twenty-two independent measures of sprawl for analysis of eighty-three metropolitan statistical areas, using a wide variety of urbanized land, housing, and population data. Although they do not define any explicit empirical measures, Torrens and Alberti (2000) conceptualize several characteristics of sprawl using advanced spatial techniques; namely, density gradients, surfaces, fractal measures, imaging, and accessibility calculations.

2.3 Alternative Attributes and Measures of Urban Sprawl

This dissertation explores the economic consequences of urban sprawl for US racial and ethnic minorities. The attributes and empirical measures of sprawl specified in this chapter serve to elicit a deeper economic understanding of those consequences. They also serve to challenge and extend some of the recent empirical findings in the literature. Urban sprawl is therefore handled as a causal determinant with measurable consequences on urban economic mobility and standards of living. This approach is distinct from the equally important question of the underlying causes of sprawl itself.

The purpose of this chapter is to rectify the lack of comprehensive employment and comparison of multiple attributes of urban sprawl in the recent literature. It also assesses the appropriateness of some empirical measures over alternatives within each attribute. Each of these measures will be utilized as independent variables, although they could certainly be used as dependent variables for other contexts and questions surrounding these topics.

The vision here is that sprawl is a multifaceted combination of distinct attributes, which is both conceptually and empirically related to minority standards of living.[8] This dissertation formally defines urban sprawl as a configuration of the following land-use attributes: low density, deconcentration, and decentralization. Furthermore, urban sprawl is operationally defined with respect to both housing and employment. The choice of attributes, indexes, and operational measures is specific.

First, these characteristics establish the most practical conceptual and empirical

[8] This approach towards sprawl draws significant inspiration from Leslie McCall's (2001) work on inequality. In Complex Inequality, McCall argues that there are multiple forms of inequality comprised of "complex intersections" (McCall, 2001, p. 6) of race, class, and gender attributes at the regional and local level.

connection between urban sprawl and the economic research questions of this dissertation. They have also been referenced widely in the larger literature on the economics of location, and employed as empirical variables in econometric analysis. According to Malpezzi and Guo (2001, p.1), "most urban economists have preferred less value-laden terms" to describe urban sprawl, as opposed to the "pejorative connotations" used in the popular literature.

Second, multiple attributes will be employed in order to describe urban sprawl in a precise way. Although low density, deconcentrated, and decentralized land-use patterns are all distinct attributes of urban sprawl, the presence of sprawl according to one attribute does not imply sprawl according to others. The expectation is that different combinations of characteristics yield different patterns of urban sprawl. This approach is based upon Cutsinger and Galster's (2006) position that "there is no sprawl syndrome;" and that instead, there are a number of sprawl typologies.

To be more specific, suppose two metro areas exhibit low density development patterns, which at first glance would indicate sprawl in both cases; but if one is relatively concentrated while the other is relatively even, the latter is generally considered more sprawl-like while the former is not. For example, both Mansfield, OH and Redding, CA have similarly low residential housing densities. However, the spatial distribution of housing in Redding is very concentrated, while in Mansfield it is more even. As such, Mansfield exhibits a higher degree of urban sprawl than Redding. Alternatively, two metro areas could exhibit high density development patterns, which is not an associated characteristic of sprawl; however, if one metro area is decentralized while the other is more centralized, the former is considered more sprawl-like while the latter is not. For

example, both Oakland, CA and New Orleans, LA have similarity high employment densities. However, since the Oakland labor market is much more decentralized, it exhibits a higher degree of urban sprawl.

Third, the selection of these three attributes is based upon a significant degree of empirical correlation with notable alternatives in the literature. According to the review by Cutsinger et al. (2005), density indexes are highly correlated with indexes of continuity and mixed land use, which means that low-density metro areas tend to exhibit discontinuous development patterns with fewer mixes of land use, while high-density areas tend to exhibit continuous development patterns with greater mixed-use development. Additionally, both concentration and centrality measures are positively correlated with measures of proximity, which indicates that concentrated and centralized metro areas tend to exhibit greater proximity between housing or jobs (or housing and jobs), and vice versa.

Fourth, the purpose of housing and employment as the operational measures of urban sprawl, as opposed to population, is to relate the economic consequences of sprawl directly to the spatial economic structure of US metro areas. Furthermore, the choice of both operational definitions is to allow for and explain potentially differing patterns of housing and employment sprawl. Galster et al. (2001) argue that measures of housing development are more useful representations of sprawl than non-residential land use, e.g. employment, for two reasons. First, in practice, urban sprawl is typically understood and referred to as a residential phenomenon. Second, non-residential land use often exhibits "lumpy" development patterns due to land regulations and agglomeration economies (Galster et al., 2001, p. 688). However, ignoring certain operational definitions because

they're less likely to exhibit sprawl brings an unnecessary degree of endogeneity to the concept of urban sprawl itself. Although Galster et al. are correct in their position that such patterns create difficulties in interpreting average measures, at an empirical level, alternative measures exist that can discern distributional patterns at disaggregated levels. At a theoretical level, distinguishing housing from employment sprawl will be a crucial component to understanding the connections between income distribution and the topics of this research agenda. Ciscel's (2001) analysis of urban sprawl in Memphis, Tennessee is helpful in this regard. While high-income residents were more likely to live in the suburbs and work in the central city, low-income residents were more likely to live in the central city and work in the suburbs. This observation leads to differing patterns of sprawl using a centrality definition, for example. Low-income residents exhibited a centralized housing pattern, while high-income residents exhibited a sprawl-like or decentralized housing pattern. With respect to employment, however, low-income residents exhibited a decentralized pattern, while high-income residents exhibited a centralized or non-sprawl-like pattern.

Each of the following empirical measures will be measured on a continuum. With the exception of the Glaeser-Kahn centrality measure, low values indicate a higher degree of urban sprawl, while high values indicate a lower degree of sprawl. Since urban sprawl is a configuration of multiple, and sometimes countervailing patterns, this research avoids the threshold definitions of urban sprawl suggested in the literature at times. Table 2.1 summarizes the empirical measures discussed in the following sections, their interpretations as measures of sprawl, as well as their possible range of numerical values.

2.3.1 Density

Density is arguably the most recognizable attribute of urban sprawl. It is frequently the first characteristic cited by most studies. Density refers to the efficiency of land use, i.e. the intensity of economic development relative to land area. It is formally defined as the frequency of economic development per square mile. Although there is little debate over what density means as an economic concept, there is significant debate over the proper operational definitions of both economic development (e.g. housing, jobs, and/or population) as well as the enclosing boundary of the metro area (e.g. extended urban areas, metropolitan statistical areas, and urbanized areas). All else constant, low density development constitutes a high degree of urban sprawl. High density development therefore constitutes a low degree of sprawl. Density values can be equal to zero, but they have no maximum. This dissertation features two categories of empirical density measures: average metro area (MA) densities as well as densities of percentiles.[9]

2.3.1.1 Average MA Density

Several studies use average MA density as a measure of urban sprawl (Cutsinger & Galster, 2006; Cutsinger et al., 2005; Galster & Cutsinger, 2007; Galster et al., 2001; Malpezzi, 1999; Malpezzi & Guo, 2001; Wolman et al., 2005). Average MA density, defined as the number of residential housing units (or employees) per square mile, is the ratio of total MA housing units (or total MA jobs) to total MA land area:

[9] For additional studies using variations of empirical density measures, see Ewing et al. (2002), Fulton et al. (2001), Nasser and Overberg (2001), and Pendall and Carruthers (2003).

$$\frac{X}{A} = \frac{\sum_{i=1}^{n} x_i}{\sum_{i=1}^{n} a_i},$$

where X equals total MA housing units (or jobs), A equals total MA land area, x_i is the number of housing units (or jobs) in areal unit i, a_i is the land area of unit i, and n is the total number of areal units in a metro area. The obvious drawbacks of this measure are that it cannot discern variations in density or density patterns, and is extremely sensitive to the boundary definition of a metro area. The empirical findings of this chapter indicate that such criticism is not insignificant.

2.3.1.2 Densities Using Percentiles

Due to the limitations of average densities, Malpezzi (1999) and Malpezzi and Guo (2001) suggest a number of alternative density measures based upon percentiles of the empirical distribution of economic development. These densities are of a reduced areal unit, such as a census tract or ZIP code tabulation area. When areal units are sorted by ascending density, the following indexes elicit patterns of density over the empirical distribution of total MA housing (or employment):

Maximum areal unit density: $\max\left(\frac{x_i}{a_i}\right)$

Density of the 90th percentile housing unit (or job): $\frac{x_i}{a_i}$ *if* $\frac{\rho(x_i)}{X} = 0.90$

Density of the 75th percentile housing unit (or job): $\frac{x_i}{a_i}$ *if* $\frac{\rho(x_i)}{X} = 0.75$

Density of the median housing unit (or job): $\frac{x_i}{a_i}$ *if* $\frac{\rho(x_i)}{X} = 0.50$

Density of the 25th percentile housing unit (or job): $\frac{x_i}{a_i}$ *if* $\frac{\rho(x_i)}{X} = 0.25$

Density of the 10th percentile housing unit (or job): $\frac{x_i}{a_i}$ *if* $\frac{\rho(x_i)}{X} = 0.10$

Minimum areal unit density: $\min(\frac{x_i}{a_i})$,

where X, x_i, and a_i are defined as before, x_i/a_i equals the density of areal unit i, and $\rho(x_i)/X$ equals the cumulative share of housing (or jobs) through areal unit i.[10] In sum, these indicators are a more complex summary of how density varies over the total number of metro area residences (or jobs). The maximum, 90th percentile, and 75th percentile densities measure the extent of high-density economic development. The minimum, 10th percentile, and 25th percentile densities measure the extent of low-density economic development. The density of the median posits the intensity of economic development in the surroundings of the median housing unit (or job). The question here is how dense are the high-density areas of a metro area? Or alternatively, how sparse are the low-density areas at the urban fringe? The expectation is that there is a significant degree of variation in areal unit densities around MA averages. What is more, these measures are less sensitive to the operational definition of the metro area boundary, since they are based upon densities of smaller areal units. Average MA densities in the West, for example, are easily skewed by metropolitan statistical area definitions that include large outlying counties, which are often larger than some entire states. The empirical results of this chapter indicate that the alternative economic perspective of density presented by these measures is warranted.

[10] All densities based upon percentiles are weighted by the number of housing units (or jobs) per areal unit.

2.3.2 Concentration

Concentration is the extent to which economic development takes place in relatively few places, or over relatively few square miles. It refers to the relative share of spatial area that is occupied by housing (or employment) across an MA. This is a facet of urban sprawl that is distinct from density: the distribution of economic development over physical space. Average densities only elicit the average intensity of economic development; they give no indication of the evenness or spatial pattern of economic development. Furthermore, although densities based upon percentiles certainly elicit variations in density patterns, those variations occur only over the empirical distribution of total housing (or jobs), and not over the spatial area that low- or high-density development occupies. Concentration measures the degree to which economic development is disproportionately uneven at high densities, or disproportionately even at low densities. All else constant, a concentrated housing (or employment) pattern constitutes a low degree of sprawl, since development occupies a small share of space. A deconcentrated pattern therefore constitutes a high degree of urban sprawl, since development is even.

The question then, both conceptually and empirically, is the relationship between density and concentration as distinct characteristics of urban sprawl. Taken together, a metro area characterized by both low densities and deconcentration would exhibit the highest degree of sprawl. A metro area characterized by both high densities and concentration would conversely exhibit the lowest degree of sprawl. However, the presence of urban sprawl on one attribute does not necessarily entail the presence of urban sprawl on others. Urban sprawl is defined here as an intersection of multiple

attributes, which often combine in countervailing ways. Some low density metro areas may in fact be concentrated, while some high density metro areas may be deconcentrated. As such, this dissertation features two categories of empirical concentration measures: the Delta index and the Gini coefficient.[11]

2.3.2.1 The Delta Index

The Delta index appears in both the urban sprawl (Cutsinger & Galster, 2006; Cutsinger et al., 2005; Galster & Cutsinger, 2007; Galster et al., 2001; Wolman et al., 2005) as well as the racial and ethnic segregation literatures (Iceland, Weinberg, & Steinmetz, 2002; Massey & Denton, 1988; Massey, Denton, & Phua, 1996) as an empirical measure of concentration. The Delta index is similar to the Index of Dissimilarity, and has a practical interpretation with respect to urban sprawl. The value indicates the share of metro area housing (or employment) that occupies areas of above-average densities, and would therefore have to physically move in order to achieve even densities across all areal units of an MA. The formula is as follows:

$$0.5\sum_{i=1}^{n}\left|\left(\frac{x_i}{X}\right)-\left(\frac{a_i}{A}\right)\right|,$$

where X, A, x_i, a_i, and n are defined as before. The term x_i/X equals the share of housing (or employment) in areal unit i relative to total MA housing (or employment). The term a_i/A equals the share of land area in areal unit i relative to total MA land area.

This indicator ranges between zero and one. A value of zero indicates complete deconcentration, or a completely even distribution of economic development across all

[11] For alternative empirical concentration measures, see Galster et al. (2001), Lopez and Hynes (2003), Malpezzi (1999), and Malpezzi and Guo (2001).

areal units, since no housing (or employment) need to shift to attain evenness. A value of one indicates complete concentration of economic development, since all residences (or employees) are located in one single area. Lower values therefore indicate a higher degree of urban sprawl, while higher values indicate a lower degree of urban sprawl.

The formula for the Delta index is based upon a Lorenz curve of housing (or employment) distribution, which in this case relates the proportion of economic development to the share of land area in a given metro area. The term $|(x_i/X)-(a_i/A)|$ is the absolute difference or 'dissimilarity' between the share of housing (or jobs) and the share of land area of a given areal unit. A greater difference indicates greater dissimilarity, while a smaller difference indicates less dissimilarity. The index is the summation of those differences for all areal units in a metro area. A higher degree of dissimilarity signals a higher degree of concentration. A lower degree of dissimilarity signals a lower degree of concentration, and thus a higher degree of sprawl.[12]

2.3.2.2 The Gini Coefficient

The Gini coefficient is also a possible empirical measure of urban sprawl (Malpezzi, 1999; Malpezzi & Guo, 2001). It has been utilized widely in the economics, geography, segregation, and biology literatures as an index of inequality or concentration in the distribution of a variable. A Gini coefficient for housing (or employment) is defined by the following formula:

$$1-\sum_{i=1}^{n}\left(\frac{\rho(x_{i-1})}{X}+\frac{\rho(x_i)}{X}\right)\left(\frac{\rho(a_{i-1})}{A}-\frac{\rho(a_i)}{A}\right),$$

[12] Alternatively, one could think of the Delta Index as the sum of vertical differences between the line of perfect equality and the Lorenz curve.

where X, A, and n are defined as before, $\rho(x_i)/X$ is the cumulative proportion of housing (or employment) through areal unit i, and $\rho(a_i)/A$ is the cumulative proportion of land area through areal unit i when units are ordered in ascending density.

The Gini coefficient also ranges between zero and one. Zero indicates complete deconcentration (perfect equality in distribution) while one indicates total concentration (perfect inequality in distribution). The higher the Gini value, the more unequal the distribution between economic development and land area, which in this setting indicates concentration of housing (or employment). The lower the Gini value, the more proportional the distribution of housing (or employment) relative to land area, which indicates deconcentration. Lower values therefore indicate a higher degree of urban sprawl, and vice versa.

Like the Delta index, the Gini formula is derived from a Lorenz curve of the cumulative proportion of housing (or employment) relative to the cumulative proportion of land area. The Gini value is the share of the triangular area defined by the lines of perfect equality and perfect inequality located above the Lorenz curve. The lesser the gap between the Lorenz curve and the diagonal of perfect equality, the lesser the degree of concentration, which constitutes a higher degree of sprawl. The greater the gap between the Lorenz curve, the greater the degree of concentration, which constitutes a lower degree of urban sprawl.

2.3.3 Centrality

Centrality refers to the extent of housing (or employment) around an identifiable central business district (CBD). According to the 1982 Census of Retail Trade (US

Census Bureau, 1984), a CBD is “an area of very high land valuation characterized by a high concentration of retail businesses, service businesses, offices, theaters, and hotels, and by a very high traffic flow.” Lack of centrality, or decentralization, is therefore a crucial attribute of urban sprawl. It represents the diffusion of economic activity away from a specific and often historical point of concentration. Empirical measures of decentralization capture the pattern of declining density and perhaps the declining economic significance of the historical urban core. These features play significant roles in mainstream as well as radical perspectives on the economics of location for their effects on urban standards of living, segregation, and the spatial structure of employment. The possible lack of a CBD is also interesting. The absence of any identifiable center (or centers) of economic development would also characterize urban sprawl in the form of deconcentration. All else constant, decentralized housing (or employment) constitutes a high degree of urban sprawl. Centralized economic development constitutes a low degree of urban sprawl.

The critical issue then, is the relationship between concentration and centrality as distinct attributes of urban sprawl. On the one hand, a deconcentrated and decentralized metro area exhibits the highest degree of urban sprawl. On the other hand, a concentrated and centralized metro area exhibits the lowest degree of urban sprawl in the form of 'mononuclearity.' As was the case with density and concentration, deconcentration does not necessarily imply decentralization, nor does concentration necessarily imply centralization. The expectation is that there are intersecting degrees of sprawl when multiple attributes are taken together. For example, the ‘edge city’ or 'polynuclear' phenomenon would consist of a relatively high degree of concentration, and potentially

density, but a relatively low degree of centralization.[13] The empirical results of this chapter indicate that these differences are fundamental to both a conceptual and empirical understanding of urban sprawl. For that purpose, this dissertation features three empirical measures of centrality, each of which considers slightly different aspects of centrality: the Glaeser-Kahn method, the Absolute Centralization index, and the Standardized Centrality index.[14]

2.3.3.1 The Glaeser-Kahn Method

The Glaeser-Kahn method, commonly referred to as the 'Job Sprawl' measure, is a prominent feature of the empirical literature since the early 2000's (Chu, 2000; Glaeser & Kahn, 2001; Glaeser et al., 2001; Kahn, 2001; Kneebone, 2009; Stoll, 2005, 2007). The facet of decentralization captured by this measure is the occupation of economic development in the periphery of a metro area. In their original article, Glaeser and Kahn (2001) define three demarcation radii around a central business district: one at three miles, one at ten miles, and one at thirty-five miles.[15] The thirty-five mile radius bounds the land area of the metro area, as opposed to an official boundary.[16] They argue that the area between the CBD and the three-mile radius measures the degree of economic centralization around a central node. The area between the three-mile radius and the ten-

[13] See Garreau (1991).

[14] For additional studies featuring variations of centrality measures, see Ewing et al. (2002), Galster et al. (2001), Malpezzi (1999), Malpezzi and Guo (2001), Song (1996), and Wolman et al. (2005).

[15] Given the considerable amount of variation in the size (and official definitions) of metropolitan areas, these demarcations are rather arbitrary. Glaeser and Kahn seem to focus more on the economic consequences of urban sprawl, rather than some of the more nuanced geographic aspects of its definition.

[16] Empirical results do not differ significantly when using an official boundary as opposed to the thirty-five mile limit.

mile radius measures the extent of economic development in the beltway or inner suburbs of a metro area. The area between the ten-mile radius and the thirty-five mile limit then measures the extent of economic decentralization.[17] The Glaeser-Kahn sprawl measure is therefore defined as the proportional share of economic development in the outermost ring relative to the total sum of economic activity within thirty-five miles of a CBD. The formula is as follows:

$$\frac{\sum_{d_{ic} \leq 35}^{d_{ic} > 10} x_i}{\sum_{d_{ic} \geq 0}^{d_{ic} \leq 35} x_i},$$

where d_{ic} is the distance between a CBD centroid and the centroid of areal unit *i*, the numerator is the sum of all housing units (or employees) between ten and thirty-five miles from a CBD, and the denominator is the total number housing units (or employees) within thirty-five miles of a CBD.[18]

This index ranges between zero and one. A value of zero implies that no housing (or employment) is located in the outermost ring. A value of one implies that all of a metro area's housing (or employment) is located in the outermost ring. Unlike the empirical measures discussed thus far, a higher value on this index implies a higher degree of sprawl, since it represents greater economic activity in the periphery of a metro

[17] Distances (*d*) between the centroid of a CBD and the centroids of all areal units are calculated using a standard Haversine formula: $d = r * [2\sin^{-1}(\sqrt{\sin^2(\frac{\Delta\alpha}{2}) + \cos\alpha\cos\alpha_{cbd}\sin^2(\frac{\Delta\Omega}{2})})]$, where *r* is the radius of the Earth, specified here as 6,371 kilometers or approximately 3,959 miles; $\Delta\alpha$ is the latitudinal difference between a CBD centroid and an areal unit centroid in radians; α is the latitude of an areal unit centroid in radians; α_{cbd} is the latitude of a CBD centroid in radians; and $\Delta\Omega$ is the longitudinal difference between a CBD centroid and an areal unit centroid in radians.

[18] Areal units are assigned to a ring if their geographic centroid falls within a radius.

area. A lower value implies a lower degree of urban sprawl, since it represents lesser economic activity in the periphery.

2.3.3.2 The Absolute Centralization Index

Although it has been utilized primarily as a measure of segregation (Iceland et al., 2002; Massey & Denton, 1988; Massey et al., 1996), Galster et al. (2001) suggest the Absolute Centralization index as an alternative measure of centrality. The facet of urban sprawl captured in this case is the accumulation of housing (or employment) relative to land area as one moves outward from a CBD. This is a slightly different perspective on decentralization than the Glaeser-Kahn method. This index measures how quickly economic development accumulates relative to land area. Beginning at a CBD, if housing (or employment) accumulates relatively faster than land area, a metro area exhibits centrality. If land area accumulates relatively faster than housing (or employment), a metro area is decentralized, since development accumulates more at the periphery. Interpretation of the Absolute Centralization index is similar to the Delta index. The Absolute Centralization index measures centrality as the percentage of total residential housing units (or jobs) across a metro area that would need to shift areal units in order to attain a uniform distribution across all areal units around a CBD, according to the formula:

$$\sum_{i=1}^{n}\left(\frac{\rho(x_{i-1})}{X} * \frac{\rho(a_i)}{A}\right) - \sum_{i=1}^{n}\left(\frac{\rho(x_i)}{X} * \frac{\rho(a_{i-1})}{A}\right),$$

where all variables are defined as before, and areal units are ordered by increasing distance from a CBD.

This index ranges between negative one and positive one. Positive results mean

that economic development accumulates closer to a CBD, while negative results mean that development accumulates in the periphery. A value of zero indicates that housing (or employment) exhibits a uniform distribution pattern around a CBD. As such, lower values on this index indicate relatively less centralization and a higher degree of urban sprawl. Higher values indicate relatively more centralization and a lower degree of urban sprawl.

2.3.3.3 The Standardized Centrality Index

The Standardized Centrality index, utilized by Cutsinger and Galster (2006), Cutsinger et al. (2005), and Galster and Cutsinger (2007), measures an aspect of centrality that is different from the two measures discussed so far. This index captures more explicitly the relative degree of distance between economic development and a CBD. The difficulty, however, is that distance as an index of decentralization can systematically vary with the areal size of a metro area. Physically larger metro areas should not be described as more decentralized simply because they are larger in size, nor should smaller areas be described as more centralized because they are smaller in size. As such, the aforementioned authors propose an alternative measure of centrality that adjusts for physical scale. The Standardized Centrality index is the average distance between an areal unit and a CBD, relative to the average distance between a housing unit (or job) and a CBD:

$$\frac{\frac{\sum_{i=1}^{n} d_{ic}}{n}}{\frac{\sum_{i=1}^{n} d_{ic} x_i}{X}}.$$

All variables are defined as before. The numerator is the average distance between a CBD centroid and an areal unit centroid. The denominator is the average distance between a CBD centroid and an areal unit centroid, weighted by the number of residential housing units (or employees) in each areal unit.

Although this measure must be greater than zero, since the average distance could never be zero, it has no maximum. A value of one indicates that the average distance between an areal unit and a CBD is proportional to the average distance between a housing unit (or job) and a CBD. A value greater than one indicates centralization, since the average housing unit (or job) is closer to the CBD than the average areal unit. A value less than one indicates decentralization, since the average housing unit (or job) is farther from the CBD than the average areal unit. Lower values on this index therefore imply higher degrees of urban sprawl, while higher values indicate lower degrees of sprawl.

2.4 Data Description

The goal of this chapter is to present a comprehensive empirical summary of urban sprawl patterns in the United States. The choice of data therefore reflects the economic and empirical objectives of the dissertation. The basic unit of observation and comparison is the metro area. The term 'sprawl' and the empirical measures used to describe it refer to an entire metro area (such as average density), although certain measures refer to circumstances at a reduced area of analysis (such as the Glaeser-Kahn method). For example, one would say ‘Mobile exhibits a greater degree of urban sprawl than Minneapolis.’ Urban sprawl describes particular distribution patterns of housing and

labor markets that often occur at smaller areal units across a metro area. As such, empirical analysis of urban sprawl requires data at small geographic levels that can be aggregated to the metro area level. Furthermore, comparison of different operational definitions of sprawl requires both housing and employment data at such levels.

This study utilizes the boundary definitions of metropolitan statistical areas (MSA), primary metropolitan statistical areas (PMSA), and New England county metropolitan areas (NECMA) for 1999 – 2000.[19] These definitions were chosen so that all census tract boundaries within the sample are unique to, i.e. do not cross, metropolitan area boundaries. Census tracts are uniquely identified within all non-New England MSA/PMSA boundaries. They are not uniquely identified within New England MSA/PMSA boundaries, but are unique to NECMA boundaries.

The 1982 Economic Censuses: Geographic Reference Manual (US Census Bureau, 1983) reports the geographic location of central business districts, which are specifically required for all centrality measures. Local officials were asked to spatially define a CBD as one or more contiguous census tracts according to 1980 boundary definitions. In cases where the metropolitan area definition contains multiple names, the CBD of the primary name was used. The GIS software package ArcGIS (version 9.3)

[19] The Office of Management and Budget (OMB) defines metropolitan areas. A metropolitan area consists of one or more large population centers and the surrounding areas that have economic and social connections to that center or centers, which consist of commuting patterns and urban population, as well as population density and growth. Formally, a metropolitan area must contain a place with a population of at least 50,000 persons or a Census-defined urbanized area, and have a total population of at least 100,000 persons (75,000 in New England). They are comprised of the whole county that contains the center (or counties that contain the centers) and the adjacent whole counties that exhibit the aforementioned connections. There are multiple categories of metropolitan areas. The consolidated metropolitan statistical area (CMSA) is a metropolitan area with a total population of at least one million persons. Two or more primary metropolitan statistical areas (PMSA) comprise a CMSA. The standard metropolitan statistical area (MSA) is simply a metropolitan area that is independent of any other definition. Their adjacent counties (county subdivisions in New England) are typically non-metropolitan in nature. New England MSA's consist of adjacent cities, county subdivisions, and towns, as opposed to whole counties. The New England county metropolitan area (NECMA) is an alternative county-based definition for New England specifically.

was used to merge contiguous tracts into one area, and then determine the geographic centroid of each uniform CBD. Previous studies have cautioned against using the 1982 CBD definitions due to the declining economic significance of central cities, and the rising significance of 'edge cities,' especially with respect to employment location. However, evidence of such a of phenomenon would not only be interesting from a historical perspective, but would also indicate a pattern of urban sprawl; namely, decentralization and perhaps polynuclearity. Recent studies have alternatively proposed the location of city hall as a locus (Cutsinger & Galster, 2006; Cutsinger et al., 2005; Galster & Cutsinger, 2007; Galster et al., 2001; Wolman et al., 2005), a choice that is questionable due to the lack of any theoretical relationship between city halls and the spatial distribution of housing and employment.

The US Census Bureau's cartographic boundary files (US Census Bureau, 2000a) are the source of all spatial data for 1999 – 2000, namely all metropolitan area boundaries, census tract boundaries, and ZIP code tabulation area boundaries. The National Historical Geographic Information System (Minnesota Population Center, 2010) is the source of census tract boundaries for 1980.

In total, given the selection of metropolitan area definitions and the availability of CBD spatial data, 272 US metropolitan areas comprise this study. The OMB definitions cover 258 MSA's and 73 PMSA's. Subtracting the 25 New England MSA's and PMSA's, and adding the 12 NECMA's yields a sample of 318 metropolitan areas. However, 46 metropolitan areas were excluded because the Geographic Reference Manual did not identify a CBD in 1982.[20]

[20] See Table 2.2 for a list of the 46 metropolitan areas excluded from the sample. With respect to region, nine metro areas are in the Northeast, two are in the Midwest, twenty-one are in the South, and fourteen are

The source of all residential housing data is the Census 2000 Summary File 1 (US Census Bureau, 2000b). This research uses the census tract as the areal unit for housing sprawl. The drawbacks of using census tracts are well-documented in this literature, as well as others. Census tracts have an optimal population of roughly 4,000 persons, but can range between 1,500 and 8,000 persons per tract. The areal size of census tracts therefore systematically increases at the urban fringe and decreases in densely-populated areas in order to maintain homogeneous population, residential, and other economic characteristics. Both concentration indexes as well as the Absolute Centralization index may be sensitive to this drawback. Furthermore, the number of tracts per metropolitan area also varies for the reasons previously stated. Density analysis using percentiles as well as the Standardized Centrality index may be sensitive to this drawback. However, census tracts are the most widely-used geographic unit in both the urban sprawl as well as the racial and ethnic segregation literature, and the problems associated with tracts would not be circumvented by using blocks, block groups, or counties. Although they are sometimes split or merged to accommodate changes in population or the physical landscape of the area – due to construction, development, or changes in transportation networks – census tracts are intended to be relatively small, stable, and permanent areal units from census to census. Summary File 1 provides all data necessary for constructing all empirical measures of residential housing sprawl, including housing unit and population counts, land area, geographic reference information, and tract centroids. Since tracts are unique to metropolitan areas, no spatial manipulation of the data is required.

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in the West. With respect to population, the largest are: Nassau-Suffolk, NY; Bergen-Passaic, NJ; Middlesex-Somerset-Hunterdon, NJ; and Monmouth-Ocean, NJ. The remaining metro areas have a population of less than 500,000 persons.

The source of employment data is Zip Code Business Patterns 2000 (US Census Bureau, 2002), maintained by the US Census Bureau. This research uses the ZIP code tabulation area (ZCTA) as the areal unit for employment sprawl.[21] ZCTA's are groups of census blocks that very roughly correspond to US Postal Service five- or three-digit ZIP code delivery areas.[22] They are not uniquely identified within any larger geographic entities, vary widely in areal size, and are often divided into multiple discontiguous areas. Although ZCTA's can be difficult geographic units to work with, Zip Code Business Patterns is the most comprehensive data source for employment counts at small geographic units. Using Zip Code Business Patterns in this research context is also not without precedent, as they have been employed in the 'Job Sprawl' literature. The data include the following micro-level information by ZIP code: total mid-March employment; total number of business establishments; total establishments by an employee-size class; total establishments by industry according to the North American Industry Classification System (NAICS); and summary first-quarter and annual payroll information.[23] The data do not include information about the self-employed, domestic service, railroad, and agricultural workers, as well as most government employment.[24]

A number of adjustments were made in order to make the data compatible with

[21] The ZCTA was a new areal unit with Census 2000. They are not directly comparable to any previous approximations of ZIP code areas.

[22] ZCTA's do not necessarily include all of the mail codes used by the Postal Service, since many ZIP codes do not correspond to actual areas.

[23] The employee-size categories are as follows: 1-4, 5-9, 10-19, 20-49, 50-99, 100-249, 250-499, 500-999, and 1,000 or more employees.

[24] The Census Bureau uses a number of sources to construct the Zip Code Business Patterns. The primary source is the Bureau's Business Register, a list of all known and reported single and multi-establishment companies. Other Bureau programs, such as the Company Organization Survey, and the Annual Survey of Manufactures and Current Business Surveys, comprise the data. Additional information is extracted from the Internal Revenue Service and the Social Security Administration.

the structure of this study. First, the data do not include locations of geographic centroids. As such, ZCTA centroids were extracted from the cartographic boundary files using ArcGIS. Second, since ZCTA's are not unique to OMB metropolitan area definitions, they were identified with a metropolitan area if their centroid fell within the metropolitan area boundary.[25] Third, total employment estimates were constructed for suppressed entries. For confidentiality reasons, the Census Bureau suppresses between fourteen and fifteen percent of total employment data in cases that would reveal the operations of a particular establishment. In those cases, the Bureau does report the number of establishments by employee-size category and industry, along with a suppression flag indicating the range of total employment for the suppressed ZIP code.[26] The standard methodology, and the one used by the 'Job Sprawl' studies, is to use the average of each employee-size category, multiply that average by the number of establishments, and then add the estimates for all size categories to reach a total employment estimate for the suppressed ZIP code.[27] Firms with 1,000 or more employees were applied an employment level of 1,250 employees. In cases where the employment estimate exceeded the maximum defined by the suppression flag, the maximum value of the flag was applied. Finally, ZCTA's are often split into discontiguous areas that sometimes cross metropolitan area boundaries. In such cases, total employment was applied to each area according to its geographic share of the ZCTA.

[25] All spatial analysis was conducted using the geographic coordinate system WGS84.

[26] The suppression flags are as follows: 0-19, 20-99, 100-249, 250-499, 500-999, 1,000-2,499, 2,500-4,999, 5,000-9,999, 10,000-24,999, 25,000-49,999, 50,000-99,999, and 100,000 or more employees.

[27] For example, suppose a suppressed ZIP code contained 6 establishments in the 1-4 employees category, 1 establishment in the 10-19 employees category, 2 in the 20-49 category, and 1 in the 50-99 category. The estimate would be: 6*2.5 + 1*14.5 + 2*34.5 + 1*74.5 = 173 total employees.

A comprehensive data set was then constructed by attaching employment data to all ZCTA's (or portions of ZCTA's) whose centroids fell within a metropolitan area boundary. ZCTA's corresponding to water features were dropped from the sample entirely. Those that had no corresponding match in the employment data, which were predominately large unsettled areas, were applied an employment estimate of zero.

2.5 Results and Analysis

For the sake of consistency and dialogue, this dissertation adopts multiple empirical measures of urban sprawl that have been suggested or utilized in the literature. However, the empirical findings of this chapter are not necessarily replications of previous studies, and in many cases are important updates or extensions of those findings. The results of this chapter differ from select studies in four principal ways. First, this research uses spatial, housing, and employment data for the year 2000. With one exception, the principal sources for all empirical measures use 1990's spatial and economic data, such as Malpezzi (1999) and Malpezzi and Guo (2001), the 'Galster Group' studies (Cutsinger & Galster, 2006; Cutsinger et al., 2005; Galster & Cutsinger, 2007; Galster et al., 2001; Wolman et al., 2005), and the early Glaeser-Kahn articles (Glaeser & Kahn, 2001; Glaeser et al., 2001; Kahn, 2001). Kneebone (2009) is the one exception. Second, this research queries a larger sample than the 'Galster Group' articles, whose sample sizes are limited to no more than fifty extended urban areas, as well as Glaeser at al. and Kneebone, who limit their samples to the one-hundred and ninety-eight largest metropolitan statistical areas, respectively. Third, this research applies different operational definitions (i.e. both housing and employment) to a number of prominent

empirical measures in the literature. Malpezzi (and Malpezzi and Guo) restrict their analysis to population data, for example, while Glaeser-Kahn operationalize their method only to employment, and not housing. Fourth and finally, this research utilizes the 1982 CBD locations as the definition of the urban core, in contrast to the 'Galster Group' studies, which use the location of city hall.

272 metropolitan areas comprise this sample. The data set includes 48,539 census tracts and 13,844 ZCTA's that correspond to 213 metropolitan statistical areas, 49 primary metropolitan statistical areas, and 10 New England county metropolitan areas. Table 2.3 reports summary statistics for total metropolitan area population, residential housing units, employment, and land area. The mean MA population for the sample is 781,172 people, although the median is 347,300.5 people. The average MA also has 313,609.9 residential housing units and 321,246 jobs. The median, however, has approximately 140,172 housing units and 120,723.3 jobs. The results for total land area depend upon the areal unit considered. According to the census tract definition, the average MA is 2,297.9 square miles compared to a median of 1,568.5 square miles. According to the ZCTA definition, the average MA is 2,341.9 square miles compared to a median of 1,597.7 square miles. Although differences in the operational definition of land area are typically small, there are a limited number of cases where the deviations are significant. These cases, typically MA's in the West, contain a small number of enormous ZCTA's in their peripheral areas. On the one hand, a large ZCTA whose centroid falls within the MA boundary may contain a significant amount of territory outside of the boundary, which would increase the estimate relative to the official MA definition. On the other hand, if the centroid of a large ZCTA falls outside of the MA boundary, the total

land area estimate would be much less since the ZCTA would not be counted as part of the estimate.

Regional variations in urban sprawl will be an important part of this analysis.[28] As such, Table 2.4 reports the distribution of metropolitan areas by census region. The South holds the largest share of MA's in the sample with 39.3%. The Midwest has the next largest share with 27.9% of the sample, followed by the West (18.8%), and finally the Northeast (14%).

Metropolitan areas also vary widely in total population size. Table 2.5 summarizes the distribution of metropolitan areas by a population-size class maintained by the Census. Over half of the metropolitan areas in this study fall within two size classes: 32.4% have a population between 100,000 and 249,999 people, while 21.7% have a population between 250,000 and 499,999 people. Only 4% of the MA's in this study have a population less than 100,000. The shares of MA's in the 500,000 to 999,999 and 1,000,000 to 2,499,999 ranges are 12.1%, respectively. The remaining 17.6% have a population of 2,500,000 or more; 6.6% in the 2,500,000 to 4,999,999 class, and 11% in the 5,000,000 or more class.

The remainder of this section discusses empirical findings for both residential housing and employment sprawl; namely, summary statistics, regional means, correlates between each measure and metropolitan size, as well as correlates among each measure. On the first correlation analysis, empirical measures should not systematically vary with metropolitan size. There are two definitions of metropolitan size, both of which are

[28] Seven metropolitan areas in the sample occupy multiple census regions: Cincinnati, OH-KY-IN; Evansville-Henderson, IN-KY; Huntington-Ashland, WV-KY-OH; Louisville, KY-IN; Parkersburg-Marietta, WV-OH; Steubenville-Weirton, OH-WV; and Wheeling, WV-OH. Those metropolitan areas were assigned to the region that held the highest share of total MA population.

considered in this analysis: population size and areal size. A correlation coefficient of zero in this case indicates that the index is independent of metropolitan size. A non-zero correlation coefficient indicates a systematic relationship between sprawl and size. On the second correlation analysis, the purpose is to examine empirical connections within, and between, different attributes of sprawl. A high degree of correlation between indexes of the same attribute ('intra-attribute' correlation) implies that the indexes elicit the same land-use characteristic. A low degree of correlation implies that each index is an independent measure of a common attribute. A high degree of correlation between measures of different attributes ('inter-attribute' correlation) indicates empirical overlap between the attributes. A low degree of correlation indicates that the attributes are empirically independent according to the measures considered. See Table 2.6 for a list of metropolitan areas that exhibit the highest, median, and lowest degrees of urban sprawl according to select measures.

2.5.1 Analysis of Residential Housing Sprawl

2.5.1.1 Residential Housing Density

Residential housing markets largely exhibit a higher degree of urban sprawl through lower densities. The empirical evidence on housing density varies by indicator. According to Table 2.7, the average metropolitan area has 174.17 housing units per square mile, which is slightly higher than the corresponding figure for employment.

Density indexes using percentiles offer detail on the intensity of residential housing distribution. The sample mean for tract density of the median housing unit is 964.39 residences per square mile. On the high-density indexes, the mean tract densities

of the 75th and 90th percentile housing units are 1,953.31 and 3,252.64 residences per square mile, respectively. The mean value for maximum tract density is 7,945.04 units per square mile. On the low-density indexes, the mean tract densities of the 10th and 25th percentile housing units are 105.07 and 342.92 residences per square mile, respectively. The mean value for minimum tract density is 7.88 units per square mile. With the exceptions of the 25th percentile and minimum measures, and unlike the average MA measure, percentile indexes for housing density are lower than those for employment. These findings support the common observation (and empirical evidence) in the literature that housing distribution is more sprawl-like than non-residential economic development through lower densities.

Variations in housing density by region are apparent. Table 2.8 reports regional means by indicator. From a density perspective, the South exhibits the highest degree of sprawl. The regional mean for each density index is below its sample mean. The South ranks lowest in average MA density, lowest on four percentile indexes, and second-lowest on the remaining three measures. The Midwest exhibits a similar pattern, albeit at slightly higher housing densities. With the exception of minimum tract density, all regional means are below their sample means. The Midwest ranks second-lowest on average MA density and four percentile indexes, and lowest on two remaining measures. Metropolitan housing markets in the West generally exhibit high densities. Although the West has the lowest mean value for minimum tract density and a low average MA density, all of the regional percentile indexes are higher than their respective sample means. This finding is likely due to the extremely large areal size of several metropolitan statistical area definitions in this region. The Northeast ranks highest in mean housing

density on all indexes, and therefore exhibits the lowest degree of urban sprawl according to this attribute.

Measures of residential housing density are sensitive to population size. Table 2.9 summarizes the correlation coefficients between all empirical measures of housing density and metropolitan size. There is a statistically significant correlation between total MA population and average MA density. More populated metropolitan areas tend to have higher average housing densities, and therefore exhibit a lower degree of sprawl. This pattern is repeated to a greater extent for all percentile-based measures except minimum tract density. With respect to physical size, there is a weak and insignificant correlation between total MA land area and average MA density. This pattern is repeated again for all percentile indexes except minimum tract density.

Table 2.10 presents a bi-variate correlation matrix between all measures of residential housing sprawl. With the exception of minimum tract density, there is a significantly positive correlation between alternative measures of housing density. Those indexes therefore evoke very similar patterns of variation as empirical measures of housing distribution and urban sprawl. The correlation between minimum tract density and all alternative density measures is weak, mostly inverse, and carries varying degrees of significance. Correlation coefficients between density and concentration measures are generally low, which suggests that the two characteristics are independent attributes of housing sprawl. The significance of those coefficients varies, although those for the Gini coefficient appear to be more significant than for the Delta index. There is a notably significant inverse relationship between minimum tract density and both concentration measures. This suggests that the lowest density housing development at the urban fringe

tends to concentrate in uneven patterns. With the exception of Absolute Centralization and minimum tract density, density and centrality measures are empirically distinct. Despite their low correlation coefficients, however, those results are mostly insignificant.

2.5.1.2 Residential Housing Concentration

Residential housing markets exhibit a higher degree of urban sprawl through less-concentrated spatial patterns. There are two ways of interpreting the summary statistics for concentration. On the one hand, both mean values for housing concentration are slightly lower than their counterparts for jobs, which indicates slightly more housing sprawl. On the other hand, the values themselves indicate a fair amount of concentration. According to the Delta index, 62.02% of residential housing units would need to shift tracts to attain a uniform distribution across the average metropolitan area. Similarly, the mean Gini coefficient of 0.7409 implies considerable inequality or concentration in the distribution of housing. There are three possible explanations of these results. First, there could be a strong regional effect. Second, there could be a strong metropolitan area size effect. Third, a significant degree of housing concentration itself does not necessarily imply an insignificant degree of sprawl. If housing development concentrates in a largely centralized pattern, then it exhibits much less sprawl through mononuclearity. If housing concentrates in a multi-nodal, 'edge city' pattern in peripheral areas, then it exhibits a potentially significant degree of sprawl through polynuclearity.

Both housing concentration indexes evoke the same regional pattern. However, regional differences in concentration are not as stark as they were in density. The Northeast is the least concentrated region. The Midwest and the South have similar

concentration values that are only slightly less than their sample means. The West registers the highest degree of concentration according to both measures. As expected, low-density sprawl does not necessarily imply deconcentrated sprawl. In fact, it typically implies the opposite. High density regions like the Northeast are generally not concentrated because the intensity of development is such that no significant variations are apparent. Competitive forces in land use may be particularly high in metropolitan housing markets with significant populations, which reduce the likelihood of uneven distribution patterns. Conversely, low density regions like the South and Midwest tend to be more concentrated. In those cases, low-density housing development is counterbalanced by greater concentration or unevenness in spatial distribution. However, an inverse relationship between concentration and density is not the general case. Metropolitan housing markets in the West exhibit both high densities as well as a high degree of concentration.

Concentration in the spatial distribution of housing is independent of population size; it is less so with respect to physical size. Both housing concentration indexes are weakly correlated with total population, although only the Gini coefficient result is statistically significant. However, both indexes are positively correlated with total land area. This implies that in physically larger metropolitan areas, a greater proportional share of housing is required to attain evenness simply because there is more territory. This finding is likely the result of using metropolitan statistical area definitions, which are generally larger than other alternatives like the urbanized area or the extended urban area.

The coefficient for intra-attribute correlation in this case is significantly high.

This is to be expected, since both indicators are based upon the Lorenz curve methodology. The coefficients between concentration and centrality, however, are interesting. First, correlation between both concentration measures and the Absolute Centralization index is very high. This is not surprising, since the construction and interpretation of the Absolute Centralization index is very similar to the Delta index. For the rest of the measures, there is a positive but relatively low correlation between concentration and centrality.[29] Deconcentrated metropolitan housing development tends to be decentralized, while concentrated metropolitan housing development tends to be more centralized. That empirical linkage, however, is not particularly strong. This suggests that housing concentration, which is quite significant on average and by region, does not completely follow the decentralized pattern predicted by the neoclassical monocentric city model. All correlates between housing concentration and housing centrality are statistically significant.

2.5.1.3 Residential Housing Centrality

Metropolitan housing markets exhibit a greater degree of urban sprawl through decentralization. Although each measure treats centrality in a slightly different way, they all support a prevailing pattern of greater evenness in the spatial distribution of housing around a CBD. The mean value for the Glaeser-Kahn measure is 0.3513, which means that 35.13% of metropolitan area housing development is located in the outermost ring. The mean Absolute Centralization index for housing is 0.5824, which indicates that

[29] The negative sign between the Glaeser-Kahn index and the two concentration indexes (and others) does not imply an inverse relationship. Lower values per Glaeser-Kahn imply a greater degree of centralization, while higher values imply a lower degree of centralization. Therefore, in less concentrated areas, the Glaeser-Kahn index tends to be higher, which implies decentralization.

58.24% of housing development across a metropolitan area would need to shift tracts to attain a uniform distribution around a CBD. Finally, the mean Standardized Centrality index is 0.9591. The interpretation is that the average housing unit is 4.09% farther from a CBD than the average tract. These results are moderately to significantly lower than their respective results for employment centrality.

Regional variations in housing centrality are fairly moderate and vary by indicator. The Northeast and South generally exhibit less centralization in the distribution of residential housing. Both sets of regional means are below their sample means. The Northeast ranks lowest in centrality on the Glaeser-Kahn and Absolute Centralization indexes and second-lowest on the Standardized Centrality index. The converse is the case for the South. The implication is that although the Northeast is the least centralized in terms of the share of housing in the periphery and the accumulation of housing near a CBD, the South tends to be the most decentralized with respect to relative distance. Despite their common lack of centrality, however, the Northeast is less concentrated (and more dense) while the South is more concentrated (and less dense). Regional centrality means for the Midwest and West are all above their sample means, indicating a higher degree of centralization and a lower degree of urban sprawl. The Midwest ranks highest in centrality according to Glaeser-Kahn and third-highest on the remaining two measures. The converse is the case for the West. The implication is that while the Midwest is the most centralized with respect to the share of housing in the periphery, the West is the most centralized with respect to the accumulation of housing near a CBD, as well as relative distance. Despite their common extent of centrality, the Midwest is less concentrated (and less dense) while the West is much more concentrated

(and more dense).

The Glaeser-Kahn housing index is positively correlated with population size, and to a lesser degree, land area. This implies that larger metropolitan areas systematically appear more sprawl-like, since higher values imply greater degrees of decentralization. Although the population coefficient for the Absolute Centralization index is insignificantly low, the land area coefficient is higher for the same reason that both concentration indexes are positively correlated with land area. In this case, positive correlation implies that larger metropolitan areas tend to appear more centralized and less sprawl-like. As intended by those who developed it, the Standardized Centrality index exhibits a very low, statistically insignificant correlation with both population size and land area.

Intra-centrality coefficients evoke interesting patterns of variation in the empirical measurement of centrality. First, the Glaeser-Kahn and Absolute Centralization indexes are positively correlated. This empirical linkage is somewhat expected, since they both handle centrality in a similar way; namely, as the extent (or lack) of economic activity in the periphery. The Standardized Centrality index is a more explicit measure of relative distance, and not correlated with the alternative measures. This suggests that the Standardized Centrality index evokes an independent aspect of centrality not captured by Glaeser-Kahn or Absolute Centralization, although its coefficient with Glaeser-Kahn is not statistically significant.

2.5.2 Analysis of Employment Sprawl

2.5.2.1 Employment Density

The distribution of employment across metropolitan labor markets generally occurs at higher densities. Empirical patterns vary by measure. Table 2.11 reports summary statistics for all measures of employment sprawl. The mean value for average MA density is 164.59 jobs per square mile. From an initial average perspective, employment is distributed in a slightly less-intense or a more sprawl-like manner relative to residential housing.

According to most percentile indexes, however, labor markets exhibit a lower degree of urban sprawl through (sometimes significantly) higher densities. Only the minimum and 25th percentile indexes show lower employment densities. The mean value for density of the median job is 979.34 employees per square mile. On the high-density measures, the mean densities of the 75th and 90th percentile jobs are 2,799.80 and 7,514.02 employees per square mile, respectively. On average, the maximum ZCTA density is 62,862.92 jobs per square mile. On the low-density measures, the mean densities of the 10th and 25th percentile jobs are 121.08 and 334.62 employees per square mile, respectively. On average, the minimum ZCTA density is 4.94 jobs per square mile.

Table 2.12 summarizes regional variations in job density. While the Northeast and West exhibit the lowest degree of density-driven employment sprawl, the South and the Midwest exhibit relatively higher degrees of density-driven employment sprawl. Job density is the highest in the labor markets of the Northeast according to all measures. Job density in the West is also very high, except on average MA density and minimum ZCTA density. In contrast, the Midwest ranks lowest on five percentile measures, second-

lowest on the density of the median job and average MA density, and third-lowest on the minimum density measure. All regional means are below their corresponding sample means. With the exception of the maximum density measure, all means for the South are also below their sample means. The South ranks second-lowest on five percentile measures, and lowest on the density of the median job and average MA density.

Empirical linkages between population size and employment density are apparent. Table 2.13 reports correlation coefficients between measures of metropolitan size and measures of employment density. Although not surprising, more populated metropolitan areas exhibit a lower degree of sprawl through higher job densities, except in the case of minimum ZCTA density. With respect to physical size, however, all employment density measures exhibit extremely low, insignificant correlations with total land area.

Although a number of exceptions are apparent, the correlation coefficients between all measures of employment sprawl presented in Table 2.14 are similar to residential housing. Intra-density correlations are significantly positive, with lower coefficients between minimum density and several percentile indexes. Density-concentration and density-centrality coefficients are typically quite low, which suggests that employment density measures are largely independent from measures of concentration and centrality. However, many of those coefficients are not statistically significant.

2.5.2.2 Employment Concentration

The spatial distribution of jobs in metropolitan labor markets exhibits less urban sprawl through concentration. The mean value for the Delta index of employment

concentration is 0.6405. This means that 64.05% of jobs would need to be redistributed to attain evenness across the average metropolitan area. The Gini coefficient of 0.7770 also suggests significant inequality in the average metropolitan area. Both sample means are slightly higher than the results for residential housing.

Both indexes suggest the same regional variations in employment concentration, although those variations are quite moderate. Job concentration is the lowest in the Northeast, followed by the Midwest. Regional means for the Midwest, however, are only slightly lower than their sample means. Employment concentration in the South is similar to the sample mean, albeit at slightly higher levels. The West is the most concentrated with respect to the spatial distribution of employment according to both indexes.

Correlation coefficients between both indexes and total population are quite low. However, coefficients between both measures and total land area are positive. Labor markets in larger metropolitan areas tend to appear more concentrated simply because more jobs need to be redistributed across a physically larger area to be even. All values in this case are statistically significant.

Significant empirical overlap exists between the Gini and Delta indexes. Intra-attribute correlation is significantly positive. Compared to housing, there are notable similarities and differences with respect to concentration-centrality correlations. First, employment concentration is very positively correlated with centrality according to the Absolute Centralization measure. This was also the case in housing, which is likely due to the commonalities in the construction of these measures. Second, the Standardized Centrality index is moderately correlated with employment concentration, although to a

somewhat greater degree. Third, unlike residential housing, there is a very weak but insignificant empirical linkage between the Glaeser-Kahn and both concentration indexes. Although concentration and centrality are largely independent empirical attributes of employment sprawl, there is a stronger association in this case between job concentrations and the location of a CBD.

2.5.2.3 Employment Centrality

On average, jobs are distributed in a relatively more centralized manner than is the case in metropolitan housing markets. Each measure supports this pattern in varying degrees and contexts. The mean value for the Glaeser-Kahn index is 0.2948, which means that 29.48% of employment is located between ten and thirty-five miles from a CBD in the average metropolitan area. That sentiment is further reflected in the Absolute Centralization measure, which indicates the proportional share of metropolitan employment that would need to shift to attain uniform evenness. In this case, the sample mean is 64.62%. The mean value for the Standardized Centrality index of 1.9476 suggests that the average job is 94.76% closer to a CBD than the average ZCTA.

Regional variations in job centrality are less distinct than housing. This suggests that labor markets exhibit regional variations in centrality patterns. The Northeast appears to have the most decentralized job sprawl. All mean centrality measures for the Northeast are below the sample means for employment. The South is also decentralized with respect to employment, although those means are only slightly below their sample means. Although the West ranks lowest on the Glaeser-Kahn index, it ranks highest in centrality on the alternative indexes. The Midwest also ranks very high on most

indicators except Absolute Centralization, where it ranks second-lowest.

There is a more significant empirical connection between metropolitan size and centrality when considering the Glaeser-Kahn and Absolute Centralization indexes. The Glaeser-Kahn index is positively correlated with population size, meaning that more populous metropolitan areas tend to feature lower degrees of job centrality and therefore higher degrees of job sprawl. The Absolute Centralization index for employment is positively correlated with areal size, meaning that physically larger metropolitan areas tend to feature greater degrees of centrality and therefore lower degrees of sprawl. Although the results aren't statistically significant, the Standardized Centrality measure is uncorrelated with both measures of metropolitan size.

Intra-attribute correlation is less significant for employment centrality. This suggests again that each measure works with different facets of centrality, be it the occupation of physical space in the periphery, the accumulation of employment from a CBD, or the relative degree of distance. As measures of sprawl, all centrality measures are positively correlated with each other. The Absolute Centralization and Glaeser-Kahn measures are less positively correlated with respect to employment. The Standardized Centrality index displays a low degree of correlation with the alternative measures. All coefficients are statistically significant.

2.6 Conclusion

This chapter establishes a set of alternative empirical measures of urban sprawl for use as independent explanatory variables in the empirical analysis of this dissertation. Urban sprawl is a multi-dimensional distribution pattern of housing and labor markets in

US metropolitan areas, characterized by three primary attributes: density, concentration, and centrality. Residential housing markets exhibit a greater degree of urban sprawl through relatively low densities, less concentration, and less centrality. The spatial distribution of employment exhibits a lower degree of sprawl through relatively high densities, greater concentration, and greater centrality. Although they differ in magnitude, regional variations are very similar for both housing and employment. The Northeast features the highest densities, the least concentration, and largely the least centrality. The West also features generally high densities, but under the highest concentration and largely the highest centrality. The South exhibits low densities (lowest in housing) and moderate concentration (more in employment), under a lack of centrality (less in housing). The Midwest is also characterized by low densities (lowest in employment) and moderate concentration (more in housing), but under greater centrality (more in housing). There are also countervailing relationships between alternative measures of urban sprawl and alternative operational definitions of metropolitan size. Density tends to increase in more populated metropolitan areas, while concentration tends to increase in physically larger metropolitan areas. Both observations indicate a lower extent of urban sprawl. The empirical independence of centrality from metropolitan size varies by measure. Notably, the Glaeser-Kahn measure systematically exhibits less centrality as both population and land area increase. With the exception of centrality, there is a significant degree of positive intra-attribute correlation. This suggests that most measures within a category of urban sprawl are similar empirical representations of the category. With the exception of concentration and centrality, there is general lack of inter-attribute correlation. This suggests that the categories suggested in this chapter are

empirically distinct attributes of urban sprawl phenomenon.

2.7 Tables

Table 2.1
Interpretative Guide
Alternative Empirical Measures of Urban Sprawl

	Sprawl	Non-Sprawl	Minimum	Maximum
Density	*"Low Density"*	*"High Density"*		
Average MA Density	Low	High	0	None
Maximum Density	Low	High	0	None
Density of the 90th Percentile	Low	High	0	None
Density of the 75th Percentile	Low	High	0	None
Density of the Median	Low	High	0	None
Density of the 25th Percentile	Low	High	0	None
Density of the 10th Percentile	Low	High	0	None
Minimum Density	Low	High	0	None
Concentration	*"Deconcentrated"*	*"Concentrated"*		
Delta Index	Low	High	0	1
Gini Coefficient	Low	High	0	1
Centrality	*"Decentralized"*	*"Centralized"*		
Glaeser-Kahn	High	Low	0	1
Absolute Centralization Index	Low	High	-1	1
Standardized Centrality Index	Low	High	>0	None

Table 2.2
Metropolitan Areas excluded from the Sample
Sorted by Region and Total MA Population

	Region	Population	Land Area
Nassau--Suffolk, NY PMSA	Northeast	2,753,913	1,198.9
Bergen--Passaic, NJ PMSA	Northeast	1,373,167	419.5
Middlesex--Somerset--Hunterdon, NJ PMSA	Northeast	1,169,641	1,044.3
Monmouth--Ocean, NJ PMSA	Northeast	1,126,217	1,108.2
Barnstable--Yarmouth, MA NECMA	Northeast	222,230	395.5
Burlington, VT NECMA	Northeast	198,889	1,258.7
Vineland--Millville--Bridgeton, NJ PMSA	Northeast	146,438	489.3
Jamestown, NY MSA	Northeast	139,750	1,062.0
Glens Falls, NY MSA	Northeast	124,345	1,704.7
Kankakee, IL PMSA	Midwest	103,833	676.7
Rapid City, SD MSA	Midwest	88,565	2,776.1
Johnson City--Kingsport--Bristol, TN--VA MSA	South	480,091	2,865.5
Melbourne--Titusville--Palm Bay, FL MSA	South	476,230	1,018.2
Fort Pierce--Port St. Lucie, FL MSA	South	319,426	1,128.1
Columbus, GA--AL MSA	South	274,624	1,570.0
Naples, FL MSA	South	251,377	2,025.3
Brazoria, TX PMSA	South	241,767	1,386.4
Myrtle Beach, SC MSA	South	196,629	1,133.7
Houma, LA MSA	South	194,477	2,339.6
Jacksonville, NC MSA	South	150,355	766.8
Decatur, AL MSA	South	145,867	1,275.6
Rocky Mount, NC MSA	South	143,026	1,045.3
Punta Gorda, FL MSA	South	141,627	693.6
Dothan, AL MSA	South	137,916	1,141.4
Greenville, NC MSA	South	133,798	651.6
Dover, DE MSA	South	126,697	589.7
Auburn--Opelika, AL MSA	South	115,092	608.7
Goldsboro, NC MSA	South	113,329	552.6
Hattiesburg, MS MSA	South	111,674	963.6
Jackson, TN MSA	South	107,377	845.5
Sumter, SC MSA	South	104,646	665.4
Jonesboro, AR MSA	South	82,148	710.8
Santa Cruz--Watsonville, CA PMSA	West	255,602	445.2
San Luis Obispo--Atascadero--Paso Robles, CA MSA	West	246,681	3,304.3
Merced, CA MSA	West	210,554	1,928.7
Chico--Paradise, CA MSA	West	203,171	1,639.5
Yolo, CA PMSA	West	168,660	1,013.3
Yuma, AZ MSA	West	160,026	5,514.1
Santa Fe, NM MSA	West	147,635	2,018.5
Yuba City, CA MSA	West	139,149	1,233.2
Flagstaff, AZ--UT MSA	West	122,366	22,609.4
Grand Junction, CO MSA	West	116,255	3,327.7
Missoula, MT MSA	West	95,802	2,598.0
Cheyenne, WY MSA	West	81,607	2,686.1
Corvallis, OR MSA	West	78,153	676.5
Pocatello, ID MSA	West	75,565	1,113.3

Source: Census Summary File 1 (2000)

Table 2.3
Summary Statistics
Total Metro Population, Housing, Employment, and Land Area

	N	Mean	Median	Standard Deviation	Minimum	Maximum
Population	272	781,172.0	347,300.5	1,264,137	57,813	9,519,338
Housing Units	272	313,609.9	140,172.0	485,747.7	26,047	3,680,360
Jobs	272	321,246.0	120,723.3	543,357.0	17,334	3,787,083
Land Area (By tract)	272	2,297.9	1,568.5	3,239.2	46.7	39,368.6
Land Area (By ZCTA)	272	2,341.9	1,597.7	2,979.7	50.5	31,473.4

Sources: Census Summary File 1 (2000) and Zip Code Business Patterns (2000)

Table 2.4
Frequency Distribution
Metropolitan Areas by Region

	Frequency	Percent	Cumulative Percent
Northeast	38	13.97	13.97
Midwest	76	27.94	41.91
South	107	39.34	81.25
West	51	18.75	100.00
Total	272	100.00	

Source: Census Summary File 1 (2000)

Table 2.5
Frequency Distribution
Metropolitan Areas by Total Population Size Category

Range	Frequency	Percent	Cumulative Percent
50,000 – 99,9999	11	4.04	4.04
100,000 – 249,999	88	32.35	36.40
250,000 – 499,999	59	21.69	58.09
500,000 – 999,999	33	12.13	70.22
1,000,000 – 2,499,999	33	12.13	82.35
2,500,000 – 4,999,999	18	6.62	88.97
5,000,000 or more	30	11.03	100.00
Total	272	100.00	

Source: Census Summary File 1 (2000)

Table 2.6
Metropolitan Areas at the Highest, Median, and Lowest Degrees of Urban Sprawl
Select Measures using Residential Housing and Employment Data

Housing	Highest Sprawl	Median	Lowest Sprawl
Average MA Housing Density	Casper, WY	Syracuse, NY Steubenville – Weirton, OH – WV	Jersey City, NJ
Density of the Median Housing Unit	Bangor, ME	Waterloo – Cedar Falls, IA St. Joseph, MO	New York, NY
Delta Index	Hickory – Morganton – Lenoir, NC	McAllen – Edinburg – Mission, TX Waco, TX	Las Vegas, NV – AZ
Gini Coefficient	Newburgh, NY – PA	Victoria, TX Cincinnati, OH – KY – IN	Las Vegas, NV – AZ
Glaeser-Kahn	Tampa – St. Petersburg – Clearwater, FL	Hamilton – Middletown, OH Florence, SC	Bloomington, IN Jersey City, NJ
Absolute Centralization Index	Jersey City, NJ	Olympia, WA Philadelphia, PA – NJ	Reno, NV
Standardized Centrality Index	Wilmington, NC	Newark, NJ San Antonio, TX	Honolulu, HI
Employment			
Average MA Employment Density	Casper, WY	Little Rock – North Little Rock, AR Charleston – North Charleston, SC	Jersey City, NJ
Density of the Median Job	Casper, WY	Wilmington, NC Akron, OH	New York, NY
Delta Index	Bloomington, IN	Erie, PA Pueblo, CO	Las Vegas, NV – AZ
Gini Coefficient	Bloomington, IN	Roanoke, VA Madison, WI	Las Vegas, NV – AZ
Glaeser-Kahn	Detroit, MI	Provo – Orem, UT Springfield, MA	Jersey City, NJ
Absolute Centralization Index	New Haven, CT	Bakersfield, CA Salem, OR	Tucson, AZ
Standardized Centrality Index	Trenton, NJ	Erie, PA Lakeland – Winter Haven, FL	Honolulu, HI

Sources: Census Summary File 1 (2000) and Zip Code Business Patterns (2000)

Table 2.7
Summary Statistics
Alternative Measures of Housing Sprawl

Density	N	Mean	Standard Deviation	Minimum	Maximum
Average MA Density	272	174.17	383.94	5.60	5,153.79
Maximum Tract Density	272	7,945.04	12,405.13	1,270.42	131,126.90
Tract Density of 90th Percentile	272	3,252.64	4,476.92	643.19	62,361.43
Tract Density of 75th Percentile	272	1,953.31	2,566.85	253.94	36,090.41
Tract Density of Median	272	964.39	1,490.66	58.63	19,653.37
Tract Density of 25th Percentile	272	342.92	770.86	7.62	8,582.76
Tract Density of 10th Percentile	272	105.07	305.95	1.39	3,489.07
Minimum Tract Density	272	7.88	8.68	0.00	62.48
Concentration					
Delta Index	272	0.6202	0.1114	0.3925	0.9172
Gini Coefficient	272	0.7409	0.0992	0.5229	0.9728
Centrality					
Glaeser-Kahn	272	0.3513	0.1704	0.0000	0.7538
Absolute Centralization Index	272	0.5824	0.1609	0.0815	0.9461
Standardized Centrality Index	272	0.9591	0.0878	0.6868	1.5360

Source: Census Summary File 1 (2000)

Table 2.8
Means by Region
Alternative Measures of Housing Sprawl

Density	Northeast	Midwest	South	West
Average MA Density	408.18	134.45	126.36	159.34
Maximum Tract Density	15,962.89	6,469.99	5,270.10	9,781.21
Tract Density of 90th Percentile	6,245.04	2,746.78	2,215.87	3,952.02
Tract Density of 75th Percentile	3,370.03	1,667.37	1,399.54	2,485.67
Tract Density of Median	1,538.90	761.88	712.14	1,367.32
Tract Density of 25th Percentile	620.54	216.87	246.90	525.37
Tract Density of 10th Percentile	238.38	52.93	74.06	148.53
Minimum Tract Density	15.16	8.93	7.24	2.27
Concentration				
Delta Index	0.5314	0.6128	0.5999	0.7402
Gini Coefficient	0.6626	0.7301	0.7231	0.8526
Centrality				
Glaeser-Kahn	0.3986	0.2870	0.3827	0.3457
Absolute Centralization Index	0.4703	0.5980	0.5584	0.6928
Standardized Centrality Index	0.9497	0.9673	0.9317	1.0113

Source: Census Summary File 1 (2000)

Table 2.9
Correlation Coefficients for Total Population and Total Land Area
Alternative Measures of Housing Sprawl

Density	Population	Land Area
Average MA Density	0.4102**	-0.0699
Maximum Tract Density	0.7613**	0.0950
Tract Density of 90th Percentile	0.5620**	0.0117
Tract Density of 75th Percentile	0.5606**	0.0399
Tract Density of Median	0.5321**	0.0564
Tract Density of 25th Percentile	0.5175**	0.0432
Tract Density of 10th Percentile	0.4769**	-0.0262
Minimum Tract Density	-0.2665**	-0.2984**
Concentration		
Delta Index	0.1103	0.3820**
Gini Coefficient	0.1591**	0.3847**
Centrality		
Glaeser-Kahn	0.4512**	0.2126**
Absolute Centralization Index	0.1092	0.2887**
Standardized Centrality Index	0.0328	0.0081

Source: Census Summary File 1 (2000)
** p<0.05 ** p<0.01*

Table 2.10
Correlation Matrix
Alternative Measures of Housing Sprawl

	MA Den	Max Den	Den P90	Den P75	Den Median	Den P25	Den P10	Min Den	Delta	Gini
				Density – Density						
MA Den										
Max Den	0.5997**									
Den P90	0.7426**	0.8771**								
Den P75	0.8079**	0.8244**	0.9675**							
Den Median	0.8567**	0.7504**	0.9145**	0.9750**						
Den P25	0.9224**	0.6987**	0.8438**	0.9154**	0.9644**					
Den P10	0.9520**	0.6539**	0.7812**	0.8503**	0.8999**	0.9654**				
Min Den	0.0383	-0.1627**	-0.0875	-0.1291*	-0.1483*	-0.1245*	-0.0536			
				Density – Concentration					*Conc. - Conc.*	
Delta	-0.0858	0.0810	0.0972	0.1724**	0.2272**	0.1615**	0.0278	-0.5879**		
Gini	-0.0681	0.1270*	0.1274*	0.1975**	0.2439**	0.1729**	0.0428	-0.6203**	0.9827**	
				Density – Centrality					*Conc. - Cent.*	
GK	0.0118	0.1884**	0.0153	-0.0100	-0.0359	-0.0047	0.0162	-0.1124	-0.2403**	-0.1724**
ACI	-0.1892**	0.0813	0.0488	0.0856	0.0968	0.0279	-0.0756	-0.4851**	0.7324**	0.7170**
SCI	0.0358	0.1533*	0.1838**	0.1282*	0.1106	0.0904	0.0713	-0.2041**	0.2550**	0.2759**

	GK	ACI	SCI
	Centrality – Centrality		
GK			
ACI	-0.4153**		
SCI	-0.1120	0.1921**	

Source: Census Summary File 1 (2000)
** p<0.05 ** p<0.01*

Table 2.11
Summary Statistics
Alternative Measures of Employment Sprawl

Density	N	Mean	Standard Deviation	Minimum	Maximum
Average MA Density	272	164.59	342.46	5.64	4,151.36
Maximum ZCTA Density	272	62,862.92	280,126.70	72.40	2,829,993
ZCTA Density of 90th Percentile	272	7,514.02	28,410.15	72.40	394,866.60
ZCTA Density of 75th Percentile	272	2,799.80	12,891.45	20.58	205,600.80
ZCTA Density of Median	272	979.34	1,899.90	20.58	28,215.21
ZCTA Density of 25th Percentile	272	334.62	512.76	4.77	4,918.67
ZCTA Density of 10th Percentile	272	121.08	216.42	3.58	1,694.75
Minimum ZCTA Density	272	4.94	58.55	0.00	965.11
Concentration					
Delta Index	272	0.6405	0.1084	0.2951	0.9208
Gini Coefficient	272	0.7770	0.1029	0.3560	0.9831
Centrality					
Glaeser-Kahn	272	0.2948	0.1820	0.0000	0.7954
Absolute Centralization Index	272	0.6462	0.1638	0.0211	0.9489
Standardized Centrality Index	272	1.9476	1.0917	0.8191	16.5759

Source: Zip Code Business Patterns (2000)

Table 2.12
Means by Region
Alternative Measures of Employment Sprawl

Density	Northeast	Midwest	South	West
Average MA Density	353.70	130.80	116.83	174.26
Maximum ZCTA Density	113,400.80	23,175.66	71,713.78	65,779.58
ZCTA Density of 90th Percentile	16,261.54	4,671.87	4,980.02	10,548.04
ZCTA Density of 75th Percentile	7,073.35	1,482.81	1,739.72	3,802.24
ZCTA Density of Median	1,572.42	801.08	785.37	1,210.06
ZCTA Density of 25th Percentile	463.62	266.73	276.16	462.33
ZCTA Density of 10th Percentile	183.03	85.43	94.91	182.96
Minimum ZCTA Density	28.46	2.21	0.70	0.36
Concentration				
Delta Index	0.5764	0.6222	0.6457	0.7050
Gini Coefficient	0.7254	0.7544	0.7827	0.8375
Centrality				
Glaeser-Kahn	0.3444	0.2298	0.2994	0.3454
Absolute Centralization Index	0.5562	0.6372	0.6437	0.7316
Standardized Centrality Index	1.7194	1.9626	1.8297	2.3423

Source: Zip Code Business Patterns (2000)

Table 2.13
Correlation Coefficients for Total Population and Total Land Area
Alternative Measures of Employment Sprawl

Density	Population	Land Area
Average MA Density	0.4829**	-0.0632
Maximum ZCTA Density	0.5787**	0.0998
ZCTA Density of 90th Percentile	0.5180**	0.0358
ZCTA Density of 75th Percentile	0.4765**	0.0138
ZCTA Density of Median	0.5977**	0.0902
ZCTA Density of 25th Percentile	0.6543**	0.1082
ZCTA Density of 10th Percentile	0.5851**	-0.0123
Minimum ZCTA Density	-0.0096	-0.0581
Concentration		
Delta Index	0.1341*	0.4204**
Gini Coefficient	0.1668**	0.4119**
Centrality		
Glaeser-Kahn	0.4430**	0.2538**
Absolute Centralization Index	0.1350*	0.3319**
Standardized Centrality Index	-0.0729	0.1165

Source: Zip Code Business Patterns (2000)
** p<0.05 ** p<0.01*

Table 2.14
Correlation Matrix
Alternative Measures of Employment Sprawl

	MA Den	Max Den	Den P90	Den P75	Den Median	Den P25	Den P10	Min Den	Delta	Gini
					Density – Density					
MA Den										
Max Den	0.4131**									
Den P90	0.5552**	0.6771**								
Den P75	0.5623**	0.6582**	0.9354**							
Den Median	0.7143**	0.6693**	0.8698**	0.9294**						
Den P25	0.8593**	0.5684**	0.6875**	0.6627**	0.8345**					
Den P10	0.8613**	0.4899**	0.5838**	0.5468**	0.7051**	0.9269**				
Min Den	0.7180**	-0.0066	0.0242	0.0269	0.1879**	0.4017**	0.4483**			
					Density – Concentration				*Conc. - Conc.*	
Delta	-0.1818**	0.1263*	0.0966	0.0744	0.1661**	0.1310*	-0.0019	-0.2044**		
Gini	-0.1896**	0.1440*	0.1287*	0.1007	0.1762**	0.1059	-0.0198	-0.2418**	0.9685**	
					Density – Centrality				*Conc. - Cent.*	
GK	0.0671	0.1325*	0.0485	0.0016	0.0217	0.1083	0.1076	-0.1035	-0.0939	-0.0149
ACI	-0.1669**	0.1473*	0.1164	0.1080	0.1687**	0.0939	-0.0200	-0.2056**	0.8190**	0.8086**
SCI	-0.0588	0.0046	0.0574	0.0938	0.1463*	-0.0074	-0.0524	-0.0531	0.3298**	0.3314**

	GK	ACI	SCI
	Centrality – Centrality		
GK			
ACI	-0.2868**		
SCI	-0.2727**	0.3747**	

Source: Zip Code Business Patterns (2000)
** p<0.05 ** p<0.01*

CHAPTER 3

IS URBAN SPRAWL GOOD FOR US MINORITY HOUSING CONSUMPTION? A CRITICAL ASSESSMENT OF KAHN (2001)

3.1 Introduction

The costs and benefits of urban sprawl have been the subject of intense theoretical and empirical debate. Critics contend that sprawl threatens open spaces and agricultural resources, creates disincentives to community-building, increases automobile dependency and pollution, raises the cost of infrastructure maintenance, and worsens inner-city decay. As a rejoinder to the indictments levied in the 'Costs of Sprawl' literature (Burchell et al., 1998; Ewing, 1997; Ewing, Pendall, & Chen, 2002), a number of scholars have developed arguments in favor of sprawl (Bruegmann, 2005; Downs, 1999; Gordon & Richardson, 1997; Kahn, 2001). The positive effect of urban sprawl on housing affordability is a celebrated defense.

Kahn (2001) advances that position by examining the contribution of sprawl to the long-term reduction in the Black-White housing consumption gap, defined in terms of number of rooms, housing unit size, suburbanization, homeownership, suburban homeownership, and housing unit age. Sprawl may increase housing affordability for Black households through two prospective channels: first, by increasing the supply of land available for development; and second, by relieving competitive pressures from suburban-employed White households for inner-city housing. Urban growth management policies could therefore have detrimental effects on Black-White inequalities in US housing markets.

These arguments were strengthened by gains in minority homeownership during the 1990's. According to Myers and Painter (2005), Black homeownership increased by

6.7%, Latino homeownership increased by 7.8%, while Asian/Pacific Islander homeownership increased by 1.9%. This is especially striking, given that all three groups experienced declines in homeownership rates during the 1980's. Yet progress did not come without costs. In the twenty-five largest metropolitan areas, the percent increase in homeowners with severe cost burdens was 38.7% for Blacks and 98.3% for Latinos, compared to 23.2% for non-Latino Whites (Simmons, 2005).[30]

As compared to the 1990's, the relationship between urban sprawl and minority housing consumption is more complex for two reasons. First, the landscape of US housing markets has changed dramatically in the continuing recovery from the housing bust and the Great Recession. According to the Center for Responsible Lending (2010), nearly 6 million foreclosures were initiated between 2007 and December 2009, with 13 million more expected by the end of 2014. Racial and ethnic disparities are clear and persistent. Relative to the number of homeowners in 2006, the share of homeowners who are at risk of foreclosure or have lost their homes is 17% for Latinos and 11% for Blacks – compared to 7% for non-Hispanic Whites (Bocian, Li, & Ernst, 2010).[31] What is more, prior to the subprime mortgage meltdown, Black and Latino homeowners were more likely than White borrowers to receive a higher-rate subprime home loan by more than 30%, even when controlling for differences in standard risk characteristics (Bocian, Ernst, & Li, 2006). Second, the study of racial and ethnic economic inequalities is evolving beyond the traditional Black-White dichotomy. The rapid growth of the US Asian and Hispanic populations (Logan, 2003; Suro & Singer, 2003), combined with

[30] According to Simmons (2005), a household faces a severe cost burden if its ratio of housing costs to income is 50% or more.

[31] The authors classify a borrower as being at "imminent risk" of foreclosure if the borrower is in the foreclosure process, or is two or more payments behind on a mortgage.

their varied economic capabilities and experiences, requires more rigorous and comparative empirical investigations. Between 2000 and 2010, the US Asian population share rose from 3.6% to 4.7%, while the Hispanic population share rose from 12.5% to 16.3% (US Census Bureau, 2000b, 2010). In contrast, the Black population barely increased from 12.1% to 12.2%, while the White population dropped from 69.1% to 63.7%.[32]

This chapter makes two unique contributions to the literature on the effects of sprawl on minority housing gaps. First, it directly compares outcomes for Blacks, Asians, and Hispanics. Second, it documents a key aspect of that relationship not scrutinized by previous empirical studies. Although urban sprawl may be a factor in closing the Black-White housing consumption gap in particular, increases in sprawl that occur below certain sprawl levels may widen the gap. The number of metropolitan areas that experience an expanding gap is not insignificant, depending on the measure of housing consumption considered.

The chapter is therefore organized in the following way. In Section 3.2, I introduce the key findings by Kahn (2001) through the process of critical replication. I replicate with significant precision Kahn's empirical results. I note where our respective results diverge, and why. In Section 3.3, I propose and calculate the 'threshold' level of urban sprawl, namely the point that demarcates metropolitan sprawl levels that may expand a housing gap from those that may close a gap. This method is then used to reanalyze previous results, and critically question the conclusions from those results. In Section 3.4, I investigate the effects of sprawl on minority housing consumption gaps

[32] Figures are for the following groups specifically: Asian alone, non-Hispanic; Hispanic or Latino; Black or African-American alone, non-Hispanic; White alone, non-Hispanic.

since the housing bust. For Blacks, the benefits from sprawl only occur above an even higher threshold, as compared to previous findings using 1997 data. Important changes in the empirical relationship between sprawl and Black housing consumption are also evident. For Asians, sprawl largely contributes to improving housing consumption to a greater extent than Whites. The model does not, however, yield statistically significant results for Hispanics. In Section 3.5, I discuss the implications of this chapter for several key questions concerning sprawl and minorities. In Section 3.6, I suggest future directions for this research agenda.

3.2 Replication of Kahn (2001)

Replication of this study first requires replication of the selected empirical measure of urban sprawl. Since urban sprawl is the causal variable in this case, the reliability of both replication and extension is highly sensitive to these estimates. Kahn selects the 'Job Sprawl' index, which has been featured elsewhere in this literature (Chu, 2000; Glaeser & Kahn, 2001; Glaeser, Kahn, & Chu, 2001; Kneebone, 2009; Stoll, 2005, 2007). This index measures the extent of employment decentralization, i.e., the proportional share of metropolitan area jobs located beyond a ten-mile radius but within a thirty-five mile radius from a central business district. A higher value indicates a greater share of employment in the metropolitan periphery, and thus a higher level of sprawl. A lower value indicates a lower level of sprawl due to a smaller percentage of employment in the periphery. With respect to data, the 1982 Economic Censuses: Geographic Reference Manual (US Census Bureau, 1983) is the source of central business district locations by census tract. ZIP Code Business Patterns 1996 (US Census Bureau, 1998) is

the source of total employment and firm counts by employee-size at the ZIP code level.

3.2.1 Replication of Descriptive Analysis

In the text, Kahn documents sprawl rankings for only thirty metropolitan statistical areas, which is a small subset of the original sample. The article does not identify exactly which metropolitan areas are included in the sample, nor does it document the total number of metropolitan areas. This prevents complete verification of my sprawl and total metropolitan area employment estimates. I verify my estimates and technique using two principal sources: Chu (2000) and Glaeser et al. (2001). Chu (2000) is a Harvard University undergraduate thesis in economics. In three articles that feature this index – Glaeser and Kahn (2001), Glaeser et al., and Kahn (2001) – the authors cite this document as the source for all distance calculations. Using data identical to Kahn's, I closely follow Chu's calculation of employment decentralization. The Glaeser et al. article is useful because it documents sprawl and total employment rankings for the one-hundred largest metropolitan areas, also using data identical to Kahn's.[33] I therefore test my estimates of metropolitan area sprawl and total employment against the rankings in Glaeser et al. Although Kahn's sample is larger, this method offers the best confirmation of my replication of Kahn's original estimates. I document my exact procedure in Appendix A, which yields the closest replication.

To test the validity of this stage of the replication, I use Spearman's ρ, a rank

[33] Although both articles cite the same data sources, the sprawl rankings in Kahn (2001) are slightly different, albeit very close to those in Glaeser et al. (2001). The reason for this is not clear, but nonetheless underscores the likelihood of a less than exact replication.

correlation coefficient.[34] The ρ value between the replication estimates of employment decentralization and the published results in Glaeser et al. (2001) is 0.9439, which is statistically significant at the one-percent level. The ρ value between the replicated and published figures for total metropolitan area employment is 0.9906, which is also significant from zero at the one-percent level. Both results imply substantial agreement between the replication rankings and those of Glaeser et al. with regard to which metropolitan areas exhibit the highest and lowest levels of urban sprawl.

Kahn employs the 1997 American Housing Survey: National Microdata (US Department of Housing and Urban Development, 2000) to test whether urban sprawl, measured as employment decentralization, shrinks the longstanding Black-White disparity in housing consumption. The American Housing Survey (AHS) is especially useful for this research question. It offers extensive detail on not only residential housing units, but also housing quality, household composition and demographics, geographic location, as well as neighborhood conditions and amenities. Most importantly, the survey includes metropolitan statistical area codes for all housing units, to which urban sprawl and total employment estimates are matched.

Kahn chooses six indicators of housing consumption: number of rooms, total living space (unit size in square feet), rate of suburbanization, rate of homeownership, rate of suburban homeownership, and the age of the unit (year unit built).[35] Table 3.1 presents Kahn's published results for mean housing consumption by race and level of

[34] Rank correlations test the degree of agreement in the rankings of two variables. A coefficient of zero implies that the rankings are independent. A coefficient of negative one implies absolute disagreement in the rankings. Positive one indicates absolute agreement in the rankings.

[35] A housing unit is classified as suburban if it is within a metropolitan statistical area, in either an urban or rural setting, but not part of the central city.

urban sprawl alongside the replication results.[36] I replicate Kahn's results with significant precision. First, our respective averages for all Black and White households are extremely close.[37] This confirms that my handling of the AHS data aligns with Kahn's, since those figures are independent of the level of sprawl, and consequently its calculation. Second, our respective averages by level of sprawl exhibit some deviations, albeit to a minimal degree. These deviations are due to differences (as well as unknowns) in the calculation of urban sprawl, which are documented and discussed in Appendix A.

According to the 1997 data, Black households face a substantial housing consumption gap relative to White households. The consumption gap is the inter-group difference between the average housing outcome for all Black households and the average outcome for all White households, regardless of the level of urban sprawl. The average Black housing unit has 8.4% fewer rooms, is 10% smaller in size, and is older than the average White housing unit by 6 years. In addition, Blacks are less likely than Whites to be homeowners by 24 percentage points, live in a suburb by 24 percentage points, and to be suburban homeowners by 23.2 percentage points.

However, Kahn argues that Blacks experience relative gains on certain measures of housing consumption at higher levels of urban sprawl. The difference-in-difference measures the intra-group effect of urban sprawl on housing consumption, regardless of differences in the level of housing consumption, i.e. the housing gaps.[38] Kahn notes

[36] The standard unit of observation in the AHS is the housing unit. All averages are weighted at the household level. The final weight provided in the 1997 survey is based upon 1980 metropolitan geography, and indicates the approximate number of households that an observation represents. The sum of all weights equals the national control total for total number of housing units.

[37] The race of the household is determined by the race of the householder.

[38] The difference-in-difference equals mean Black housing consumption in a high-sprawl metropolitan area relative to a low-sprawl area, less mean White housing consumption in a high-sprawl area relative to a low-

correctly that Black households experience relative gains with respect to number of rooms, total living space, and homeownership, due to the presence of positive difference-in-difference values. However, it is also clear that White households witness progress relative to Black households with respect to suburbanization, suburban homeownership, and the age of the housing unit, given the negative difference-in-difference values for those measures.

3.2.2 Replication of Regression Analysis

In order to understand the independent effect of sprawl on the racial housing consumption gap, Kahn estimates separate ordinary least squares (OLS) regression models for each indicator of housing – first for Black households, and then for White households. The models additionally include a set of household-level demographic variables (*DEMO*): the age of the householder, age of the householder squared, log of household income, number of adults, and number of children; a set of Census-defined regional dummies (*REG*); and the log of total metropolitan statistical area employment (*JOBS*).[39] The level of housing consumption for household *i* in metropolitan area *j* (H_{ij}) is estimated by the following equation:

$$H_{ij} = \beta_0 + \beta_1 DEMO_{ij} + \beta_2 REG_{ij} + \beta_3 \ln(JOBS_{ij}) + \beta_4 SPRAWL_{ij} + \beta_5 SPRAWL_{ij}^2 + \varepsilon_{ij} \quad (1)$$

where β_0 is a constant, ε is an error term, and *SPRAWL* is the metropolitan area level of urban sprawl, measured as the degree of employment decentralization. Regressions for

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sprawl metropolitan area. Using the information in Table 3.1, the calculation is (High-Sprawl Black – Low-Sprawl Black) – (High-Sprawl White – Low-Sprawl White). Positive results imply that the average gain in housing consumption associated with sprawl for Blacks is larger than the average gain for Whites. Negative results imply that the average gain for Whites is larger than the average gain for Blacks.

[39] The West is omitted to avoid perfect multicollinearity.

suburbanization, homeownership, and suburban homeownership are linear probability models. Each regression is weighted by the AHS final weight. In addition, standard errors are adjusted for metropolitan area clustering.[40]

Table 3.2 reports the published housing regression results for Black households alongside the replication results. Table 3.3 repeats the same exercise for White households. For both sets of models, the replication coefficients and standard errors for the demographic control variables are extremely close to the published values. As stated previously, this confirms that my treatment of the AHS aligns with Kahn's treatment of the data. Results for log of metropolitan employment are also very similar, which is unsurprising, in light of the strong rank correlation coefficient for this variable. Although in varying degrees, I replicate the coefficients and standard errors for the two sprawl variables with considerable accuracy. I attribute any differences to two primary sources: first, documented variations in the calculation of urban sprawl; and second, discrepancies in the number of observations for each group of models. The replication models consistently feature a larger number of observations – less so for the Black household regressions, but more so for the White household regressions. Due to the lack of extensive descriptive statistics in the original article, I am unable to verify which metropolitan areas in the 1997 AHS are included in the original sample, or perhaps conversely, which are excluded from the sample. Nonetheless, at an empirical level, the results of this replication support the same substantive conclusions as Kahn.

The replication also supports the same findings of statistical significance. The F-test tests the null hypothesis that the two sprawl variables are jointly insignificant. For

[40] The AHS national dataset includes multiple observations for each metropolitan area. This violates the OLS assumption of independently and identically distributed (i.i.d.) variables across observations. Clustered standard errors therefore adjust for any intra-metropolitan area correlation.

Black households, there is a statistically significant relationship between employment decentralization and housing when considering two measures: number of rooms and homeownership. For White households, the null hypothesis is rejected for four indicators: number of rooms, suburbanization, homeownership, and suburban homeownership.

Regression results for rooms and homeownership are suitable for extended assessment, since their relation to sprawl is statistically significant for both Blacks and Whites. With respect to changes in sprawl, as indicated by the regression coefficients for sprawl, White households have the advantage. All else constant, an increase in employment decentralization leads to an increase in the number of rooms for both groups, although the increase for Whites only slightly exceeds the increase for Blacks. With respect to homeownership, unlike Whites, Blacks are less likely to own with greater sprawl. However, the impact of sprawl on housing consumption also depends upon the level of sprawl, as indicated by the coefficients for sprawl squared. At higher levels, Blacks now have the advantage. At high levels of employment decentralization, both Blacks and Whites experience losses in the number of rooms, with a lesser decline for Blacks. At the same time, Blacks have a higher probability of homeownership.

Interpretation of the coefficients for the sprawl variables requires consideration of the empirical distribution of urban sprawl. The first derivative of equation (1) represents the rate of change in housing consumption with respect to a change in urban sprawl. The following equations therefore differentiate the change in housing consumption specifically for Black households (H_b) and White households (H_w),

$$\frac{dH_b}{dS} = \delta_w + 2\lambda_w S \qquad (2)$$

$$\frac{dH_w}{dS} = \delta_b + 2\lambda_b S \qquad (3)$$

where δ and λ are the coefficients for sprawl and sprawl squared respectively, and *S* is the level of urban sprawl. Using equations (2) and (3), one can then compare rates of change in housing consumption at a representative level of sprawl. Table 3.4 presents detailed summary statistics for employment decentralization based upon the replication procedure. The level of urban sprawl experienced by the median metropolitan area is 0.3026, which means that 30.26% of metropolitan employment resides in the peripheral area between ten and thirty-five miles from a central business district. At that level, White households consume 1.19 more rooms, and are more likely to be homeowners by 0.22 percentage points.[41] Black households, on the other hand, consume 1.56 more rooms, and are more likely to be homeowners by 0.10 percentage points.[42]

3.3 Threshold Effects and the Black-White Housing Consumption Gap

This section advances the analysis of the impact of urban sprawl on minority housing consumption gaps. A closer examination of Kahn's results themselves reveals a more complex relationship, especially for Black households, which has not been seriously examined in the literature. Furthermore, under specific circumstances, an increase in sprawl may contribute to greater racial disparities in US housing markets.

This model features a quadratic specification, in which the independent variables

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[41] With respect to number of rooms, dH_w/dS = 2.857 - (2*2.750*0.3026) = 1.19
With respect to homeownership, dH_w/dS = 0.297 - (2*0.119*0.3026) = 0.22

[42] With respect to number of rooms, dH_b/dS = 2.729 - (2*1.936*0.3026) = 1.56
With respect to homeownership, dH_b/dS = -0.334 + (2*0.710*0.3026) = 0.10

are the level of sprawl and sprawl squared. The purpose is to capture not only the effect of greater sprawl on housing consumption, but also the extent to which that effect depends upon the level of sprawl. In some cases, the effect of sprawl on housing may exhibit a 'peak' relationship, as it does for number of rooms, whereby housing initially increases with greater sprawl, but diminishes at high sprawl levels. Or, the effect of sprawl may exhibit a 'trough' relationship, as it does for Black homeownership, whereby sprawl contributes to lower housing consumption, but eventually leads to greater consumption at higher levels of sprawl.

The critical concern is what happens to the ***gap*** in housing consumption as urban sprawl increases. A quadratic specification implies that the gap varies with the level of sprawl, since the coefficients on the two sprawl variables are different for Blacks and Whites. In practical terms, the model predicts a scenario where the impact of sprawl on a minority housing consumption gap depends upon the initial level of sprawl.

Previous studies do not discuss the behavior and variation of the gap in response to changes in urban sprawl. For example, Kahn compares predicted levels of housing consumption at sprawl levels of twenty and sixty percent.[43] The conclusion from that analysis is simply that "sprawl helps close the black/white housing gap for rooms, unit size in square feet, and homeownership propensity" (Kahn, 2001, p. 82). What is lacking, however, is an examination of the predicted change in the Black-White housing consumption gap between those two points in the empirical distribution of sprawl. At what levels of sprawl does the housing gap diminish, i.e. at what point does minority housing consumption increase at a faster rate than White housing consumption? Are

[43] Kahn calculates predicted housing consumption under the following assumptions: the household consists of two adults and two children, the householder is forty years old, the household income is $35,000, and the metropolitan area has 250,000 employees.

there sprawl levels where the housing gap expands? In both cases, is there any regularity to this phenomenon?

To answer these questions, for a given measure of housing I derive the 'threshold' level of sprawl, namely the sprawl level at which the racial consumption gap begins to diminish (or in some cases, expand). The difference between equations (2) and (3), $dH_b/dS - dH_w/dS$, expresses what happens to the racial housing consumption gap as a result of changes in the level of urban sprawl. Let's assume that higher values of a particular housing variable (*H*) are positively associated with housing consumption.[44] If $dH_b/dS > dH_w/dS$, the racial housing consumption gap narrows, since the increase in Black housing consumption from sprawl is greater than the increase in White housing consumption. If, on the other hand, $dH_b/dS < dH_w/dS$, the gap widens due to stronger gains in housing for White households relative to Black households. The threshold level of sprawl (*S**) for a measure of housing consumption is the sprawl level at which no change in the gap occurs, or simply $dH_b/dS = dH_w/dS$:

$$S^* = 0.5 * \frac{(\delta_b - \delta_w)}{(\lambda_w - \lambda_b)}.^{45} \qquad (4)$$

This point demarcates metropolitan sprawl levels that may expand a housing gap from

[44] This is the case for the housing measures discussed thus far, such as number of rooms, unit size, suburbanization, homeownership, suburban homeownership, and year unit built. Higher values indicate greater housing consumption, and vice versa. This is not the case for other variables that measure housing quality, for example. If the survey question is "Does the roof have any holes?", then higher values are negatively associated with housing consumption.

[45] If $dH_w/dS = dH_b/dS$, $\delta_w + 2\lambda_w S = \delta_b + 2\lambda_b S$

$2\lambda_w S - 2\lambda_b S = \delta_b - \delta_w$

$2S(\lambda_w - \lambda_b) = (\delta_b - \delta_w)$

Therefore, $S^* = \frac{1}{2}\frac{(\delta_b - \delta_w)}{(\lambda_w - \lambda_b)}$

those that may close a gap. Let's reexamine the 1997 results using this approach.

When considering number of rooms and homeownership, greater sprawl is associated with a smaller differential in Black-White housing consumption – eventually. That process can take place in different ways, however. In order to understand this variation, identification of the threshold sprawl levels is crucial. The threshold will vary by measure of housing consumption, since each measure is regressed separately. For clarity, Figure 3.1 features a histogram of this urban sprawl index using the replication data.

In the case of number of rooms, the threshold is 7.86%.[46] Although the racial difference in housing consumption briefly diverges at extremely low levels of sprawl (only metropolitan areas below the ninth percentile), it continuously converges as employment decentralization progresses in the vast majority of metropolitan areas in this sample.[47] For example, Shreveport, Louisiana has a very low sprawl index of 5.03%. According to this model, Whites would have a slight housing consumption advantage in metropolitan areas characterized by similar sprawl levels, who would consume 2.6 more rooms compared to 2.5 more rooms for Blacks. In metropolitan areas characterized by higher sprawl levels, such as San Francisco (36.63%), Blacks would consume 1.3 more rooms, while Whites would only consume 0.8 more rooms.

The effect of an increase in sprawl on the racial disparity in homeownership, on the other hand, exhibits initial divergence at lower levels of sprawl, followed by

[46] 0.5 * ((2.729-2.857) / (-2.750+1.936)) = 0.0786

[47] Z = (0.0786 – 0.3016) / 0.1670 = -1.34. ϕ(Z) = 0.0901

convergence. The threshold value of 38.06% in this case is much higher.[48] The implication is that an increase in sprawl raises the probability of homeownership for Whites to a greater degree than Blacks in the 68% of the metropolitan areas below the threshold, which is a crucial and unexamined point in the literature. In fact, greater sprawl reduces the Black propensity to own in absolute terms at any sprawl level below 23.52%, which is the thirty-fourth percentile in this sample.[49] Convergence in homeownership rates only takes place in the top 32% of metropolitan areas in the distribution of employment decentralization.

In sum, this model essentially predicts three possible outcomes in terms of changes in the Black-White homeownership differential from changes in sprawl. First, an increase in sprawl could reduce the probability of Black homeownership in metropolitan areas that feature a sprawl level below 23.52%. In cases like Bridgeport, Connecticut – with a sprawl index of 12.58% – White homeownership would increase by 0.27 percentage points, while Black homeownership would decrease by 0.16 percentage points. Second, an increase in sprawl could increase the likelihood of Black homeownership, but to a lesser degree than the increase in White homeownership. This is the case for metropolitan areas with sprawl levels between 23.52% and 38.06%. In cases similar to Birmingham, Alabama (30.98%), the 0.22 percentage point increase in White homeownership exceeds the 0.11 percentage point increase in Black homeownership. Third, an increase in sprawl could increase the likelihood of Black

[48] 0.5 * ((-0.334-0.297) / (-0.119-0.710)) = 0.3806

[49] According to the regression coefficients, Black homeownership exhibits a 'trough' relationship. The level of sprawl above which Black homeownership increases is simply where Equation (2) equals zero, or $\frac{-\delta_b}{2\lambda_b}$.

homeownership to a greater degree than White homeownership. According to the results of this model, such a scenario would take place in metropolitan areas characterized by sprawl levels above 38.06%. In Los Angeles (57.72%), for example, the predicted increase in Black homeownership propensity is three times that of White homeownership propensity: 0.48 percentage points compared to 0.16 percentage points respectively.

3.4 Urban Sprawl and Minority Housing Consumption Gaps since the Housing Bust

The question now is to what extent does urban sprawl continue to facilitate gains in minority housing consumption, as compared to 1997? This section considers that question by revisiting the models with recent data. It also broadens the analysis to include Asians and Hispanics. With respect to the measurement of urban sprawl, I use ZIP Code Business Patterns 2007 (US Census Bureau, 2007) for employment data, ESRI Data and Maps 2010 (Environmental Systems Research Institute, 2010) for ZIP code centroid data, and the Census Bureau's cartographic boundary files (US Census Bureau, 2000a) for the boundary definitions of metropolitan statistical areas and primary metropolitan statistical areas for 1999 – 2000. With respect to housing consumption data, I use the 2009 American Housing Survey: National Microdata (US Department of Housing and Urban Development, 2009). All empirical analysis follows the identical method as the replication, with the exception of the definition of the householder's race or ethnicity. The models now feature four mutually-exclusive racial or ethnic categories: White (non-Hispanic), Black (non-Hispanic), Asian (non-Hispanic), and Hispanic.[50]

[50] The AHS follows the same procedure as the Census for identifying a person's race or ethnicity by asking two separate questions. The first question queries the respondent's race, i.e. White, Black, American Indian/Alaskan Native, Asian, Hawaiian/Pacific Islander, as well as various combinations of two or more

Table 3.5 reports updated descriptive statistics for the six measures of housing consumption.[51] A high-sprawl metropolitan area today is one in which the percentage of jobs in the outer periphery is 52% or higher, as compared to 44% in 1997.[52] With the exceptions of suburbanization and year unit built, Black-White housing gaps generally worsened. Black-White difference-in-differences also largely worsened, although there was improvement in suburbanization and suburban homeownership, despite the fact that both remain negative. One notable change is the result for housing unit size. In 1997, Black households experienced progress relative to Whites in living space. In 2009, that progress is reversed. White households make relative gains on four of the six measures of housing consumption.

Minority housing consumption in 2009 varies widely when considering both gaps and difference-in-differences. Asians face the smallest housing consumption gaps across all measures. The average Asian household owns a younger housing unit by 5.3 years compared to the average White household. Blacks face the highest housing consumption gaps according to most measures, albeit less so according to number of rooms and living space. The average Black housing unit has 10.4% fewer rooms, 12.9% less living space, and is 2.2 years older than the average White housing unit. Black households are also less likely to own by 28.1 percentage points, live in the suburbs by 18.9 percentage points, and own in the suburbs by 24.1 percentage points. Hispanics largely face the

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races. The second question queries the respondent's ethnicity, i.e. if the respondent is Hispanic or Spanish-American.

[51] These results are highly sensitive to the designation of the 'high-sprawl' range of values.

[52] In the original article, 44% is roughly the eightieth percentile in the unweighted empirical distribution of sprawl. However, as Table 3.4 indicates, recent sprawl averages are higher than the replication averages. As such, 52% is the eightieth percentile in the recent empirical distribution of urban sprawl. Approximately 22% of the metropolitan areas in the respective samples fall under the high-sprawl category.

second-highest gaps, with more significant disparities in number of rooms and living space. Relative to the average White household, the average Hispanic household is less likely to own by 24.5 percentage points, live in a suburb by 13.3 percentage points, and be a suburban homeowner by 18.8 percentage points. Hispanics also consume 12.5% fewer rooms, 26.1% less living space, and slightly older housing units by 0.6 years.

Difference-in-differences in minority housing consumption also indicate a varying and complex situation. When considering number of rooms, for example, all three groups make relative progress. When considering unit size or year unit built, however, all three groups experience relative losses. Positive values are also largely the case for suburbanization (but not for Blacks) and homeownership (but not for Asians). Blacks make relative gains on two measures of housing consumption: number of rooms and homeownership. Despite smaller housing consumption gaps relative to Whites, Asians make relative gains only on number of rooms and suburbanization. Hispanics experience the most relative progress on four indicators: number of rooms, suburbanization, homeownership, and suburban homeownership. In fact, Hispanics are the only minority to do so on suburban homeownership according to this analysis.

Table 3.6 presents the housing regression models using recent data for White, Black, Asian, and Hispanic households.[53] The most significant findings occur once again for number of rooms and homeownership, for Whites, Blacks, and now Asians. The models do not yield statistically significant results for Hispanics.

With respect to number of rooms, the effect of urban sprawl on the Black-White housing consumption gap has gone through important changes since 1997: Increases in sprawl no longer contribute to a uniform reduction in that gap. Table 3.7 directly

[53] See Tables 3.9 through 3.12 for detailed results.

compares the previous regression coefficients with the 2009 coefficients.[54] In 1997, for both Black and White households, there is a positive relationship between employment decentralization and number of rooms, which eventually peaks at very high sprawl levels. At any level above the threshold of 7.86%, urban sprawl diminishes the Black-White housing gap. In 2009, that relationship continues to hold for Whites, but not Blacks. For Black households, there is now an inverse relationship between employment decentralization and number of rooms at lower sprawl levels, which turns into a positive relationship after reaching a 'trough.' As a result, the new threshold sprawl level – 43.77% – is significantly higher. This means that at lower levels of sprawl, an increase in sprawl now leads to an expansion of the Black-White disparity in number of rooms. It could also mean that metropolitan areas that were above the threshold in the 1990's could now be below that threshold. At San Francisco's recent sprawl level of 36.20%, Black households would consume 0.85 more rooms versus 1.4 more rooms for White households – nearly opposite of the result in 1997. Although rising sprawl reduces racial inequality in number of rooms above the threshold, 64% of the metropolitan areas in the sample are now below that threshold. Figure 3.2 presents an updated histogram of the urban sprawl index in order to note the significance of this finding.

This analysis also finds a statistically significant relationship between urban sprawl and number of rooms for Asian households. According to the regression coefficients, that relationship is similar to the relationship for White households and dissimilar to the one for Black households. The effect of rising urban sprawl on Asian housing consumption is predominantly positive. At any level of sprawl below 64.47%,

[54] Changes in the sprawl coefficients for number of rooms are statistically significant. The t-statistic in this case tests the null hypothesis that the change in each sprawl coefficient between 1997 and 2009 is zero.

which is nearly the ninety-fifth percentile in this sample, greater sprawl increases Asian housing consumption to a greater degree than White housing consumption with respect to number of rooms. At a level of sprawl experienced by the median metropolitan area, which corresponds to Trenton, New Jersey, Asians would consume 2.5 more rooms, compared to 1.3 and 0.9 for Whites and Blacks respectively. Table 3.8 summarizes and compares all threshold figures for Blacks and Asians.

With respect to the rate of homeownership, the empirical relationship between urban sprawl and the Black-White consumption gap is unchanged. Below the threshold, sprawl leads to divergence in homeownership rates; above the threshold, sprawl leads to convergence in homeownership rates. However, that threshold has risen from 38.06% to 46.69%. This means that in the 70% of metropolitan areas below the threshold, urban sprawl continues to expand the Black-White difference in homeownership.

Asians experience nearly the opposite. Urban sprawl expands White homeownership more than Asian homeownership only at very high levels of sprawl. For example, Chicago's sprawl index is quite high at 67.65%. Asians would be more likely to own by only 0.09 percentage points, versus 0.35 percentage points for Blacks and 0.19 percentage points for Whites. The threshold in this case is 55.58%, which is the eighty-fifth percentile. Below that threshold, Asian households experience greater gains in homeownership compared to similar White households.

3.5 Discussion

The findings presented above suggest four questions of interest to scholars and policymakers: (1) Is urban sprawl good for minorities? (2) What explains the presence

of thresholds for Black housing consumption? (3) Has urban sprawl made housing more affordable for Blacks and Hispanics? (4) Why does sprawl yield significant housing opportunities for Asians?

3.5.1 Is urban sprawl good for minorities?

The answer to this question is multifaceted, and depends upon the racial or ethnic minority, the initial level of sprawl, and the measure of housing consumption. For Blacks, the answer is particularly complex. It is clear that urban sprawl does not facilitate a uniform reduction in the Black-White housing consumption gap. Urban sprawl may reduce the gap, but only in metropolitan areas that have reached a minimum threshold level of sprawl, typically at high levels. According to the recent data, this is the case for both number of rooms and homeownership. Below that threshold, rising sprawl contributes to an expanding disparity in housing consumption. This threshold effect is not unique to 2009 data, and was clearly present for homeownership in 1997. The only measure that did indicate a nearly uniform reduction in a Black-White housing differential is number of rooms. As sprawl increases, however, that differential now expands before it shrinks, resulting in a much higher threshold.

For Asians, the answer is predominantly 'yes.' Urban sprawl facilitates an almost uniform improvement in Asian housing consumption to a much larger extent than White housing consumption. The threshold effect in this case is nearly the opposite of the threshold effect for Blacks. Asians experience advantages from sprawl in metropolitan areas below a threshold, while Blacks experience advantages in metropolitan areas above a threshold. Except in metropolitan areas with extremely high levels of sprawl, the

positive impacts from sprawl on number of rooms and homeownership are greater for Asian households than for identical White households. For Hispanics, however, according to the results of this model, the answer is unclear.

The argument here is that the negative implications of anti-sprawl policies suggested in the 'Defense of Sprawl' literature only apply to a subset of metropolitan areas, and an even narrower subset of housing consumption measures. At best, those implications are premature; at worst, they are misinformed. Anti-sprawl policies do not inevitably increase racial and ethnic inequalities in housing consumption. In many cases, urban sprawl itself is responsible for that outcome.

3.5.2 What explains the presence of thresholds for Black housing consumption?

The answer to this question relies upon the degree of regularity in the attributes of metropolitan areas that are above (or below) a threshold. The most marked difference between those two groupings is metropolitan size, measured as the total number of metropolitan area jobs. Small- to mid-sized metropolitan statistical areas tend to be below a threshold, where sprawl contributes greater housing advantages to Whites; large population centers tend to be above a threshold, where sprawl contributes greater housing advantages to Blacks. More specifically, there is a moderate degree of correlation between this measure of urban sprawl and total metropolitan employment. The Pearson's *r* between the index of employment decentralization and the log of total metropolitan area employees is 0.5697, and is statistically significant at the one-percent level. Furthermore, the median employment level in areas above the Black homeownership threshold is 3.6 times higher than the median employment level in areas below that threshold: 835,409

employees compared to 229,430 employees respectively. Causal explanations for this difference could feature a number of possibilities.

One possible explanation is racial discrimination.[55] Large metropolitan areas tend to feature higher concentrations of non-Black minorities compared to Blacks. Farley and Frey (1994) argue that metropolitan areas with relatively more Asians and Hispanics are associated with less hostility towards Blacks. As such, the new housing opportunities from urban sprawl could be more accessible to Blacks in large metropolitan areas, thus facilitating a smaller consumption gap with Whites. In small and mid-sized metropolitan areas, especially those with greater concentrations of Blacks relative to other minorities, antagonism towards Blacks could be more prominent. Greater employment decentralization could therefore be associated with an expanding racial housing consumption gap, if discrimination prevents access to more living space and/or new homeownership opportunities for Blacks.

A second explanation, which could be intimately related to the first, is racial segregation.[56] Segregation refers to the extent to which a population group is distributed in an uneven, isolated, concentrated, centralized, and/or clustered manner across a metropolitan area. Although urban sprawl may help to shrink the Black-White housing consumption gap, perhaps some of those gains are made possible by the greater residential segregation of Blacks. This effect could be particularly important in large metropolitan areas, where smaller racial housing differentials are indeed more likely.

[55] Discrimination is understood here to mean the collective acts of exclusion by Whites against Blacks, or what Cutler, Glaeser, and Vigdor (1999) label as "collective action racism."

[56] Although discrimination is one explanation for Black-White segregation, Galster and Cutsinger (2007) identify four other possibilities: differences in purchasing power between Blacks and Whites, i.e. income and wealth; differing preferences for housing and neighborhood attributes, i.e. structural attributes, environmental amenities, and local taxes and services; spatial biases in housing market information about housing opportunities; and finally, differing preferences for neighborhood racial or ethnic composition.

Empirical studies of segregation consistently find a strong positive correlation between Black-White segregation and population size. Large metropolitan areas tend to feature higher segregation levels than both medium-sized and small metropolitan areas across several measures of segregation (Iceland, Weinberg, & Steinmetz, 2002). The argument here is that in large metropolitan areas, the housing opportunities contributed by greater sprawl could be distributed in two possible ways: non-Hispanic Whites may seek to isolate themselves from racial or ethnic minorities; or, the expansion of Black housing consumption only occurs in central cities, inner suburbs, or new exurbs with significant Black concentrations. In such cases, greater segregation may be a conduit for a smaller Black-White housing gap.[57]

A third explanation takes account of the effects of urban sprawl on minority purchasing power in metropolitan housing markets, and spatial mismatch. These effects could be particularly important in metropolitan areas with sprawl levels below a threshold. The results of this model indicate that an increase in sprawl could expand the Black-White housing consumption gap in low-sprawl metropolitan areas. According to this index, a low-sprawl metropolitan area is one that is very compact or centralized, meaning a substantial share of employment is located in the beltway or inner suburbs. Compactness may amplify competition over land use between residential and non-residential purposes, which could drive up land and housing prices. Higher prices could then create greater affordability problems for Blacks, whose incomes and wealth are typically lower compared to Whites (Oliver & Shapiro, 2006). In such cases, a greater affordability disparity translates into a greater housing consumption disparity.

[57] This explanation focuses on the role of "decentralized racism (Cutler et al., 1999)," i.e. when segregation is the result of prejudice and the desire by Whites to isolate themselves, not necessarily the explicit prevention of improvements or expansions in Black housing.

Increases in sprawl could further magnify that disparity through spatial mismatch. Spatial mismatch refers to the degree of separation between Black residences and job opportunities in metropolitan areas (Kain, 1968, 1992). In low-sprawl areas, the initial relocation of major employment centers to the periphery could be a disadvantage to Blacks living in central cities or other segregated exurbs, if new employment development is not accompanied by new residential development. Faced with higher commuting and transportation costs, and possibly structural unemployment, Blacks may see a further reduction in purchasing power, thus exacerbating the housing gap with Whites. The empirical results of this research indicate that the likelihood of such outcomes is quite high, and higher than the likelihood that sprawl reduces the housing consumption gap with Whites.

3.5.3 Has urban sprawl made housing more affordable for Blacks and Hispanics?

One of the chief arguments in defense of urban sprawl is that it helps to increase homeownership, especially among minority and/or low- to moderate-income groups. Recent theoretical and empirical work in that literature typically examines the nature and causes of sprawl through the traditional lens of unplanned market forces and individual choices. Kahn (2001) argues that sprawl increases housing affordability by increasing the supply of land available for development, although he does not explain clearly what he means by 'affordable.' Glaeser and Kahn (2001) contend that the most significant causal factor for sprawl is consumer demand for suburban living. Bruegmann (2005) also makes the case that rising affluence is the most historically significant cause of urban sprawl, arguing that affluence has allowed individuals to attain three amenities once

exclusive to the elite: privacy, personal and social mobility, and new choices for housing, employment, and leisure. Urban sprawl is therefore the spatial outcome of how individuals express those choices.

These arguments deserve more scrutiny in light of the housing bubble and bust, and their complex impact on minority homeownership. It is difficult to accept that urban sprawl made housing more 'affordable' for minorities, at least from the standard perspective of price relative to income, for two well-documented reasons. First, housing prices went up, not down. Second, during the period of the bubble, real incomes remained stagnant. Such was the case for US minorities in particular. According to Reidenbach and Weller (2010), US minorities did not witness significant improvements in several labor market outcomes during the 2001 – 2007 business cycle. Unemployment rates were about the same in December 2007 as they were in March 2001. Employment growth was positive, but generally low, and less than population growth. Black-White and Hispanic-White earnings gaps persisted.

Understanding the effects of urban sprawl on minority homeownership therefore requires a different and more effective understanding as to the nature of sprawl itself. The argument here puts greater emphasis on the initiatives by the US government and financial institutions to expand low-income homeownership, which largely contributed to urban sprawl, and less emphasis on the role of individual consumer decision-making in unplanned markets. The data suggest that between 1996 and 2007, the sprawl level of the median metropolitan area increased by over 23%. As others suggest, this no doubt expanded the supply of land available for residential development. Greater market supply, however, did not necessarily result in greater housing 'affordability' through

lower market prices. These initiatives largely generated expanded access to credit, which was unaffordable in a number of cases that has still not reached a limit.

That Blacks and Hispanics were the beneficiaries of such initiatives was not unintentional. The push to increase minority and low-income homeownership accelerated during the early years of the Clinton administration. While the causes of the housing boom are numerous and complex, one of the largest public initiatives to target and spread homeownership came from the Department of Housing and Urban Development under the direction of Henry Cisneros (Streitfeld & Morgensen, 2008). Cisneros helped to ease longstanding barriers in mortgage lending to low-income, first-time buyers, many of whom were minority borrowers. By the end of the Clinton years, the goal of higher homeownership rates for Blacks and Hispanics was clearly observable. It is perhaps not surprising then, that Kahn (2001) found favorable gains in housing consumption for Blacks relative to Whites in 1997, as a result of urban sprawl. The G.W. Bush administration also took up homeownership as a policy goal, as a means of expanding the Republican base to include more minorities, but also to advocate Bush's vision of an "ownership society" (Becker, Stolberg, & Labaton, 2008). Minorities were arguably direct beneficiaries of the new residential development that characterized sprawl during this period. Communities like Park Place South in Atlanta (Becker et al., 2008) and Lago Vista in San Antonio (Streitfeld & Morgensen, 2008) were examples of new exurbs where working class and minority families purchased starter homes with subprime loans and/or federal assistance.

Since the housing bubble, and in addition to other structural changes that have already created greater barriers to homeownership for Blacks and Hispanics – such as the

ongoing loss of manufacturing jobs – the positive contribution of sprawl to minority housing consumption will likely be more difficult to realize. Indeed, this chapter found marked deteriorations in Black-White housing gaps and difference-in-differences, as well as increases in threshold levels, in 2009. If minority and low-income homeowners were crucial beneficiaries of the policies and lending practices that led to the boom, they will likely face disproportionate challenges in the recovery from the bust. The futures of Fannie Mae and Freddie Mac include, at the very least, substantial restructuring. Commercial banks are hoarding excess reserves. Many of the federal assistance programs and tax deductions in residential real estate may well be scaled back, or eliminated entirely, in the interest of deficit reduction. What is more, Blacks and Hispanics have suffered more significantly from the erosion of household wealth following the Great Recession. According to the Pew Research Center, real median net worth dropped 16% for White households, compared to 53% for Black households and 66% for Hispanic households between 2005 and 2009 (Kochhar, Fry, & Taylor, 2011). Current data suggests that a larger percentage of Whites have investments in stocks, mutual funds, and retirement accounts. Given the recovery of the stock market since the 2008 financial crisis, Whites have been able to buffer against the continuing decline in housing prices to a larger degree than Blacks and Hispanics.

3.5.4 Why does sprawl yield significant housing opportunities for Asians?

The empirical relationship between urban sprawl and housing consumption for Asians is similar to that relationship for Whites. Sprawl contributes to an increase in number of rooms and homeownership, which eventually subsides at high levels of

sprawl. Neither group experiences the 'troughs' that continue to characterize the effects of sprawl on Black housing, whereby consumption first decreases before it increases with greater sprawl. As such, thresholds in Asian consumption only occur at very high sprawl levels.

The presence of more significant housing opportunities for Asians (in comparison to both Blacks and Whites) could be due a number of factors. Asians are often in a more favorable economic situation relative to other minorities, and may therefore have been less reliant on some of the policies and mortgage practices that occurred during the housing bubble. With respect to the labor market, recent unemployment rates for Asians are the lowest of any racial or ethnic group, while median household income is the highest of any group: 18% higher than Whites, 73% higher than Hispanics, and 91% higher than Blacks (Reidenbach & Weller, 2010). Wealth disparities between Asians and other US minorities are also clear. In 2009, median net worth for Asian households was $78,066, compared to just $6,325 for Hispanics and $5,677 for Blacks (Kochhar et al., 2011). Asians also largely experience lower levels of racial and ethnic segregation compared to Blacks and Hispanics (Iceland et al., 2002), which may improve access to housing opportunities with respect to homeownership and living space, by perhaps limiting spatial mismatch problems.

Housing outcomes for Asians will likely become more complex as their share of the US population grows. The Asian population is greatly concentrated in the West, but incredibly diverse. Although they face lower levels of racial segregation, recent data suggests that those levels are on the rise (Iceland et al., 2002). Furthermore, Asian household wealth, which exceeded White household wealth in 2005, dropped 54% by

2009, a figure that was slightly more than the drop in Black household wealth (Kochhar et al., 2011). Higher population growth, greater migration within the US, rising segregation, and their experience in the continuing recovery from the Great Recession, will no doubt make the analysis of urban sprawl's contribution to minority housing consumption even more intricate.

3.6 Conclusion

The empirical results of this research suggest several avenues of further investigation. One direction is to consider alternative definitions and measures of urban sprawl besides centrality, such as density (frequency of economic development per square mile), concentration (degree to which economic development takes place in relatively few places), and nuclearity (extent to which development takes place near multiple loci). Recent empirical research on the nature of urban sprawl consistently demonstrates that sprawl is a multi-dimensional phenomenon. If sprawl is indeed a contributing factor in racial and ethnic housing outcomes, whether those outcomes diverge or converge, the empirical specification of sprawl must accurately reflect its multifaceted nature. In addition, one could also test the sensitivity of this model to a residential-based definition of sprawl, as opposed to employment.

Incorporating alternative definitions and measures of sprawl could clarify the presence of thresholds discussed in this chapter. For example, one could consider the interaction of density and centrality in the context of this research question. Perhaps lower housing prices and greater affordability only occur in metropolitan areas that have achieved significant decentralization and low densities; but in decentralized metropolitan

areas with high densities, competition for access to new space may increase residential housing prices, constrict affordability for minorities, and expand the racial housing gap.

Another direction is to directly engage the issue of affordability, which others have argued is the primary means by which sprawl transmits benefits to housing markets. For minorities in particular, are the housing consumption gains from sprawl distributed equally or unequally? Do both low-income and high-income households take advantage of those gains? Previous scholars have hypothesized that Blacks and low-income households in the inner city benefit greatly from urban sprawl, but that channel remains empirically unexamined. In a similar vein, one could also explore whether new housing opportunities for minorities occur in the older housing stock of inner suburbs, or in new exurban developments.

A final direction is to examine the effect of sprawl on racial and ethnic segregation. Two issues are crucial: first, whether that relationship is positive or inverse in nature; and second, whether that relationship varies by minority. Even if urban sprawl does close the Black-White housing consumption gap, perhaps it does so at the expense of greater levels residential dissimilarity, isolation, concentration, centralization, and/or clustering.

3.7 Tables and Figures

Table 3.1
Mean Housing Consumption by Race and Level of Urban Sprawl
Original Results using the 1997 American Housing Survey with Replication

Index	Source	Black Head of Household			White Head of Household			Gap (%)	Difference-in-Difference
		All	Low-Sprawl	High-Sprawl	All	Low-Sprawl	High-Sprawl		
Rooms	Kahn	5.066	4.870	5.252	5.533	5.482	5.592	-0.084	0.272
	Replication	5.125	5.010	5.243	5.554	5.512	5.607	-0.077	0.138
Unit Size (sq. ft.)	Kahn	1755.184	1629.196	1887.771	1949.937	1879.737	2030.654	-0.100	107.658
	Replication	1753.220	1696.570	1811.530	1946.620	1918.050	1981.460	-0.099	51.550
Suburbanization	Kahn	0.272	0.214	0.326	0.512	0.417	0.619	-0.240	-0.090
	Replication	0.265	0.238	0.292	0.524	0.455	0.613	-0.259	-0.104
Ownership	Kahn	0.377	0.347	0.405	0.617	0.604	0.632	-0.240	0.030
	Replication	0.394	0.370	0.419	0.621	0.608	0.637	-0.227	0.020
Suburban Ownership	Kahn	0.122	0.101	0.141	0.354	0.287	0.431	-0.232	-0.104
	Replication	0.123	0.114	0.132	0.368	0.314	0.437	-0.245	-0.105
Year Unit Built	Kahn	1951	1949	1952	1957	1955	1959	-6	-1
	Replication	1951	1950	1952	1957	1956	1959	-6	-1

Sources: American Housing Survey (1997) and ZIP Code Business Patterns (1996)

Note: All results are weighted. A 'high-sprawl' metropolitan area is one in which 44% or more of total employment resides in the periphery. If peripheral employment is less than 44%, the metropolitan area is considered 'low-sprawl.'

Table 3.2
Housing Regressions for Black Households
Original Results using the 1997 American Housing Survey with Replication

	Rooms		Unit Size		Suburbanization		Ownership		Suburban Ownership		Year Unit Built	
	Kahn	Replication	Kahn	Replication	Kahn	Replication	Kahn	Replication	Kahn	Replication	Kahn	Replication
Age	0.062***	0.070***	18.178	15.957	-0.001	0.001	0.018***	0.020***	0.009***	0.011***	-0.151	-0.108
	0.010	*0.009*	*14.158*	*13.568*	*0.003*	*0.003*	*0.003*	*0.003*	*0.003*	*0.003*	*0.161*	*0.152*
Age Squared	0.000***	0.000***	-0.061	-0.057	0.000***	0.000	0.000***	0.000***	0.000***	0.000***	0.000	0.000
	0.00	*0.000*	*0.135*	*0.128*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.001*	*0.001*
Log of Income	0.273***	0.267***	146.733***	142.686***	0.058***	0.054***	0.100***	0.099***	0.048***	0.046***	2.234***	2.210***
	0.04	*0.035*	*38.397*	*36.119*	*0.011*	*0.010*	*0.014*	*0.013*	*0.007*	*0.006*	*0.491*	*0.442*
Number of Adults	0.519***	0.503***	160.390***	152.153***	-0.014	-0.014	0.071***	0.064***	0.006	0.005	-0.699	-0.694
	0.056	*0.052*	*36.209*	*33.332*	*0.010*	*0.008*	*0.011*	*0.011*	*0.007*	*0.007*	*0.507*	*0.485*
Number of Children	0.389***	0.372***	85.783***	73.735***	0.000	0.000	0.018***	0.016***	0.011***	0.009**	-0.446	-0.331
	0.039	*0.037*	*30.018*	*26.541*	*0.009*	*0.008*	*0.006*	*0.005*	*0.004*	*0.004*	*0.434*	*0.439*
Log of MA Total Jobs	-0.186***	-0.206***	6.721	1.367	0.015	0.008	-0.047***	-0.042**	0.006	0.005	-0.224	-0.202
	0.070	*0.069*	*50.436*	*53.831*	*0.038*	*0.037*	*0.016*	*0.016*	*0.016*	*0.017*	*0.906*	*0.954*
Sprawl	**2.729*** **	**3.014*** **	**981.048***	**885.555**	**0.645**	**0.880***	**-0.334**	**-0.062**	**0.163**	**0.348**	**-22.146**	**-16.156**
	1.054	***1.046***	***598.602***	***640.004***	***0.572***	***0.462***	***0.259***	***0.326***	***0.276***	***0.216***	***16.194***	***15.984***
Sprawl Squared	**-1.936** **	**-2.204** **	**-696.275**	**-554.142**	**-0.550**	**-0.801***	**0.710*** **	**0.384**	**-0.113**	**-0.320**	**18.044**	**11.265**
	0.967	***0.924***	***599.053***	***620.937***	***0.589***	***0.460***	***0.242***	***0.302***	***0.295***	***0.220***	***16.854***	***16.354***
Constant	0.914	1.011	-1218.459*	-990.807	-0.576	-0.496	-0.732***	-0.919***	-0.743***	-0.785***	1946.022***	1951.235***
	0.974	*0.939*	*723.676*	*718.221*	*0.512*	*0.509*	*0.262*	*0.254*	*0.269*	*0.269*	*11.745*	*12.771*
F test	3.79**	4.30**	1.90	1.46	0.82	1.82	9.05***	3.88**	0.47	1.33	1.23	0.81
R-Squared	0.273	0.266	0.152	0.142	0.064	0.062	0.242	0.240	0.069	0.067	0.213	0.208
Observations	2,484	2,733	908	1,043	2,484	2,733	2,453	2,733	2,453	2,733	2,484	2,733

All regressions are weighted and include regional dummies. Clustered standard errors are reported.
The F-Test tests the null hypothesis that the sprawl variables are jointly insignificant.
*** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table 3.3
Housing Regressions for White Households
Original Results using the 1997 American Housing Survey with Replication

	Rooms		Unit Size		Suburbanization		Ownership		Suburban Ownership		Year Unit Built	
	Kahn	Replication	Kahn	Replication	Kahn	Replication	Kahn	Replication	Kahn	Replication	Kahn	Replication
Age	0.118***	0.120***	43.996***	44.467***	0.008***	0.009***	0.032***	0.032***	0.021***	0.022***	0.043	0.074
	0.006	*0.006*	*5.081*	*4.769*	*0.002*	*0.002*	*0.001*	*0.001*	*0.002*	*0.002*	*0.077*	*0.067*
Age Squared	-0.001***	-0.001***	-0.322***	-0.326***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	-0.001	-0.001
	0.000	*0.000*	*0.047*	*0.043*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.001*	*0.001*
Log of Income	0.492***	0.468***	246.147***	226.683***	0.042***	0.042***	0.129***	0.123***	0.087***	0.084***	2.036***	1.981***
	0.040	*0.040*	*19.655*	*17.472*	*0.007*	*0.007*	*0.008*	*0.007*	*0.007*	*0.008*	*0.347*	*0.364*
Number of Adults	0.490***	0.463***	75.604***	68.086***	0.023***	0.022***	0.057***	0.049***	0.047***	0.043***	-0.964***	-0.957***
	0.039	*0.037*	*14.104*	*12.814*	*0.007*	*0.006*	*0.007*	*0.006*	*0.006*	*0.005*	*0.312*	*0.274*
Number of Children	0.397***	0.395***	81.505***	79.773***	0.014***	0.015***	0.050***	0.048***	0.036***	0.036***	0.179	0.193
	0.030	*0.030*	*13.434*	*13.319*	*0.005*	*0.005*	*0.005*	*0.006*	*0.006*	*0.006*	*0.255*	*0.251*
Log of MA Total Jobs	-0.236***	-0.228***	18.210	17.623	-0.028	-0.036	-0.067***	-0.069***	-0.033	-0.039	-1.985**	-2.098**
	0.069	*0.067*	*26.217*	*25.474*	*0.040*	*0.043*	*0.015*	*0.014*	*0.028*	*0.031*	*0.883*	*0.862*
Sprawl	**2.857*** **	**2.694*** **	**719.093***	**429.630**	**1.168** **	**0.873***	**0.297**	**0.338***	**0.919** **	**0.659***	**-3.704**	**-1.705**
	0.844	***0.816***	***367.752***	***336.354***	***0.533***	***0.521***	***0.187***	***0.182***	***0.371***	***0.358***	***15.678***	***15.221***
Sprawl Squared	**-2.750*** **	**-2.370*** **	**-734.647***	**-346.103**	**-0.662**	**-0.008**	**-0.119**	**-0.078**	**-0.569**	**0.028**	**10.490**	**12.161**
	0.827	***0.806***	***435.513***	***347.093***	***0.536***	***0.537***	***0.189***	***0.187***	***0.373***	***0.381***	***17.208***	***17.124***
Constant	-1.549	-1.691*	-2594.652***	-2530.677***	-0.187	-0.157	-1.057***	1.047***	-1.126***	-1.102***	1963.864***	1968.040***
	0.982	*0.980*	*370.684*	*368.101*	*0.471*	*0.522*	*0.198*	*0.193*	*0.366*	*0.405*	*11.676*	*11.099*
F test	5.84***	5.47***	2.02	0.99	5.52***	8.66***	3.62**	6.49***	6.17***	10.38***	1.09	2.07
R-Squared	0.295	0.281	0.146	0.138	0.072	0.104	0.275	0.260	0.155	0.175	0.125	0.128
Observations	12,322	13,379	6,853	7,552	12,322	13,379	12,179	13,379	12,179	13,379	12,322	13,379

All regressions are weighted and include regional dummies. Clustered standard errors are reported.
The F-Test tests the null hypothesis that the sprawl variables are jointly insignificant.
*** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Table 3.4
Comparison of Summary Statistics for Urban Sprawl
1996 Replication vs. 2007 Update

	1996	2007
N	130	129
Mean	0.3016	0.3790
Standard Deviation	0.1670	0.1685
Minimum	0.0000	0.0000
10th Percentile	0.1037	0.1519
1st Quartile	0.1706	0.2552
Median	0.3026	0.3731
3rd Quartile	0.4189	0.4995
90th Percentile	0.5264	0.6257
Maximum	0.7883	0.8074

Sources: ZIP Code Business Patterns (1996; 2007)

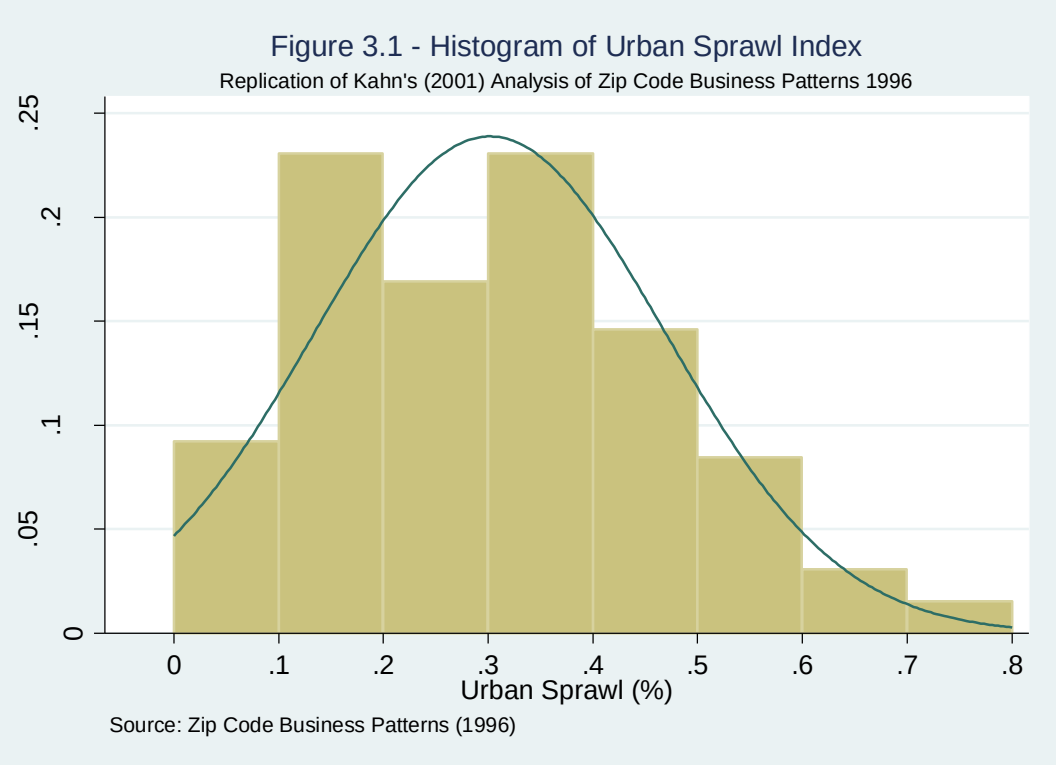

Table 3.5
Mean Housing Consumption by Race or Ethnicity and Level of Urban Sprawl
Results using the 2009 American Housing Survey

	Rooms	Unit Size	Suburbanization	Ownership	Suburban Ownership	Year Unit Built
White – All	5.743	1890.990	0.508	0.690	0.386	1961
White – Low Sprawl	5.704	1834.250	0.457	0.678	0.347	1958
White – High Sprawl	5.796	1967.060	0.577	0.706	0.439	1965
Black – All	5.148	1646.630	0.319	0.409	0.145	1959
Black – Low Sprawl	5.057	1591.340	0.281	0.387	0.125	1957
Black – High Sprawl	5.250	1707.140	0.361	0.433	0.167	1961
Consumption Gap (%)	-0.104	-0.129	-0.189	-0.281	-0.241	-2.2
Difference-in-Difference	0.102	-17.010	-0.040	0.018	-0.050	-3.0
Asian – All	5.322	1681.780	0.447	0.577	0.292	1966
Asian – Low Sprawl	5.219	1630.160	0.374	0.575	0.255	1964
Asian – High Sprawl	5.440	1740.000	0.532	0.579	0.334	1969
Consumption Gap (%)	-0.073	-0.111	-0.061	-0.113	-0.094	5.3
Difference-in-Difference	0.130	-22.970	0.038	-0.024	-0.013	-2.5
Hispanic – All	5.026	1397.730	0.375	0.445	0.198	1960
Hispanic – Low Sprawl	4.947	1356.900	0.272	0.415	0.144	1960
Hispanic – High Sprawl	5.108	1438.630	0.482	0.476	0.255	1961
Consumption Gap (%)	-0.125	-0.261	-0.133	-0.245	-0.188	-0.6
Difference-in-Difference	0.069	-51.080	0.090	0.033	0.019	-6.0

Sources: American Housing Survey (2009) and ZIP Code Business Patterns (2007)
Note: All results are weighted. A 'high-sprawl' metropolitan area is one in which 52% or more of total employment resides in the periphery. If peripheral employment is less than 52%, the metropolitan area is considered 'low-sprawl.'

Table 3.6
Housing Regressions by Race and Ethnicity
Results using the 2009 American Housing Survey

Index		White	Black	Asian	Hispanic
Rooms	Sprawl	2.645**	-0.340	5.341**	0.794
	Sprawl Squared	-1.761*	1.649	-3.852	-0.138
	F test	3.62**	7.03***	7.76***	1.97
Unit Size (sq. ft.)	Sprawl	463.399	-391.407	-126.185	-1305.831
	Sprawl Squared	-86.755	578.593	1554.922	1927.788
	F test	2.29	0.16	3.79**	1.64
Suburbanization	Sprawl	1.510**	0.689	1.095	-0.481
	Sprawl Squared	-0.613	-0.446	-0.420	1.123
	F test	10.28***	1.30	4.64**	2.78*
Ownership	Sprawl	0.243	-0.095	0.741	0.066
	Sprawl Squared	-0.036	0.326	-0.484	0.068
	F test	6.36***	4.10**	6.41***	0.63
Suburban Ownership	Sprawl	1.113**	0.349	0.752	0.076
	Sprawl Squared	-0.393	-0.241	-0.173	0.235
	F test	10.52***	1.13	6.14***	2.10
Year Unit Built	Sprawl	-25.187	-20.913	-19.881	0.467
	Sprawl Squared	37.583**	21.164	27.621	-6.154
	F test	3.34**	0.47	0.20	0.49

**** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$*

Table 3.7
Comparison of Housing Regressions for Black and White Households
1997 Replication vs. 2009 Update

Index		White Head of Household			Black Head of Household		
		1997	2009	Change, 1997 - 2009	1997	2009	Change, 1997 - 2009
Rooms	Sprawl	2.857***	2.645**	-0.212	2.729***	-0.340	-3.069*
		0.844	*1.142*	*1.420*	*1.054*	*1.213*	*1.607*
	Sprawl Squared	-2.750***	-1.761*	0.989	-1.936**	1.649	3.585**
		0.827	*1.055*	*1.341*	*0.967*	*1.231*	*1.565*
	F test	5.84***	3.62**		3.79**	7.03***	

Ownership		White Head of Household			Black Head of Household		
		1997	2009	Change, 1997 - 2009	1997	2009	Change, 1997 - 2009
	Sprawl	0.297	0.243	-0.054	-0.334	-0.095	0.239
		0.187	*0.175*	*0.256*	*0.259*	*0.292*	*0.390*
	Sprawl Squared	-0.119	-0.036	0.083	0.710***	0.326	-0.384
		0.189	*0.168*	*0.253*	*0.242*	*0.265*	*0.359*
	F test	3.62**	6.36***		9.05***	4.10**	

**** p < 0.01 ** p < 0.05 * p < 0.10*

The t-statistic for the change between 1997 and 2009 tests the null hypothesis that the difference between the respective regression coefficients equals zero.

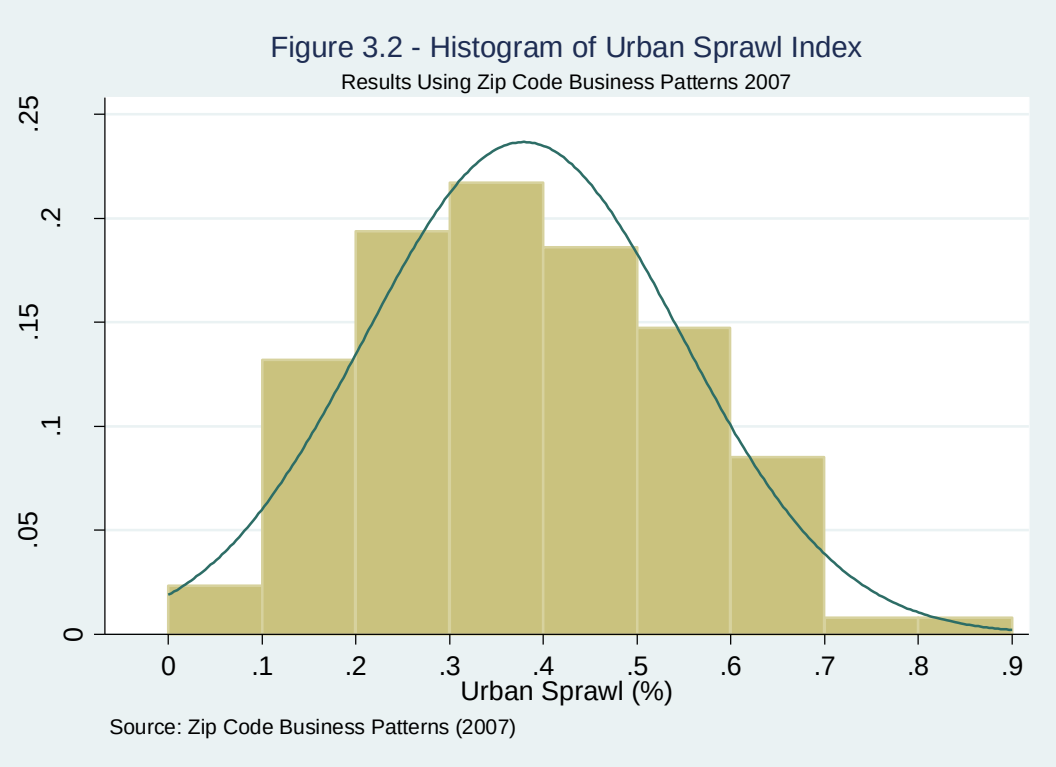

Table 3.8
Comparison of Sprawl Thresholds for Black and Asian Households
1997 Replication vs. 2009 Update

	Black Head of Household		Asian Head of Household
Index	1997	2009	2009
Rooms	0.0786	0.4377	0.6447
Ownership	0.3806	0.4669	0.5558
Sprawl contributes to greater housing consumption relative to Whites . . .	*Above Threshold*		*Below Threshold*

Sprawl values range between 0 and 1.0, and indicate the share of metropolitan employment in the periphery. Low values indicate low sprawl levels. High values indicate high sprawl levels.

Table 3.9
2009 Housing Consumption Regressions
White Head of Household

	Rooms	Unit Size	Suburbanization	Ownership	Suburban Ownership	Year Unit Built
Northeast	0.111	101.747	0.215***	0.046*	0.210***	-15.934***
	0.155	*68.937*	*0.069*	*0.025*	*0.054*	*3.468*
Midwest	0.270**	43.447	0.099	0.083***	0.129**	-6.761***
	0.106	*63.832*	*0.067*	*0.017*	*0.052*	*2.457*
South	0.176	116.245	-0.013	0.047***	0.027	3.028
	0.117	*83.873*	*0.074*	*0.018*	*0.056*	*2.588*
Age	0.077***	45.684***	0.010***	0.027***	0.017***	-0.010
	0.006	*8.612*	*0.002*	*0.001*	*0.002*	*0.081*
Age Squared	0.000***	-0.270***	0.000***	0.000***	0.000***	0.000
	0.000	*0.083*	*0.000*	*0.000*	*0.000*	*0.000*
Log of Income	0.457***	207.175***	0.013*	0.112***	0.057***	1.272***
	0.034	*36.026*	*0.008*	*0.007*	*0.007*	*0.378*
Number of Adults	0.529***	231.051***	0.033***	0.030***	0.041***	-0.692**
	0.031	*46.592*	*0.007*	*0.005*	*0.006*	*0.348*
Number of Children	0.520***	219.487***	0.045***	0.064***	0.054***	1.189***
	0.023	*33.820*	*0.007*	*0.006*	*0.007*	*0.309*
Log of MA Total Jobs	-0.247***	-19.737	-0.049	-0.046***	-0.044	-1.558*
	0.075	*33.868*	*0.040*	*0.010*	*0.031*	*0.887*
Sprawl	**2.645****	**463.399**	**1.510****	**0.243**	**1.113****	**-25.187**
	1.142	***695.182***	***0.720***	***0.175***	***0.560***	***17.748***
Sprawl Squared	**-1.761***	**-86.755**	**-0.613**	**-0.036**	**-0.393**	**37.583****
	1.055	***778.901***	***0.774***	***0.168***	***0.608***	***18.300***
Constant	-0.435	-2405.084***	0.026	-1.023***	-0.812**	1975.569***
	1.051	*541.108*	*0.469*	*0.150*	*0.390*	*12.075*
F test	3.62**	2.29	10.28***	6.36***	10.52***	3.34**
R-Squared	0.312	0.045	0.121	0.229	0.154	0.107
Observations	11,377	10,300	11,377	11,377	11,377	11,377

All regressions are weighted. Clustered standard errors are reported.
The F-Test tests the null hypothesis that the sprawl variables are jointly insignificant.
**** p < 0.01 ** p < 0.05 * p < 0.10*

Table 3.10
2009 Housing Consumption Regressions
Black Head of Household

	Rooms	Unit Size	Suburbanization	Ownership	Suburban Ownership	Year Unit Built
Northeast	0.099	278.654*	-0.103	0.032	-0.032	-17.721***
	0.208	*155.333*	*0.065*	*0.060*	*0.036*	*3.362*
Midwest	0.350**	331.918*	-0.085	0.105***	-0.008	-12.559***
	0.156	*178.005*	*0.061*	*0.037*	*0.036*	*3.540*
South	0.255	372.460**	0.026	0.076**	0.037	2.051
	0.157	*151.335*	*0.072*	*0.036*	*0.041*	*3.201*
Age	0.046***	17.117	0.000	0.015***	0.008***	-0.278
	0.009	*27.607*	*0.003*	*0.003*	*0.002*	*0.174*
Age Squared	0.000***	-0.042	0.000	0.000*	0.000***	0.001
	0.000	*0.267*	*0.000*	*0.000*	*0.000*	*0.002*
Log of Income	0.308***	178.230***	0.045***	0.114***	0.052***	1.733***
	0.041	*41.401*	*0.011*	*0.010*	*0.010*	*0.333*
Number of Adults	0.519***	214.467**	0.000	0.067***	0.022***	-1.549***
	0.038	*86.522*	*0.010*	*0.009*	*0.008*	*0.539*
Number of Children	0.349***	77.390*	0.007	0.001	0.015**	-0.494
	0.031	*44.674*	*0.008*	*0.008*	*0.007*	*0.490*
Log of MA Total Jobs	-0.175***	110.676*	0.020	-0.045***	0.012	-0.369
	0.054	*60.788*	*0.038*	*0.013*	*0.020*	*0.926*
Sprawl	**-0.340**	**-391.407**	**0.689**	**-0.095**	**0.349**	**-20.913**
	1.213	***1412.671***	***0.654***	***0.292***	***0.321***	***21.970***
Sprawl Squared	**1.649**	**578.593**	**-0.446**	**0.326**	**-0.241**	**21.164**
	1.231	***1539.456***	***0.681***	***0.265***	***0.333***	***23.715***
Constant	1.286	-3085.782***	-0.561	-0.892***	-0.971***	1969.74***
	0.940	*992.670*	*0.556*	*0.211*	*0.352*	*13.560*
F test	7.03***	0.16	1.30	4.10**	1.13	0.47
R-Squared	0.288	0.029	0.055	0.223	0.078	0.154
Observations	3,207	2,448	3,207	3,207	3,207	3,207

All regressions are weighted. Clustered standard errors are reported.
The F-Test tests the null hypothesis that the sprawl variables are jointly insignificant.
**** p < 0.01 ** p < 0.05 * p < 0.10*

Table 3.11
2009 Housing Consumption Regressions
Asian Head of Household

	Rooms	Unit Size	Suburbanization	Ownership	Suburban Ownership	Year Unit Built
Northeast	0.100	406.063	-0.072	0.000	0.025	-18.772***
	0.247	*293.092*	*0.103*	*0.046*	*0.075*	*3.834*
Midwest	0.353**	400.947	-0.036	0.071*	-0.001	-2.272
	0.153	*277.425*	*0.095*	*0.041*	*0.059*	*2.691*
South	0.436***	153.464	0.007	0.026	-0.019	7.905**
	0.154	*94.919*	*0.128*	*0.049*	*0.073*	*3.213*
Age	-0.001	-23.645	-0.002	0.016***	0.005	0.175
	0.026	*47.505*	*0.004*	*0.006*	*0.005*	*0.291*
Age Squared	0.000	0.502	0.000	0.000	0.000	-0.003
	0.000	*0.529*	*0.000*	*0.000*	*0.000*	*0.003*
Log of Income	0.552***	323.676***	0.043**	0.156***	0.087***	2.636***
	0.065	*72.543*	*0.019*	*0.016*	*0.016*	*0.790*
Number of Adults	0.406***	143.669**	0.019	0.057***	0.042**	-1.007
	0.091	*70.044*	*0.017*	*0.020*	*0.018*	*0.770*
Number of Children	0.336***	131.156***	0.025	0.042***	0.028*	-0.441
	0.055	*47.599*	*0.017*	*0.013*	*0.015*	*0.698*
Log of MA Total Jobs	-0.317***	-219.774**	0.003	-0.069***	-0.028	-3.681***
	0.088	*94.281*	*0.046*	*0.018*	*0.034*	*1.277*
Sprawl	**5.341****	**-126.185**	**1.095**	**0.741**	**0.752**	**-19.881**
	2.138	***2096.411***	***0.998***	***0.499***	***0.782***	***39.353***
Sprawl Squared	**-3.852**	**1554.922**	**-0.420**	**-0.484**	**-0.173**	**27.621**
	2.473	***2213.767***	***1.129***	***0.577***	***0.891***	***48.304***
Constant	0.237	283.069	-0.568	-1.097***	-0.945*	1994.949***
	1.249	*1330.763*	*0.578*	*0.308*	*0.502*	*20.305*
F test	7.76***	3.79**	4.64**	6.41***	6.14***	0.20
R-Squared	0.290	0.078	0.010	0.232	0.134	0.181
Observations	1,025	931	1,025	1,025	1,025	1,025

All regressions are weighted. Clustered standard errors are reported.
The F-Test tests the null hypothesis that the sprawl variables are jointly insignificant.
**** p < 0.01 ** p < 0.05 * p < 0.10*

Table 3.12
2009 Housing Consumption Regressions
Hispanic Head of Household

	Rooms	Unit Size	Suburbanization	Ownership	Suburban Ownership	Year Unit Built
Northeast	0.024	-12.041	-0.151**	-0.175***	-0.070	-20.435***
	0.172	*132.334*	*0.076*	*0.056*	*0.044*	*2.969*
Midwest	0.377***	165.857**	-0.125*	0.069	0.011	-10.687***
	0.137	*71.489*	*0.067*	*0.044*	*0.043*	*2.462*
South	0.271**	221.048**	-0.010	0.066**	0.041	4.808**
	0.123	*85.192*	*0.080*	*0.033*	*0.050*	*2.088*
Age	0.052***	28.126***	0.004	0.024***	0.012***	-0.367***
	0.009	*9.063*	*0.004*	*0.003*	*0.003*	*0.129*
Age Squared	0.000***	-0.206**	0.000	0.000***	0.000***	0.002
	0.000	*0.091*	*0.000*	*0.000*	*0.000*	*0.001*
Log of Income	0.460***	202.801***	0.054***	0.143***	0.067***	1.619***
	0.062	*36.278*	*0.013*	*0.016*	*0.015*	*0.476*
Number of Adults	0.259***	143.084**	-0.005	0.024**	0.018**	-2.150***
	0.023	*57.763*	*0.012*	*0.011*	*0.008*	*0.324*
Number of Children	0.283***	33.881	-0.008	0.023***	-0.003	-0.226
	0.028	*27.059*	*0.007*	*0.006*	*0.004*	*0.341*
Log of MA Total Jobs	-0.244***	-86.057*	0.030	-0.052***	0.012	-2.876**
	0.051	*46.031*	*0.029*	*0.014*	*0.016*	*1.112*
Sprawl	**0.794**	**-1305.831**	**-0.481**	**0.066**	**0.076**	**0.467**
	1.529	***984.463***	***0.889***	***0.493***	***0.459***	***25.756***
Sprawl Squared	**-0.138**	**1927.788**	**1.123**	**0.068**	**0.235**	**-6.154**
	1.730	***1187.664***	***1.055***	***0.548***	***0.569***	***27.176***
Constant	0.645	-629.317	-0.709	-1.193***	-1.170***	2003.218***
	1.024	*841.048*	*0.464*	*0.338*	*0.355*	*16.145*
F test	1.97	1.64	2.78*	0.63	2.10	0.49
R-Squared	0.264	0.040	0.092	0.249	0.108	0.208
Observations	2,954	2,521	2,954	2,954	2,954	2,954

All regressions are weighted. Clustered standard errors are reported.
The F-Test tests the null hypothesis that the sprawl variables are jointly insignificant.
**** p < 0.01 ** p < 0.05 * p < 0.10*

CHAPTER 4

RACIAL AND ETHNIC SEGREGATION IN THE ERA OF URBAN SPRAWL: A COMPARATIVE ANALYSIS OF BLACK, HISPANIC, AND ASIAN OUTCOMES

4.1 Introduction

Segregation refers to the degree of uneven distribution, isolation from the majority, concentration into relatively few places, centralization near the urban core, and/or clustering into enclaves, of a minority population group across a metropolitan area (Massey & Denton, 1988). According to Iceland, Weinberg, and Steinmetz's (2002) widely-cited analysis of the Census 2000 data, Blacks experienced steady declines in segregation levels across multiple measures over the previous two decades. However, those levels are still the highest of the three primary minority groups. Hispanics register the second-highest segregation levels, but experienced increases in segregation according to some measures (although not all). Asians experienced similarly rising segregation patterns, but at the lowest levels. In particular, centralization near the urban core steadily declined for all three groups during this period.

Explanations of racial and ethnic segregation in the United States remain controversial and contested.[58] An undoubtedly short list of such explanations would include the historical legacy of formal segregation and other forms of "collective action racism" (Cutler, Glaeser, & Vigdor, 1999), animosity towards another population group (or groups), domestic migration patterns, foreign immigration patterns, the spatial distribution of capital and employment, access to credit, and inequalities in wealth and income, among many others. Segregation is thus a key focus of contemporary and

[58] Cutler, Glaeser, and Vigdor (1999) and Galster and Cutsinger (2007) offer comprehensive examinations of the various explanations of segregation in the literature.

historical scholarship in urban economics and other social sciences.

Theoretical and empirical research on the relationship between segregation and urban sprawl is an intriguing and growing literature. In a sense, the convergence of the segregation and sprawl literatures is not surprising. Both investigate phenomenon whose very definitions are multi-dimensional and heavily debated. However, both have made progress in resolving methodological inconsistencies in empirical measurement. Such developments allow for more rigorous analysis of the association between the predominant settlement patterns of minorities and the predominant spatial patterns of land use.

While previous studies have contributed crucial insights, important limitations are clear and apparent. First, recent research focuses heavily on density as an attribute and measure of urban sprawl. Although a limited number of studies empirically examine the relationship between multiple measures of sprawl and segregation, an even smaller number take account of countervailing patterns of land use.[59] Metropolitan areas do not generally exhibit high-sprawl (or low-sprawl) characteristics across multiple measures. Spatial patterns of land use typically exhibit some combination or 'configuration' of both low-sprawl and high-sprawl attributes. The understanding of land use as a countervailing, multi-dimensional phenomenon has been supported and expanded by chapter two of this dissertation. Second, previous research focuses primarily on Black segregation, with little comparison with new minority outcomes. The reason is largely due to the finding that segregation measures can be unreliable when the population group is very small (Massey & Denton, 1988). This is a significant limitation for previous

[59] One exception is Cutsinger and Galster (2006), who identify various sprawl typologies with respect to the distribution of housing and employment. However, they do not explore the consequences of those typologies using regression analysis.

studies that utilize Census 1990 data. In light of the rapid growth of both the Asian and Hispanic populations, such comparison is now possible. Although a select number of studies examine the relationship between local land-use regulations and new minority segregation, none have explicitly investigated the relationship between sprawl and new minority segregation. Third, the literature often lacks comprehensive analysis of the five dimensions of segregation suggested by Massey and Denton. This is also a crucial omission, as the unexamined dimensions of segregation are often the ones that characterize new minority segregation in particular.

This chapter contributes to the literature by exploring the relationship between alternative configurations of land use and racial and ethnic segregation, and by comparing outcomes for Blacks, Hispanics, and Asians. Land-use attributes contribute to changes in segregation through changes in housing prices, the distribution and mix of different housing types, commuting costs, as well as residential preferences for neighborhood composition and amenities. The preceding literature, however, lacks precision in two important areas. First, how are these changes transmitted in metropolitan areas with a combination of high-sprawl and low-sprawl characteristics, as compared to those with uniformly high-sprawl or low-sprawl attributes? Second, to what extent are these channels more (or less) significant for each minority group? The position of this study is that different combinations of multiple land-use attributes generate specific shifts in those factors that decrease (or increase) racial and ethnic segregation. Regression analysis indicates that those contrasting effects on segregation are present not only when examining outcomes within each group, especially for Blacks and Hispanics, but also when comparing outcomes across all three minority groups. These complexities

would not be observable by simply controlling for one attribute of land use, or by examining one population group.

The chapter is divided into the following sections. Section 4.2 reviews the literature and its major findings. Section 4.3 defines the theoretical framework of this chapter, namely the various configurations of land use, as well as the selected dimensions and measures of segregation. It also includes a discussion of the major research questions and hypotheses of this study. Section 4.4 introduces summary statistics for all empirical measures. Section 4.5 presents the regression model and compares results for Blacks, Hispanics, and Asians. Section 4.6 discusses the implications of this study for each minority group, followed by an exploration of future research avenues in Section 4.7.

4.2 Literature Survey

Since the early 2000's, there has been a diverse and growing literature on the relationship between spatial patterns of land use and segregation. That diversity, however, often makes direct comparisons between studies difficult. Previous studies vary extensively by conceptual definitions of land use, land use policies, and segregation, as well as operational specifications and empirical measures of those definitions. Furthermore, they vary by the scope of analysis, i.e. case or regional studies versus national studies, and the extent of inter-minority comparison. These factors establish the need for comprehensive analysis.

To begin, a number of studies in this literature examine the relationship between density and segregation. Operational definitions of both density and segregation vary.

For example, Huie and Frisbee (2000) investigate the relationship between various specifications of density and five dimensions of Black segregation, controlling for inter-regional variations and the total number of metropolitan housing units. Using Census 1990 data for the fifty-eight largest metropolitan areas, they define five measures of density: population per square mile, structures per square mile, rooms per unit, persons per room, and units per structure. Furthermore, the authors calculate general/non-race specific densities (i.e. of the entire metropolitan area population), as well race-specific densities (i.e. of the Black population only). Two findings from their regression models are noteworthy. First, across multiple measures, lower general densities are associated with higher levels of Black segregation, in the form of concentration and centralization. Second, lower density, defined as the number of structures per square mile with a Black householder, is associated with lower levels of Black dissimilarity, isolation, and clustering.

In contrast, Pendall and Carruthers (2003) measure density as the number of persons and jobs per acre of developed land. Using a sample of 318 metropolitan areas, the authors analyze the connection between density and Black income segregation over the 1980, 1990, and 2000 decennial censuses, controlling for a wide array of environmental, demographic, socioeconomic, and political variables. Their analysis of segregation is limited to two dimensions, however: dissimilarity and isolation. They find that the relationship between density and income segregation is quadratic in-nature, meaning that segregation is the lowest in low-density metropolitan areas, highest in medium-density areas, and slightly lower in high-density areas.

Several other works scrutinize the relationship between segregation and local

land-use policies. Although they do not control for urban sprawl directly, their findings and conclusions certainly carry significance for sprawl-related scholarship. However, they differ from the aforementioned studies in that they often feature comparisons of Black and non-Black minority outcomes.

Using survey data from twenty-five metropolitan areas, Pendall (2000) argues that growth management policies contributed to lower minority concentration of Blacks and Hispanics between 1980 and 1990, controlling for other housing, racial, socioeconomic, community location, and metropolitan area characteristics. Land-use regulations refer to low density-only zoning, building permit caps, building permit moratoria, adequate public facilities ordinances, and urban growth boundaries. Pendall also controls for the effect of "boxed-in status," a situation in which urbanization is limited by surrounding incorporated areas or natural boundaries. Minority concentration is measured as the ratio of the local minority population share relative to the metropolitan region's population share. Pendall finds that low density-only zoning creates a "chain of exclusion" that reduces the availability of rental housing, and thereby the Black and Hispanic populations. Building permit caps have a similar effect on Hispanic concentration.

Quigley, Raphael, and Rosenthal's (2004) case study of California assesses the impact of land-use policies on demographic changes in metropolitan areas during the 1990's. Several findings are significant. Metropolitan areas with low-density residential development were likely to experience net gains in the non-Hispanic White population, while those with high-density development tended to experience net losses. A similar relationship is present for Blacks, although to a weaker degree. For both Asians and Hispanics, however, low-density development contributed to net losses in their respective

populations.

Two additional policy studies are also quite useful. In Nelson, Sanchez, and Dawkins (2004), the authors analyze the relationship between various urban containment policies, and changes in Black, Hispanic, and Asian dissimilarity between 1980 and 2000. According to their sample of 331 metropolitan areas, Black dissimilarity is predicted to be lower in metropolitan areas with significant long-term containment plans, controlling for other population, socioeconomic, and regional factors. No significant relationship is found between the proposed policy influences and new minority segregation. Utilizing a smaller sample, Nelson, Dawkins, and Sanchez (2004) find that metropolitan areas with mandatory local housing elements are likely to exhibit higher Black dissimilarity, while metropolitan areas with urban growth boundaries are likely to exhibit lower Black dissimilarity.

The Galster and Cutsinger (2007) piece occupies a rare space in the literature by examining multiple measures of both sprawl and racial segregation. They find a largely positive (and non-linear) contribution of sprawl to reducing Black segregation levels in fifty metropolitan areas between 1990 and 2000. However, both Black isolation and centralization are predicted to be higher in metropolitan areas with sprawl-like characteristics. While this study is distinguished for its comprehensive and multi-dimensional nature, in terms of its handling of both sprawl and segregation, it has several shortcomings. First, the sample size is very small. Second, it does not consider consequences for non-Black minorities. Third, each measure of segregation is regressed on each measure of sprawl separately, yielding thirty-five models. As such, this specification does not explicitly account for the various combinations of low-sprawl and

high-sprawl attributes that metropolitan areas frequently exhibit. For example, although low-density sprawl may contribute to lower segregation, there is a wide range of concentration and centralization outcomes across low-density metropolitan areas. While some low-density areas are decentralized, which is typically associated with sprawl, others are highly-centralized. The question of whether those variations mitigate (or abet) segregation is an important one, and the entry point of this chapter.

4.3 Framework and Theoretical Approach

4.3.1 Configurations of Land Use

This dissertation defines urban sprawl as a multi-faceted combination of land-use characteristics, which frequently combine in countervailing ways. The selection of attributes and empirical measures, as well as the operational specification of sprawl, is specific. The reader is referred to chapter two of this dissertation for an extensive analysis of the various attributes and empirical measures of urban sprawl.

Three primary attributes describe metropolitan land-use patterns: density, concentration, and centrality. Density refers to the frequency of economic development per square mile. Concentration is the extent to which economic development takes place in relatively few places. Centrality refers to the extent of economic development around a historical central business district. A low-sprawl metropolitan area exhibits high density patterns, significant concentration (or unevenness), and significant centralization. A high-sprawl metropolitan area exhibits low density patterns, deconcentration (or evenness), and decentralization. These attributes have been referenced widely in the literature, and establish the most plausible theoretical connection between sprawl and the

research questions of this chapter. The choice of attributes is also based upon their strong empirical connection with other alternatives in the literature, such as continuity, mixed land use, and proximity.

This chapter operationally defines sprawl with respect to housing, as opposed to employment. The purpose is to examine the consequences of housing development, and different patterns of housing development, on racial and ethnic segregation. This reflects the common argument in the literature that segregation is a largely residential phenomenon. The relationship between the spatial pattern of employment and segregation, and how it compares to residential-based specifications of sprawl, are no doubt fruitful research questions. For a national study, however, housing carries several advantages. National employment data sources (e.g. County Business Patterns and ZIP Code Business Patterns) exclude most government employment, and also suppress a fair amount of data for confidentiality reasons. One-hundred percent data on residential housing units are available from the Census Summary Files. Housing data are also available at the more stable census tract-level, whereas disaggregated employment data are only available at the highly-irregular ZIP code-level. Finally, census tracts conform perfectly to metropolitan statistical area and New England county metropolitan area boundaries, in contrast to ZIP code tabulation areas.

This study adopts the following empirically-distinct measures of metropolitan land-use patterns: average residential housing density, the Delta index of residential housing concentration, and the Standardized Centrality index of residential housing. For all measures, low index values indicate high-sprawl development patterns, while high index values indicate low-sprawl development patterns.

Average residential housing density, defined as the number of residential housing units per square mile, is the ratio of total metropolitan housing units to total metropolitan land area. Metropolitan densities are strictly positive (tract densities can be zero), but have no maxima. Average density has been utilized widely as an empirical measure of sprawl (Cutsinger & Galster, 2006; Cutsinger, Galster, Wolman, Hanson, & Towns, 2005; Galster & Cutsinger, 2007; Galster et al., 2001; Malpezzi, 1999; Malpezzi & Guo, 2001; Wolman et al., 2005).

The Delta index measures the share of metropolitan housing that occupies areas of above-average densities, and would therefore have to physically move in order to achieve even densities across all tracts of a metropolitan area. The lowest possible value of zero indicates complete deconcentration or evenness, meaning that no residence would need to shift in order to attain evenness. The highest possible value of one indicates complete concentration, meaning that all housing units are located in one tract. Numerous analyses have utilized the Delta index as a measure of sprawl (Cutsinger & Galster, 2006; Cutsinger et al., 2005; Galster & Cutsinger, 2007; Galster et al., 2001; Wolman et al., 2005).

The Standardized Centrality index, suggested by Cutsinger and Galster (2006), Cutsinger et al. (2005), and Galster and Cutsinger (2007), measures the relative degree of distance from a historical central business district. Unlike a simple average distance measure, the index adjusts for physical size. With respect to land area, large metropolitan areas should not be designated as decentralized simply because they are large, nor should small metropolitan areas be designated as centralized simply because they are small. More specifically, the index is the ratio of the average distance between a tract and a

central business district, relative to the average distance between a residence and a central business district. The numerator is the unweighted average distance between the central business district and a tract. The denominator is the average distance between the central business district and a tract, weighted by the number of residential housing units in each tract.[60] Like density, values are strictly positive, with no maxima. When the index is less than one, the metropolitan area exhibits decentralization, since the average residence is farther from the central business district than the average tract. When greater than one, the metropolitan area exhibits centralization, since the average residence is closer to the central business district than the average tract. When equal to one, the average residential distance is proportional to the average tract distance.

Informed by the empirical analysis featured in chapter two, this study proposes the following configurations of metropolitan land-use patterns. See Table 4.1 for a concise summary of these definitions.

(1) Uniform, High-Density Metropolitan Areas: If density were the only attribute considered, these metropolitan areas would be unambiguously characterized as low-sprawl for their high densities. Yet they also exhibit sprawl-like characteristics for their even and decentralized land-use patterns, based upon low index values for concentration and centrality. These metropolitan areas are uniformly dense across the metropolitan landscape, with no concentrated pockets of residential development near the center, or in the periphery. This configuration includes metropolitan areas in the Northeast, such as Trenton, NJ, Hartford, CT, and Pittsburgh, PA; outside of the Northeast, examples include Milwaukee, WI, Wilmington, DE, and Atlanta, GA.

(2) Decentralized, Clustered Metropolitan Areas: This configuration features low

[60] Distances are calculated between centroids.

densities, but with highly-concentrated pockets that do not correspond to the historical central business district. Measures of centrality only quantify the pattern of land use around one nucleus, i.e. the central business district. If a metropolitan area exhibits significant concentration, but also extensive decentralization, then at least one other nucleus of residential activity exists in the periphery. As such, index values for concentration are high, while those for centrality (and density) are low. This combination reflects many metropolitan areas in the South, especially in Texas (e.g. Laredo, Abilene, Amarillo, and Wichita Falls); outside of the South, examples include Fort Collins, CO, Bakersfield, CA, and Kansas City, MO.

(3) Mononuclear, Low-Density Metropolitan Areas: Mononuclearity refers to the degree of concentration near the central business district. When index values for concentration and centrality are both high, indicating significant concentration and centralization, the metropolitan area largely features a single core of residential development. This concentration does not extend far from the central business district, however, as these metropolitan areas exhibit low average densities. This configuration reflects land-use patterns in the Midwest, such as Bloomington, IL, Cedar Rapids, IA, and Lincoln, NE; examples outside of the Midwest include Boulder, CO, Tacoma, WA, and Tulsa, OK.

(4) Mononuclear, High-Density Metropolitan Areas: Index values for these metropolitan areas reflect a significant degree of low-sprawl attributes. This configuration exhibits high densities, significant concentration, and centralization. Metropolitan areas feature a central core, but also high average densities. Examples of this combination occur in the West – such as Seattle and San Francisco – but also in

metropolitan areas like New York and Miami.

(5) Uniform, Low-Density Metropolitan Areas: The last combination accounts for the most sprawl-like development patterns according to the attributes and measures of this study. A metropolitan area in this category features low average densities, decentralized residential development, and no particular areas of concentration. All index values are therefore low. Examples include Alexandria, LA, Utica, NY, Columbia, SC, and Portland, ME.

4.3.2 Dimensions and Measures of Segregation

For the purpose of dialogue with the literature, this chapter utilizes the five dimensions of segregation proposed by Massey and Denton (1988): evenness, exposure, concentration, centralization, and clustering. Furthermore, this chapter adopts the following empirical measures of those dimensions, as suggested by Iceland et al. (2002): the Dissimilarity index (*D*), the Isolation index (*XPX*), the Delta index (*DEL*), the Absolute Centralization index (*ACI*), and the Spatial Proximity index (*SP*), respectively. For all index values, lower values indicate lower segregation, and vice versa. Table 4.2 summarizes the dimensions and measures adopted by this study, their interpretations as measures of segregation, as well as their possible range of index values. The reader is also referred to Appendix B for the technical formulas for all measures.

The Dissimilarity index is the most common measure of evenness. Evenness refers to the distribution of a minority group (relative to the majority) across the sub-areas of a metropolitan area. The index value represents the percentage of minority residents that would need to move in order for all sub-area minority population shares to equal the

metropolitan area minority population share. The lowest value of zero indicates complete evenness, and therefore the lowest degree of segregation. All sub-area population shares are the same as the metropolitan population share, so no minority residents would need to move to obtain evenness. The highest value of one indicates complete unevenness, and therefore the highest degree of segregation. In this case, all minority residents reside in one sub-area, and share no other sub-areas with the majority group.

The Isolation index measures the degree of exposure of minority residents to other residents of the same minority group (as opposed to residents of the majority group). Unlike evenness, this dimension encompasses the degree of social interaction between minority residents, and by implication, the degree of isolation of the minority population from the majority. Unlike the Dissimilarity index, the Isolation index incorporates the relative size of the minority group. Specifically, the index indicates the probability that a minority resident shares a residential sub-area with another member of the same population group. The lowest value of zero indicates the lowest segregation by virtue of the least minority isolation. The probability that a randomly-selected minority resident resides in a sub-area with another minority resident is zero. The highest value of one indicates the highest segregation by virtue of the highest isolation. In this case, the probability of a minority resident sharing a sub-area with another member is one-hundred percent.

The Delta index measures concentration as an aspect of segregation. Concentration takes account of the share of physical space that a minority group resides in across the metropolitan area. The Delta index also ranges between zero and one, and measures the share of the minority population that would need to relocate in order to

attain uniform minority population density. It is therefore a more specific version of the Dissimilarity index. Lower values indicate less concentration and lower segregation, meaning that the minority population occupies a significant share of physical space. Higher values indicate more concentration and higher segregation, meaning that the minority population occupies a small share of physical space.

The Absolute Centralization index calculates the extent of segregation in the form of proximity to the historical central business district.[61] A highly centralized minority group exhibits greater segregation, while a decentralized minority group exhibits less segregation. Interpretation of this index is similar to the Delta index. The figure represents the percentage of the minority population that would need to shift sub-areas in order to obtain a uniform population distribution around the central business district. Values range between negative one and positive one. Values closer to positive one indicate significant centralization, i.e. a tendency for the minority group to live near the central business district. Values closer to negative one indicate significant decentralization, i.e. a tendency for the minority group to live in the periphery. A value equal to zero indicates a completely even distribution around the central business district.

The Spatial Proximity index quantifies the nature of clustering into racial or ethnic enclaves. Clustering, as a dimension of segregation, is distinct from centralization. It refers to the degree to which minority sub-areas are contiguous, or adjacent to one another, independent of the location of the central business district. The highest form of segregation in this case occurs when all minority sub-areas are adjacent to one another in one single enclave. Lower levels of segregation occur when minority sub-areas tend to be separated. An index value of one indicates no difference in clustering between the

[61] Distances are calculated between centroids.

minority and the majority. An index value greater than one indicates a tendency for minority residents to live closer to other minority residents, rather than majority residents. An index value less than one indicates a rare tendency for minority residents to live closer to majority residents, rather than other minority residents.

4.3.3 Research Questions and Hypotheses

This section discusses the key research questions and hypotheses with respect to the relationship between metropolitan land-use patterns and minority segregation levels. These questions are informed by the theoretical approach and empirical measures adopted by this chapter. Alternative approaches and specifications will undoubtedly generate different questions.

(1) How does the effect of alternative land-use patterns on Black segregation compare to new minority segregation? Are there any discernible differences between Blacks and Asians (and/or Hispanics)? Are there any discernible similarities?

(2) How do both the "decentralized clustering" and "mononuclear low-density" configurations affect Black segregation? In the former's case, has the growth of decentralized, suburban residential clusters contributed to less Black segregation? In the latter's case, does the presence of a central core continue to abet Black segregation?

(3) What effect does the "uniform low-density" configuration have on racial and ethnic segregation? Of the alternative patterns suggested in this chapter, this configuration exhibits the highest degree of urban sprawl across all three attributes. The nature of that relationship, and any differences or similarities between minority groups, will be of particular interest to scholars in this literature.

(4) Finally, and most importantly, what explains the connection between metropolitan land-use patterns and minority segregation levels? This analysis explores that relationship using two groups of explanatory channels. The first group includes traditional economic factors, such as housing and land prices, commuting and transportation costs, and the mix of the metropolitan housing stock. The second group includes various influences on residential preferences for neighborhood amenities and composition, such as the quality of local education, local racial and ethnic composition, as well as the presence of immigrants. The expectation is that this framework will not only enhance the precision of previous insights in the literature, but also extend the understanding of this relationship by comparing outcomes for metropolitan areas with combinations of high-sprawl and low-sprawl characteristics to those with uniform characteristics across multiples measures of land use, examining how differences in the configuration of land use contribute to more (or less) segregation within a minority population, and by establishing the significance of those channels, or lack thereof, across all three minority populations.

4.4 Data and Summary Statistics

This sample uses the Office of Management and Budget's boundary definitions of metropolitan statistical areas, primary metropolitan statistical areas, and New England county metropolitan areas for 1999 – 2000. A sub-area, neighborhood, or area of residence is the Census-defined tract. Tract boundaries are unique to the selected metropolitan area definitions. For centrality-based measures of sprawl and segregation, the 1982 Economic Censuses: Geographic Reference Manual (US Census Bureau, 1983)

identifies the location of central business districts in 1980. Census tract boundaries for 1980 were drawn from the National Historical Geographic Information System (Minnesota Population Center, 2010). Central business district centroids were determined using the GIS software package ArcGIS (version 9.3). The source for all residential housing, population, land area, geographic reference, and tract centroid data is the Census 2000 Summary File 1 (US Census Bureau, 2000b). Given the metropolitan area definitions of this sample, and the availability of central business district data in 1980, 272 metropolitan areas constitute this sample, including 258 metropolitan statistical areas, 73 primary metropolitan statistical areas, and 12 New England county metropolitan areas.[62]

Table 4.3 presents summary statistics for the metropolitan and demographic control variables of this study. With respect to population size, the average metropolitan area in this sample has 781,172 people, while the median has 347,300.5 people. With respect to land area, the average metropolitan area is 2,297.9 square miles, while the median is 1,568.5 square miles. Two definitions of the minority population share are reported.[63] The traditional definition is simply the total minority population of the metropolitan area relative to the total population of the metropolitan area. The mean Asian population share is 2.43%, compared to 10.59% and 10% for Blacks and Hispanics, respectively. An alternative definition is the minority population share of the median tract. On average, Asians comprise 4.19% of the population in the median census tract. Blacks comprise 26.65% of the population, while Hispanics constitute 14.97% of

[62] 46 metropolitan areas were excluded due to the lack of central business district data in 1980. See Table 2.2 (Chapter 2) for a list of these metropolitan areas.

[63] Results are for Asians who identify as Asian alone (non-Hispanics), Blacks who identify as Black alone (non-Hispanic), and Hispanics.

the population in such areas.

Table 4.4 reports mean data for the three measures of urban sprawl, and compares results for the entire sample with those for the five configurations of land use. A configuration was determined using the z-scores for the selected empirical measures. For example, metropolitan areas in the uniform low-density category are those with negative z-scores across all three measures, since lower values indicate a higher degree of sprawl. While the average residential density of the sample is 174.17 housing units per square mile, the average density of this configuration is 92.01 units per square mile. In these metropolitan areas, 52.14% of the housing stock would need to move in order to contain evenness, compared to 62.02% when considering the entire sample. The average residential housing unit is also 11.16% farther from the central business district than the average census tract for this combination of land use, compared to 4.09% for all metropolitan areas. Configurations that feature low-sprawl characteristics of land use are those with positive z-scores for those measures. For example, metropolitan areas in the decentralized, clustered category are those with negative z-scores on density and centrality, but positive z-scores on concentration.

Table 4.5 reports summary statistics for the five measures of segregation by minority group.[64] Blacks face the highest degree of segregation across all measures. On average, roughly half of the Black population in metropolitan areas would need to move in order to attain evenness. Blacks also experience a fair amount of isolation. A randomly-selected Black resident has over a one in four chance of sharing a neighborhood with another Black resident. About 80% of the Black population would need to relocate in order to reduce concentration. Furthermore, over 75% of the Black

[64] Whites who identify as White alone (non-Hispanic) are the majority group.

population would need to relocate in order to attain evenness around the central business district. Finally, Black residents are more likely to cluster near other Black residents, rather than Whites, by over 15%.

Segregation levels for new minorities are lower than those for Blacks, although the extent of that difference depends upon the dimension of segregation. With respect to exposure, Hispanics face significantly greater segregation than Asians. On average, the likelihood that an Asian resident will reside in the same neighborhood as another Asian resident is 5.12%; for Hispanics, that probability is 16.35%. Hispanics are also more clustered than Asians, albeit to a moderate degree. Moderately greater segregation is also the case for Asians according to evenness, concentration, and centralization.

Table 4.6 presents correlation matrices for the five dimensions of segregation by race and ethnicity. These findings indicate whether metropolitan areas that are segregated for one group, according to a given dimension, are also segregated for another group. For example, are metropolitan areas with high levels of Black centralization also associated with high levels of Hispanic (or Asian) centralization? The table largely features positive correlation coefficients in the low to moderate range. This means that, for a dimension of segregation, segregation of one group is somewhat associated with segregation of another group. Coefficients for concentration and centralization exhibit the strongest associations. Asian and Hispanic clustering, as well as Asian and Black evenness, are also moderately correlated. Very rarely is the segregation of one group associated with less segregation of another group. Although the degree is low, there is an inverse correlation between Black and Hispanic exposure, meaning that metropolitan areas with higher levels of Black isolation are associated with lower levels of Hispanic isolation.

The remaining coefficients in the table exhibit weak to low associations.

4.5 Regression Analysis

How do different configurations of land use contribute to the level of racial and ethnic segregation, controlling for metropolitan area population, land area, and the minority group's population share? This section explores that question using ordinary least squares regression models for each measure of segregation, and compares results for each minority group. The regression analysis includes three standard control variables: the log of total metropolitan area population (*POP*), the log of total metropolitan land area (*AREA*), and the minority group's metropolitan population share (*PMIN*). The independent variables are dummy variables for each configuration of land use: Uniform low-density (D^{ULD}), Uniform high-density (D^{UHD}), Decentralized clustering (D^{DCL}), Mononuclear low-density (D^{MLD}), and Mononuclear high-density (D^{MHD}). The dependent variables are the five indexes of segregation. For all measures of segregation except Absolute Centralization, the dependent variables are expressed in logarithmic form. A coefficient indicates the percent difference in segregation contributed by the configuration, compared to metropolitan areas without such characteristics. For the Dissimilarity, Isolation, Delta, and Spatial Proximity indexes, the level of segregation (SEG) in metropolitan area i is estimated for each minority group by the equation,

$$\ln(SEG_i) = \beta_0 + \beta_1 \ln(POP_i) + \beta_2 \ln(AREA_i) + \beta_3 PMIN_i + \beta_4 D_i^{ULD} + \beta_5 D_i^{UHD} + \beta_6 D_i^{DCL} + \beta_7 D_i^{MLD} + \beta_8 D_i^{MHD} + \varepsilon_i,$$

where β_0 is a constant and ε is an error term. For the Absolute Centralization index, the dependent variable is expressed in unit form, since the index can have negative values. A

regression model using a logarithmic transformation would exclude metropolitan areas with negative index values, i.e. those with highly-decentralized minority populations. A coefficient indicates the percentage point difference in segregation contributed by the configuration, compared to metropolitan areas without such characteristics. In this case, the level of segregation (SEG) in metropolitan area i is estimated for each minority group by the equation:

$$\mathrm{SEG_i} = \beta_0 + \beta_1 \ln(POP_i) + \beta_2 \ln(AREA_i) + \beta_3 PMIN_i + \beta_4 D_i^{ULD} + \beta_5 D_i^{UHD} + \beta_6 D_i^{DCL} + \beta_7 D_i^{MLD} + \beta_8 D_i^{MHD} + \varepsilon_i.$$

For each specification, all models are weighted by the minority group's metropolitan population, in order to avoid the inconsistencies that occur when measuring the segregation of small populations (Massey & Denton, 1988). Robust standard errors are reported. Tables 4.7, 4.8, and 4.9 summarize the results of these models. A positive coefficient implies that, all else constant, the configuration contributes to greater segregation. A negative coefficient implies that the configuration contributes to lower segregation.

Across all three minority groups, "decentralized clustering" and "mononuclear low-density" are the most statistically significant configurations. Both are largely associated with higher levels of segregation across all three groups, especially with respect to minority concentration. For example, in mononuclear metropolitan areas with low residential densities, concentration is predicted to be 6.7% higher for Blacks, 8.2% higher for Asians, and 10.1% higher for Hispanics. In decentralized areas with suburban clusters, concentration is predicted to be approximately 9% higher for all of the groups considered.

Results for these two categories underscore the importance of considering alternative combinations of multiple attributes of land use. These configurations share a common lack of residential density (and concentration), but differ with respect to centrality. That difference matters for predicting the influence of land-use patterns on Black segregation. With respect to exposure, under "mononuclear low-density," the Black isolation index is predicted to be 37% lower. With respect to centralization, the Black absolute centralization index is predicted to be 0.078 percentage points higher under "decentralized clustering." These diverging outcomes would not be observable when controlling for density (and/or concentration) alone, as the model would not control for this variation in housing centrality.

Both of the "uniform" configurations yield significant results for new minorities. These findings establish the importance of comprehensive comparison of all minorities, as those configurations have differing effects on Hispanic and Asian segregation. In uniform metropolitan areas with high-densities, Asians experience lower segregation, while Hispanics experience higher segregation. In uniform areas with low-densities, however, Hispanics experience lower segregation, while Asians experience higher segregation.

The significance of examining alternative land-use configurations is also clear for Hispanics. Three configurations have a statistically significant effect on Hispanic concentration: "mononuclear low-density," "decentralized clustering," and "uniform low-density." Although these configurations feature low residential densities, they differ with respect to both housing concentration and centrality. As was the case for Blacks, those differences have uneven effects on segregation. While Hispanics are predicted to be less

concentrated and isolated under "uniform low-density," they are predicted to be more concentrated under "decentralized clustering" and "mononuclear low-density." The complexity of this outcome is not visible if density was the only attribute and measure of land use.

Asians are the only minority group for which "mononuclear high-density" is a statistically significant land-use configuration. In such metropolitan areas, concentration is predicted by 8.3% higher, while clustering is predicted to be 5.2% higher, as compared to metropolitan areas that do not exhibit such characteristics.

With respect to summarizing these results, an alternative perspective is to consider which segregation measures are the most significant. The question in this case is how do these specific measures inform our understanding of segregation? For which group (or groups) do they inform that understanding? From this perspective, the Isolation and Delta indices are the most statistically significant measures of segregation across all three minority groups. The Dissimilarity and Spatial Proximity indices are significant only for Asians, while Absolute Centralization is significant for both Asians and Blacks.

4.6 Discussion

4.6.1 Analysis of Black Segregation

This study finds a statistically significant association between two configurations of land use and Black segregation in 2000. In decentralized metropolitan areas with suburban clusters, Black concentration and centralization are both predicted to be higher. In low-density metropolitan areas with a central core, Black concentration is expected to be higher, while isolation is expected to be lower. These findings indicate that

combinations of low-sprawl and high-sprawl attributes have significant but varying effects on Black segregation. The argument here is that these configurations generate changes in economic factors, specifically the mix of housing and commuting costs, to which Blacks are particularly sensitive.

Let's consider first the coefficients for Black concentration, a case in which two alternative configurations have a similar effect on segregation. Why are both land-use categories associated with greater segregation according to this measure? Both configurations share a common degree of low density. A traditional explanation in the literature is that lower residential density contributes to lower segregation through a land/housing price channel (Pendall & Carruthers, 2003; Galster & Cutsinger, 2007). In low-density metropolitan areas, the absence of intense competitive pressures over space results in lower land and housing prices, and as a consequence, greater affordability. The argument is that Blacks are particularly sensitive to this expansion of affordability, given the degree to which their incomes are lower than Whites. As such, Blacks are more likely to afford homeownership and other amenities of suburban life, resulting in lower segregation. Metropolitan areas featuring a higher degree of sprawl, according to density, should therefore exhibit lower segregation.

Yet Black segregation is not predicted to be lower in these cases. The reason is that this shared lack of density is not uniform across the metropolitan area. Both configurations also exhibit a significant degree of housing concentration. Despite their low average densities, both categories feature one or more 'pockets' of concentrated residential development. The presence of areas of high housing concentration may contribute to greater segregation in two ways. First, competitive pressures could drive up

land and housing prices in intensely-developed neighborhoods. For the reasons stated above, Blacks are less likely to afford housing in such areas, and would tend to settle in neighborhoods with cheaper land values. Alternatively, intense pressure over space could lead to the construction of more rental and multi-family units in these particular areas. If Blacks lack the wealth and credit necessary for homeownership, they would tend to settle in high-density areas with a large supply of rental housing, whereas Whites would tend to settle in low-density areas with single-family homes. In either scenario, relative to Whites, the result is a greater concentration of Blacks over the physical space of the metropolitan area. The complexity of these opposing characteristics in land use, between a high-sprawl attribute (low density) and a low-sprawl attribute (high concentration), would not be perceptible using a single characteristic of land use.

Let's now consider a case in which alternative two configurations have opposing effects on segregation. Why is Black centralization predicted to be higher under "decentralized clustering?" Why is isolation predicted to be lower under "mononuclear low-density?" This case illustrates the significance of examining multiple attributes of land use, multiple combinations of those attributes, as well as multiple dimensions of segregation. The difference in results reflects the difference in housing centrality. Previous research argues that residential decentralization contributes to greater segregation through a commuting and transportation cost channel (Galster & Cutsinger, 2007). In decentralized metropolitan areas, commuting costs to employment centers will be higher, independent of the number and suburban status of such centers. The argument is that this commuting cost burden will make homeownership and/or suburbanization less affordable for Blacks and other low-income groups, relative to Whites, which again

contributes to segregated settlement patterns. In centralized metropolitan areas, however, lower segregation results from the easing of such commuting costs due to closer proximities to the employment center. Thus, a metropolitan area featuring a higher degree of sprawl should feature higher segregation.

In decentralized metropolitan areas with suburban clusters, not only are Blacks more likely to concentrate, they are indeed more likely to settle near the central business district.[65] The effect of higher commuting costs in such areas may be an important explanation, despite the presence of low densities in housing. If the metropolitan employment base shifts to these residential clusters, as the widely-cited research by Glaeser and Kahn (2001) has suggested, then inner-city Blacks may face significant spatial mismatch problems. The key implication of this finding is that, despite the decentralization of economic activity to suburban 'edge cities,' Blacks are more likely to live near the central city.

In low-density metropolitan areas with a central core, the compact nature of the metropolitan area could mitigate certain forms of Black segregation. In this case, the presence of lower commuting costs would contribute to less isolation from Whites. The positive coefficient for Black concentration is not necessarily a contradiction, and both may be explained together. The positive coefficient implies that Blacks occupy a relatively smaller share of metropolitan space. Concentration only refers to the occupation of the minority group relative to land area, and not necessarily the degree of exposure or proximity to the majority. Due to the centrality and compactness of the metropolitan area in this case, Blacks and other minorities may simply concentrate with Whites, which further explains the predicted drop in isolation. The implication here is

[65] This is the case in metropolitan areas like New Orleans, LA, St. Louis, MO, and Kansas City, MO.

that despite the significant degree of housing centrality, which is typically regarded as a low-sprawl characteristic, Blacks are less likely to be segregated.[66]

4.6.2 Analysis of Hispanic Segregation

Hispanic segregation is sensitive to several configurations of land use. As was the case for Blacks, Hispanic concentration is predicted to be higher in low-density metropolitan areas with a central core, as well as decentralized metropolitan areas with suburban clusters. However, both Hispanic concentration and isolation are predicted to be lower in metropolitan areas with uniformly low housing densities, while isolation is predicted to higher in areas with uniformly high densities. The sensitivity of Hispanic segregation to alternative configurations of land use can be explained using traditional economic variables, as well as residential preferences specific to the Hispanic community. In particular, Hispanics present a unique case where a configuration featuring low housing densities contributes to less segregation.

Let's consider first the coefficients for "decentralized clustering" and "mononuclear low-density." In both cases, concentration of the Hispanic population into relatively few areas is predicted to be higher. Explanation of this outcome mirrors the explanation of a similar outcome for Blacks. The common effect on segregation reflects the common characteristics of the two land-use categories. Despite their low residential densities on average, these metropolitan areas feature at least one area of significant housing concentration. This variation in the intensity of residential development results in a segregated metropolitan housing stock, with few areas of mixed housing types.

[66] Modesto, CA, Santa Barbara, CA, and Spokane, WA are cases of "mononuclear low-density" with high levels of Black concentration but low levels of Black isolation.

Given the economic disparity relative to Whites, Hispanics will tend to settle either in areas with cheaper land values, or high-density areas with more rentals and multi-family units.

The lack of housing concentration under "uniform low-density" may therefore explain the predicted drop in Hispanic segregation associated with that configuration of land use.[67] In metropolitan areas with uniformly low housing densities, no such 'pockets' of concentration exist, which could mitigate the negative effects on segregation noted above. Perhaps then the traditional land and housing price channel is the appropriate causal explanation for lower Hispanic concentration and isolation. In the absence of significant variations in the housing stock and intensity of residential development, low densities contribute to lower land and housing prices, greater affordability, and less segregation.

This channel could also explain the predicted increase in Hispanic isolation in metropolitan areas with uniformly high housing densities. Despite the degree of evenness and decentralization, which are typically indicators of sprawl, these metropolitan areas are very dense. Although they don't feature any particular areas of concentrated residential development, the intensity and competitive pressure over space is simply widespread across the metropolitan area. The effect of high density could therefore contribute to higher segregation via higher land and housing prices.

The traditional price channel is not the only plausible explanation of this outcome, especially when considering this particular dimension of segregation. Hispanics are predicted to face not only higher segregation under "uniform high-density," but also

[67] Examples in this case include Olympia, WA, Tallahassee, FL, and Columbia, SC.

higher isolation from Whites.[68] This means that Hispanics are more likely to live in neighborhoods with other Hispanics. Metropolitan areas in this configuration are typically large population centers. Empirical analysis in this dissertation finds a significantly positive correlation between density and metropolitan population size. Hispanics may be more segregated in these large population centers, especially those with significant Hispanic population shares, due to the formation of ethnic enclaves. Furthermore, these population centers may also function as "immigrant gateways" (Singer, Hardwick, & Bretell, 2008), given the significant presence of immigrants in the Hispanic population. According to this sample, that presence is over 30% of the metropolitan Hispanic population, on average. This effect could further explain the predicted drop in segregation in metropolitan areas with uniformly low-densities, especially small and mid-sized areas with such characteristics. Perhaps Hispanics are less likely to live near other Hispanics, simply because of the lack of ethnic neighborhoods or a sizeable Hispanic community.

4.6.3 Analysis of Asian Segregation

Land-use patterns have a statistically significant effect on Asian segregation. Asian segregation is sensitive to each of the land-use configurations suggested by this study. Each segregation measure is sensitive to at least one configuration. Furthermore, most configurations of land use contribute to higher segregation levels. As was the case for Blacks, both "decentralized clustering" and "mononuclear low-density" are associated with higher Asian segregation across several measures. The model also predicts higher segregation, in the form of concentration and clustering, under "mononuclear high-

[68] This reflects Hispanic segregation levels in Jersey City, NJ, Chicago, IL, and Hartford, CT.

density." Asians are the only minority group for which that pattern is significant. In contrast to Hispanics, the model predicts higher Asian segregation under "uniform low-density," but lower Asian segregation under "uniform high-density."

Explanations for the preceding minority groups have largely focused on economic capabilities. A configuration of land use contributes to reducing (or abetting) racial and ethnic segregation through changes in land and housing prices, the mix and distribution of different housing types, as well as commuting and transportation costs. Such explanations are plausible for any metropolitan population group, including Asians. However, Blacks and Hispanics are likely to be particularly sensitive to such changes, given the income and wealth gaps between Whites and both groups.

Asians may not be as responsive to such changes, given their more favorable economic standing as compared to other minorities (and sometimes Whites). The argument here is that this economic advantage affords greater selectivity in residential choices. Residential preferences, and their possible connection to the types of metropolitan areas identified in this study, are key considerations in explaining Asian segregation. This analysis does not, however, discount the contribution of residential preferences to Black and/or Hispanic segregation. Although the emergence of affluent (albeit segregated) suburban Black enclaves is clear (Lacy, 2007), that trend has primarily occurred in the surrounding areas of Washington, DC, Atlanta, and New York. Consideration of such phenomenon as comprehensive explanatory variables may therefore not be suitable for a national study.

Asian residential preferences, with respect to both housing and neighborhood choices, could take account of a number of factors. First, Asians may prefer to live near

one another for a sense of comfort, community, and/or security. The share of the metropolitan Asian population that is foreign-born, which is over 70% according to this sample, is also likely to be a factor in such choices. Second, Asian settlement patterns may reflect preferences for local amenities, such as public education. Finally, such patterns may simply indicate prejudice or animosity towards other population groups, or other minorities. In any case, the greater the degree to which Asians are selective or sensitive to such factors, the greater the expected level of segregation.

Turning now to the results of this study, what explains the contribution of land-use patterns to largely higher levels of Asian segregation? What characteristics of the metropolitan areas in these categories account for the predictions of this model? How are those characteristics associated with the formation of residential preferences by Asians? For example, the "mononuclear high-density" combination, which is associated with higher levels of both Asian concentration and clustering, frequently occurs in the West. As has been documented elsewhere, the West features a high concentration of the US Asian population. This tendency could reflect the long-term presence of established ethnic (and immigrant) enclaves.[69] Indeed, the result for the Spatial Proximity index is an indication of such forms of segregation. Regional variations may also explain a similar tendency under "decentralized clustering" and "mononuclear low-density." Those patterns frequently occur in the South and Midwest respectively. However, research by Logan and Zhang (2010) finds that those regions have not attracted Asians to the same degree as other regions. As such, the higher likelihood of segregation, especially isolation and concentration, could result from the lack of established Asian communities.

What is interesting is that Black segregation is also predicted to be higher under

[69] San Francisco, CA, Seattle, WA, and New York, NY support this hypothesis.

both configurations of land use. An intriguing literature in sociology is a key source of insight on the possible connections between Asian and Black segregation. According to Logan and Zhang (2010), "global neighborhoods" are an emerging form of diversity, whereby the influx of Asians and Hispanics into all-White neighborhoods facilitates the integration of Blacks. However, the impact of these new multi-racial and multi-ethnic communities on segregation has been mixed. In some cases, this transition could mitigate segregation of both Asians and Blacks. In other cases, this transition could abet segregation of both minority groups. Logan and Zhang find evidence of both possibilities.

On the one hand, the movement of new minorities into previously all-White neighborhoods could act as a "buffer" against White flight. As Asians and Hispanics move into these communities, the new sense of diversity contributes to reducing long-standing barriers against Blacks. The expectation is that both Black and Asian segregation would be lower in these types of metropolitan areas, since non-Hispanic Whites are less likely to relocate.

On the other hand, the integration of new minorities into such communities could fuel White flight through a process of "invasion-succession." The growth of heavily-mixed or all-minority areas may create a sense of uneasiness for non-Hispanic Whites, which leads to the formation of new all-White enclaves elsewhere in the metropolitan areas. In this case, Asians (and Hispanics) replace the former majority White population. The expectation here is that both Asian and Black segregation would be higher in these types of metropolitan areas.[70]

[70] Another possibility of the combined increase in Black and segregation, and one suggested by Logan, could be Asian aversion towards Black neighborhoods. According to the "invasion-succession" hypothesis,

The results of this study suggest that the "invasion-succession" channel may be prevalent under "decentralized clustering" and "mononuclear low-density". The results indicate the possibility of the "buffer" channel under "uniform high-density." However, no significant results are available for Blacks for this configuration. Understanding these phenomena will likely require more micro-level analysis of neighborhood composition and diversity, a point well-made by Logan and Zhang (2010). Clarification of these outcomes could also involve analysis of minority segregation from other minority groups.

4.6.4 Summary of Segregation Analysis

Alternative configurations of land use generate changes in economic factors that are particularly significant for Blacks. Two configurations contribute to greater Black segregation despite their similarly low housing densities. While traditional economic models predict less segregation under low densities, due to the absence of significant competitive pressures on land and housing prices, countervailing forces in land use appear to negate that prediction in each circumstance. Blacks are expected to be more concentrated under "decentralized clustering" and "mononuclear low-density" due to the high degree of housing concentration in both cases, which creates a segregated housing stock with pockets of high-priced areas. They are also expected to be more centralized under "decentralized clustering," due to the increase in commuting costs associated with decentralized housing markets. However, Blacks are expected to be less isolated under "mononuclear low-density," where commuting costs are less, despite the presence of a low-sprawl attribute.

Blacks and Asians may be more segregated from Whites, but they cohabitate together in all-minority neighborhoods. According to this hypothesis, both groups are segregated from Whites, but they are also more segregated from each other.

Hispanic segregation is sensitive to changes in economic factors associated with the configuration of land use, as was the case for Blacks, but is also responsive to the particular residential preferences of Hispanics. Hispanic concentration is predicted to be higher under "decentralized clustering" and "mononuclear low-density" for the same reasons as Blacks. However, Hispanic concentration and isolation are predicted to be lower under "uniform low-density." This indicates that the contribution of lower housing density to lower segregation, as traditional models suggest, only occurs if the metropolitan area lacks significant variation in the housing stock and concentration of residential development. Hispanics are predicted to be more isolated under "uniform high-density" for the opposite reasons, and perhaps due to the formation of ethnic enclaves with significant Hispanic communities.

The contribution of alternative land-use configurations to Asian segregation is largely influenced by residential preferences for neighborhood composition and other amenities. With one exception, each configuration is associated with higher levels of Asian segregation. Like Hispanics, those preferences may reflect the desire to live in established ethnic neighborhoods, especially those with a sizable immigrant population. In other cases, the expected increase in segregation could indicate the lack of established Asian communities. Regional variations in settlement patterns may further explain these outcomes. Finally, changes in Asian segregation could be affected by the decisions of non-Hispanic Whites to either remain in, or segregate themselves from, new forms of multi-racial and multi-ethnic communities.

4.7 Conclusion

This chapter makes two significant contributions to the literature. First, the study investigates the effect of multi-dimensional, and sometimes countervailing, patterns of land use on levels of racial and ethnic segregation. Second, the study compares outcomes for Blacks, Hispanics, and Asians. These results and conclusions are intended to stimulate further debate and research. Several avenues are suitable for further investigation.

One possibility is to consider employment-based configurations of land use. Several studies in the literature, including this dissertation, examine the nature and consequences of job sprawl. How might configurations of the spatial pattern of jobs affect racial and ethnic segregation, and why might those configurations have different outcomes as compared to residential-based definitions? Furthermore, one could also define configurations that include spatial patterns of both housing and jobs.

A second possibility is to examine changes between the 2000 and 2010 decennial censuses. The research question here is how do changes in land-use configurations contribute to changes in segregation? Between 2000 and 2010, Asians grew to 4.7% of the population from 3.6%, while Hispanics rose to 16.3% from 12.5% of the population. In contrast, the Black population share remained virtually unchanged, from 12.1% to 12.2%, while the White population dropped from 69.1% to 63.7% (US Census Bureau, 2000b; 2010). With the continuing release of the Census 2010 data, as well as continuing demographic shifts, this direction will no doubt be fruitful.

Finally, one could investigate the presence of reverse causality. This chapter considers land-use patterns to be a causal contributor to racial and ethnic segregation.

The model here is that differences in the metropolitan environment lead to changes in economic factors and preferences that affect minority settlement patterns. However, a converse relationship may also be present, with segregation contributing to different forms of land use and sprawl. This alternative model is that the level of segregation generates variations in the metropolitan environment itself. Perhaps animosity towards another population group (or groups) results in specific configurations of residential land use, some of which may be considered urban sprawl. For example, the desire of Whites to isolate themselves and cluster into suburban enclaves could result in the formation of metropolitan land-use policies that favor decentralized, low-density residential development patterns. While recent work by Zhao and Kaestner (2009) examines the possible endogeneity of population density as a measure of sprawl, this direction also requires deeper investigations into the formation of residential preferences.

4.8 Tables

Table 4.1
Interpretative Guide
Configurations of Land Use

Configurations	Attributes		
	Density	Concentration	Centrality
Uniform Low-Density	Low	Low	Low
Uniform High-Density	High	Low	Low
Decentralized Clustering	Low	High	Low
Mononuclear Low-Density	Low	High	High
Mononuclear High-Density	High	High	High

"Low" refers to a low index value, or a high-sprawl development pattern.
"High" refers to a high index value, or a low-sprawl development pattern.

Table 4.2
Interpretative Guide
Dimensions and Measures of Segregation

Attribute	Measure	Low segregation	High segregation	Minimum	Maximum
Evenness	Dissimilarity Index	Low	High	0	1
Exposure	Isolation Index	Low	High	0	1
Concentration	Delta Index	Low	High	0	1
Centralization	Absolute Centralization Index	Low	High	-1	1
Clustering	Spatial Proximity Index	Low	High	1	None

Table 4.3
Summary Statistics
Metropolitan and Demographic Control Variables

	Mean	Median	Standard Deviation	Minimum	Maximum
Total Metropolitan Population	781,172.0	347,300.5	1,264,137	57,813	9,519,338
Total Metropolitan Land Area	2,297.9	1,568.5	3,239.2	46.7	39,368.6
Metropolitan Population Share					
Black	0.1059	0.0708	0.1031	0.0015	0.5077
Hispanic	0.1001	0.0424	0.1498	0.0048	0.9428
Asian	0.0243	0.0144	0.0388	0.0030	0.4526
Population Share of the Median Tract					
Black	0.2665	0.1930	0.2444	0.0024	0.9399
Hispanic	0.1497	0.0640	0.1948	0.0051	0.9605
Asian	0.0419	0.0249	0.0582	0.0041	0.5636

Source: Census Summary File 1 (2000)
N = 272

Table 4.4
Means by Measure of Land Use
Results for Configurations and Sample

	N	Density	Concentration	Centrality
All Metropolitan Areas	***272***	***174.17***	***0.6202***	***0.9591***
Uniform Low-Density	63	92.01	0.5214	0.8884
Uniform High-Density	23	581.76	0.5430	0.9035
Decentralized Clustering	40	84.38	0.7216	0.9058
Mononuclear Low-Density	64	72.13	0.7203	1.0291
Mononuclear High-Density	16	544.46	0.7053	1.0054

Source: Census Summary File 1 (2000)

Table 4.5
Summary Statistics
Alternative Measures of Racial and Ethnic Segregation

	Mean	Median	Standard Deviation	Minimum	Maximum
Blacks					
Evenness (D)	0.5029	0.5075	0.1336	0.2235	0.8401
Exposure (XPX)	0.2807	0.2691	0.2117	0.0031	0.7861
Concentration (DEL)	0.8067	0.8258	0.0861	0.5105	0.9686
Centralization (ACI)	0.7665	0.8246	0.1866	-0.0755	0.9844
Clustering (SP)	1.1595	1.1175	0.1560	1.0010	1.8230
Hispanics					
Evenness (D)	0.3357	0.3373	0.1132	0.1039	0.6910
Exposure (XPX)	0.1635	0.0789	0.1876	0.0068	0.9445
Concentration (DEL)	0.7194	0.7286	0.0993	0.3779	0.9525
Centralization (ACI)	0.6593	0.7047	0.1939	-0.2502	0.9690
Clustering (SP)	1.0729	1.0335	0.0925	1.0010	1.4230
Asians					
Evenness (D)	0.3802	0.3852	0.0803	0.1433	0.6202
Exposure (XPX)	0.0512	0.0307	0.0631	0.0051	0.5426
Concentration (DEL)	0.7722	0.7813	0.0877	0.4158	0.9685
Centralization (ACI)	0.7208	0.7569	0.1773	-0.1644	0.9758
Clustering (SP)	1.0254	1.0140	0.0336	1.0010	1.2250

Source: Census Summary File 1 (2000)
N = 272

Table 4.6

Correlation Matrices

Alternative Measures of Segregation by Race and Ethnicity

Evenness (D)			
	Black	Hispanic	Asian
Black			
Hispanic	0.2455***		
Asian	0.4276***	0.0928***	

Exposure (XPX)			
	Black	Hispanic	Asian
Black			
Hispanic	-0.1943***		
Asian	-0.0355	0.2580***	

Concentration (DEL)			
	Black	Hispanic	Asian
Black			
Hispanic	0.6396***		
Asian	0.4690***	0.5839***	

Centralization (ACI)			
	Black	Hispanic	Asian
Black			
Hispanic	0.6886***		
Asian	0.5926***	0.6801***	

Clustering (SP)			
	Black	Hispanic	Asian
Black			
Hispanic	0.2982***		
Asian	0.2266***	0.5259***	

Source: Census Summary File 1 (2000)

*** $p < 0.01$

N = 272

Table 4.7

Regression Models

2000 Black Segregation

	Log of Evenness (D)	Log of Isolation (XPX)	Log of Concentration (DEL)	Centralization (ACI)	Log of Spatial Proximity (SP)
Log of MA Population	0.117***	0.147***	0.044***	0.025	0.106***
	0.028	*0.043*	*0.011*	*0.013*	*0.022*
Log of MA Area	-0.080***	-0.073	-0.018	0.019	-0.044
	0.030	*0.052*	*0.015*	*0.017*	*0.025*
MA Black Population Share	0.337**	3.611***	-0.436***	-0.187**	0.416***
	0.163	*0.299*	*0.080*	*0.092*	*0.096*
Uniform Low-Density	0.037	0.014	-0.009	-0.026	-0.001
	0.058	*0.075*	*0.031*	*0.051*	*0.033*
Uniform High-Density	0.039	0.043	-0.014	0.025	0.030
	0.062	*0.099*	*0.031*	*0.033*	*0.049*
Decentralized Clustering	0.016	-0.168	0.087***	0.078***	-0.025
	0.066	*0.127*	*0.028*	*0.030*	*0.035*
Mononuclear Low-Density	-0.075	-0.370***	0.067***	0.047	-0.024
	0.066	*0.116*	*0.025*	*0.036*	*0.036*
Mononuclear High-Density	-0.085	-0.131	-0.016	-0.005	-0.080
	0.067	*0.099*	*0.027*	*0.036*	*0.047*
Constant	-1.626***	-2.950***	-0.636***	0.279	-0.938***
	0.286	*0.446*	*0.111*	*0.144*	*0.180*
R-Squared	0.320	0.582	0.336	0.152	0.597
N	272	272	272	272	272

All regressions are weighted by the MA Black population. Robust standard errors are reported.

**** p < 0.01 ** p < 0.05*

Table 4.8

Regression Models

2000 Hispanic Segregation

	Log of Evenness (D)	Log of Isolation (XPX)	Log of Concentration (DEL)	Centralization (ACI)	Log of Spatial Proximity (SP)
Log of MA Population	0.105***	0.223***	0.017	0.004	0.068***
	0.018	*0.042*	*0.011*	*0.027*	*0.011*
Log of MA Area	-0.015	-0.036	0.033***	0.081**	-0.010
	0.019	*0.040*	*0.012*	*0.032*	*0.012*
MA Hispanic Population Share	0.248***	2.743***	-0.091	-0.035	0.116**
	0.078	*0.188*	*0.051*	*0.061*	*0.053*
Uniform Low-Density	-0.042	-0.388***	-0.066**	-0.096	-0.015
	0.047	*0.130*	*0.027*	*0.051*	*0.027*
Uniform High-Density	0.085	0.209**	-0.040	-0.021	0.058
	0.059	*0.102*	*0.031*	*0.054*	*0.031*
Decentralized Clustering	-0.067	0.180	0.089***	0.042	0.040
	0.060	*0.107*	*0.030*	*0.047*	*0.033*
Mononuclear Low-Density	-0.047	0.209	0.101***	0.001	0.054
	0.071	*0.115*	*0.028*	*0.056*	*0.037*
Mononuclear High-Density	-0.043	-0.064	0.042	0.080	-0.008
	0.044	*0.115*	*0.029*	*0.043*	*0.032*
Constant	-2.285***	-4.778***	-0.786***	0.000	-0.762***
	0.286	*0.475*	*0.101*	*0.231*	*0.121*
R-Squared	0.416	0.736	0.532	0.337	0.535
N	272	272	272	272	272

All regressions are weighted by the MA Hispanic population. Robust standard errors are reported.

**** p < 0.01 ** p < 0.05*

Table 4.9

Regression Models

2000 Asian Segregation

	Log of Evenness (D)	Log of Isolation (XPX)	Log of Concentration (DEL)	Centralization (ACI)	Log of Spatial Proximity (SP)
Log of MA Population	0.121***	0.429***	-0.023	-0.015	0.025**
	0.022	*0.042*	*0.018*	*0.025*	*0.011*
Log of MA Area	-0.055***	-0.130***	0.059***	0.060**	0.002
	0.020	*0.041*	*0.020*	*0.026*	*0.012*
MA Asian Population Share	-0.420***	6.298***	-0.095	-0.022	0.266***
	0.121	*0.808*	*0.095*	*0.144*	*0.096*
Uniform Low-Density	0.109**	-0.016	-0.008	-0.012	0.020
	0.052	*0.129*	*0.030*	*0.052*	*0.017*
Uniform High-Density	-0.074	0.150	-0.095***	-0.103**	0.033
	0.045	*0.126*	*0.034*	*0.052*	*0.019*
Decentralized Clustering	0.030	0.430**	0.090***	0.091**	0.045**
	0.050	*0.180*	*0.025*	*0.036*	*0.022*
Mononuclear Low-Density	-0.067	0.345***	0.082***	0.080	0.019
	0.044	*0.118*	*0.027*	*0.044*	*0.017*
Mononuclear High-Density	-0.027	0.195	0.083***	0.078	0.052***
	0.048	*0.137*	*0.029*	*0.043*	*0.019*
Constant	-2.176***	-8.057***	-0.405**	0.453	-0.350***
	0.254	*0.522*	*0.189*	*0.296*	*0.119*
R-Squared	0.449	0.824	0.676	0.423	0.607
N	272	272	272	272	272

All regressions are weighted by the MA Asian population. Robust standard errors are reported.

**** p < 0.01 ** p < 0.05*

CHAPTER 5

CONCLUSION

This dissertation investigates the economic consequences of urban sprawl for racial and ethnic minorities in the United States. Three essays contribute to the longstanding and vigorous debate over sprawl within economics and other disciplines. The dissertation has four major research objectives: namely, to revisit and analyze notable empirical findings in the literature; to reappraise the conclusions from those findings with recent data; to extend the analysis to include new minorities; and lastly, to integrate new approaches to these research questions.

With respect to the first objective, the first essay (chapter two) deepens the understanding of sprawl as an economic process. The primary motivation is to familiarize economists with sprawl as a concept. The secondary motivation is to address methodological inconsistencies in the empirical measurement of urban sprawl. The essay comprehensively compares and analyzes thirteen measures of sprawl using recent data, consistent operational specifications of economic development, and a national dataset. This study supports and expands the approach to sprawl as not only a multi-dimensional, but also a countervailing, spatial 'configuration' of land use.

With respect to the second objective, the second essay (chapter three) establishes the importance of reappraising previous empirical approaches with updated data, especially in the aftermath of the housing bubble. Indeed, this essay documents marked deteriorations in the purportedly positive contributions of sprawl to the decline in the Black-White housing gap.

With respect to the third objective, the latter two essays (chapters three and four)

emphasize the richness of comparing outcomes for Blacks, Hispanics, and Asians. Both essays accentuate the complexity of the consequences of sprawl for minorities, in terms of housing inequalities and segregation, as well as the range of diverging experiences across all three groups. Moreover, the effect of alternative land-use configurations on new minority segregation is a heretofore unexplored area in the literature.

With respect to the final objective, the latter two essays introduce new approaches to understanding the research questions of this dissertation, and the literature at large: the analysis of thresholds in the relationship between sprawl and minority housing gaps, and the effect of alternative land-use configurations on racial and ethnic segregation. The second essay (chapter three) reveals a previously unexamined facet of the relationship between sprawl and the Black-White housing gap, namely a threshold effect. This effect is not limited to recent findings. The process of critical replication documents the presence of this effect in previous studies. These findings raise considerable skepticism concerning arguments that metropolitan growth management regulations reduce minority gains in housing consumption. The conclusion from this essay is that those arguments only apply to a limited number of metropolitan areas and housing measures. What is more, the essay establishes that the empirical results that inform such arguments are sensitive to the minority group considered, as well as the initial level of sprawl.

The third essay (chapter four) integrates alternative patterns of multiple land-use attributes, i.e. unique combinations of both high-sprawl and low-sprawl attributes, to understanding key questions regarding sprawl and racial and ethnic segregation. These effects are visible not only when comparing multiple minority groups, but also when examining the outcomes for one group in particular. The complexity of these findings,

and thereby the understanding of these relationships, would not be as visible using limited dimensions of segregation and imprecise specifications of land-use attributes.

This dissertation provides a clear foundation for a future research agenda. On the question of minority housing consumption gaps, one could examine the sensitivity of these findings to residential-based measures of sprawl as opposed to employment-based measures. On the question of segregation, one could conduct the same analysis with employment-based or joint housing and employment-based configurations of land use. The continuing release of new data, such as Census 2010 and the biannual American Housing Survey, will provide a basis for further investigations into the long-term effects of sprawl in all of the research areas of the dissertation. Furthermore, as the understanding of sprawl and its causal effects deepens, inquiries into the presence of reverse causality will be necessary and crucial. Other topics tangential to the questions of this dissertation – such as the explicit definition and analysis of minority housing affordability issues in the wake of the housing bubble, as well as intra-minority analysis of the effects of sprawl – are fruitful areas of investigation. Finally, many of the topics within this research agenda would be enriched through more case studies and micro-level analyses.

Perhaps the most intriguing and growing research question moving forward is: In the aftermath of the Great Recession, is the era of urban sprawl coming to a close? If the housing bust leads to more renting and less homeownership over the long run, urban sprawl, in the form of expansive low-density residential development, may subside. Higher energy prices could dampen the willingness to commute, which could also reduce the demand for low-density development. In high-sprawl metropolitan areas, especially

those with fiscal constraints, high maintenance costs of infrastructure and public services could further intensify the appeal of compactness. These issues, and surely others, will no doubt provide opportunities to advance the debates and complexities surrounding the research questions of this dissertation.

APPENDIX A

CALCULATION OF EMPLOYMENT DECENTRALIZATION

This index of urban sprawl measures employment decentralization; namely, the share of employment located outside of a ten-mile radius from the central business district of a metropolitan area, relative to total employment within a thirty-five mile radius. If d_{ic} is the distance between a ZIP code centroid and the centroid of the central business district, and n_i is the number of employees in ZIP code *i*, the formula is as follows:

$$\frac{\sum_{d_{ic}>10}^{d_{ic}\leq 35} n_i}{\sum_{d_{ic}\geq 0}^{d_{ic}\leq 35} n_i}.$$

Expressed in percentage terms, possible values range between zero (least sprawled) and one (most sprawled).

The first step in this procedure is to determine the locations of central business districts. The 1982 Economic Censuses: Geographic Reference Manual (US Census Bureau, 1983) lists the central business districts of metropolitan areas by one or more census tracts as defined in 1980. In cases where the metropolitan area definition contains multiple metro areas, I used the central business district of the primary name. I acquired the census tract boundary file for 1980 from the National Historical Geographic Information System (Minnesota Population Center, 2010). Using the GIS software package ArcGIS (version 9.3), I merged contiguous tracts into one uniform area and extracted its geographic centroid.

Next, I identified ZIP codes within metropolitan areas. On this procedure, Chu and I differ. Chu cites ESRI Data and Maps 1999 (Environmental Systems Research Institute, 1999) as well as the MABLE Geocorrespondence Engine as the sources for ZIP code centroid data. It is unclear why two sources were used. Both are comprehensive, but they also likely differ. ZIP code boundaries are not official and frequently change over time. Whereas the ESRI ZIP codes were current to 1999, the MABLE definitions had not been updated since 1991. I attempted to clarify with Chu exactly how each data source was used in the thesis. Given the length of the time since its completion, he understandably does not recall the exact procedure. However, he indicated that he may have obtained a separate list of ZIP codes by metropolitan area, and used both centroid data sources because each had missing observations. Since a full replication of this procedure is impossible, I simply used the ESRI centroids in my calculations. Using ArcGIS, I exported all ZIP codes that have their centroid within the 1990 boundary definition for each metropolitan area. I obtained the 1990 boundary file from the Census Bureau's cartographic boundary files (2000a). For all spatial analysis, I used the Contiguous US and Hawaiian Albers Equal-Area Conic Projection Systems.

I then calculated the distance between each ZIP code centroid and its corresponding central business district centroid. Chu uses ArcView to calculate distances, although he is again unsure as to which module he used at the time. For simplicity's sake, I imported all centroid data into STATA, assigned to all ZIP codes their corresponding central business district, and entered a Haversine distance formula. If r is the Earth's radius (approximately 6,371 kilometers or 3,959 miles), $\Delta\alpha$ is the difference in latitude between a ZIP code centroid and the CBD centroid in radians, α is the latitude of a ZIP code centroid in radians, α_{cbd} is the latitude of the CBD centroid in radians, and $\Delta\Omega$ is the difference in longitude between a ZIP code centroid and the CBD centroid in radians, the formula for distance (d) is:

$$d = r * [2\sin^{-1}(\sqrt{\sin^2(\frac{\Delta\alpha}{2}) + \cos\alpha\cos\alpha_{cbd}\sin^2(\frac{\Delta\Omega}{2})})].$$

Although our methods differ, I expect that our calculations are very similar.

After that, I merged to each ZIP code the total number of mid-March employees from ZIP Code Business Patterns 1996 (US Census Bureau, 1998). I assigned an employment estimate of zero to ZIP codes with no corresponding record in ZIP Code Business Patterns. In cases where the Census suppresses total employment for confidentiality reasons, I followed Chu's estimation procedure. I took the average of the employee-size category, multiplied that average by the number of establishments in the ZIP code, and then added those estimates for all size categories to estimate total employment. I assigned an employment level of 1,200 to firms with 1,000 or more employees. In addition, for cases where this estimate exceeded the maximum defined by a suppression flag, I assigned the maximum value specified by the flag.

Lastly, I calculated urban sprawl and total employment by metropolitan area. First, I summed employment for the area containing all ZIP codes outside of ten miles but within thirty five miles of the central business district. Second, I summed total employment for all ZIP codes within thirty-five miles of the central business district. Finally, I divided the former value by the latter value.

APPENDIX B

MEASURES OF RESIDENTIAL SEGREGATION

1. Dissimilarity Index of Evenness (*D*):

$$D = \frac{\sum_{i=1}^{n}[t_i|(p_i - P)|]}{[2TP(1-P]}$$

t_i = Population of tract *i*
p_i = Minority population share of tract *i*
P = Minority population share of the metropolitan area
T = Population of the metropolitan area
n = Total number of census tracts in the metropolitan area

2. Isolation Index of Exposure (*XPX*):

$$XPX = \sum_{i=1}^{n}[\left(\frac{x_i}{X}\right)\left(\frac{y_i}{t_i}\right)]$$

x_i = Minority population of tract *i*
X = Minority population of the metropolitan area
y_i = Majority population of tract *i*
t_i = Population of tract *i*
n = Total number of census tracts in the metropolitan area

3. Delta Index of Concentration (*DEL*):

$$DEL = 0.5\sum_{i=1}^{n}|\left(\frac{x_i}{X}\right) - \left(\frac{a_i}{A}\right)|$$

x_i = Minority population of tract *i*
X = Minority population of the metropolitan area
a_i = Land area of tract *i*
A = Land area of the metropolitan area
n = Total number of census tracts in the metropolitan area

4. Absolute Centralization Index of Centrality (*ACI*):

$$ACI = \sum_{i=1}^{m}\left(\frac{\rho(x_{i-1})}{X} * \frac{\rho(a_i)}{A}\right) - \sum_{i=1}^{m}\left(\frac{\rho(x_i)}{X} * \frac{\rho(a_{i-1})}{A}\right)$$

$\frac{\rho(x_i)}{X}$ = Cumulative share of minority population through tract *i*
$\frac{\rho(a_i)}{A}$ = Cumulative share of land area through tract *i*
m = Total number of census tracts in the metropolitan area, ordered by increasing distance from the central business district

5. Spatial Proximity Index of Clustering (*SP*):

First, construct a contiguity matrix (*C*) that identifies the proximity between all census tracts. Contiguity is measured as the negative exponential of the distance between two tracts: $c_{ij} = e^{-d_{ij}}$, where d_{ij} is the distance between tracts *i* and *j*. When c_{ij} equals one, tracts *i* and *j* are contiguous. The value of c_{ij} declines as distance from a given tract increases.

Second, calculate the average proximity between members of the minority group.

$$P_{xx} = \sum_{i=1}^{n}\sum_{j=1}^{n}\frac{x_i x_j c_{ij}}{X^2}$$

x_i = Minority population of tract *i*
x_j = Minority population of tract *j*
X = Minority population of the metropolitan area
n = Total number of census tracts in the metropolitan area

Next, calculate the average proximity between members of the majority group.

$$P_{xx} = \sum_{i=1}^{n}\sum_{j=1}^{n}\frac{y_i y_j c_{ij}}{Y^2}$$

y_i = Majority population of tract *i*
y_j = Majority population of tract *j*
Y = Majority population of the metropolitan area
n = Total number of census tracts in the metropolitan area

Finally, calculate the average proximity between all members of the entire metropolitan area.

$$P_{xx} = \sum_{i=1}^{n}\sum_{j=1}^{n}\frac{t_i t_j c_{ij}}{T^2}$$

t_i = Population of tract *i*
t_j = Population of tract *j*
T = Population of the metropolitan area

n = Total number of census tracts in the metropolitan area

The Spatial Proximity index is the average of the minority and majority intra-group proximities, weighted by the percentage of their respective population groups in the metropolitan area population.

$$SP = \frac{[X(P_{xx}) + Y(P_{yy})]}{T(P_{tt})}$$

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