HOUSING CHOICE VOUCHER PROGRAM:

PATTERNS AND FACTORS OF SPATIAL CONCENTRATION IN CLEVELAND

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Dedicated to my father who inspired me with his sense of humor, positive outlook on life, and enthusiastic pursuit of knowledge.

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ABSTRACT

Housing Choice Voucher Program is the single largest housing subsidy program in the USA with the goal of poverty deconcentration and race desegregation. This study aims to identify the presence and locations of voucher holders' spatial concentration, and to investigate the factors associated with the location outcomes of voucher recipients in Cleveland from 2005 to 2009. Analyzing voucher recipients' information from Cuyahoga Metropolitan Housing Authority, this dissertation found meaningful results for the voucher program performances.

Hotspot analysis indicated that location patterns of voucher recipients do not show even distribution over the study area. Additionally, voucher holders have clustered together and their concentrations have changed during the five years. Voucher recipients were highly concentrated in the east part of Cuyahoga County, and over time, concentration patterns spread out from the central city to suburbs. Spatial concentrations were significantly different by race and ethnicity, but not by income.

Regression analysis identified several factors associated with voucher recipients' concentration, which include race, availability of affordable housing, poverty rates, vacancy rates, and accessibility to public transportation. The spatial error model estimation and Geographically Weighted Regression (GWR) account for spatial autocorrelation and spatial heterogeneity. The GWR model substantially improved the

explanatory power compared to the OLS and spatial models, and revealed spatial variation of estimated coefficients. Factors showing a spatial non-stationarity were confirmed by Monte Carlo tests.

Results from the dissertation presented the limited potential of the voucher program since voucher holders are still clustered in specific neighborhoods, even though they tend to move in less poor neighborhoods over time. However, in terms of poverty deconcentration, the voucher program has been successful to disperse low-income households in suburbs. On the other hand, desegregating minority population seemed to be hard to achieve through the voucher program alone because voucher holders are found in neighborhoods where minorities are predominant. A promising tendency is that they tend to move in suburban neighborhoods where white population is the majority. In order to overcome these limitations, policy makers should consider ways to encourage landlords' participation in the program, and to make neighborhoods accessible to public transportation.

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CHAPTER I

INTRODUCTION

1.1 Research background

Since the 1970s, housing policies in the United States could be characterized by a turn away from the direct provision of large scale public housing by government and a turn towards indirect subsidies of low-income families using market mechanisms (Schwartz, 2006; Katz &Turner, 2007; Grigsby & Bourassa, 2004). During the 1970s and 1980s, there were growing concerns over the negative effects of concentrated poverty and resistance to locating public housing projects; HUD had increasingly turned to tenant-based rental assistance rather than constructing new public housing developments as the primary means of expanding the stock of housing affordable to very-low income households. Emphasis of housing policy has been shifted from supply side provision to demand side subsidies (Orlebeke, 2000; Grigsby & Bourassa, 2004).

Initially launched in 1974, the Housing Choice Voucher program is the single largest housing subsidy in the United States, enabling almost two million low-income households to choose their residence in the private rental housing markets (Goering & Feins, 2003). This program is seen as a way of delivering poverty deconcentration and race desegregation through the use of a portable voucher. Expected to address the problems of public housing, the voucher program was understood as a mechanism for freeing public housing tenants from poverty and segregation. As Utt (1996) noted,

> In contrast with public housing, vouchers allow the assisted family to choose its place of residence from private landlords in the community, provided that the required rent stays within the established limits. This freedom allows assisted families to escape the worst urban communities. (p.2)

Stimulated by William Julius Wilson's (1987) contentions about the deleterious consequences of concentrated poverty, substantial literature has addressed the negative effects of poverty concentration (Massey & Denton, 1993; Ellen & Turner, 1997; Jargowsky, 1997). Policy makers have considered various ways of creating diverse environments of neighborhoods (Lane, 1995; Hoffman, 1996). Residential mobility programs, which help low-income families move to low-poverty areas, are one approach, which is being studied in Chicago's Gautreaux program (Rosenbaum, 1995) and in the national MTO program (Hanratty, McLanahan, & Pettit, 1998; Katz, Kling, & Liebman, 1999; Ladd & Ludwig, 1997). With mobility, the voucher program allows low-income household to live in mixed-income neighborhoods expecting positive outcomes for the underprivileged. Expected benefits have encompassed social, economic, and educational

opportunities, such as providing social role models and social control, reducing anti-social behavior, increasing employment, school performance, mental health, and neighborhood satisfaction (Katz, Turner, Brown, Cunningham, & Sawyer, 2003; Arthurson, 2002; Sarkissian, 1976; Mills et al., 2006; Tunstall & Fenton, 2006). Changing living environments from high-poverty, racially segregated to low-poverty, racially mixed neighborhoods will be expected to lead behavioral changes of the poor. On the other hand, the dispersal policy aimed to mitigating the degree of poverty concentration has been criticized as a social engineering approach assuming that the underprivileged will change their behavior simply because they have been exposed to different physical environments such as neighborhoods with better schools and low poverty rates. Dispersal program is not the program to address the poverty concentration issue, rather it simply the poor invisible by spreading out over space. On this regard, it is no surprise that the Moving to Opportunity (MTO) demonstration found no effects on employment after four years (Orr et al., 2003) and the use of a voucher had no effect on employment over a 3.5 year time frame (Mills et al., 2006).

However, scholars and policy analysts have become concerned that voucher users are increasingly moving into certain low-income and minority neighborhoods (Husock, 2004; Galster, Smith, Santiago, & Petit, 2003). Based on this reason, vouchers have been a target of criticism of producing a reconcentration of poverty, rather than serving as a way of deconcentrating poverty. Here is the importance of examining spatial patterns to assess the program's achievement, whether the voucher program contributes to poverty deconcentration and race desegregation, and which factors affect the spatial outcomes of voucher recipients.

1.2 Previous research

Studies on location outcome of vouchers have been conducted by comparison of neighborhood poverty levels and racial composition by different time, different geography, and/or different types of housing programs. Analyses at the level of national aggregation presented that the voucher program seemed to achieve its poverty deconcentration goal (Devine et al., 2003; Varady & Walker, 2000; Patterson et al., 2004; Mills et al., 2006). Also, many research reported that the voucher program had at least some effect on diminishing minority concentration (McClure, 2008; Teater, 2008; Gubits, Khadduri, & Turnham, 2009; Mills et al., 2006). Moreover, a comparison between project-based programs made a convincing argument that this program is successful in desegregating minorities and deconcentrating poverty (Newman & Schnare, 1997; Hartung & Henig, 1997; Deng, 2007). On the other hand, recent evidences tend to reveal that vouchers are not helping renters locate in low-poverty areas any more effectively than other project-based program (McClure, 2008; Williamson, Smith, & Strambi-Kramer, 2009; DeFilippis & Wyly, 2008; Guhathakurta & Mushkatel, 2000; Climaco, Finkel, Nolden, & Vandawalker, 2006). However, those approaches are characterized as a-spatial, simply comparing non spatial cross tabulation across geographies. Recently, more research have been done considering spatial aspects of voucher locations (Oakley & Burchfield, 2009; Wang & Varady, 2005; Wang, Varady, & Wang, 2008; Wyly & DeFilippis, 2010). The researchers have attempted to find whether there is spatial

concentration of voucher recipients and where they are clustered. When considering spatial aspects, research findings revealed that voucher holders still tend to cluster to some degree and in specific neighborhoods depending on several factors.

Studies on factors affecting vouchers' location outcomes have mainly identified three categories: personal preferences, racial segregation, and market conditions. As residential segregation is caused by both voluntary and involuntary processes (Bourne, 1981), voucher holders' personal preferences and non-personal barriers play a significant role in their location outcomes. Voucher recipients choose their residence simply because of proximity to family, friends, churches, and services (Varady, Walker, & Wang, 2001; Varady & Walker, 2007). At the same time, due to their income level, they are inevitably constrained by a location choice in an area served by public transportation (Varady et al., 2001; Popkin & Cunningham, 2000). A second influencing factor is related to race such as racial discrimination, segregation, fear, or preference of the same race. Many voucher holders expressed their fears of encountering discrimination when they began to search for housing (Popkin & Cunningham, 2000; Basolo & Ngyugen, 2005). The severity of racial segregation even outweighed the influence of the weak market conditions in terms of voucher concentration (Deng, 2007). A third set of studies examined the effect of market conditions on voucher location. Market conditions refer to various indicators depending on the focus of the research. However, market conditions can be divided into three groups in terms of factors affecting vouchers' location based on previous researches: the availability of affordable housing, vacancy rates, and landlords' participation in the program, which are related to each other. Generally, weak markets tend to provide more opportunities to finding voucher housing in areas other than the

central city (Finkel & Buron, 2001; Deng, 2007). Since weak markets show low housing sales prices, high vacancy rates, and low rent levels, landlords have an incentive to participate in the program that ensures stable rent based on the fair market rent, which would not be expected otherwise (Turner & Cunningham, 2000; Cunningham, Sylvester, & Turner, 1999; Finkel & Buron, 2001). One of the most important factors influencing location pattern is the availability of affordable housing. Location patterns of voucher families tend to mirror the geographic distribution of affordable rental housing units. Several studies confirm the relationship between voucher location and the availability of affordable housing (Devine et al., 2003; Ladd & Ludwig, 1997; Turner & Wilson, 1998; Turner & Cunningham, 2000).

1.3 Limitations of previous study

Various attempts have been made to examine the locational outcomes and factors limiting voucher recipients' spatial choice. The majority of research tried to evaluate the performance of the voucher program by comparing neighborhood indicators with different time or different types of housing projects (Devine et al., 2003; Newman & Schnare, 1997; Hartung & Henig, 1997; Deng, 2007; Pendall, 2000a; Guhathakurta & Mushkatel, 2000; Williamson et al., 2009; McClure, 2008; Basolo & Ngyuen, 2005; Kingsley, Johnson, & Petit, 2000). However, only a relative handful of studies (Oakley & Burchfield, 2009; Wang & Varady, 2005; Wyly & DeFilippis, 2010) have utilized spatial approach and specifically identified the spatial clusters of voucher households in several areas including Chicago, Cincinnati, and New York.

Research efforts have been also devoted to identifying the factors important to account for voucher holders' spatial choice: personal preferences, racial discrimination, and market conditions (Popkin & Cunningham, 2000; Goetz, 2003; Finkel & Buron, 2001; Turner, 2003; Varady et al., 2001; Turner & Wilson, 1998; Ladd & Ludwig, 1997; Cunningham et al., 1999). However, not much has tested the significance of the factors (Finkel & Buron, 2001; Oakley & Burchfield, 2009; Pendall, 2000a; Wyly & DeFilippis, 2010). Furthermore, most analysis focused on one of the factors such as race (Oakley & Burchfield, 2009), poverty (Wyly & DeFilippis, 2010), vacancy rate (Finkel & Buron, 2001); they failed to incorporate comprehensive impact. Specifically, despite the emphasis on public transportation in voucher holders' location (Varady et al., 2001; Popkin & Cunningham, 2000), no research has been conducted to examine the significance and the degree of effect on voucher locations.

Furthermore, most of the research that adopted regression analysis did not properly deal with spatial issues: spatial autocorrelation and spatial heterogeneity. Data on voucher recipients have spatial characteristics. Yet, regression analysis without considering spatial issues when dealing with spatial data cannot provide unbiased estimates, thus misleading the results of analysis. However, research utilizing spatial regression did not detect spatial variation or local differences of parameter estimates since OLS and spatial regression provide one estimate for each independent variable with the assumption that the effect of the variable is constant over space. Given the intrinsic uniqueness of space, sophisticated analysis is necessary to detect the local variations of a factor.

1.4 Importance of the study area

Cleveland, as a case study area, is a unique example of weak housing markets as well as severe racial segregation. Cleveland area has experienced declining population in its central city, an unprecedented foreclosure crisis, and high rates of abandoned and vacant properties. Cleveland as a central city of Cuyahoga County has lost more than a half of its residents during the last six decades, decreasing from over 900,000 in 1950 to less than 400,000 in 2008. Recently, the number of foreclosure filings has quadrupled from 1995 to 2007, which puts already vulnerable neighborhoods at a further disadvantage (Coulton et al., 2007; Coulton et al., 2010). The Cleveland area ranked in the top ten foreclosure filings in the nation (Schiller & Hirsh, 2008). At the same time, Cleveland has suffered weak economic conditions and stagnant housing prices, which leave almost one out of five its inhabitants living below the poverty level (U.S. Census Bureau, 2009). Furthermore, Cleveland has left a substantial portion of its land vacant; vacancy rates reach 22% in Cleveland as of 2008, generating negative externalities for the community (U.S. Census Bureau, 2009). More specifically, rental vacancy rates around the Cleveland metropolitan area have ranked high among 75 largest metropolitan areas. Rental housing vacancy rates in the fourth quarter of 2009 are 14.2% in Cleveland-Elyria-Mentor MSA, which is above the national average of 10.7% (U.S. Census Bureau, 2010).

Locational outcomes of the voucher holders have been affected by tightness of the local housing market and the severity of racial segregation. Weak market conditions would provide voucher recipients with more chances to find housing, since landlords are

less likely to find tenants under the conditions of high vacancy rates, especially when rental vacancy rates are high (Finkel & Buron, 2001). On the other hand, the severity of racial segregation tends to affect the residential choice negatively (Deng, 2007). The scarcity of information on the spatial outcomes of the voucher program in Metropolitan Cleveland, Cuyahoga County, is regrettable. This is because Cleveland has been recognized as a highly segregated area in the country (Abramson, Tobin, & VanderGoot, 1995; Glaeser & Vigor, 2001; U.S. Census Bureau, 2002), even though there is evidence that the absolute level of segregation in U.S. metropolitan areas has declined since 1970s (Glaeser & Vigdor, 2001). Furthermore, efforts have been devoted to reduce racial segregation and promote racial integration in housing in the suburbs of metropolitan Cleveland since 1960s (Keating, 1994). However, Cleveland is one of the places that residential segregation remains strikingly high (Massey & Denton, 1989, 1993; Logan, Stults, & Farley, 2004; Chandler, 1992). Hence, Cleveland is the place that needs the program to promote racial and economic integration in neighborhoods. Nonetheless, knowledge is very limited thus far on where the voucher families are located and which factors contribute to their spatial concentration in Cleveland metropolitan area.

Without knowing where the voucher families live, it is hard to confirm whether the voucher program achieves its goal to deconcentrate poverty and contribute to making neighborhoods diverse. Thus, this study will examine the spatial patterns of voucher users and examine the factors that are influential to spatial outcomes in Cuyahoga County, which includes the central city of Cleveland. In doing so, this study will fill the gap in paucity of research and provide policy makers with useful information on how the voucher program works in a unique place which needs race and income integration.

1.5 Uniqueness of the study

This study will identify the location of voucher clusters over space, changing patterns over time, and the factors associated voucher locations using a case of Metropolitan Cleveland. In doing so, there are three distinguishing components of this analysis from previous researches: block group as a unit of analysis, spatial approach, and spatial regression analysis. First, a finer geographic level than previous researches will highlight a more detailed picture of voucher locations. The majority of researches have adopted census tract as a unit of analysis when investigating voucher location outcomes. Specifically, all of previous researches considering spatial aspects analyzed census tract level or a higher level such as community area (Oakley & Burchfield, 2009). Even though census tract is the most widely used geographic level as a proxy for a neighborhood, finer geography such as block group will provide more rich analysis and a clearer picture of voucher locations. Thus, this dissertation will adopt block group as a unit of analysis, enabling richer results and capturing more in detail.

Second, spatial analysis will be considered to identify the spatial concentration. Contrary to the traditional a-spatial approach usually comparing poverty rates in census tract, this research will incorporate spatial consideration using the exploratory spatial data analysis approach. Not only will this study utilize the traditional a-spatial approach to describe the relationship between voucher concentration and the level of poverty, and racial composition in block group, but it will also incorporate the spatial approach to identify the locations of spatial concentration over space, as well as to analyze the change

of spatial patterns over time. This study will employ several techniques including dot mapping, density map, and hot spot analysis.

Last but not least, spatial regression and Geographically Weighted Regression (GWR) analysis will shed light on the impact of factors affecting voucher locational outcomes. Not much has been done to identify the factors constraining voucher locations employing statistical analysis. Studies on factors influencing voucher location have often used focus group interviews or surveys. Even though many research efforts pointed out that the accessibility to public transportation plays a critical role in voucher holders' location choice, no research has been conducted to confirm the statistical significance of this factor. Thus, this study will test the degree of several factors affecting voucher locations with the regression model. Moreover, considering the characteristics of voucher data, spatial aspects should be taken into account. Spatial regression and GWR account for spatial autocorrelation and spatial heterogeneity which OLS regression often fails to carry out when dealing with spatial data.

1.6 Research issues and approach

The purpose of this study is to examine how the voucher program works in terms of poverty deconcentration and race desegregation in Cuyahoga County. The research questions being asked in the dissertation consist of two parts: patterns of voucher recipients' spatial concentration and factors associated with their spatial concentration in Cuyahoga County, Ohio. Thus, this research seeks to;

(1) Identify the presence of spatial clustering of voucher recipients.

(2) Identify the locations of spatial concentration of voucher recipients by their races, ethnic backgrounds, and income levels.

(3) Examine the factors associated with voucher recipients' spatial concentration.

(4) Examine the spatial variation of influencing factors.

The remainder of the dissertation starts with evolution of public housing policy which provides background to understand how the housing choice voucher program was initiated. Also, brief overview on characteristics and performance of the voucher program is presented in Chapter II. This chapter is followed by theoretical backgrounds and literature review in Chapter III. Theories are categorized into seven groups in explaining residential segregation by income and race. These are Chicago school's invasion-succession (Park & Burgess, 1925), personal preferences (Schelling, 1971; Granovetter, 1978), economic and structural aspect (Wilson, 1987), cultural explanation (Lewis, 1966), racial discrimination (Massey & Denton, 1993), government role (Schill & Watcher, 1995), and resistance of landlords and neighborhoods. The following literature review focuses on the locational outcomes of voucher recipients in terms of whether the voucher program has been successful in terms of poverty deconcentration and race desegregation. This chapter is also devoted to identifying factors affecting voucher recipients' location outcomes. Chapter IV explains methodologies adopted in this dissertation, including hotspot analysis, spatial regression analysis, and GWR. Next, Chapter V investigates patterns of spatial concentration of voucher recipients from 2005 to 2009, utilizing hotspot analysis as well as description of voucher holders' demographic characteristics and neighborhood conditions. Chapter VI identifies factors associated with voucher

recipients spatial concentration and spatial variation of these factors over space. A series of regression analyses is conducted from traditional OLS, spatial error model estimation, to GWR. Final chapter concludes with summary findings of the study, policy implication, limitations, and further research issues.

CHAPTER II

HOUSING POLICY AND HOUSING CHOICE VOUCHER PROGRAM

2.1 Public Housing Policy

The public housing program in the United States was authorized by the U.S. Housing Act of 1937. It was the first major federal program aimed at providing low-rent housing to low-income families. Although housing problems had been acknowledged for decades, it was not until the Great Depression in the 1930s that the federal government became involved with housing on a large scale. The U.S. Department of Housing and Urban Development (HUD) administers federal aid to local public housing authorities (PHAs) that manage the housing for low-income residents at rents they could afford. Public housing was to be limited to low-income families and individuals.

The Housing Act of 1949 reauthorized the public housing program and committed the nation to build 810,000 units over the subsequent six years, which did not reach the

goal until 1970 (Schwartz, 2006). Racial segregation, crime, unemployment, and social isolation among residents increased greatly in the 1970s and 1980s since high-rise, high-density, and large scale public housing projects were often built on cheap and undesirable land. In the past three decades, more resources have gone to the preservation and redevelopment of public housing projects than to the production of new public housing (Schwartz, 2006).

According to Katz and Turner (2007), public housing policies in the United States have evolved with three distinct programs: public housing production programs, tenant-based assistance programs, and place-based transformation programs. Since the 1930s, production programs have stimulated the construction of millions of publicly subsidized housing units. Since the 1970s, tenant-based assistance programs have helped millions of renters to live in neighborhoods with better quality access to public services. In addition, since the mid-1990s, the place-based, demolition and replacement of distressed public housing has transformed the economic and physical landscape of the most distressed projects in the United States.

2.1.1 Public housing production program

As a major source of providing affordable housing for extremely low income families, public housing production programs have evolved in three distinct phases. During the first phase, from the 1930s through the 1960s, the federal government financed the construction of over 1 million public housing units through contracts with PHAs. These contracts required the PHAs to maintain the affordability of public housing units in perpetuity. During the second phase, dominant from the 1960s to the early 1980s,

the federal government subsidized the construction of over 1.3 million units of privately owned affordable housing through a combination of below-market financing, income tax preferences, and operating support. Under these programs, the federal government executed contracts directly with for-profit and non-profit developers of affordable housing rather than with local PHAs. The current phase of federal production policy, dominant since the mid-1980s, has delegated key decisions to state and local governments. These governments have a responsibility for allocating federal tax credits and block grant funding in accordance with federally mandated affordability plans. In general, these federal resources have been used to produce quality affordable housing in low-income neighborhoods often through community-based housing providers. The key subsidy programs of this period were the Low Income Housing Tax Credit (LIHTC) program, the Community Development Block Grant (CDBG), and the HOME investment Partnership Program (Katz & Turner, 2007).

Public housing was originally intended to provide decent and affordable accommodations to low-income families for whom market rents were out of reach. Overall, public housing production programs have been successful in terms of stimulating the production of the affordable housing. The public housing stock reached its peak of 1.4 million units in 1994; as of 2004, it had declined by 12% to 1.23 million units (Schwartz, 2006).

However, by the end of the 1980s, public housing was widely considered as a failure. The problems due to mass concentration of public housing included extreme racial and economic segregation and inadequate public services. Due to historical discrimination, deliberate neglect, and prejudice, public housing tenants suffered from

racial and economic segregation from outside of the society. In addition, poor construction, inadequate management and maintenance, high crime and disorder in public housing aggravated the problem. The combination of intense poverty, physical deterioration, and social disorder called for a radical approach to revitalization of public housing policy in the United States. Responding to the failure of public housing, housing programs increasingly tried to blend low-income households with more affluent neighbors. Governments responded in two basic ways. One approach, called the dispersal program or tenant-based assistance program, helps underprivileged public tenants and low-income households move into middle-income, often suburban neighborhoods. The other tries to put households with varying levels of income within the same building or development (Schwartz, 2006). Housing choice voucher programs are an example of the former, HOPE VI (Homeownership Opportunities for People Everywhere) program can be the latter.

2.1.2 Tenant-based assistance program

Several poverty dispersal programs have been implemented in the US over the last several decades, beginning with the Gautreaux Program, which served as a model for a tenant-based dispersal approach. The 1976 Gautreaux Demonstration was the first large-scale attempt at reversing a history of discriminatory housing practices (Rubinowitz & Rosenbaum, 2000). The Gautreaux program resulted from the U.S. Supreme Court ruling, which charged the Chicago Housing Authority had employed racially discriminatory policies in the administration of low-rent public housing programs with the tacit approval of HUD. As a result, between 1976 and 1998, over 7,000 African

American families moved, over half of them to suburban communities. A new round of the Gautreaux program began in 2002, and until recently, it has moved hundreds of families (Duncan & Zuberi, 2006).

A recent study showed that both Gautreaux programs provided beneficial outcomes: female-headed African American families moving from Chicago's housing projects to predominantly middle-class white suburbs secured better jobs for themselves and better schooling for their children than mothers placed within Chicago's city limits. In terms of poverty rates, Gautreaux One played a substantial role in reducing neighborhood poverty rates by more than half; on average, families came from neighborhoods with poverty rates of 42%. They have since moved to neighborhoods with poverty rates of 17% (Duncan & Zuberi, 2006). However, the new Gautreaux program fails to confirm the suburban advantages found in the previous experience. In terms of criminal records of Gautreaux children, suburban placement helped boys but not girls (DeLuca, Duncan, Keels, & Mendenhall, 2010). Nevertheless, the latest research on the new Gautreaux program revealed that families moved back into poor segregated neighborhoods because they felt social isolation, had poor integration into new neighborhoods, struggled with distance from relatives, and children faced negative reactions to their new neighborhoods (Boyd, Edin, Clampet-Lundquist, & Duncan, 2010). The Gautreaux program endeavored to place families in low-poverty, racially integrated neighborhoods; however, about one-fifth of families was placed in high-poverty, and highly segregated neighborhoods due to the difficulties of finding neighborhoods that met these criteria. Since participating families have moved into better communities, their neighborhood conditions have significantly improved.

Moving to Opportunity (MTO) is a more recent example of a people-based poverty deconcentration program. The MTO program, first implemented in the early 1990s, provided Section 8 vouchers to public housing residents so that they could move into low poverty areas. The goal of the experimental program was to examine the impact of the new neighborhoods on the life chances of participants through an experimental design. Participants in the MTO demonstration were randomly assigned to three different situations: an experimental group that had received vouchers, counseling, and had to move to neighborhoods with less than 10% poverty; a comparison group that had just received vouchers; and a control group that had remained in public housing (Briggs, Popkin, & Goering, 2010).

The MTO demonstration program has to date shown mixed results: encouraging evidence for security, safety, and health; at the same time, no significant effect on employment, education, and boys' behavior. As a result of the strength of the initial design, interim evaluations of the MTO program provide strong evidence of some of the merits of moving from high poverty to low poverty neighborhoods over the short to mid-term (1-6 yrs) (Orr et al., 2004). Positive MTO findings include dramatic improvements in housing and neighborhood conditions; enhancing sense of safety and security; significant improvements in both mental and physical health of adults; significant mental health improvements and less risky behavior in girls ages 15 to 19; significant but small effects on the characteristics of the schools children attended, (although most families remained within the same, central-city school district). However, several less than desirable outcomes were also witnessed, including no significant impact on educational performance, employment, earnings, or welfare receipt; and worse mental and behavioral

outcomes in teenage boys. And lastly, un-counseled subsequent moving was more likely than for the treatment group, and they were more likely to be return to high-poverty areas than the comparison or control groups (Orr et al., 2004).

In order to answer the unexpected results of the social experiments, researchers focused on MTO families' experiences in detail, adopting qualitative interviews and ethnographic field research (Briggs et al., 2010). The findings revealed the discrepancy between planners' ideal expectation and families' desperate needs. Unexpected positive outcomes in regards to security and safety could be explained by the primary motives of the MTO participants who wished to escape their former public housing in order to be safe, and not to get better schools or job opportunities. However, planners of the program expected that moving to opportunity neighborhoods that have lower poverty rates would give participants better chances of living in terms of housing, education, and employment. This was the typical example of the planner's expectations which were apart from reality. Rather, the poorest and most vulnerable families were considered only with living in a safe environment. As Briggs et al. (2010) noted, "many MTO parents were focused on safety first, last and always, viewing getting away from the pervasive violence and disorder as the most important thing they could do for themselves and their children" (p.89).

A kin-centered community played a pivotal role not only in organizing social life around MTO families but also in pulling them back to high poverty neighborhoods. Any benefits gained by living in safer communities could be quickly lost once MTO families return to those distressed neighborhoods. Hence, researchers took the kin-oriented relationship as a mixed blessing at best (Briggs et al., 2010).

Compared to the Gautreaux program, the MTO program creates modest changes in participants' living conditions: MTO participants moved shorter distances, into neighborhoods with higher poverty and unemployment rates, more disproportionate minority rates, and poorer school systems (Rosenbaum & Zuberi, 2010). Different outcomes could be explained by the different program designs (Rosenbaum & Zuberi, 2010), different motives of participants, or different support systems enabling participants to stay in better neighborhoods (Briggs et al., 2010). Merely changing neighborhoods does not necessarily guarantee the success that policy makers were hoping for, such as more work and higher earnings, greater independence from welfare, and intergenerational success (Duncan & Zuberi, 2006).

In any case, tenant-based dispersal programs have limited potential, considering the heavy reliance on market mechanisms and choices available to participants. Finding affordable housing in lower poverty neighborhoods is significantly hindered by both supply and demand. As for the supply side, the scarcity of affordable housing and a landlord's voluntary participation in the program are critical. As for the demand side, participants' preferences, lack of information, and kin-oriented relationships constrain their location choice.

2.1.3 Place-based transforming program

In the past decade, the federal government has endeavored to change the face of public housing: demolish the worst public housing projects and replace them with housing that is more economically mixed, better designed, less dense, and integrated into local neighborhoods. The HOPE VI program has had success meeting four goals: (1)

demolition of severely distressed housing units, (2) replacement with higher quality units, (3) increased sense of safety and well being, (4) and a reduction in poverty rates. However, the program has had failures in the following: (1) a low rate of returnees, (2) a reduction of public housing stock, (3) and less frequent social interaction than expected.

The HOPE VI program has accomplished its most basic goal to demolish severely distressed housing units and to replace them with new, high quality mixed income housing containing innovative design, management, and financing. The HOPE VI program, funded with annual appropriations of $300 to $500 million, has been central to the transformation of public housing since the early 1990s. Focusing on the most distressed public housing development, HUD allocated a total of $4.55 billion from 1993 to 2002 to demolish 78,000 units of public housing and to transform these projects into mixed income housing developments (Schwartz, 2006).

HOPE VI relocation has provided former residents with safety benefits. Through HOPE VI, many former public housing residents received vouchers and were able to relocate to better housing in safer neighborhoods (Popkin et al., 2004). More recently, HOPE VI Panel Study illustrated that HOPE VI movers have gained a dramatically improved sense of safety and a reduced fear of crime through relocation to the private market or new mixed-income developments (Popkin & Cove, 2007). [1] Similar to the MTO experiences, successful participants with vouchers reported improved mental health

[1] The HOPE VI Panel Study and the HOPE VI Tracking Study are the first systematic, multi-city studies commissioned by the US Congress in 1999, in order to examine what happened to the original residents of HOPE VI developments. The Tracking Study was intended to provide a snapshot of living conditions and well-being of former residents of eight HOPE VI sites where redevelopments began between 1994 and 1998. The HOPE VI Panel Study focused on the longer-term effect in five sites, in terms of neighborhood conditions, physical and mental health, and socioeconomic outcomes for 887 original residents (Popkin, 2006; Buron et al., 2002).

and less behavior problems among their children (Popkin, 2010).[2] In addition, HOPE VI has generated benefits for the neighborhoods surrounding public housing (Popkin et al., 2004).

At the neighborhood level, HOPE VI redevelopments have a positive impact on residents' living environments, including poverty rates. Nationwide research on HOPE VI developments in 48 cities confirmed that the majority of relocates from the HOPE VI program moved to neighborhoods that have lower poverty rates than those they left behind (Kingsley et al., 2003). Percentage of relocates by the type of neighborhoods indicated that most of residents (91.5%) lived in neighborhoods where the poverty rates are at least over 30% before HOPE VI developments; while after development this figure decreased to 38.7%. In contrast, the percentage of relocatees living in better neighborhoods with poverty rates below 10% has increased from 0.2% to 12.5% due to HOPE VI projects. In a study of 9,200 mixed income multifamily federally funded housing projects, Khadduri and Martin (1997) concluded that successful mixed income housing was more likely to succeed in low poverty neighborhoods than in high poverty ones. However, they also found that mixed income projects might work in high poverty areas in tight market conditions where there is little alternative accommodation for working families.

Several issues have resulted from the implementation of the HOPE VI program: the low rate of returnees, reduction of public housing stock, and less frequent social interaction than expected. The first issue related to the HOPE VI program is whether the original tenants would return to the new mixed-income housing. Studies revealed that

[2] On the contrary, movers to another traditional public housing did not gain the similar benefits of increasing a sense of safety (Popkin, Levy, & Buron, 2009).

only a relatively small number of residents had moved into new housing, varying from less than 10% to 75%; while government expected 46% of residents to return on average (Buron, Popkin, Levy, Harris, & Khadduri, 2002; Holin, Buron, Loke, & Cortes, 2003; Popkin et al., 2004). There are diverse reasons that original residents did not return. The low level of return is partly by design itself: most HOPE VI sites built fewer public housing units than they demolished. Other reasons relate to personal preferences, and regulations on eligibility contribute as well. Former tenants of public housing decided not to come back since they are happy with their new housing, do not want to move again, and simply distrust promises that the new housing will really be better (Popkin, 2010). However, former residents could not move back due to the strict screening criteria requiring employment history, no criminal records, and no history of delinquency of paying bills as well.[3] Often, long periods of time delay between demolition and completion of the new developments are associated with low rates of return (Wilen & Nayak, 2006; Popkin, 2010).

Another reason to prohibit returning is attributed to loss of affordable housing units available for former residents. HOPE VI developments typically have fewer public housing units than the projects they replace by demolishing high-rise public housing projects into a smaller scale and mixed-income projects. Only about half of the public housing units demolished under HOPE VI were replaced with new public housing. The 217 HOPE VI redevelopment grants involved the demolition of 94,500 public housing

[3] Chicago Housing Authority (CHA) requires tenants to meet the criteria for moving into the new mixed-income developments. Under the CHA's minimum tenant selection plan, families must be up to date on their rent and utilities, have no outstanding debts or lease violations, pass a three-year criminal background check, provide documents that all children are attending school on a regular base, and require that all household members over the age of 18 must be employed at least 30 hours a week (Popkin, 2010).

units from 1993 through 2003, and the replacement of 95,100 units. However, only 48,800 of these new units can be considered equivalent to public housing necessary to support households with very low incomes (Schwartz, 2006).

Infrequent social interaction undermines the weights of mixing different groups of residents in proximity. HOPE VI research showed that there was relatively little interaction between higher- and lower-income residents, and also that the interactions that did occur were relatively superficial (Popkin et al., 2004). Similar outcomes appeared in Chicago where residential segregation is severe and place-based programs are active (Rosenbaum, Stroh, & Flynn, 1998). There have been efforts in an attempt to identify the factors curtailing active social interaction. For example, a study in the case of Seattle indicated several factors influencing the interaction among residents: proximity within the development, community events, and the presence of children in the household. Differences in socioeconomic background including language and family composition impede social interaction between households of different incomes and housing tenures (Kleit, 2005). HOPE VI residents' tracking study revealed similar results and causes of low level social interaction. The low levels of interaction were associated with a lack of opportunity, language or cultural barriers, and personal preferences for keeping social distance from neighbors (Buron et al., 2002). Another research focused on mixed-income developments in Chicago, also confirmed a lack of social interaction across income levels. Joseph (2008) examined the reasons in several aspects from physical design to lack of common interests. Minimal shared public space did not provide a chance of interacting. Plus, homeowners expressed reluctance in living with former public housing residents in close proximity. In an effort to build community in mixed-income developments,

Chaskin and Joseph (2010) suggested that resident meetings, associations, common interests, and shared needs would function in bringing residents together as a catalyst for social interaction.

The place-based transforming program is both promising and controversial. On one hand, it provides an opportunity and the resources to improve the terrible living conditions of many public housing residents. On the other hand, these efforts have significantly reduced the number of permanent public housing units, and disrupted the lives of residents at many sites. Plus, they cost millions of dollars of public money with little evidence that lower poverty neighborhoods help achieve the desired favorable outcomes such as frequent social interactions.

2.2 Housing Choice Voucher Program

2.2.1 Origin and evolution

Beginning in the mid-1970s, housing vouchers have emerged as the most substantial subsidized housing program in the United States. Vouchers are the most direct way to deal with the affordability problems of the poor since vouchers allow the recipients to decide where to live. As Goering and Feins (2003) asserted, the housing voucher program can be utilized to mitigate racial and economic segregation by reversing the historic practice of concentrating poor minority households in distressed neighborhoods. By helping families relocate from high-poverty to low-poverty neighborhoods, the housing voucher program has the potential to lead to significant improvements in their living conditions and well-being.

By 1974, Congress was convinced that tenant-based housing assistance was a viable alternative to public housing. The Housing and Community Development Act of 1974 authorized the Section 8 program. The Section 8 program included two different forms: Section 8 New and Section 8 Existing. The former refers to Section 8 project-based assistance for existing, which is for newly constructed or rehabilitated housing. The latter refers to Section 8 existing housing program, which is a newly created housing assistance program to be administered by PHAs provided tenant-based subsidies. The Section 8 existing program was also known as the rental certificate program. By mid-1980s, the rental voucher program was formally authorized as a program in the Housing and Community Development Act of 1987. The program was similar to the rental certificate program, but it allowed families more options in housing selection. Major differences between the rental certificate and rental voucher programs were: (1) the rental voucher program did not have a fair market rent limitation and (2) the rental voucher program provided assistance to families based on a pre-determined amount of assistance. The 1998 Public Housing Reform Act authorized the merger of the certificate and voucher programs into a single program with a single set of regulations. The change started the housing choice voucher program, effective October 1, 1999 (HUD, 2000; HUD, 2001).

2.2.2 Program overview

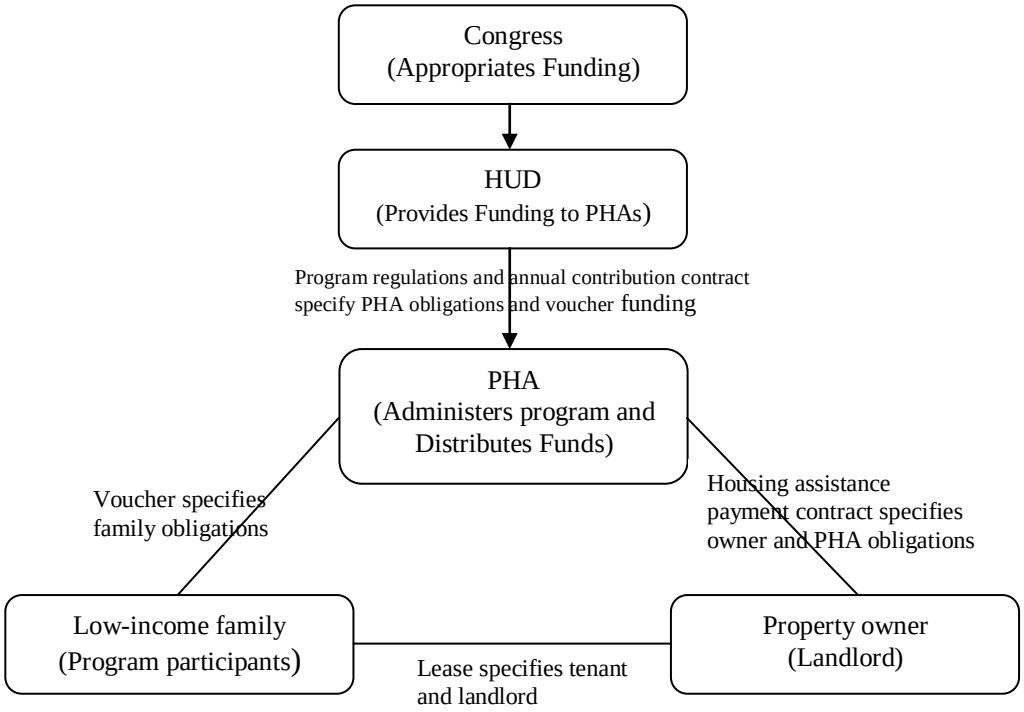
Public Housing Authorities (PHAs) play a central role in administering the voucher program. Appropriated by Congress, funding for the voucher program is provided by HUD to PHAs. The annual contributions contract between HUD and PHA

specifies the PHA's responsibilities, obligations, and funding for housing assistance to very-low income households. Under the contract with HUD, the PHAs are responsible for the voucher program's administration such as determining family eligibility; maintaining the waiting list and selecting eligible families; calculating family portions of rent and housing assistant payments; approving units with housing inspections and rent reasonableness tests; and conducting outreach to landlords (HUD, 2001).

The voucher program includes several steps, such as application, selection of eligible family, housing searching, unit inspection and approval, housing subsidy contract, and annual reexamination. In order to receive rental assistance through the voucher program, families should apply to the waiting list. An applicant has to be added to the waiting list and be selected as an eligible household since the voucher program is a discretionary program, not entitlement. Entitlement will allow everyone who has an income below a certain income level with high rent the right to apply for housing support and to receive a housing benefit irrespective of the funding levels (Priemus, Kemp, & Varady, 2005). Due to the need for housing assistance and limited budgets, it takes time to be selected to receive housing subsidies. As of 2008, the average waiting time was 26 months (HUD, 2010c). Eligibility for the voucher program is based on family definition, income limits, citizenship status, and eviction history for drug-related criminal activity. Considering the criteria, applicants are selected by priority or by random choice. Income limits are determined by HUD, based on family size and the metropolitan area where the PHA is located. HUD also announces the income targeting requirements: at least 75% of the families who are admitted to PHA's voucher program during the PHA fiscal year

must be extremely low-income where their income is at or below 30% of the area median income (HUD, 2001).

Figure 2-1 Relationship in the Housing Choice Voucher Program



Source: Adapted in part from HUD (2001, p.1-12)

Once the eligible families are selected, they receive the voucher, which is a document issued by the PHA given them for admission to the program. This indicates the terms of the voucher, authorized bedroom size, and family obligations. Using the voucher, families start to find housing units to meet their needs and rent level. When the family finds a housing unit, the unit should pass the inspection that ensures the housing quality standards. In addition, the rent level should be at or below the Fair Market Rents (FMRs) level that is determined by HUD annually. FMRs represent the 40th percentile value of rents, which is the dollar amount below 40 % of the standard quality rental housing units.

[4] FMRs vary by bedroom size, and include utility costs. The 40th percentile rent is obtained from the distribution of rental units occupied by movers who are renter moved into their unit within the past 15 months (HUD, 2007a). As of 2010, FMRs in Cleveland-Elyria-Mentor MSA is $735 for two bedroom housing unit (HUD, 2010d). HUD's published FMRs are based for calculating housing assistance payments that the PHA pays to the owner on behalf of the family leasing the unit. Average FMRs for a two bedroom unit has increased from $625 in 2000 to $899 in 2009 as shown in Table 2-1.

Table 2-1 U.S. Average two bedrooms Fair Market Rent

Year	2000	2001	2002	2003	2004
FMR	$625	$646	$696	$735	$754
Year	2005	2006	2007	2008	2009
FMR	$762	$786	$812	$861	$889

Source: HUD (2010d), FMR History

Fair Market Rents vary by housing markets. In fiscal year 2010, the FMR for a two bedroom unit ranged from $ 399 in Puerto Rico to $1,800 in Stamford-Norwalk, Connecticut, followed by $1,760 in San Francisco, California. FMRs tend to be higher in the nation's major metropolitan areas. As shown in Table 2-2, the mean FMR for the 50 largest metropolitan areas in 2010 is $1,045 for a two bedroom unit, and almost a half of these areas have FMRs greater than $1,000. As described, FMRs are flexible since they vary by regions and housing sizes; however, they also limit residential choice because of FMRs ceiling.

[4] Standard quality rental housing units have the following attributes: occupied rental units paying cash rent; specified renter on 10 acres or less; with full plumbing; with full kitchen; unit more than 2 years old, and meals are not included in rent (HUD, 2007a).

Table 2-2 2010 Fair Market Rent in 50 largest metropolitan areas

Metropolitan Area	FMR($)	Metropolitan Area	FMR($)
San Francisco, CA	1760	Austin-Round Rock, TX	954
Orange County, CA	1594	VA Beach-Norfolk-Newport News, VA-NC	934
Nassau-Suffolk, NY	1592	Denver, CO	921
Washington, DC-VA-MD	1494	Phoenix-Mesa, AZ	919
San Jose, CA	1438	Atlanta, GA	912
Los Angeles-Long Beach, CA	1420	Minneapolis-St.Paul, MN-WI	899
Bergen-Passaic, NJ	1379	Dallas, TX	894
Oakland, CA	1377	Houston-Baytown-Sugar Land, TX	892
New York, NY	1359	Fort Worth-Arlington, TX	861
Fort Lauderdale, FL	1358	Milwaukee-Waukesha, WI	858
Boston-Cambridge-Quincy, MA-NH	1357	Portland-Vancouver, OR-WA	839
San Diego, CA	1324	Salt Lake City, UT	836
Newark, NJ	1279	Kansas City, MO-KS	834
Miami, FL	1206	Nashville, TN	807
Baltimore, MD	1203	Charlotte-Gastonia-Concord, NC-SC	806
Riverside-San Bernardino, CA	1108	Detroit-Warren, Livonia, MI	796
Philadelphia, PA-NJ	1095	San Antonio, TX	796
Hartford, CT	1095	St. Louis, MO-IL	771
Las Vegas, NV	1063	Indianapolis, IN	754
Seattle-Bellevue, WA	1056	Columbus, OH	750
Orlando-Kissimmee, FL	1052	Cleveland-Lorain-Elyria, OH	735
Sacramento, CA	1039	Pittsburgh, PA	730
Chicago, IL	1015	Buffalo-Niagara Falls, NY	728
New Orleans, LA	982	Cincinnati-Middleton, OH-KY-IN	726
Tampa-St.Petersburg-Clearwater, FL	959	Greensboro-High Point, NC	703

Source: HUD (2010d), FMR History

Under the voucher program, voucher holders locate a suitable rental unit in the private market and generally pay 30% of their adjusted gross income directly to the landlord for rent. The voucher program subsidizes the remaining portion of the contract

rent that is the difference between 30% of the tenant's income and the FMR for the area. So, the housing choice voucher program provides flexibility and options, by issuing vouchers to eligible households to help them pay rent in privately owned apartments of their choice. Additionally, HUD requires annual reexamination of the voucher participants and the units: the family must be recertified to determine continued eligibility for the program, and the housing units must be inspected and meet housing quality standards annually (HUD, 2001; CMHA, 2009b).

2.2.3 Program performance and characteristics of voucher recipients

The housing choice voucher program has experienced significant growth not just in size, but in importance as an appropriate method for providing housing assistance for very low income families (HUD, 2000). Since 1970, HUD's housing voucher program has grown from about 30,000 households to about 2 million vouchers today. Table 2-3 shows the growth of vouchers from 1975.[5] For many years, the primary source of increased assistance for very poor households was new annual appropriations for additional vouchers, called incremental vouchers. Since 1990s, however, no incremental vouchers were funded during 1995 through 1998, and from 2003 to 2007. After 2007, Congress appropriated funding for 15,000 incremental vouchers in fiscal year 2008;

[5] A total of 225,000 non-incremental vouchers were included from 1995 to 2004 periods. During the periods, half of the voucher growth derived from increases in the number of new, incremental vouchers, and other half reflected transfers of households from public housing and other project-based subsidy programs to the voucher program (Schwartz, 2006).

13,000 new vouchers in FY 2009; and 11,000 new vouchers in FY 2010 (National Low Income Housing Coalition, 2010).[6]

Table 2-3 Cumulative issuance of Section 8 Certificates and Vouchers, 1975-2010

Year	Period total	Cumulative total
1975-1980	624,604	624,604
1981-1985	287,334	911,938
1986-1990	301,523	1,213,461
1991-1995	186,544	1,400,005
1996-2000	110,000	1,510,005
2001-2005	338,000	1,848,005
2006-2010	39,000	1,887,005

Sources: HUD, 2000; Schwartz, 2006; National Low Income Housing Coalition, 2010

According to resident characteristics reports in the HUD PIH information center, in the United States, a total of 1,885,987 units received voucher subsidies as of June 30, 2010. Since the voucher program is one of the major federal programs intended to bridge the gap between the cost of housing and the household income, the households have low income levels. The average household annual income is $12,644, and the majority (66%) of households falls into extremely low income categories (HUD, 2010a). The low income level of voucher recipients reflects federal eligibility standards that give priority to extremely low income households. As Table 2-4 illustrates, less than 1% of recipients have income above the low income level.

[6] For FY 2010, the housing choice voucher program is funded at $18.18 billion (National Low Income Coalition, 2010).

Table 2-4 Voucher recipients' income level

Income category	Extremely low	Very low	Low	Above low	Unavailable
Count	1,238,863	383,412	77,650	4,796	181,264
Percent	66	20	4	0	10

Source: HUD (2010a), Resident Characteristic Report

In addition, over 70% of families have income less than $15,000 per year, and less than 10% of families earn over $25,000 annually.

Table 2-5 Voucher recipients' income distribution

Income level	$0	$1-$5,000	$5,001-$10,000	$10,001-$15,000	$15,001-$20,000	$20,001-$25,000	Above $25,000
percent	3	10	32	24	14	7	8

Source: HUD (2010a), Resident Characteristic Report

As the voucher program intended, participants tend to pay about 30% of their income for rent. Total Tenant Payment (TTP), typically consists of 30% of voucher recipients' income, which is $294 per month on average. Female-headed households with children pay $307 TTP per month. Families of elderly with children tend to pay more rent than other types of families.

Table 2-6 TTP by family type

	No Disabled		Disabled	
	Elderly	Non Elderly	Elderly	Non Elderly
No Children	$301	$286	$279	$254
With Children	$403	$303	$385	$347

Source: HUD (2010a), Resident Characteristic Report

As Table 2-7 shows, slightly over half of families are white (51%), followed by African American 45%. Less than one out of five (18%) recipients report their ethnicity as Hispanic or Latino.

Table 2-7 Distribution of family race

Race category	White only	Black/ African American only	Asian only	American Indian or Alaskan Native only	Other race
Percent	51	45	2	1	< 1

Source: HUD (2010a), Resident Characteristic Report

The voucher program is successfully serving different types of families. Of the 1,885,987 families currently being served, 52% have children, and 39% are persons with disabilities. Specifically, almost half (49%) of families are female-headed families with children.

Table 2-8 Distribution of family type

	No Disabled				Disabled			
	Elderly		Non Elderly		Elderly		Non Elderly	
No Children	128,829	7%	193,123	10%	207,594	11%	367,352	19%
With Children	7113	0%	812,478	43%	13,344	1%	156,154	8%

Source: HUD (2010a), Resident Characteristic Report

Two bedroom housing units are the most commonly found types of housing for families with vouchers (36%), followed by 3 bedrooms (31%) and then 1 bedroom (24%). Finally, Table 2-9 shows how long voucher holders have resided within their current units. About 30% have been in the same place for 5 to 10 years, 24% for 2 to 5 years, and 19% for more than 10 years, while 16% of families moved in their homes last year.

Table 2-9 Voucher recipients' stay period

Stay period	Moved in past year	1 – 2 years	2 – 5 years	5 – 10 years	10 – 20 years	Over 20 years
Count	309,157	216,474	449,065	551,602	293,136	61,477
Percent	16	11	24	29	16	3

Source: HUD (2010a), Resident Characteristic Report

2.3 Conclusion

Since the 1970s, providing public housing has widely recognized as a failure in American public housing policy. In response to residential segregation by income, race, and geography (central city versus suburbs), public housing policy has adopted radical approach, resulting in demolition of older, dysfunctional public housing projects and dispersal of subsidized households (Goetz, 2010). The Housing Choice Voucher program intends to mitigate residential segregation by utilizing a portable voucher that gives families a choice in their house in the private market. Funded by HUD, PHAs administer the voucher program within their jurisdiction. HUD provides FMRs annually, which set a standard for rental subsidies. FMRs vary by regions and tend to be higher in the nation's major metropolitan areas. Voucher holders find their housing unit that meets the requirement of proper rent levels and housing quality standards.

The voucher program has expanded its volume and importance. As a single largest housing program, the voucher program serves about 2 million households today. Also, the voucher program plays an important role in providing decent house for vulnerable households. The majority of voucher recipients fall into extremely low-

income households; almost half of them are female-headed families with children; and a significant portion of families are elderly or person with disabilities. As Sard (2001) noted, the voucher program should be a major component of future housing policy for the lowest income families since the voucher program meets the needs of and provides flexibility for those families who, unless otherwise, have hardships in living in decent house.

CHAPTER III

THEORETICAL BACKGROUND AND LITERATURE REVIEW

3.1 Theoretical Background of Spatial Segregation

Large metropolitan areas in the United States are segregated (Massey & Denton, 1987), in the face of significant efforts to mitigate housing discrimination. From 1960 to 1990 the poor were becoming increasingly concentrated by race and income into ghettos, barrios, and slums (Jargowsky, 1997). Research efforts have been devoted to explain the cause of spatial separation by income and race. None of factors can exclusively explain the cause of the residential segregation. Yet, mechanisms of spatial separation fall into following seven categories: natural process (Park & Burgess, 1925), personal preferences (Schelling, 1971; Granovetter, 1978), economic and structural aspect (Wilson, 1987), cultural aspect (Lewis, 1966), racial discrimination (Massey & Denton, 1993), government role (Schill & Watcher, 1995), and resistance of landlords and neighborhoods (Turner, Popkin, & Cunningham, 2000; Saints, Flavell, & Fox, 2009). This section reviews the major theoretical perspectives on causes of residential

segregation by income and race. These theoretical backgrounds illustrate how the housing choice voucher program was structured to counteract the concentrated poverty and minority population in the central cities.

3.1.1 Natural process: Invasion and succession

The Chicago school of sociologist used the term "invasion-succession" to describe the replacement in one neighborhood with different racial or income groups. Borrowing the concept from ecology, scholars of the Chicago school proposed human ecology to explain the process of city growth. Burgess (1925) illustrated the typical process of the expansion of a city as a series of concentric circles; the loop, zone in transition, zone of workingmen's homes, residential zone, and commuters' zone. In this model, working class homes are closely located to the central business district and affluent households reside further from the city center. The expansion of cities was explained by the process of invasion-succession. As a city grows, demand for space push into the next outer ring (invasion), and residents who lived in the inner ring take over the space of next zone (succession). Park (1936a) explicitly referred succession as the movement of immigrant groups from the settlement near the centers of cities to areas of second and third settlement, toward the periphery of the city. According to Park (1936b), the driving force behind invasion-succession is competition between culturally defined groups over land use.

As a result of invasion-succession process, residential areas were inevitably segregated and poverty tended to concentrate in the area close to the central city while suburbs were occupied by residents who can afford larger single family house and

commuting costs. Even though Park and Burgess (1925) did not explicitly point this out, their work implied the racial conflicts during succession process since the current residents of the inner zone, minorities, tend to invade, succeed, and eventually occupy the outer zone where whites were once the majority.

Developed at a time when the city grows quickly with the influx of new immigrants, the human ecological model provided a logical explanation for the process of city expansion and residential differentiation. However, the human ecological perspective has been criticized for its linear nonreversible view on residential change. As Aldrich (1975) argued, "succession generally begins with invasion along a fairly coherent line of expansion, and, once begun, the process is rarely, if ever reversed" (p.334). Such a conclusion may be correct when dealing with areas that are transforming from primarily white to black or Hispanic dominant neighborhoods. However, the expansion of lower-income groups may be halted or even reversed when middle-class groups reoccupy those areas through the urban revitalization or gentrification process (Hudson, 1980).

The Chicago school explained residential differentiation as a natural process of city growth; however, the residential segregation is also explained by the personal preferences of others to live near people of similar backgrounds.

3.1.2. Personal preferences: Tipping point hypothesis and threshold

3.1.2.1 Schelling's residential segregation model

Individual preferences are attributed to residential segregation either by race or by income. Schelling (1971) contends that racial change is purely driven by preferences.

Schelling (1971) was the first to suggest that threshold effects could play a significant role in neighborhood change. He created a theoretical model that showed that different racial groups prefer to be surrounded by different percentages of other racial groups, with their group being the majority. When a certain threshold share of another group is reached, tipping will occur as one or more of the other racial groups depart.

According to Schelling (1972), tipping is the mechanism that occurs "when some recognizable minority group in a neighborhood reaches a size that motivates the other residents to begin leaving" (p.157). Schelling (1972) asserted that tipping is not merely a phenomenon that causes change in neighborhood occupancy, but is a mechanism or process that generates the observable departure of the group that was formerly the majority. For example, racial makeup of a white neighborhood will dramatically change once the percentage of blacks in a neighborhood exceeds some threshold level; the black population in the area will continue to increase until the neighborhood becomes mostly black. Through individual preference, Schelling's model explains how neighborhoods change their racial composition, furthering residential segregation. Schelling's neighborhood segregation model has become widely cited and examined since residential segregation is a serious social and political issue in the USA.

One of the most remarkable aspects is that Schelling's model accounts for individual motives that give rise to change at the aggregate level. Even if some people wished to live in mixed neighborhoods, the sum of the individual free choices would generate still segregated communities. Not only is Schelling's model unusually simple, but it also illustrates the idea of unintended consequences resulting from the interaction

between individuals. Segregation occurs even though no individual explicitly chooses this.

3.1.2.2 Granovetter's threshold model of collective behavior

In addition to Schelling, Granovetter also demonstrated how collective outcomes can be paradoxical and inconsistent with the intentions of the individuals. As Schelling (1972) suggested, the tipping point represents a threshold (percentage of non-white residents) at which whites are no longer comfortable moving into a racially mixed neighborhood. Granovetter (1978) defined threshold as "the point where net benefits begin to exceed net costs for … particular actor" (p. 1420). Based on this definition, Granovetter showed how collective results occurred regardless of individuals' motives.

Granovetter (1978) argued that knowing the norms, preferences, motives, and beliefs of participants in collective behavior can only provide a necessary but not a sufficient condition for the explanation of outcomes. This is because outcomes cannot be determined by any simple counting of preferences. So, he provided the model that the collective outcomes can seem paradoxical, inconsistent with the intentions of the individuals who generate them.

In his threshold model of collective behavior, Granovetter (1978) set several assumptions. Actors have two distinct and mutually exclusive behavioral decisions. The individuals are assumed rational; they act so as to maximize their utility. The crucial concept is that individuals have a different threshold when they decide to move or not. Thus, the threshold is that "point where the perceived benefits to an individual of doing the thing in question exceed the perceived costs" (Granovetter, 1978, p. 1422).

This model is valuable in helping to understand situations where outcomes do not seem intuitively consistent with the underlying individual preferences. These collective behaviors can be applied to explain residential segregation and neighborhood change as well as migration patterns and rioting.

After Schelling and Granovetter's work, many researchers have tried to identify the tipping point that causes racial segregation in a neighborhood (Goering, 1978; Clark, 1991; Galster, Quercia, & Cortes, 2000; Quercia & Galster, 1997; Laurie & Jaggin, 2003; Granovetter & Soong, 1988; Galster, 1990). In the review of empirical research conducted prior to 1978, Goering (1978) did not find concrete evidence in support of or against the racial tipping hypothesis because there are other significant factors affecting a household's decision to move that would cause a shift in neighborhood racial composition. However, the tipping points for whites in the articles reviewed ranged from a neighborhood black population reaching 25 to 30 percent. More recently, Galster (1990) examined residential turnover rates in the Cleveland area. As a result, Galster found that census tracts with 55 percent or more black population in 1970 experienced the highest rate of racially motivated turnover in 1980. Also, tipping points varied from 2 to 47 percent black within one standard deviation of the mean level of white's segregationist sentiments. The tipping points or threshold effects that have been widely adopted in explaining neighborhood change or social disorder are income, unemployment rate, crime rate, high school dropouts, welfare recipients, and housing investments (Quercia & Galster, 2000). Based on the evidence of racially motivated neighborhood change, scholars pointed out the importance of integration policy at the neighborhood level (Glaster, 1990; Keating, 1994).

However, the tipping point hypothesis was criticized by the presence and stability of racially mixed neighborhoods since it assumed that once the black population exceeds certain point, the threshold, then the neighborhood will inevitably become mostly segregated black (Ottensmann, 1995; Ellen, 1998; Ellen, 2000). Due to the fact that poverty concentration and racial segregation in urban space are not solely driven by individual preference level, scholars attempted to explain the segregation and poverty phenomenon considering structural, economic change as a whole.

3.1.3 Structural aspect of poverty concentration

As opposed to aforementioned theories that the neighborhood spatial segregation are caused by natural process and personal preference, Wilson (1987) argued that poverty concentration should be understood in the context of urban structural change.

Wilson (1987) explained the process of poverty concentration and racial segregation in inner city neighborhoods as the result of economic structural change. An influx of young minority population in central cities occurred at a time when the basic economy transformed from production to a service oriented structure. The flow of migrants was associated with age structure and unemployment since black migrants in central cities had been relatively younger, predicting lower probability of high income than for whites. Also, a young demographic structure would explain disproportionately increasing rates of social dislocation in the central city such as crime. At the same time, unskilled minority workforces were vulnerable to economic shifts that require higher levels of education. The structural economic changes included the "shift from goods-producing to service-producing industries, the increasing polarization of the labor market

into low-wage and high-wage sectors, technological innovation, and the relocation of manufacturing industries out of the central cities " (p.39). As a consequence, there were significant job losses in industries with lower education requirements while job growth concentrated in industries requiring higher levels of education. Furthermore, the movement of middle and working class black professionals from the inner city had resulted in a concentration of disadvantaged black poor, which Wilson called the ghetto underclass. Thus, under the environment of economic shifts and residential movement, unprepared young minorities had less chance to survive and find stable job opportunities, and were left behind in central cities resulting in spatially concentrated poverty and racial segregation.

Wilson (1987) stressed the importance of middle and working class families whose presence acts as role models in ghetto neighborhoods. The author referred to those families as a social buffer that help demonstrate the importance of regular employment and education as well as prevent concentration effects. The presence of a sufficient number of working- and middle-class professional families acts to "absorb the shock or cushion the effect of uneven economic growth and periodic recessions on inner-city neighborhoods" (p.144).

The concentration effects were used to capture the differences in the experiences of low income families who live in the inner city areas from the experiences of those who live in other parts of the central city. As a result of social transformation of the inner city, a disproportionate uneducated and poor black population was concentrated. Along with the social buffer, concentration effects are important to understand the significance of structural change of the inner city. As Wilson (1987) defined,

> Concentration effects refer to the constraints and opportunities associated with living in a neighborhood in which the population is overwhelmingly socially disadvantaged – constraints and opportunities that include the kinds of ecological niches that the residents of these communities occupy in terms of access to jobs, availability of marriageable partners, and exposure to conventional role models. (p.144)

Those vulnerable poor minorities in the inner city have less chance to get stable jobs, resulting in joblessness, poverty, female-headed families, and welfare dependency in the face of economic change since 1970, despite the creation of several new policies such as Great Society programs and antidiscrimination and affirmative action programs.

Wilson (1987) suggested policy implications to alleviate the problems of concentrated inner city poverty. The most realistic approach would be to provide the disadvantaged families with the resources that promote social mobility, which will lead to geographic mobility. In addition, elimination of government practices that enhance poverty concentration will improve the economic and educational resources of inner city residents; those practices include the location of public housing in poor neighborhoods where the minorities are concentrated and the manipulation of zoning and land use controls to prevent construction of affordable housing. Confronting conservative arguments which are skeptical to this approach and favorable to the culture of poverty concept, Wilson asserted that "cultural values emerge from specific circumstances and life chances and reflect an individual's position in the class structure" (p.158).

Wilson's (1987) work sheds light on the importance of urban structural change in understanding the cause of poverty and minority concentration in the inner city. Consistent exposure to an environment that lacks role models reinforces social dislocation and constrains social mobility of poor people. Researchers have empirically confirmed a consistent relationship between spatial isolation and social dislocation such as high rates of teenage pregnancy, poor school performance, and welfare dependency (Jargowsky, 2003; Clark, 1991; Crane, 1991).

3.1.4 Racial discrimination

Massey and Denton (1993) stressed the importance of racial discrimination as a major motive of poverty concentration. As illustrated earlier, Wilson (1987) pointed out the role of neighborhood sorting, one of the causes contributing to the concentration of poor minorities in inner city, which refers to the flight of working- and middle-class black populations from the inner city resulting in poverty concentration and economic segregation. Massey and Denton (1993), however, challenged this hypothesis. They claimed that racial discrimination and segregation play a pivotal role in poverty concentration, not the economic segregation that Wilson proposed. Massey (1990) illustrated the mechanism of how racial segregation acts to concentrate poverty without the movement of middle-class minority members from the ghetto.

According to Massey and Denton (1993), many Americans view the residential segregation of blacks as a natural outcome of impersonal social and economic forces; however, they argue that this is not the case,

> This extreme racial isolation did not just happen; it was manufactured by whites through a series of self-conscious actions and purposeful institutional arrangements that continue today. (p.2)

Due to residential segregation, blacks inevitably face an environment that is abundant in poverty, joblessness, out-of-wedlock birth, welfare dependency, educational failure, and social and physical deterioration, which are similar to what Wilson called social dislocation. As Massey and Denton (1993) argued, the effect of persistent exposure to this destructive environment on personal well-being is not individual but structural. It limits the opportunities of black people beyond individual motivations and personal characteristics. Even further, Massey and Fischer (2000) provided the evidence that the degree of racial and ethnic segregation can cause differences in the effects of changes in socioeconomic structure. Hence, racial segregation is of central importance in understanding residential segregation.

Based on empirical analysis, however, Jargowsky (1997) contended that racial segregation plays a lesser role than Massey and Denton purported, because they failed to explain why increases in concentrations of poverty occurred despite reduction in racial segregation during the 1970s and the 1990s. According to Jargowsky (1997), although racial segregation is fundamental in understanding the presence of poverty stricken black neighborhoods, the empirical evidence to support their thesis that racial segregation plays a direct role in the increase of such neighborhoods is mixed at best. Instead, Jargowsky (1997) argued that "racial and economic segregation play secondary roles, and their

importance varies depending on whether we are examining the levels of ghetto poverty in 1970, 1980, and 1990 or the changes in ghetto poverty in recent decades" (p.144).

Nonetheless, a series of studies to address residential segregation by race confirmed the presence of racial discrimination and geographic steering that cause residential segregation. From the results of paired testing conducted over the last several decades confirmed the presence and significance of housing discrimination based on race and ethnicity. As a tool to enforce fair housing laws that outlaw discrimination in housing on the basis of race and ethnicity, paired testing used a pair of employees who acted actual home-seekers with the same financial ability, expressing the same preference but the only differences between the two were the race and ethnicity. They separately visited real estate or rental agents to ask about available housing.

Two previous paired-tests, conducted in 1977 Housing Market Practice Study and the 1989 housing discrimination study, revealed a significant degree of racial and ethnic discrimination in the housing market, both rental and sales, nationwide. The recent study in 2000, launched by the U.S. Department of Housing and Urban Development (HUD) was conducted in twenty two large metropolitan areas with rigorous design. Each house or apartment was randomly selected through local advertisements; one white and one minority tester were assigned to visit each house or apartment to visit; they were identical with the same level of income, debt, and assets except the race or ethnicity (Turner & Ross, 2005).

The housing discrimination study in 2000 indicated that minorities still face significant discrimination even though the level of discrimination has generally declined since 1989. The presence of housing discrimination is not place specific but rather is a

national phenomenon. More importantly, geographic steering was identified as an important form of discrimination while other measures of discrimination were less prominent when compared with the previous study. Minorities are steered to mixed or minority neighborhoods: African Americans are told about fewer neighborhoods overall; are shown less homes in predominantly white neighborhoods; hear favorable things about less affluent neighborhoods. On the contrary, whites are encouraged to consider more affluent neighborhoods and more predominantly white neighborhoods than comparable blacks or Hispanics (Turner & Ross, 2005). The presence of geographic steering may help create and sustain residential segregation by race and ethnicity.

3.1.5 Cultural explanation

One of the explanations of the causes of persistent poverty is the cultural aspect. Cultural explanations for the poor can be traced to the work of Oscar Lewis who identified a culture of poverty. Based on observations and life history data in Latin American poverty, Lewis (1966) described the culture of poverty as "both an adaptation and a reaction of the poor to their marginal position in a class-stratified, highly individuated, capitalistic society" (p.21). However, Lewis also viewed the traits of culture of poverty as intergenerational influence, stating

> Once the culture of poverty has come into existence it tends to perpetuate itself. By the time slum children are six or seven they have usually absorbed the basic attitudes and values of their subculture. Thereafter they are psychologically unready to take full advantage of changing conditions or improving opportunities that may develop in their lifetime. (p.21)

Because the members of the marginal communities believe success is impossible to achieve, they respond to their hopelessness and despair in a way that is called culture of poverty, typified by a lack of impulse control, a strong present-time orientation, and little ability to defer gratification. Hence, culture of poverty as a subculture of ghetto communities has been internalized and influenced behavior over the generations. Although Lewis stated the connection between these cultural traits with structural conditions in society, Lewis' explanation has been widely criticized as "blaming the victim" because he argued that the culture of poverty had intergenerational influence, and it became an independent cause of poverty. In addition, Lewis's culture of poverty thesis has been criticized for being too deterministic and diverting attention away from the structural causes of poverty (Curley, 2005). According to Massey and Denton (1993), black disadvantages were attributed not to a defective culture but to the persistence of institutional racism in the United States. Wilson (1987) also criticized that the culture of poverty by placing strong emphasis on the autonomous character of the cultural traits once they come into existence. As Jargowsky (1997) pointed out, "neighborhood poverty is not primarily the product of 'the people who live there' or a 'ghetto culture' that discourages upward mobility" (p.193). Rather, the cultural traits of the poor should be viewed more appropriately as symptoms and consequences, not as the root cause of poverty and community distress (O'Connor, 2001).

3.1.6 Government's role in concentrated poverty and creating housing segregation

The government has played a significant role in the concentration of poverty and minority populations through its implementations of housing policy. Public housing has historically been located in the poorest neighborhoods and contributed to poverty concentration due to the income limitations that usually accompany subsidized housing projects. Schill and Wachter (1995b) examined how the public housing program has contributed to the concentration of poverty in the inner city. They pointed out several factors affecting poverty concentration in the central city such as government structure, local mismanagement, and income limitations. First of all, the federal government was removed from the decision of where to place public housing after the Louisville case in 1935, which decided that providing housing for low income workers was "not a public purpose and beyond the scope of the government's eminent domain powers" (p.1291). After this court decision, local governments became responsible for choosing the location of public housing in their jurisdiction. Instead of being dispersed through metropolitan governments, public housing was primarily placed in the central city since most suburban authorities did not accept construction of housing for the poor. Along with suburban reluctance to participate in the program, the requirement known as "equivalent elimination" also played a role in excluding suburbs because this provision mandated that one unit of substandard housing should be eliminated for each unit of public housing constructed. Suburban governments were sometimes unable to participate in the public housing program simply because most suburbs did not have enough substandard housing (Schill & Wachter, 1995b).

Locating public housing in central cities often resulted in high density developments since the land values in central city were relatively higher than the periphery. Mass construction of high density towers ensured anonymity among residents, causing security problems and losing sense of community. Along with poor management by local public housing authorities, public housing have also been isolated from outside of the projects and often occupied by minorities. In addition, income requirements exacerbated the situations. Contrary to the intention to provide decent housing for the poor, income limitations ensured the poor would live in housing that was already filled with poor households. Plus, the income ceiling forced those who exceed maximum income levels to move out of the public housing (Schill & Wachter, 1995b). Through those processes, the inner city has been overconcentrated with a poor minority population, especially in public housing sites. Contrary to their poor investment in underprivileged areas, the federal government has actively promoted home ownership among the working poor and the middle class through mortgage assistance programs. According to Schill and Watcher (1995b), these programs have sometimes had the effect of destabilizing inner-city communities and contributing to their transformation into ghettos.

Goetz (2003) also made a similar argument to Schill and Watcher (1995b). Goetz identified the implementation of the Fair Housing Act of 1968 as a contributor to the flight of the black middle class from inner cities. Plus, homeownership assistance programs provided middle class blacks and whites the opportunity to move to new suburbs, while the poor were left behind in the inner city neighborhoods with few resources that could help stabilize neighborhoods or help them move to the suburbs.

At the local government level, the practice of zoning systems is also attributable to residential segregation. Local governments have utilized zoning ordinances to maintain socially and economically homogeneous neighborhoods, resulting in a stable tax base. Common use of zoning ordinances includes minimum lot size, minimum floor space, restriction of building multi-family housing, maximum density limitations, and other land use controls. Zoning regulations affect the land prices that comprise a substantial portion of housing prices. Under the circumstances, the construction of affordable housing becomes costly, and limited, or sometimes prohibited; effectively excluding low income minorities (Seitles, 1998).

Downs (1991) indicated three reasons that local governments' regulations exclude affordable housing in their jurisdictions. The reasons are economic, social, and political motivation. The economic reason is that homeowners fear the lower-priced housing in proximity to their own, which would reduce the market prices of their homes. Since housing is the single largest asset of most homeowners, they tend to be afraid of lowering value of that asset. The second motive is primarily social. Invasion of low-income residents might produce negative externalities in mostly middle and upper-income suburbs. Undesirable consequences include rising crime rates and drug use. In addition, construction of high density housing could cause congestion of local facilities. Hence, residents in affluent suburbs support local regulations that cause residential and economic segregation. The third motive is more political and fiscal. Local governments desire ensuring a community's tax base by keeping local housing prices rising steadily. By excluding high-density housing for lower-income residents, the local governments can maintain a tax base without increasing tax rates. As Downs (1991) mentioned, "this gives

the members of local government itself a strong motive for maintaining high housing prices in their communities" (p.1116).

The underlying structure enabling local government to restrict housing for low-income households lies in the fragmented political system that has resulted in independent local governments. The issue about land use remains in the hand of state governments because the U.S. Constitution says little about it. Historically, land use decisions delegated to local governments from state governments. Local governments have been responsible to handle the local zoning regulations. Initially started from desires of landowners and municipalities to restrict nuisance, local land regulations have evolved to separate people of different income and color, to stabilize property values, and to protect single-family homes. Only recently they have begun to embrace regional approaches such as growth management. Only a few states, such as California, Massachusetts, New Jersey, and Oregon, require local governments to provide housing opportunities to all income groups (Nelson, Pendall, Dawkins, & Knaap, 2002; Pendall, Puentens, & Martin, 2006).

Researchers found that there is a relationship between the types of land use regulations and the availability of affordable housing. Metropolitan areas that adopt traditional land use regulations are more likely to have low densities and less likely to provide housing opportunities for lower-income residents than those that have embraced growth management tools (Pendall et al., 2006). Specifically, Pendall (2000b) referred to the process as "chain of exclusion". Discriminatory results of land use controls affect the housing market, excluding minorities from wealthy communities. As a consequence, areas that utilize restrictive land use control, such as low-density zoning, tended to reduce

rental housing in their jurisdiction, and substantially limit minority residents as well (Pendall, 2000b).

3.1.7 Landlord's resistance and NIMBY phenomenon

In reality, residential separation is caused by individual discrimination or collective action of neighborhoods. Low-income households with rental subsidies have faced landlords' rejection in renting an appropriate house. More collectively, residents in wealthier neighborhoods have resisted locating housing projects for lower-income households through land use politics.

Since the voucher program has operated based on voluntary participation of landlords, many voucher holders have had hardships in finding their house when landlords discriminate voucher holders. Even though participating in the voucher program ensures landlords stable rents, it has not been enough to appeal many landlords to accept voucher holders. The Census Bureau (1998) reported several reasons on this issue. According to a survey conducted in 1995 for property owners and managers who have rental units, over 42% of property owners responded not to accept voucher holders. One of the most frequently mentioned reasons of refusing subsidized tenants involved the program structure itself. Participating in the voucher program requires landlords to comply with regulations such as housing quality standards and periodic inspections. Landlords pointed out "too many regulations" and "too much paperwork" as the causes of reluctance to join the program. Additionally, the survey found out that many landlords were not well informed with the program: less than one in six owners of rental units were familiar with the voucher program. Even further, property owners of affordable units

were less likely to be familiar with the program than owners of more expensive ones. This fact is consistent with findings from Kennedy and Finkel (1994). Using focus group study, they concluded that most participants ended up renting from the same set of landlords who are familiar with the voucher program.

At the same time, discrimination against voucher holders is related with behavioral problems and stereotypes. The survey (Census Bureau, 1998) pointed out that landlords expressed concerns about problems with tenants. In particular, landlords fear that renting to poor families would cause property damage, noise, crime, overcrowding, and illegal activities, since voucher holders tend to have many children and are more likely to stay at home all day because of unemployment (Turner et al., 2000; Johnson-Spratt, 1999). Furthermore, as Beck (1996) described, voucher recipients faced discrimination simply because of receiving rental subsidies.

> Regardless of their eventual success or failure in finding housing, most recipients experience discrimination from at least one landlord because of their Section 8 status. Possession of a Section 8 subsidy marks its holder as a low-income person, a status that with it a multitude of negative stereotypes. (pp.161-162)

In response, several states and local governments prohibit discrimination against voucher holders based on the source of income. For example, city ordinances, county ordinances, or state statutes are providing in some jurisdictions of California, Maryland, and Washington. However, these protections have faced judicial challenges, questioning whether such laws are appropriate (Sterken, 2009).

In addition to individual landlords, the NIMBY (Not In My Back Yard) phenomenon, especially in the suburbs, has effectively limited most lower-income housing to inner cities. Saints et al. (2009) described this process as land use politics. Zoning regulations are created, amended, and enforced at the local level, which makes zoning a local issue. Local land use is mostly controlled by local ordinances and local boards. Local politicians do their best in response to residents in order to reelect or keep their position safe. Local residents oppose a project that would adversely affect their property, which is usually the single most important investment for their lives. Citizens raise their voices based on their perceptions and accordingly act to oppose change in their neighborhoods. These changes, so called LULU (locally unwanted land uses), usually include public housing projects and affordable housing for low-income households. As Saints et al. (2009) noted,

> Land use proposals affect people's perceptions – and in politics, perception is reality. His perception of the potential danger is real, and it is irrelevant whether the perception reflects objective truth. What counts is that the person believes it and acts accordingly. … What people think and believe informs how they act, speak, and vote, even (or especially) if they are, objectively speaking, wrong. (pp. 3-5)

As a result, individually or collectively, property owners have tried to limit exposure to externalities, reduce competition for public services, keep neighborhood homogeneous, and protect their property values, consequently excluding poor minority households.

3.1.8 Conclusion

As reviewed above, residential segregation by income and race cannot be solely explained by a single theory since it has involved various aspects encompassing from individual preferences and prejudice, economic structural changes, institutional discrimination, to policy practices and land use regulations. The Housing Choice Voucher Program was created to challenge race and economic segregation by encouraging program participants to move into mixed income, racially diverse neighborhoods which are usually located in the suburbs. Residents living in neighborhoods with high poverty and minorities would be consistently exposed to the risk of being unemployed, poor, and dependent to welfare. As Wilson (1987) asserted, in order to alleviate the problems of concentrated poverty, one of the pragmatic approaches is to give the poor a chance to live outside of the distressed neighborhoods in the inner cities. The voucher program is designed to counterbalance previous federal policies that caused poverty and minority concentration in the inner city.

3.2 Literature Review

3.2.1 Introduction

The Housing Choice Voucher Program seeks to promote choice or mobility among its recipients by enabling them to select the housing of their choice and to promote economically mixed-income neighborhoods by utilizing the private market to provide housing for low-income individuals and families (U.S. House, 2003). Due to

portability, the voucher program enables qualified families to choose their place to live, expecting to move into more affluent neighborhoods than they lived before. Many believe that the voucher program offers recipients greater locational choices, contributing to poverty deconcentration and race desegregation.

There are broadly two categories of literature relevant to answering the questions regarding whether the voucher program has contributed to achieving deconcentration and desegregation goals: location outcomes of voucher recipients and factors affecting their location outcomes. Numerous studies have attempted to find the location outcomes of voucher recipients from the onset of the program. The majority have analyzed location outcomes of vouchers using traditional a-spatial analysis, while spatial analysis has been utilized more in recent literature to identify the location of concentrations.

Research efforts have identified the factors limiting or enlarging voucher holders' location choice; these factors include individual needs of voucher households, accessibility to public transportation, availability of affordable housing, race, market conditions, and landlords' participation in the program.

3.2.2 Location outcome of voucher recipients

U.S. Department of Housing and Urban Development (HUD) has encouraged housing voucher families to relocate to low-poverty neighborhoods through housing in the private market. Often, this goal has been regarded as a success, while sometimes the findings do not confirm the goal has been achieved. The evaluation of the voucher program has usually been conducted by a comparison of the poverty rate and a proportion of minority groups in the census tract by different time, and/or different types of housing

projects. The extent to which the housing choice voucher program meets the goal of deconcentration of poverty varies by location, such as the inner city or suburban areas, and is relatively positive when compared to public housing residents. To date, vouchers appear to have been less effective in promoting racial and ethnic integration than in helping to deconcentrate poverty.

However, the majority of studies are a-spatial since they compare several indicators in a format of simple cross tabulation. Recently, the spatial approach has increased in use when identifying the location of voucher concentrations over space (Oakley & Burchfield, 2009; Wang & Varady, 2005; Wang et al., 2008; Wyly & DeFilippis, 2010). In the following section, research efforts are reviewed as to how well the voucher program contributes to poverty deconcentration and race desegregation, incorporating the traditional a-spatial approach and the spatial approach.

3.2.2.1 Poverty deconcentration

The voucher program has effectively addressed some of the serious shortcomings of traditional, project-based housing programs. Many research efforts have found that the voucher program has contributed to poverty deconcentration of residents, specifically compared to public housing residents. One of the recent comprehensive researches from HUD, Devine, Gray, Rubi, and Taghavi (2003) investigated the locational patterns of housing voucher recipients residing in the 50 largest metropolitan areas using the Multifamily Tenant Characteristics Study and the 1990 census data. They discovered that almost 30% of voucher recipients live in the low poverty census tract with poverty concentrations below 10%, and less than 10% of voucher holders live in the high poverty

census tract with poverty concentrations above 40%. However, the poverty deconcentration also varied by location; central city residents were more likely to live in a high poverty area. Only 6% of residents who live in suburban areas live in the high poverty census tract with poverty concentration above 30% compared to more than 33% of recipients in the central city.

In research to evaluate the Welfare to Work Voucher program, Mills et al. (2006) also reported that voucher recipients had a better residential location such as lower poverty rate, lower minority concentration. HUD intended to assess the net impacts of the Welfare to Work Voucher program on housing conditions, employment outcomes, and family well being. This was the result from the five-year research period using total sample of 8,371 families who was randomly assigned over the six sites in the country.

Varady and Walker (2000) found that households relocated from four distressed developments in Baltimore, Newport News, VA, Kansas City, MO, and San Francisco resided in less impoverished neighborhoods. Likewise, Patterson et al. (2004) discovered that participants in the Welfare to Work Voucher Program moved to better neighborhoods with voucher subsidies.

Early evidence suggests that Section 8 vouchers can be successful in helping public housing residents relocate to low-poverty neighborhoods. Kingsley et al. (2003) found that public housing residents who received vouchers as a result of relocation through the HOPE VI program moved to neighborhoods that were less distressed than their original neighborhoods.

When compared to project-based housing, voucher housing is likely to be located in lower poverty neighborhoods. One of the most distinguished results was from

Newman and Schnare's (1997) work. They discovered that only 5.3% of voucher recipients nationwide lived in high-poverty neighborhoods, while 36.3% of public housing and 12.6% of other HUD-assisted units did. In addition, Hartung and Henig (1997) analyzed the census tract data for racial deconcentration and economic integration of tenant-based housing and public housing in the Washington D.C. Metropolitan area. They found that voucher holders tend to be located in census tracts with higher median household incomes compared to public housing, while public housing tends to be located in census tracts of low median household incomes. Also, they discovered that voucher recipients were more evenly spread throughout the city and suburbs than project based housing units. In addition, Devine et al. (2003) also reported the similar results. Whereas 22% of tenant-based voucher families live in neighborhoods that are at or above the moderate-poverty threshold, close to 46% of those participating in project-based section 8 and fully two-thirds of those participating in the public housing program live in such neighborhoods. In fact, almost one-half of public housing families live in neighborhoods above the 40% poverty threshold. Similarly, Turner and Wilson's (1998) study in six metropolitan areas indicated that, compared with public housing residents, voucher holders are less likely to live in high-poverty neighborhoods.

As shown above, there are several results supporting the facts that the voucher program helps low-income families move into low-poverty areas; however, there are also different outcomes of the voucher holders' location pattern. When Feins and Patterson (2005) examined the geographic mobility of families with children who entered the voucher program between 1995 and 2002, they found inconclusive results. Overall, about 75% of the families moved during the same period and moving at least once was

associated with small improvements in neighborhood quality. Voucher families with children moved to neighborhoods which have a slightly lower poverty concentration than the ones from which they moved. However, the degree of change in concentrated poverty was very small; based on this study, it is hard to confirm that the voucher program contributes to poverty deconcentration. In addition, a comparison with Low Income Housing Tax Credit (LIHTC) did not provide evidence as to how well the voucher program facilitates poverty deconcentration. Comparing the effect of vouchers and LIHTC in six metropolitan areas, Deng (2007) found that voucher recipients were less likely than LIHTC tenants to live in very low-income neighborhoods, but more likely to live in low-income neighborhoods.

On the contrary, there is also contradictory evidence that voucher holders tend to cluster in specific neighborhoods which are not significantly different from public housing residents. Guhathakurta and Mushkatel (2000) examined the locational patterns of three types of subsidized housing, including conventional project-based, Section 8, and shelter plus care supported housing in Phoenix, Arizona. The results showed that these programs were reinforcing the existing concentration of subsidized housing in some neighborhoods, and voucher programs did not achieve the goal of deconcentration of the poor. Rather, the census tract with the concentration of voucher housing reflected the similar socioeconomic attributes of project-based public housing concentration, such as low incomes, high percentage of minorities, and high unemployment.

Research on public housing relocates also found that even though voucher contributed to relocate former public housing tenants to low-poverty neighborhoods, they

tended to cluster in minority neighborhoods with moderate poverty rates (Kingsley et al., 2003).

Combined with LIHTC projects, voucher holders tend to live in poverty concentrated neighborhoods which provide incentives to construct LIHTC projects. One of studies discovered that almost one half of all LIHTC developments had at least one resident with a voucher (Climaco et al., 2006). In addition, a recent study also showed that over 30% of LIHTC units in poverty concentrated neighborhoods had voucher holders. The LIHTC housing in poverty concentrated areas was more likely to be occupied by voucher recipients. This location outcome of vouchers may cause even greater concentrations of poor households in troubled neighborhoods that already suffer from a high concentration of the poor (Williamson et al., 2009). The LIHTC is a potential source of housing for voucher holders; however, it is difficult to prove that living in LIHTC housing constructed in troubled neighborhoods supports the policy goal of dispersal of voucher holders away from areas of concentrated poverty. Even further, analysis of national datasets across several housing programs revealed that vouchers were not helping renters locate in low-poverty areas any more effectively than were current project-based subsidies (McClure, 2008).

While participating in the voucher program gives families an advantage over those in place-based subsidy program, the residential choice of voucher families are not significantly different from those of unassisted families. When compared with unassisted rental households, voucher participants were not much different in terms of their ability to avoid poverty concentrated neighborhoods (Newman & Schnare, 1997; Devine et al.,

2003). Voucher families were only slightly more likely to live in high-poverty neighborhoods than unsubsidized tenants living in affordable units (Devine et al., 2003).

There is a recent study supporting the evidence that vouchers were closed tied to neighborhood poverty (DeFilippis & Wyly, 2008). To examine the relationship between poverty and vouchers, they conducted the regression analysis. The result revealed that the link between housing assistance and neighborhood poverty was strongest for vouchers, not for project-based units. Based on the findings, they concluded that the voucher program clearly failed to break the link between neighborhood poverty if poverty was used as the indicator of program success, at least for the case of New York City.

Different from the traditional approach reviewed above, recent efforts have considered the spatial pattern and location of clusters of voucher households (Oakley & Burchfield, 2009; Wang & Varady, 2005; Wang et al., 2008; Wyly & DeFilippis, 2010). As far as the policy goal is concerned, Wang et al. (2008) did not find enough evidence that the voucher program had contributed to poverty deconcentration. Using hot spot analysis in eight U.S. metropolitan areas, Wang et al. (2008) concluded that there was little evidence that the voucher program was promoting poverty or minority deconcentration. They failed to find the supporting evidence that the voucher program had contributed to promoting income and race diversity since the proportion of voucher households in high-poverty and high-minority block groups remained stable during the 2000 to 2005 period. They also indicated that although voucher recipients were becoming less concentrated in hot spots in Chicago and Phoenix, the opposite was true in the other metropolitan areas, especially in New York, Cincinnati, and Baltimore. Based on their

findings, it is hard to confirm that HCVP has positively affected neighborhood diversity and contributed to deconcentration of poverty.

Using spatial analytic techniques, Oakley and Burchfield (2009) analyzed the spatial pattern of voucher holders who relocated from public housing projects in Chicago. They identified significant spatial clustering of voucher holders, and this pattern negatively related with factors indicating neighborhood disadvantages, such as, poverty rate, unemployment rate, and minority composition. Their findings showed that voucher housing tends to be clustered in poor African American neighborhoods where the majority of relocated public housing residents settle.

A more recent study in New York revealed disappointing results regarding how the voucher program fails to achieve poverty concentration. Wyly and DeFilippis (2010) analyzed three types of housing programs in New York including conventional public housing, project-based Section 8, and housing voucher holders. Contrary to program expectations, voucher holders are more likely to live in poverty stricken neighborhoods than public housing residents. More than 40% of voucher recipients live in neighborhoods where there is a significant spatial clustering of severe poverty, while less than 30% of public housing residents do so. A more rigorous analysis to disentangle the relative effects of different types of housing on neighborhood poverty confirms the spatial pattern of concentration. In this study, several models were utilized from ordinary least squares regression (OLS), through spatial models, to geographically weighted regression. Yet, all models confirmed that even after controlling for racial composition and spatial autocorrelation, vouchers had a stronger link to the neighborhood poverty rate than all the other types of housing projects. Specifically, voucher holders' location choice

was inevitably confined to the outlying parts of the city, implying that vouchers play a significant role in poverty reconcentration in these areas.

On the other hand, even though clustering of voucher recipients is a cause of concern in several neighborhoods, national research suggests that clustering is not a widespread problem. Devine et al. (2003) indicated that vouchers are occupied in only a small portion of the total occupied housing stock. Similarly, Kingsley et al. (2003) stated that only a few sites witnessed the clustering, which means a large number of relocated households were living in the same census tracts as when they analyzed HUD administrative data.

3.2.2.2 Race desegregation

While many efforts have been devoted to finding out whether the voucher program helps poverty deconcentration, researchers have also been interested in the location outcomes of race. A recent study discovered that the voucher program helped prevent minority concentration in poor neighborhoods (McClure, 2008). An analysis using the national database of LIHTC and voucher holders indicated that race and ethnicity appeared to play a significant role in how well the voucher program promotes movement to low-poverty areas. Minority voucher households did not locate in low-poverty tracts at the same rate as others. In this analysis, only 17% of black and 19% of Hispanic voucher households lived in low-poverty census tracts, which were well below the percentage of affordable units, total black households, and total Hispanic households: 30%, 26%, and 29% respectively.

Also, a case study of Columbus, OH implied that racial desegregation has been successful in that area (Teater, 2008). The researcher analyzed the survey data of residential mobility and found that the mobility of voucher recipients did not predict a change in poverty, and a recipient's race did not predict a change in racial composition. The findings suggested that poverty deconcentration and racial desegregation had been achieved in the study area.

Hartung and Henig (1997) compared location outcomes of the voucher programs and project-based programs in the Washington, DC area. They reported a positive result. The authors found that voucher and certificate holders were less concentrated in poor and minority neighborhoods than residents of project-based public housing. They also specifically focused their research on whether vouchers promote racial integration and the dispersal of low-income residents throughout a metropolitan area. They discovered that both public housing and project-based subsidized housing were far more concentrated in the District of Columbia than certificates and vouchers. Vouchers were more evenly spread throughout the city and suburbs.

Furthermore, nationwide study conducted by Newman and Schnare (1997) also provided a positive outcome. When neighborhoods were defined as segregated, more than 40% of households were headed by minorities, the vouchers appeared more integrated than public housings and other HUD subsidized units: 26.4%, 55.4%, and 34.5% respectively. In a study of six metropolitan areas, Turner and Wilson (1998) also found that black and Hispanic voucher recipients are more likely to live in high-poverty neighborhoods than their white counterparts.

However, analyzing data from the experimental design study of the Effects of Housing Vouchers on Welfare Families, Gubits et al. (2009) reported that the voucher program had some effect on diminishing racial concentration by enabling African American families to move to more racially diverse neighborhoods. However, the effects were modest in size and concentrated among black families who started in the poorest and most racially segregated neighborhoods. Based on their findings the authors remarked that "we cannot rely on vouchers by themselves … to reduce racial concentrations" (p.3).

Moreover, many research efforts have also shown that the voucher program did not work well in race desegregation. One of the studies found that minority voucher recipients were more likely to end up in high-poverty neighborhoods than nonminority recipients, even after controlling other factors (Basolo & Ngyuen, 2005). Based on the findings, they concluded that "the assumption that choice will result in deconcentrating poverty and minorities is not strongly supported by our data" (p.319). Similar result found in other site. DeFilippis and Wyly (2008) compared project-based and tenant-based housing assistance in New York City. They reported that the voucher program as a deconcentration mechanism, did not work better than project-based programs. The racial composition of each program's clients closely mirrored the neighborhoods in which they live. Combined together, those findings strongly suggest that the voucher program did not promote the deconcentration of poverty or the desegregation of people of color, relative to the project-based housing program.

Furthermore, Polikoff (1995) found evidence that voucher recipients were simply relocating to neighborhoods with similar racial characteristics. Specifically, 7,500

voucher recipients in 19 public housing agencies were tracked and census data used to compare characteristics of their pre-program and post-program neighborhoods. The level of concentration at the neighborhood level did not change when pre-program and post-program locations were compared.

In addition, McClure's (2004) study showed that in Kansas City, voucher recipients did not use vouchers to move to areas of greater employment opportunity, but rather, remained in racially concentrated areas with fewer job prospects. Still, voucher concentrations were most likely to be found in predominantly minority communities with high proportions of poverty rate. Black and Hispanic voucher holders were more likely than White households to live in census tracts with poverty concentrations above 30% (Devine et al., 2003). Even though minority voucher holders were less likely to be found in low-poverty areas compared to the total minority population, the degree of fostering deconcentration was not an impressive amount (McClure, 2008). With an analysis of national databases, McClure (2008) concluded that the project-based LIHTC program has been more effective in deconcentrating low income households into low-poverty areas than the household-based voucher program.

Despite conflicting results, the voucher program seems to perform relatively better than place-based housing programs in terms of poverty deconcentration and race desegregation. This is no surprise considering the origin and the characteristics of the voucher program; the program was developed to address the deep rooted problem of poverty concentration in public housing. The voucher program enables low-income households to move out of poor neighborhoods through portable vouchers allowing freedom of choice to reside. However, recent studies also identified the poor performance

of the voucher program in dispersing poor residents over a wider geographic area. Several factors were attributed to reasons why voucher holders tend to concentrate or inevitably choose to live in poor neighborhoods: voucher holder preferences (individual needs), the accessibility to public transportation, the availability of affordable housing, market conditions, and landlords' participation in the voucher program. These factors will be examined in the following section.

3.2.3 Factors affecting voucher recipients' location outcome

As Tiebout (1956) implies, households sort themselves into communities with similar tastes and incomes. People tend to live in neighborhoods with similar socio-economic characteristics and backgrounds. This natural tendency results in voluntary segregation, while barriers to enter specific neighborhoods cause involuntary residential segregation. Voucher holders have also experienced similar obstacles in locating appropriate residences. Although HUD has encouraged low-income families to relocate to more affluent areas, often this goal has not been achieved in many cases. Many voucher recipients make short-distance moves, often to areas of concentrated poverty with high proportions of minorities or to fragile neighborhoods experiencing racial change (Goetz, 2002; Khadduri, 2001; Popkin & Cunningham, 2000). Previous literature suggests that voucher concentrations are most likely to be found in predominantly black communities, in areas with high proportions of families in poverty, and in communities with abundant low-cost rental properties (Hartung & Henig, 1997).

These locational outcomes and clustering reflect several factors including personal preference, market conditions, and discrimination. With personal preferences,

voucher holders may demonstrate an unwillingness to move away from friends, relatives, and accessible public transportation. Market conditions may be tight causing a lack in availability of affordable rental housing. Discrimination may occur through a combination of unwilling landlord participation, race, and voucher status (Goetz, 2003; Finkel & Buron, 2001; Penall, 2000; Popkin & Cunningham, 2000; Turner, 2003; Varady et al., 2001). The next section will discuss these factors affecting voucher holders' location outcomes.

3.2.3.1 Personal preferences

One of the main factors influencing residential choice is the desire to be close to family, friends, and/or services such as desirable schools. Voucher holders exhibit these same personal preferences when they search for housing. Since the voucher program explicitly leaves the final decision about location up to the particular families, their needs and preferences play a critical part in explaining patterns of geographic clustering.

Varady et al. (2001) provided the survey results of voucher mobility in four cities: Baltimore, MD; Newport News, VA; Kansas City, MO; San Francisco, CA. They found that distance played an insignificant role in the neighborhood satisfaction of voucher recipients. The results showed that short distance moving decision were attributed to the proximity of friends, family members, schools, public transportation, and surrounding neighborhoods. Voucher recipients sought to remain in or close to their neighborhoods to be near friends and relatives and a familiar public transportation system. Thus, long distance moving toward suburban areas does not necessarily guarantee a high level of neighborhood satisfaction. According to this study, voucher recipients who made short-

distance moves were just as likely to be satisfied as those who made longer-distance moves. Recipients making short-distance moves can be very satisfied with their new home because they know the neighborhoods, their children do not have to change schools, and they are close to friends, family, jobs, and public transportation, even though the new neighborhood is essentially the same as their former one.

In addition, according to McClure (2001), voucher holders often made short-distance moves, and as a result, lived in neighborhoods where the proportions of poor residents and minorities were only slightly lower than that at their previous location. Specifically, researchers discovered that the majority of recipients stayed within five miles of their original place of residence. This result came from the comparison of the preprogram and destination addressed for a one-year cohort of new Section 8 recipients in the District of Columbia and its suburbs (Cunningham et al., 1999).

Focus group interviews in Chicago, Popkin and Cunningham (2000) also found that the lack of transportation acts as a barrier to searching for housing. Since many voucher holders had very low incomes and no cars, they inevitably relied on public transportation. Popkin et al. (2000) confirmed that voucher holders had concerns about lack of transportation or services in suburban neighborhoods. Thus, the availability and accessibility of public transportation plays a critical role in voucher holders' locational outcomes.

3.2.3.2 Race factors

Race plays a significant role in spatial patterns of voucher recipients. To some degree, locational outcomes of vouchers reflect the racial discrimination or preferences of

the same race. Studies on residential mobility indicated that minorities were less likely to move to predominantly White neighborhoods and more likely to move to minority or racially mixed neighborhoods (Stearns & Logan, 1986; South & Crowder, 1998). However, in another case, few Blacks expressed a preference for living in predominantly Black neighborhoods (Harris, 2001). For Asians and Hispanics, voluntary ethnic clustering appeared to play a role in explaining neighborhood outcomes (Alba, Logan, & Stults, 2000).

Personal preferences have been invoked as one of the factors that explain the patterns of racial segregation in cities (Clark, 1986). The preferences hypothesis argues that residential segregation reflects the different preferences of blacks and whites. According to this hypothesis, both races desire to live in neighborhoods where they are numerically dominant. Hence, blacks and whites would live in different neighborhoods even though they have similar incomes because of their different tastes not discrimination. Based on survey in the Los Angeles metropolitan area, Clark (1992) concluded that the expressed preference for own race/own ethnicity was likely to maintain present patterns of separation in U.S. metropolitan areas.

Farley, Fielding, and Krysan (1997) confirmed that racial preferences affected residential choices. They analyzed the residential preferences of a sample of Blacks and Whites in four metropolitan areas, using several tests to evaluate preference for and comfort with neighborhoods of different racial makeup. They found that Whites' willingness to move into a neighborhood was inversely related to the density of Blacks living there. Black preferred integrated neighborhoods, but ones with a substantial

representation of Blacks. Only 35% of the Black was willing to move into an all-white neighborhood.

While racial discrimination is often subtle, most voucher recipients expressed their fears of encountering discrimination when they began to search for housing. Using a focus group study in Chicago, researchers found that many voucher holders experienced discrimination when searching neighborhoods due to their race. Many families expressed concerns about potential discrimination if they were to move (Popkin & Cunningham, 2000). Another research confirmed that voucher families seeking to move to low-minority areas had to overcome several barriers including a fear of experiencing discrimination in predominantly white areas (Popkin et al., 2000). A mail survey of voucher holders in California revealed that voucher recipients faced significant budget, supply constraints, and most likely discrimination (Basolo & Ngyuen, 2005).

At the same time, mixed with fear of possible racial discrimination, there was a personal preference and comfortability remaining near the same race. Although African Americans appear to prefer an integrated neighborhood to an all-black one, they also prefer an all-black neighborhood to a mostly white one. Even though racially integrated stable neighborhoods exist (Ellen, 1998), they are more the exception than the case (Pendall, 2000a).

The severity of racial segregation also affects residential choices. Deng (2007) found that the more segregated an MSA, the more likely a voucher-assisted family is to live in a highly segregated neighborhood. In addition, the degree of racial segregation even outweighed the influence of weak market conditions in terms of voucher concentration (Deng, 2007). While the severity of racial segregation persisted, personal

preference, fear, and lack of information available to minority voucher holders also contributed to the concentration of minority voucher holders.

3.2.3.3 Availability of affordable housing

The geographic choice of voucher recipients has been limited by the availability of affordable housing. To some degree, location patterns of voucher units may simply mirror the geographic distribution of affordable rental housing. There are two aspects constraining a voucher holders' location choice: the voucher program itself and land use regulation.

As far as the program requirements are concerned, there are several steps be for voucher holders can lease a unit: finding a unit under the specific rent level, landlord's willingness to accept vouchers, and ensuring housing quality standards for a unit. Qualified voucher families should find a unit at or below the local payment standard. Payment standards are set by local housing authorities and can range between 90 and 110% of Fair Market Rent (FMR) by HUD. HUD releases FMR every year for metropolitan areas based on rent levels in the local housing market. Finding a unit at or below the local payment standard can be difficult in tight housing markets where landlords can lease their units for rents above the FMR. However, finding a unit below the FMR does not necessarily mean the voucher household can lease the unit. The landlord still has a choice whether to accept the voucher. Plus, the unit should pass the housing quality standards.

Among those factors, availability of affordable housing units is crucial in locating voucher recipients. Turner and Wilson (1998) analyzed six metropolitan areas and found

that Section 8 recipients were significantly less widely dispersed geographically than the below fair market rent stock in four out of six metropolitan areas and that affordable housing is relatively more plentiful in the central city than in the suburbs. In the aggregate, the ratio of affordable housing to occupied housing units in central cities was about double what it was in suburban areas (Devine et al., 2003). Similarly, Ladd and Ludwig (1997) estimated that only 15% of the dwellings in suburban Baltimore have rents below the HUD-established limits, compared with 30% of dwellings in the city. However, the ratio of vouchers to all affordable housing units showed little difference when comparing the central city and the suburban areas, 6.2% in the former and 6.4% in the latter (Devine et al., 2003). Low-cost rental housing units are not always in desirable neighborhoods.

On the other hand, many affluent suburbs have utilized zoning and land use regulations to limit the development of rental housing in order to maintain their property tax base and social homogeneity. As a consequence, the rental housing stock tends to be located in the central cities, older suburbs, and less- affluent neighborhoods. Thus, voucher recipients may be effectively excluded from some desirable neighborhoods by the absence of affordable rental housing in these communities (Turner & Cunningham, 2000). In many cases, voucher holders are constrained to living in less-affluent neighborhoods.

Pendall (2008) also argued that local land use regulations are critically important in the location of subsidized households because local governments have the authority to approve or disapprove sites for subsidized housing. Hence, families with vouchers cannot live in areas without rental housing and are unlikely to choose jurisdictions whose

policies have raised rents above fair market rents. A case representing these local land use regulations is Parma, OH. This large Cuyahoga County suburb was given a federal housing integration order in 1980 due to the patterns and practices of intentional racial discrimination. The court order required the city of Parma not to use its planning and zoning powers to exclude low- and moderate-income rental housing development (Keating, 1994).

3.2.3.4 Market conditions

Market conditions are another factor affecting voucher recipients' location outcomes. Families participating in the voucher program were more likely to find housing units in soft market conditions than in tight housing markets (Finkel & Buron, 2001). However, soft housing markets did not necessarily guarantee the success of helping voucher holders find housing out of distressed neighborhoods (Pendall, 2000a). In a study of six MSAs, the soft market conditions did not grant voucher families more choices of quality neighborhoods. Specifically in Cleveland, persistent racial segregation diminished the positive outcome for voucher families (Deng, 2007).

In general, voucher holders are expected to have more chances to search for housing in less poverty stricken neighborhoods when housing market conditions are not tight. However, Deng (2007) indicated that voucher holders in soft markets live in either very low or low income neighborhoods, and they are more likely to do so than the voucher families in the tight housing markets. To examine the local market environment, Deng (2007) considered two factors: rental vacancy rates and job-housing balance, which is the ratio of job growth to new housing construction.

Finkel and Buron (2001) used several indicators to determine local housing market conditions, including estimates of vacancy rates, PHA assessments of the local market, and local FMRs and payment standards. First, the vacancy rates consisted of two measures: the estimated vacancy rates and the census vacancy measure. The former included estimated vacancy rates in the portion of the market available to voucher holders; the latter was the census vacancy rates for metropolitan areas, using a three-year weighted average of the rental vacancy rate to smooth out the data. Their findings suggested that the tighter the market conditions, the harder it was for voucher recipients to find housing. Specifically, vacancy rate was the most significant indictor to predict the success of finding units by voucher recipients.

3.2.3.5 Landlord's participation

Related to market conditions, landlord participation also limits or enlarges the choice of voucher location. The voucher program encourages landlords to participate in the program, benefiting stable payments and ensuring fair market rental rates. However, landlords who own rental property in desirable neighborhoods might not be motivated to participate in the voucher program, especially when the market demand is strong. In addition, some landlords report not wanting to join the program due to the bureaucratic procedures of public housing agencies (Turner & Cunningham, 2000).

Many landlords either lack information about the voucher program or find participation unattractive. To rent a unit to a voucher recipient, the landlord must submit to unit inspection and other paperwork that would not be necessary to rent to an unsubsidized tenant. One of extensive surveys showed the attitudes of landlords toward

the voucher program.[7] Only about one in six owners of single-family rental units was very familiar with the voucher program; however, owners of multifamily rental properties were much more aware of the program. The landlords who would not accept voucher tenants most often cited three reasons: "potential problems with tenants, too many regulations, and too much paperwork" (HUD, 1997, p.9). Likewise, based on focus groups with participating landlords, Kennedy and Finkel (1994) found that most participants ended up renting from the same set of landlords who are familiar with the Section 8 market and choose to rent to Section 8 recipients.

Moreover, many of the landlords who participated in the voucher program reported that they made only part of their units available to voucher families, while other units were not available for vouchers. This pattern has been verified in the Washington, D.C. and Chicago areas (Cunningham et al., 1999).

Generally, the landlord participation in the voucher program will be higher when the market condition is weak. As housing prices and rent have decreased, landlords have had difficulty finding tenants or leasing their units at market rate. In other cases, in weak market conditions homeowners have had difficulties selling or have been reluctant to sell their housing units, so they have decided to participate in the voucher program waiting for a market recovery since participating in the voucher program ensures fair market rent.

Not much has been done to measure the degree of landlords' participation in the program as a predictor of voucher locations. Considering landlord participation in the voucher program, Finkel and Buron (2001) estimated the success rate of voucher

[7] U.S. Housing Market Conditions (U.S. Department of Housing and Urban Development, February 1997) reported on information about the Section 8 tenant-based program collected in the Property Owners and Managers Survey (POMS) conducted for HUD by the U.S. Bureau of the Census.

recipients. Success rates were higher in markets where PHA staff assessed landlords' acceptance of the program was high. Most voucher holders were found in local market areas in which PHA staff thought there was a moderate degree of landlord acceptance of the program. Rate of success in finding an appropriate housing unit within specific time frames seemed to be high when more landlords participated in the program. However, there are two caveats of this result. First, the difference between the markets with high and moderate acceptance rates was not statistically significant. The proportion of households in the market with high and moderate acceptance was 30% and 68% respectively; the success rate of each group in each market was 73% and 67%, respectively. So, while fewer households lived in highly acceptable markets, the possibility of finding housing in them was higher than voucher households living in moderately acceptable market conditions. Second, the variable used in the regression model to represent landlord acceptance was based on personal judgment of staff in each public housing authority during a telephone interview. The survey instrument showed there are three options to this question: perception of landlord acceptance of Section 8 is "high", "moderate", and "little or no acceptance". Only one out of 48 PHAs in the study answered this question as "little or no acceptance". Even though the authors tried to consider the effect of the degree of landlord participation on vouchers, the results were not statistically significant and were not free from the generalization problems.

3.2.4 Conclusion and limitations of previous research

As reviewed earlier, there is growing literature on the distribution of voucher recipients. However, these studies showed mixed evidences on the success of vouchers

allowing poor households to move into neighborhoods which are less segregated and more affluent. To data, the voucher program appears to be less effective in promoting racial integration than in helping to deconcentrate poverty. Moreover, many of these research pieces have focused on national aggregations and there has been little consideration of spatial aspects of location outcome.

Most of aforementioned studies have focused on the poverty rates and/or minority composition in a given geographic areas in order to show that voucher holders tend to live in less poverty stricken and less racially segregated neighborhoods over time (Devine et al., 2003; Hartung & Henig, 1997; Kingley et al., 2000; Polikoff, 1995). In another case, comparisons between project-based programs and the voucher program made convincing arguments that the voucher program is successful to minority desegregation and poverty deconcentration (Newman & Schnare, 1997; Hartung & Henig, 1997). Both of these approaches are a-spatial, simply comparing non spatial cross tabulation across geographies. Recently, more researchers have been considering spatial aspects of voucher locations (Oakley & Burchfield, 2009; Wang & Varady, 2005; Wang et al., 2008; Wyly & DeFilippis, 2010). They have sought to determine whether there was spatial concentration and where the vouchers were clustered. Examining spatial aspects of voucher locations revealed that voucher holders still tended to cluster, to some degree, in specific neighborhoods depending on several factors. Hence, exploratory spatial data analysis is needed to identify the presence of spatial concentrations and the locations of clusters to uncover the spatial patterns of voucher holders' location outcomes over space and over time. This analysis also should be disaggregated by race and by income to

answer the questions regarding whether the voucher program helps race desegregation and poverty deconcentration.

Several factors were identified in influencing the location outcome of voucher holders, including personal preferences, market conditions, and racial segregation. Residential segregation was caused by both voluntary and involuntary processes (Bourne, 1981). Voucher holder's personal preferences and non personal barriers played significant roles in location outcomes. Often voucher holders chose their residence simply to gain proximity to family, friends, churches, and services (Varady et al., 2001; Varady & Walker, 2007). Likewise, their income level caused them to limit location choices to areas served by public transportation (Varady et al., 2001; Popkin & Cunningham, 2000). Race played a significant role in the spatial patterns of voucher recipients. To some degree, locational outcomes of vouchers reflect the racial discrimination or preference of the same race to cluster in neighborhoods. Many voucher holders revealed their fears of encountering discrimination when they began to search for housing (Popkin & Cunningham, 2000). In addition to race, market conditions limited or enlarged the choice of voucher location. Generally, weak markets tended to provide more opportunities to finding voucher housing in areas other than the central city (Finkel & Buron, 2001). Since weak markets slows housing sales prices, increases vacancy rates, and lowers rent levels, landlords have an incentive to participate in the program that ensures them stable rent based on the fair market rent, which would not be expected in stressed economic times. One of the most important factors influencing location pattern was the availability of affordable housing. The location patterns of voucher families tend to mirror the geographic distribution of affordable rental housing units. Several research

pieces confirmed the relationship between voucher location and the availability of affordable housing (Devine et al., 2003; Ladd & Ludwig, 1997; Turner & Wilson, 1998; Turner & Cunningham, 2000).

As illustrated earlier, even though many research efforts found that the accessibility to public transportation played a critical role in voucher holders' location choice, no research has been conducted to estimate the effect on location outcomes. In addition, many researchers suggest that market conditions affect the choice of location for voucher families, but only part of them examined the statistical significance, so it was hard to exclude the confounding effects other than market condition factors (Finkel & Buron, 2001; Oakley & Burchfield, 2009; Pendall, 2000a; Wyly & DeFilippis, 2010). Also, previous research showed that there was no consensus of factors representing market conditions: vacancy rate, ratio of job growth to housing construction, affordable housing units under FMR, the absolute level of the FMR itself, PHA's assessment of the local market, adequacy of local payment standards are all used in the literature (Deng, 2007; Pendall, 2000a; Finkel & Buron, 2001). Among those indicators, vacancy rates and availability of affordable housing at or below FMRs were the most commonly used as relevant variables to explain vouchers' location outcomes.

Thus, this study will test the significance of several factors explaning voucher locations using the spatial regression model. This study will incorporate factors identified as influential to location outcome: the accessibility of public transportation, availability of affordable housing, vacancy rates, and racial composition. Furthermore, spatial regression and geographically weighted regression will account for spatial

autocorrelation and spatially varying relationships, which OLS regression analysis fails to capture when dealing with spatial data.

CHAPTER IV

METHODOLOGY

4.1 Hypotheses and Model

4.1.1 Research questions and hypotheses

The purpose of this study is to examine how the voucher program works in terms of patterns and factors influencing spatial concentration in Cuyahoga County. There are two sets of research questions and hypotheses. The first set is to address the questions on spatial patterns of voucher recipients. The second set is to identify the factors affecting voucher holders spatial concentration.

First, the voucher program is expected to achieve deconcentration of poverty by utilizing mobility of voucher holders. If the voucher program properly achieved its deconcentration and desegregation goals, voucher recipients would be shown in scattered patterns, not concentrated in specific neighborhoods. Thus, it could be hypothesized that

voucher recipients in Cleveland would not concentrate in poor neighborhoods. The first set of research questions and corresponding hypotheses are as follows.

First, is there spatial clustering of voucher recipients?

Ho: There is no spatial clustering of voucher recipients.

Ha: Voucher recipients concentrate spatially.

Second, is there spatial clustering of voucher recipients with different races, different ethnic backgrounds, and different income levels?

Ho: There is no difference of spatial patterns of voucher recipients by different races, ethnic backgrounds, and income levels.

Ha: Spatial patterns of voucher recipients vary by different races, ethnic backgrounds, and income levels.

Third, are spatial patterns of voucher recipients changing over time?

Ho: There is no difference of spatial patterns of voucher recipients over time.

Ha: Spatial patterns of voucher recipients change over time.

Exploring spatial patterns will be followed by specific questions pertaining to factors associated with location outcomes of voucher households. These factors include public transportation, affordable housing, market conditions, race, and poverty. Accessibility to public transportation plays a critical role in choosing residence for voucher recipients due to their low income level. Availability of affordable housing turned out pivotal elements to limiting or enlarging residential choice of voucher holders.

In addition, voucher recipients would have more choices in a weak market than in a strong one. Since the weak market shows high vacancy rate and low rent, landlords have an incentive to participate in the program. Thus, the regression model in this study will examine five hypotheses on which factors are attributable to spatial concentration of voucher holders.

First, voucher recipients are limited their location choice by the availability of affordable housing whose rent levels do not exceed the Fair Market Rents (FMRs). I expect therefore a significant positive relationship between the proportion of voucher households and the proportion of affordable housing below FMRs in block groups. Research question and corresponding hypotheses are as follows:

Does availability of affordable housing affect voucher holders' concentration?

Ho: There is no relationship between concentration of voucher recipients and availability of affordable housing.

Ha: Concentration of voucher recipients is related positively with the availability of affordable housing.

Second, I expect that voucher holders' race will influence the spatial concentration. Preferences for the same race as well as racial segregation would affect minority concentration. Considering the fact that the majority of voucher holders are head by African American in Cuyahoga County, I expect a significant relationship between minority and voucher concentration in neighborhoods. If the relationship is statistically positive and significant, it would imply racial preferences and segregation influence the voucher concentration. Research question and hypotheses are posed as:

Does race affect voucher recipients' concentration?

Ho: There is no relationship between concentration of voucher recipients and racial composition in neighborhoods.

Ha: Concentration of voucher recipients are positively related with minority concentration in neighborhoods.

Third, voucher holders' concentration is expected to relate positively with the rental vacancy rate. When a large proportion of the rental stock is vacant, tenants have more choices and landlords have fewer incentives to discriminate against voucher holders. In this situation, landlords have more incentives to participate in the voucher program. Hence, voucher recipients will have more chances to find housing units in neighborhoods showing higher vacancy rates. Thus, research question and null and alternative hypotheses are stated as follows:

Do rental vacancy rates affect voucher recipients' locations?

Ho: There is no relationship between concentration of voucher recipients and the rental vacancy rates.

Ha: Concentration of voucher recipients are positively related with the rental vacancy rates.

Fourth, concentrations of voucher recipients have related with neighborhood poverty rates. In general, low income households tend to live in high poverty neighborhoods. However, the voucher program subsidizes rents for low income households to live in less distressed neighborhoods, and the program tries to contribute to

poverty deconcentration. Considering those characteristics, if successfully implemented, the poverty rates and voucher concentrations would have a negative relationship. On the other hand, if the program is not successful to disperse low income voucher holders, the result would have a positive relationship between voucher concentration and neighborhood poverty rates.

Does poverty rate affect voucher recipients' location?

Ho: There is no relationship between concentration of voucher recipients and the poverty rate.

Ha: Concentration of voucher recipients are related with the poverty rate.

Finally, voucher recipients will locate residences where public transportation is accessible. Voucher holders are low-income households: the average income is $10,886 as of 2009 in Cuyahoga County. Therefore, the chance of having a car is very low and their location choice is inevitably limited by the accessibility of public transportation. Thus, I expect a significant positive relationship between voucher holders and the accessibility of public transportation. Research question and a pair of hypotheses are as follows:

Does the accessibility of public transportation affect voucher recipients' location?

Ho: There is no relationship between concentration of voucher recipients and the accessibility to public transportation.

Ha: Concentration of voucher recipients are positively related with the accessibility to public transportation.

4.1.2 Model

How can we explain the concentration of voucher recipients? Here is a formal model based on the literature and theories discussed earlier for attempting to answer this question:

$$Y = \beta_0 + \beta_1 AFFORDH + \beta_2 BLACK + \beta_3 ASIAN + \beta_4 HISPANIC + \beta_5 VACANCY + \beta_6 POVERTY + \beta_7 TRANPORT + u$$

Y represents the dependent variable, which is the percentage of voucher units among the total occupied housing units in a block group. *AFFORDH* is the proportion of rental housing units below FMRs in a block group. *BLACK*, *ASIAN*, and *HISPANIC* are, respectively, the proportion of Black, Asian, and Hispanic population. *VACANCY* is the rental housing vacancy rate, which is calculated as vacant dwelling available for rent divided by the total number of occupied rentals and vacant for rent dwellings. *POVERTY* is the proportion of persons living below the poverty level. *TRANSPORT* is the proportion of area accessible to public bus stops within a quarter mile distance, which is first defined by Clarence Perry (1929) in Neighborhood Unit concept as a desirable walking distance for daily-routine.[8]

4.2 Data

[8] Clarence Perry (1929) introduced a concept of "neighborhood unit" as an ideal residential neighborhood with school, churches, and recreational areas. The neighborhood unit design allowed residents to walk no more than a quarter mile to reach these community facilities and discouraged unwanted through traffic. School was placed in the center of the neighborhood so children could reach school within a quarter mile distance without crossing a major arterial street. Major arterial streets along the perimeter defined and distinguished the neighborhood. Since its inception, the neighborhood unit has widely served as the primary design concept for new residential development.

This study will investigate the voucher program's effect as a case study of Cuyahoga County. Cuyahoga Metropolitan Housing Authority (CMHA) is the housing agency that administers the Housing Choice Voucher Program in Cuyahoga County. Chartered in 1933, CMHA is the first housing authority in the United States, and it is one of the ten largest housing authorities in the country. CMHA provided the voucher information of address, income, race, and rent level from 2005 to 2009. At the end of 2009, a total of 14,043 vouchers were issued by CMHA in Cuyahoga County.

In addition to voucher information, 2000 census data at a block group level will be used in regression analysis to get neighborhood characteristics such as poverty rates, vacancy rates, minority proportions, and affordable housing units. The U.S. Census Bureau data is available at the block group level to account for neighborhood characteristic variables.

Lastly, this study needs public transportation data which identify the routes and bus stops in Cuyahoga County. Northeast Ohio Areawide Coordinating Agency (NOACA) provided the information as of 2009. Information from NOACA will be used to calculate the proportion of area in each block group that is accessible to public transportation within a quarter mile distance.

4.3 Hotspot analysis

To investigate the first set of questions pertaining to locational outcomes, this study will utilize spatial analyses, including dot mapping, density mapping, and hot spot analysis. First, the spatial pattern of voucher holders, over time, will be examined

employing hot spot analysis followed by geocoding voucher addresses. This analysis is useful to examine changes of voucher recipients' spatial concentration patterns for a particular area over time (Wang & Varady, 2005). Dot mapping and density mapping will show the difference of results and highlight the relevance of hotspot analysis. Getis-Ord G statistics will indicate the presence of spatial concentrations, measure the degree of concentrations, and identify the locations of hotspots where voucher recipients cluster. In order to answer the first set of research questions, this study will conduct hotspot analysis by race, by income, and by ethnicity from 2005 to 2009, analyzing the differences of spatial patterns by different characteristics of vouchers and the changing patterns over time.

4.3.1 Exploratory Spatial Data Analysis

Exploratory spatial data analysis (ESDA) is the method of exploratory data analysis that takes into account the spatial aspects of the data. Anselin (1999) defines ESDA as, "a collection of techniques to describe and visualize spatial distributions, identify atypical locations or spatial outliers, discover patterns of spatial association, clusters or hot spots, and suggest spatial regimes or other forms of spatial heterogeneity" (p.258). Hence, ESDA should focus on the analysis of spatial aspects of the data in terms of spatial dependence and spatial heterogeneity.

Contrary to traditional data that does not have spatial aspects, spatial data need special consideration due to the spatial dependence, which implies that the value of a variable is spatially associated with its value in neighboring geographic areas. Tobler's First Law of Geography captures this phenomenon as, everything is related to everything

else, but near things are more related than distant things (Tobler, 1970). There are two types of spatial effects: spatial dependence and spatial heterogeneity. Spatial dependence, often referred to as spatial autocorrelation, results from Tobler's First Law of Geography. Due to the spatial clustering of observations, the results from the geographic data will not be independent. This violates the assumption of traditional multiple regression models that assume independent observations. Spatial heterogeneity is related to the intrinsic uniqueness of each location itself. None of the traditional tools of exploratory data analysis (EDA) are geared to dealing with spatial data. Many EDA techniques explore the correlation between variables that generate measures of fit and of significance. This becomes invalid in the presence of spatial dependence (Anselin, 1996).

4.3.2 Global and Local index of spatial autocorrelation

The magnitude of the spatial effects can be measured using a number of statistics of spatial autocorrelation. Two kinds of statistics, global and local, are utilized to capture the presence and the magnitude of the spatial structure. Global statistics can identify the presence of spatial structure such as clustering, autocorrelation, and uniformity; however, they do not identify where the clusters are, nor do they quantify how spatial dependency varies from one place to another. On the other hand, local statistics can quantify spatial autocorrelation and clustering within small areas (Jacquez, 2008). Clustering is a global aspect of the spatial pattern and is measured by a single statistic. In contrast, clusters are local in nature, which can identify specific locations where the values are more similar than usual (Anselin, 2005a). Many local statistics have global counterparts that often are calculated as functions of local statistics. Specifically, the sum of local indicator of

spatial associations for all observations is proportional to a global indicator of spatial association (Anselin, 1995).

4.3.3 Getis-Ord G statistics

The global and local Getis-Ord G statistics measure the presence and magnitude of spatial autocorrelation in dataset. The global form of the Getis-Ord G statistic (*G*) is also called general G statistic, for it deals with the entire study area rather than a localized area. In contrast, the local Getis-Ord G statistic (G_i*) identifies the location and degree of clusters. The global G statistic is expressed as:

$$G = \frac{\sum_i \sum_i w_{ij} z_i z_j}{\sum_i \sum_i z_i z_j}, i \neq j$$

The local G_i^* is given as

$$G_i^* = \frac{\sum_j w_{ij} z_j}{\sum_j z_j}, i \neq j$$

where w_{ij} *(d)* is the spatial weight matrix with $w_{ij}=1$ when *i* and *j* are within a distance d from each other and zero otherwise, and the observations z_i, z_j are in deviations from the mean. Getis-Ord G statistics are calculated under the assumption of normality, which indicates the significant local spatial association for each observation. Getis-Ord G statistics can be easily implemented and visualized in GIS software. Moreover, these statistics are particularly useful in the detection of potential non-stationarity, such as the spatial clustering of similar values in a specific region of the study area. A positive Getis-Ord G statistic means clustering of high values and a negative one indicates clustering of low values (Getis & Ord, 1992; Anselin, 1996).

The expected value of G and G_i* under Complete Spatial Randomness (CSR) is:

$$E(G) = \frac{\sum_i \sum_i w_{ij}}{n(n-1)} = \frac{W}{n(n-1)}, i \neq j$$

where n is the number of points or zones in the study area, and W is the sum of the weights. The equivalent expected value for the local variant is:

$$E(G_i^*) = \frac{\sum_j w_{ij}}{(n-1)} = \frac{W}{(n-1)}$$

where n is the number of points or zones within the threshold distance for point or zone i. This produces the z-score, which allows the significance test of the global and local G statistics (De Smith, Goodchild, & Longley, 2009).

4.3.4 Hotspot analysis

Hotspot analysis is ArcGIS tool that identifies statistically significant spatial clusters of high values (hot spots) and low values (cold spots). By creating a new feature containing z-score and p-value for each feature, hotspot analysis determines whether the null hypothesis can be rejected or not. The z-score is calculated on the basis of randomization. The null hypothesis for the pattern analysis is complete spatial randomness (CSR). Under the CSR, the theoretical pattern is assumed that (1) objects are located independently of each other, and (2) a study area has an equal chance of receiving an object (Getis, 1999). Since p-value is a probability, a small p-value means low probability that the observed spatial pattern is the result of a random process. In this case, the null hypothesis of a random pattern can be rejected.

As a result of hotspot analysis, a high z-score and a small p-value indicates a spatial clustering of high values. On the contrary, a low negative z-score and a small p-value indicate a spatial clustering of low values. The higher or lower the z-score, the more intense the clustering; however, a z-score near zero means no apparent spatial clustering.

In order to find the patterns of voucher holders' spatial concentration, this study employs hotspot analysis utilizing Getis-Ord G statistics as a means of detecting spatial autocorrelation. There are several statistics to identify spatial autocorrelation such as the Moran's I, Geary C, and Getis-Ord G statistic. One of the frequently used statistics is Moran's I. Both Moran's I and Getis-Ord G statistics of global spatial autocorrelation indicate that there is spatial autocorrelation in voucher distribution in the study area. After detecting global spatial autocorrelation, the location of clusters should be searched to identify the locations of clusters. In this study, I employ the Gi* statistic and hotspot analysis to identify the locations of clusters, instead of using Moran's I statistic and LISA maps. First, both statistics allow the inference of local spatial autocorrelation. Second, the spatial clusters shown in the LISA cluster map only refer to the core of the cluster based on the comparison under spatial randomness. Unlike the Moran's I, the Getis-Ord G statistic identifies the degree to which high or low values cluster together. Third, hotspot analysis is useful to examine changes of spatial concentration patterns for a particular area over time (Anselin, 2005; Wang & Varady, 2005).

The biggest difference between the two is that Moran's LISA map identifies both spatial clusters and spatial outliers while hotspot analysis focuses on spatial clusters rather than outliers. Considering the focus of the study with spatial clusters, the hotspot

analysis fits for serving the purpose of my study which is to identify the presence and locations of spatial concentration. In addition, the study will examine not only the spatial concentration of voucher recipients, but also the change of spatial pattern over time, so hotspot analysis fits for purpose of this study.

4.4 Spatial regression analysis

4.4.1 Spatial autocorrelation and spatial regression analysis

Regression analysis will be used to identify the factors affecting voucher concentrations. Spatial regression analysis will be considered to account for the spatial dependence of whether the presence of voucher holders in a block group increases the likelihood of voucher recipients in neighboring areas.

Spatial regression deals with the incorporation of spatial effects (spatial autocorrelation and spatial heterogeneity) in regression models (Anselin, 1988). As Can (1990) put,

> Spatial dependence refers to the possible occurrence of interdependence among observations that are viewed in geographic space, and violates the assumption of uncorrelated error terms … Spatial heterogeneity … refers to the systematic variation in the behavior of a given process across space, and usually leads to heteroskedastic error terms. (p.256)

Any systematic patterns in the spatial distribution of a variable indicate the presence of spatial autocorrelation. If the value of nearby or neighboring areas are similar,

then it implies positive spatial autocorrelation. On the contrary, negative autocorrelation describes patterns when the values of neighboring areas are dissimilar. Spatial autocorrelation is important because the presence of spatial autocorrelation signifies the violation of assumption in traditional econometric models, which assumes that the values of observations in each sample are independent each other. Thus, if the observations are spatially clustered in some way, the estimates obtained from the ordinary least squares regressions (OLS) will be biased and cannot be precise because OLS estimators are based on the assumption that the observations have been selected randomly (Anselin, 1988; De Smith et al., 2009; Oakley & Burchfield, 2009).

Statistically significant spatial autocorrelation implies that the regression model is not properly specified and that one or more new variables should be entered into the regression model (Getis, 1999). Anselin (2002) claimed that the essence of spatial regression models is the incorporation of spatially lagged variables in the regression specification. The new variables could be a dependent variable, a explanatory variable, or a regression error terms, depending on the spatial externalities (Anselin, 2005a).

GeoDa is one of the most intensively used tools developed for dealing with spatial data. It starts with mapping and geovisualization, proceeds through ESDA and spatial autocorrelation analysis, and ends up with spatial regression. The core functionality of spatial regression in GeoDa is centered on diagnostics for spatial autocorrelation, maximum likelihood estimation of the spatial lag and spatial error model. The estimation and specification of spatial regression models in GeoDa are based on the maximum likelihood method (Anselin, 2005a).

Diagnostics for spatial autocorrelation and running the relevant spatial regression model are straightforward in GeoDa. First, statistically significant Moran's I indicates a problem with spatial autocorrelation. The Moran's I statistic has great power in detecting model misspecification, however, it is not useful to determine which model is appropriate. Second, Lagrange Multiplier (LM) test statistics decide the relevant model. There are five LM test statistics: LM-Lag, Robust LM-Lag, LM-Error, Robust LM-Error, and LM-SARMA. When none of the LM statistics are significant, there is no need to run a spatial regression model; OLS results are appropriate and precise. On the other hand, when either of the LM-Lag or LM-Error statistic is significant, then the significant one is the model to be run. If the LM test shows that the LM-Lag statistic is significant, then the spatial lag model is the proper alternative; while if the LM-Error statistic is significant, the spatial error model should be considered. In the case where both statistics (LM-Lag and LM-Error) are significant, Robust LM diagnostics will be examined. Typically, one of the Robust LM statistics will be significant, or one will be more significant than the other in terms of the magnitude such as small p-value. The decision is straightforward that estimates the spatial regression model as matching the significant statistic or the most significant one (Anselin, 2005b).

4.4.2 Spatial lag model and spatial error model

A general multiple regression with incorporating spatial lags is formulated as:

$$y = \rho Wy + X\beta + u \qquad \text{(Equation 1)}$$

y is an $n \times 1$ vector of observations on a dependent variable, X is an $n \times k$ matrix of observations on independent variables, β is k×1 vector of regression coefficients, u is an

$n \times 1$ vector of independent and identically distributed random error terms, and W is the $n \times n$ exogenous spatial weights matrix that specifies the assumed spatial structure or connections between the observations. Wy is the spatially lagged dependent variable to account for spatial dependence. The parameter ρ refers to spatial correlation or a spatial dependence parameter. The value of ρ is equal to zero in a traditional linear regression model. Equation (1) for y is expressed as:

$$y = (I - \rho W)^{-1} X\beta + (I - \rho W)^{-1} u \qquad \text{(Equation 2)}$$

I is the $n \times n$ identity matrix. Two inverse expressions in Equation 2 indicate spatial multipliers (Anselin, 2003). A spatial lag model is useful to account for spatial autocorrelation in the dependent variable and prevents a parameter estimate from bias and inconsistency that could happen in OLS regression.

When spatial autocorrelation is present in residuals, a spatial error model specification is relevant to improve the precision of the estimated parameters. A general version of a spatial error model can be formulated as (Anselin, 2003):

$$y = X\beta + \varepsilon, \qquad \text{where } \varepsilon = \lambda W\varepsilon + u$$

W is the weight matrix and λ (Lambda) is a spatial autoregressive parameter to be estimated jointly with the regression coefficients. The two vectors of errors are assumed to be uncorrelated. The above equation can be solved for ε and expressed as:

$$y = X\beta + (I - \lambda W)^{-1} u \qquad \text{(Equation 3)}$$

Inverse matrix in Equation (3), $(I - \lambda W)^{-1}$, is called a spatial multiplier. Equation 3 indicates that the value of the dependent variable for each location is affected by the stochastic errors at all locations through the spatial multiplier.

4.5 Geographically Weighted Regression (GWR)

4.5.1 Spatial heterogeneity

There are two types of spatial issues when dealing with spatial data: spatial autocorrelation and spatial heterogeneity. While the spatial lag or the spatial error model is appropriate to deal with spatial autocorrelation, Geographically Weighted Regression (GWR) is utilized to account for spatial heterogeneity.

OLS regression estimates regard each individual area independently of the values of its neighbors; however, in general, contiguous areas share similar social and market conditions than areas that are far apart. Therefore, the results from the OLS regression can only be interpreted as generating average parameter values for the study area as a whole. In this sense, estimates from OLS present a global characteristic of the relationship between dependent and independent variables (Fotheringham, Brunsdon, & Charlton, 2002). Hence, OLS results cannot detect spatial variation or local differences.

Contrary to conventional OLS, GWR allows coefficients to vary across space. GWR applies the linear regression model at the local level, so that local parameters are estimated. Instead of a global parameter in OLS, local parameters are estimated and present a way of accommodating spatial heterogeneity. For each point in the dataset, it uses a subset of the data surrounding the point of interest to estimate locally linear regression parameters. Thus, at each data point, GWR provides a different parameter

estimate and t statistics, allowing us to see how the relationship between dependent and explanatory variables change over space.[9]

4.5.2 Geographically Weighted Regression (GWR) model

Fotheringham et al. (2002) provides a detailed description of GWR. A conventional multiple regression, so called global regression, can be presented as,

$$y = \beta_0 + \sum_k \beta_k x_{ik} + \varepsilon_i \qquad \text{(Equation 4)}$$

where the prediction of the dependent variable (y) is obtained through a linear combination of the independent variables. β_k is the parameter estimate for variable k, x_{ik} is the value of the k^{th} variable for i, and ε_i is the error term. The OLS estimator takes the form of

$$\hat{\beta} = (X^T X)^{-1} X^T y$$

where $\hat{\beta}$ is the vector of estimated parameters, X is the matrix that contains the values of the independent variables, y is the vector of observed values, and $(X^TX)^{-1}$ is the inverse of the variance-covariance matrix.

The global model estimates a single regression equation for all observations. Contrarily, GWR constructs a separate regression equation for each observation, and each equation uses different weighting of observations. The global model shown in Equation 4 can be rewritten as GWR in Equation 5

[9] True spatial regression models should deal with both characteristics of spatial data (spatial autocorrelation and spatial heterogeneity). At present, no spatial regression methods are effective for both issues of spatial data. However, for a properly specified GWR model, spatial autocorrelation is typically not a problem (ArcGIS, 2010).

$$y = \beta_0(u_i, v_i) + \sum_k \beta_k(u_i, v_i) x_{ik} + \varepsilon_i \qquad \text{(Equation 5)}$$

where β_0 is the intercept, (u_i, v_i) indicates the coordinates of the i^{th} point in space, x_{ik} is the value of the explanatory variable *k* (Fotheringham et al., 2002). The parameter estimates in GWR are taken from the weighting that is based on the spatial proximity to the specific location under consideration. Since the weighting of an observation is not constant over space, the GWR model can estimate the local variation of parameters. The estimator of the parameter vector for regression point *i* is:

$$\hat{\beta}(u_i, v_i) = (X^T W(u_i, v_i) X)^{-1} X^T W(u_i, v_i) y \qquad \text{(Equation 6)}$$

where $\hat{\beta}$ is an estimate of β, *X* is a matrix of independent variables, *W* is a weighting matrix. Diagonal elements of *W* represent the geographical weighting of each observed data for regression point *i*, and off-diagonal elements of *W* equal to zero (Fotheringhan et al., 2002).

$$w_i = \begin{bmatrix} w_{i1} & 0 & \dots & 0 \\ 0 & w_{i2} & \dots & 0 \\ 0 & 0 & w_{i3} & 0 \\ . & . & . & . \\ 0 & 0 & 0 & w_{in} \end{bmatrix}$$

where w_{in} is the weights of the data point *n* in the calibration of the model for location *i*. The weighting matrix acts in a way that data near to location *i* are weighted more than data from observations far away.

Charlton and Fotheringham (2009) propose two kernel types to determine the weighting matrix: fixed and adaptive kernel. A fixed kernel type is useful when the observations are regularly positioned in the study area, while an adaptive kernel type is appropriate when the observations are clustered, so that the density of observation varies

over space. For a fixed kernel with a Gaussian function, W_{ij} is represented as a continuous function of d_{ij} that denotes Euclidean distance between observation *i* and *j*.

$$w_{ij} = \exp\left[-\frac{(d_{ij}/b)^2}{2}\right]$$

where *b* refers to a bandwidth, *j* represents a specific point in space at which data is observed, and *i* indicates any point in space for which parameters are estimated. Choosing a bandwidth *b* is important, for there is a trade-off between the bias and the variance in GWR estimation. A low bandwidth helps reduce the bias, but increase the variance because the sample size around each estimated coefficient will be low. On the other hand, a larger bandwidth provides more smooth results. An adaptive kernel that uses the bi-square function is expressed as

$$w_{ij} = \left[1-(d_{ij}/b)^2\right]^2 \quad \textit{if } d_{ij} \leq b, \textit{ otherwise } w_{ij}=0$$

where *j* represents a point in space at which data are observed, *i* represents any point in space for which parameters are estimated, d_{ij} is the Euclidean distance between point *i* and *j*, and *b* is the bandwidth. This function is called "adaptive" because the trace of the weight matrix is allowed to expand and contract, conditional upon a given location. The measure of goodness of fit in GWR is the corrected Akaike Information Criterion (AICc) score, given as

$$AICc = 2n\log_e(\hat{\sigma}) + n\log_e(2\pi) + n\left[\frac{n+tr(S)}{n-2-tr(S)}\right]$$

where *n* is the number of observations in the dataset, $\hat{\sigma}$ is the estimate of the standard deviation of the residuals, and *tr(S)* is the trace of the hat matrix of the GWR, which is defined as

$$\hat{y} = Sy$$

where y and $\hat{y}$ is the vector of the dependent variable and the GWR estimated value, respectively. The AICc is advantageous in terms of taking into account the different degrees of freedom among models. In addition to comparison models with different independent variables, the AICc is useful to compare the global OLS model with a local GWR model. When the difference between the two AICc values is less than 3, then the two different models are considered to be equivalent (Charlton & Fotheringham, 2009).

4.6 Summary

The purpose of the dissertation consists of invoking two sets of research questions: patterns and factors of voucher holders' spatial concentration. In terms of spatial patterns of voucher holders, the presence and location of spatial concentration are examined by hotspot analysis through global and local indicators of spatial autocorrelation. Next, factors of influencing their location outcomes are identified by the regression analysis. OLS regression analysis will provide the degree of statistical significance of factors, such as availability of affordable housing, race, vacancy rates, poverty rates, and the accessibility of public transportation. Moreover, the spatial regression analysis will capture the presence and the effect of spatial autocorrelation on each factor identified in OLS regression. Finally, GWR will detect local variations of a factor, which could not present by either OLS or spatial model. Comparing results from OLS and GWR will shed light on the importance of spatial variation and local difference derived from the spatial heterogeneity.

CHAPTER V

PATTERNS OF SPATIAL CONCENTRATION OF VOUCHER RECIPIENTS

This chapter presents the findings from both a-spatial and spatial analysis. The demographic characteristics of voucher recipients from CMHA administrative data are reported, along with their neighborhood conditions in terms of income level, poverty rates, and racial composition. Followed by a-spatial description, the spatial analysis indentifies voucher holders' location and spatial concentration pattern by race, ethnicity, and income level from 2005 to 2009. This chapter concludes with the results from the hotspot analysis, showing significant spatial concentration of voucher recipients.

5.1 A-spatial analysis

5.1.1 Demographics of voucher recipients

5.1.1.1 Race, ethnicity, and housing type

This study analyzes voucher information provided by Cuyahoga Metropolitan Housing Authority (CMHA) from 2005 to 2009. CMHA is the housing agency that administers the Housing Choice Voucher Program in Cuyahoga County. Charted in 1933, CMHA is the first housing authority in the United States, and it is one of the ten largest housing authorities in the country (CMHA, 2009a). CMHA provided the voucher information for this study including the address, race, ethnicity, income, and rent level from 2005 to 2009.

During the five-year study period, a total of 68,515 vouchers were issued by CMHA. On average, 13,703 vouchers are issued annually. By race, the majority of voucher recipients are African American comprising 89.2%, white 10.3%, and other race less than 1%. By ethnicity, Hispanic origin comprises of 3.4%. In terms of housing type, one half of voucher holders live in a single family house while the other half lives in either a multi-family or apartment type of dwelling. These characteristics are shown in Table 5-1 below.

Table 5-1 Demographics of voucher holders

Year		2005		2006		2007		2008		2009		mean
Total		count	%	count	%	count	%	count	%	count	%	%
		13720	100	13095	100	14039	100	13618	100	14043	100	13703
Race	White	1458	10.6	1385	10.6	1410	10	1376	10.1	1416	10.1	10.3
	Black	12191	88.9	11644	88.9	12547	89.4	12167	89.3	12548	89.4	89.2
	AI/AN	31	0.2	28	0.2	31	0.2	30	0.2	31	0.2	0.2
	Asian	40	0.3	38	0.3	51	0.4	45	0.3	48	0.3	0.3
Ethni-city	Hispanic	436	3.2	420	3.2	491	3.5	484	3.6	510	3.6	3.4
	Non Hispanic	13284	96.8	12675	96.8	13548	96.5	13134	96.4	13533	96.4	96.6
House	Single Family House	6497	47.4	6253	47.8	6496	46.3	7602	55.8	7674	54.6	50.4
	Multifamily	7223	52.6	6842	52.2	7543	53.7	6016	44.2	6369	45.4	49.6

Source: Cuyahoga Metropolitan Housing Authority (CMHA)
Note: AI/AN indicates American Indian/ Alaska Native populations

5.1.1.2 Income and rent level

The income level of voucher recipients is extremely low, $10,737 on average. During the five year research period, income and rent levels have been stable: under $11,000 and around $650 respectively.

Table 5-2 Average value of income and rent

Year	2005	2006	2007	2008	2009	mean
Income	$10,474	$10,650	$10,725	$10,950	$10,886	$10,737
Rent	$644	$641	$636	$649	$654	$645

Source: Cuyahoga Metropolitan Housing Authority (CMHA)

Based on the guidelines developed by the U.S. Department of Housing and Urban Development (HUD, 2007b), voucher holders' income levels can be grouped into four categories: extremely low, very low, low, and above low. The income levels correlate with less than 30%, less than 50%, less than 80%, and above of the area's median income. Poverty cutoffs are approximately 30% of area median income even though they cannot be compared directly to the Federal poverty line.[10] Area median incomes in Cuyahoga County, collected from HUD for 2005 to 2009, categorize the income level of voucher recipients. Area median income level for 2005 was $60,200, and increases to $64,800 in 2009.

[10] The poverty line for a family of four is approximately equivalent to 33% of Area Median Income. Based on this criteria, as of 2007, 46% of very low income households and 81% of extremely low income households were considered as poor (HUD, 2010b)

Table 5-3 Area median income level during 2005 to 2009

Year	2005	2006	2007	2008	2009
Area Median Income	$60,200	$61,400	$60,700	$62,100	$64,800

Source: HUD (2010e)

Table 5-4 illustrates that 83.3% of voucher recipients fall into the extremely low income group, while less than 0.1% of households have an income above 80% of the area median income. Income distributions reflect HUD's requirements for income targeting: at least 75% of the families should be extremely low-income, which equivalent for incomes below 30% of the AMI (HUD, 2001).

Table 5-4 Income group of voucher recipients

	2005		2006		2007		2008		2009		Mean
Income group	count	%	count	%	count	%	count	%	count	%	%
Extremely low	11458	83.5	10892	83.2	11603	82.6	11183	82.1	11905	84.8	83.3
Very low	2012	14.7	1942	14.8	2142	15.3	2141	15.7	1907	13.6	14.8
Lower	239	1.7	249	1.9	279	2	276	2	227	1.6	1.9
Above Lower	11	0.1	12	0.1	15	0.1	18	0.1	4	0	0.1

Source: Cuyahoga Metropolitan Housing Authority (CMHA)

5.1.1.3 Central city proportion

As Table 5-5 indicates, over half of voucher households live in the central city. This is a significantly high concentration when it compared to the proportion of households in Cuyahoga County as a whole. A third of households live in the central city, while over the half of voucher households reside in the city of Cleveland. When taking into account two neighboring cities of Cleveland (Euclid and East Cleveland), the proportion rises up to 75% in 2006, for example.

Table 5-5 Central city proportion of voucher households

	Year	Total	Cleveland	%	Cleveland, Euclid, and East Cleveland	%
Voucher households						
	2005	13,720	7,943	57.9	10,152	74.0
	2006	13,095	7,825	59.8	9,867	75.3
	2007	14,039	7,902	56.3	10,134	72.2
	2008	13,618	8,072	59.3	10,013	73.5
	2009	14,043	7,393	52.6	9,669	68.9
Total Households						
	2000	571,457	190,638	33.4	226,201	39.6
	2009*	520,657	181,779	34.9	214,029	41.1

Source: 2000 household data is from Census 2000; 2009 household data is based on 2009 estimated data from Geolytics.

5.1.2 Distribution of voucher recipients

5.1.2.1 Distribution by neighborhood income level

Where do voucher recipients live in terms of neighborhood income level? Are they living in low income neighborhoods? If they turned out living in poor neighborhoods, it would be hard to say that the intended goal of the voucher program is achieved since the voucher program tries to deconcentrate poverty through the choice of residence. Answering this question requires neighborhood grouping whether the residences of voucher recipients are poor neighborhoods. In order to categorize neighborhoods by income level, HUD's (2007b) criteria is adopted, which is consistent with grouping voucher recipients' income group. In this case, block groups are considered as a neighborhood since block groups are a finer and smaller geographic entity used to obtain various socioeconomic data than the census tract, giving a rich and

detailed picture of neighborhoods.[11] Block groups with a median income of less than 30% of HUD area median income (AMI) are defined as extremely low neighborhoods; block groups with a median income of 50 to 80 % of AMI are defined as low income neighborhoods; block groups with a median income of 80 to 100% of AMI are defined as moderate neighborhoods; block groups with a median income higher than 100% of AMI are defined as middle income neighborhoods.

Two time periods of neighborhood income level is also considered: 2000 and 2009. As of 2009, Census 2000 data is only available comprehensive data, but it seems too outdated. Recent data from a 2009 estimation provided by Geolytics is also considered in categorizing neighborhood income group in order to fill the gap between decennial census periods and also to mirror the present conditions of neighborhoods.

Due to the differences of HUD area median incomes between 2000 and 2009, direct comparison between two years might not be appropriate until the new 2010 census is released. Rather, comparison of the share of vouchers' location from 2005 to 2009 reflects how many vouchers reside in poor neighborhoods.

As shown in Table 5-6, voucher recipients tend to live out of poor neighborhood during a five year period. Neighborhood income levels are categorized by comparing 2009 HUD area median income and 2009 block group level median income. In 2005, almost 20% of voucher recipients lived in the extremely low income neighborhoods, but the proportion has lowered to 15.4% in 2009, with an average of 17.5% over five years. Also, voucher holders living in very low income neighborhoods have decreased from

[11] Block groups generally contain between 600 and 3,000 people with an optimum size of 1,500 people. A census tract, which clusters of one to nine block groups, typically has between 1,500 and 8,000 people, with an average size of about 4,000 people (U.S. Census Bureau, 2008)

47.7% to 45.3%, in 2005 and 2009 respectively. The most promising changes have happened in low income neighborhoods, from 28.6% to 34.9% in the same period. However, proportions of living in moderate or middle income neighborhoods are almost consistent during the last half decade. This is quite surprising considering the fact that over 83% of voucher holders are extremely low income, almost 15% are very low income and less than 1% is of the moderate or middle income group.

Table 5-6 Distribution of voucher holders by neighborhood income level (2009)

2009 Neighborhood	2005		2006		2007		2008		2009		Average
	count	%	count	%	count	%	count	%	count	%	%
Extremely Low	2,659	19.5	2,396	18.4	2,431	17.5	2,252	16.6	2,160	15.4	17.5
Very low	6,495	47.7	6,064	46.6	6,540	47	6,207	45.7	6,342	45.3	46.4
Low	3,897	28.6	3,981	30.6	4,330	31.1	4,492	33.1	4,884	34.9	31.7
Moderate	408	3	417	3.2	438	3.1	461	3.4	450	3.2	3.2
Middle	169	1.2	156	1.2	177	1.3	167	1.2	166	1.2	1.2
Total	13,628	100	13,014	100	13,916	100	13,579	100	14,002	100	100

Note: Neighborhood types derived based on 2009 data from Geolytics

Using 2000 census income data indicates a similar story with only a few differences. Neighborhood income level is constructed by comparing 2000 HUD area median income with 2000 block group level median income. If the neighborhood income level is constant during ten years and the proportion of voucher recipients in each neighborhood category changes, it would imply that the voucher holders have changed their residence to less poor neighborhoods. This shows more promising results than above. Proportions of vouchers living in extremely low income neighborhoods have decreased from 12.5% to 10.2%; proportions of vouchers living in very low income neighborhoods have also dropped from 42.7% to 36.0%. On the other hand, voucher

recipients living in low income neighborhoods have grown from 35.1% to 43.2%, and voucher recipients in moderate income neighborhoods have also increased.

Table 5-7 Distribution of voucher holders by neighborhood income level (2000)

2000 Neighborhood	2005		2006		2007		2008		2009		Average
	count	%	count	%	count	%	count	%	count	%	%
Extremely Low	1,707	12.5	1,549	11.9	1,582	11.4	1,460	10.8	1,430	10.2	11.3
Very low	5,825	42.7	5,308	40.8	5,578	40.1	5,206	38.3	5,040	36.0	39.6
Low	4,789	35.1	4,835	37.2	5,341	38.4	5,455	40.2	6,046	43.2	38.8
Moderate	931	6.8	946	7.3	1,037	7.5	1,120	8.2	1,152	8.2	7.6
Middle	376	2.8	376	2.9	378	2.7	338	2.5	334	2.4	2.6
Total	13,628	100	13,014	100	13,916	100	13,579	100	14,002	100	100

Note: Neighborhood types derived based on 2000 census data

Comparing voucher holders' race with neighborhood types indicates that African American voucher holders are more likely to live in poorer neighborhoods than White voucher holders. Over one half of Black voucher users live in neighborhoods with very low income levels (extremely low or very low compared to AMI), while one third of White voucher users do. Both races have moved out of extremely low income toward low income neighborhoods during last five years (Table 5-8 and Table 5-9).

Table 5-8 African American voucher holders by neighborhood income level

	2005		2006		2007		2008		2009		Mean
Neighborhood	N	%	N	%	N	%	N	%	N	%	%
Extremely Low	1565	12.9	1439	12.4	1477	11.9	1371	11.3	1344	10.7	11.8
Very low	5383	44.4	4905	42.4	5177	41.6	4825	39.8	4640	37.1	41.0
Low	4063	33.5	4117	35.6	4597	37.0	4698	38.7	5249	41.9	37.4
Moderate	806	6.7	825	7.1	901	7.2	981	8.1	1021	8.2	7.5
Middle	296	2.4	291	2.5	287	2.3	261	2.2	259	2.1	2.3
Total	12113	100.0	11577	100.0	12439	100.0	12136	100.0	12513	100.0	100

Table 5-9 White voucher holders by neighborhood income level

	2005		2006		2007		2008		2009		Mean
Neighborhood	N	%	N	%	N	%	N	%	N	%	%
Extremely Low	137	9.5	108	7.9	100	7.2	84	6.1	84	6.0	7.3
Very low	408	28.3	373	27.2	374	26.8	356	26.0	375	26.6	27.0
Low	702	48.6	692	50.4	706	50.6	722	52.8	757	53.7	51.2
Moderate	118	8.2	117	8.5	127	9.1	131	9.6	121	8.6	8.8
Middle	79	5.5	82	6.0	88	6.3	75	5.5	73	5.2	5.7
Total	1444	100.0	1372	100.0	1395	100.0	1368	100.0	1410	100.0	100

In sum, the analysis of voucher location by neighborhood's income levels reveals the tendency of moving out of extremely poor neighborhoods toward less poor neighborhoods. Even though the proportions are slightly different between the two time periods (2000 and 2009), the overall story looks similar – voucher recipients tend to live in less poor neighborhoods.

5.1.2.2 Poverty rate and voucher concentration in Cuyahoga County

In the case of Cuyahoga County, most of the voucher recipients in suburban areas live in low poverty neighborhoods with less than 20% of poverty rate.[12] At the same time, suburban voucher recipients living in high poverty neighborhoods are only 10.3%, while 37.9% of voucher holders in the central city live high poverty areas with over 30% of

[12] With regard to poverty level, there is no absolute threshold above which poverty level can be said to adversely affect the welfare of all voucher families. Nevertheless, the 40% level has been frequently cited as a threshold for extreme poverty concentration and the 30% level as a threshold for moderate concentration. Families and neighborhoods are assumed to be negatively affected when poverty concentrations reach these levels. Therefore, the location of voucher families are described here in reference to the 30% and 40% poverty thresholds as well as to the entire continuum of poverty concentration (Jargowsky, 1997; Galster, 2002; HUD, 2007b).

poverty rate. Not surprisingly, as shown other research (such as Devein et al., 2003), suburban families are much less likely than central city families to live in high poverty neighborhoods. Finding suggests that the voucher program seems to achieve poverty deconcentration goal in the study area since over three quarter of voucher recipients avoid to live in high-poverty neighborhoods which are poverty rate over 30%.

Table 5-10 Neighborhood poverty level and voucher concentration

Poverty level	Total vouchers		Cleveland		Suburbs	
	N	%	N	%	N	%
Under 10%	3475	24.8	611	8.3	2864	43.3
10-20%	3798	27.1	1699	23.0	2099	31.8
20-30%	3249	23.2	2279	30.9	970	14.7
30-40%	2253	16.1	1740	23.6	513	7.8
40% or higher	1218	8.7	1054	14.3	164	2.5
Total	13993*	100.0	7383	100.0	6610	100.0

Notes: Number of vouchers is 2009 data, poverty rate data is from 2000 Census data.
*There are 9 missing information due to the availability of poverty rate in block group from 2000 Census data

5.1.2.3 Distribution by neighborhood racial composition

Where do voucher holders live in terms of racial makeup in neighborhoods? Do black voucher holders live in neighborhoods with the same color? Location Quotient (LQ) is used to investigate the distribution of vouchers by neighborhood racial composition. The LQ is calculated as the ratio between the share of race groups of all of the population in the block group and the similar share in the entire county. A LQ_{white} of more than 1 indicates that the white population is overrepresented in the block group when compared to the entire county. Conversely, a LQ_{white} of less than 1 implies that the white population is underrepresented in the block group when compared to the entire

County. The LQ value of 1 means a block group contains a fair share of race group when compared to the entire County. LQ is calculated as follows:

$$LQ_{white} = \frac{\text{(White population in block group) / (total population in block group)}}{\text{(White population in County) / (total population in County)}}$$

$$LQ_{black} = \frac{\text{(Black population in block group) / (total population in block group)}}{\text{(Black population in County) / (total population in County)}}$$

Based on the LQ calculation, neighborhoods are categorized as white, black, and mixed neighborhoods. A neighborhood is designated as white when LQ_{white} is equal to or greater than 1 and LQ_{black} is less than 1; a black neighborhood is when LQ_{black} is equal to or greater 1 and LQ_{white} is less than 1; a mixed neighborhood occurs when both LQs are either over 1 or less than 1.

Table 5-11 Types of neighborhoods based on LQ

	$LQ_{white} \geq 1$	$LQ_{white} < 1$
$LQ_{black} \geq 1$	Mixed neighborhoods	Black neighborhoods
$LQ_{black} < 1$	White neighborhoods	Mixed neighborhoods

Based on 2000 census data, the majority of voucher recipients live in black neighborhoods. On average, 69.8% of voucher holders reside in black dominant neighborhoods, however, the trend shows the proportion decreased over time from 72.4% in 2005 to 67.9% in 2009. Meanwhile, voucher recipients living in white dominant neighborhoods are growing from 23.5% to 28.2% during the same time. Mixed neighborhoods have only 4% of vouchers but the rate is consistent over time.

Table 5-12 Distribution of voucher holders by neighborhood racial type (2000)

Neighborhood Racial type	2005		2006		2007		2008		2009		average
	count	%	count	%	count	%	count	%	count	%	%
Black	9,871	72.4	9,237	71	9,670	69.5	9,298	68.5	9,502	67.9	69.8
Mixed	559	4.1	514	3.9	578	4.2	567	4.2	540	3.9	4.0
White	3,198	23.5	3,263	25.1	3,668	26.4	3,714	27.4	3,953	28.2	26.1
Total	13,628	100	13,014	100	13,916	100	13,579	100	14,002	100	100

As of 2009, the picture of voucher location is not much different from 2000. The same approach divides neighborhoods into three types using 2009 race data: dominantly black, dominantly white, and mixed neighborhood. When comparing neighborhood proportions from 2000 data, Table 5-13 indicates that a slightly higher percentage of vouchers live in black dominant neighborhoods; at the same time, more vouchers reside in white neighborhoods as well. However, mixed neighborhoods only comprise 1% of vouchers, which is the biggest difference between the two tables using different time data.

Table 5-13 Distribution of voucher holders by neighborhood racial type (2009)

Neighborhood Racial type	2005		2006		2007		2008		2009		Average
	count	%	count	%	count	%	count	%	count	%	%
Black	9,945	73.0	9,304	71.5	9,746	70.0	9,382	69.1	9,595	68.5	70.4
Mixed	150	1.1	136	1.0	170	1.2	166	1.2	155	1.1	1.1
White	3,533	25.9	3,574	27.5	4,000	28.7	4,031	29.7	4,245	30.3	28.4
Total	13,628	100	13,014	100	13,916	100	13,579	100	14,002	100	100

When neighborhood racial composition is compared with voucher holders' race, the majority of voucher recipients tend to live in the similar type of neighborhood in terms of race. On average, 76.4% of African American voucher holders live in black dominant neighborhoods (Table 5-14) while 74.5% of white voucher holders live in

white neighborhoods (Table 5-15). The number of voucher holders living in neighborhoods of a different color indicates that African American vouchers tend to live more in white neighborhoods while white vouchers tend to live less in black dominant neighborhoods over time. Overall, 20.3% of African Americans live in white dominant neighborhoods, 15.3% of white vouchers live in black neighborhoods. Interestingly, black vouchers living in white neighborhoods are growing over time; conversely, white vouchers living in black neighborhoods are decreasing at the same time. In addition, white voucher holders are more likely to live in mixed neighborhoods than African American voucher holders. On average 20% of white, and 3.3% of black voucher recipients live in mixed neighborhoods.

Table 5-14 Distribution of African American voucher holders by neighborhood racial type (2000)

Neighborhood Racial type	2005		2006		2007		2008		2009		average
	count	%	count	%	count	%	count	%	count	%	%
Black	9,606	79.3	9,011	77.8	9,441	75.9	9,080	74.8	9,277	74.1	76.4
Mixed	385	3.2	360	3.1	431	3.5	427	3.5	398	3.2	3.3
White	2,122	17.5	2,206	19.1	2,567	20.6	2,629	21.7	2,831	22.6	20.3
Total	12,113	100.0	11,577	100.0	12,439	100.0	12,136	100.0	12,513	100.0	100.0

Note: Neighborhoods racial types are classified by LQ using 2000 census data

Table 5-15 Distribution of White voucher holders by neighborhood racial type (2000)

Neighborhood Racial type	2005		2006		2007		2008		2009		average
	count	%	count	%	count	%	count	%	count	%	%
Black	250	17.3	210	15.3	206	14.8	198	14.5	207	14.7	15.3
Mixed	164	11.4	147	10.7	138	9.9	130	9.5	130	9.2	10.1
White	1,030	71.3	1,015	74.0	1,051	75.3	1,040	76.0	1,073	76.1	74.5
Total	1,444	100.0	1,372	100.0	1,395	100.0	1,368	100.0	1,410	100.0	100.0

Note: Neighborhoods racial types are classified by LQ using 2000 census data

Based on the analysis of racial distribution, it is hard to confirm that the voucher program contributes to race desegregation since over 70% of voucher recipients live in the neighborhoods of the same color. However, the degree of race segregation tends to decrease over time. While the majority resides in the same color neighborhood, the more voucher recipients choose neighborhoods with different color from 2005 to 2009. Specifically, 20% of black and 15% of white voucher recipients live in neighborhoods that the other color is dominant.

5.1.2.4 Affordable housing units and voucher distribution

Voucher holders in Cuyahoga County occupy relatively higher shares of affordable units when compared with 50 MSAs as a whole. On average, 8.4% of affordable units are occupied by voucher holders, which is 2% point higher than 50 MSAs in previous research. According to Devine et al (2003), the housing choice voucher program utilizes only a very modest portion of the affordable housing stock, just over 6%, within the 50 largest MSAs. The proportion of voucher holders to affordable housing is not very different between suburbs and the central city, which is 6.4% in the former and 6.2% in the latter (Devine et al., 2003).

Table 5-16 Affordable housing units and voucher concentration

	Total	Central city	Suburbs
Total occupied units (2000) (A)	571,457	191,278	380,179
Total affordable units (2000) (B)	166,036	86,361	79,675
Total voucher units (2009) (C)	14,002	7,392	6,610
Affordable units/occupied units (B/A)	29.1%	45.1%	21.0%
Voucher units/ occupied units (C/A)	2.5%	3.9%	1.7%
Voucher units/ affordable units (C/B)	8.4%	8.6%	8.3%

Note: Central city indicates the city of Cleveland, and suburbs are the rest of the cities in Cuyahoga County

Affordable rental units are estimated by comparing rent levels in 2000 census data with Fair Market Rents (FMRs), which indicate the rents that include units costing up to the 40th percentile of rents for the metropolitan area, controlling for bedroom size. As of 2010, FMRs in the Cleveland metropolitan area are $735 for a two-bedroom unit. Based on this rent, affordable rent units are calculated by summing up the rental units under rent level $749 from the 2000 Census data, which is the most reliable and recent data available at the time of analysis.[13]

Affordable rental units comprise about 30% of total occupied housing units and voucher holders utilize a moderate share (8.4%) of affordable housing. Interestingly, there is no significant difference between the central city and suburbs in terms of the proportion of voucher recipients to the affordable housing units. An 8.6% of affordable housing units in the central city and an 8.3% of those in the suburbs are occupied by voucher holders.

[13] However, the affordable rental units do not necessarily represent the total number of units available for voucher holders unless all landlords having affordable units participate in the voucher program.

5.2 Spatial Analysis

5.2.1 Dot mapping

5.2.1.1 Dot mapping results

In order to identify the voucher locations, ArcGIS is utilized to geocode the addresses. The address matching function, which compared the street name and house number with voucher address point, identified the voucher holder's addresses. This process identified locations for 68,134 out of 68,515 addresses from 2005 to 2009, representing 99.4% match on average.

Table 5-17 Address matching results by year

year	Total	Matched addresses	% of matching
2005	13,720	13,627	99.3
2006	13,095	13,014	99.4
2007	14,039	13,916	99.1
2008	13,618	13,577	99.7
2009	14,043	14,001	99.7
Sum	68,515	68,134	99.4

Figure 5-1 shows the address matching result of vouchers from 2005 to 2009. Each voucher holder is represented as a point in an ArcGIS shapefile. As shown below, many vouchers look clustered in the middle of the county. However, it is hard to tell the differences between years. Although simple dot mapping has advantage to show spatial pattern geographically, dots on the same address cannot be shown because of overlapping. Thus, dot mapping can mislead to find the areas with high concentration of voucher

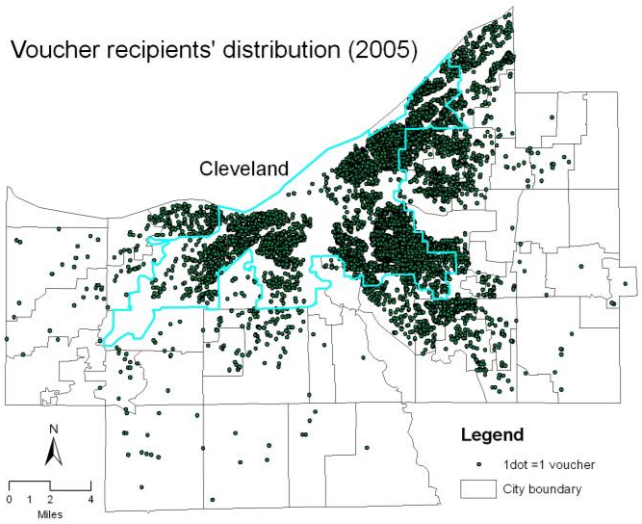
recipients. In order to improve understanding of spatial distribution of voucher recipients, it is necessary to investigate different approach taken density into account.

5.2.1.2 Limitation of dot mapping

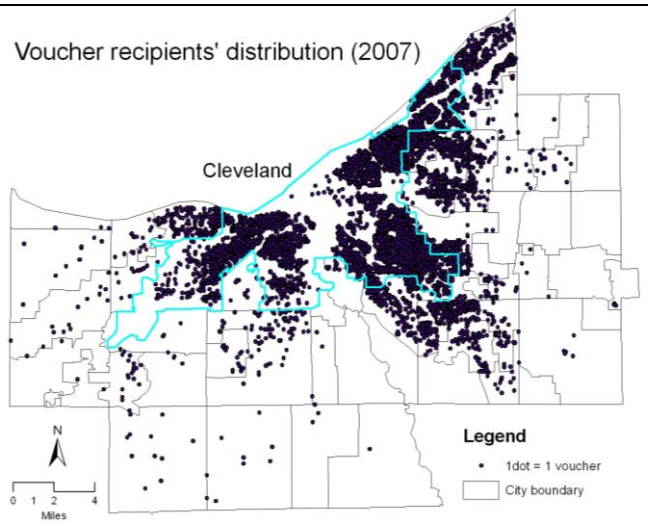
Although the density variable has advantage representing the spatial distribution over simple dot mapping, it also has a limitation. Density, based on census tract or block group boundaries, is calculated by the number of vouchers divided by the area where they belong. Since the boundaries of each census tract or block group are artificially delineated, the density map could also be misleading. Census tract or block group boundaries usually correspond to streets (Wang & Varady, 2005). Vouchers concentrated across the street cannot be calculated in the same equation if they are designated into the different census tract or block group. In addition, the effect of clustering voucher houses on the side of the census tract will decrease because the density takes total area into account. Unless the voucher houses are evenly distributed over the census tract, the density should be considered in different way. Thus, density based on the same size of area will adjust the problem caused by areal unit.

Figure 5-1 Address matching results by year

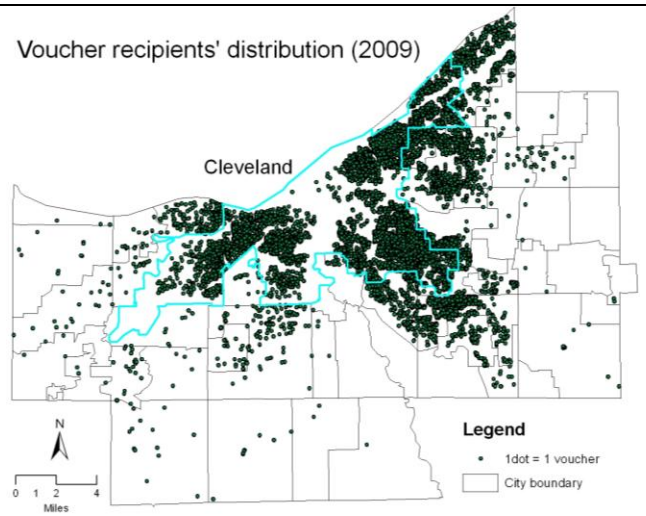
2005



2007



2009



5.2.2 Density mapping

5.2.2.1 Method of density mapping

In order to calculate the voucher density, Cuyahoga county area was divided into small grid cells of equal size. Points that fall within the search area are summed, and then divided by the search area size to get each cell's density value. Both cell size and search distance affect the result of density calculation.

The cell size determines how coarse or fine the patterns will appear. The smaller the cell size, the smoother the surface will be. In general, cell size between 10 and 100 cells per density unit is recommended (Mitchell, 1999). Based on this, cell size would be between 500 and 1,700 feet since the density unit is number of voucher units per square mile. Therefore, Cuyahoga County was divided into 500 by 500 feet cells.

The size of the search area affects the level of generalization. The larger the search radius, the more generalized the patterns will be. A smaller search radius usually shows more local variation while it may not show broader patterns due to very low density values which derived from the small search radius (Mitchell, 1999). However, increasing the radius will not greatly change the calculated density values. Although more points will fall inside the larger neighborhood, this number will be divided by a larger area when calculating density. The main effect of a larger radius is that density is calculated considering a larger number of points, which can be farther from the center of cell. This results in a more generalized output (Allen, 2009; De Smith et al., 2009). After conducting a series of different search radii from a quarter mile to two miles, I found a

half mile radius to be an optimum choice large enough to show spatial pattern yet small enough to show details.

In this process, the GIS defines a neighborhood based on a search radius specified around each cell center. Then, it totals the number of points that fall within that neighborhood and divides that number by the area of the neighborhood. That value is assigned to the cell. Next, it moves to the next cell and does the same thing until it is completed. This creates a running average of features per area, creating a smoothed surface (Mitchell, 1999).

5.2.2.2 Result of density mapping

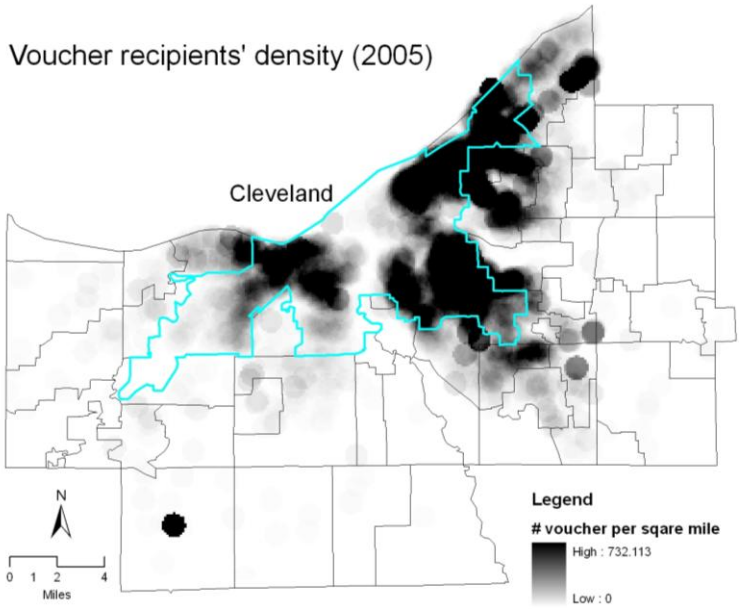
Density calculation indicates that maximum density decreased from 729 households per square mile in 2005 to 680 households per square mile in 2009. However, mean density is almost the same at 18 and 19 in 2005 and 2009 respectively. When it was compared to other places, as of 2005, overall voucher density in New York was 55 households per square mile; Los Angeles was 13; and Baltimore was 8 (Wang et al., 2008).

The darkest areas represent the high density places which hold over 200 voucher units per square mile. The white part indicates no vouchers. In general, the vouchers' spatial pattern tends to become less concentrated during the study period. From 2005 to 2009, the high concentrated areas have become less conspicuous in the east-northern side of the county while more places have been occupied by voucher recipients in the outer part of the county. Density maps of 2005 and 2009 show that voucher recipients tend to

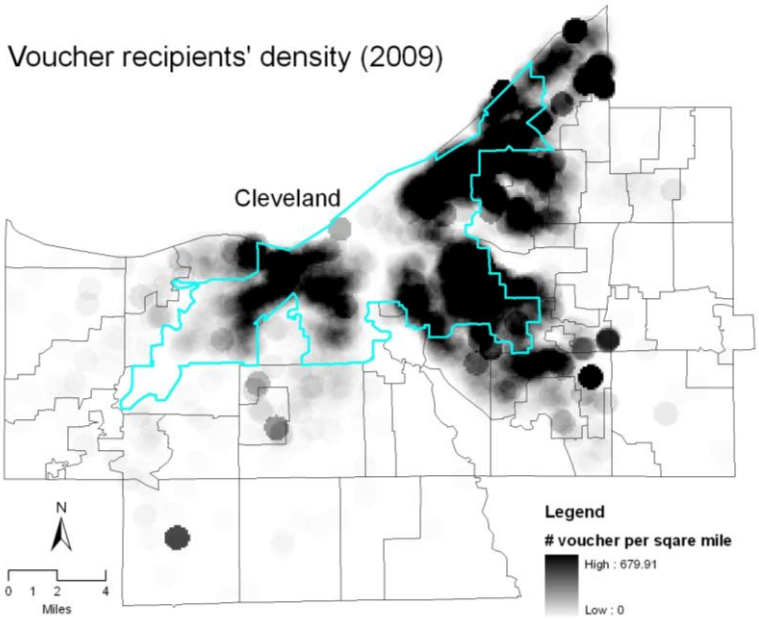
live more in suburbs in 2009 than in 2005. The spatial pattern of vouchers, based on density, show a trend of spreading out of the central city into the rest of the county.

Figure 5-2 Voucher density map by year

2005



2009



5.2.3 Hotspot analysis

5.2.3.1Getis-Ord G statistics

General and local G statistics identify the presence of clustering and the locations of clusters. The General G statistic measures concentrations of high or low values over the entire study area. It is termed "General" because it deals with the entire study area rather than a localized area. The distance is critical in seeing the compactness of the grouping, and will be used later in the hot-spot analysis. Running the analysis at various distances will determine the maximum z-score, confidence level, and distance band for clustering. The distance that produces the largest z-score will be the distance with the most significant clustering (Allen, 2009). In this case, the null hypothesis for the analysis is that the voucher locations are evenly distributed across the county.

After Getis-Ord G statistic (General G) found out that there is a statistically significant clustering in the study area, then local Getis-Ord statistics (G_i*) will identify the hotspots that high values are clustered by high values. Hotspot analysis in ArcGIS spatial statistical tools is applied to show the hotspots and their changing patterns from 2005 to 2009. The Hot Spot analysis tool in ArcGIS calculates the G_i* statistic for each feature. The Gi* statistic is given as:

$$G_i^* = \frac{\sum_{j=1}^{n} w_{ij}x_j - \overline{X}\sum w_{ij}}{S\sqrt{\frac{n\sum_{j=1}^{n} w_{ij}^2 - (\sum_{j=1}^{n} w_{ij})^2}{n-1}}}$$

where x_j is the attribute value for feature j, w_{ij} is the spatial weight between feature i and j, n is equal to the total number of features and:

$$\overline{X} = \frac{\sum_{j=1}^{n} x_j}{n}$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - \left(\overline{X}\right)^2}$$

The G_i* statistic produces z-score, allowing to visualize which locations are significant at the given level of confidence interval (Allen, 2009; De Smith et al., 2009).

To be a statistically significant hotspot, a feature will have a high value and be surrounded by other features with high values as well. The local sum for a feature and its neighbors is compared proportionally to the sum of all features; when the local sum is much different than the expected local sum, and that difference is too large to be the result of random chance, a statistically significant z-score will be provided. For statistically significant positive z-scores, the larger the z-score is, the more intense the clustering of high values (hotspot). Contrarily, for statistically significant negative z-scores, the smaller the z-score is, the more intense the clustering of low values (coldspot).

In sum, Getis-Ord G statistics test the null hypothesis that there is no clustering in a study area. Once clustering is found, the Global G index shows a significant level. This leads to questions of hot spot locations. Local G_i* statistic is utilized to answer this question. In this study, a hot spot analysis in ArcGIS was used to identify hot spots during the five year periods.

5.2.3.2 Process of hotspot analysis

From the density mapping, it is hard to tell that the high clustered areas are statistically meaningful or significant. So the spatial statistical approach is required. Spatial autocorrelation detection has two steps. First voucher addresses are spatially joined after geocoding into block group layer in order to count vouchers in the block group. Then, the spatial weights matrix generates the weight in measuring the General G index. It is termed "General" because it deals with the entire study area rather than a localized area. Series of calculation indicate that there is less than 1% likelihood that the clustering of high values could be the result of random chance. Spatial weights matrix results in the highest z-score of 30.41 ($p < 0.001$) among several options of spatial relationship which include inverse distance, inverse squared distance, and fixed distance. Choosing spatial weights matrix is reasonable to further hot-spot analysis, because the option that produces the largest z-score will be the one with the most significant clustering (Allen, 2009).

Instead of using a grid cell of equal size to construct a polygon grid over the voucher locations, block group layer is used to analyze hot spot analysis. Using grid cell or fishnet is good to show the number of vouchers falling within each grid. However, it is not possible to get any socioeconomic data for each cell. The block group is geographically smaller than a census tract allowing socioeconomic data. This allows further investigation of relationships between the voucher clustering and the characteristics of the area. Employing block group level data will provide more detailed and richer outcomes compared to using a census tract level analysis.

5.2.3.3 Hotspot analysis results

Voucher recipient's location pattern does not show even distribution. Global spatial autocorrelation statistics (General G) indicates a significant clustering during five years. General G index results are summarized in Table 5-15. High z scores and small p-values imply that the clustering of voucher recipients are statistically significant, meaning that there is less than 1% likelihood that the clustering of vouchers could be the result of random chance. Results shown in Table 5-18 are calculated spatial weight matrix. Other spatial relationships to calculate General G index are also considered including inverse distance, inverse distance square, and fixed distance. These results are also similar in terms of significant spatial clustering (high z scores and small p-values), and presented in Appendix A.

Table 5-18 General G index by year

Year	G index	Z score	P value
2005	0.002	30.41	0.0000*
2006	0.001	30.61	0.0000*
2007	0.001	30.42	0.0000*
2008	0.001	30.01	0.0000*
2009	0.001	28.36	0.0000*

Note: * indicates that there is less than 1% likelihood that the clustering of high values could be the result of random chance.

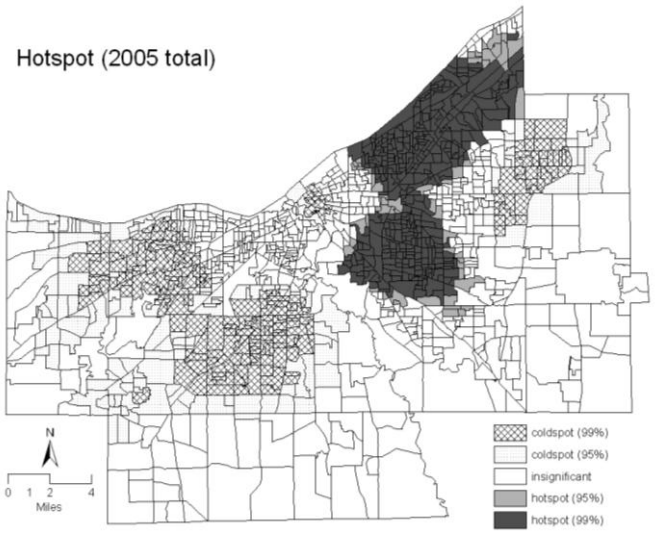
Since Global G index shows significant spatial clustering, then local statistics (G_i*) will find the clusters of voucher recipients. Hotspot analysis based on G_i* calculation clearly indicates the concentration of voucher holders and their changing pattern over time. A Series of maps shown in Figure 5-3 presents hotspots of voucher

users. The dark areas represent clustering of high values, and the hatched areas and areas in dots represents clustering of low values, which are number of voucher recipients.

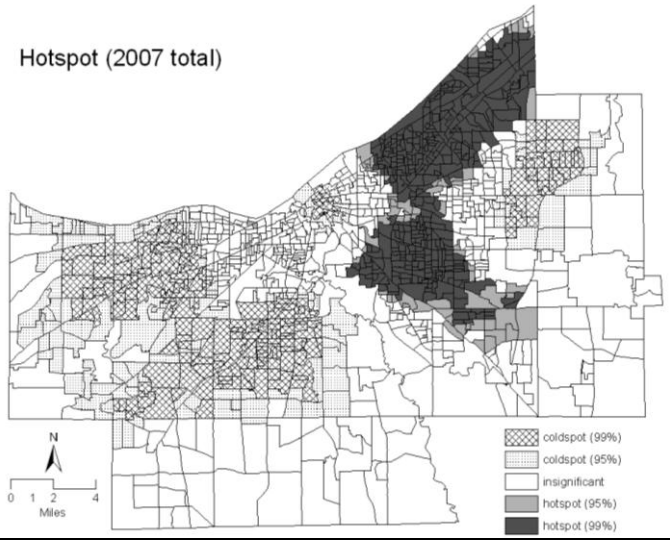
This is a dramatic result having two significant implications. First, hot spots and cold spots are divided by the downtown area; vouchers are highly concentrated in the eastern part of the county while low values are clustered in the western part. Second, location patterns spread out from the central city from 2005 to 2009. The lower part of the hot spot is getting longer toward the south-east direction, and the upper part of the hot spot is stretching to the end of the county. This pattern clearly indicates that the concentration of vouchers still exists even though the locations of concentration spread out to the suburb.

Figure 5-3 Hotspot maps for total voucher holders by year

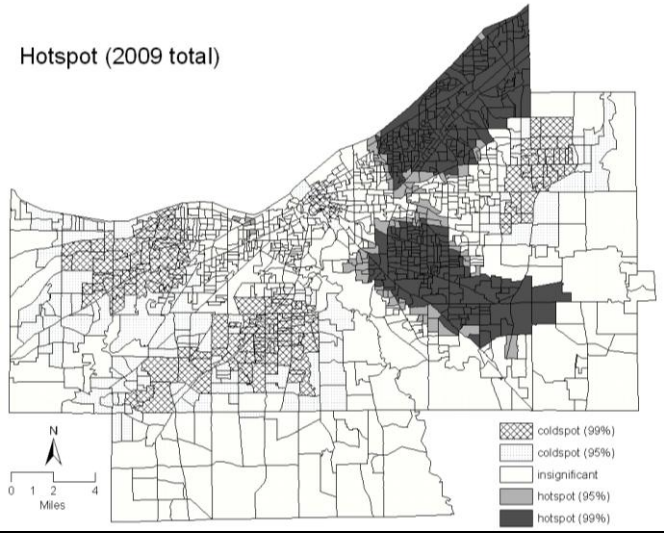
a. 2005



b. 2007



c. 2009



Based on hotspot analysis employed Getis-Ord global and local statistics, the first research question on the presence of spatial clustering of voucher recipients can be rejected. The high z-scores and small p-values indicate the presence of spatial clustering of voucher holders during the study period from 2005 to 2009. In addition, hotspot analysis with local G_i* statistic identify the locations of voucher concentration. Clusters of high value (hotspot) are found in the eastern side of the study area, and they are moving toward the suburbs from 2005 to 2009.

5.2.3.4 Hotspot analysis by race

Getis-Ord G and Gi* statistics along with hotspot maps show the presence of spatial clustering and the locations of clusters over space during five years. First, Getis-Ord global G index by race suggests that there is significant clustering of voucher holders by their race. Table 5-19 indicates that both races (White and African Americans) of voucher holders are clustering together. A small p-value in each year means that the chances are less than 1% that clustering is occurred by randomly.

Identifying the presence of spatial clustering by race is followed by investigation of clusters by each race. Hotspot maps based on local G_i* calculation are presented in Figure 5-4. Hotspot analysis by race finds that White and African American voucher holders are living in different side of the county. White voucher holders concentrate in the west and the south part of the region, while African American voucher recipients cluster in the east and the north side of the study area. From 2005 to 2009, hotspots of both races have spread toward the suburbs.

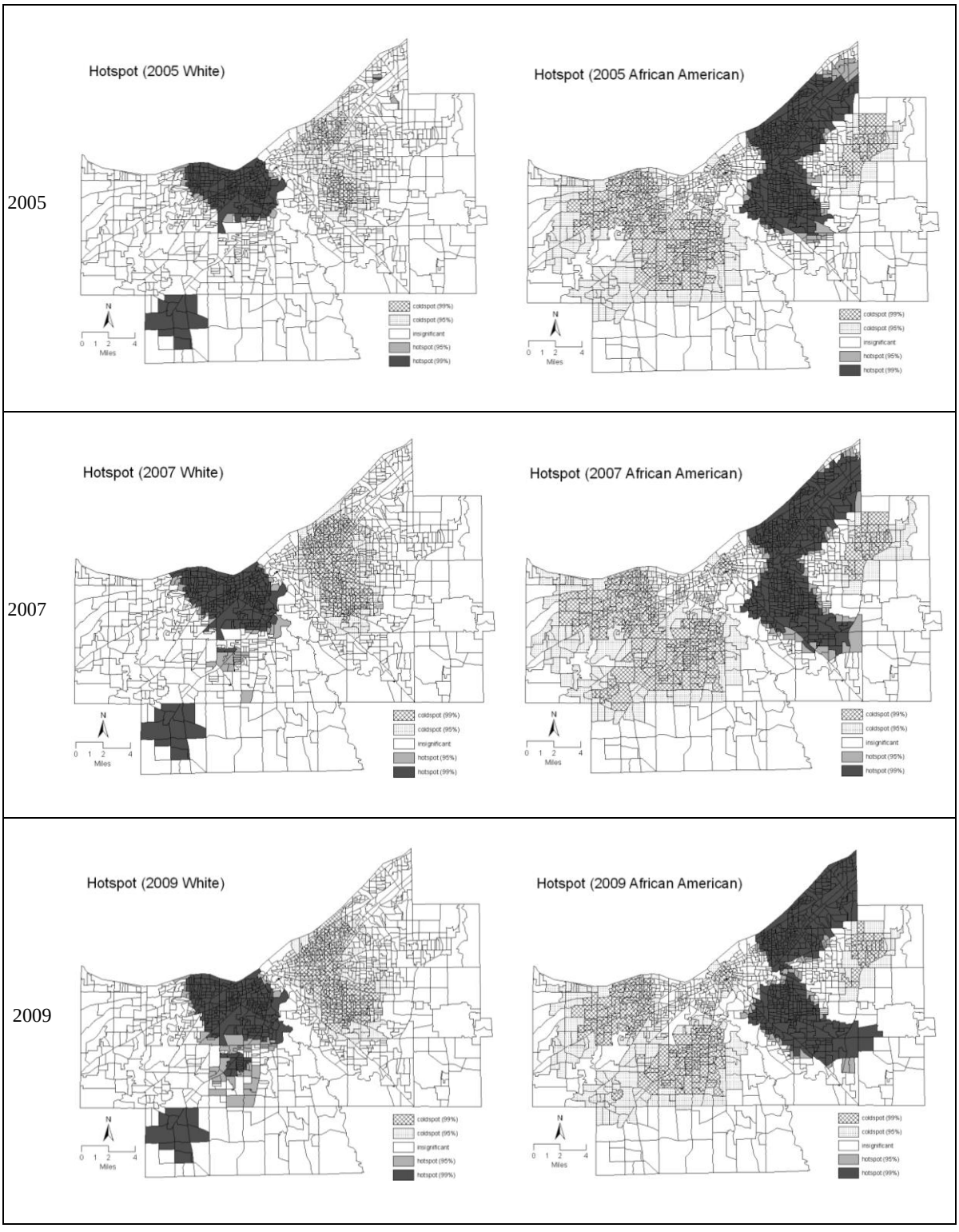
Table 5-19 General G index by race

Year	Race	G index	Z score	P value
2005	White	0.002	13.99	0.0000*
	African American	0.002	36.42	0.0000*
2006	White	0.002	16.92	0.0000*
	African American	0.001	36.34	0.0000*
2007	White	0.002	17.01	0.0000*
	African American	0.001	35.39	0.0000*
2008	White	0.002	18.09	0.0000*
	African American	0.001	34.90	0.0000*
2009	White	0.002	19.28	0.0000*
	African American	0.001	32.64	0.0000*

Note: * indicates that there is less than 1% likelihood that the clustering of high values could be the result of random chance.

Hotspot analysis enables us to answer the second research questions on the presence and the locations of spatial concentration by race. Global G statistic results in significant spatial clustering of voucher recipients by race; White and African American voucher holders are significantly concentrated. Local G_i* statistic and hotspot maps provide the locations and patterns of spatial concentration by race. Both races are clustered in different side of the county, and they tend to spread out to the suburbs over time.

Figure 5-4 Hot spot maps by race



5.2.3.5 Hotspot analysis by ethnicity

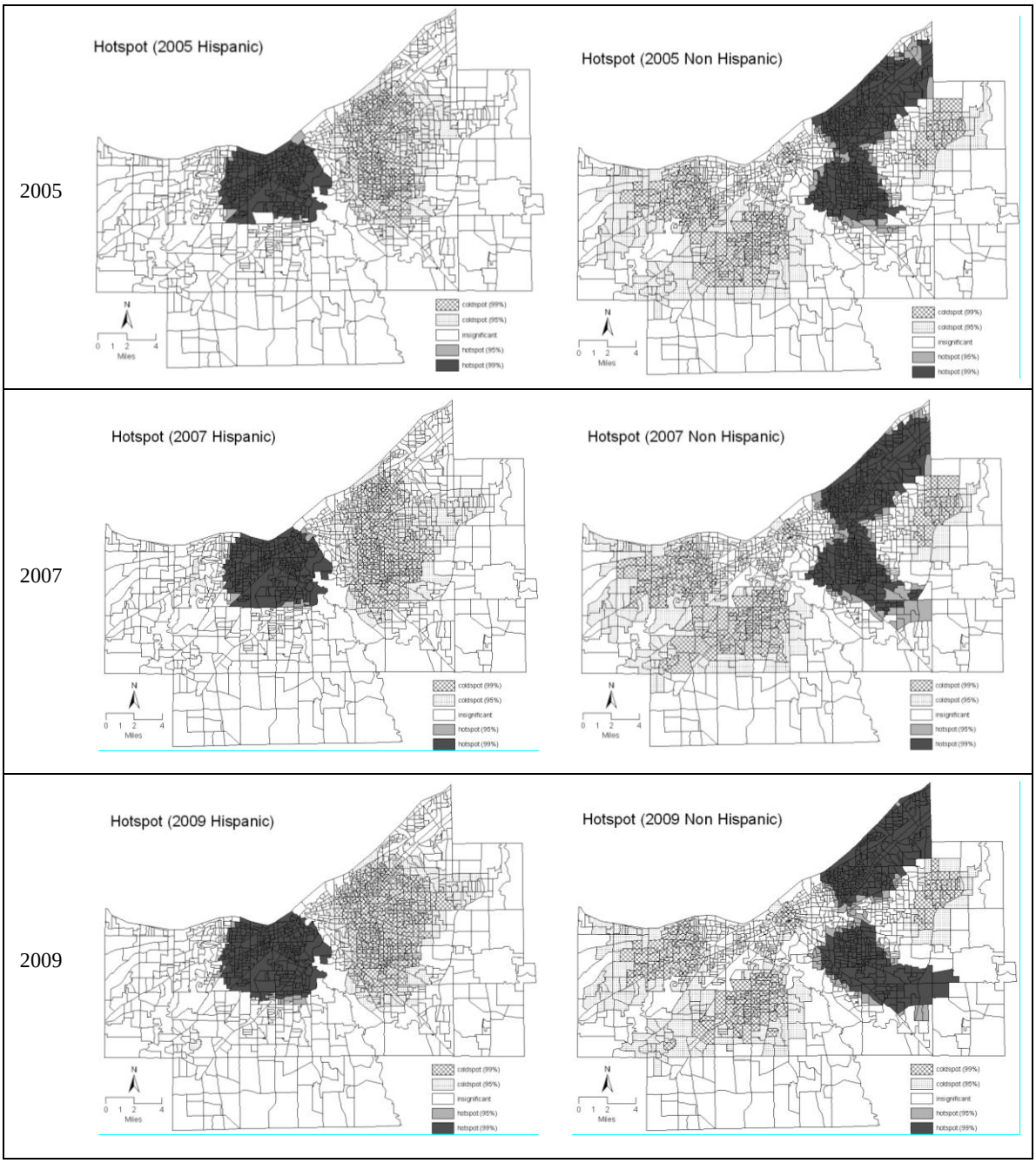
Analyzing hotspot by ethnicity also indicates significant clustering and different hotspots by ethnic group. Hispanics tend to cluster in the central city while non Hispanics live in the northeast side of the county. However, spatial pattern of Hispanic group does not spread out from 2005 to 2009 as non Hispanic does. Table 5-20 and Figure 5-5 illustrate the results of General G statistic and hotspots by ethnicity. Based on the General G statistic and hotspot analysis, it can be inferred that voucher recipients tend to cluster with the same ethnic group and non Hispanic voucher holders have spread out to suburbs from 2005 to 2009 while Hispanic voucher holders have concentrated in the central city.

Table 5-20 General G index by ethnicity

Year	Ethnicity	G index	Z score	P value
2005	Hispanic	0.003	53.25	0.0000*
	Non Hispanic	0.001	31.09	0.0000*
2006	Hispanic	0.003	54.01	0.0000*
	Non Hispanic	0.001	31.35	0.0000*
2007	Hispanic	0.003	57.64	0.0000*
	Non Hispanic	0.001	31.18	0.0000*
2008	Hispanic	0.003	55.39	0.0000*
	Non Hispanic	0.001	30.84	0.0000*
2009	Hispanic	0.003	55.04	0.0000*
	Non Hispanic	0.001	29.21	0.0000*

Note: * indicates that there is less than 1% likelihood that the clustering of high values could be the result of random chance.

Figure 5-5 Hot spot maps by ethnicity



Strong spatial concentration of Hispanic voucher holders is somewhat consistent with finding from HPS 2000 study that Housing discrimination against minority especially Hispanic renters has not declined over the decade (Turner & Ross, 2005). In 2000 the U.S. Department of Housing and Urban Development (HUD) launched national

paired-testing study (shortened here to HPS 2000) to measure patterns of racial and ethnic discrimination in urban housing markets nationwide. This was the third time since the 1977 Housing Market Practices Study and the 1989 housing discrimination study conducted. HPS 2000 was designed to rigorously assess the extent of progress in the fight against housing discrimination. Findings indicate that African Americans and Hispanics still face significant discrimination in both rental and sales markets in metropolitan areas nationwide even though the degree of discrimination has generally declined since 1989. However, Hispanic renters are the only group that discrimination has not declined over the decade. In addition, while overall levels of discrimination against minority homebuyers are falling, there are still subtle ways of discrimination in geographic steering and unequal assistance with mortgage finance (Turner & Ross, 2005).

5.2.3.6 Hotspot analysis by income level

In order to investigate the question regarding whether voucher holders spatial patterns differ by income level, voucher recipients are divided into four groups, consistent with categories adopted in previous analysis. They are extremely low income, very low income, low income, and above low income group. These income groups correspond with less than 30%, 30-50%, 50-80%, and above 80% of the area's median income. Results of general Getis-Ord G statistic are presented in Table 5-21. Most income group shows spatial clustering during five years, except above low income group. Similarly to findings by race and ethnicity, clustering of different income groups happens with high probability.

Hotspot analysis is conducted for those three income groups: extremely low, very low, and low income group. Figure 5-6 shows how each income group clusters together; however, the spatial patterns do not clearly distinguished since those income groups clusters in the northeastern regions. Regarding research question and hypotheses, there is statistically significant spatial clustering by income group among voucher holders; however, spatial patterns are not clearly differentiated among different income group.

Table 5-21 General G index by income group

Year	Income Group	G index	Z score	P value
2005	Extremely low	0.00133	27.44	0.00000*
	Very low	0.00136	38.03	0.00000*
	Low	0.00131	12.46	0.00000*
	Above low	0.00139	0.91	0.36384
2006	Extremely low	0.00129	27.84	0.00000*
	Very low	0.00127	33.38	0.00000*
	Low	0.00141	15.59	0.00000*
	Above low	0.00134	0.91	0.36285
2007	Extremely low	0.00127	27.70	0.00000*
	Very low	0.00128	34.92	0.00000*
	Low	0.00127	14.56	0.00000*
	Above low	0.00121	0.89	0.37591
2008	Extremely low	0.00125	26.59	0.00000*
	Very low	0.00126	36.57	0.00000*
	Low	0.00131	13.79	0.00000*
	Above low	0.00139	1.370	0.17080
2009	Extremely low	0.00125	26.00	0.00000*
	Very low	0.00128	33.24	0.00000*
	Low	0.00123	10.30	0.00000*
	Above low	0.00000	-0.397	0.69164

Note: * indicates that there is less than 1% likelihood that the clustering of high values could be the result of random chance.

Figure 5-6 Hot spot maps by income group

5.3 Summary of findings

A-spatial analysis of voucher recipients in Cuyahoga county shows that the vast majority of voucher recipients are in the lowest income group, of an African American racial profile, and live in the central city. In terms of neighborhood racial composition, voucher families are likely to live in neighborhoods that the same racial group is

predominant. Over 75% of African American voucher holders reside in dominantly black neighborhoods, White voucher holders are also likely to live in dominantly white neighborhoods. Both African American and White voucher users have moved into dominantly white neighborhoods over time.

Many voucher recipients live in poor neighborhoods. Three quarters of voucher families do not live in neighborhoods that are at or above the moderate poverty thresholds, Black voucher families are more likely than White households to live in poor neighborhoods. However, families who live in suburban locations are much less likely to live in high-poverty neighborhoods. About one third of voucher recipients in the central city live in neighborhoods with a poverty level less than 20%, while almost two thirds of voucher holders in suburbs are living in the same neighborhood conditions in terms of poverty level. Both African American and White voucher recipients have moved out of extremely poor neighborhoods over time. Thus, voucher users have lived in poor neighborhoods, with neighborhoods of the same racial background; however, over time, they have moved into less poor neighborhoods and into white dominant neighborhoods.

Spatial analysis allows testing the first set of research questions. The first research question asks if there is spatial concentration of voucher recipients. The hypothesis is that there is no spatial concentration of voucher recipients in Cuyahoga County. This question is important because the housing choice voucher program intends to de-concentrate and desegregate poor and minority families. Identifying spatial concentrations, which are statistically significant, assists in evaluating the program's goal achievement. Hotspot analysis answers the first research question on whether there is spatial concentration of

voucher users. Voucher recipients are likely to concentrate in specific locations such as the northeast part of the county, but they tend to scatter as time goes on.

The second research question asks if there is any difference in spatial patterns between different races, different ethnic backgrounds, and different income levels. The hypothesis is that there is no difference of spatial patterns between these variables. If African American and/or low income families tend to cluster, it increases the necessity for further investigation into a relationship between voucher recipient characteristics and neighborhood characteristics. Spatial analysis suggests that African Americans tend to cluster in the northeast part of the county while White populations tend to live the west side of the downtown. A strong spatial concentration of Hispanic voucher holders was identified by hotspot analysis. They tend to cluster in the central part of the Cleveland. Spatial clustering was also found by different income levels; however, spatial patterns were not significantly different from other income groups.

The a-spatial approach is good for a quick understanding of the general tendency of location outcomes, while it is hard to account for the real locations in which spatial clustering occurs. Hence, spatial approach overcomes the limitation of a-spatial description. Analysis of spatial distribution, including dot mapping, density map, and hotspot analysis, offers insight into the pattern of spatial concentration of voucher recipients; however, this is probably not the most effective research method for exploring factors contributing to spatial concentration of voucher recipients. Thus, in order to overcome the shortcomings of exploratory spatial data analysis, the next chapter will utilize spatial regression analysis in exploring factors influencing voucher concentration in Cuyahoga County.

CHAPTER VI

FACTORS ASSOCIATED WITH VOUCHER RECIPIENTS' CONCENTRATIONS

6.1 Model and variables

6.1.1 Regression model

Regression analysis is conducted to identify the degree of significance of factors explaining voucher recipients' location outcome. Previous literature and theories identified several factors such as the availability of affordable housing, race, vacancy rates, poverty rates, and the accessibility of public transportation.

The regression model incorporating these factors is specified as follow.

$$Y = \beta_0 + \beta_1 AFFORDH + \beta_2 BLACK + \beta_3 ASIAN + \beta_4 HISPANIC + \beta_5 VACANCY + \beta_6 POVERTY + \beta_7 TRANPORT + \varepsilon$$

Where,

Y = proportion of voucher recipients;

AFFORDH = availability of affordable housing;

BLACK, *ASIAN*, and *HISPANIC* = proportion of each group of minority;

VACANCY	=	rental vacancy rates;
POVERTY	=	poverty rates;
TRANSPORT	=	accessibility to public transportation;
β	=	parameters to be estimated;
ε	=	error term.

6.1.2 Descriptive statistics of variables

In regression model, dependent variable (y) represents housing units that are occupied by voucher recipients as a proportion of total occupied housing units in a block group. As of 2009, a total of 14,043 vouchers were issued by CMHA. There are 1,261 block groups in Cuyahoga County. ArcGIS is utilized to calculate the number of voucher holders in block groups through conducting geocoding and spatial join function. Geocoding is employed to identify every single address of voucher recipients in the study area. Then spatial join function allows us to count the number of vouchers in each block group layer. Results of geocoding address show a 99.7% match; 14,001 out of 14,043 are identified. Summing up all voucher holders in the block group is then divided by the total number of occupied housing units in order to get the proportion of voucher housing in each block group. The mean value of the dependent variable is 2.5 with a maximum of 25.8. So, there is a block group where voucher users are one out of four households in neighborhoods.

As an independent variable, *AFFORDH* represents the availability of affordable housing as the proportion of rental housing below FMR among all occupied housing units in the block group. Affordable rental housing unit is defined as renter occupied housing

units with cash rent under $749.[14] So, availability of affordable housing is calculated as the affordable rental housing units divided by total occupied housing units in the block group. Availability of affordable housing below FMR is 29.1% on average. When using central city and suburbs dichotomy, only 21% of the dwellings in suburbs have rents below the FMR, compared with 45% of dwellings in the city of Cleveland.[15] Accordingly, twice as many voucher holders are located in the central city than the suburbs among total occupied housing units (3.9% vs. 1.7%). In contrast, when considering affordable housing units below the FMR, voucher holders show a relatively even distribution between the central city and suburbs; 8.6% in the central city and 8.3% in the suburbs.

[14] FMR for two-bedroom unit in Cuyahoga County changes from $619 to $752 during 2000 and 2010. Thus, threshold $749 might slightly overestimate the actual housing stock below FMR. So, it is hard to assert that rental units under rent of $749 reflect the exactly correct number of actual affordable housing for voucher holders. However, this is not a significant overestimate considering the fact that payment standard for rental subsidies is set up to 110% of FMRs. Furthermore, previous studies also have used similar criteria to estimate the number of affordable housing below FMR (Pendall, 2000a; Finkel & Buron, 2005).

Year	Efficiency ($)	1 bedroom ($)	2 bedrooms ($)	3 bedrooms ($)	4 bedrooms ($)
2000	398	500	619	787	887
2001	442	555	687	874	984
2002	467	587	726	924	1040
2003	481	603	748	951	1070
2004	483	606	752	956	1075
2005	508	578	703	916	980
2006	488	566	682	874	929
2007	502	583	702	900	956
2008	518	602	725	929	987
2009	496	576	694	890	945
2010	526	610	735	942	1001

Fair Market Rents by bedroom size in Cuyahoga County
Source: http://www.huduser.org/portal/datasets/fmr.html

[15] Ladd and Ludwig (1997) estimated similar finding in Baltimore study: only 15% of the dwellings in suburban Baltimore have rents below the HUD-established limits, compared with 30% of dwellings in the city.

Table 6-1 Availability of affordable housing and voucher distribution

	Total	Central city	Suburbs
Affordable units/total occupied units	29.10%	45.1%	21.0%
Voucher units/ total occupied units	2.50%	3.9%	1.7%
Voucher units/ affordable units	8.40%	8.6%	8.3%

Note: Central city refers to the city of Cleveland; Suburbs mean the rest of cities except the city of Cleveland in Cuyahoga County.

BLACK, *ASIAN*, and *HISPANIC* respectively indicate the proportion of each minority population among all population in the block group. On average, minorities comprised of 31.9% of African Americans, 1.7% of Asian, and 3.8% of Hispanic.

VACANCY represents the rental vacancy rates which are calculated as the proportion of rental vacant housing units among all housing units in block group. There is an average 7.4% of rental vacancy rates in the study area.

POVERTY represents the poverty rates in block group, which is the proportion of person living below the poverty level. In Cuyahoga County, almost 15% of the population is living under the poverty level.

TRANSPORT represents the accessibility to public transportation, which is calculated as the proportion of area accessible to public transportation in a quarter mile distance divided by the total area of the block group. ArcGIS geo-processing tools create a buffer area from the public transportation line with the radius of a quarter mile. A quarter mile is adopted as a walking distance based on C. Perry's (1929) Neighborhood Unit concept. Perry organized the neighborhood unit around several physically oriented ideals such as location of school in the center of the neighborhood so that a child can walk to school without crossing a major arterial street. The distance for a child's walk to school is only about one-quarter of a mile. The area covered by a quarter mile buffer is

divided by the total area of the block group to get the accessibility of public transportation. On average, 76% of the area is accessible to public transportation. Descriptive statistics of variables for regression model is shown in Table 6-2.

Table 6-2 Descriptive statistics of regression variables

Variables	Name	Minimum	Maximum	Mean	Standard Deviation
Dependent	Voucher	0.00	25.81	2.81	3.37
Independent	*AFFORDH*	0.00	100.00	28.56	25.39
	BLACK	0.00	100.00	31.94	38.58
	ASIAN	0.00	57.89	1.65	3.83
	HISPANIC	0.00	59.86	3.77	8.06
	VACANCY	0.00	100.00	7.39	7.51
	POVERTY	0.00	100.00	14.95	15.67
	TRANSPORT	0.00	100.00	76.47	30.49

6.2 OLS regression

6.2.1 OLS base model results

Ordinary Least Squares (OLS) regression analysis is utilized to estimate the coefficient of each independent variable and to identify the statistical significance and the degree of effect. Base model refers to OLS regression model that specified previously, which includes seven independent variables (affordable housing, race, vacancy rates, poverty rates, and transportation). The dependent variable is proportion of units occupied by voucher holders divided by total occupied housing units in a block group. In order to confirm the functional form of the dependent variable, several types are tested, including original raw data (number of voucher), logarithm (ln(number of voucher)), proportion (percentage of voucher among occupied housing units), density (number of vouchers per

square mile), and concentration (LQ of voucher, ((Vouchers in block group)/(Vouchers in County))/((Housing units in block group)/(Housing units in County))). As a result of testing various forms of the dependent variable, the form of proportion is selected as the most relevant and appropriate type of the dependent variable.

Two regression models are considered with different time period of the dependent variables. The results of the previous chapter show that voucher holders are spatially concentrated and their locations are changing from 2005 to 2009. Thus, regressions with different time (the dependent variable in 2005 and 2009) would result in different coefficient estimates if voucher holders' locations have substantially changed. In this case, the different coefficients would reflect the changing relationship between voucher locations and neighborhood conditions. Also, analysis with 2005 voucher data decreases the time gap with 2000 census data.

OLS base model results show that in both years all dependent variables are significant and have the same direction of effects. They are statistically significant at least at a 95% confidence interval, except the poverty rates in the 2005 model, which is significant at a 90% level. In both models, Asian population and poverty levels are negatively associated with voucher holders. Contrarily, availability of affordable housing, African American population, Hispanic population, vacancy rates, and accessibility of public transportation are positively associated with voucher recipients. For example, holding other constant, a 10% affordable housing increase is associated with a 0.17% and 0.21% increase of voucher recipients in 2005 and 2009, respectively. A 10% increase of African American population is related with a 0.56-0.57% increase of voucher holders under the same condition of other variables.

Table 6-3 OLS base model results

Base Model	2005					2009				
	Estimate	Std Err	t-value	Prob	sig	Estimate	Std Err	t-value	Prob	sig
Intercept	-0.1176	0.2097	-0.5607	0.5756		0.0613	0.1999	0.3067	0.7591	
BLACK	0.0573	0.0027	20.9566	0.0000	***	0.0557	0.0026	21.3882	0.0000	***
ASIAN	-0.0608	0.0205	-2.9689	0.0030	***	-0.0396	0.0195	-2.0273	0.0428	**
HISPANIC	0.0623	0.0108	5.7783	0.0000	***	0.0738	0.0103	7.1833	0.0000	***
AFFORDH	0.0174	0.0049	3.5808	0.0004	***	0.0208	0.0046	4.4970	0.0000	***
POVERTY	-0.0167	0.0088	-1.8836	0.0600	*	-0.0474	0.0084	-5.6210	0.0000	***
VACANCY	0.0306	0.0133	2.3077	0.0212	**	0.0270	0.0127	2.1318	0.0332	**
TRANSPORT	0.0065	0.0029	2.2390	0.0253	**	0.0087	0.0028	3.1512	0.0017	***
Adjusted R^2	0.4642					0.4239				

Note: ***p<0.01, **p<0.05, *p<0.1

6.2.2 Regression diagnostics

Multiple regression analysis is based on several assumptions known as Gauss-Markov assumptions. These multiple linear regression (MLR) assumptions can be listed as follows: Assumption MLR.1 (linear in parameters); Assumption MLR. 2 (random sampling); Assumption MLR. 3 (no perfect collinearity); Assumption MLR. 4 (zero conditional mean); and Assumption MLR. 5 (homoskedasticity) (Wooldridge, 2006). Under Assumption MLR. 1 through MLR. 5, the OLS estimator is the best linear unbiased estimator (BLUE). Regression diagnostics are necessary to detect whether the regression coefficients are estimated under the above mentioned assumptions.

First, residual analysis is conducted to check the possibility of whether there are variables suspect to suffer a misspecification problem. Examining residual plots implies that one independent variable in the 2005 model and four independent variables in the 2009 model should be included as a form of square terms in each regression model since

their residuals show quadratic forms of distribution (refer to Appendix B). These are availability of affordable housing, poverty rates, vacancy rates, and accessibility of public transportation in the 2009 model and vacancy rates in the 2005 model. In order to address a model misspecification issue based on residual analysis, those variables are incorporated in the model along with square terms. Then, these variables are run through the regression equation. Including square terms in the model is verified by the residual plots which provide a relatively flat form compared the initial curved form (Appendix C).

Second, Variance Inflation Factor (VIF) is calculated to identify the presence and degree of multicollinearity. The VIF measures the impact of collinearity among the variables in a regression model. In the 2005 model, the VIF for each variables is less than 6, suggesting no multicollinearity issue (refer to Appendix D). In the 2009 model, the average VIF shows 10.81, implying some collinearity problems in this model (refer to Appendix E). However, Assumption MLR. 3 rules out perfect multicollinearity. Thus, there should be no exact linear relationship among independent variables. Regression can suffer collinearity to some degree; multicollinearity is a matter of degree. The VIF score of this model indicates no huge multicollinearity problem.

Third, F tests are conducted to find out whether the model includes irrelevant variables. A series of restricted models are constructed and tested using the F statistic. None of the tests reveal statistically insignificant results (refer to Appendix F). Thus, there is no reason to drop any of the variables in the regression model. A significant p-value of the F statistic and the Wald statistic indicate overall model significance (F statistic 133.7 and Wald statistic 888.2 are both significant at the 95% level in the 2009 model, for example).

6.2.3 Revised model results

The revised model contains relevant square terms based on regression diagnostics. Table 6-4 shows the results from the revised model. In both years, the revised model performs better than the previous base model. Regression coefficients are all significant at the 95% confidence interval, except two variables in the 2009 model. In the 2005 model, poverty and vacancy rates increase their significance and magnitude of impact compared to the base model. Coefficient estimates of other variables tend to decrease more than the previous model. The adjusted R^2 has slightly increased in the revised model.

Similar to the results from the base model, several factors influence voucher concentration in a positive way: African American population, Hispanic population, the availability of affordable housing, vacancy rates, and transportation accessibility. Minority population is a good indicator of voucher concentration. African American and Hispanic populations are positively related with voucher holders' concentration, while the Asian population is negatively associated. So, voucher recipients tend to live in neighborhoods that minorities are concentrated in. This implies that the voucher program has not performed well in terms of race desegregation. Poverty rates show mixed results in both years. In the 2005 model, poverty rates reveal a negative relationship with voucher concentration, implying the voucher program has been successful to deconcentrate poverty in this study area. However, as shown on the right side of Table 6-4, the 2009 revised model results in a quadratic relationship with poverty rates and

voucher holders. Until poverty rates reach 22%, the relationship is positive; however, when poverty rates in block groups are over 22%, then the relationship is reversed.[16]

Table 6-4 Revised model results

Revised Model	2005					2009				
	Estimate	Std Err	t-value	Prob	Sig	Estimate	Std Err	t-value	Prob	Sig
Intercept	-0.3224	0.2107	-1.5304	0.1265		-0.5873	0.2735	-2.1476	0.0319	**
BLACK	0.0547	0.0027	19.9344	0.0000	***	0.0471	0.0027	17.3601	0.0000	***
ASIAN	-0.0598	0.0202	-2.9528	0.0032	***	-0.0431	0.0189	-2.2855	0.0224	**
HISPANIC	0.0552	0.0107	5.1444	0.0000	***	0.0442	0.0105	4.2055	0.0000	***
AFFORDH	0.0116	0.0049	2.3567	0.0186	**	0.0370	0.0115	3.2270	0.0013	***
POVERTY	-0.0218	0.0088	-2.4813	0.0133	**	0.0749	0.0190	3.9467	0.0000	***
VACANCY	0.1378	0.0236	5.8474	0.0000	***	0.0451	0.0230	1.9656	0.0497	**
TRANSPORT	0.0065	0.0029	2.2696	0.0234	**	0.0236	0.0104	2.2720	0.0231	**
SQ_VACANCY	-0.0021	0.0004	-5.4752	0.0000	***	-0.0005	0.0004	-1.2846	0.1996	
SQ_AFFORDH	-	-	-	-		-0.0003	0.0001	-2.5846	0.0099	***
SQ_POVERTY	-	-	-	-		-0.0017	0.0003	-6.5232	0.0000	***
SQ_TRANPORT	-	-	-	-		-0.0002	0.0001	-1.9433	0.0520	*
Adjusted R^2	0.4767					0.4637				

Note: ***p<0.01, **p<0.05, *p<0.1

The threshold effect should be mentioned since several variables in the 2009 model show a quadratic relationship with the dependent variable. These quadratic form variables include public transportation, affordable housing, vacancy, and poverty rates. Based on the revised OLS model results, accessibility of public transportation is positively associated with voucher location until 59% of the area is accessible to public

[16] However, when square term of poverty rates are added in the 2005 revised model, the direction of coefficients are consistent with the results from the 2009 revised model. So, it is safe to say that the threshold effect is possible rather than asserting a linear relationship with voucher concentration and poverty rates.

transportation; however, after that point, the relationship between public transportation and vouchers is reversed. Similarly, the proportion of affordable housing stock and voucher holders are positively related until 62% of housing is affordable, and then the relationship is negative. Poverty rates affect voucher locations in a positive way to the point at which poverty rates reach 22%; however, the direction of association reverses past that point. Vacancy rates are also positively related with voucher holders until neighborhood vacancy rates reach 45%, and after that point the relationship turns negative.

Positive association of public transportation with voucher location suggests that improving accessibility to public transportation in suburbs will contribute to spreading voucher holders to suburban areas. However, this is the case until public transportation serves 60% of the neighborhood area within a quarter mile distance.[17] Similarly, vacancy rates, affordable housing, and poverty rates show the threshold like relationship. Vacancy rates are used as a proxy for landlords' participation in the program. Under the weak housing market conditions, vacancy rates are high and it is hard for landlords to find tenants, so they will consider participating in the voucher program that will ensure stable rents. The threshold might be 45%; however, the relationship would be interpreted as linear rather than quadratic considering the fact that the square term of vacancy rates is not significant and there is almost no observation that has vacancy rates over 45%.

The threshold effect of poverty implies that the voucher program is useful to deconcentrate poor households with voucher subsidy. A positive relationship holds until

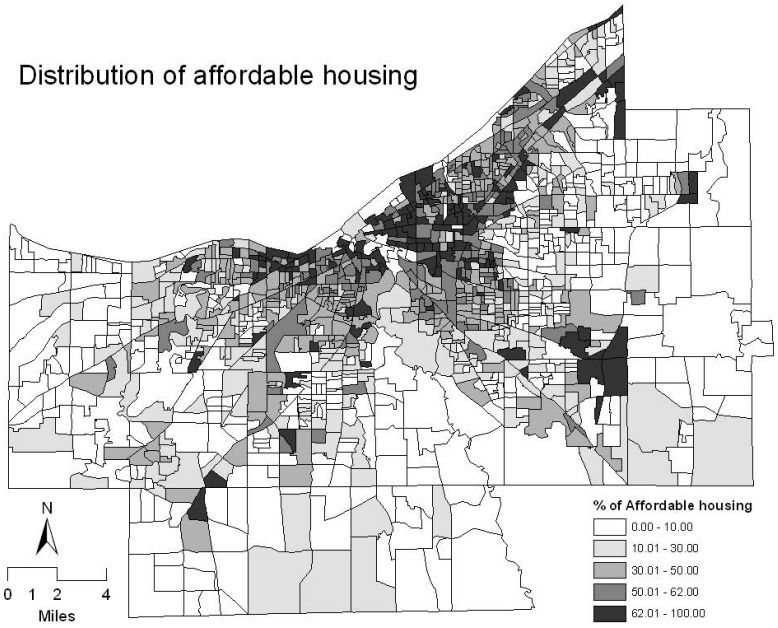
[17] This might be explained by the fact that most of the downtown block groups are covered by public transportation within a quarter mile distance. So, block groups near the downtown have 100% accessibility of public transportation.

poverty rates reach 22%, which means that voucher recipients are more likely to be found in areas with low poverty rates since the relationship turns negative after that point. In this regard, it can be inferred that the voucher program enables low-income households to live out of extremely poor neighborhoods by utilizing rental assistance.

Abundance of affordable housing below FMRs does not necessarily attract voucher users after passing some point since the coefficient of affordable housing shows threshold point. Voucher holders are easy to find their house where there are plenty of housing under the certain rent level. However, voucher recipients are supported part of the rent by the government, they do not have to find an extremely low-rent house. As Figure 6-1 indicates, the east side of the Cleveland near down is abundant of affordable rental housing; over 60% of rental housing is below FMRs. However, not many voucher holders live that region as shown in previous chapter. Plus, regression results confirm the relationship is overturn when affordable housing comprises over 60% of total rental housing. As Figure 6-2 shows, the regions that are overcrowded with affordable housing is overlapped with the regions that are abundant of low rent level, such as rent level below $400.[18] Even though voucher holders are in extremely low-income households, they are affordable to live in decent rental housing that meets their needs through rental subsidies. Thus, the threshold effect implies that the voucher program enables voucher families to live units that meet their housing needs regardless of their income level.

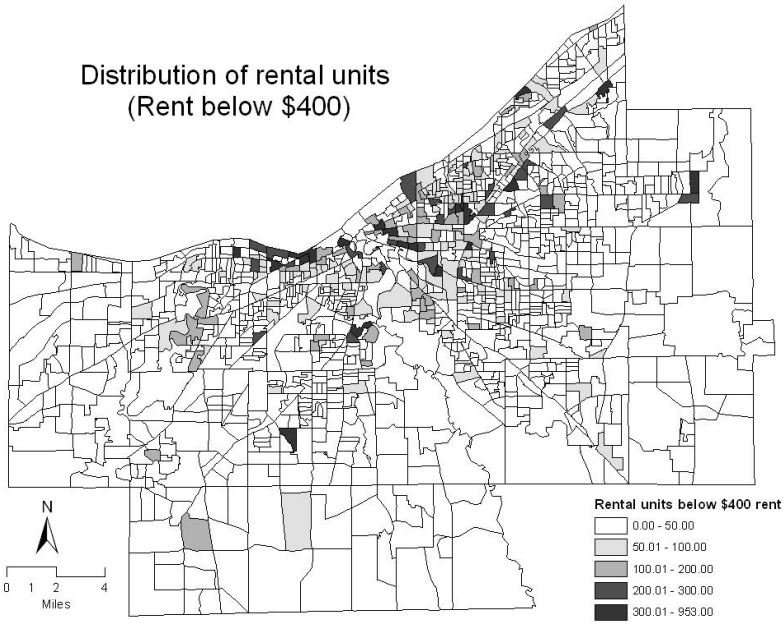
[18] Distribution of affordable rental below $300 shows similar patterns.

Figure 6-1 Distribution of affordable housing



Note: Data for affordable housing are based on 2000 Census results

Figure 6-2 Distribution of rental units below $400



Note: Data for rental units below $400 are based on 2000 Census results

6.3 Spatial regression

6.3.1 Spatial model diagnostics

Estimation of the regression model with spatial data often violates the classic regression assumptions. One of the OLS assumptions, independence of observations, is not satisfied due to spatial autocorrelation in data. This leads to a biased estimation of the standard errors of parameters, consequently misleading significance tests (Anselin, 1988). In order to identify the types of spatial dependency, LM tests were conducted. As shown in Table 6-5, a significant Moran's I indicates the presence of spatial autocorrelation, subsequently requiring a spatial regression model to address the spatial autocorrelation issue.

Table 6-5 Diagnostics for spatial dependence

	2005 model			2009 model		
TEST	MI/DF	Value	Prob	MI/DF	Value	Prob
Moran's I (error)	0.223417	14.1304	0.000000	0.236734	14.7020	0.0000000
Lagrange Multiplier (lag)	1	189.4334	0.000000	1	197.6614	0.0000000
Robust LM (lag)	1	11.3362	0.000760	1	9.9055	0.0016478
Lagrange Multiplier (error)	1	190.0554	0.000000	1	205.2978	0.0000000
Robust LM (error)	1	11.9529	0.000544	1	17.5218	0.0000281
Lagrange Multiplier (SARMA)	2	201.3916	0.000000	2	215.2033	0.0000000

Proper spatial regression is selected by the results of spatial dependence diagnostics. OLS regression results show that both of the standard LM statistics are significant, so Robust LM statistics are examined. Both Robust statistics are significant at

the level of $p<0.05$. In this case, the magnitude of significance will be criteria to select the relevant spatial model. Following the rule addressed by Anselin (2005b), the spatial error model is selected as the appropriate model (the Robust LM statistic for error is significant $p<0.0001$ compared to $p<0.001$ of the Robust LM statistic for lag in 2009, for example).

6.3.2 The spatial error model and spatial weight matrix

Spatial autocorrelation happens when the value at any one point in space is dependent on values at the surrounding points. The coefficients estimated cannot be unbiased or efficient in the presence of spatial autocorrelation, because OLS assumes the independence among all variables.

If there is spatial autocorrelation in residuals, it means that the model is systematically overestimating the observed values in some regions, and underestimating the observed values in others. Presence of spatial autocorrelation indicates that the model is not properly specified, thus the coefficients estimated by OLS are not unbiased. Anselin (1988) described model forms that deal with spatial autocorrelation. A spatial error model is appropriate when there appears to be a structure in the residual terms, while a spatial lag model is appropriate when a spatial structure is present in the variables in the model. Unbiased parameter estimates can be derived from both model types when maximum likelihood is applied as the fitting method.

This study conducts the spatial error model based on the spatial diagnostics. The spatial error model that includes a spatial autoregressive error term is specified as,

$$y = X\beta + \varepsilon, \qquad \text{with } \varepsilon = \lambda W\varepsilon + u$$

where y is a vector of observations on the dependent variable, W is the spatial weight matrix, X is a matrix of observations on the explanatory variables, ε is a vector of spatially autocorrelated error terms, μ is a vector of iid (independent and identically distributed) errors, and λ and β are parameters. Based on the above equation, the spatial error model for the study is written

$$y = \beta_1 AFFORDH + \beta_2 BLACK + \beta_3 ASIAN + \beta_4 HISPANIC + \beta_5 VACANCY + \beta_6 POVERTY + \beta_7 TRANSPORT + (I - \lambda W)^{-1} u$$

where $(I - \lambda W)^{-1}$ is a spatial multiplier.

There are several options to create a spatial weights matrix in the GeoDa software, which are contiguity-based, distance-based, and neighborhood-based spatial weights. A contiguity-based spatial weight matrix is used for a polygon shape file to include neighboring spatial entities with shared boundaries, and a distance-based spatial weight matrix is useful for a point shape file to calculate the distance between points. Plus, a neighborhood based spatial weight matrix, such as k-nearest neighbor criterion, ensures that each observation has exactly the same number (k) of neighbors (Anselin, 2005b).

Since the base map for this analysis is a shapefile, a contiguity-based option is selected to create a spatial weight matrix. There are also two different options in contiguity-based spatial weights: rook contiguity and queen contiguity weight matrix. A spatial weight matrix with queen contiguity criterion can include all neighborhoods that do not have a full boundary in common, while rook criterion often eliminates those neighborhoods which have a full boundary segment in common. The queen criterion determines neighboring units as those that have any point in common, including both common boundaries and common corners. Therefore, the number of neighbors for any

given unit according to the queen criterion will be equal to or greater than that of using the rook criterion (Anselin, 2005b). Thus, this analysis will employ the queen contiguity type as constructing a spatial weight matrix because the queen method can include neighborhoods where full boundaries are not in common.

6.3.3 Spatial error model results

Estimates and measures of fit are given in Table 6-6, showing the results from the spatial error model. In the Maximum Likelihood (ML) estimation, the R^2 listed in the results is a pseudo-R^2, which is not directly comparable with the measure given for OLS results. The proper measures of fit are the Log likelihood, AIC (Akaike Info Criterion) and SC (Schwarz Criterion). AIC and SC are methods of comparing alternative specifications by adjusting the number of coefficients in the model and value of log likelihood.[19] The higher the log likelihood, the better the model fit. On the contrary, the lower AIC and SC are, the better the model specification (Anselin, 2005b).

Spatial error model estimation presents better performance in terms of Log likelihood, AIC, and SC. When compared with OLS results, we notice an increase in the Log-Likelihood from -3013 (for OLS) to -2942 in the 2005 year model. Compensating the improved fit for the added variable (the spatial autoregressive error term), the AIC (from 6044.94 to 5902.40) and SC (from 6091.19 to 5948.65) both decrease relative to OLS, suggesting an improvement of fit for the spatial error specification.

[19] In GeoDa software, AIC is calculated as AIC=-2L+2K, where L is the log likelihood and K is the number of parameters in the model. SC is measured as SC=-2L+Kln(N), where ln is the natural logarithm and N is sample size (Anselin, 2005b).

Table 6-6 Comparison of revised model performance between OLS and the Spatial model

	2005 model		2009 model	
	OLS	Spatial Error	OLS	Spatial Error
R^2 (Adjusted/ Pseudo)	0.4767	0.5569	0.4641	0.5580
Log likelihood	-3013.47	-2940.46	-2920.76	-2836.84
Akaike info criterion	6044.94	5898.91	5865.52	5697.67
Schwarz criterion	6091.19	5945.17	5927.19	5759.35

Table 6-7 shows the results of the Maximum Likelihood estimation of a spatial error model of voucher concentration. The spatial autoregressive coefficient is estimated as 0.4565 and 0.5039 in 2005 and 2009 respectively, and both are highly significant ($p<0.0000$). The results confirm a strong positive and significant spatial autoregressive coefficient. Relative to the OLS results, the coefficient for *POVERTY* (in the 2005 model) has become insignificant. This implies that inferences based on OLS estimates may be misleading because OLS cannot account for spatial autocorrelation. The value of the coefficient estimates is slightly smaller in terms of the absolute value relative to the OLS results, except for *VACANCY* (in the 2009 model), where the change occurs from 0.0451 to 0.0557.

The threshold effect still remains in the spatial error model. In the 2005 model, vacancy rates (*VACANCY*) are associated with voucher concentration in a positive way until vacancy rates reach 30.4%, and then the relationship reverses.[20] In the 2009 model, *AFFORDH* and *POVERTY* show the quadratic relationship with voucher concentration. The affordable housing and poverty rates affect positively on voucher location until

[20] This threshold for OLS model is estimated 32.8%. The difference reflects the consideration of spatial autocorrelation in model estimation.

affordable housing reaches 50.2% and poverty rates reach 23.3%, and reverse impact past that point. As is the case in the 2005 model estimation, the 2009 spatial error model results in slightly different coefficients from ones estimated by OLS. For the 2009 model, OLS regression presents that four variables (*AFFORDH*, *POVERTY*, *VACANCY*, and *TRANSPORT*) have the threshold effect. The threshold point is estimated differently. For example, the threshold of affordable housing decreases from 61.7% (OLS) to 50.2% (spatial error model), while the threshold of poverty rates increases from 22.0% (OLS) to 23.3% (spatial error model).

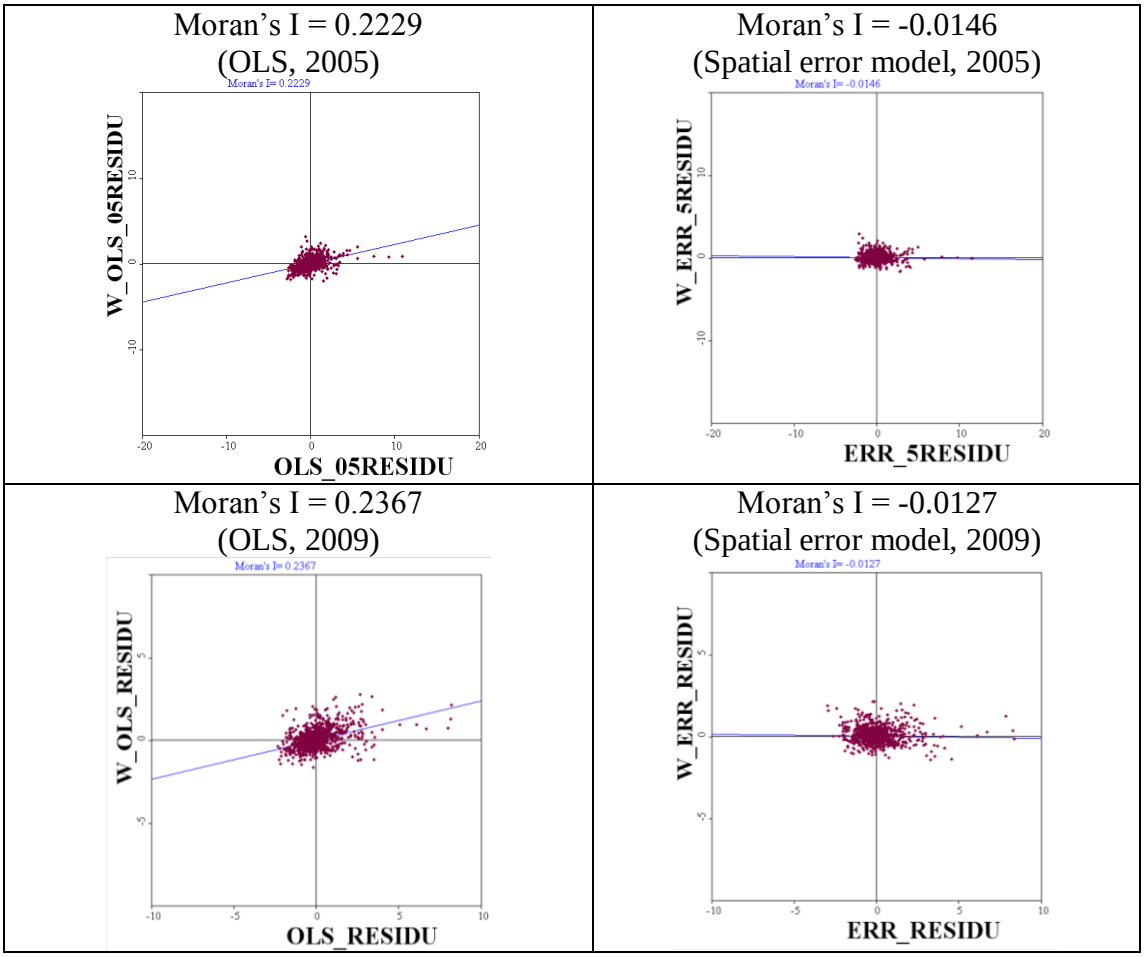
Table 6-7 Spatial error model estimation

Spatial Model	2005 Spatial Error Model					2009 Spatial Error Model				
	Estimate	Std Err	z-value	Probability	Sig	Estimate	Std. Err	z-value	Probability	Sig
Intercept	-0.1579	0.2736	-0.5771	0.5639		-0.3655	0.3171	-1.1527	0.2490	
BLACK	0.0508	0.0036	13.9619	0.0000	***	0.0448	0.0036	12.5950	0.0000	***
ASIAN	-0.0490	0.0211	-2.3165	0.0205	**	-0.0390	0.0196	-1.9938	0.0462	**
HISPANIC	0.0521	0.0137	3.7972	0.0001	***	0.0344	0.0131	2.6218	0.0087	***
AFFORDH	0.0087	0.0048	1.8004	0.0718	*	0.0301	0.0110	2.7249	0.0064	***
POVERTY	-0.0087	0.0086	-1.0038	0.3155		0.0560	0.0177	3.1623	0.0016	***
VACANCY	0.1033	0.0221	4.6690	0.0000	***	0.0557	0.0210	2.6471	0.0081	***
TRANSPORT	0.0066	0.0032	2.0554	0.0398	**	0.0182	0.0104	1.7519	0.0798	*
SQ_VACANCY	-0.0014	0.0004	-3.9258	0.0000	***	-0.0004	0.0003	-1.1842	0.2363	
SQ_AFFORDH						-0.0003	0.0001	-2.2144	0.0268	**
SQ_POVERTY						-0.0012	0.0002	-5.1396	0.0000	***
SQ_TRANSPORT						-0.0001	0.0001	-1.3231	0.1858	
Lambda	0.4734	0.0359	13.1536	0.0000	***	0.5039	0.0349	14.4535	0.0000	***
Pseudo R^2	0.5569					0.5580				

Note: ***p<0.01, **p<0.05, *p<0.1

Moran scatter plots for the spatial error model are visualized as shown below. For residuals of the spatial error model, the Moran's I test statistic is -0.0146 (in the 2005 model) and -0.0127 (in the 2009 model), showing essentially zero. This indicates that including the spatially autoregressive error term in the model has eliminated all spatial autocorrelations.

Figure 6-3 Moran scatter plots for residuals from OLS and Spatial error models



6.4 Geographically weighted regression (GWR)

6.4.1 GWR analysis

Coefficient estimates from the OLS regression do not incorporate spatial effects. Spatial regression analysis accounts for spatial autocorrelation; however, it still assumes that spatial effects are constant over the study area. So, coefficient estimates from the spatial regression indicate the mean value that does not vary over space. Contrarily, GWR is relevant to capture spatially varying relationships between the dependent and independent variables.

The GWR model to identify the factors influencing voucher location is specified as follows:

$$y(u_i, v_i) = \beta_0(u_i, v_i) + \beta_1 AFFORDH\,(u_i, v_i) + \beta_2 BLACK\,(u_i, v_i) + \beta_3 ASIAN\,(u_i, v_i) + \beta_4 HISPANIC\,(u_i, v_i) + \beta_5 VACANCY\,(u_i, v_i) + \beta_6 POVERTY\,(u_i, v_i) + \beta_7 TRANPORT\,(u_i, v_i) + \varepsilon_i$$

where β_0 is the intercept, (u_i,v_i) is the coordinates of the i^{th} point in space, and β_1 through β_7 are the parameter estimates changing across the space.

GWR statistical software (GWR 3.0) developed by Fotheringham et al. (2002) provides locally varying parameter estimates and their significance based on a Monte Carlo test. There are several options to conduct GWR estimation: choosing kernel type, bandwidth, and type of significance test. An adaptive kernel, a corrected Akaike Information Criterion (AICc) minimization methods, and a Monte Carlo significance test are adopted to conduct GWR. When choosing kernel types, there are two types such as fixed or adaptive. An adaptive kernel is utilized to provide the geographic weighing in the model. If the observations are regularly distributed in the study area, a fixed kernel is appropriate. However, if the observations are clustered so that the density of observations

varies over the study areas, then an adaptive kernel is appropriate. In this regard, the adaptive kernel type is relevant for this study, since voucher recipients show spatial concentration over the study area. Also, the AICc method finds the bandwidth which minimizes the AICc value. The AICc method is recommended due to interaction between the bandwidth and the complexity of the model. Finally, Monte Carlo tests are utilized to determine the significance of the spatial variability in the local parameter estimates. Testing individual parameter stationarity is essential to determine whether the observed variation is sufficient to reject the hypothesis that the parameter is globally fixed. As a consequence, if the results of Monte Carlo tests on the local estimates are significant, this indicates that there is significant spatial variation in the local parameter estimates for the variable (Fotheringham et al., 2002; Charlton & Fotheringham, 2009).

6.4.2 GWR model performance

GWR provides better performance than OLS. Diagnostic information is listed in Table 6-8. In both year models, GWR provides a significantly low value of the residual sum of squares, which is the difference between an observed y-value and its estimated value returned by the GWR model. AICc is useful to compare the measure of model performance. The model with the lower AICc value provides a better fit to the observed data because AICc is a measure of spatial collinearity within the model data. GWR models show significantly better performance level in terms of AICc, indicating a decreasing value from 380 (2005 model) to 160 (2009 model). These big differences are

strong evidence of an improvement in the fit of the model to the data.[21] More intuitively, an adjusted R^2 confirms a substantial improvement of GWR compared to OLS. Specifically, in the 2005 model, it increases from 0.4762 to 0.7103, indicating that the OLS model explains less than a half of the variance of the data while the GWR explains over 70% of the variance.

Table 6-8 GWR model performance

	2005		2009	
	OLS	GWR	OLS	GWR
Residual sum of squares	8788.99	3866.60	7587.30	6216.90
Effective number of parameters	9	265	12	55
Sigma	2.65	1.97	2.46	2.27
Akaike Information Criterion	6047.09	5666.10	5867.81	5707.22
Adjusted r-square	0.4763	0.7103	0.4637	0.5449

Table 6-9 Results of ANOVA test for GWR over OLS

Year	2005				2009			
Source	SS	DF	MS	F	SS	DF	MS	F
OLS Residuals	8789.0	9.0			7587.3	12.0		
GWR Improvement	922.4	255.9	19.2346		1370.4	42.8	32.0063	
GWR Residuals	3866.6	996.1	3.8818	4.9551	6216.9	1206.2	5.1542	6.2098

ANOVA results also reports that the GWR model improves significantly over the OLS counterpart. The ANOVA tests the null hypothesis that the GWR model represents no improvement over a global model (Fotheringham, et al., 2002). High F-values in Table 6-9 suggest that the local model has a significant improvement over the global

[21] As a rule of thumb, if the AICc difference between two models is less than 3 to 4, then there is no significant improvement and there is little evidence to choose one over the other.

model in determining the relationship between voucher concentration and the various factors.

6.4.3 GWR results

Table 6-10 and Table 6-11 summarize the results of OLS and GWR analysis. The Monte Carlo test calibrated for the GWR model finds that most of explanatory variables displayed significant spatial non-stationarity in the case of 2005 model. Seven independent variables (*BLACK, ASIAN, HISPANIC, POVERTY, VACANCY*, and *TRANSPORT*) turn out to be significant in terms of spatial variation. These variables are also significant in OLS analysis; however, the significant local parameters indicate that the locally varying impact of these independent variables on the dependent variable. Thus, in some areas the influence of the variable might be stronger than in other areas.

Furthermore, the 2005 GWR model explain 71% of the variance, so GWR provides better explanatory power than the global OLS model (Adjusted R^2=0.4763). The local R^2 of each individual GWR model ranges from 0.1064 to 0.9305, with a mean of 0.5465. Only about 35% of the local R^2 values are lower than the global OLS value, and over 60% are higher than 0.5. Based on the GWR results, it can be inferred that the relationship between voucher concentration and factors affecting voucher holders' location choice is better captured by the GWR model in the study area.

Table 6-10 GWR results (2005 model)

	OLS				GWR				
	Estimate	Std Err	t	Sig	Min	Median	Max	p-value	Sig
Intercept	-0.3224	0.2107	-1.5304		-6.8339	-0.0040	14.7082	0.0000	***
BLACK	0.0547	0.0027	19.9344	***	-0.2245	0.0338	0.1461	0.0000	***
ASIAN	-0.0598	0.0202	-2.9528	***	-1.0737	-0.0264	1.7689	0.0000	***
HISPANIC	0.0552	0.0107	5.1444	***	-0.6815	0.0357	0.7152	0.0000	***
AFFORDH	0.0116	0.0049	2.3567	**	-0.0862	0.0035	0.1910	0.2300	
POVERTY	-0.0218	0.0088	-2.4813	**	-0.1389	0.0100	0.4744	0.0000	***
VACANCY	0.1378	0.0236	5.8474	***	-1.9763	0.1212	1.1364	0.0000	***
TRANSPORT	0.0065	0.0029	2.2696	**	-0.1455	0.0013	0.0688	0.0000	***
SQ_VACANCY	-0.0021	0.0004	-5.4752	***	-0.0361	-0.0048	0.1530	0.0000	***
Adjusted R^2	0.4763				0.7103				

Note: Significance ***p<0.01, **p<0.05, *p<0.1

GWR Significance based on Monte Carlo test for spatial non-stationarity

Table 6-11 GWR results (2009 model)

	OLS				GWR				
	Estimate	Std Err	t	Sig	Min	Median	Max	p-value	Sig
Intercept	-0.5873	0.2735	-2.1476	**	-0.9464	-0.4455	0.2939	0.4300	
BLACK	0.0471	0.0027	17.3601	***	0.0229	0.0438	0.0719	0.0000	***
ASIAN	-0.0431	0.0189	-2.2855	**	-0.2301	-0.0389	0.0811	0.0000	***
HISPANIC	0.0442	0.0105	4.2055	***	0.0061	0.0448	0.1037	0.0700	*
AFFORDH	0.0370	0.0115	3.2270	***	0.0024	0.0331	0.1409	0.0300	**
POVERTY	0.0749	0.0190	3.9467	***	-0.0587	0.0900	0.1508	0.1100	
VACANCY	0.0451	0.0230	1.9656	**	-0.0917	0.0592	0.1595	0.5700	
TRANSPORT	0.0236	0.0104	2.2720	**	-0.0202	0.0219	0.0928	0.0100	***
SQ_VACANCY	-0.0005	0.0004	-1.2846		-0.0055	-0.0010	0.0097	0.1600	
SQ_AFFORDH	-0.0003	0.0001	-2.5846	***	-0.0015	-0.0003	0.0004	0.1400	
SQ_POVERTY	-0.0017	0.0003	-6.5232	**	-0.0032	-0.0016	0.0003	0.3500	
SQ_TRANPORT	-0.0002	0.0001	-1.9433	*	-0.0008	-0.0001	0.0002	0.0100	***
Adjusted R^2	0.4637				0.5449				

Note: Significance ***p<0.01, **p<0.05, *p<0.1

GWR Significance based on Monte Carlo test for spatial non-stationarity

The 2009 model also shows similar results regarding model performance and spatial non-stationarity of variables. The explanatory power of the model has been improved from 0.4637 (OLS) to 0.5449. Six out of eleven independent variables turn out to be significant in terms of spatial variation. These variables include race variables, affordable housing, and public transportation. Thus, the influence of these variables over space might be varying locally, which is contrary to the results from OLS that assumes a constant estimate over the study area.

6.4.3.1 Local R^2 variation

Local R^2 in the 2005 model ranges from a minimum of 0.1064 to a maximum of 0.9305. Local R^2 indicates how well the local regression model fits the observed y-value. Very low values indicate that the local model is performing poorly, while high values report that the local model fits well. The local R^2 map reveals a local variation in the performance of the model across space. The 2005 GWR model explains at least 50% of variation in the north regions and the eastern part of the county. These cities include Euclid, Richmond Heights, Cleveland Heights, Garfield Heights, Shaker Heights, Warrensville Heights, and Mayfield Heights. However, the model fits poorly in the area around the east side of Cleveland and southwestern suburbs, such as Parma and Strongsville. These local variations cannot be detected by the OLS and Spatial error model estimations.

Local R^2 in the 2009 model indicates spatial variation of model fitness; however, it has a different pattern when compared to the 2005 model. Local R^2 in the 2009 model ranges from 0.3664 to 0.6518. The model fits well in the south suburbs such as Parma

and Parma Heights. Also, the model explains more than half of the variation in the east and the west suburbs. Spatial variation of the local R^2 in the 2005 and 2009 models is mapped in Figure 6-4 and Figure 6-5.

Figure 6-4 Spatial variation of local R^2 (2005 GWR model)

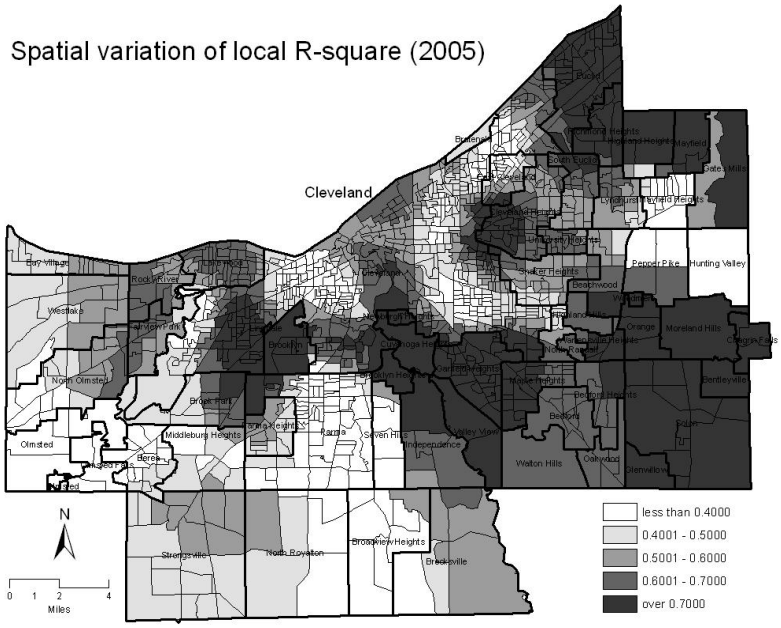
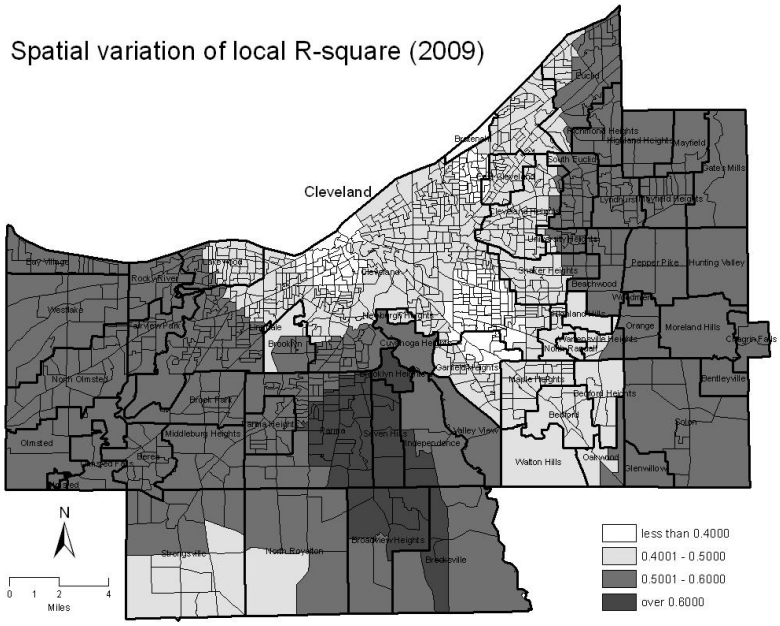


Figure 6-5 Spatial variation of local R^2 (2009 GWR model)



6.4.3.2 African American population

Local coefficient estimates for *BLACK* are shown in Figure 6-6 through Figure 6-9. The coefficient estimate of *BLACK* in the 2005 global model was 0.0547, with a standard error of 0.0027. The map of the local coefficients variation reveals that the influence of the *BLACK* variable in the 2005 GWR model varies considerably over Cuyahoga County. The influence of black population on voucher concentration is strong on the east side of the county such as in East Cleveland, South Euclid, Cleveland Heights, University Heights, Shaker Heights, Garfield Heights, Lyndhurst, Mayfield, Mayfield Heights, Bedford, and Bedford Heights. In these areas, voucher holders' concentrations are positively related to African American population. Except those areas and the west part of the Cleveland near Brooklyn, the relationship is not significant at a 95% confidence interval, as shown in Figure 6-7.

Figure 6-8 presents the *BLACK* parameter distribution in the 2009 model. The global estimate of *BLACK* is 0.0448 with a standard error of 0.0036 in the 2009 revised OLS. The local coefficients vary from 0.0229 to 0.0719 and show significant spatial variation based on the Monte Carlo test. The northeast and the southwest part of the regions have larger coefficient estimates than the regions in the middle; however, the t-value map discovers that the *BLACK* parameters are significant in all regions at the 95% level. Thus, it can be inferred that black population significantly influences voucher locations, and impacts are stronger in suburban regions.

Figure 6-6 *BLACK* parameter variation (2005 GWR model)

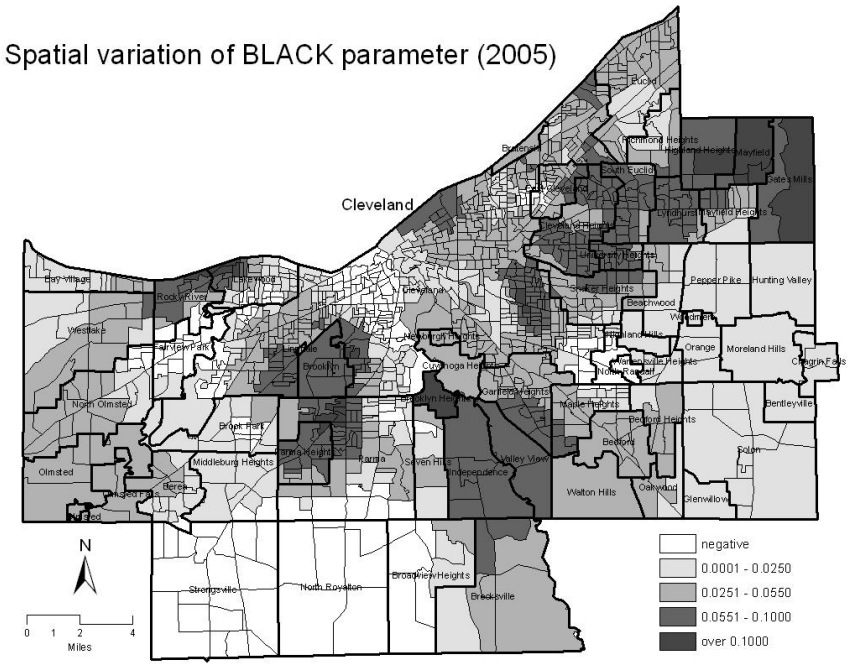


Figure 6-7 *BLACK* t-value variation (2005 GWR model)

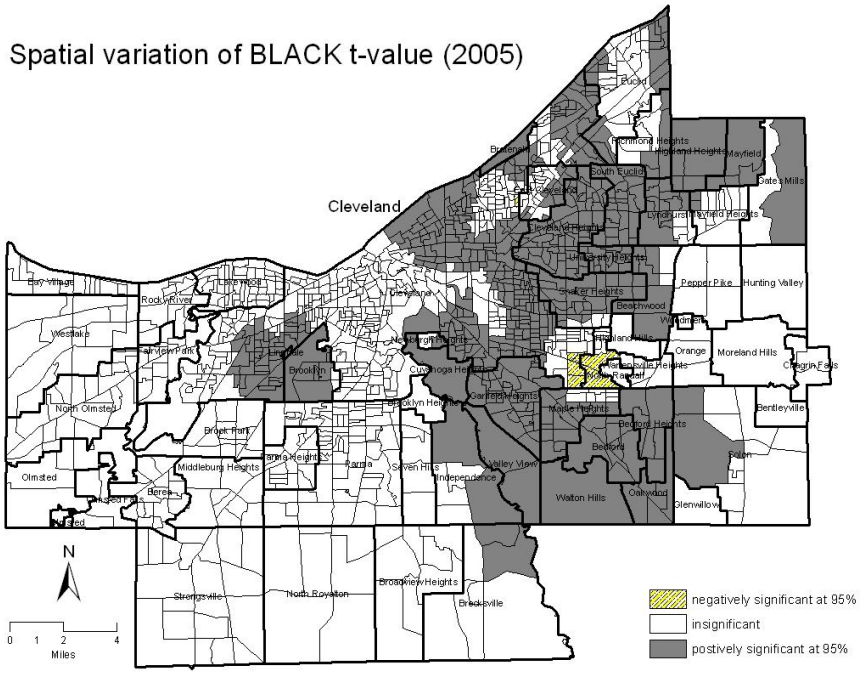


Figure 6-8 *BLACK* parameter variation (2009 GWR model)

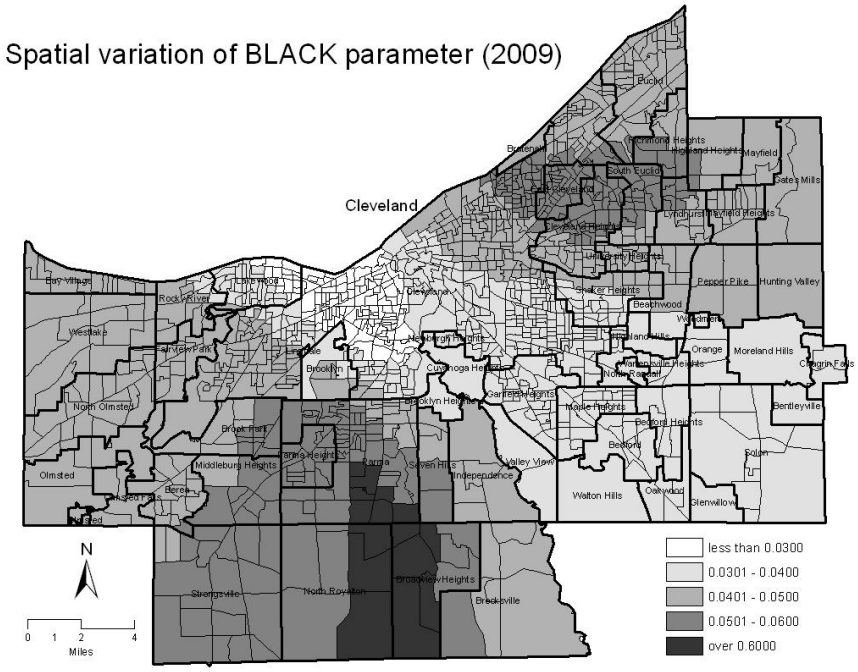
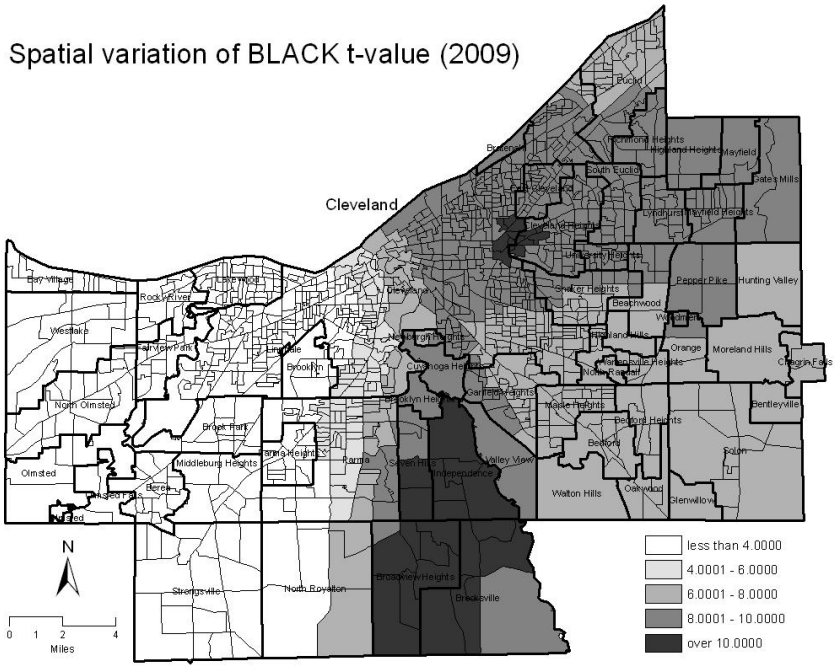


Figure 6-9 *BLACK* t-value variation (2009 GWR model)



6.4.3.3 Asian population

GWR analysis shows how the relationship between Asian population and voucher holders varies over space, while the global OLS model shows the relationship is linear and negative. The 2005 GWR model indicates that several cities have a negative impact of Asian population on voucher locations, such as part of Euclid, Cleveland, and Richmond Heights. Few areas have a positive effect of Asian population in the 2005 GWR model.

The 2009 GWR model exhibits a different pattern of effect. Many of the eastern regions show a significant negative relationship, implying that increase of Asian population is negatively associated with voucher holders' location outcomes.

Figure 6-10 *ASIAN* parameter variation (2005 GWR model)

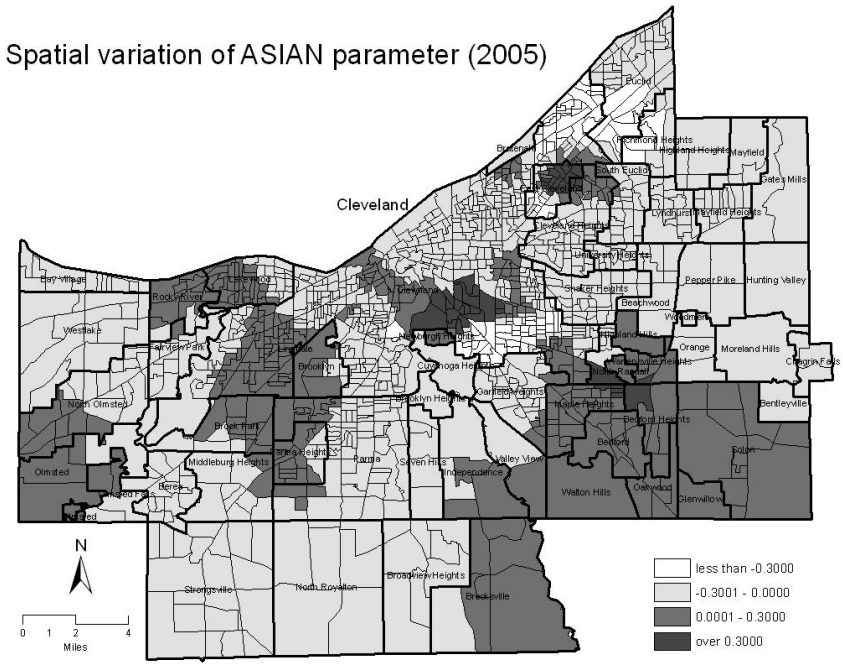


Figure 6-11 *ASIAN* t-value variation (2005 GWR model)

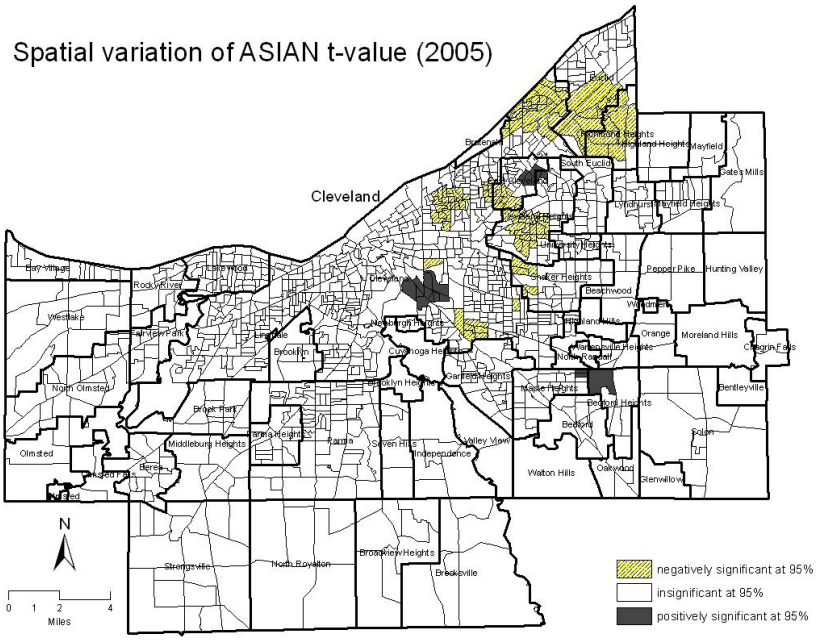


Figure 6-12 *ASIAN* parameter variation (2009 GWR model)

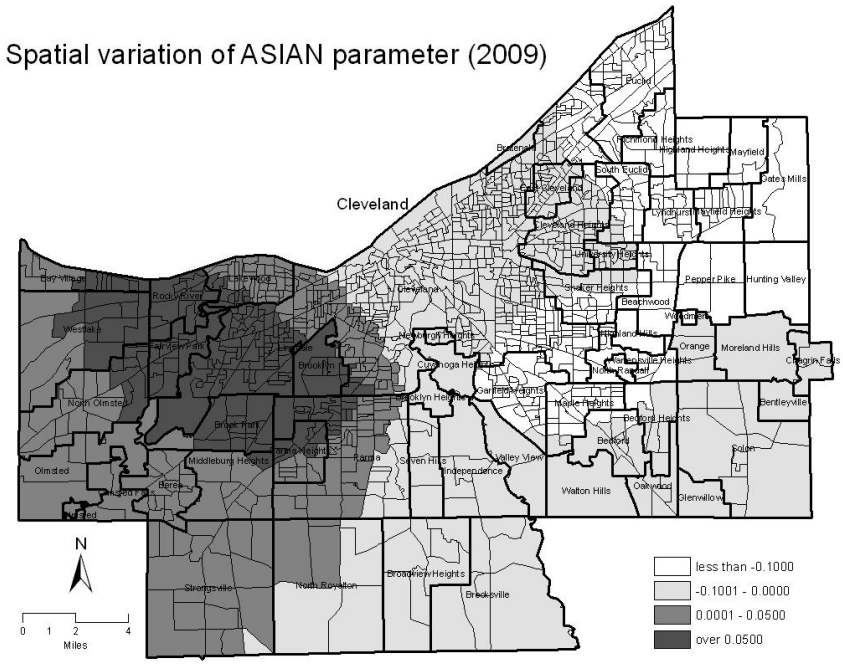
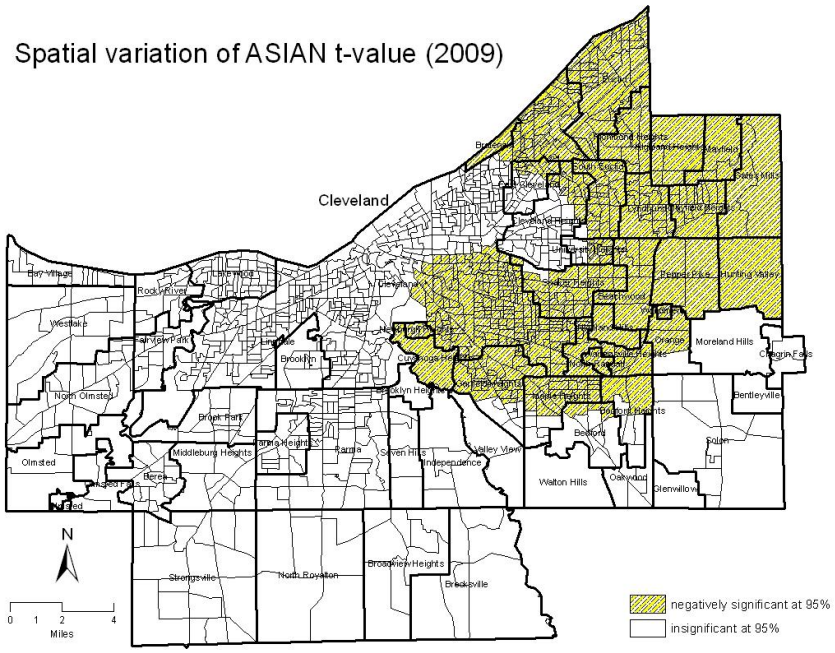


Figure 6-13 *ASIAN* t-value variation (2009 GWR model)



6.4.3.4 Hispanic population

Hispanic variable is significant in the 2005 GWR model, and it shows significant t-values in several regions. A positive impact exists in the middle of City of Cleveland, Brooklyn, and part of Cleveland Heights. On the contrary, a negative effect is found in the north part of City of Cleveland, the west side of Shaker Heights.

Figure 6-14 *HISPANIC* parameter variation (2005 GWR model)

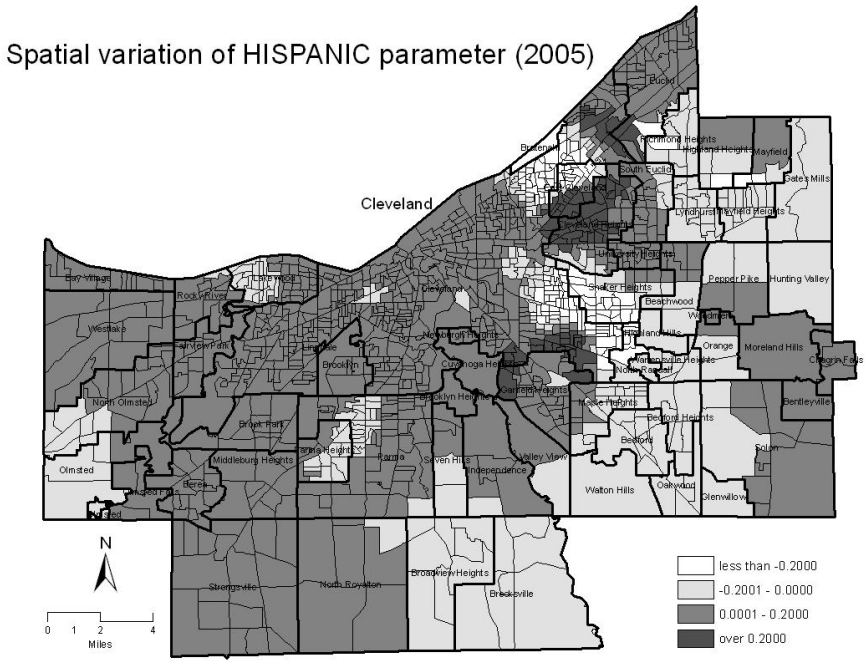
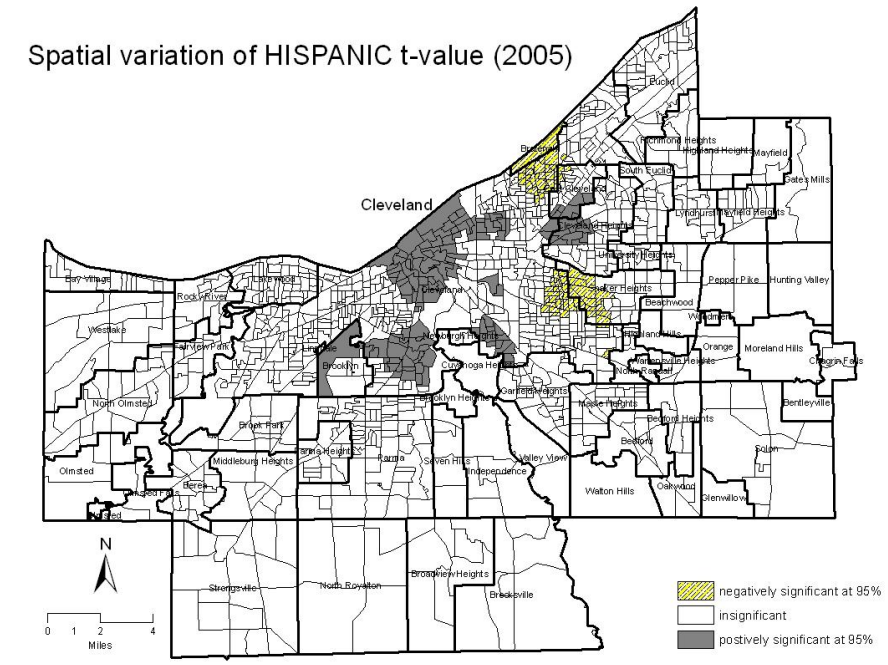


Figure 6-15 *HISPANIC* t-value variation (2005 GWR model)



6.4.3.5 Affordable housing below FMRs

The Monte Carlo test for spatial non-stationarity shows that there is significant spatial variation in the local parameter estimates for the variable *AFFORDH* in the 2009 model. As expected, voucher holders' locations are positively related with the availability of affordable housing, which is rental housing whose rent level is below the FMRs. Based on GWR model, the relationship is especially significant in the northeast regions, such as the east side of the City of Cleveland, East Cleveland, Cleveland Heights, Richmond Heights, and Euclid. Spatial variation of local parameters and significance are shown in Figure 6-16 and Figure 6-17 for the 2009 GWR model.

Figure 6-16 *AFFORDH* parameter variation (2009 GWR model)

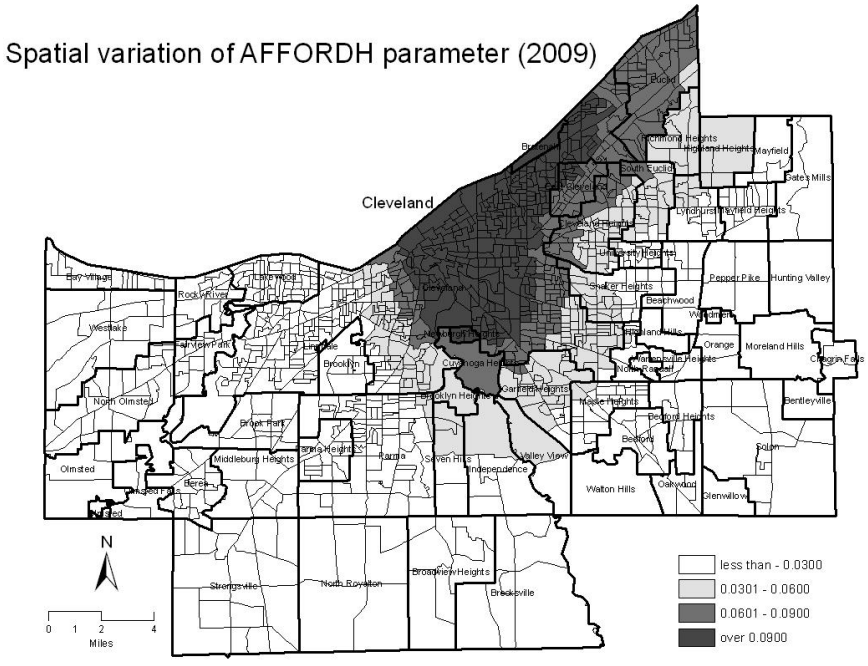
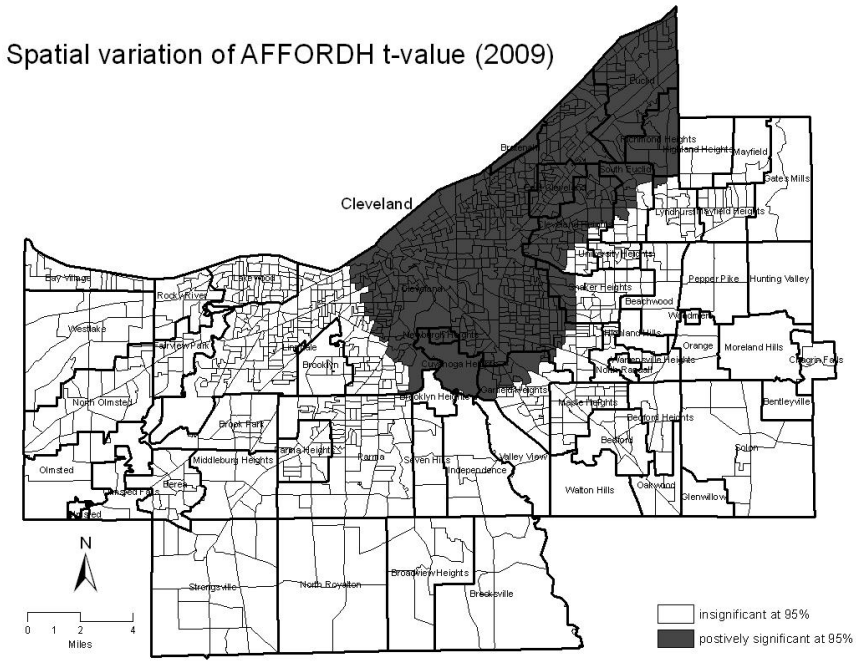


Figure 6-17 *AFFORDH* t-value variation (2009 GWR model)



6.4.3.6 Poverty rates

The 2005 GWR model confirms the local variation of poverty variable. The global estimate of the poverty variable was -0.0218 with the standard deviation of 0.0088; GWR parameter ranges from -0.1389 to 0.4744. As shown in Figure 6-19, the relationship between voucher concentration and poverty rates are negative in some areas near City of Cleveland. In these areas, voucher recipients tend to live in low poverty neighborhoods, implying that the voucher program works relatively well in terms of poverty deconcentration. In contrast, there is a different type of story in suburban areas. Poverty rates influence voucher concentrations in a positive way in the north regions (Euclid and Richmond Heights) and the south regions (Bedford, Bedford Heights, Warrensville, and Maple Heights). In these suburbs, the poverty coefficient is estimated positively significant, suggesting that voucher recipients tend to live in high poverty

neighborhoods, which is contrary to what is expected to be achieved through the voucher program. In general, the voucher program in Cuyahoga county has achieved the poverty deconcentration goal based on the 2005 global model, since it shows negative relationship. However, it is hard to assert that poverty deconcentration has achieved in all areas because the GWR model results show substantial variation both in local coefficients and t-values. Based on both global and GWR model, it can be inferred that voucher holders living in or near the central city tend to find their house in neighborhoods with low poverty rates; however, voucher holders in suburbs are likely to end up neighborhoods with high poverty rates, even though the absolute level of poverty rates in suburbs are significantly lower than those of in the central city.

Figure 6-18 *POVERTY* parameter variation (2005 GWR model)

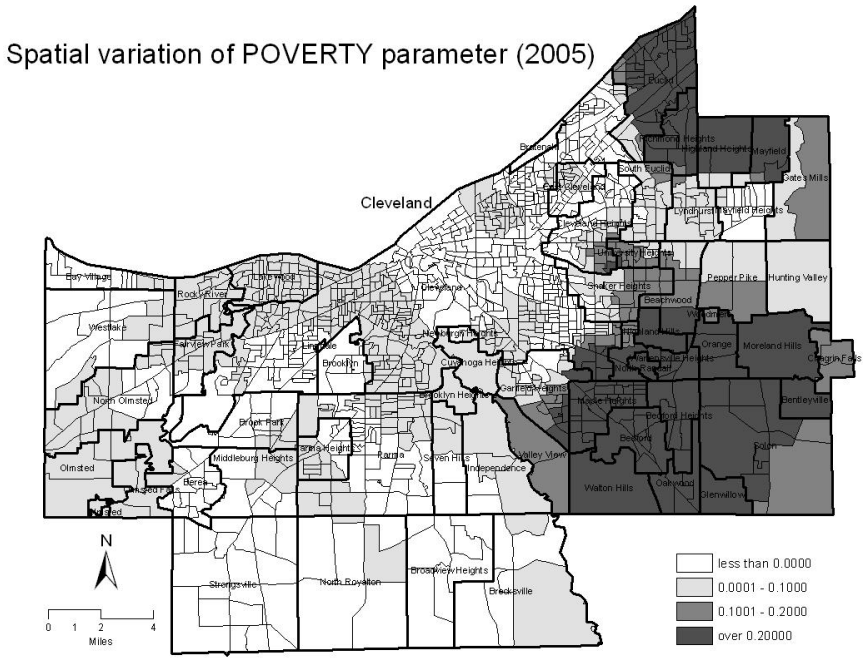
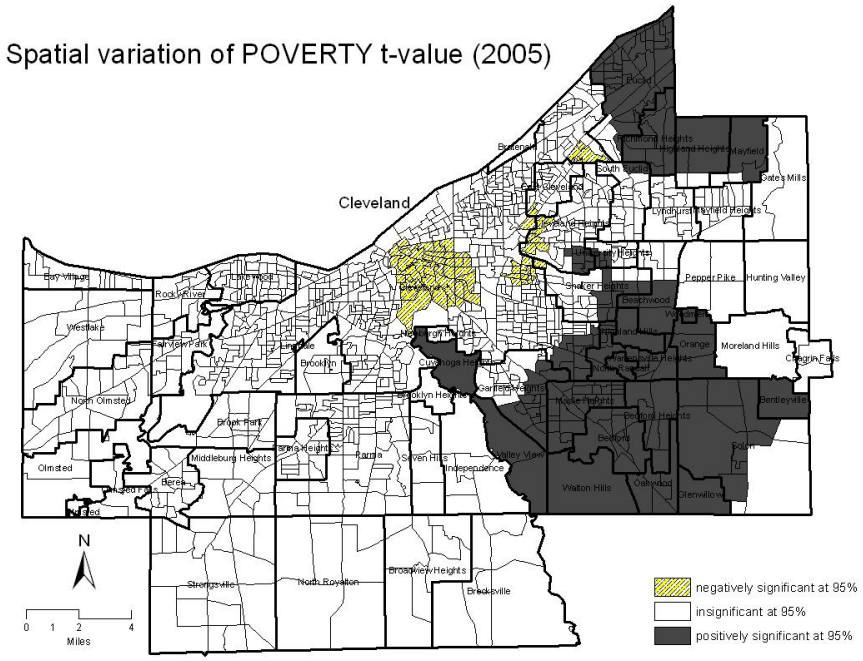


Figure 6-19 *POVERTY* t-value variation (2005 GWR model)



6.4.3.7 Vacancy rates

Vacancy rates have a positive effect on voucher concentration and their impacts vary over space. Vacancy rates in the 2005 global model had a significant positive impact on voucher concentration with the coefficient of 0.1378. The map for the local coefficients of the variable indicates that the influence varies significantly. The relationship between voucher concentration and vacancy rates are negative and significant in the north suburbs such as Euclid and Richmond Heights. Contrarily, several regions reveal a positive relationship. These areas include the east side of the Cleveland, East Cleveland, Cleveland Heights, the southern part of Shaker Heights, and Bedford Heights.

Figure 6-20 *VACANCY* parameter variation (2005 GWR model)

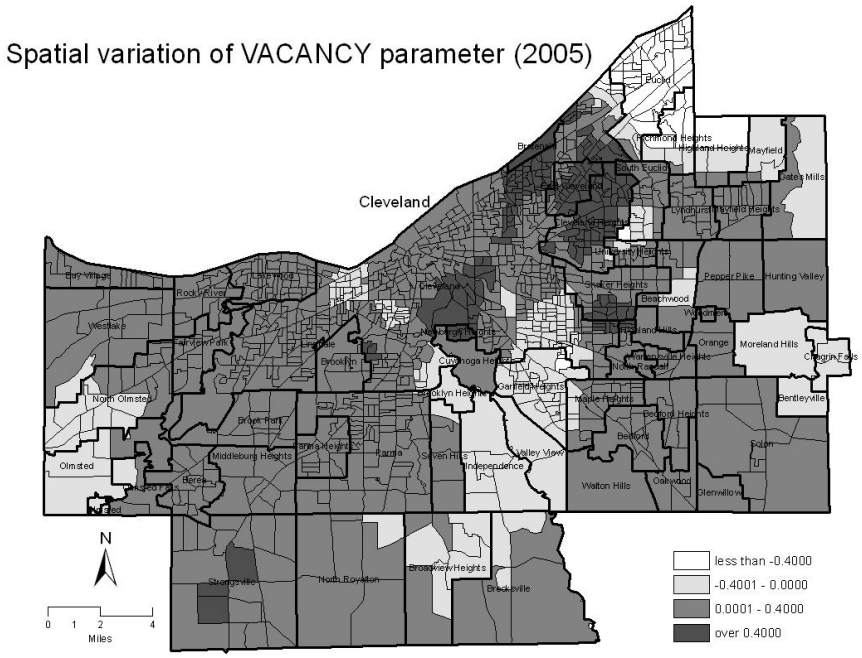
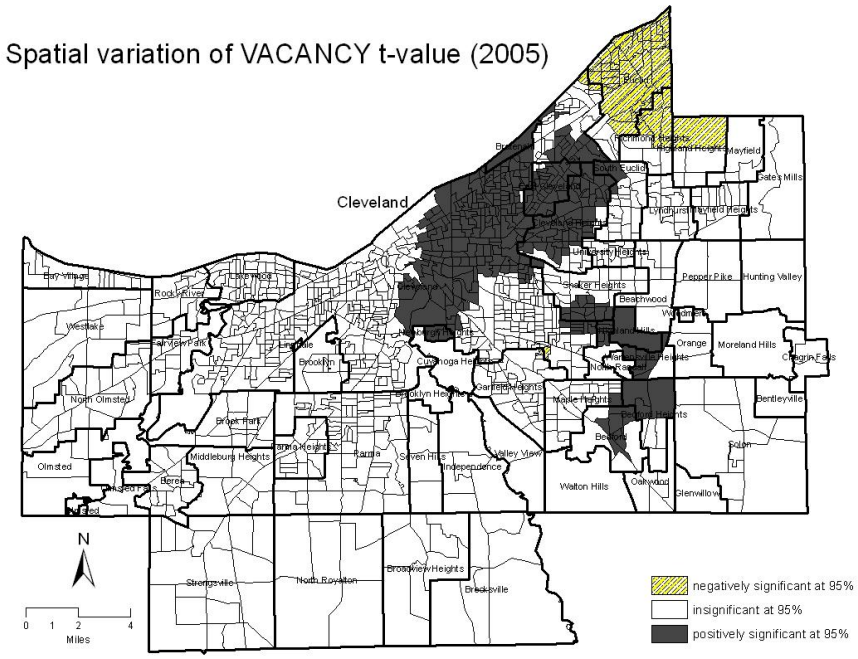


Figure 6-21 *VACANCY* t-value variation (2005 GWR model)



Vacancy rates in this model are incorporated to account for landlords' participation in the program. Research found that landlords have more incentives to participate in the voucher program where vacancy rates are high, so they have difficulty in finding tenants. Local parameter variation of vacancy rates implies that location choice of voucher holders in and near the central city is positively influenced by vacancy rates (or landlords' participation, or weak market conditions). However, vacancy rates and voucher holders are positively related in the north suburbs.

The comparison of global (OLS) and local (GWR) models provides enhanced understanding of the relationship between voucher locations and vacancy rates. Based on the global model (2005 revised OLS), vacancy rates affect voucher holders location outcomes in a positive way until vacancy rates reach 32.8%; after that point, the relationship is negative. The 2005 GWR model identifies the place where the relationship is positive or negative.

6.4.3.8 Accessibility to public transportation

Accessibility to public transportation has a different degree of influence across the study area. The 2009 GWR model shows distinct patterns. In general, areas more accessible to public transportation have more voucher holders living in them. This phenomenon is especially true for the northeast regions, such as the east side of the Cleveland, Cleveland Heights, South Euclid, Euclid, Shaker Heights, and University Heights. Also, the voucher location is explained well by the accessibility of public transportation in the south suburbs, such as Maple Heights, Bedford, and Bedford Heights.

Figure 6-22 *TRANSPORT* parameter variation (2005 GWR model)

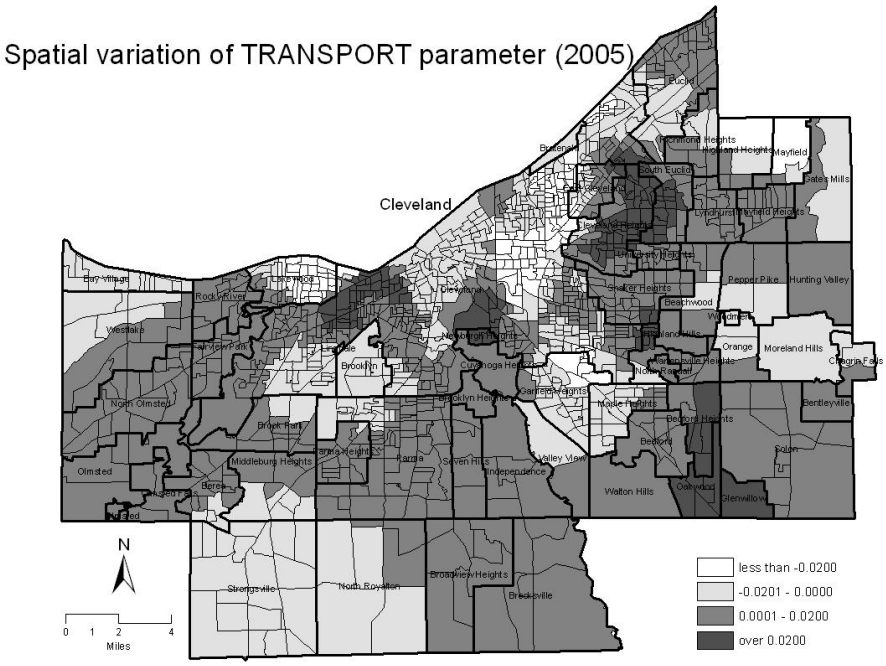


Figure 6-23 *TRANSPORT* t-value variation (2005 GWR model)

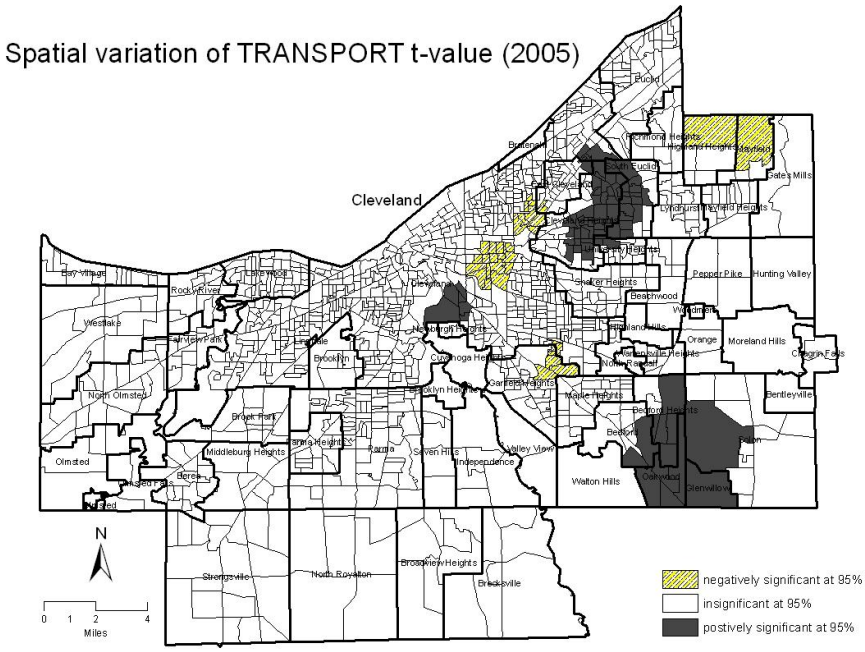


Figure 6-24 *TRANSPORT* parameter variation (2009 GWR model)

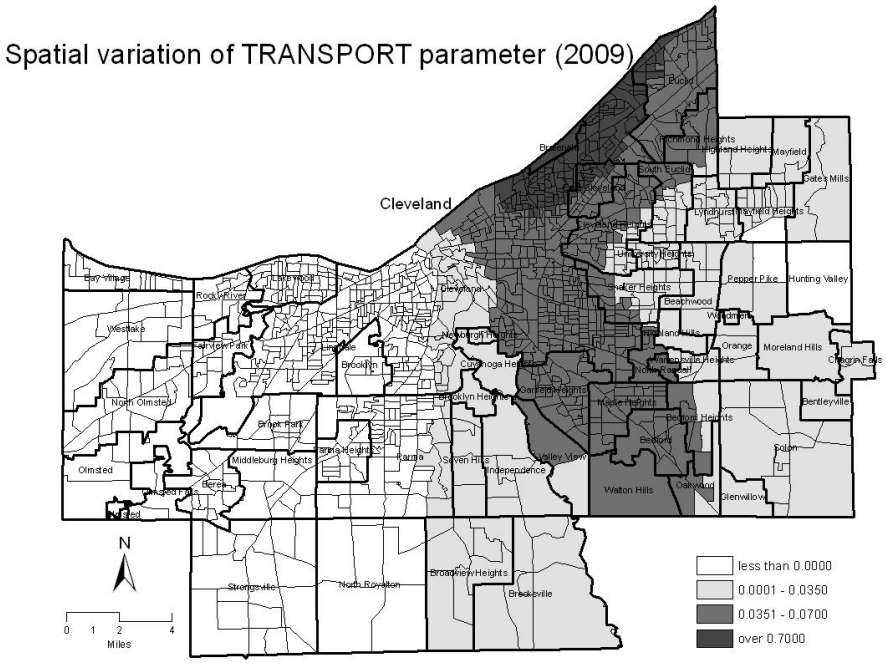
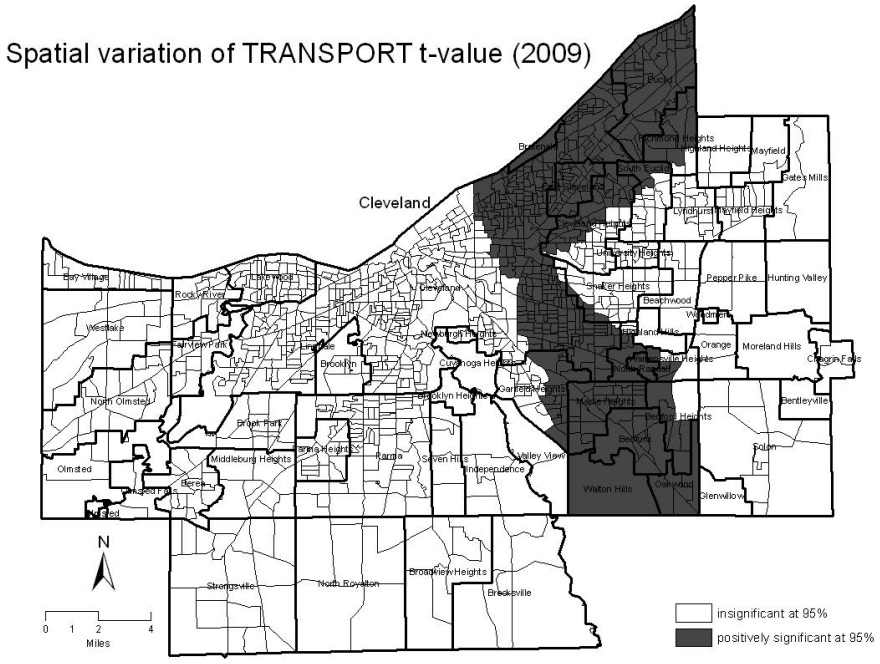


Figure 6-25 *TRANSPORT* t-value variation (2009 GWR model)



6.5 Summary of findings

A series of regression analyses are conducted to identify the factors explaining voucher location outcomes. The OLS regression model, spatial regression model, and GWR model are considered in order to find the relevant functional forms, to incorporate spatial autocorrelation, and to account for spatial heterogeneity. OLS regressions point out the threshold effect of several variables such as affordable housing, poverty, vacancy, and public transportation. Analyzing spatial data requires spatial diagnostics to prevent biased estimates. Spatial diagnostics show that the error model is relevant for this study. Incorporating the spatial autoregressive error term confirms the results obtained by OLS. Also, it eliminates all of the spatial autocorrelation issues noticed in the OLS models. In addition, the GWR model is adopted to deal with spatial heterogeneity issues. The Monte Carlo tests confirm that spatial patterns of several variables vary significantly over space.

Comparing and contrasting the findings from GWR (local model) with OLS (global model) sheds light on the local variation of influential factors on voucher location. The global model results are only average across the study areas and can hide many interesting spatial variations in a relationship that is illuminated in the local analysis. The results of the OLS model are hard to visualize and give a global parameter estimate for each variable that is applied to every point in the study area regardless of location. This is an issue when relationships between variables change over space. In this regard, the GWR model is appropriate in terms of estimating local fit in multiple locations and of visualizing the local variation.

With regard to policy implication, a statistically significant global variable that has little local variation informs region-wide policy. On the contrary, statistically significant global variables that exhibit strong regional variations suggest local policy (Charlton & Fotheringham, 2009). As results from the global model show, all independent variables are statistically significant; however, there are significant local variations of the variable.

The 2005 GWR model substantially improves the explanatory power compared to global OLS model (from 0.4763 to 0.7103). Most of the factors identified as significant in the global OLS model are also found out to be significant and show a spatial non-stationarity. Local variation of explanatory power in the 2005 GWR model is mostly well explained by the variable *BLACK*. Poverty rates account for the local variations in the north and the southeast suburbs, and vacancy rates fit well in regions from the east side of the central city to the north suburbs. Explanatory power of the accessibility of public transportation also varies over the study area.

The 2009 GWR model also increases the ability of explaining variation compared to global OLS (from 0.4637 to 0.5449). Several factors turn out to be significant in terms of spatial variations, which include minority population, affordable housing, and public transportation. The 2009 GWR model fits relatively better in the east and the south part of suburban regions. African American population is positively and significantly related with voucher outcomes. Spatial variations of affordable housing availability are well aligned with regions stretched from the center to the north end of the Cuyahoga County. Also, public transportation plays a positive role in locating voucher holders in the area from the northeast to southeast part of the study area.

Considering policy goal achievement, the results are mixed in terms of poverty and race deconcentration through the voucher program. Minority populations are a significant predictor of voucher concentration, which implies that the voucher recipients tend to live in neighborhoods with the high proportion of minorities (African American and Hispanic, but not Asian). In this case, it is hard to assert that the voucher program has contributed to race desegregation considering the facts that the majority of voucher holders are minorities and they tend to live in predominantly minority neighborhoods. In terms of poverty deconcentration, however, the voucher program has contributed to dispersing poor households with rental subsidies. The poverty rates variable is a significant and meaningful predictor of voucher concentration and has a threshold point of 23%. Poverty rates of suburban areas are usually less than 23%. This implies that the voucher recipients are more likely to live in low poverty neighborhoods and less likely to live in high poverty ones since the relationship between voucher holders and poverty rates are positive until the threshold point of 23%.

The availability of affordable housing and vacancy rates are positively related with concentration of voucher recipients. The voucher program allows voucher recipients to find a house whose rent levels are below the FMRs. Therefore, the positive relationship between the availability of affordable housing and voucher concentration has confirmed the fact that voucher holders' location choice is limited by the local housing market conditions in terms of affordable housing. Vacancy rates also result in a positive relationship with voucher concentration. The higher the vacancy rates, the more choices for tenants to find a house. In this situation, landlords would have more incentives to participate in the voucher program and fewer incentives to discriminate against voucher

holders. Based on the findings, weak housing markets provide voucher users with more chances to find their housing units.

Public transportation plays a less important role than expected in explaining voucher holders' location outcomes. OLS reveals a positive effect of public transportation; however, when considering spatial autocorrelation, the effect is significant at a 90% level. The positive effect of public transportation confirms the fact that voucher holders' housing choice is dependent on the accessibility to public transportation due to their low income level.

CHAPTER VII

CONCLUSION AND IMPLICATIONS

7.1 Importance of the topic

Nearly one out of four renters, 18.6 million households as of 2008, face severe cost burdens that spend more than half of their incomes on housing (Joint Center for Housing Studies of Harvard University, 2010). Voucher holders in Cuyahoga County live with less than $11,000 income on average. At this level, their monthly housing costs would have to be no more than $275 in order to meet the affordability standard, which is 30% of income toward housing cost. Regardless of their extremely low income levels, voucher holders have lived in decent quality houses whose rent levels are around $650 since the differences have been subsidized. In this way, the Housing Choice Voucher Program contributes to decreasing the income-housing cost mismatch for low-income renters who otherwise struggle to meet their housing needs.

The voucher program is the single largest housing subsidy in the nation, serving almost two million low-income households. Using the household's choice, the program

intends to disperse minority and low-income households in neighborhoods where they could have better living environments such as safety, schools, employments, and public services. Thus, there has been an increasing interest in the voucher program achievements, whether it has contributed to deconcentrating the poor and minorities. At the same time, growing concerns have been raised on voucher recipients' concentration in poor neighborhoods and re-concentration in less-poor neighborhoods. However, not much has been investigated in the Cleveland area where poverty and minority segregation remains strikingly high. Therefore, Cleveland is the place that needs the program the most to promote racial and economic integration in its neighborhoods. In these regards, identifying locations of individual voucher recipients and examining spatial distribution over space are critical to evaluate the program performance. Where have voucher recipients lived? Are spatial patterns of voucher recipients different by their race, income, and over time? What factors have influenced their spatial concentration? Do relationships between variables vary across space? This dissertation explored these questions by analyzing data of voucher recipients from the Cuyahoga Metropolitan Housing Authority.

This dissertation makes a contribution to the literature because it is the first work conducted in the Cleveland area and to incorporate various spatial statistical approaches in identifying spatial concentration and influential factors. Contrary to most previous research that adopted a-spatial analysis, this study considered both a-spatial and spatial aspects by utilizing spatial analyses such as hotspot analysis, spatial regression, and Geographically Weighted Regression (GWR).

Methodological improvements should be mentioned. Limited knowledge has been reported among previous works that examined the relationship between voucher

concentration and neighborhood characteristics. Only a handful of studies dealt with spatial autocorrelation issues in regression analysis. Among others, GWR is a relatively new methodology that accounts for spatial heterogeneity in spatial data. GWR enables researcher to capture spatially varying relationships over space and make it visualize by using maps. With improved methodology, this dissertation not only examined the relationships between variables, but also visualized local variations that cannot be identified by OLS nor spatial regression models. Policy implications can be drawn based on local differences of effects, whether region-wide policy or local policy would be appropriate for addressing voucher concentration.

7.2 Summary of key findings

7.2.1 Patterns of voucher recipients' locations

This study aims to find patterns of voucher holders' spatial outcomes incorporating both a-spatial and spatial analysis. In terms of a-spatial approach, descriptive analysis presents that voucher users tend to move from extremely poor neighborhoods to less poor neighborhoods from 2005 to 2009. However, over half of the voucher recipients still live in very poor neighborhoods where a median income level is less than 50% of the area median income. Regarding racial makeup in neighborhoods, the majority of voucher users are living in neighborhoods where African American population is dominant. At the same time, the trends show that voucher holders are moving toward neighborhoods that the majority population is white. Even though descriptive statistics provide general understanding of voucher holders' living

environments, it is hard to identify where they live, whether they are concentrated, and whether the concentrations are statistically significant. Spatial analysis is necessary to answer the above questions.

Hotspot analysis shows that voucher recipients are concentrated and they are moving toward suburban areas from 2005 to 2009. Hotspot analysis is useful to detect spatial concentration and to examine changes of concentration patterns for a particular area over time. Voucher recipients tend to cluster in the east side of the county. African American voucher holders are especially concentrated in the northeastern areas while white voucher holders are clustered in the western regions. Spatial patterns of both racial groups have spread toward suburban areas from 2005 to 2009. Hispanic voucher holders are also concentrated in the Cleveland. Investigating spatial patterns by income levels show spatial clustering; however, spatial clusters by income levels are not significantly different from other income groups. This might be attributed to the fact that the majority of voucher holders are extremely low income households and they tend to move from extremely poor neighborhoods to ones that are less poor.

Combining the a-spatial description and spatial analysis provides better understanding on how voucher holders are distributed over space. The a-spatial approach is good for a quick understanding of the general tendency of location outcomes while hard to identify the place where spatial clustering occurs. The spatial analysis is useful to test statistical significance whether the clustering is significantly different enough to reject the null hypothesis. The spatial approach overcomes the limitation of a-spatial description, and suggests that voucher holders are clustered in specific areas and their

clusters have changed over time. Moreover, spatial concentrations of voucher holders are significantly different by race and ethnicity but not by income level.

7.2.2 Factors associated with voucher recipients' spatial concentration

A series of regression analyses explored which factors related to voucher holders' spatial concentrations. Starting from traditional OLS, spatial regression analysis was utilized to account for spatial autocorrelation. In addition, GWR was conducted in order to incorporate spatial heterogeneity and to provide spatially varying relationship.

Several factors were tested their significance on voucher concentrations, these factors included availability of affordable housing, minority populations, poverty rates, vacancy rates, and accessibility to public transportation. Consistent with previous research, minority populations were significant predictors for voucher concentrations. This finding implies that voucher holders tend to live in minority neighborhoods. Based on this result, it is hard to assert that the voucher program is successful to make neighborhood diverse in terms of racial composition. On the other hand, poverty rates turned out to be significant and showed the threshold point. Based on this relationship, it can be inferred that the voucher program has contributed to dispersing poor households into better neighborhoods in terms of poverty rates. As expected in hypotheses, availability of affordable housing, vacancy rates, and public transportation are significantly associated with voucher concentration. OLS and spatial error model estimation confirmed that several variables showed a threshold effect on voucher concentration. The thresholds were at 50%, 23%, and 30% of affordable housing, poverty rates, and vacancy rates, respectively.

GWR results account for spatial heterogeneity, providing local variation of significant factors on voucher locations. The GWR model substantially improved the explanatory power compared to the OLS model. Most of the factors identified as influential in global OLS model were also found out to be significant and showed a spatial non-stationarity by Monte Carlo tests. Significantly different local variations were found in minority populations, affordable housing, poverty, vacancy rates, and public transportation. Spatial variations of affordable housing availability were well aligned with regions stretched from the central city to the north; poverty rates accounted for the local variation in the north and the southeastern suburbs; vacancy rates fitted well in regions where cover from the east side of the central city to the north part of suburbs; public transportation explained well in areas from the northeast to southeast suburbs.

7.3 Policy implications

Results presented here on patterns and factors of voucher concentration provide several policy implications. Consistent with previous findings, this study also shows that the voucher program has played a substantial role in poverty deconcentration based on the fact that the voucher recipients tend to live in less poor neighborhoods over time from the extremely low income neighborhoods. This is important considering the fact that the majority (over 80%) of the recipients is in the extremely low income group. Thus, the findings reflect that the voucher program performs well in terms of dispersing poor tenants. Furthermore, statistical analysis finds that poverty rates are meaningful predictors of voucher location outcomes but the effects vary across space. The

relationship with voucher locations and poverty rates is positive until poverty rates reach 23%, and the relationship turns negative. Places with lower poverty rates (below 23%) correspond with suburban communities and higher poverty areas are found in areas near the central city. Considering both findings from regression analyses and distribution of neighborhood poverty rates, it can be inferred that the voucher program has been successful to disperse extremely low-income households toward suburbs. Voucher holders are more likely to find their housing units in areas with low poverty rates.

Desegregating minority population seems to be hard to achieve through the voucher program. Voucher users were found in neighborhoods where minorities are predominant. African American and Hispanic populations were positively associated with voucher users' concentrations. Spatial analysis confirmed their clustering in specific neighborhoods, but they tend to move into suburbs during last five years. Descriptive analysis also showed that voucher holders tend to move from black neighborhoods to white neighborhoods. These findings reflected promising trends that voucher holders are concentrated in specific neighborhoods but they have moved into suburban neighborhoods where white are majority. Therefore, it can be inferred that the voucher program has potential to desegregating minority with some limitations.

Overcoming spatial concentration of voucher holders will involve in encouraging landlord's participation in the voucher program. Voucher holders have a limited choice when landlords do not accept vouchers and rent levels are over FMRs. Vacancy rates as proxies for landlords' participations reveal significant effects on voucher locations. Landlord's participation will increase voucher recipients' choice, and subsequently contribute to disperse them. Previous survey (US Census, 1998) found that landlords'

were reluctant to be in the program because of bureaucratic process, paper works and/or unfamiliarity with the program itself. Thus, the federal and local agencies for the voucher program should consider the way to inform landlords the merits and procedures of the voucher program, especially for those who have housing units in suburban areas.

In addition, it is worth noting that making neighborhoods accessible to public transportation will broaden voucher recipients' location choices. Voucher holders' location choices were increasing until a point that almost 60% of area in a neighborhood is accessible to public transportation. This is especially well explained in the northeast and the southeast regions of the study area. Thus, if policy makers have expected voucher deconcentration to suburbs, they should consider making neighborhoods accessible to public transportation.

7.4 Limitations and implications for future research

This dissertation explores how voucher recipients have utilized their choices in the Cleveland area in terms of spatial patterns and limiting factors. This study identified meaningful findings; however, there remain limitations and further research areas. Outdated neighborhood data should be mentioned. Due to the time gap of census data, neighborhood characteristics are hard to reflect the most recent changes that might occur during ten years. Thus, analysis with newly released 2010 ACS (American Community Survey) data will be necessary to confirm the findings obtained this study.

Analysis with disaggregated data will give an insight for the program performance. This study used aggregated data at the level of block groups. If public

housing agencies had had records on previous locations of voucher recipients, researcher could conduct study on mobility patterns and motivations. Changes of address will show individual movement from place to place over time, so the mobility pattern will be clearly demonstrated. Once mobility patterns are identified, researchers should consider investigating factors that cause voucher recipients' residential choice. They might choose to stay in their old neighborhoods simply because of the proximity to their acquaintances. On the other hand, they might move their residence because of racial factors, accessibility to public transportation, or the desire to live in a safe neighborhood. Conducting surveys will help to understand whether the motivation lies in a personal or structural reason. Motivation and mobility analysis will contribute to investigating how the program operates at the individual level.

Moreover, tracking studies of voucher recipients will play a significant role in understanding and evaluating the performance of the voucher program. Research efforts related to dispersal programs have been devoted to compare the living conditions of the underprivileged either by providing information on several sites simultaneously or by tracking the locations of the former public housing tenants over time. For example, the Gautreaux program developed the metropolitan-wide mobility program in Chicago, in order to address discriminatory practices in public housing. Researchers have compared mobility outcomes, both in personal benefits and neighborhood conditions, before and after relocating residents, which inspired Congress to initiate MTO experiments. With rigorous research designs and restrictions, the MTO program has helped scholars investigate causal links in neighborhood conditions and the benefits gained, through the comparison of experiences at several sites. On the other hand, HOPE VI programs have

provided more systematic evidences through panel and tracking study. Compared to Gautreaux and MTO program, HOPE VI is larger both in scale and in scope; it has been implemented nationwide, involved more sites, and affected more residents and neighborhoods. The HOPE VI Tracking Study has provided a snapshot of the living conditions and well-being of former tenants of eight different sites. More importantly, HOPE VI Panel Study provides comparative analyses with longitudinal data from five sites. Thus, this panel study enables researchers and policy makers to evaluate the long term effects of relocating former residents from their neighborhood conditions, physical and mental health, and socioeconomic outcomes. However, panel data for voucher recipients have not been available thus far, resulting in a lack of information on how extremely low families fare with rental subsidies. Not much has been reported about the long term effects of the voucher recipients on their living conditions and benefits that are expected, while nearly one out of five voucher holders have stayed in the program for more than ten years. At the local level, constructing systems that require PHAs identify the former residences of voucher users is essential to understand the mobility pattern of the beneficiaries. At the same time, comparing and contrasting the similarities and differences from several sites will provide comprehensive and systematic information on the performance of the voucher program. Given the significance of the program and the potential benefits for the residents, it is critical to understand what has happened to these vulnerable households since they chose their locations of residence.

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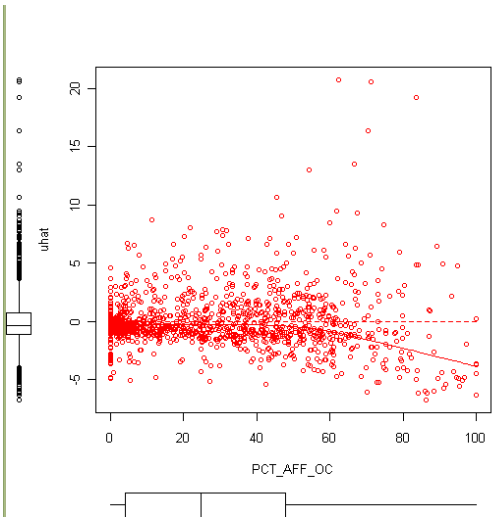
APPENDICIES

Appendix A. General G index results

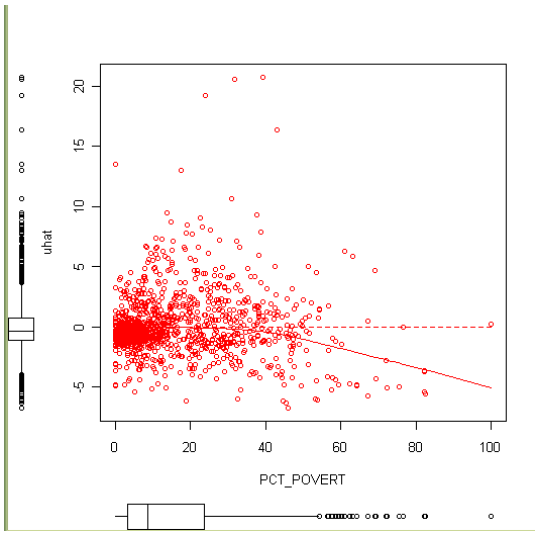
Year	Conceptualization of spatial relationships	Observed G	Expected G	Variance	Z score	P value
2005	Inverse distance	0.00002	0.00001	0.00000	21.44992	0.00000
	Inverse distance square	0.00000	0.00000	0.00000	18.32121	0.00000
	Fixed distance	0.10701	0.05007	0.00001	20.93612	0.00000
	Spatial weight matrix	0.00133	0.00079	0.00000	30.41131	0.00000
2006	Inverse distance	0.00002	0.00001	0.00000	20.41566	0.00000
	Inverse distance square	0.00000	0.00000	0.00000	17.25876	0.00000
	Fixed distance	0.10165	0.05007	0.00001	20.01762	0.00000
	Spatial weight matrix	0.00128	0.00079	0.00000	30.60887	0.00000
2007	Inverse distance	0.00002	0.00001	0.00000	19.44786	0.00000
	Inverse distance square	0.00000	0.00000	0.00000	16.59800	0.00000
	Fixed distance	0.09835	0.05007	0.00001	18.99722	0.00000
	Spatial weight matrix	0.00127	0.00079	0.00000	30.41952	0.00000
2008	Inverse distance	0.00002	0.00001	0.00000	18.07948	0.00000
	Inverse distance square	0.00000	0.00000	0.00000	15.30544	0.00000
	Fixed distance	0.09431	0.05007	0.00001	17.70703	0.00000
	Spatial weight matrix	0.00125	0.00079	0.00000	30.00792	0.00000
2009	Inverse distance	0.00002	0.00001	0.00000	15.72959	0.00000
	Inverse distance square	0.00000	0.00000	0.00000	13.06455	0.00000
	Fixed distance	0.09018	0.05007	0.00001	15.53380	0.00000
	Spatial weight matrix	0.00125	0.00079	0.00000	28.35731	0.00000

Appendix B. Residual plots for regression model

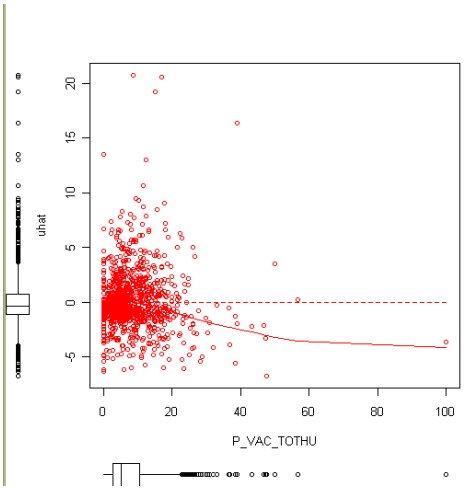
Affordable housing (2009 model)



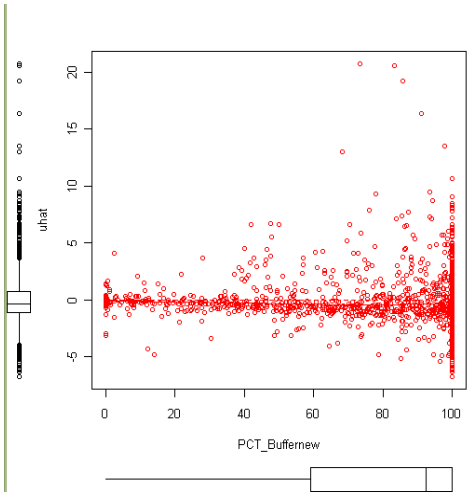
Poverty (2009 model)



Vacancy (2009 model)

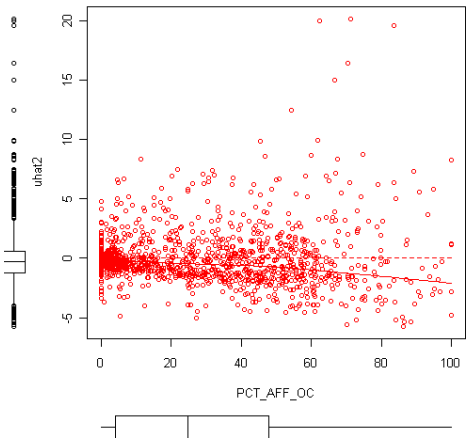


Public transportation (2009 model)

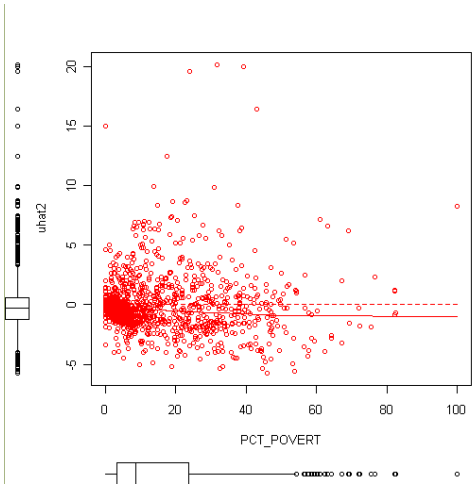


Appendix C. Residual plots after adding square terms

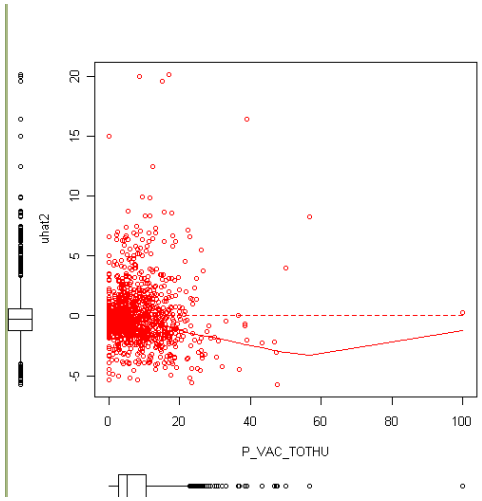
Affordable housing (2009)



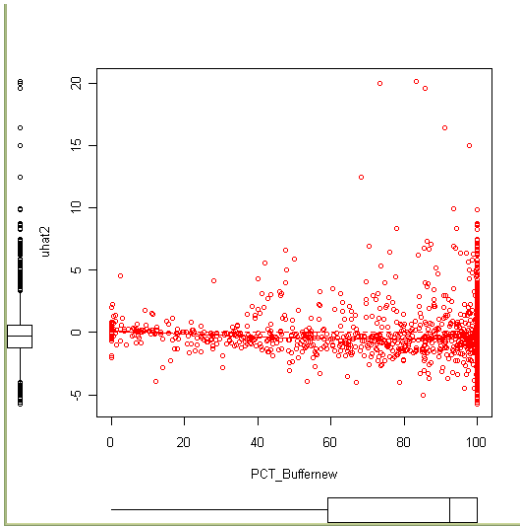
Poverty (2009)



Vacancy (2009)



Public transportation (2009)



Appendix D. VIF in 2005 model

Variable	Coefficient	Std. Error	t value	Pr(>|t|)	Sig	VIF
Intercept	-0.3222	0.2107	-1.529	0.1265		----------
BLACK	0.0547	0.0027	19.934	0.0000	***	2.0083
ASIAN	-0.0598	0.0202	-2.954	0.0032	**	1.0767
HISPANIC	0.0552	0.0107	5.144	0.0000	***	1.3433
AFFORDH	0.0116	0.0049	2.356	0.0186	**	2.8044
POVERTY	-0.0218	0.0088	-2.48	0.0133	**	3.4059
VACANCY	0.1377	0.0236	5.845	0.0000	***	5.6192
SQ_VACANCY	-0.0021	0.0004	-5.473	0.0000	***	3.5897
TRANSPORT	0.0065	0.0029	2.269	0.0234	**	1.3695

Note: ***p<0.01, **p<0.05, *p<0.1

Appendix E. VIF in 2009 model

Variable	Coefficient	Std. Error	t value	Pr(>|t|)	Sig	VIF
Intercept	-0.5873	0.2735	-2.1473	0.03195	**	--------
BLACK	0.0471	0.0027	17.3631	0.00000	***	2.2745
ASIAN	-0.0431	0.0189	-2.2862	0.02239	**	1.0804
HISPANIC	0.0442	0.0105	4.2085	0.00003	***	1.4870
AFFORDH	0.0370	0.0115	3.2262	0.00130	**	17.5949
SQ_AFFORDH	-0.0004	0.0001	-2.5830	0.00990	**	14.0668
POVERTY	0.0748	0.0189	3.9413	0.00009	**	18.3229
SQ_POVERTY	-0.0017	0.0003	-6.5179	0.00000	***	11.5517
VACANCY	0.0451	0.0230	1.9645	0.04969	**	6.1622
SQ_VACANCY	-0.0005	0.0004	-1.2835	0.19956		3.9113
TRANSPORT	0.0236	0.0104	2.2737	0.02314	**	20.8296
SQ_TRANSPORT	-0.0002	0.0001	-1.9450	0.052	*	21.5775

Note: ***p<0.01, **p<0.05, *p<0.1

Appendix F. F test results

Explanatory variables in restricted model	F value	Pr(>F)
AFFORDH+Sq_Affordh+BLACK+ASIAN+HISPANIC +VACANCY+Sq_Vacancy+POVERTY+Sq_Poverty +TRANSPORT+Sq_Tranport	100.2	< 2.2e-16
AFFORDH+Sq_Affordh+BLACK+ASIAN+HISPANIC +VACANCY+Sq_Vacancy+POVERTY+Sq_Poverty	121.4	< 2.2e-16
AFFORDH+Sq_Affordh+BLACK+ASIAN+HISPANIC +VACANCY+Sq_Vacancy+TRANSPORT+Sq_Tranport	110.6	< 2.2e-16
AFFORDH+Sq_Affordh+BLACK+ASIAN+HISPANIC +POVERTY+Sq_Poverty+TRANSPORT+Sq_Tranport	121.7	< 2.2e-16
AFFORDH+Sq_Affordh+VACANCY+Sq_Vacancy +POVERTY+Sq_Poverty +TRANSPORT+Sq_Tranport	71.44	< 2.2e-16
BLACK+ASIAN+HISPANIC+VACANCY+Sq_Vacancy +POVERTY+Sq_Poverty+TRANSPORT+Sq_Tranport	120.3	< 2.2e-16