Is Smart Growth Smart for Low-Income Households: A Study of the Impact of Four Smart Growth Principles on the Supply of Affordable Housing

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This research tests the relationship between each of four smart growth principles and the supply of affordable housing for low-income households. The four principles are higher residential density, a variety of housing options, mixed land use, and the preservation of open space. The relationships are tested at the neighborhood level in two different types of metropolitan regions, those with an urban containment policy to combat sprawl and those without. Four regions were chosen to represent two pairs. Each pair consisted of two regions which had similar urban containment policies at one point in time and different policies at a second point. By comparing regression analyses from these two points in time, the research design can detect the influence of urban containment on the relationships among the specific smart growth principles and the supply of affordable units.

The first pair of regions is of Portland and Seattle. Urban growth boundaries were present in the Portland region in 1990, but not in the Seattle region. Such boundaries were present in both regions in 2000. The second pair consists of the regions of Baltimore and Philadelphia. Neither region had urban containment in 1990, but priority funding areas were established throughout the Baltimore region by 2000.

The research provides evidence for the following conclusions. First, a variety of housing options, specifically the availability of multi-unit structures, is associated with a greater supply of affordable rental units. Second, greater residential density in general is typically associated with a greater supply of affordable rental units. Third, a variety of housing options better explains the variation in the supply of affordable units than a general measure of density. Fourth, urban containment policies do not influence the relationships between the smart growth principles and the supply of affordable housing. A policy implication of these conclusions is that growth management mandates to increase residential density should also specify the type of housing developed if growth management is to have positive consequences for the supply of affordable units.

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PREFACE

Even though a dissertation is the work of one person, this one would not have been accomplished without the help and strong support of a number of people. They all deserve a thank you. First, my dissertation committee was exceptional throughout the entire process. As my chair, Sabina Deitrick's guidance on my topic and reviews of my drafts gave me invaluable experience about how to write in a clear manner without excluding details. Her guidance taught me to notice the nuances of various arguments. Angela Foster was always available to answer my endless questions about statistics, modeling, and affordable housing. Steve Farber's and John Engberg's comments vastly improved my theory and testable hypotheses. Steve remained involved with my dissertation even in retirement. John happily joined my committee even without knowing me.

Second, my friends were a strong source of support and deserve a thank you. As my roommate, Jill put up with my occasional outburst of frustration with the dissertation process. Kelly encouraged me to get out of the house and relax with movie nights. Katherine and Katy were entertaining at our happy hour(s). Matt and Heidi and Carrie and Matt are great friends and great dinner companions. Lunch discussions with Sungsoo were helpful in seeing the broader picture of the dissertation process. Chris always had good advice about data, as well as

interesting tidbits of information to share regarding just about anything. Jane's phone calls provided optimism when the process seemed endless.

Finally, my family deserves a big thank you. I am grateful to my brother and sisters who always provide encouragement (after they remind me that most people my age have full-time jobs and are no longer in school). Judy took in the piano when it was in danger of becoming homeless, for which I am appreciative, and she opened her home in Florida to me anytime I wanted a vacation. Pat and Jan have been equally supportive.

I save my final, and most important, thanks for my parents. Just prior to starting my dissertation, I was telling a family friend the topic of my research while standing next to my Dad's hospital bed. At that moment, Dad literally took his last breath of life. Without hesitation, someone informed me that he died of boredom. I'm almost certain he didn't, but then again the dissertation did turn out to be more than 300 pages. My parents taught their children to think for themselves and to follow their own path. I'm sure at times they worried about the decisions their children were making (at least my decisions), but my Dad was and my Mom continues to be supportive of anything I or my siblings decide to do. I'm grateful for their confidence.

1.0 INTRODUCTION

The purpose of this dissertation is to examine the relationship between smart growth and the supply of affordable housing for low-income households. The research is guided by the current debate surrounding smart growth's impact on housing costs and its ability to address America's shortage of housing for the lowest income households. The two primary research questions are:

- What is the relationship between smart growth principles – specifically neighborhood density, a variety of housing options, mixed land use, and public open space – and the supply of affordable housing for extremely and very low-income households?

- Are these relationships different in metropolitan areas which have implemented a form of urban containment, such as urban growth boundaries or priority funding areas, from areas which have no such policy? If so, what are these differences?

Smart growth is defined by set of land use and development principles which together serve as an alternative to the dominant pattern of metropolitan growth broadly known as sprawl. Sprawl is characterized by low-density development, the segregation of residential land use from other activities, the rapid consumption of undeveloped land, inequitable regional development as older communities are abandoned for new development on the urban fringe, and the segregation of housing types as single-family dwellings are typically surrounded by other single-family dwellings (Nelson and Duncan 1995, p. 1; Downs 1998; Galster et al. 2001; Orfield 2002, p. 96; Burchell et al. 2005, p. 12). The Smart Growth Network (SGN), a group of government agencies and non-profit organizations, adopted ten principles of smart growth to counteract against these characteristics of sprawl. These ten principles are (SGN 2002; Chen 2003):

1. Compact building design as opposed to low-density development;
2. A variety of housing choices for a range of household types and incomes rather than development dominated by single-family homes;
3. A greater level of mixed land use rather than segregated land uses;

4. Walkable neighborhoods;
5. A strong sense of place within communities;
6. Preservation of open space rather than the rapid consumption of land by development;
7. Equitable regional development;
8. A variety of transportation options;
9. Predictable and fair development decisions; and
10. Citizen participation in the planning process.

This research tests the relationship between four smart growth principles and the supply of affordable housing for low-income households at the neighborhood level. The four principles chosen are those most likely to influence housing prices and the supply of affordable units. Among the smart growth principles,

- Compact development, or greater housing density, can result in lower housing costs and a greater supply of affordable units as dwelling sizes are reduced and less land is used for housing units.

- A variety of housing options for a range of household incomes can increase the supply of affordable units. In contrast to the exclusive development of detached single-family homes, smart growth promotes a mixture of housing types, including multi-family and attached single-family units. These units are more likely to be affordable to lower-income households than single-family homes (Downs 2004).

- Mixed land use development can provide for a better balance between affordable housing units and low-wage jobs within neighborhoods. Mixed land use typically implies a variety of housing types, as well as a variety of land uses, which includes attached homes and multi-unit structures.

- Preservation of open space, in the form of public parks, may decrease the supply of affordable units for two reasons. First, it reduces the supply of land available for residential development, increasing land and housing costs. Second, public parks often provide a positive amenity to local residents, increasing demand and the price for housing near them.

The Smart Growth Network (2001) argues that greater density, a variety of housing options, and mixed land use can better meet the affordable housing needs of low-income households than the traditional development patterns of sprawl. But, there is no current empirical research testing these claims.[1] An explicit purpose of this research is to do so.

Another important focus of this research is the impact of urban containment on the relationships between the four smart growth principles and affordable housing. Urban containment refers to policies which prohibit urban development outside of specified boundaries with the purpose of preserving land from development on the urban fringe and redirecting growth to existing communities (Nelson and Duncan 1995, p. 73; Pendall, Martin, and Fulton 2002, p. 3). By pushing development away from the undeveloped urban fringe and toward existing communities, urban containment is a tool to achieve the smart growth principle of the preservation of open space.

Urban containment also helps to achieve other smart growth principles. Land outside of urban containment boundaries is not available for development. These restrictions on the supply of developable land increase its price, which encourages developers to use land more intensely, increasing density. Mixed use may also increase as a result of the same process. More costly developable land may entice developers to use land more efficiently (Nelson and Dawkins 2004).

Density may increase also as a result of government mandates implemented along with urban containment. As the supply of developable land is restricted and its price increases, housing prices also increase.[2] To alleviate the upward pressure on housing prices as a result of urban containment, greater density is typically enforced or encouraged in order to ensure that the

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[1] There are numerous studies which test the relationships among housing density, mixed land use and housing prices in general, but only two studies focus specifically on affordable units for low-income households. Both of those studies, by Alexander and Tomalty (2002) and Burton (2000), found evidence that greater density was associated with less affordability for low-income households. These studies are discussed in Chapter 3.

[2] Chapters Three and Four will discuss the relationship among urban containment, land values, and housing costs.

population's housing needs can be met even while development is restricted outside of urban containment boundaries.[3]

Given that housing prices may be pushed upward as a result of urban containment, do the smart growth principles have the same impact on affordable housing in regions with urban containment as in regions without urban containment? In regions of urban containment, greater housing density, multi-unit structures, and mixed land use may be a means to alleviate the upward pressure on the cost of the average priced dwelling through the production of smaller units or the use of less land per unit. The literature review in Chapter Three provides evidence that an increase in density and a change in housing types in the marketplace help to maintain moderately priced housing in areas of land use regulation and urban containment. However, do increasing prices from urban containment weaken the positive impact that density, multi-unit structures, and mixed use may have affordable housing for low-income households?

A modified quasi-experimental research design is utilized to compare the relationship between specific smart growth principles and the supply of affordable housing in regions with and without urban containment. To do so, four regions were chosen to represent two pairs of regions for an analysis of smart growth and affordable housing at two different points in time. The regions were selected so that each pair includes a region with urban containment and a region without urban containment at one point in time. At the other point in time, the two regions of each pair have similar urban containment policies. The results from these two different points in time are then compared.

The first pair includes the regions of Portland and Seattle. In 1990 only Portland had a region-wide urban containment policy in the form of urban growth boundaries. Urban growth boundaries are "lines in the land" beyond which urban development is prohibited.[4] In 2000, both Portland and Seattle had urban growth boundaries. Interaction variables are included in the model to measure the extent to which the smart growth principles influenced affordable housing

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[3] An example is Portland, Oregon's Metropolitan Housing Rule which was legislated after the region's implementation of urban containment. Fearing that housing prices would become unaffordable, the state legislation requires municipalities within the region to meet certain density targets. Other examples can be found in almost every state which has legislated urban containment for their metropolitan regions. In many instances, density targets are not specifically mandated but are encouraged.

[4] "Line in the land" is from the title of an article by Staley, Edgens, and Mildner (1999).

differently in Portland than in Seattle in 1990. These results could then be compared to the analysis in 2000 when both regions had similar urban containment policies.

A similar analysis is conducted for the second pair of regions, Baltimore and Philadelphia. In 1990, neither region had a region-wide urban containment policy. In 1997, Maryland passed the Smart Growth Act which requires every county in the state to direct state infrastructure funds to specified areas known as priority funding areas. The purpose of these areas is to limit sprawl by steering public infrastructure funds away from the urban/rural fringe and toward existing communities and areas approved for future growth. Therefore, the Baltimore region had priority funding areas in 2000 while Philadelphia did not have a region-wide urban containment policy. Once again, interaction variables for each of the smart growth principles of interest to this research were included in the analysis to capture differences between Baltimore and Philadelphia with regard to the impact of the smart growth principles on the supply of affordable housing.

1.1 OUTLINE OF STUDY

Chapter Two provides an overview of the context in which this research occurs. The chapter first presents the primary housing problem which low-income households face, which is predominantly a lack of affordable units. The severe shortage of affordable housing units for low-income households means that the impact of policies which, whether intentionally or not, influence the supply of affordable units must be fully understood. The chapter also illustrates the importance of the private market to the supply of affordable low-income units as the private market, rather than public subsidies, provides the majority of affordable units.

Chapter Two then defines sprawl. It is difficult to discuss smart growth without defining sprawl, the dominant pattern of metropolitan growth which smart growth is proposed to alleviate. The chapter explains the relationship between sprawl, the housing market, and affordable housing. It then defines smart growth and discusses its relationship to the housing market and affordable housing.

Chapter Three is a review of the literature pertaining to urban containment, the four smart growth principles and their impact on housing costs and affordable housing. A significant conclusion from the review is that while there is a growing body of research concerning the smart growth principles and housing costs, there is little empirical research regarding their impact on housing specifically affordable to low-income households.

Chapter Four presents the theoretical framework, drawn from economic theory of land use and housing markets, from which hypotheses can be drawn concerning the impact of the smart growth principles on the supply of affordable housing. This framework presents the hypotheses that density, multi-unit structures providing multiple housing options, and mixed may have a positive association with affordable housing within regions of no urban containment policy, but the association will be weaker in regions with urban containment policies. Open space, as measured by neighborhood parks, is expected to be associated with a lower supply of affordable units.

Chapter Five presents the research design through which the hypotheses are tested. Quasi-experimental designs are discussed as a means to address our inability to conduct a true experiment in which urban containment and smart growth are isolated from other possible explanations for the variation in the supply of affordable housing. The chapter also presents the potential threats to the validity of research findings.

Chapter Six continues the discussion of methodology by presenting the regions chosen for this research. The chapter first describes the selection process for two pairs of regions. Portland and Seattle are the first pair of regions, both sharing many similar characteristics except for the timing of their urban containment policies. The second pair of regions consists of Baltimore and Philadelphia. The chapter then provides detailed descriptions of each region's growth management techniques, affordable housing policies, and changes in housing affordability during the 1990's.

Chapter Seven presents the model and data used to formally test the hypotheses in each of the two pairs. The first section of Chapter Seven presents the model utilized in this study. The second section discusses the operationalization and measurement of the variables included in the model. The third section describes the data sources from which the variables are measured. The fourth section of Chapter Seven presents the descriptive statistics of the variables included in the model. The fifth section then discusses the statistical assumptions that are necessary to test the hypotheses through regression analysis. The sixth and seventh sections present the findings of the statistical analysis regarding the relationships between each smart growth principle and the supply of affordable housing for low-income households, as well as the impact of urban containment on these relationships. The sixth section discusses the findings of smart growth's impact on affordable housing for extremely low-income households, while the seventh section presents the findings for rental units affordable to very low-income households.

Chapter Eight relates the findings from Chapter Seven to each of the hypotheses drawn from the theoretical framework. It then discusses the implications of these findings, as well as suggests future research to address the limitations of this current study.

2.0 AFFORDABLE HOUSING, SPRAWL, AND SMART GROWTH

The purpose of this research is to test the relationships of four smart growth principles and the supply of affordable housing for low-income households. To understand the context in which this research occurs, this chapter presents four major issues related to affordable housing, sprawl, and smart growth. These issues are:

1. the current shortage of housing for lower income households causing them to spend a significant portion of their income on housing;
2. the importance of the private market in the provision of affordable units;
3. sprawl's relationship to the housing market and affordable housing; and
4. the set of principles known as smart growth which are often proposed as solutions to sprawl and may impact the supply of affordable housing.

The first section of this chapter discusses affordable housing for low-income households. It first defines affordable housing and then reveals a severe shortage of it, particularly for extremely low-income renters. The shortage forces approximately 64% of extremely low-income households to spend more than half of their income on housing.

The first section then discusses three significant sources of affordable housing, which are the Federal government, the non-profit sector, and the unsubsidized, private market. The section provides an overview of the Federal programs which provide subsidized housing for low-income households. This housing is owned either by the Federal government itself, by non-profit organizations, or by private developers. The section then shows that the private, unsubsidized housing market provides a significant number of affordable units, as well.

The second section discusses sprawl, which is the dominant land use pattern of metropolitan growth. Sprawl presents implications for housing for low-income households as development occurs further away from the central city of metropolitan regions. Wealthier households find it in their economic interest to move further from the central city, while lower-income households remain in close proximity to it. The purpose of the section is to present the current process of development which smart growth is intended is to interrupt.

The third section presents smart growth, the most recent attempt to control sprawl through a variety of principles and policies. Among the principles of smart growth are higher density, mixed land use neighborhoods, and an increase in the variety of housing types from which to provide greater housing opportunities to all households across a range of incomes. Advocates contend that these principles can increase the supply of affordable units for low-income households by promoting smaller homes and more multifamily and attached housing units. However, a dominant theme within the smart growth movement is the preservation of undeveloped land at the fringes of metropolitan regions by redirecting growth inward, rather than allowing outward growth of sprawl. Restricting development on the urban/rural fringe may have a harmful effect on affordable housing as it increases housing prices.

2.1 AFFORDABLE HOUSING

Affordable housing is housing which households can afford given their current income. As defined by the U.S. Department of Housing and Urban Development (HUD), affordable housing is housing which costs less than 30% of a household's income (HUD 2005, pp. 4 and 39). Renter households spending more than 30% of their income on rental costs are said to have rent burdens.

Based on these definitions, HUD measures affordable housing needs for three different categories of "low-income", as shown in Table 2.1. The three low-income categories for households are extremely low-income, very low-income, and low-income. These categories include households whose income is less than 30%, between 30% and 50%, and between 50% and 80% of their area's median income (AMI), respectively (Pelletiere 2006, p. 1). Because HUD's definitions of low-income are used to set eligibility guidelines for many of its supported housing programs, they are a common definition of low-income used in the affordable housing literature (Nelson 1994; Bogdon and Can 1997; Millenial Housing Commission 2002; Green and Malpezzi 2003; Pelletiere 2006).

Table 2-1. Definition of Low-Income Households, Affordable Housing, and Rent Burdens

Low-Income Category	**Level of Household Income for Category**	**Moderate Rent Burden**	**Severe Rent Burden**	**Affordable Housing Unit For Income Category**
Low-income	50% to 80% of AMI	30%-50% of Household Income	More than 50% of Household Income	< 30% of 80% of AMI
Very low-income	30% to 50% of AMI	30%-50% of Household Income	More than 50% of Household Income	< 30% of 50% of AMI
Extremely low-income	< 30% of AMI	30%-50% of Household Income	More than 50% of Household Income	< 30% of 30% of AMI

Source: U.S. Department of Housing and Urban Development, 2005.

There are two significant measures of affordable housing needs calculated for each category of low-income households. These measures are also summarized in Table 2.1. The first measure is the number of households in each low-income category spending more than 30% of their income on housing.[5] Households spending between 30% and 50% of their income on housing costs are defined as having a moderate rent burden while those spending more than 50% of their income on housing are defined as having a severe rent burden (HUD 2005, Appendix B).[6]

The second measure of affordable housing needs uses a rental cost-to-income ratio to determine the available supply of affordable units for these different income ranges. As defined by HUD, an affordable housing unit is one whose cost is less than 30% of the highest possible income in each income category. Therefore, a housing unit is considered 'affordable' for extremely low-income households if its cost is less than 30% of 30% of the AMI. A unit is affordable for very low-income households if its cost is less than 30% of 50% of the AMI and is affordable for low-income households if its cost is less than 30% of 80% of the AMI.

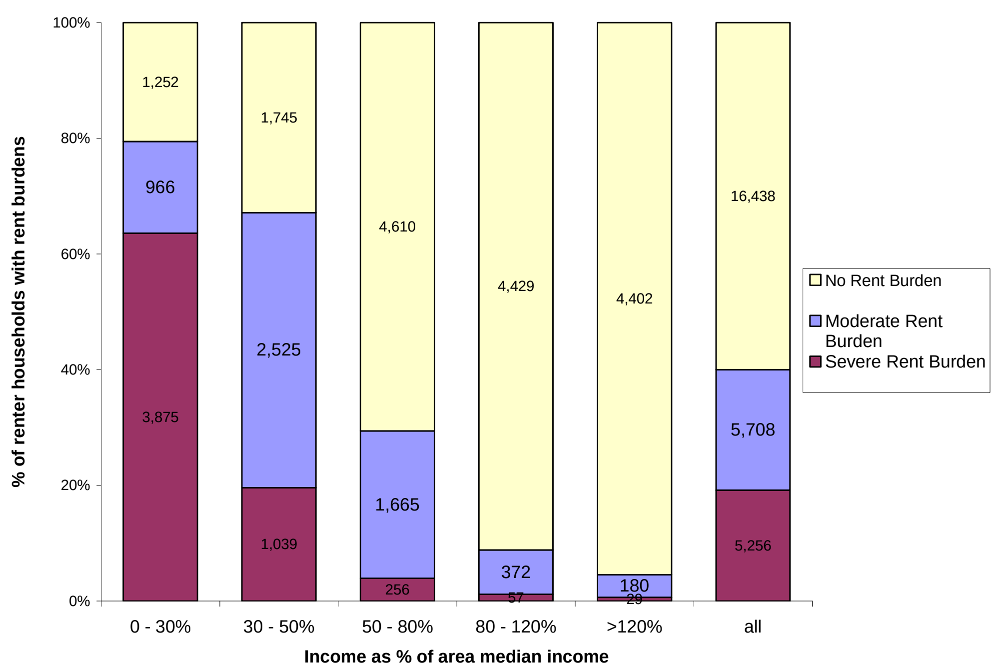
[5] The 30% housing cost-to-income ratio (HCIR) was established by the Housing and Urban-Rural Recovery Act of 1983. Prior to 1983, the standard HCIR was 25%. The HCIR standard is used to determine the amount of rent low-income renters receiving public housing assistance are expected to contribute toward their housing. The standard is more the result of political, cultural, and social reasons than empirical findings that households should spend, at most, a specified proportion of their income for housing (Feins and Lane 1981; Hulchanski 1995).

[6] Similar definitions are also used by the Joint Center for Housing Studies at Harvard University (2003; 2005), as well as by the National Low-Income Housing Coalition (Pelletiere 2006) in measuring rent burdens among low-income households. Together with HUD, these three organizations provide the most commonly used estimates of affordable housing for low-income households.

2.1.1 The Affordability Problem

Bi-annually, HUD publishes data on the housing needs among low-income households. The reports emphasize a housing affordability problem which is especially acute for extremely low-income households. Figure 2.1 illustrates the number and proportion of renter households who are not receiving government housing assistance and experiencing moderate and severe rent burdens by income category in 2003. Among extremely low-income renter households, 63.6%, or approximately 3.9 million out of 6.1 million, experience severe rent burdens while another 15.9%, or almost 1 million, experience moderate rent burdens.[7]

Figure 2-1. Rental Cost Burdens by Income for Unassisted Renter Households



Note: A moderate rent burden is housing costs that are between 30-50% of a household's income. Severe rent burden is housing costs that are more than 50% of a household's income. Numbers are in thousands. Source: U.S. Department of Housing and Urban Development, 2005; American Housing Survey, 2003.

[7] Throughout this section, numbers in text are rounded to nearest 100,000 while percentages are calculated from the actual numbers.

Among all renter households, the proportion with a severe rent burden declines as income increases. When compared to extremely low-income renter households, very low-income renter households are much less likely to have severe rent burdens, but are still susceptible to moderate rent burdens. Only 19.6%, or approximately 1.0 million out of 5.3 million very low-income renter households, experience severe rent burdens. However, another 47.6%, or approximately 2.5 million, have moderate rent burdens. Among the 6.5 million low-income renter households, only 3.9% have severe rent burdens while 25.5% have moderate rent burdens.

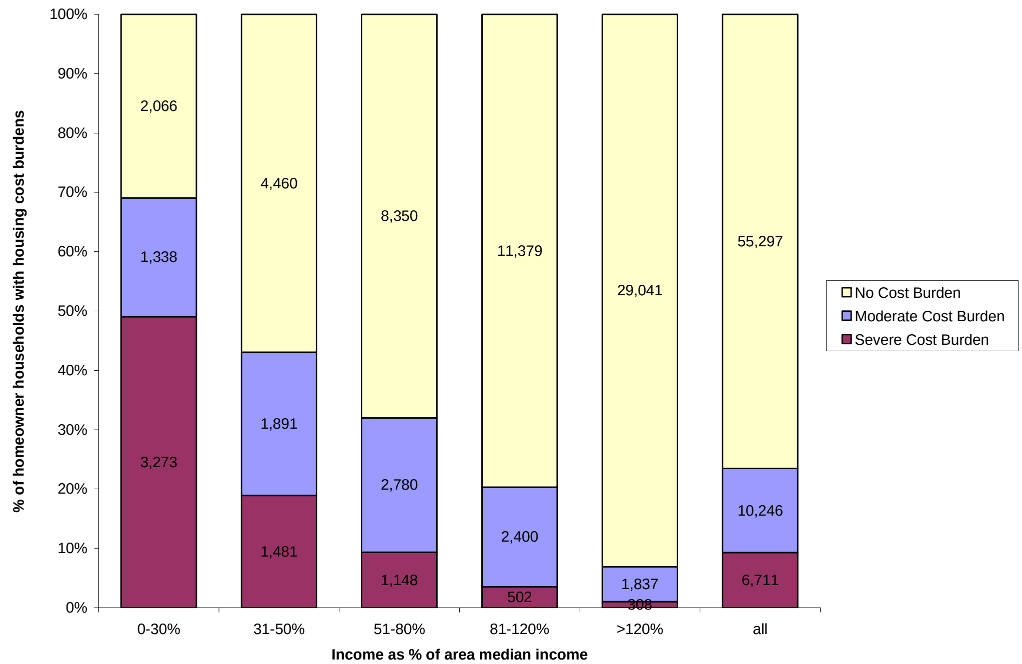
Housing cost burdens are not isolated to low-income renter households. Figure 2.2 illustrates the prevalence of housing cost burdens among homeowners. Slightly more than 49% of extremely low-income homeowner households, or approximately 3.3 million out of 6.7 million, experience severe housing cost burdens as they spend more than half of their income on housing (HUD 2005, p. 53).[8] Another 1.3 million extremely low-income homeowner households, or 20%, experience moderate housing cost burdens.

In comparison to extremely low-income homeowner households, only 18.9% of very low-income homeowner households, or approximately 1.5 million out of 7.8 million, have severe housing cost burdens. An additional 1.9 million very low-income homeowner households, or 24.1% of the total, have moderate housing cost burdens. Meanwhile, 9.4% of low-income homeowner households, or approximately 1.1 million of 12.3 million, have severe housing cost burdens. 22.6% of low-income homeowner households, or 2.8 million, have moderate housing cost burdens.

A comparison of Figures 2.1 and 2.2 reveals that a higher proportion of extremely low-income and very low-income renters have housing cost burdens than homeowners of the same income. Slightly more than 79% of extremely low-income renters versus 69% of homeowners have housing cost burdens. Among very low-income households, 67% of renters versus 43% of homeowners have housing cost burdens.

[8] Similar results were found by the U.S. Congress' Millenial Housing Commission (2002, p. 15 and p. 93).

Figure 2-2. Housing Cost Burdens by Income for Homeowner Households



Note: A moderate cost burden is housing costs that are between 30-50% of a household's income. Severe cost burden is housing costs that are more than 50% of a household's income. Numbers are in thousands. Source: U.S. Department of Housing and Urban Development, 2005; American Housing Survey, 2003.

This section examined the proportion of households experiencing housing cost burdens at various income levels. It defined housing cost burdened households as those who spend more than 30% of their income on housing. However, there are number of criticisms of the housing cost-to-income ratio as a measure of affordability and affordable housing needs. The next section presents those criticisms and alternative measures of affordability which attempt to address them.

2.1.1.1 Alternative Measures of Affordability

The criticisms of the housing-cost-to-income ratio as a measure of affordability focus on the fact that a ratio is kept constant across varying housing units and households. However, housing units vary drastically in quality from one another while households vary in their non-housing and housing needs. Ignoring differences in housing unit quality and households, the ratio can overestimate or underestimate the need for affordable housing for low-income households.

The first criticism of the cost-to-income ratio is that it ignores the varying life-cycle situations among households (Hulchanski 1995). Cost-to-income ratios will show that very young householders at the beginning of their wage earning years, as well as older householders beyond their wage earning years, are more likely to have housing affordability problems than householders in their prime earning years. In this regard, an affordability problem will be overestimated among younger householders, who may expect to have higher incomes in the future to help pay for housing, and among older householders who likely have access to savings or wealth which are used to pay for housing costs that appear to be unaffordable based solely on current income. On the other hand, the ratio will show housing to be more affordable for householders in their peak earning years (Quigley and Raphael 2004, p. 194). The affordability problem may be underestimated for these householders as they should be saving a portion of their current income for future uses.

The second criticism of a 30% cost-to-income ratio as a measure of housing affordability is that not all households share the same capability of spending the same proportion of their income on housing (Grigsby and Rosenburg 1975; Hancock 1993; Stone 1993; Kutty 2005). A low-income household may be able to afford housing costs up to 30% of its income, but an extremely low-income household may not be able to afford that level of housing costs, if anything, after other necessities, such as food and transportation, are purchased. Similarly, larger households or households with children may have less of their income available for housing after they obtain other necessities than smaller households and those without children.

Stone (1993, pp. 35-50) proposed a sliding scale measure of housing affordability based on household disposable income minus the cost of a non-housing basket of goods of acceptable adequacy as set by the Bureau of Labor Statistics (BLS) for a given family size. He chose to use as the non-housing basket of goods, a 'Lower Family Budget' which is the budget necessary for a minimum quality, minimum adequacy package of food, transportation, household furnishings, clothing, medical care, entertainment, and other personal care goods and services.[9] The

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[9] The official Federal poverty line uses a similar approach to determine the necessary income for a family to meet its basic needs. However, Stone used the BLS estimates rather than the official poverty line as a starting point for his package of goods because he argued the BLS estimates were more comprehensive. He argued that the poverty line was inadequate for three reasons. First, the poverty line is based solely on the cost of a minimal food budget to meet basic needs and does not explicitly account for the actual cost of other necessities. Second, the food plan used to calculate the poverty line is based on an emergency food budget that is not meant to be a permanent level of food consumption. And third, the poverty line does not take into account the deduction of personal income taxes from

proportion of income remaining after the deduction of the cost of the non-housing basket of goods is available for housing.[10] Households spending a higher proportion of income on housing than this calculated level are said to be experiencing "shelter poverty" as they do not have enough disposable income after housing costs for the non-housing basket of goods of minimal adequacy. Stone's "shelter poverty" measure finds four important features of housing affordability:

1. The proportion of income spent on housing (or maximum cost of housing) that households could afford while still having enough income for the non-housing necessities increased steeply with increases in income. For example, a four-person household with gross income of $20,000 could afford housing costs of 7% of income, but the same household with income of $30,000 could afford 29%.[11]

2. The proportion of income spent on housing (or maximum cost of housing) that households could afford varied greatly with household size. For example, he found that a single-mother with one child could afford housing costs of 37% of income, but a single-mother of three children could afford 0%.

3. There are households of every size that cannot afford anything for housing. Their household income is low enough that money for housing is not available after other necessities are purchased. Larger households are much more likely to be unable to pay anything for housing using Stone's method.

4. Alternatively, there are households of every household size that can afford to pay more than the conventional ratio of 30% of income for housing. Their income is high enough that they spend less than 70% of it on non-housing necessities.

Stone (2006, p. 47) estimated that there were 32 million "shelter-poor" households in the United States in 2001. The number of "shelter-poor" households was not much different from the 34.5 million households that were paying more than 30% of their income on housing. These numbers include both renter households and homeowner households. Among "shelter-poor" households, approximately 15 million were renter households and 17 million were homeowner households (Stone 2006, p. 51).

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income (Stone 1993, p. 323-324). The BLS Family Budget estimates were discontinued in 1981, but Stone updated the figures using the Consumer Price Index (CPI).

[10] This method is sometimes called the "residual approach" as it measures how much income a household has left for housing after other necessary and basic needs are met. Stone credits Cushing Dolbeare, the late founder of the National Low-Income Housing Coalition, as the first person to propose such a measure (Dolbeare 1966; Stone 2006).

[11] These figures are from 1991. However, the concepts remain the same.

The primary difference between Stone's shelter poverty measure and the conventional cost-to-income ratio of 30% was the demographic distribution of the affordable housing problem. As expected, the shelter poverty measure of affordability showed that households of a larger size, as well as households with smaller incomes, were more likely to have housing affordability problems than smaller and higher-income households. The impact of household size on the incidence of shelter poverty is evident when comparing the number of households in shelter poverty to the number of people. There were 2.5 million fewer households in shelter poverty than paying more than the conventional 30% of income for housing. However, 6 million more *people* were living in shelter poverty than paying more than 30% of income for housing.

Kutty (2005) used a measure similar to Stone's shelter poverty to calculate the number of households with housing affordability problems, but based it on the official poverty line rather than the minimal Family Budget of BLS. Poverty thresholds are based on the idea, developed in the 1960's, that households spend a 1/3 of their income on food, 1/3 on housing and, 1/3 on other goods. The poverty line is calculated by determining the cost of an 'economy' or 'thrifty' food plan for a temporary or emergency situation for a household of a given size and multiplying it by three. In theory, this amount is the level of income necessary for a family of a given size to afford basic necessities.[12] Kutty subtracted a household's housing costs from its total income. If disposable income after the deduction of housing expenses was less than 2/3 of the poverty line (1/3 for food, 1/3 for other goods), she considered the households to be in "housing-induced" poverty. Households with income slightly above poverty could experience "housing-induced" poverty if they are spending a large share of their income on housing. Kutty argued that her measure was more appropriate for public policy discussions than Stone's "shelter poverty" measure because the poverty line is the officially recognized standard for determining the household income needed to meet basic needs (p. 119).

Using 1999 data, Kutty (p. 124) estimated that 17.2 million renter and homeowner households were in housing-induced poverty. In comparison, there were 14.4 million households in official poverty. In comparison, 30.1 million households had housing costs of more than 30% of income using the standard housing cost-to-income ratio. The number of

[12] For a summary of critiques of the official poverty threshold, as well as alternative measures of appropriate family budgets, see Bernstein et. al. (2000) and Citro and Michael (1995). The typical argument against the poverty thresholds are that they are too low as they are based on the cost of an 'emergency' food plan and do not include specific measures of the cost of other non-food necessities.

households in housing induced poverty is lower than the number in Stone's shelter poverty and the number spending more than 30% of income on rent. Using the poverty budget provides conservative estimates of the housing affordability problem. The budget for a minimally adequate standard of living is more generous in the Lower Family Budget than in the poverty budget. Therefore, the assumed level of necessary expenditures on non-housing goods is lower using Kutty's housing-induced poverty measure.

The third criticism of the conventional housing cost-to-income ratio as a measure of housing affordability is its inability to account for housing quality (Lerman and Reeder 1987; Bogdon and Can 1997; Thalmann 1999). A household might be spending more than 30% of its income on housing, but doing so to live in a housing unit that is of higher quality or size than necessary (Linneman and Megbolugbe 1992). Likewise, a household may be spending less than 30% of its income on housing, but occupying a unit of inadequate quality. Lerman and Reeder (1987) used a hedonic price equation to estimate the cost of a rental unit of a minimally adequate quality. Using data from the Annual Housing Survey from 1975 and 1983, their hedonic equation regressed current household rental costs on a combination of housing characteristics.[13] A hedonic model provides the value that is placed on each marginal unit of a specific housing characteristic. Lerman and Reeder then used their hedonic results to estimate the cost of minimally adequate housing units of different sizes in different sized cities based on HUD's adequacy criteria for publicly subsidized units. Any household of a given size with income less the cost of a minimally adequate-quality unit divided by .3 was considered to have a housing affordability problem because the minimally adequate unit would consume more than 30% of the household's income.[14]

A comparison of the conventional cost-to-income ratio and Lerman and Reeder's quality-adjusted measure indicated that the conventional ratio may overestimate the housing affordability problem. In 1983, 45.1% of renter households, or 12.7 million households, were spending more than 30% of their income on housing expenses. However, the rental cost of a minimally adequate unit would be more than 30% of income for only 36.3%, or 10.2 million, of renter households. A significant number of households, 4.4 million households, were spending

[13] The Annual Housing Survey later became the American Housing Survey.
[14] The cost of the unit should not be greater than 30% of the household's income. Therefore, the rent of unit ⁄ .30 = necessary household income.

more than 30% of their income on housing because they were residing in a unit that was of higher quality than necessary. On the other hand, 2 million renter households who did not have a housing affordability problem according to the conventional ratio did have a problem according to the minimal quality rental cost to income ratio (Lerman and Reeder 1987, p. 398). A criticism of Lerman and Reeder's measure is that it ignores the possibility that there is an inadequate supply of units of minimally adequate quality to meet the need, forcing households into higher quality units which they cannot afford and would not choose if lesser quality units were available (Kutty 2005, p. 117).

Thalmann (1999) criticized Lerman and Reeder's quality-based measure on the basis that it may overestimate the number of households with affordability problems. Thalmann argued that households with not enough income to pay only 30% of income for a minimally adequate unit (which would be counted a household with housing problems by Lerman and Reeder) may actually not have a housing problem as they may live in a unit of acceptable quality but at a cost that is lower than the average price for a similar adequate-quality unit. While these households could not afford a minimally adequate-quality unit in theory, they are able to afford the particular unit in which they are residing because of the lower than average rental price. Thalmann argues that households can pay lower than average rents if their landlord is simply charging too little, they are receiving some form of rental assistance, or have a low-rent agreement from a family member. These households do not have a current housing problem, but would have a problem if they tried to move. He found that 3.7% of households fit this category in Switzerland (p. 1943).

Despite their differences, the various measures of affordability all indicate that a significant number of households spend a large portion of their income on housing. Table 2.2 provides a summary of four measures of affordability for low-income households discussed in this section. While the measures are of different time periods and cannot be directly compared to one another, the table easily illustrates that each measure shows millions of U.S. households in need of affordable housing.

Table 2-2. Alternative Measures of Affordability

Author (Year)[a]	Method	Results
HUD (2003)	Conventional Cost-to-Income Ratio	11 million renter households paying more than 30% of income for housing
Kutty (1999)[b]	Housing-Induced Poverty	17.2 million renter and homeowner households in housing-induced poverty
Lerman & Reeder (1983)	Quality-Adjusted Cost-to-Income Ratio	10.2 million households for whom a minimally adequate rental unit would consume more than 30% of their income
Stone (2001)	Shelter Poverty	15 million shelter-poor renter households

a. Indicates year of data from which the measure was calculated.
b. Includes both renter households and homeowner households. The other three entries include only renter households.
Sources: (Lerman and Reeder 1987; Kutty 2005, p. 124; HUD 2005, p. 56; Stone 2006, p. 51)..

2.1.1.2 Using the Cost-to-Income Measure Despite the Criticisms

Despite the criticisms of the housing cost-to-income ratio as a measure of housing affordability and housing needs among low-income households, it remains the most commonly used measure for several reasons. First, a ratio is used by Federal housing programs to determine the contribution that a low-income household is expected contribute on its own toward housing costs when they receiving housing assistance (Nelson 1994). The ratio of 30% is considered an affordable rent by HUD and is therefore accepted as the normative standard even though the ratio may be as much the result of politics, government budgetary constraints, or historical assumptions as it is the result of solid evaluation of households' ability to pay (Feins and Lane 1981; Mitchell 1985; Hulchanski 1995).

The second reason for the continual use of the conventional ratio is that the quality-adjusted measures that have been proposed fail to take into account the actual supply of minimally adequate-quality housing units (Hancock 1993; Kutty 2005). Hancock points out that households may be living in housing units that are of higher quality or larger size than necessary because they cannot find units of lower quality or smaller size. If the household has an income that allows it to afford a minimally adequate-quality unit with 30% of its income, it would not be considered to have a housing problem. However, the household actually does have an affordability problem if it is forced to pay more than 30% of income for higher quality housing because lower quality housing is not available.

The third benefit of the conventional ratio is the ease at which it is calculated with little data. The measures of shelter poverty, housing induced poverty, and quality-based level of affordability are useful in providing a more comprehensive picture of the type of households who are experiencing housing affordability problems. The poverty measures provide a more accurate picture of the distribution of housing needs among households of varying sizes and incomes. The quality-adjusted measures provide insight into whether households are paying too high of a proportion of their income for housing because of their choice of housing quality of because of too little income. However, these measures require significantly more data and complex analysis and they all conclude that a large number of low-income households are in need of more affordable housing.

2.1.2 Supply

As shown in Section 2.1.1, there are a large number of U.S. households who experience severe and moderate rent burdens. The problem is particularly acute among extremely low-income and very low-income households. There are two causes of this problem. The first cause is the national deficit of rental units available to extremely low-income renters. According to the National Low-Income Housing Coalition, there were 6 million rental units affordable for the 7.7 million extremely low-income renter households in 2003 (Pelletiere 2006, p. 4).[15] Therefore, there was an absolute deficit of 1.7 million units for extremely low-income renter households.

The second cause of the high proportion of rental cost burdens among extremely and very low-income renter households is the occupancy of affordable units by higher income households. A large number of units are affordable *but not available* for extremely and very low-income households because they are occupied by higher income households. The occupancy of affordable units by higher income households exacerbates the problem of a limited supply of affordable units for extremely low and very-low income households (Pelletiere 2006).[16]

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[15] Estimates from the NLIHC differ slightly from HUD estimates. While both organizations utilize data from the American Housing Survey, NLIHC uses an older method of estimating Area Median Income and income limits than HUD. See Pelletiere (2006, p. 13) for further details.

[16] These figures are not meant to criticize higher-income households who exercise their freedom of choice by choosing to reside in low-cost units which lower their housing costs. The numbers are provided only to emphasize that many units that would be counted as part of the affordable housing stock are not actually utilized by low-income households. 'Available' in the discussion and in Table 2.2 does not indicate that the units are vacant.

Table 2.3 presents the number of renter households, the number of affordable units, the number of the affordable units occupied by higher income households, and the overall number of *affordable and available* rental units for the three categories of low-income as of 2003. These figures were calculated by the National Low-Income Housing Coalition. Affordable and available rental units are defined as units which are affordable and either vacant or currently occupied by a household with income of the specified low-income range (HUD 2005, p. 86). The income categories presented in this table are cumulative. Therefore, extremely low-income renter households are households with less than 30% of the area median income, very low-income renter households are those with income less than 50% of the area median income, all low-income renter households are those with less than 80% of the area median income.

Table 2-3. Number of Affordable and Available Rental Units and Renter Households, 2003

	Extremely Low-Income (0 – 30% AMI)	**Extremely & Very Low-Income[b] (0 – 50% AMI)**	**All Low-Income[b] (0 – 80% AMI)**
Number of Households	7,723,592	13,732,752	20,731,167
Number of Affordable Units[a]	6,027,628	15,565,448	31,152,926
Absolute Surplus (Deficit) of Affordable Units	(1,695,964)	1,832,696	10,421,759
Number of affordable units occupied by higher income households	2,773,350	5,718,592	9,078,059
Number of Units Affordable and Available[c]	3,254,278	9,846,854	22,074,867
Surplus (Deficit) of Affordable & Available Units	(4,469,314)	(3,885,898)	1,343,700

a. Includes both the private market and subsidized units.
b. Income categories are cumulative. For example, "very low-income" includes households and units that are extremely low-income, as well as very low-income.
c. Affordable and available indicates the affordable unit is not currently occupied by a higher-income household.
Source: Pelletiere, 2006; author's calculation.

Of the 6 million rental units affordable to extremely low-income renter households, 2.8 million are occupied by households with higher incomes. Therefore, only 3.2 million of the affordable units are actually *affordable and available* to extremely low-income renters, leaving a deficit of 4.5 million affordable and available rental units. When the definition of 'low-income' is broadened to include extremely *and* very low-income households, there remains a deficit of 3.9 million *affordable and available* units. Of the 15.6 million affordable rental units for the 13.7 million very low-income renter households, 5.7 million are occupied by higher income households. Therefore, there is a 3.9 million deficit of affordable and available affordable rental units for very low-income renters.

Among all low-income renter households, there is a surplus of affordable and available rental units. Of the 31.2 million affordable units, 9.1 million are occupied by higher income households. Therefore, there are 22.1 million affordable and available units for the 20.7 million low-income renters, leaving a surplus of 1.3 million rental units.

There are three significant sources of affordable housing for low-income households. The first significant source is financial subsidies from the Federal government. Federal housing subsidies and tax credits are expended to assist eligible low-income households with housing costs. HUD has a 2006 budget of approximately $33.5 billion dollars of which approximately $26.5 billion is spent on the three largest low-income housing programs in the country, public housing, Section 8-project based, and Section 8-tenant based assistance (NLIHC 2006, pp. 1-2). Despite being the largest sources of subsidized housing in the country, these three programs currently fail to provide a significant level of new units to the affordable housing stock as most of the money is spent to maintain the current stock of subsidized units (Dolbeare, Saraf, and Crowley 2004, p. 4; Dreier 2006, p. 111). The Low-Income Housing Tax Credit (LIHTC), administered by the Internal Revenue Service, is the most significant program in terms of the production of new affordable housing units, at a cost to the U.S. Treasury of $3.85 billion dollars per year (NLIHC 2006). Since its inception in 1986 to 2003, the LIHTC has produced slightly more than 1.2 million affordable units (HUD 2006). A final Federal program, the HOME Investment Partnership Program provides block grants to state, county, and local jurisdictions for affordable housing. Since 1992, HOME has assisted approximately 367,000 rental units for low-income households (NLIHC 2006).

The second source of affordable housing is the non-profit sector, which in addition to receiving funding from federal programs such as LIHTC and HOME, receive money for housing initiatives from a variety of sources. These sources include private foundations, intermediary organizations, and banking institutions. The most significant type of non-profit organization with regard to the production of affordable housing units is the Community Development Corporation (CDC). CDC's are organizations characterized by their community-based leadership and their goal of improving the social and physical environment of their surrounding community or neighborhood (Bratt 2006, p. 340). The National Congress for Community

Economic Development (NCCED) estimated that by 2005, CDCs had produced 1.25 million units of housing nationwide for low and moderate income households (National Congress for Community Economic Development 2005, p. 4).[17]

The third significant source of affordable housing for low-income households is the private rental market (O'Flaherty 1995; Green and Malpezzi 2003). Table 2.4 compares the number of affordable rental units in the private market to the number of Federally subsidized units.

Table 2-4. Total Affordable Rental Housing Units for Extremely Low-Income and Very Low-Income Households by Federally Subsidized and Private Sectors, 2006 (in millions)

Source	Number of Units	
Federally Subsidized Units		
Public Housing	1.3	
Section 8-Project Based	1.4	
Section 8-Tenant Based	2.0	
HOME Rentals (including tenant-based assistance)	0.4	
Low-Income Housing Tax Credit	+ 1.2	
TOTAL Subsidized Units[a]		***6.3***
Private Sector		
Affordable Private Sector Units[b]	9.3	
Affordable Private Sector Units Occupied by Higher Income Households[c]	- 5.7	
***Affordable and Available* Private Sector Units**		***3.6***
Total Affordable and Available Rental Housing Units[d]		***9.9***

Notes: a. The total number of subsidized units is over-estimated. There are two reasons for this over-estimation. First, no distinction is made between subsidized units available for extremely low-, very low-, and low-income households. As the next section reveals, almost all of the units are required to be occupied by households with no more than 65% or 50% of the Area Median Income. Second, a proportion of LIHTC and HOME units receive subsidies from additional sources. Therefore, there are some units that are likely double-counted as a single unit can receive more than one type of subsidy.

b. Calculated by subtracting 6.3 million subsidized units from the approximately 15.6 million affordable units for very low-income households (both private and subsidized) reported in Table 2.3. Table 2.3 provides data from 2003, which was the most recent data available regarding the supply of affordable units in the private market.

c. As shown in Table 2.3.

d. Differs from Table 2.3 because of rounding.

Sources: (CBPP 2006; HUD 2006; NLIHC 2006; Pelletiere 2006).

[17] NCCED was disbanded in August of 2006.

The supply of 9.3 million affordable, unsubsidized rental units in the private market is significantly larger than the 6.3 million units subsidized by the five Federal affordable housing programs. Unfortunately, many of these private units are occupied by higher income households. Only 3.6 million of the private sector units are *affordable and available*.[18]

The next three sections examine these three significant sources of affordable housing. Section 2.1.2.1 provides an overview of the major Federal housing programs which provide subsidies for low-income housing. Section 2.1.2.2 discusses the role of the non-profit sector, particularly of CDCs, in the provision of affordable units. Section 2.1.2.3 explains the private market's provision of affordable housing, particularly through the process known as filtering. As new housing is constructed for higher-income households, a chain of events occurs in which the oldest and lowest quality units become available to low-income households.

2.1.2.1 Federally Subsidized Housing Programs

There are five significant federal programs from which subsidies for low-income housing are provided.[19] The oldest of these programs is public housing, established by the Housing Act of 1937 as part of President Roosevelt's package of New Deal policies to deal with the depression. The Act initially provided funds for less than 160,000 housing units, but was significant in that it created the framework of publicly-owned housing, in which local public housing authorities became responsible for developing, owning, and operating housing developments which were subsidized for eligible low-income households (Meehan 1977; Mitchell 1985).[20]

Title III of the Housing Act of 1949 greatly expanded funding for public housing. The Act authorized construction of an additional 800,000 units, which were to be completed by 1955 (Banfield and Meyerson 1955). However, public housing took a back seat in comparison to

[18] Author's calculation.
[19] This section only focuses on the largest federal housing programs. For information on smaller federal programs, see Olsen (2001) and U.S. General Account Office (2002). For information on federal housing subsidies not limited to low-income housing, see Dreier (2006).
[20] As with most low-income housing policies, the Housing Act of 1937 was not concerned primarily with affordable housing for low-income households. Meehan (1977, p. 6) argued that the provision of public housing was seen as a means to raise employment in the construction industry during the depression and remove slums. He wrote, "progress tended to be measured in terms of dollars spent, units of housing produced, construction wages generated, or number of units of dilapidated housing demolished rather than the amount of quality housing-in-use supplied to the poor."

other urban redevelopment programs funded by the Housing Act of 1949, such as slum clearance and improving the appeal of the inner city to the middle and upper class. More housing units were demolished than rebuilt (Von Hoffman 2000). Anderson (1964, pp. 66-67) estimated that by 1961 only 28,000 housing units had been built and few of them were for low-income households. But in 1968, there was a push for subsidized housing as the Nixon administration adopted a large-scale supply-side strategy to address the shortage of low-income housing. The administration and Congress provided record levels of public housing funding from 1968 to 1972 (Bratt and Keating 1993). By 1974, there were 1,115,000 units of public housing (Meehan 1977, p. 8).

The sudden increase in government spending on public housing in the late 1960's, however, backfired. Plagued by poor quality and maintenance of the housing units, growing public frustrations with the perceived failures of the liberal social policies of 1960's, poor public perceptions of public housing, and financial scandals at HUD, President Nixon declared a moratorium on new subsidized housing construction in 1973 (Bratt and Keating 1993; Burchell and Listokin 1995, p. 598; Wallace 1995, p. 793; Von Hoffman 1996; Orlebeke 2000, pp. 496-502). Support for public housing never regained momentum after the moratorium. Practically no net additions to the supply of public housing units have been made since the early 1980's and the number of units has been slowly declining from a high of 1.4 million units in 1991 (Olsen 2001, Table 5; Dreier 2006).

The last major public housing initiative began in the early 1990's. In 1994, more than $3.5 billion were committed to HOPE VI, a housing program initiated by HUD to financially assist public housing authorities to upgrade severely distressed public housing sites by turning them into mixed-income neighborhoods with new housing and supportive services (HUD 1999; GAO 2002). These funds were not meant to increase the number of public housing units, but were allocated to improve housing and neighborhood quality. To improve the quality of both the neighborhood and the housing units, HOPE VI funds were used to demolish dilapidated housing units and rebuild more modern units which were often built at lower densities than the previous units. In addition, HUD removed restrictions requiring local housing authorities to give priority for housing assistance to the lowest income households. HUD also eliminated the one-to-one replacement standard requiring local housing authorities to replace every demolished public housing unit with a new public housing unit (Salama 1999, p. 96). The result was that by 2000, the HOPE VI program had demolished over 30,000 public housing units and had built over 7,000 new ones (GAO 2002, p. 79). From 1996 to 2002, 62,797 public housing units were lost through demolition in total and another 43,000 demolitions were proposed by public housing authorities (NLIHC 2002, p. 88).

Today, approximately 14,000 public housing developments contain a total of more than 1.273 million units (GAO 2002, p. 78; NLIHC 2006). Typically, 40% of new renters in public housing must be extremely low-income. Residents pay rental costs that are the highest of 30% of their adjusted monthly income, 10% of their monthly gross income, their welfare shelter allowance, or an amount (not exceeding $50) that is set by the local authority. Most residents pay 30% of income for rent. The other rent levels are to ensure that every household pays at least some amount of rent regardless of their income.

The second and third significant federally subsidized housing programs are broadly known as Section 8, established by the Housing and Community Development Act of 1974.[21] Section 8 housing assistance is provided in two distinctly different forms. The first form of Section 8 is project-based subsidies provided to private developers and property owners to encourage them to develop and provide units to low-income households. This was the one of the first large-scale attempts to encourage private entities to develop and operate affordable housing rather than a government agency.[22]

Section 8 project-based subsidies provide 15 to 20 year rental contracts in which the Federal government subsidizes the portion of rent that low-income households cannot afford pay. The private owners were initially expected to obtain conventional mortgages for the construction of the units, to be repaid with the rental subsidies. However, most developers had to use Federally insured mortgages in order to obtain funding (Wallace 1995).

There have been no new Federal commitments made for new Section 8 project-based units since 1983. In the early 1980's, two shifts in housing policy occurred which would end future commitments to new project-based units. First, priority for housing was given to

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[21] This Act also introduced Community Development Block Grants (CDBG).

[22] The federal government's first attempts to encourage private developers to supply affordable rental units were through the use of lower-than-market rate mortgages, beginning in 1961. Private developers of affordable units could obtain federally insured mortgages through a program known as Section 221(d)3 which provided 3% interest or, later, through program Section 236 which provided an interest rate of 1%. Combined, these two programs created approximately 728,000 new affordable units from 1961 to 1973 (Schwartz 2006, pp. 130-131).

households who had income of less than 50% of the median. This priority increased the cost of the subsidies to the Federal government as these households can afford less of the rental cost on their own as compared to households with income between 50% and 80% of the area median income (Listokin 1991, p. 166). Second, the country grew increasingly more conservative on social policy, as well as faced a growing problem with the national debt (Sternlieb and Hughes 1991, p. 133). Amid growing concerns over the cost of project subsidies, President Reagan's conservative views on social policy, and a belief that the marketplace could solve the nation's housing problems, the President's Commission on Housing stated that Federal housing programs should "help people rather than build projects" and recommended ending the project-based subsidy in favor of vouchers which the tenant can use for any housing unit of his or her choosing (Listokin 1991; Burchell and Listokin 1995, p. 599; Winnick 1995; Dreier 2006, p. 116). In 1983, the Section 8-project based subsidy was no longer available for additional affordable housing units.

Today, approximately 1.4 million households live in Section 8 project-based assisted units (Olsen 2001, Table 5; NLIHC 2006). To be eligible for project-based assistance, households must have income less than 80% of the area median income. In addition, 40% of new residents must be extremely low-income. Households pay 30% of their adjusted monthly income toward rent, while HUD subsidies provide the remaining rental cost. The total rental price is a contract rent, based on Fair Market Rent (FMR), between HUD and the private owner of the unit. In most areas, the FMR is the rent amount of the 40% percentile of rental units into which a new household has moved into in the past two years.

The second form of Section 8, created in 1974, is Section 8 tenant-based assistance.[23] Rather than providing a subsidy to owners of specified properties, tenant-based assistance provides a voucher to tenants which they can use for a housing unit of their choosing. In theory, a low-income household receiving tenant-based assistance is free to choose where they will reside. The housing assistance follows the household, it is not tied to a specific unit. However, the housing unit must meet HUD standards of quality and the landlord must be willing to enter

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[23] At the time of the passage of the Housing and Community Development Act of 1974, Section 8-project based assistance was refered to as "Section 8 New and Rehab" and Section 8-tenant based assistance was called "Section 8 Existing" (HUD 2000).

into a contract with the public housing authority or other administrative agency that is administering the voucher (HUD 2000; Sard 2001).

The number of low-income households receiving Section 8 tenant-based assistance has steadily, yet slowly, increased over time (Olsen 2001). The program was expanded by the Housing and Urban-Rural Recovery Act of 1983 and the Housing and Community Development Act of 1987 in response to the discontinuation of funding for new Section 8 project-based units (HUD 2000).[24] This growth has been the result of the program being credited with improving the mobility of low-income recipients. Tenant-based assistance is currently looked upon favorably. There is evidence that tenant-based assistance is less likely than project based assistance to be used in neighborhoods of concentrated poverty (Newman and Schnare 1997; HUD 2000; Shroder 2001; Feins and Patterson 2005); is likely to help households manage the welfare-to-work requirements of welfare reform because it provides recipient households with improved mobility (Rosenbaum and Popkin 1991; Rosenbaum and DeLuca 2000; Sard and Lubell 2000); and is provided at a lower cost per unit to the Federal government than project-based assistance (HUD 1995; GAO 2002).

One drawback to tenant-based assistance is that they are not accepted by all landlords, limiting the range of housing options among recipients. Poor public perceptions of the Section 8 program limits the number of new landlords willing to accept the vouchers, forcing a large number of recipients to use their vouchers in their current location or among landlords who already accept vouchers from other tenants (Kennedy and Finkel 1994; HUD 2001). In an evaluation of Section 8 in Chicago, Popkin and Cunningham (1999, p. 25-26) found that landlords refused Section 8 vouchers despite Chicago's Human Rights ordinance which prohibits housing discrimination on "sources of income."

Another drawback to tenant-based assistance is that certain types of households have a more difficult time finding appropriate housing for which to use their vouchers than other households. Finkel and Buron (2001) measured the success rates among tenant-based assistance

[24] Section 8 tenant-based assistance, established in 1974, created certificates requiring tenants to choose units that rented at a price below an established maximum. The 1980's saw the introduction of housing vouchers which are similar to certificates except that recipients are not limited in choice by a maximum rent level. Voucher recipients are permitted to choose a unit priced higher than the maximum allowable rent as long as they are willing to pay the difference, with the only limitation being that the rent paid by the recipient cannot be more than 40% of their income. The 1998 Public Housing Reform Act merged the certificate tenant-based assistance into the voucher tenant-based assistance. Therefore, there is no longer a distinction between the two (HUD 2000; Lubell 2001).

recipients across multiple metropolitan areas. They found that 67% of households with five or more members succeeded in locating a housing unit in which to use their voucher. This was statistically lower than the 72% of households with 3 to 4 people who were able to successfully use their assistance. It is more difficult to locate larger rental units for households with greater than 4 people.

A third drawback is the difficulty of using rental vouchers in a 'tight' housing market in which there are fewer vacancies. Finkel and Buron (2001) found only 66% of vouchers were successfully used in tight housing markets with a vacancy rate of 2% to 4%. 61% of vouchers were successfully used in very tight markets with a vacancy rate of 2%. In contrast, they found that 73% and 80% of vouchers were successfully used in markets with vacancy rates of 7% to 10% and greater than 10%, respectively.

Despite these criticisms, Section 8 tenant-based assistance is the largest Federal affordable housing program today for low-income households. It is received by approximately 2.0 million households (CBPP 2006). With Section 8 tenant-based assistance, a tenant pays 30% of income for rent and HUD pays the remaining rental cost up to a set rental amount. The maximum assistance that HUD will provide is the difference between 30% of the household's income and the maximum allowable rent, the "rent standard", which in most cases is set at the FMR. All new voucher recipients must be very-low income households, with income that is less than 50% of the area's median. If public housing authorities decide to make low-income households (with income less than 80% of the area's median) eligible for tenant-based assistance, the authority must state to HUD the reasons for doing so. Regardless, 75% of all new voucher recipients must be extremely low-income households, with income less than 30% of the area's median (CBPP 2003).

The fourth significant Federal housing program for low-income households is the HOME Investment Partnership Program (HOME). Authorized by Congress in 1990 by the Cranston-Gonzales National Affordable Housing Act, the HOME program provides Federal block grants to participating jurisdictions (PJs) which are state, county, and local governments. 40% of HOME funds are reserved for the states while the remaining 60% are reserved for cities and counties which are capable of adequately utilizing at least $500,000 from the program. Small municipalities, therefore, are not eligible. To receive funds, local PJs must create a five year, HUD-approved consolidated plan which addresses the jurisdiction's affordable housing needs, as well as provide matching non-Federal funds of $0.25 for every $1 of HOME funds received (O'Regan and Quigley 2000; NLIHC 2006). The HOME funds can be used for four primary purposes. They are (Urban Institute 1998, p. 8):

- purchase, construction, or renovation of rental housing.
- renovation or construction of for-sale housing and assistance to individual homebuyers.
- rehabilitation of owner-occupied housing units.
- tenant-based rental assistance.

The PJs can then use the funds as they see fit in addressing affordable housing needs in their area.

Supporters of the HOME program, at the time of its creation, argued that housing programs needed to be less encumbered by HUD's bureaucracy as local jurisdictions have better knowledge of local needs, the types of households living in subsidized housing, and local housing conditions (Cavanaugh 1992). Therefore, local jurisdictions are better able to decide on the best mix of housing assistance – such as subsidies, low-interest loans, operating support, and grants – to improve the supply of affordable housing in their area (National Housing Task Force 1988; Orlebeke 2000, p. 510). After decades of experience in dealing with Federal housing programs, many housing advocates believed that local jurisdictions had the "capacity and experience" to pursue housing goals without hindrance from bureaucratic HUD guidelines.

HOME funds are less restricted by Federal regulations than Section 8 or public housing in terms of income eligibility requirements. HUD does not require units to be set aside for extremely low-income households, although local jurisdictions may do so (Urban Institute 1998). At least 90% of HOME units must be occupied by households with income less than 60% of the area median income. The other 10% must be occupied by households with income less than 80% of the area median income. If a housing development has more than 5 HOME-funded units, 20% of the assisted units must be occupied by very low-income households with income less than 50% of the area median income.

With a budget of $1.7 billion in 2006, the HOME program is small compared to the $26.5 billion that HUD spends on public housing and Section 8 project-based and tenant-based units (NLIHC 2006). However, HOME is the most significant HUD program in terms of increasing the supply of subsidized units as neither the Section 8 project-based program nor the public housing program provide new commitments for additional units (O'Regen and Quigley 2000; GAO 2002). From 1992 to 2005, HOME funds were used to subsidize approximately 234,600 rental units and 132,700 tenant-based vouchers for low-income households. In addition, approximately 406,800 units were assisted for homeownership opportunities for low-income households (NLIHC 2006).

The HOME program is criticized because it does not target assistance to the poorest households with the greatest need for affordable housing (Nelson and Khadduri 1992; Nelson 1994). While public housing and Section 8 programs target extremely low-income households, Federal guidelines do not require HOME funds to be targeted to the lowest income groups. However, Nelson (1994) and Daskal (1998) found that affordable units were consistently in short supply for households with extremely low-income. Extremely low-income households are more likely to experience severe housing costs burdens, caused by the lack of affordable units, than other income groups (HUD 2005; Joint Center for Housing Studies 2005). Evaluations of the HOME program indicate that between 80% and 90% of residents of HOME rental units have household income of below 50% of the area's median (Urban Institute 1998, p. 88; Abt Associates 2001, p. 8; Swack 2006, p. 265). A recent sample of HOME households indicated that 47% were extremely low-income (Abt Associates 2001, pp. vi & 33).

Another criticism of the HOME program is the rent structure (Nelson and Khadduri 1992). Rather than paying 30% of household income toward rent, a low-income tenant's rental cost for a HOME unit is pre-established. Rents are typically set at the FMR for the area or 30% of 65% of the area median income, whichever is lower. Because there is no relation between rents and income, many low-income families living in HOME-funded housing units pay more than 30% of their income for rent (NLIHC 2006). Abt Associates found that the average extremely low-income household in a HOME-funded unit had a rent burden of 53% of its income (Abt Associates 2001, pp. vi & 33). In order to afford a HOME funded unit, extremely low-income households need an additional subsidy. The evaluations of the HOME program found that between 40% to 50% of households in a HOME unit received additional tenant-based assistance which allowed them to afford it (Urban Institute 1998, pp. xiii and 88; Abt Associates 2001, p. 37).

The fifth significant Federal affordable housing program is the Low-Income Housing Tax Credit (LIHTC). It is currently the most active Federal affordable housing program in terms of new unit production (Wallace 1995; Cummings and DiPasquale 1999; NLIHC 2006). From

1987 to 2003, the program assisted in the development of more than 1.25 million low-income households units (HUD 2006).

Unlike the other housing assistance programs, LIHTC is not a direct expenditure from the Federal budget. The program provides a tax credit administered by the Internal Revenue Service. The program was established by the Tax Reform Act of 1986 to encourage investors and developers to invest in the construction and rehabilitation of low-income rental housing in the face of disappearing tax shelters from rental units which the reform act eliminated (Case 1991; Marcuse and Keating 2006, p. 150). The LIHTC gives investors a tax credit of 9% per year for 10 years of total construction costs for new construction. The credit is 4% for rehabilitation projects of existing properties or projects financed by tax-exempt bonds (Wallace 1995, p. 797; Swack 2006, p. 267).

Criticisms of the LIHTC are similar to those of the HOME program (Nelson 1994). The LIHTC is not targeted to extremely low-income households. To qualify for the tax credit, housing developments for which the LIHTC is applied must either reserve 40% of the units for households with income less than 60% of the area's median or at least 20% of the units for households with income less than 50% of the area's median. An assessment in 2000 revealed that approximately 40% of LIHTC units were occupied by extremely low-income households with income less than 30% of the area's median and another 34% were occupied by households with income between 31% and 50% of the area's median (Abt Associates 2000, pp. vi & 3-6).

Similar to the HOME program, there is no rent-to-income ratio to determine the tenant's rent payment. The tenant's rent is pre-established by the landlord. The maximum allowable rent is 30% of the maximum income that a household can have to quality for a tax credit unit (either 50% or 60% of area median income). Qualifying households with income levels close to the maximum allowed are better able to afford the rent, while households with the lowest income are often unable to afford the rent without additional assistance. Approximately 70% of extremely low-income renters and 39% of all renters who reside in LIHTC units also receive an additional housing subsidy, typically through a Section 8 voucher or HOME funds, to assist with the rent (GAO 1997, p. 45).

A concern regarding the LIHTC is the extent to which the housing remains available to low-income households after occupancy requirements expire. As initially implemented, the LIHTC gave investors a tax credit for 10 years, but required the units for which the credit applied to remain affordable to low-income households for 15 years. The property's owner was free to rent the units to any household, regardless of income, after 15 years. This problem was partially addressed early in the history of the LIHTC through two Acts. First, the Revenue Reconciliation Act of 1989 requires LIHTC units completed after 1989 to remain restricted to occupancy by low-income households for an additional 15 years. Second, the Omnibus Budget Reconciliation of 1990 requires owners of tax-credit properties to give qualified non-profit groups and public agencies the right of first refusal if they decide to sell their properties which received tax credits (Collignon 1999, pp. 10-11; Schwartz 2006, p. 96).

These two new requirements are placed on all LIHTC units completed after 1990. Therefore, LIHTC units completed after 1990 are more likely to remain available to low-income households than units completed from 1986 to 1989. Collignon (1999, p. 18) estimated that approximately 170,000 units produced through the LIHTC program between 1986 and 1989 had no affordability requirements after 15 years. However, nearly half of these units have other funding sources in addition to the LIHTC which extend affordability requirements longer than 15 years (Schwartz 2006, p. 97).

The five Federal housing programs described in this section provide approximately 6.3 million rental units to low-income households. The oldest and largest programs, public housing, Section 8 project-based assistance, and Section 8 tenant-based assistance, require low-income households to contribute 30% of their income to their housing while the Federal subsidy covers the remaining portion of rental costs. In comparison, the HOME and LIHTC programs require the same rent amount to be contributed by households regardless of their income. The two programs establish rents at 30% of the highest income level eligible for assistance. Therefore, households with income near the eligibility cut-off are better able to afford the units than households with the lowest incomes not receiving additional assistance from another program. The next section will examine the growing role of the non-profit sector in the provision of affordable housing for low-income households.

2.1.2.2 Non-Profit Sector

Non-profit organizations are the second significant source of affordable housing for low-income households. There are three significant reasons why the non-profit sector has become an important source of affordable housing. First, the federal government made a concerted effort to reduce its role in the provision of low-income housing during the early 1980's. The termination of the Section 8 project-based program in 1983 signaled the end of the federal government's direct involvement in categorical funding for the production of new low-income housing units. As the federal government's direct involvement in affordable housing declined, non-profit organizations began to fill the void (Keyes et al. 1996).

The second significant reason for the growth of the non-profit sector was the availability of money for non-profits to fill the void left by the federal government. As early as 1974, block grants were introduced as a means to give greater autonomy to counties and local municipalities over their spending of federal grants. Much of this money was made available to non-profit organizations. The most well-known block grant is the Community Development Block Grant (CDBG) established in 1974. Seventy percent of CDBG money goes to cities with more than 50,000 residents and to counties with more than 200,000. At least 70% of CDBG money received by any jurisdiction must be spent for the benefit of low-income and moderate-income households (NLIHC 2006). From 2004 to 2006, CDBG funds were used by local jurisdictions to provide housing assistance for approximately 170,000 units per year (HUD 2007). From 2001 to 2006, the average amount of CDBG money disbursed for housing services was $1.18 billion. This represents approximately 24.5% of total CDBG money available each year. The remaining CDBG funds are used for commercial development, administration, and public improvements and services (HUD 2007).

The importance of the non-profit sector in providing affordable housing was solidified by the HOME and LIHTC programs, described in the previous section. At least 15% of a jurisdiction's HOME funds must be set aside for local community-based housing development organizations (CHDO), which are non-profit housing organizations (NLIHC 2007).

The third significant reason for the growth of the non-profit housing sector is the technical and financial assistance provided by foundations and intermediary organizations to small, local oriented non-profits focusing on affordable housing. To understand the role of these large intermediary organizations, this section will first present the types of non-profit organizations that are significant to the production of affordable housing. The three most significant types of non-profit organizations are Community Development Corporations (CDC); intermediary organizations which provide both technical assistance and funding to CDCs; and regional non-profit housing organizations (Burchell and Listokin 1995; Bratt 2006; Schwartz 2006).

A CDC is a community-based organization whose goal is to improve the structural, social, and economic characteristics of its local community. The most frequent area of interest among CDCs is the physical improvement of the local community (Stoecker 1997). Another primary characteristic of the CDC is its resident-based leadership drawn from its local community. The Board of Directors consists of volunteer residents.

CDCs were initially created in the 1960's to address the problems created by urban decline. From 1966 to 1980, the Federal government provided more than $500 million to these newly created, local community organizations focusing on economic development and social services in their local neighborhoods (National Center for Economic Alternatives 1981; as cited by Bratt 2006, p. 341).[25] Over time, CDCs moved their primary attention to the development of low-income housing and away from other development or social service programs. By 2005, more than three-quarters of all CDCs were producing housing units, many of which affordable to low and moderate income households. By 2005 these local non-profit organizations were credited with producing approximately 1.25 million affordable units, utilizing a variety of financial sources to do so (National Congress for Community Economic Development 2005).

Intermediary organizations which provide funding to these local CDCs are the second type of significant non-profit organization for the production of affordable units. Between 1979 and 1981, the Enterprise Foundation, the Local Initiatives Support Corporation (LISC), and the Reinvestment Corporation were founded to provided provide money and technical assistance to non-profit housing organizations, particularly CDCs. These organizations serve as intermediaries as they raise pools of funds through foundations, banks, private corporations, and the syndication of tax credits for low-income housing (Vidal 1997; Schwartz 2006, p. 202).[26] Vidal suggested that a function of these organizations is to act as community development "banks" as they provide financial tools to non-profit housing organizations. According to reports reviewed by Schwartz (2006, pp. 202-203), the Enterprise Foundation has raised approximately

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[25] The Ford Foundation was also a significant financial supporter of CDCs from the mid-1960s through the 1970's. For a history of the CDC, see Halpern (1995, Chapt. 4) and Stoutland (1999). Also see Stoecker (1997).
[26] LISC and the Enterprise Foundation are the largest intermediary organizations. There are also similar organizations which focus on specific geographic regions, particular large cities or metropolitan areas. For a discussion of these organizations, see Nye and Glickman (2000).

$6 billion to distribute to 2500 nonprofit groups for the development of 175,000 affordable housing units. Meanwhile, LISC has financially assisted in the development of more than 158,000 affordable units.

The third significant non-profit organization is the regional, or large city, housing organization (Schwartz 2006). These are non-profit organizations whose function is to develop housing for low-income households, but they do not focus on a single neighborhood or small community as CDCs do. Rather, they develop housing throughout a large geographic area. These organizations include the Bridge Housing Corporation which has produced more than 10,000 affordable units in Southern California, Phipps Houses which has produced more than 5,500 units throughout New York City, and the Community Builders, a national organization which has produced more than 17,000 units in eight states.[27]

The Housing Partnership Network is a networking organization consisting of 90 of these large non-profit housing producers. Through this partnership, they share knowledge, skills, and most importantly, financial resources. The Network also has raised money for loan funds to help their members in various stages of the development process. The network has been able to raise these funds from such investors as private foundations and financial institutions.[28]

2.1.2.3 Unsubsidized, Private Market Provision of Affordable Housing

The private, unsubsidized housing market is the third significant source of affordable housing for low-income households. The unsubsidized market typically does not produce *new* affordable units. The cost of producing new housing units and, more importantly, the rent charged to consumers for these new units exceeds the expense that low-income households can afford to pay. The Joint Center for Housing Studies (2005, p. 23) estimated that $400 was the highest rent the poorest 1/3 of renter households could afford. They calculated that only 10% of the newly built rental units rented for less than $400, compared to 25% of existing rental units. More than 43% of these newly built units rented for more than $800 as compared to 25% of existing units. Simultaneously, many of the new rental units merely replaced old ones. As the Center states, replacing older rental units improves quality, but does nothing for affordability. The Center found that, from 1993 to 2003, new construction was responsible for a net addition of rental units

[27] These numbers were taken from Schwartz (2006, p. 203).
[28] See www.housingpartnership.net

only among those that rented for at least $600. Sternlieb and Hughes (1991) provided anecdotal evidence that these unaffordable rents among new units are the result of the of construction, even when regulatory barriers such as building codes and land use restrictions are relaxed.

There are two sources of affordable housing in the unsubsidized, private market. The first source is manufactured homes.[29] There are approximately 8.6 million manufactured homes in the United States, accounting for slightly more than 6.9% of all housing units (U.S. Bureau of the Census 2005, Table 1A-7). Of these homes, 6.9 million are occupied. Their median monthly cost is $417 for an owner-occupied unit and $513 for a renter-occupied unit. This is significantly lower than the median monthly cost of $809 for a conventional owner-occupied unit and $694 for a conventional rental unit (U.S. Bureau of the Census 2005, Tables 3-13 and 4-13).

Manufactured homes are cheaper than a conventional home because they are typically on smaller lots and are of smaller size than a conventional home (Beamish and Goss 2001, p. 375). Despite the public's perception that manufactured housing is of poor quality, there is no evidence for this belief (Genz 2001; Beamish and Goss 2001). Since 1976, new manufactured homes have been built to meet at least a minimum level of quality as defined by HUD.

Manufactured housing is most typically used as a homeownership opportunity for lower-income households. Of the 6.9 million occupied manufactured homes, more than 79% are owner-occupied (U.S. Bureau of the Census 2005, Tables 1A-1 and 3-1). The median household income for owners of manufactured homes is $30,486, which is lower than the median household income of $55,571 for all owner households and the $71,350 median household income of owners of new housing less than four years old (U.S. Bureau of the Census 2005, Table 3-12). Renters occupy approximately 1.4 million manufactured housing units, with a median household income of $19,833, as compared to $27,051 for all renter households (U.S. Bureau of the Census 2005, Table 4-12).

The second source of affordable housing in the unsubsidized, private market is older housing units as they decline in value and quality in response to new (unaffordable) units being

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[29] These are commonly referred to as mobile homes because they are built on a chassis, allowing them to be delivered on wheels. Disgruntled by the negative connotation given to the word "mobile" home, the Mobile Home Manufacturers Association changed its name to the Manufactured Housing Institute in 1975. In 1980, the Institute successfully lobbied Congress to change the word "mobile" to "manufactured" in all relevant legislation. For further details and history of manufactured housing, see Wallis (1991). For challenges facing the manufactured housing industry, see Genz (2001).

built. The mechanism by which older housing units become affordable in the private market is known as filtering (Baer and Williamson 1988; Downs 1994, pp. 9-10; O'Flaherty 1995; Green and Malpezzi 2003, p. 16-17). New units in the private market are typically of high quality and contain the most current amenities. Households with preferences and financial resources for this housing will vacate their older units for these new units. These vacated older units are then available to other households. If there is not a strong enough demand for these vacated units, they will 'filter down' in price. A second group of households otherwise not able to afford the vacated units, could afford them if they decline in price. This second group of households will vacate their current units, which will then decline in price for a new group of households of even lower income. Filtering is a chain reaction as the oldest housing filters down to the lowest income households. In one of the first popular definitions of filtering, Ratcliff (1945, p. 322) wrote:

> It is a common argument that the needs for additional housing on the part of the low income groups can be met by the production of new housing for higher income groups. Thus, used houses will be released to be passed down to successively lower levels until the effect has reached the bottom of the market…this process is popularly referred to as filtering down and is described most simply as the changing of occupancy as the housing which is occupied by one income group becomes available to the next lower income group as a result of decline in market price, i.e., in sales price or rent value.

Table 2.5 provides a summary of significant empirical research of filtering. These studies are not discussed in the text as filtering is not the primary focus of this dissertation. There are a limited number of empirical studies of filtering, but they suggest that older units do filter down in price to become affordable to low-income households. More importantly, there is some suggestion that low-income households can experience an improvement in the quality of their housing as households 'move up' to a higher level of housing quality when new housing is constructed.

Section 2.1.2 emphasized the importance of Federal subsidies, the non-profit sector, and the unsubsidized, private housing market in the provision of affordable housing to low-income households. From this section, we can conclude that the unsubsidized, private market is an important component regarding the supply of affordable units for low-income households. The private market provides as many affordable units as federal subsidies. This section concluded with the concept of filtering, the process by which older housing units may become affordable in the private market through the production of new, higher quality units for higher-income households.

Table 2-5. Empirical Evidence of Filtering

Author	Location	Unit of Analysis	Method	Independent Variable of interest	Dependent Variable	Significant Finding
Grigsby (1963)	9 metropolitan areas	SMA (Standard Metropolitan Area)	Correlations	New housing construction	Prices of existing units	Strong correlation between new construction and decline in housing prices (relative to income).
Kristof (1965)	New York City	Households moving into vacant units (beginning with newly built unit)	Vacancy Chain	Occupation of a newly constructed housing unit (first time to be occupied)	Movement of households down the 'chain' of units	For every new housing unit, 2.4 households were able to make voluntary adjustments to their housing situation.
Lansing et al. (1969)	13 Metropolitan Areas	Households moving into vacated units (beginning with a newly constructed unit)	Vacancy Chain	Occupation of a newly constructed housing unit (first time to be occupied)	Movement of households down the 'chain' of units	Construction of 1,133 new homes allowed 3,039 households to move. 9% of the households were poor. 55% of the households had lower incomes than the households which previously occupied the unit..
Sands and Bower (1976)	Erie County, NY; Bronx, NYC; Rochester Metropolitan Area	Households moving into vacated units (beginning with a newly constructed unit)	Vacancy Chain	Occupation of a newly constructed private and subsidized housing units (first time to be occupied)	Movement of households down the 'chain' of units	New, private suburban homes had little, if any, impact on housing for low-income households. New city units and subsidized units for moderate-income households improved the housing for low-income households.
Somerville & Holmes (2001)	44 Metropolitan Areas	Housing Unit	Multinomial Logit Regression	Unit characteristics and neighborhood characteristics	1. Probability of unaffordable unit becoming affordable. 2. Probability of an affordable unit becoming unaffordable.	1. Increase in age of unit was associated with an increase in the odds of the unit filtering down to an affordable rent level. 2. Increase in unit age was associated with a lower probability of an affordable unit 'filtering up' to an unaffordable rent level.
Somerville & Mayer (2003)	44 Metropolitan Areas	Housing Unit	Multinomial Logit Regression	New single-family building permits, in addition to unit and neighborhood characteristics	1. Probability of unaffordable unit becoming affordable. 2. Probability of affordable unit becoming unaffordable.	1. No association between single-family building permits and probability of unaffordable unit become affordable. 2. An increase in single-family building permits was associated with a decrease in the odds of an affordable unit filtering up to unaffordable rent level.
Weicher & Thibodeau (1988)	59 Standard Metropolitan Statistical Areas	SMSA	Simultaneous Equations (connecting 3 sub-markets of sub-standard quality, standard quality, and new housing	New housing construction	Supply of sub-standard housing units	One new unit was associated with the removal of 1.4 (Census data) or 1.92 (AHS data) sub-standard units.

The next section presents sprawl, which is the dominant pattern of growth for metropolitan regions in the U.S. Sprawl is the result of new development, both residential and commercial, outside of the urban environment of a region's central city and older suburbs. As new development occurs on the urban/rural fringe of metropolitan areas, housing affordability in the private market may improve for low-income households because of the filtering process. Wealthier households move to new housing developments on the urban/rural fringe, while vacating units in older communities. The older units then become available to households of lower income.

2.2 SPRAWL

This section presents the pattern in which metropolitan areas grow outward from the central city. This outward growth occurs as the majority of new housing, as well as commercial sites, are developed outside of the central city and on the urban fringe where there is an abundance of undeveloped land. This outward growth of metropolitan areas is typically referred to as sprawl and has implications for housing for low-income households. This section first discusses multiple interpretations and dimensions that have been given to sprawl. It then presents an economic theory of land use used to explain sprawl's occurrence. This explanation includes the issues of land use, housing, and transportation.

2.2.1 Definition of Sprawl

Sprawl is the residential and commercial decentralization of cities as populations move to newly developed outer areas of metropolitan regions, consuming previously undeveloped land. Nationally, the amount of land in the United States considered 'urbanized' increased by 47% from 1982 to 1997, but the nation's population grew by only 17% (Fulton et al. 2001, p. 1). Urbanized land is defined as land that is developed and is used for residential, industrial, commercial, institutional, and recreation uses and infrastructure such as highways, garbage landfills, and sewer and water treatment plants. Out of 281 metropolitan regions across the U.S., Fulton et al. found that 264 experienced a greater growth rate in urbanized land than in population. Their findings imply that the density of development, which is the amount of development per unit of land, is decreasing in almost every metropolitan region of the country as development spreads out further from each region's central business district (CBD) at lower densities than in the center.

Gordon and Richardson (2000, p. 2) simply call sprawl "the shorthand term for most current suburban and exurban development." Gillham (2002, p. 3) writes that most people picture sprawl as "great urban centers erupting across the countryside in a devastating flow of superhighways, shopping centers, baking asphalt, and twinkling cars." Despite the notion that everyone can identify sprawl, creating a precise definition for it is difficult as the word typically is used to refer to multiple characteristics, including land use patterns, consequences of those patterns, and aesthetic qualities (Galster et al. 2001; Mattson 2002; Burchell et al. 2005).

Table 2.6 provides a summary of the most commonly identified characteristics of sprawl in found in the literature. The characteristics can be divided into land-use patterns, consequences of those land use patterns,[30] and consequences of government structure.

Table 2-6. Characteristics of Sprawl

Sprawl as land use pattern	Sprawl as a consequence of land use patterns	Sprawl as a result of government structure
Low density development, particularly low-density single-family housing	Loss of undeveloped farmland and open space	No centralized planning
Segregated land uses	"Trickle-down" (filtering) as source of affordable housing	Fragmentation of land use powers among jurisdictions
Leapfrog development (non-contiguous development)	Reliance on automobile for transportation	
Commercial Strip Development		
Development in rural, undeveloped locations		

Sources: (Ewing 1997; Burchell et al. 1998; Downs 1998; Duany, Plater-Zyberk, and Speck 2000; Burchell et al. 2002; Orfield 2002).

[30] There is a large literature regarding the consequences of the land–use patterns of sprawl. For a comprehensive review of the "cost of sprawl" literature, see the Cost of Sprawl reports by Burchell et al. (1998; 2002; 2005).

The four most commonly cited land use characteristics of sprawl are large areas of low-density development, segregated land uses, commercial strip development, and leapfrog development (Nelson and Duncan 1995, p. 1; Ewing 1997, p. 108; Burchell et al. 2005, p. 12). Low-density development is likely the most typical land use pattern associated with sprawl. It is typically defined and measured as the number of people or number of housing units per an area of land (Pendall 1999). Density of a metropolitan area declines as the amount of developed land grows faster than the population, consuming a greater amount of land per person (Fulton et al. 2001).

In addition to lower density, new residential developments are often segregated from commercial and public land uses. Duany et al. (2000) identify five components, each segregated from one another, of which sprawl consists. These five components are: housing clusters that consist only of residences and are typically of low-density single-family housing; shopping centers that are exclusively for shopping; isolated office parks surrounded by parking lots and highways; civic institutions, such as schools, churches, and other public gathering places, located just about anywhere rather than in convenient central places; and an extensive system of roads connecting the other four segregated components.

Commercial strip development is the cluster of commercial enterprises located along the stretches of road (Altshuler and Gomez-Ibanez 1993; Ewing 1997). These commercial developments, because of their location along busy highways and segregation from residential neighborhoods, typically require an automobile for access. They are located along highways which connect towns or large-scale residential developments to one another, while the residential developments themselves have little commercial activity.

Leapfrog development refers to the way in which large tracts of privately owned land between developments remain vacant, separating new developments from one another (Clawson 1962; Altshuler and Gomez-Ibanez 1993). This land, while not immediately developed, is kept in private hands away from public use (Ewing 1997). Private owners keep the land vacant for speculative purposes, expecting the value of their undeveloped land to increase as development occurs around it (Clawson 1962; Mills 1981). This type of development pattern leads to non-contiguous developments that cover a wider area of land than necessary.

A fifth land use characteristic of sprawl is the unlimited development outward from the central city (Downs 1998; Burchell et al. 1998; Squires 2002). This outward growth consumes farmland and other undeveloped exurban land, located on the urban/rural fringe at a distance farther from the city than current suburbs (Kline 2000; American Farmland Trust 2003). In a recent literature review of the costs of sprawl for the Transportation Review Board, Burchell et al. (2002, p. 3) ignored all other land use characteristics and, instead, limited their definition of sprawl to high growth rates in non-urban and undeveloped locations. The authors argued that there is no way to categorize development in rural, undeveloped locations as non-sprawl unless they are organized and planned centers of development, which are rare in the United States. Likewise, they argued that additional development in already developed areas cannot be considered sprawl. They add that sprawl is:

> Growth where it would be unproductive; i.e., in places that are less desirable from resource consumption or capital provision perspectives. These include rural, undeveloped, or developing suburban counties that simultaneously (1) lack infrastructure to support that growth; and (2) siphon development away from established development areas, effectively diluting the intensity of use for infrastructure that is already in place in these areas (p. 58).

There are also non land-use characteristics that have been used to define sprawl. A sixth characteristic is the lack of centralized land use planning (Nelson and Duncan 1995; Downs 1998). The Florida Department of Community Affairs, a state which took an early lead in growth management in an attempt to direct growth away from environmentally sensitive areas, defines sprawl as "scattered, untimely, poorly planned urban development that occurs in urban fringe and rural areas and frequently invades lands important for environmental and natural resource protection" (Mattson 2002, p. 19).

Advocates of growth management argue that planning can prevent the traditional land use patterns that are associated with sprawl (Ewing 1997; Nelson 1999; Weitz 1999; Abbott 2002). Regional or state level growth management techniques, such as urban growth boundaries, comprehensive planning, and regional coordination of local growth plans, are implemented in an attempt to manage growth in exurban areas, prevent rapid consumption of undeveloped land, and protect environmentally sensitive areas. Three of the most prominent state and regional growth management programs, in Portland, Oregon; Seattle, Washington; and Baltimore, Maryland are discussed in a later chapter.[31]

A few scholars add fragmented land use powers to the list of non land-use characteristics of sprawl (Carruthers and Ulfarsson 2002; Orfield 2002). Orfield (2002, p. 96) credits competition for a strong tax base among multiple and fragmented municipal governments within a region as one of the causes of sprawl-like development. An individual municipality is financially better off if it allows residential development which brings more public revenue to the local government than public costs. Because local governments typically rely on property taxes as their primary source of revenue, they are sensitive to attracting types of development that will provide more revenue than require in public costs (Orfield 2002, p. 88-89). The types of residential development which fit this criterion are large, expensive single-family homes or small apartments of only one or two bedrooms. Large, expensive homes provide for a stronger tax base from which to draw public revenues greater than the cost of public services used by the households in these large units. Small apartments attract either single or two-person households without children who are typically in need of little public services, yet the landlord of their apartment still pays property taxes. In contrast, inexpensive single-family homes and higher density developments, such as large apartments or townhouses, are more likely to cost more in public services than the revenue they provide. This is due to that fact that these types of residential units are more likely to attract moderate to low-income families with children, yet provide smaller source of property tax revenue than larger homes.

Orfield suggested that this process encourages sprawl as it provides an incentive for municipalities to allow large lot single-family homes and prohibit smaller, higher density ones. Therefore, newer homes are more likely to be large-lot single-family units. In addition to this municipal behavior, households continually have an incentive to move from high cost (in terms of property taxes) older areas to newer areas which have lower taxes because these new areas do not have the burdens of providing public services to a wide range of households with regard to income and needs for public services.[32]

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[31] For discussions of the variety of growth management legislation, including requirements for planning, that has been passed in order to address sprawl see Stein (1993), Porter (1996; 1997), and Weitz (1999).

[32] This characteristic is based on the "public choice theory" cause of sprawl. For in depth explanations of public choice theory and its application to household and municipal behavior, see Mueller (2003), Fischel (2001), Peterson (1981), Hamilton (1975), and Tiebout (1956). Razin and Rosentraub (2000) questioned the extent to which

Another non land-use characteristic of sprawl is the reliance on the automobile as the primary means of transportation (Burchell et al. 1998; Duany, Plater-Zyberk, and Speck 2000; Downs 2004). The automobile is the dominant means of transportation as employment opportunities, commercial activities, and residential developments are segregated from one another, often by large highways making them inaccessible to and from one another without motorized transportation. At the same time, public transit is economically inefficient and has lower utilization in sprawling, low-density communities with fewer than seven housing units per buildable acre than higher-density communities (Downs 2004, p. 210).

Downs (1998, p. 8) adds another characteristic to his definition of sprawl, which is a "reliance on trickle-down to provide low-income housing." Trickle-down is Downs' term for the filtering of older housing from higher-income to lower-income households. He is the only author to explicitly relate sprawl to affordable housing through the filtering process. As households move up to larger, newer homes in the outlying areas of metropolitan regions, older housing in older areas becomes less desirable among consumers. As demand for the older housing declines, they become more affordable for lower-income households.

As discussed in Section 2.1.2.2, there are few recent studies of filtering. Meanwhile, there are no recent studies which specifically test the relationship between sprawl and the supply of affordable units for low-income households. Theoretically, the relationship between the two is positive. As more households move to new units further away from central cities and older communities, we would expect more of the older housing units to become affordable to low-income households. However, the one study which explicitly examines the relationship between new suburban development and its impact on housing for low-income households, which was conducted in the 1970's, found little support for this theory (Sands and Bower 1976). The limited availability of empirical evidence may be the reason filtering is rarely linked to sprawl in the literature.

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competition among fragmented local governments cause sprawl within a region. In a regression analysis for 98 metropolitan regions, they found that fragmentation did not cause sprawl. Rather, they found sprawl to be a weak predictor of fragmentation. Their findings suggest that sprawl occurs with or without fragmentation. Nonetheless, fragmentation is often identified as a characteristic of sprawl despite unclear evidence as to whether it is a cause of sprawl, an effect of sprawl, or neither.

2.2.2 Measuring the Complexity of Sprawl

Sprawl is a complex phenomenon to measure. It is typically measured by land use patterns, but not all of its characteristic land use patterns need to exist in order for suburban growth to be called sprawl. Leapfrog, or non-contiguous, development could occur in which there are large tracts of vacant land separating developments of high density (Harvey and Clark 1965; McKee and Smith 1972). In a case study of Houston, Mieszkowski and Smith (1991) found that the region had a significant amount of leapfrog development in which population centers were separated from one another by large tracts of vacant land. This type of development is a characteristic of sprawl and in this regard Houston could be characterized as sprawling. On the other hand, the residential density of these developed centers declined slowly as distance from the central business district decreased, at a rate of 5.0% for every mile. In terms of the density, Houston does not appear to sprawl because the density of its population on developed land is more consistent throughout the region than compared to metropolitan regions which experience a greater decline in density as the distance from the central business district increases. Mieszkowski and Mills give a number of explanations for this development pattern, including Houston's system of financing infrastructure for undeveloped land which encourages clustered development, the heterogeneity of land which discourages development on some large tracts of land, and its network of freeways which also encourage clustered development (Mieszkowski and Smith 1991, pp. 192-194).

Los Angeles also illustrates the complexity of sprawl. In a recent review of the literature regarding density, Myers and Kitsuse (1999, p.22) ask "is Los Angeles sprawl?" They claim popular perceptions equate Los Angeles with sprawl despite the region having the highest gross population densities among the 20 largest U.S. metropolitan regions. Despite its high density, Ewing (1997) implies that Los Angeles style sprawl is not desirable because of its lack of accessibility (without a car) and a lack of open space within the region.

Recognizing these complexities, two recent research projects by two different groups were undertaken to measure its multiple characterizations and dimensions. Defining sprawl as specific patterns of land use in an urban area, Galster et al. (2001) proposed eight dimensions by which to measure it. The dimensions captured as many of the various characterizations of sprawl as possible, including low-density, segregated land uses, non-contiguous development, and centralization. Each of the dimensions pertained to land use. These dimensions were defined as (pp. 687-697):

(1) density – the average number of residential units per square mile;

(2) continuity – the degree to which land is developed in a continuous or, at the other end of the spectrum, leapfrog fashion;

(3) concentration – the degree to which development is located in relatively few square miles rather than spread evenly throughout the urban area;

(4) clustering – the degree to which development has been tightly knit to minimize the amount of land in each square mile that is developed;

(5) centrality – the degree to which development is located close to the central business district;

(6) nuclearity – the extent to which the urban area is characterized by one center as opposed to multiple centers;

(7) mixed use – the degree to which two different land uses (such as residential and commercial) exist in the same small area and the extent to which it occurs throughout the urban area;

(8) proximity – the degree to which different land uses are close to each other across an urban area (this is different from mixed use in that because different land uses can be close to one another but not necessarily 'mixed' within the same square mile.

The authors operationalized and quantified six of the eight dimensions within one square mile grids for thirteen urban areas. They did not measure mixed use and continuity because of limited data. Adding up the z-score (standardized score) for the measures of each dimension for the 13 urban areas, they found that Atlanta, Miami, and Detroit were the three most sprawling while New York, Philadelphia, and Chicago were the least sprawling. More importantly, they found that each dimension on its own provided a different analysis of sprawl. For example, Houston was the least sprawling in terms of clustering, which indicates that the metropolitan area has tightly knit development which minimizes the amount of land used for developement, but was the most sprawling in terms of nuclearity, which means that there are a greater number of centers of development in Houston than the other 12 urban areas.

Galster et al.'s multi-dimensional measures of sprawl have been criticized for three reasons. First, data are not readily available regarding different land uses within one square mile grids, which served as the basis for measuring neighborhood mixed use and proximity of different land uses. Second, these measures require use of complex GIS techniques which are difficult and time-consuming to carry out for a large number of urban areas (Lopez and Hynes 2003). Finally, Ewing et al. (2002) argued that by measuring these dimensions among urban areas, Galster et al. ignored parts of metropolitan areas that were not urban, which are locations where sprawl is occurring.

Ewing et al. (2002) developed the second multi-dimensional measure of sprawl using a four-factor index for metropolitan areas. These four factors focused on density, the diversity of land uses, significance of population centers, and street accessibility as indicators of sprawl. Using 22 potential components of sprawl that were each assigned to one of the four factors, principal components analysis was used to measure the four scores for 83 metropolitan areas. Table 2.7 lists the measures for each factor.

Table 2-7. Multiple Measures For Each Factor of Sprawl

Density	**Mixed Land Uses**	**Significance of Centers**	**Street Accessibility**
Gross population density per square mile	% of residents with businesses or institutions within a block of their homes	Coefficient of variation of population density across census tracts (stnd. deviation by mean density)	Approximate average block length in the urbanized areas of the metro
% of population living in densities less than 1,500 persons/sq. mile	% of residents with satisfactory neighborhood shopping within 1 mile	Density gradient (rate of decline of density with distance from center (CBD) of metro area)	Average block size
% of population living in densities less than 12,500 persons/sq. mile	% of residents with a public elementary school within 1 mile	% of metro employment less than 3 miles from the CBD	% of small blocks (less than .01 square miles)
Estimated density at center of the metro area (estimated from negative exponential density function)	Job-resident balance	% of metro employment less than 10 miles from the CBD	
Population of urban lands	Population-serving job-resident balance	% of metro population relating to centers or sub-centers within the same metro[33]	
Weighted average lot size (sq. feet) for single-family dwellings	Population-serving job mix (entropy)	Ratio of weighted density of population centers within the MSA to the highest density center to which a metro relates	
Weighted density of all pop. centers within metro area			

Source: (Ewing, Pendall, and Chen 2002, pp. 16-25).

[33] The authors used data from Claritas, Inc. to identify census tracts as being within "spheres of influence" of a population center within the same MSA, a population center within a different MSA, a population center not in an MSA, or not within a sphere of influence of any population center. For example, some census tracts in the northern portion of Akron, OH MSA were identified as relating to higher density areas in the Cleveland MSA.

Each of the four factors was a weighted combination of the original measures assigned to the factor. The greater the correlation between the original measure and the factor to which it was assigned, the greater the weight it was given in the overall factor score. The factor scores were then converted to a scale with a mean value of 100 and standard deviation of 25. An overall sprawl index, which included all four factors, was calculated by summing the four individual factor scores. The overall sprawl index was also transformed to have a mean value of 100 and a standard deviation of 25. A score of 100 indicated that a metropolitan region was average, among the 83 metropolitan areas, in terms of sprawl. A number less than 100 indicated that a metropolitan area had greater than average sprawl and a score greater than 100 indicated lower than average sprawl.

Like Galster et al., Ewing et al. (2002, pp. 35-36) found that sprawl occurs in a number of different forms as metropolitan areas grow in a variety of ways. In a comparison of Tucson, Arizona and Ft. Lauderdale, Florida, both regions were slightly less sprawling than the average metropolitan region. They had an overall sprawl index of 109 and 108, respectively. Despite their similar scores on the overall index, the regions significantly differed from one another with regard to the individual underlying factors of sprawl.

Tucson had one of the lowest urban densities of all 83 metropolitan areas for which the index was measured. With 1,767 people per square mile, its score on the density factor was 90, or 90% of the average. On the other hand, Tucson's development is highly concentrated with almost all employment being within 10 miles of downtown. In terms of the strength of its center, Tucson's score on the centrality factor was 106. The area also scored well on the diversity of land uses to which residents had access, with a score on the mixed use factor of 121.

In contrast to Tucson's lower than average density, Fort Lauderdale scored better than average on the density factor, scoring 114. The region had an average urban density of 4,837 people per square mile. But while Fort Lauderdale is more densely developed, the region had a higher degree of segregation among its land uses and scored a 94 on the mixed use factor. Further, the region scored poorly on the centrality factor. With less than 15% of the region's employment located within 3 miles of the central business, Fort Lauderdale had a centrality factor of 75.

2.2.3 Economic Theory of Land Use – Explanation of Sprawl

Economic models of land use are often used to explain the growth of sprawl. These models provide explanations as to why development occurs at lower densities outside of the central city than within it, as well as why low-income households appear to reside in the central city as higher-income households move to the suburbs or beyond. This section provides the general economic theory of residential land use within metropolitan regions. It begins by introducing the first well-recognized scholars of residential land use. It then presents the assumptions which the model makes regarding household behavior, employment patterns, and commuting. The assumptions are followed by the primary theory of the model which is followed by conclusions drawn from the model.

William Alonso (1964) proposed one of the first complete urban location theories to explain the land use patterns of a metropolitan region. One of the primary questions he asked was whether the amount of money spent for land was associated with household income and distance from the central city (Alonso 1964, p. 125). Alonso's model hypothesized that a household divides its income among three primary items, which are residential land, transportation costs, and a bundle of other goods. There are two important points about the combination of these three items. First, consumers must find a balance between these three general items which will meet their preferences and satisfy their needs. Second, transportation costs increase as distance from the central city increases, but the cost of residential land will decrease. Land prices decrease with greater distance from the central city because greater transportation costs make the land less desirable. On the supply-side, there is an increasing supply of land at greater distances from the central city. Consumers, therefore, will make a trade-off between transportation costs and land costs.

Mills (1967; 1972) and Muth (1969) applied Alonso's theory of land use to housing services rather than to residential land. Rather than make a trade-off solely between land costs and transportation costs, consumers in the Mills' and Muth's models make a trade-off between the costs of a constant-quality unit of housing services and transportation. Housing services refers to the components of a housing unit, such as the land on which the unit is located, the unit's size, and other unit amenities, from which the household receives benefits, or 'services'. Muth (1969, p. 18) defines housing services as a "bundle of services yielded both by structures and also by the land or sites on which they are built… (it) refers to the flow of services and the satisfactions they yield."

The Alonso-Muth-Mills model of urban spatial development is based on a number of significant simplifying assumptions. These assumptions must be presented prior to the discussion of the model's predictions regarding residential land use patterns. The assumptions which underlie the model are (Muth 1969, pp. 17-21; Mills 1972, pp. 98-104; Mills and Hamilton 1989, pp. 426-428; Yinger 2005, Chapter 1.3, p. 3-6):

- The region is monocentric. It has one central business district (CBD) in which all employment and economic activity occurs. This assumption allows the model to ignore the possibility that households may reside a distance from the CBD and not experience greater commuting costs if their location of employment is also located a distance from the CBD.

- There is only one mode of transportation which has a constant cost per unit of travel over any distance from the CBD. This assumption simplifies the model as a distinction does not have to be made between modes of transportation and the differences (in cost and time) among them.

- Distance to work is the only locational characteristic that is significant in household decision-making. This assumption removes extraneous factors to the model, such as neighborhood amenities (separate from distance to work) or air quality, that may attract households.

- Land is available for urban uses in all directions from the CBD. It is also assumed that land is available for urban uses at any distance away from the CBD.

- A household cannot change its income by moving to a different location. It is assumed that households already reside in an optimal location for their income and will not gain from a move.

- Households are perfectly mobile within an urban area. Therefore, households are at their maximum level of utility (maximum satisfaction of their preferences). They will move if they have an opportunity to improve their utility.

- All households have the same preferences.

- There are no local governments. All public services are identical throughout the region. This assumption removes the complexity of different levels of public services being offered throughout the region.

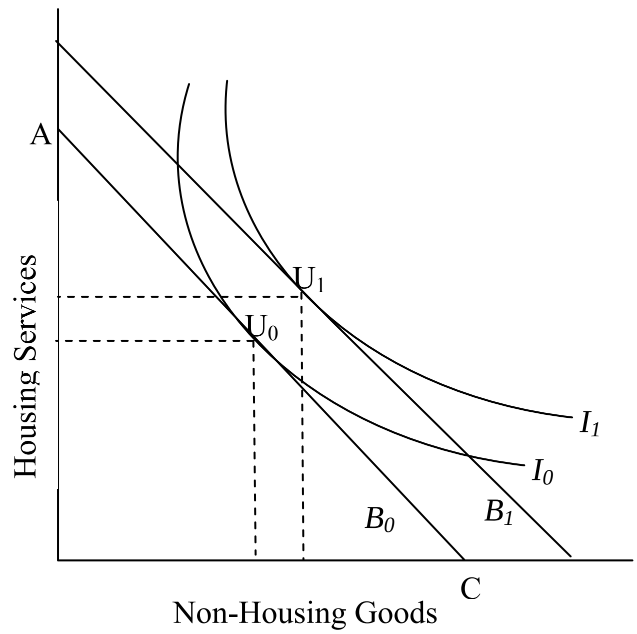
- Housing services are produced with a Cobb-Douglas production function with constant returns to scale. If capital or land inputs increase by 20%, housing services will increase by 20%. Housing services are a function of capital and land.

The Alonso-Muth-Mills model assumes that households will maximize their utility. [34] Utility, as an economic term, is the degree of satisfaction that a variety of different bundles of goods provides to consumers. It is assumed that consumers will purchase a bundle of goods that maximizes their satisfaction. In the Alonso-Muth-Mills model, households can choose any combination of housing services (H) and a composite of other non-housing goods (Z) that satisfies their preferences to the greatest extent possible. The budget constraint on the combination chosen by consumers is income. Households cannot spend more money on a combination of Z and H than their income. The greater the proportion of income a household spends on housing, the less it has available to spend on non-housing goods.

Higher income households consume a greater amount of housing services and non-housing goods to satisfy their preferences than lower income households. Figure 2.3 graphically presents a utility function and budget constraint for a household. The Y-axis represents quantity of housing services and the X-axis represents quantity of non-housing goods. Line B_0 represents the budget constraint, or household income, which limits the amount of housing services and non-housing goods the household can consume. It illustrates the trade-off that the household must make between the two goods. The greater the quantity of non-housing goods consumed by the household (x-axis), the lower the quantity of housing services that can be consumed (y-axis). Point A on the graph represents consumption for a household spending its entire income on housing services. Point C represents consumption for a household spending its entire income on non-housing goods.

[34] The explanation of the model developed by Alonso, Muth, and Mills draws heavily from the following texts: (Alonso 1964; Muth 1969; Mills 1972; Mills and Hamilton 1989; O'Sullivan 2003; Briassoulis 2005).

Figure 2-3. Indifference Curve and Budget Constraint



Curve I_0 on Figure 2.3 represents an indifference curve for the household with the budget constraint of B_0. The curve represents the combination of housing services and non-housing goods that will provide the household with an equal amount of utility, or satisfaction. It is called an indifference curve because households receive the same utility along any points on the line. Therefore, households are indifferent to which combination they choose. A household with a large quantity of either housing services or non-housing goods receives less additional utility per unit of the good of which they have abundance. Therefore, a household with a great amount of non-housing goods is assumed to be willing to give up more units of non-housing goods for an additional unit of housing services (or vice versa). This phenomenon is the marginal rate of substitution and explains the convex shape of the indifference curve. The point along I_0 which is equal to the household's budget constraint presents the combination of housing services and other goods that the household should consume to maximize its utility. This point is represented in Figure 2.3 by U_0. Although a household can purchase any combination of goods along B_0, no other point along B_0 meets the household's preferences.

Line B_1 represents the budget constraint for a household with greater income. This level of income allows the household to increase its utility curve from I_0 to I_1. U_1 represents the greatest degree of utility that the household with income of B_1 can achieve. Figure 2.3 illustrates that a household with higher income will consume more of both housing services and non-housing goods to satisfy its preferences. This explains the purchase of more housing services on the part of higher income households.[35]

The Alonso-Muth-Mills model of land use predicts that higher income households are better off as they move away from the central business district (Goodall 1972; Wheaton 1977; Margo 1992; O'Sullivan 2003). Based on the assumption that transportation costs remain constant per unit of travel, commuting costs change only by the distance (u) from the CBD. As a household moves away from the CBD, its income available for housing services and other goods is reduced by the additional commuting costs that are incurred. Therefore, the per unit cost of housing services must decrease by at least as much as commuting costs increase as the household moves further from the CBD. This can be written as:

$$t * \Delta u = -\Delta P_H * H \qquad (2.1)$$

Or,

$$(t * \Delta u) / H = -\Delta P_H \qquad (2.2)$$

Where t is the commuting cost per unit of travel, Δu is a change in the distance from the CBD, H is the total quantity of housing services, and ΔP_H is the change in the price per unit of housing services.

It can be seen from equation 2.2 that households consuming a larger quantity of housing services (H) require a smaller decline in the price per unit to move further from the CBD as commuting costs are spread out over a greater quantity of housing. For example, if the distance from the CBD (t) is 10 miles and the cost of commuting (u) is $10 per mile, a household consuming 500 square feet of housing services (H) of must benefit from a decline in the cost of housing services of $.20 per square foot ($-\Delta P_H$). A household consuming housing services (H) of

[35] This assumes that the demand for housing services is income elastic. Income elasticity is the ratio of the % change in the quantity of a good demanded to the % change in income. If the ratio is close to zero, demand is said to be income inelastic and demand for the good does not increase with increases in income. A higher ratio indicates a greater elasticity of demand. It is widely accepted in the literature that there is a positive income elasticity of demand for housing services though there is significant debate regarding its magnitude, as well as methodological concerns in measuring it (De Leeuw 1971; Mayo 1981; Olsen 1987; Green and Malpezzi 2003, pp. 9-11).

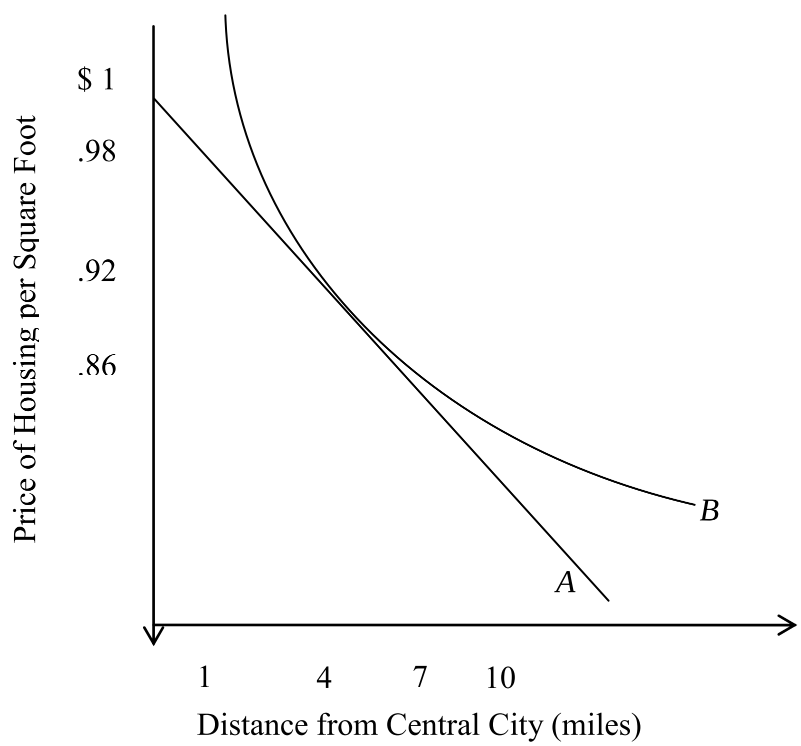
1000 square feet must only benefit from a decline in the cost of housing services ($-\Delta P_H$) of \$.10 per square foot.

If all housing units throughout the region are homogenous, meaning each unit provides the same quantity of housing services, equation 2.2 illustrates that there would be an exact linear relationship between the price per unit of housing services and distance from the CBD. Line *A* in Figure 2.4 graphically shows this relationship. In the following example, housing services will be measured as the size of the housing unit. If transportation costs (t) are \$20 per mile and the quantity of housing (H) provided by each unit is 1000 square feet, then at one mile from the CBD the price of housing must be cheaper by \$.02 per square foot. Because housing is assumed here to be homogeneous, the quantity of housing services consumed by a household remains constant at any distance from the CBD. Therefore, the cost of housing services must decline by \$.02 per square foot for every mile from the CBD. If the cost of housing is \$1 per square foot at the CBD where commuting distance is 0, then the cost of housing at 4 miles from the CBD must be \$.92 per square foot. At 4 miles from the CBD, commuting costs will be \$80 (4 x \$20 per mile) higher than at the CBD and costs for 1000 square feet of housing will be \$80 (1,000 x .08 per square foot) lower.

Housing, however, is not homogeneous throughout the region. Housing units differ from one another in terms of size, as well as in quality. As the price per unit of housing declines, consumers will demand more of it (De Leeuw 1971, pp. 8-9; Hanushek and Quigley 1980; Mills and Hamilton 1989, p. 192-193; O'Sullivan 2003, pp. 179-181). They will demand more housing services either by demanding larger housing units or units of better quality. Therefore, as the price of housing declines with distance from the CBD, households will increase their consumption of housing services. Because the demand for housing services increases, the relationship between cost per unit of housing services and distance from the CBD is no longer linear. The new relationship is convex and is represented by line *B* in Figure 2.4. It is convex because as the cost of transportation is spread out over greater quantities of housing services, the price per unit of housing services needs to decline less. For example, assume that H is 700 square feet at 4 miles from the CBD. Using the assumption that the cost of commuting (t) is \$20 per mile, the cost per unit of housing services must decline by \$.029 rather than by \$.02 as in the example of homogeneous housing units. Assume that H is 1300 square feet at 10 miles from the

CBD. At mile 10, then per unit cost of housing services must decline by $.015. As distance from the CBD increases, the per unit cost of housing services will decline at a diminishing rate.

Figure 2-4. Price per Unit of Housing Services with Distance from CBD



O'Sullivan (2003, pp. 186-187) provides evidence that higher-income households have a greater economic incentive to consume housing services at a distance further from the CBD than lower-income households. Assume there are two households, a high-income household which consumes 2,000 square feet of housing and a low-income household that consumes 200 square feet of housing. The low-income household is limited to this amount of housing because of its budget constraint. Also assume that commuting costs are $40 per mile for the high-income household and $20 per mile for the low-income household. Table 2.8 provides information on the decline in the price per unit of housing which will occur at each mile from the CBD. The marginal benefit of moving an additional mile from the CBD is calculated for both the high-income and low-income household by multiplying the decline in price per unit of housing by the quantity of housing consumed (2,000 square feet and 200 square feet, respectively). For example, the marginal benefit of moving from 2 miles from the CBD to 3 miles is $160 for the high-income household and $16 for the low-income household. Meanwhile the marginal cost of each additional mile from the CBD is $40 for the high-income and $20 for the low-income household.

Table 2-8. Benefit and Cost of Moving Further from CBD for a High-Income and Low-Income Household

Miles from CBD	Decline in Price Per Unit of Housing Services (slope of Housing-Price Function)	Marginal Benefit for High-Income Household (2,000 x decline in price per unit of housing)	Marginal Cost of High-Income Household (Commuting Cost)	Marginal Benefit of Low-Income Household (200 x decline in price per unit of housing)	Marginal Cost of Low-Income Household
1	.12	240	40	24	20
2	.10	200	40	**20**	**20**
3	.08	160	40	16	20
4	.06	120	40	12	20
5	.04	80	40	8	20
6	.02	**40**	**40**	4	20
7	.01	20	40	2	20

Source: (O'Sullivan 2003, p. 187).

The households will choose to consume housing at a distance from the CBD at which the marginal benefit will equal the marginal cost of living an additional mile from the CBD. If households consume housing at a distance close enough to the CBD that the marginal benefits of moving further away are greater than the marginal cost, they are not optimizing their utility and would do so if they moved further from the CBD. If households consume housing at a distance far enough from the CBD that the marginal cost of their location is greater than the marginal benefit, they also are not at their optimal location. These households would benefit by moving closer to the CBD.

Table 2.8 illustrates that the optimal location for the high-income household is at 6 miles from the CBD. At this point, the marginal benefit of an additional mile from the CBD is equal to the marginal cost of the addition mile ($40). The high-income household should not move further away than 6 miles from the CBD. If the household moved to a distance of 7 miles from the CBD, the marginal cost is greater than the marginal benefit of the additional mile. The low-income household is at an optimal location at only 2 miles away from the CBD. At that point, the marginal benefit of an additional mile from the CBD is equal to the marginal cost of an additional mile ($20).

Based on the models of Alonso, Muth, and Mills, the economic theory of land use presented in this section provides an explanation for the phenomenon of sprawl. The model leads to the following conclusions:

- Sprawl occurs because households benefit by living further from the CBD. The marginal benefit of lower housing costs by moving an additional mile from the CBD can be higher than the marginal cost of an additional mile of commuting costs.

- As transportation becomes cheaper, sprawl will increase. With lower commuting costs per unit of travel, the marginal costs of living an additional mile from the CBD declines while the marginal benefit remains the same. By looking at Table 2.8, we can see that if the marginal cost of an additional mile from the CBD declined, both the high and low-income household would benefit by moving further away from the CBD.

- The cost per unit of housing services declines as distance from the CBD increases. Because of lower prices, consumers purchasing housing services at a distance from the CBD will demand a greater quantity of housing services in the form of large homes, larger lots, or both. The demand for a greater quantity of housing services by each household lowers density as distance from the CBD increases.

- Higher income households consume a greater quantity of housing services than lower-income households. As shown in Figure 2.4, households with greater income have budget constraints which allow them to consumer more housing, as well as non-housing, goods than households with lower incomes.

- Higher-income households receive greater benefits by living further from the CBD than lower-income households. Because higher-income households consumer a greater quantity of housing services, they receive a greater marginal benefit in savings on housing costs than lower-income households. Additionally, higher-income households have a greater quantity of housing services over which to spread over the cost of commuting to the CBD.

- Because of the greater benefits to higher-income households of living further from the CBD than lower-income households, we can surmise that income segregation occurs. Lower-income households are concentrated closer to the CBD while higher-income households live further away.

The purpose of this section was two-fold. First, the section explained sprawl as a result of the economics of land use, housing, and transportation.[36] It explained why households tend to move further from the CBD when their income increases, as well as when transportation costs decline. The second purpose of the section was to illustrate the impact of sprawl on lower-income households as compared to higher income households. One conclusion of the section is that lower income households are more likely to live closer to the CBD.

The next section will present smart growth, which is currently a popular alternative to sprawl proposed by anti-sprawl advocates, and smart growth's relationship with affordable housing for low-income households.

2.3 SMART GROWTH

Smart growth is the most current attempt to control the outward growth of cities and reduce sprawl. In 1996, the Environmental Protection Agency (EPA) initiated the creation of the Smart Growth Network (SGN), an organization which consists of numerous Federal agencies, as well as national non-profit organizations. SGN promotes 10 principles, or goals, for metropolitan growth which for the most part are in contrast to the current sprawl-like growth patterns. These 10 principles define smart growth. They are (Smart Growth Network 2002): [37]

(1) Mixed land use rather than the segregation of different land uses from one another. For example, residential units should be in close proximity to commercial and entertainment activities that serve the residents' needs.

(2) Compact building design rather than low-density development which is the prominent pattern of growth.

(3) Housing opportunities and choices for a range of household types and incomes rather than the dominant pattern in new developments of single-family homes.

(4) Walkable neighborhoods rather than a reliance on the automobile.

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[36] Two additional significant causes of sprawl are discussed in the literature. Sprawl is widely believed to also be the result of Federal transportation, housing, and urban redevelopment policies, as well as a result of public choice economics.

[37] For alternative (yet similar) sets of smart growth principles, see Nelson (2000) and Downs (2001).

(5) Strong sense of place within the community.

(6) Preservation of open space, farmland, and critical environmental areas rather than the continued development on undeveloped land and in environmentally sensitive areas.

(7) More balanced regional development by reinvesting in and strengthening existing communities rather than the continual creation of new communities further from the center of the metropolitan region.

(8) Variety of transportation options rather than a reliance on the automobile for travel.

(9) Predictable, fair, and cost-effective development decisions.

(10) Citizen and stakeholder participation in development decisions.

Downs (2004, p. 3) describes smart growth as a "set of broad policies designed to counteract sprawl. Goals (of these policies) usually include limiting outward expansion; encouraging higher-density development; encouraging mixed-use zoning instead of fully segregating land uses; reducing travel by private automobiles; revitalizing older areas; and preserving open space." To this end, there is large number of state, regional, and local policies that are used to achieve the ten principles of smart growth (Nelson 2000; Downs 2001; Smart Growth Network 2002). Appendix A provides a comprehensive list of policies recommended by SGN.

At the regional level, the policies most often proposed by smart growth advocates are urban containment to preserve open space and farmland on the fringes of metropolitan regions; regional transportation planning to reduce dependence on the automobile and address congestion; tax-base sharing to reduce the fiscal disparities between wealthy and poor communities; and reinvestment in older communities (Hollis 1998; Nelson 2000; Katz 2002). Among these, urban containment policies have become one of the most significant and commonly used tools for smart growth (Nelson 2000; Pendall, Martin, and Fulton 2002).

Urban containment policies prohibit, or at least discourage, development outside of pre-determined boundaries. The two primary purposes of these policies are to preserve agricultural, environmentally sensitive, and undeveloped land outside of a defined area, as well as encourage compact development and redevelopment in urban areas that can be efficiently served by public services (Nelson and Duncan 1995, p. 73; Nelson, Dawkins, and Sanchez 2004, p. 425). There are three commonly utilized techniques of urban containment. They are (Nelson and Duncan 1995, pp. 75-80; Farquhar 1999, p. 1; Pendall, Martin, and Fulton 2002, pp. 4-5):

- Urban growth boundaries (UGB) are boundaries outside of which development is prohibited. Included within the boundaries are existing urban development, municipalities, and undeveloped land designated for future growth. Typically, UGBs are designed to include enough land to accommodate expected growth for at least 20 to 30 years into the future. Development of land outside of the boundaries is typically prohibited by zoning laws which set required densities at 1 unit per 10 to 20 acres, low enough that development cannot occur (Nelson and Dawkins 2004, p. 3). UGBs are typically accompanied by mandates to increase density within the boundaries to ensure compact and efficient development.

- Urban service areas are boundaries which establish where public investment in infrastructure such as roads, water, and sewer will occur. The boundaries serve as a guide as to where public funds for infrastructure are spent, as well as where they will be spent in the future. They are more flexible than urban growth boundaries as they are not necessarily meant to limit development, but are to ensure that development occurs in an efficient manner (Farquhar 1999). Typically, urban service areas include a system of "tiers" which "direct public infrastructure into new areas in a particular sequence in order to eliminate leapfrog development, encourage orderly urban expansion and reduce the cost of public infrastructure (Pendall, Martin, and Fulton 2002, p. 5)." The urban service area does not necessarily prohibit development outside of its boundaries as private developers can incur the costs of the necessary infrastructure if they are willing to do so.

- Greenbelts are tracts of public land around existing development to preserve open space. The land for greenbelts is usually purchased with public conservation funds or by private non-profit land trusts for the sole purpose of ensuring the land will be permanent open space that will not be developed at any point in the future (Hollis and Fulton 2002). They differ from UGBs and urban service areas in that greenbelts are not typically adjusted to accommodate future growth nor are they necessarily accompanied by land use planning to ensure compact development in particular areas.

The use of urban containment policies to counteract against sprawl and the spread of development further from the center of metropolitan regions has steadily grown in the past two decades. In a survey of government jurisdictions within the 25 largest metropolitan regions in the early 1990's, 44% of county governments and 15% of cities had some form of urban containment policy to manage growth (Pendall, Martin, and Fulton 2002, p. 8). The number of local and county governments within these 25 regions implementing some type of urban boundary increased steadily from the 1960s to the time of the survey.

Increasingly, states are including urban containment policies in their attempts at managing growth. Oregon was the first state to require local municipalities and counties throughout the state to implement urban growth boundaries as a part of its growth management legislation passed in 1973. Since the 1980's, other states have followed Oregon's lead in making urban containment policies a component in their attempts to manage growth. Some have chosen to encourage urban containment policies of counties and local governments, while others have chosen to require them. The states include:

- Florida's Growth Management Act of 1985 which encouraged local governments to designate urban service areas for future infrastructure investments (Fulton et al. 2006).

- New Jersey's Planning Act of 1985 which designated central places in which to try to steer growth through the allocation of infrastructure funds. However, the Act did not require a specific urban containment policy (Epling 1993; DeGrove 1994)

- Washington's Growth Management Act of 1990 and 1991 which required most municipalities and counties to establish urban growth boundaries as a part their comprehensive land-use planning (Pendall, Martin, and Fulton 2002).

- Maryland's Smart Growth Act of 1997 which required municipalities and counties to establish priority funding areas. The spending of state infrastructure funds outside of these areas is restricted (Cohen 2002).

- Tennessee's Growth Policy Law of 1998 which required every county to identify urban growth boundaries for the municipalities within each county (Johnson, Jordan, and Salkin 2002; Pendall, Martin, and Fulton 2002).

- Pennsylvania's Acts 67 and 68 in 2000 which gave counties and municipalities the authority (optional) to create urban growth areas (Johnson, Jordan, and Salkin 2002)

- Maine's new legislation in 2000 which limits the state's growth related capital investments to designated growth areas identified in local comprehensive plans or to areas already served by a public sewer system (Johnson, Jordan, and Salkin 2002).

Greenbelts have also grown in popularity in recent years. In 2006, 99 ballot measures were approved by voters in 23 states in support of state and local government spending on land preservation. Combined, these measures approved approximately $5.73 of public spending on conservation measures to protect land from development (Trust for Public Land 2006). Most of the money will be raised from bond issues, the proceeds of which will be used to purchase land for preservation from development.

Urban containment policies, such as urban growth boundaries and urban service areas, are popular tools within the smart growth movement because they can be used to achieve a variety of the smart growth principles. First, they preserve undeveloped land by directing growth away from rural areas and toward existing places. UGBs "push" urban development toward areas within the urban boundaries by restricting land use outside of them. Urban service areas, on the other hand, "pull" development away from lands outside of the boundaries by limiting the level of infrastructure, such as public sewer and water, which is available (Pendall, Martin, and Fulton 2002). The lack of infrastructure (or planned infrastructure) provides a dis-incentive for development to occur outside of an urban service area's boundaries (Cohen 2002).

A second smart growth principle believed to be achieved through urban containment is reinvestment and revitalization of existing communities, particular the central city, by steering investment away from the rural fringe. Nelson and Milgroom (1995) argued that effective central-city revitalization cannot occur without some type of regional growth management technique to prevent the continuing investment in more rural areas of a region. They tested their argument by comparing the central city vitality of Portland, a region with strong urban growth boundaries, and Atlanta, a region known for its rapid growth in population and sprawl. They found that the City of Portland enjoyed greater gains in revitalization in development relative to its region than the City of Atlanta. From 1960 to 1990, the City of Portland gained a greater regional share of retail sales, added twice as many housing units to its housing stock, and held a greater share of the region's total employment than the City of Atlanta (Nelson and Milgroom 1995, p. 7)

In a more recent study, Nelson et al. (2004) compared the number of newly constructed residential units, as well as the total value of non-residential construction, in central cities of regions with urban containment policies to central cities in regions with no such policy from 1985 to 1995. Out of a sample of 144 central cities, 21 were in "urban containment" regions. In comparing the mean number of newly constructed residential units per 1,000 residents of the two groups, the authors found a statistically significant difference between the two groups of cities. The central cities of urban containment regions had 150 newly constructed residential units, on average, while cities in uncontained regions had 110. They found a similar statistically significant difference between the two groups of central cities with regard to the value of non-residential construction per capita. The value was $4,210 in central cities of urban containment regions and was $3,203 in uncontained regions.

Nelson et al. then used Ordinary Least Squares to control for other explanatory factors of central city revitalization, such as input costs of land, labor, and materials and economic conditions of the region. They used 6 dependent variables to test the hypothesis that urban containment increased investment in the central city. These 6 dependent variables were the new construction value per capita for single family homes, multi-family homes, residential additions to established homes, commercial additions to commercial structures, office space, and retail/warehouse space in the central city. They found a statistically significant relationship between urban containment and each dependent variable with the exception of retail and warehouse investment. They conclude that urban containment appears to steer investment toward the inner city. However, they also note that suburban investment continues to grow with or without urban containment.

The third smart growth principle that urban containment is typically believed to assist in achieving is greater density of development and a greater variety of housing options. The association between urban containment and higher density is made for two reasons. First, restricting development activity outside of urban boundaries will push a region's demand for developable land to inside the boundaries (Nelson and Dawkins 2004). Because of the greater demand, the value of land within the urban boundaries will increase. As the value of land increases, developers will use it more intensely by investment more capital in structures per unit of land, thereby increasing density (Knaap and Nelson 1992; Nelson and Dawkins 2004). This process is discussed further in the theoretical chapter regarding the impact of urban containment on the smart growth principles and the supply of affordable housing.

Second, urban containment policies are often accompanied by density requirements to ensure that higher density development occurs within the urban boundaries (Danielsen, Lang, and Fulton 1999, pp. 527-529; Fischel 2001, pp. 237 - 239; Carruthers 2002). Density requirements are thought to reduce the pressure on housing prices which may occur as a result of urban containment's restriction on the supply of developable land. Without greater density, the restriction on the supply of land increases in value which, in turn, can increase housing prices (Landis 1986; Danielsen, Lang, and Fulton 1999). The Portland Metro's Metropolitan Housing Rule requiring specific density targets for municipalities within their jurisdiction is one such example (Knaap and Nelson 1992, p. 79; Portland Metro 2000). The Metropolitan Housing Rule requires each municipality within the Portland region to use zoning ordinances to obtain residential densities of 6, 8, or 10 housing units per net buildable acre, depending on the municipality's size. In addition, the rule requires the zoning ordinances to allow at least half of all new housing construction to be of multi-family units.

The fourth smart growth principle potentially addressed by urban containment is that of mixed land use, for two reasons (Nelson and Dawkins 2004). Mixed land use is the diversity of land uses, such as residential and commercial, in close proximity to one another. The first connection between urban containment and mixed land use are zoning codes accompanying urban containment policies are which encourage mixed land use development. The second connection between urban containment and mixed land use development is the potential impact of higher land values. Nelson and Dawkins (2004) contend that these high values will improve the efficiency of land use patterns. One of those improved efficiencies is better access to employment, shopping, and other services.

2.3.1 Smart Growth and Affordable Housing

Many smart growth proponents argue that the affordable housing needs of low-income households can be better met by higher-density, mixed land use neighborhoods, and a greater variety of housing options than the current growth patterns of sprawl occurring in metropolitan areas (Arigoni 2001; Kalinosky 2001; NLIHC 2001; Smart Growth Network 2001). The Smart Growth Network (2001) linked a few of the 10 smart growth principles to affordable housing, including:

- Compact development, which can result in lower housing costs as dwelling sizes are reduced.

- Housing opportunities and choices for a range of household types and incomes. Rather than focusing exclusively on single-family detached units, new developments should include multi-family and attached single-family housing units. Lower-income households are more likely to be able to afford the multi-family and attached units (Downs 2004).

- Mixed land use, which can provide for a better balance between the location of jobs and housing. In addition, mixed land use also includes a variety of housing types including multi-family and attached single-family units.

- Investing in existing communities, which can improves the infrastructure and public services in older communities where lower-income households are more likely to reside.

Smart growth may make some types of housing more expensive, but other types more affordable (Voith and Crawford 2004, p. 101). Voith and Crawford theorized about the impact of smart growth on the cost of single-family homes, as well as on higher-density units such as townhouses. The implementation of an urban containment policy, combined with a mandate for higher density within the urban boundary, would reduce the supply of large-lot single family homes which would increase their cost. However, the price of townhouses could decline as they become more abundant. In addition, they hypothesized that residents in higher-density neighborhoods also benefit from lower costs of a more efficient infrastructure and public services.

The Smart Growth Network (2001) argues that smart growth also incorporates regional solutions for affordable housing for lower-income households to achieve the smart growth principle of providing housing opportunities for a wide range of incomes. Two common solutions to the housing problem for low-income households are fair-share housing ordinances and inclusionary zoning practices. A fair-share program requires each municipality to accept its 'fair-share' of its region's affordable units based on each municipality's size in comparison to other localities in the region, employment, current housing conditions, and estimated population growth in the future.[38]

The second common solution is inclusionary zoning which require new developments larger than a specified size to include units affordable to lower-income households (Porter 2004). For example, Montgomery County, Maryland requires at least 15% of units in new developments of 50 or more units to be affordable to the poorest one-third of the county's households (Burchell et al. 2000, p. 13). However, inclusionary zoning programs vary widely with regard to affordability requirements. Some programs require units to be affordable for households with income below 50% of the area median income, while others require units be affordable for households with income below 120% of the area median income (Porter 2004, pp. 222-225).

A range of incentives are given to developers to reduce their costs of providing affordable units. Developers are typically given density bonuses by the local zoning board to achieve the affordable housing requirement. Density bonuses allow a developer to build at a higher density than would normally be allowed. The higher density allows the developer to build additional units from which the profits can be used to offset the costs of providing the lower-income units. Other incentives offered by a municipality to developers in order to make inclusionary zoning feasible include the waiving of impact fees, "fast-tracking" the development approval process, waiving of zoning requirements, or local tax abatements.[39]

However, affordable housing programs suffer from the phenomenon of "not in my backyard" (NIMBY) attitudes among local residents and rarely achieve strong political support (Advisory Commission on Regulatory Barriers to Affordable Housing 1991; Stein 1996; Pendall 1999; Downs 2003; HUD 2004). This lack of political support makes regional solutions for affordable housing difficult to implement. There are two primary reasons why affordable housing does not gain support. First, municipalities find it in their economic interest to prohibit housing that attracts low-income households to their jurisdiction (Orfield 2002, Chapter 5).

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[38] For overviews of fair-share initiatives for affordable housing, see Meck, Retzlaff, and Schwab (2003).
[39] For an overview of inclusionary zoning programs, see Brown (2001), Burchell et al. (2000), and Porter (2004).

Municipalities are better off financially if they can attract higher-income households with the development of large, expensive homes rather than low-income households with affordable housing. The higher-income households provide more public revenue than the costs for public services they require. Municipalities are able to prohibit affordable housing through exclusionary zoning which restricts small lot and multi-family housing. For this reason, a higher level of government, such as the state, must have some authority over local municipalities regarding housing if regional solutions to the shortage of affordable housing are to work (Calavita, Grimes, and Mallach 1997; Downs 2004).

The second reason for the lack of political support for affordable housing is the fear that multi-family and low-income housing will lower adjacent property values (HUD 2004, p. 7). Fischel (2001, pp. 9-11) argues that homeowners fear the risk of any changes to their neighborhood that could possibly lower property values because they cannot insure against losses in the value of their home or neighborhood decline like they can against fire or theft. The fear of declining home values is significant because the home is the most valuable asset for the majority of homeowners even though research shows that the relationship between affordable housing and adjacent house values depends on many factors, including the concentration of affordable units, the type of housing it is, and overall housing conditions of the neighborhood (Galster 2004).

Pendall (1999) studied opposition to new housing developments to determine the extent to which residents opposed the developments based on the fear that the new development would have an impact on adjacent uses, particular on the value of adjacent single family homes. He examined the approval process for 182 proposed new housing developments in the San Francisco Bay area in the 1980's. Of these planned developments, 58 had only single family homes, 102 had multifamily or attached units, and 22 had a mix of the two. 56 of the developments had single-family or multifamily units affordable to lower-income households.

Complaints were submitted by residents to the local planning board or council against 113 of the proposed developments. Complaints based on residents' fears of the development's negative impact on adjacent units were classified by Pendall as NIMBYism. He found that 50 developments received opposition based on NIMBYism. 38 developments received opposition based on anti-growth concerns with regard to traffic congestion and infrastructure.

Using a logistic regression, Pendall (pp. 127-131) found that proposed developments adjacent to single-family homes were 28% more likely to receive NIMBY protests than proposed developments next to other types of sites. He also found that for every 1% increase in the community's reliance on property taxes for public revenue, there was a 1% increase in the likelihood the development would be opposed on NIMBY grounds. The type of proposed development was also significant in explaining NIMBY opposition. Multifamily units were 42% more likely to receive opposition and affordable housing was 38% more likely to receive opposition than single-family and market-rate developments. Pendall's findings support the contention that home-owners will oppose developments which fear will lower their property values, as well as cause fiscal pressures on the local municipality.

Downs (2003; 2004) argued that only in exceptional cases are efforts made within the smart growth movement to specifically address housing affordability for low-income households, particularly for households earning less than 50% of the area median income. There are three explanations for this reluctance to include housing for poor households in the smart growth debate. First, advocates of smart growth would risk alienating too many potential supporters by strongly advocating for affordable housing for the lowest-income households as there is more political opposition than political support for it. Worse than not advocating for affordable units, smart growth, if it focuses too much on preserving open space at the expense of other principles, may even harm the supply of affordable housing. In its 2004 report on the barriers to affordable housing, HUD (2004, pp. 6-7) claimed that some community groups have gained ammunition to exclude affordable housing by emphasizing the preservation of land and limits to growth, in the name of smart growth, and ignoring the other principles thought to improve housing affordability, such as higher-density development.

Schill (2004, p. 103) wrote that "popular support for smart growth is based on a variety of factors that will create strong incentives for municipalities to adopt growth management restrictions without simultaneously promoting affordable housing." Smart growth advocates are typically more interested in restricting growth to protect the environment, reduce the cost of public services, and relieve traffic congestion than in housing for low-income households. Restricting growth from suburban or exurban areas, however, may be in direct conflict with improving the supply of affordable housing as limiting the supply of residential land likely increases the cost of housing. The impact of restricting growth through urban containment is discussed in the next chapter.

The second reason for the reluctance of smart growth advocates to encourage affordable housing is the nature of the affordable housing problem. The majority of housing for poor households is provided by older units. The easiest method to increase the supply of units for these households is to have values of the current stock decrease. However, practically no owners of the current stock would view it ‘smart’ to take actions to lower values, especially as for many homeowners their housing is their biggest asset (Downs 2004, p. 268). Legislation and local ordinances, such as high quality standards and prohibition of multi-family and manufactured housing, are passed to protect values of existing homes.

Finally, when smart growth advocates discuss affordability, they are usually discussing housing at a level of costs that are affordable to moderate-income households, rather than at a level affordable to households with less than 50% of the median income. But, it is these poorest households that have the greatest need in terms of affordable housing (Downs 2003).

2.4 SUMMARY

This chapter aimed to accomplish four things. The first purpose of the chapter was to present the housing affordability problem which many extremely low-income and very low-income households face. More than 79% of extremely low-income renter households spend more than 30% of their income on housing costs and more than 63% spend more than 50% of their income on housing. Among very-low income renter households, slightly more than 67% spend more than 30% of their income on housing and slightly more than 19% spend more than half of their income for housing. This large proportion of low-income renters who have high rent burdens is a result of a lack of an adequate supply of affordable and available rental units.

The second purpose of the chapter was to emphasize the importance of the unsubsidized, private market to the supply of affordable housing units for low-income renter households. Approximately 9.3 million rental units in the private housing market are affordable to households with less than 50% of their area's median income. However, many of these units are occupied by households with higher income. Approximately 3.5 million rental units are affordable and available to these households in the private market. In comparison, approximately 6.3 million rental units are subsidized by Federal housing programs for these low-income households. Therefore, public policies and development practices affecting the private market will have an impact on the supply of units on which low-income renters rely for housing.

The third purpose of the chapter was to explain the relationship between sprawl and housing. Sprawl occurs as higher income households find it in their economic interests to move a further distance from the CBD. As they move away from the CBD, lower income households remain closer to the CBD. In addition, the theoretical framework of filtering relates sprawl, particularly the development of new housing, to a possible increase in the supply of units to lower income households. However, the empirical evidence for this theory is weak.

The fourth purpose of the chapter was to present smart growth, the most recent set of goals and policies intended to disrupt the dominant land use pattern of sprawl. Smart growth was defined as a set of ten principles espoused by the Smart Growth Network. Some of these principles were identified as a potential means of increasing housing opportunities for lower-income households. Two of the principles which smart growth advocates argue will improve the affordable housing supply are higher density and mixed land use development. They argue that these principles can improve housing opportunities for low-income households because they promote smaller housing sizes, a greater variety of housing including multi-family and attached housing units, a better geographic balance between jobs and housing improving access to employment, and improving infrastructure and services in older communities where low-income households are more likely to reside. However, the next chapter will show that there is little empirical evidence for these claims.

A significant component of smart growth is the preservation of land, typically through forms of urban containment. The restriction on the supply of developable land can increase housing prices and, in turn, decrease the supply of housing for low-income households. However, smart growth advocates claim that urban containment, if accompanied by higher density and mixed land use development, will not have a harmful impact on affordable housing.

The chapter's discussion of smart growth ended with its potential relationship to affordable housing. While some authors contend that smart growth addresses the supply of affordable housing through regional solutions, many other scholars contend that smart growth's significant emphasis is on preserving open space and limiting development rather than on the principles which may increase affordable housing. This lack of attention to affordable housing is attributed to NIMBYism and the lack of political support for affordable housing.

The next chapter reviews the empirical evidence regarding the claims made by smart growth advocates. It reviews the literature regarding the impact of four smart growth principles on the supply of affordable housing for low-income households. These four principles are greater density, mixed land use, a greater variety of housing options, and the preservation of open space.

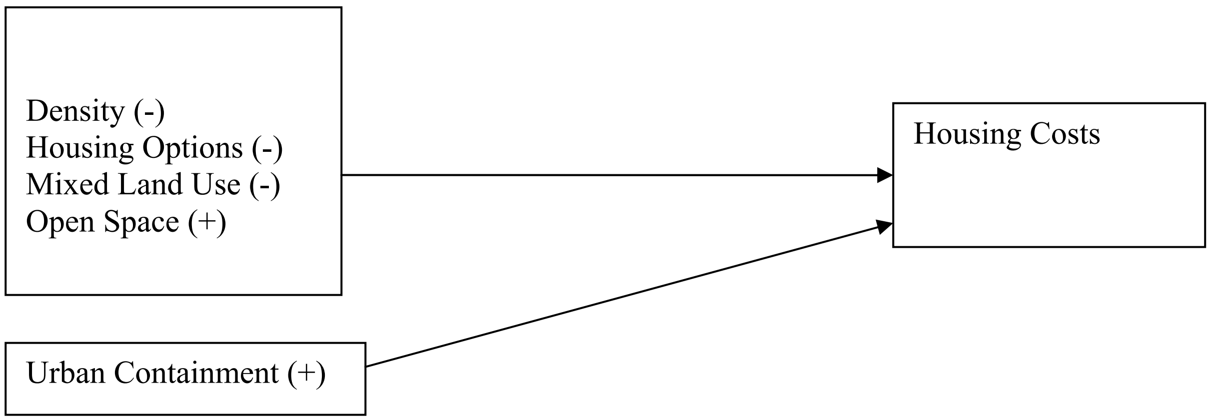
3.0 IMPACT OF FOUR SMART GROWTH PRINCIPLES AND URBAN CONTAINMENT ON HOUSING COSTS

Chapter Two defined smart growth as ten principles for future metropolitan growth. These principles are higher density, mixed land use, a variety of housing options for a range of household incomes, pedestrian-friendly neighborhoods, a strong sense of 'place' within the community, preservation of open space and farmland, more balance regional development by reinvesting in existing communities, a variety of transportation options, predictable and cost-effective development decisions, and citizen and stakeholder participation in development decisions. Four of these principles, higher density, a variety of housing options, mixed land use, and open space are those most likely to impact the affordability of housing and the supply of units for low-income households.

Chapter Two also discussed urban containment as an important component of smart growth. Urban containment is a policy adopted by metropolitan regions, counties, or local municipalities to limit development outside of pre-determined boundaries in order to preserve undeveloped land. The previous chapter presented the argument proposed by urban containment's advocates that keeping development to within specified boundaries not only preserves land from development, but also directs reinvestment into existing communities, while increasing density and mixed land use. However, urban containment also has the potential to increase housing prices because of the restriction it places on the supply of residential land.

The purpose of the current chapter is to review the empirical literature regarding the impact of urban containment and the four smart growth principles on housing costs and the supply of affordable housing for low-income households. The four principles are higher density, a variety of housing options, mixed land use, and preservations of open space. Figure 3.1 illustrates the pattern of these relationships as found in the literature. The figure focuses on housing costs as the review points out that little research explicitly tests the impact of urban containment or the smart growth principles on the supply of affordable units for low-income households.

Figure 3-1. Diagram of Impact of Urban Containment and Four Smart Growth Principles on Housing Costs



Note: Sign in parentheses is expected relationship to the cost of housing.

The literature review is presented in two sections and illustrates conflicting evidence regarding these relationships. The first section reviews the research regarding the impact of urban containment policies on housing costs. Urban containment's restriction on the supply of developable land increases its price (Knaap 1985; Nelson 1986). The cost of land is a significant component in the price of housing because the cost of a unit consists of the cost of land on which the unit sits plus the cost of the structure itself. Therefore an increase in the cost of developable land may increase housing costs (Staley, Edgens, and Mildner 1999; Staley and Mildner 1999). However, there is an unresolved debate revolving around whether it is restrictions on land or an expanding economy that present the strongest influence on housing prices. Some scholars argue that higher housing costs in regions with urban containment can be attributed to a growing economy which brings greater demand for land and housing and cannot be attributed to solely to urban containment (Phillips and Goodstein 2000; Downs 2002).

The second section discusses the relationship between each of the four smart growth principles and housing costs. The first smart growth principle is density. Greater density has been shown to reduce the potentially negative impacts of growth management and urban containment on housing costs (Miller 1986; Carruthers 2002). Greater density can offset higher housing costs caused by land use restrictions because it reduces the amount of land needed for each unit. But other research has found a lower supply of affordable units for low-income households in denser neighborhoods (Burton 2000).

The second smart growth principle is a variety of housing types available in the market. This principle is closely related to density. Large lot single-family homes lead to lower density while smaller single-family units, attached units, such as townhouses, and multifamily units are housing types of greater density as they require less land. An increase in attached units and multifamily units increase the supply of housing, which decreases housing prices. Low-income households are more likely to rely on these types of housing as they are typically more affordable than single-family detached homes on larger lots (Pendall 2000; Downs 2004).

The third smart growth principle is mixed land use. There is evidence that consumers value neighborhoods which are dominated by single-family homes and contain a limited amount of commercial activity (Stull 1975; Song and Knaap 2003). Therefore, it is possible that demand for housing in mixed land use neighborhoods is lower than the demand for housing in exclusively residential neighborhoods. This lower demand would decrease housing prices in mixed land use neighborhoods.

The fourth smart growth principle is open space. Public parks are a specific form of open space. Unlike undeveloped land preserved on the fringes of metropolitan areas through urban containment, public parks are open space preserved within developed areas. Parks typically create a positive amenity to residents, thereby increasing the demand for housing in close proximity. This would increase housing prices. However, this positive impact is significant only at close distances (Farber 2004). The literature review also reveals that the magnitude of the positive impact decreases per unit of land as the amount of open space surrounding a home increases. This indicates that public parks are more valuable to residents in areas that are highly developed.

3.1 URBAN CONTAINMENT AND HOUSING COSTS

The effect of urban containment policies on housing prices and affordability is a topic of much debate among scholars.[40] Urban containment is a policy which establishes a boundary outside of which urban development is restricted. Three common urban containment techniques are urban growth boundaries which prohibit development outside of specified boundaries, urban service areas which establish boundaries outside of which public infrastructure will not be expanded yet development is not explicitly prohibited, and greenbelts which are large tracts of publicly-owned land which cannot be developed.

The implementation of an urban growth boundary or urban service area is likely to divide the land market into two segmented markets (Gleeson 1979, pp. 351-352; Whitelaw 1980; Knaap and Nelson 1992, pp. 42-47). One segment of the market will be for land inside of the boundary, while the other segment will be for land outside of it. Within the boundary, demand for land will increase because anyone wishing to pursue new development must do so there. With the implementation of urban containment, those who would otherwise have pursued developable land outside of the urban boundaries must shift their demand to locations within the boundaries. At the same time, an urban boundary limits the supply of developable land to the amount of land within the boundaries. The increase in demand and the limit on its supply will increase the value of land within the boundaries.

Outside of urban containment boundaries, demand for land will decrease because urban growth boundaries prohibit development while urban service boundaries discourage development through the lack of infrastructure such as public sewer and water systems. The decrease in demand for land outside of the boundaries will decrease its value.

An early test of the segmentation of the land market as a result of urban containment was conducted by Gleeson (1979) in Brooklyn Park, Minnesota. He examined the impact of an urban service area, which is a form of urban containment, on the price of vacant land. In 1962, the Minneapolis suburb chose to prevent development beyond a specified boundary on the north side of town. The city purposely did not extend water or sewer services beyond the boundary they

[40] This section deals only with the impact of urban containment on land and housing prices. For a review of other types of land-use regulation and their impact on housing costs, see Lillydahl and Singell (1987), Nelson et al. (2002), and Quigley and Rosenthal (2005).

had established. The city then passed an ordinance that prohibited development which could not be served by the public sewer system. The combination of these two decisions created an urban containment policy through the control of infrastructure.

To test the impact of Brooklyn Park's urban containment policy on land prices, Gleeson chose a stratified sample of 378 unimproved, vacant parcels of land. 247 parcels were vacant unfarmed (urban) land of which 188 parcels were developable and 59 were not developable because they were outside of the infrastructure boundary. An additional 131 parcels were farmed (agricultural) land of which 33 of the parcels were developable and 98 were not. Gleeson used a regression analysis, controlling for explanatory factors of land prices including parcel size, access to downtown, and soil type, to measure the difference in prices between land within the boundary and land outside of it. He found that developable farm land was significantly more expensive, $1,463 per acre, inside the boundary. However, he found that there was no difference in prices, after controlling for other factors, between vacant non-farm (urban) parcels within the boundary and similar parcels outside of it. He concluded that the segmentation in the land market occurred in the market for undeveloped, developable farm land because these parcels were, on average, much larger in size than the non-farm parcels. Developers presented a greater demand for large parcels which they could subdivide than for smaller non-farm parcels.

Nelson (1985) tested the impact of an urban growth boundary on land prices in Salem, Oregon. His sample included 209 parcels of vacant land which were sold over a three year period. 86 of the parcels were located within Salem's urban growth boundary and 123 were located beyond the urban boundaries. He used a regression analysis to control for the parcel's size, soil type, taxes, zoning, income and education of residents of the census tract in which the parcel was located, access to water and sewer services, and distance from Salem's central business district. He found that a dummy variable indicating whether or not the parcel was located within the urban growth boundary was statistically significant in explaining the value of the parcel.

Knaap (1985) also examined the impact of an urban growth boundary on land prices. His sample consisted of 455 vacant lots for single family homes in two counties of the Portland metropolitan region, Clackamas and Washington County. The dependent variable was the sales price of each parcel. He used regression analysis to control for each parcel's size, peak-hour travel time to the central city of Portland, sewer access, taxes, slope, race and income of the parcel's census tract, and municipality. He included two dummy variables to measure the impact of Portland's urban growth boundary. First, he included a dummy variable for whether or not the parcel was located within the boundaries. Second, he included a dummy variable to indicate if the parcel was zoned for densities less than 4.4 housing units per acre which he called non-urban or for densities greater than 4.4 housing units per acre which he called urban. He found that non-urban parcels within the urban growth boundary were more highly valued than non-urban parcels outside of the boundary.[41] He argued that the higher prices for non-urban land within the boundary reflected buyers' expectations that non-urban land within the boundary would, in the future, become zoned for urban densities before land outside of the boundary.

Gleeson, Nelson, and Knaap each controlled for the parcel's accessibility to the central business district. By including a variable for accessibility, they were able to control for the fact that land values decline as distance from the central business district increases.[42] Keeping the distance or travel time to the central business constant, each of the authors still found that the value of land within urban containment boundaries is greater as compared to land outside of the boundaries.

A number of studies have tested the impact of urban containment policies not on land values, but on housing costs. Knaap et al. (2003) conducted a preliminary analysis of the Maryland Smart Growth and Neighborhood Conservation Initiative's impact on housing markets and development trends. One component of Maryland's smart growth legislation was the requirement of counties to implement priority funding areas (PFAs) to which state infrastructure funds must be directed for future growth. PFAs are similar in concept to urban services areas as no state funds are allowed for infrastructure outside of these boundaries. PFAs must include every municipality in the state plus additional land each county identifies for future development. Knaap et al. compared recent housing trends between Maryland and Virignia, a state without urban containment policies. They found that Maryland had fewer housing starts and a slightly greater increase in housing prices. The authors concluded that Maryland's PFAs may be a partial cause of these differences.

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[41] There were no "urban" parcels outside of the urban growth boundary which prevented a comparison of urban parcels within the boundary to urban parcels outside of it.

[42] See Section 2.2.3 and Alonso (1964).

Phillips and Goodstein (2000) examined the impact of land use regulations on housing prices, with a particular focus on the effect of Portland's urban growth boundary. For 37 metropolitan regions, they regressed the metro's median house price in 1996 on land use regulation while controlling for each region's income, unemployment rate, climate, construction costs, number of municipalities, and change in housing prices for the prior five years. To measure land use regulation, the authors used an index called the Wharton regulatory index which measures regulation as the length of time it takes, on average, to get development approval in each metropolitan region.[43] The authors then modified Portland's index score to indicate that the region was the most restrictive in terms of land use regulation. They argued that this modification made adjustments for Portland's urban growth boundary.

Phillips and Goodstein found only weak evidence that Portland's urban growth boundary raised housing prices. They argued that Portland's strong housing market during the 1990's was mostly the result of a strong regional economy, but that the growth boundary also likely played some role. They concluded that "the UGB has probably increased median housing prices; the most likely interpretation is that the price increase is less than $10,000" (p. 341). Economic measures such as the unemployment rate had a much larger impact.

Downs (2002) also tested the impact of Portland's urban growth boundary on housing prices. He regressed the change in the median home price in 85 metropolitan areas on 25 independent variables and a dummy variable indicating the Portland region. He also included a dummy variable for every other region. He conducted multiple regression models for different periods of time. One model examined the change in housing prices from 1990 to 1994, another for changes from 1996 to 2000, and another for changes from 1990 to 2000.

Downs found that Portland's dummy variable was significant in explaining price changes from 1990 to 1994. The dummy variable for Portland was the only statistically significant dummy variable in this model. He concluded that something in Portland, likely the growth boundary, was unique from the other metropolitan areas in explaining increases in housing prices during this time period. He also found the Portland dummy variable to be significant in the model for 1990 to 2000. However, the Portland variable was not significant in explaining changes in housing prices from 1996 to 2000. He concluded that Portland's urban growth

[43] For more details of the Wharton regulatory index, see Malpezzi (1996).

boundary had some impact on rising prices, but only during the time period in which the region was experiencing strong economic and population growth. He concluded that an urban growth boundary, on its own, did not raise housing prices but could exacerbate rising prices during periods of rapid growth. His conclusion was that urban growth boundaries must be flexible enough to be adjusted in times of growth.

Staley et al. (1999) used cased studies to study both urban growth boundaries, as well as urban service areas. Two of their case studies were of the urban growth boundary in the region of Portland and the urban service area of Boulder, Colorado. They examined housing prices, boundary expansions, and other forms of growth control in each location. They determined that Portland's significant increase in housing prices during the 1990's was a result of the inflexible nature of its urban growth boundary. The boundary was not adequately expanded in response to the strong economic growth that the region was experiencing. In contrast, Boulder's urban service areas were more flexible than Portland's urban growth boundaries. The urban service areas were allowed to "breath" by being expanded to include a greater supply of vacant land. This expansion increased the supply of developable land. From 1990 to 1997, the municipalities in Boulder County annexed approximately 11,598 additional acres of land to include within their boundaries. Staley et al. argued that this increase in land within Boulder's urban service areas prevented housing prices in the county from rising as significantly as they did in Portland.

Other scholars have tested the impact of urban containment policies on the production and supply of housing, which in turn would impact housing prices. Levine (1999) studied the impact of various growth control mechanisms in 490 California jurisdictions. Using ordinary least squares with the change in the number of units in each jurisdiction from 1980 to 1990 as the dependent variable, he found that strong growth controls in the form of zoning and maximum density regulations reduced production of new housing units. However, he found that urban growth boundaries were a weaker form of regulation than zoning. The boundaries were not statistically significant in explaining the change in the number of housing units from 1980 to 1990.

Pendall (2000) examined the impact of various land-use regulations on the production of housing, as well as on the supply of multifamily units, rental units, and affordable rental units. He surveyed 1,510 cities, towns, townships, and counties of the 25 largest metropolitan areas regarding their land-use regulations. Using ordinary least squares, Pendall found evidence that low-density zoning, which restricts higher-density multifamily units, was statistically significant in explaining a lower proportion of units being multifamily units and a lower proportion of units being rentals. He then found that a lower supply of multifamily units was statistically significant in explaining a smaller supply of affordable rental units. However, Pendall found no statistically significant relationship between urban growth boundaries and the supply of multifamily units, rental units, or affordable rental units. He concluded that low-density zoning was more significant in explaining the lack of affordable housing than urban growth boundaries which were not significant at all.

Table 3.1 summarizes the literature addressing the relationship between urban containment and the costs of land and housing. The literature reveals four important facts regarding these relationships. First, urban containment policies increased land values within urban boundaries and reduced values outside of the boundaries. Evidence of this impact was found for urban growth boundaries, as well as for urban service areas. This finding is not surprising given that the purpose of these policies is to restrict development to locations within specified boundaries, thereby limiting the supply of land from which developers can choose for development.

The second important finding is that the flexibility of urban boundaries may be an important factor which dictates the impact of the boundaries on housing values. There is evidence from Staley et al. (1999) that Boulder's flexibility in expanding the amount of land within its urban services areas alleviated at least some of the pressures created by population and economic growth on housing prices in the county. Further evidence is found in the Portland region. Downs (2002) suggested that had Portland's urban growth boundary been more flexible, the region may not have experienced as strong of an increase in housing prices as it did during the economic boom of the early 1990's.

The third finding is the importance of the economy as a factor influencing the impact of urban containment policies on housing values. Portland's urban growth boundary did not appear to impact housing values until the region's economic boom in the early 1990's (Phillips and Goodstein 2000; Cox and Utt 2001). Prior to that there was little growth throughout the region and housing in the area was some of the most affordable in the country among metropolitan regions (Phillips and Goodstein 2000, p. 337). Therefore, constraints on the supply of developable land were not a significant concern until growth began to occur.

Table 3-1. Review of Relationship Between Urban Containment and Land/Housing Costs

Author	Location	Unit of Analysis	Method	Policy/ Independent Variables	Dependent Variable	Significant Finding
Impact on Land Values						
Gleeson (1979)	Brooklyn Park, MN	Unimproved vacant parcels (n=378)	Ordinary Least Squares	Dummy variable for inside and outside of urban service area	Assessed value	Farm land within urban service area had higher values
Knaap (1985)	Portland, OR	Sold vacant single-family parcels (n=455)	Ordinary Least Squares	Dummy variable for inside or outside UGB	Sale price	Vacant lots inside of UGB were more valuable
Nelson (1985, 1986)	Salem, OR	Sold vacant parcels (n=209)	Ordinary Least Squares	Dummy variable for inside or outside UGB	Sale price	Vacant lots inside of UGB were more valuable and increased faster in value
Impact on Housing Values						
Downs (2002)	U.S.	Metropolitan regions (n=85)	Ordinary Least Squares	Dummy variable for Portland UGB	Change in house prices	Economy was more significant in explaining increasing housing prices than the UGB
Knaap et at. (2003)	Maryland and Virginia	States and Counties	Case studies	Land use restriction	Housing starts and house prices	Maryland's smart growth legislation may be a cause of lower housing starts and higher prices
Levine (1999)	California	Local jurisdictions (n=490)	Ordinary Least Squares	Dummy variables for 'strong' and 'weak' growth controls	Change in number of housing units from 1990 to 2000	UGBs were 'weak' control measures that did not influence housing production
Phillips and Goodstein (2000)	U.S.	37 Cities (n=37)	Ordinary Least Squares	Regulation index (with adjustment to Portland for its UGB)	Median house price	Weak evidence that UGB increased housing price. The economy has played a more significant role
Pendall (2000)	U.S.	Jurisdictions in the 25 largest metro areas	Ordinary Least Squares	Dummy variable for UGB	% of population that is black and % that is low-income black	UGB was not significant in explaining supply of affordable units or exclusion of low-income or minority populations
Staley et al. (1999)	Portland, OR; Lancaster County, PA; Boulder, CO; Napa County, CA	Region or County	Case studies	Urban Containment	Housing prices	Portland's inflexible UGB is one of the causes of rising prices

Finally, urban containment does not appear to impact the supply of affordable housing for low-income households. Levine (1999) found that urban growth boundaries in California did not affect the number of new housing units produced between 1980 and 1990. Therefore, they did not appear to limit the supply of housing. However, he did not examine the boundaries' impact on affordability. In the only study to explicitly test the impact of urban growth boundaries on affordable rental units, Pendall (2000) found no statistically significant relationship between the boundaries and the supply of affordable rental units.

3.2 SMART GROWTH PRINCIPLES AND HOUSING COSTS

This section reviews the empirical literature regarding each of the four smart growth principles of interest to this research and their impact on housing costs and affordable housing.

3.2.1 Density

The first smart growth principle of interest is greater density. Two significant factors make smart growth's goal of higher housing density pertinent to a study of affordable housing. First, density is often associated with a greater proportion of rental and multi-family units, which are more likely to be affordable for low-income households than single-family dwellings (Pendall 2000; Smart Growth Network 2001; Downs 2004). An argument is made that higher density housing development will help to address the housing needs of lower-income households because of this association. Second, proponents of urban growth boundaries, and to a lesser extent urban service areas, argue that higher land and housing costs caused by the restricted supply of developable land can be off-set by increased density that should accompany any urban containment policy (Hannah, Kim, and Mills 1993; Nelson and Moore 1996; Phillips and Goodstein 2000).

This section first reviews the empirical evidence of the relationship between density and housing prices without consideration of the potential impact of urban containment policies. The literature reveals an association between greater density and lower housing prices in general. However, greater density is not associated with an improvement in housing affordability for low-income households. Two studies indicate that greater density is negatively associated with housing affordability at lower price ranges which are affordable to low-income households.

This section then presents the empirical evidence of the impact of density on housing prices in regions that have implemented urban containment policies. These studies support the contentions among smart growth advocates that urban containment will not have negative effects on housing affordability, in general, if density is increased in tangent with the implementation of urban containment. The studies illustrate that greater density will at the very least partially off-set the pressure that urban containment may place on housing values. Unfortunately, the studies also show that greater density does not improve affordability for low-income households.

Li and Brown (1980) found no significant relationship between residential density and home values when they studied the sales price of 781 housing transactions in suburban Boston. They tested the impact of a variety of structural and neighborhood characteristics, public service costs, and accessibility to the central business district on each home's price. One of their neighborhood attributes was residential density. They measured density as the number of residential units per square mile. Using ordinary least squares, they found that the density of the neighborhood had no significant relationship with the sales price of the house.

Other scholars have found statistically significant relationships between density and housing costs. Song and Knaap (2003) examined the relationship between the price of 48,000 individual real estate transactions over a ten year time period in Washington County, Oregon and neighborhood density. They defined the neighborhood as the census block group in which the real estate parcel was located. They defined density as the number of households per area of land in the neighborhood, as well as the number of single-family units per area of residential land in the neighborhood. They regressed the sales price of the parcel on a variety of neighborhood features, including the mix of land uses, distance to public parks, distance to commercial uses, distance to bus stops, transit options, density, and walkability.[44] They found a statistically significant relationship between greater density and lower real estate prices. Song and Knaap concluded that people typically prefer neighborhoods with low residential density.

Shultz and King (2001) also found a statistically significant relationship between greater density and lower housing prices. They analyzed the median house value of 6,277 census blocks in Tucson, Arizona, in a variety of regressions. In each regression, the dependent variable was the median house value of the census block. The independent variables were structural and land use characteristics of the neighborhood. The geography at which the independent variables were

[44] The authors were testing the impact of specific features of new urbanism on the price of real estate. For an explanation of new urbanism, see Katz (1994) and the charter of the Congress for New Urbanism (2001). For a study of the impact of new urbanism on the price of single-family homes, see Eppli and Tu (1999).

measured was changed for each model. The independent variables were first measured at the block, then the census block group, then the census tract level. A census block is the smallest level of geography for which Census data is reported and represents the size of a typical urban street block. A census block group represents a group of adjacent blocks. A census tract is consists of multiple block groups and contains approximately 2,500 to 8,000 residents. Census tracts are designed with the purpose of containment population, economic status, and living conditions with the tract as homogenous as possible.[45] They used two variables to represent residential density. The first variable was the number of single-family dwellings per area of land classified as single-family land use. The second variable was the number of total residential units per area of land. Shultz and King found that greater residential density of the neighborhood was associated with lower house values regardless of whether the neighborhood was defined as a block, a block group, or census tract. Similar results were found for both measures of density.

Alexander and Tomalty (2002) warned that higher density may not necessarily correlate with cheaper housing for low-income households. They examined data from 26 municipalities in the British Columbia region of Canada. Using a correlation analysis, they found that the municipalities with the highest densities also had the largest proportion of households paying more than 30% of their income on housing costs. They suggested that there was an inverse relationship between density and housing affordability. But, their conclusion was tentative as they recognized that inner cities were the densest in their sample. At the same time, the inner cities had a larger proportion of low-income households. Therefore, density may have been correlated with the proportion of households spending more than 30% of their income on housing costs because they had lower incomes.

Burton (2000) examined the association between density and housing for low-income households. Her primary purpose was to test the claim that compact development increases social equity among different income groups. Using data from 25 medium-sized British cities, she used multivariate regression to test the relationship between density and housing costs. She controlled for each city's economic and social characteristics, size, and location within England. Her dependent variable was the average price of a "bottom-of-the-market" dwelling relative to the average earnings for males working full-time manual labor. "Bottom-of-the-market"

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[45] For detailed definitions of census geography, see the U.S. Census Bureau's (1994) Geographic Areas Reference Manual which is available at http://www.census.gov/geo/www/garm.html.

dwellings were those build before 1919 of a certain style most likely to be affordable for lower-income households. She found that greater density was associated with an increase in the relative housing prices for low-income workers. She concluded that higher density was found in more expensive housing markets, but could not conclude that density caused higher prices. Some towns in her sample which were dense were old, historic cities. She surmised that demand for housing in some of these old, historic and denser cities caused prices to be high.

Other scholars have examined the impact of density on housing costs in locations with growth management or urban containment policies to limit sprawl. The following research tested the argument that greater density helps to relieve pressure on house costs which may occur as a result of restrictions on the supply of land.

Miller (1986) studied growth control in Boulder, Colorado, and Petulma, California, during the 1970's. He found that housing prices between the two communities behaved differently in response to restrictions on the number of new units that could be produced within a given year. Boulder maintained a supply of moderately priced units, while Petulma became a more expensive, more exclusive community. One potential reason for this difference was an additional ordinance passed in Boulder requiring a certain proportion of new homes be moderately priced. Boulder's housing market responded to the combination of growth restrictions and moderate-priced housing mandates with the provision of different housing types, through conversion and new construction, to include a higher proportion of smaller, attached units and condominiums. The proportion of smaller, attached units grew in Boulder, while Petulma's housing stock remained mostly single-family, detached dwellings. Miller concluded that growth control did not necessarily eliminate moderate priced housing if the type of housing changes to include smaller units through government mandates.

Staley and Gilroy (2001) recently studied growth management, density, and housing affordability among counties in Washington and Florida, both growth management states. Regressing the growth in median house prices from 1995 to 2000 in each county on income growth, population growth, and the length of time the county was in compliance with the state's growth management legislation, they found a significant and positive relationship between the growth management and prices in both states. However, density was a significant variable only in only Washington State's counties. Higher densities were associated with higher prices in Washington, but not in Florida. They asserted that Washington's urban growth boundary increased density, as well as put pressure on prices because of constraints on the supply of land. Their analysis did not measure the extent to which housing prices would have increased in Washington in response to growth management without any increase in density.

Carruthers (2002) studied the impact of state-level growth management programs in 283 metropolitan counties at four different points in time which were the years of 1982, 1987, 1992, and 1997. Their analysis included counties from 14 different states, five of which had growth management programs for at least part of the time period. The five growth management states were Oregon, Washington, California, Georgia, and Florida. All 14 states were experiencing rapid population growth. The authors used simultaneous equations to measure the impact of growth management on five outcomes, which were the amount of developed land in the county, density, property values, infrastructure expenditures, and population. They measured density as the number of jobs and residents per acre of developed land. The variable measuring growth management was the number of years that a state mandated growth management was in place for each county.

Carruthers presented two important findings with regard to density. First, he found that Oregon State's growth management mandates had a statistically significant impact on increasing density. Oregon was the only growth management state in which this relationship was found. At the same time, Oregon was the only state in which the relationship between growth management and property values was negative although it was not a statistically significant relationship. Therefore, Carruthers concluded that Oregon's growth management program, including urban growth boundaries, did not increase housing prices possibly because of the increase in density.

The second important finding of Carruther's work was the endogenous relationship between housing prices and density. Greater density was a statistically significant variable in explaining higher property values. But at the same time, higher property values were a statistically significant variable in explaining greater density. This finding illustrates that density may be associated with higher home values because density increases in more expensive housing markets. It is not density that is the cause of higher housing prices.

Table 3.2 summarizes the literature regarding density and the cost of housing. Three important items are drawn from this literature. First, little is know about the relationship between density and the supply of housing specifically affordable for low-income households.

The research that does exist suggests that density may not have positive consequences for low-income housing (Burton 2000; Alexander and Tomalty 2002).

Table 3-2. Review of Relationship Between Density and Housing Prices

Author	Location	Unit of Analysis	Method	Measure of Density	Dependent Variable	Finding
Alexander and Tomalty (2002)	British Columbia, Canada	Municipality (n=26)	Correlation analysis and Case studies	People per hectacre; housing units per hectacre	% of households paying more than 30% of income for housing	Positive correlation between density and proportion of households paying more than 30% of income for housing
Burton (2000)	Brittain	City/Town (n=25)	Multivariate analyses	14 indicators	Ratio of avg. selling price at 'bottom of market' to avg. earnings of manual labor jobs	Positive relationship between density and price and lower affordability at low end of housing market
Carruthers (2002)	14 U.S. States	Metropolitan Counties at 4 different time periods (n=1,131)	3SLS	# of jobs and people per acre of developed land	Assessed property value per acre	Endogenous relationship between density and value. Oregon's growth management had no impact on value because of increase in density
Li & Brown (1980)	Boston, MA	Property Sales (n=781)	Least Squares	Housing units per square mile within property's census tract	Sale price	No statistically significant relationship
Miller (1986)	Boulder, CO and Petulma, CA	Municipality (n=2)	Case studies	% of units that were attached homes	% of homes that were in 'moderate price range'	Growth control in Petulma lowered affordability because density did not increase. Boulder maintained moderately-priced housing because density increased with larger supply of smaller units
Shultz & King (2001)	Tucson, AZ	Census block groups (n=6,277)	Hedonic Pricing Model	Number of residential units per acre	Avg. of median value of owner occupied units and median value of capitalized rents for rental units	Negative relationship
Song and Knaap (2003)	Washington County, OR	Real estate transactions (n=48,070)	Hedonic Pricing Model	Single-family units per residential area of block group; also households per land area of block group	Sale price	Negative relationship
Staley & Gilroy (2001)	Washington and Florida States	County	Case study; Regression	People per square mile	Growth in median house price (1995 to 2000)	Positive relationship in Washington State

Second, the level of geography at which density is measured may influence the conclusions concerning the relationship between density and housing costs. It is interesting to note that the studies which measured density at the neighborhood level found greater density was associated with lower housing prices (Shultz and King 2001; Song and Knaap 2003). Meanwhile, studies measuring density at the municipal or county level found greater density was associated with higher housing costs (Staley and Gilroy 2001; Carruthers 2002). These different findings may result from the fact that measurements of density at the county or municipal level hide the variation in density which occurs within a large jurisdiction. As shown by Carruthers, housing costs and density are endogenous at the county-level. A county with a more expensive housing market will likely be more dense than a county with a weaker housing market. However, residents within the more expensive county may still prefer low density neighborhoods.

Third, the evidence is mixed as to the extent to which greater residential density will off-set the impact of growth management on housing prices. Staley and Gilroy (2001) found that while density increased in the state of Washington after growth management was implemented, housing prices also rose. Carruthers (2002), on the other hand, found that the relationship between growth management and property values was not statistically significant in Oregon. In Oregon, growth management was associated with greater density. Carruthers credited this increase in density as the reason for no relationship between growth management and housing prices. Miller (1986) made a similar conclusion by crediting an increase in density for the ability of Boulder, Colorado to maintain a supply of moderately-priced housing after its implementation of growth control.

The research in this dissertation addresses two gaps in the research left by Staley and Gilroy (2001), Carruthers (2002), and Miller (1986) in their studies of the impact of density within the broader context of growth management. First, their analyses used either the county or municipality as the level of observation. Using such a large geographic area ignores the relationship between density and housing prices that occurs at smaller geographic levels such as the neighborhood. There is a wide range of densities which are found within a single county or municipality. Aggregation of data to the county does not capture this range. Second, none of these authors specifically addressed affordable housing for low-income households. They can only make generalizations regarding growth management, density, and general housing prices. They cannot make generalizations about the supply of affordable housing.

3.2.2 Variety of Housing Options

The second smart growth principle is the provision of a variety of housing options for a wide range of household incomes. This principle is closely related to the principle of density. Greater residential density can be achieved in three ways. Lot sizes for single-family homes can be decreased, the supply of multifamily units can be increased, or the supply of attached single-family homes can be increased. Therefore, one path to increasing density is to increase the variety of housing types to include multifamily and attached units.

In a recent literature review titled "The Effects of Affordable and Multifamily Housing on Market Values of Nearby Homes," Galster (2004, p. 178) wrote that there is little research that measures the impact of non-subsidized, market-rate multifamily units on adjacent property values. He found that the literature dealt with subsidized housing's impact on property values and argued that there is little information that can be generalized to non-subsidized units. Nonetheless, there are a limited number of studies that have examined the impact of market-rate multifamily housing on nearby house values.

Song and Knaap (2004) examined the impact of multiple neighborhood land-use characteristics on the sale price of 4,314 single-family homes sold in the year 2000 in Washington County, Oregon. They used an hedonic price model to measure the extent to which each land use characteristic was statistically significant in explaining each home's sale price. In their first model, they included distance from the home to a multifamily housing as an independent variable. They found that a greater distance from multifamily housing was associated with an increase in the price of the single-family home.

In their second model, they included the proportion of land in the neighborhood designated for multifamily residential use. Song and Knaap defined the neighborhood as the Census Transportation Analysis Zone (TAZ) and land use data were obtained from the Portland Metro. They found that the proportion of land designated for multifamily housing was not statistically significant in explaining the sales value of single-family homes. The authors concluded that buyers of single-family homes preferred not to live adjacent to or near multifamily units given the results they found in their first model. However, the amount of multifamily housing in the neighborhood was not significant.

Cao and Cory (1982) tested the relationship between land use for multifamily housing and the median value of single-family homes in 52 neighborhoods of Tucson, Arizona. They regressed the median value of homes on the proportion of land that was used for multifamily units, commercial activity, industrial activity, and public use. They also included the age and average size of the housing units, school quality, and property tax rates as additional independent variables. In contrast to Song and Knaap, Cao and Cory found that a greater amount of land occupied by multifamily units was associated with higher single-family home values. Their analysis, however, included neighborhoods of only one city. Therefore, they could only conclude that multifamily housing units were associated with higher values for single-family homes within the city.

There is no empirical research that tests the relationship between the variety of housing types and the supply of housing that is specifically affordable for low-income households. The papers mentioned earlier only examined the effect of multi-family housing on the value of single-family homes. As mentioned previously, it is widely accepted that multifamily units are more likely to be occupied by low-income households than single-family units (Downs 2003). Therefore, we could assume that a neighborhood with a larger supply of multifamily units will be more likely to have a larger supply of affordable units than neighborhoods dominated by single-family homes. This research directly tests that assumption.

3.2.3 Mixed Land Use

The third smart growth principle which is believed to be associated with a greater supply of affordable units is the principle of mixed land use neighborhoods. Mixed land use is defined as a diversity of land use activities found within a specified area. It is associated with a more diverse housing stock in the form of accessory units, as well as with apartments in the upper floors of commercial buildings occupied by retail space and offices on lower floors (Talen 2002, p. 181).

The mix of land uses in a neighborhood is expected to impact the value of the neighborhood's housing. The research reviewed in this section shows that housing values are typically higher in neighborhoods which are predominantly single-family homes with some limited commercial activity. Consumers prefer these neighborhoods. The types of land use within the mix also have an impact on housing values. Mixed land use may include activities that produce negative externalities, such as industrial or undesirable facilities, which decrease housing prices (Farber 1998). On the other hand, a mix of uses that mostly includes amenities thought to be desirable will increase housing prices. These positive uses include retail, entertainment, health, and education.

In an early study of land use effects on housing prices, Crecine et al. (1967) examined the sale price of single family dwellings in Pittsburgh from 1956 to 1963. They used ordinary least squares with the sales price of each single-family dwelling that was sold as the dependent variable. The independent variables representing land use were the proportion of land within the home's block that was zoned for industrial, commercial, institutional, and multifamily use. Each land use was represented by a variable. They found that land uses within the block of the house were not statistically significant in explaining the sales price of homes sold in Pittsburgh. The authors performed separate regressions for each neighborhood within the study to control for neighborhood factors that could not be captured at the block level. One drawback to this research is that the authors used zoning to measure land use rather than the actual use of the land.

Stull (1975) criticized Crecine et al's study for performing separate regressions for each neighborhood and using the blocks of each neighborhood as the level of analysis. He argued that land use throughout an entire neighborhood may influence home prices rather than the mix of uses just within the block of the home. Stull looked at the median value of owner-occupied single-unit structures of 40 suburban cities outside of Boston. He used both ordinary least squares, as well as two stage least squares to control for the possible endogenous relationship between his dependent variable of median single-family home values and his independent variables. He controlled for the median size, average age, and average lot size of the cities' homes. He also controlled for each city's tax rates. He utilized two stage least squares because he feared lower tax rates would explain higher house values while higher home values explained lower tax rates.

In his first analysis, he used only one independent variable to measure land use. The variable was the proportion of land that was not single-family homes. He found that a greater proportion of land devoted to single-family homes was associated with higher housing prices. This indicated that consumers preferred towns of mostly single-family homes. In a second analysis, he used multiple independent variables for land use, including the proportion of land in the city that was multi-family, commercial, industrial, and vacant land. The only favorable land use he found, in terms of a positive influence on home prices, was commercial use. However, the relationship was quadratic. As commercial uses increased up to 5% of the land, home prices increased. As the proportion of commercial uses became greater than 5% of the total land area, home prices declined. He concluded that home buyers preferred municipalities that were of, predominantly, single-family homes with a small amount of commercial land uses.

Cao and Cory (1982) examined the relationship between the mix of land uses and the median value of single-family homes in Tucson, Arizona's, fifty-two neighborhoods. They used ordinary least squares with the proportion of land zoned and used for multifamily housing, commercial activities, industrial use, and public use serving as independent variables. In the first analysis, the authors used the proportion of land that was zoned for each land as the independent variables. Similar to Crecine et al., they found no statistical significance in the relationship between zoning and house values.

In their second analysis, Cao and Cory's independent variables were the proportion of land that was actually used for each type of land use, as opposed to the amount of land that was zoned for each particular use. They found that a greater proportion of land used for purposes other than single-family homes was associated with lower single-family home values. Their findings differed from Stull in that he found only a smaller proportion of commercial use was associated with greater home values.

Cao and Cory asserted that one potential reason for the difference is that they examined the relationship within one city's neighborhoods while Stull tested the relationship among multiple cities. Tucson's zoning codes limited the amount of non-residential land uses that could be located in residential neighborhoods. Therefore, the majority of their observations, which were the neighborhoods, had low levels of commercial activity. More than 75% of their neighborhoods had less than 20% of the land utilized by commercial activities. They cautioned that this limited amount of commercial activity in most neighborhoods may have biased their results upward. Their findings may not be applicable to neighborhoods with a large proportion of commercial uses. They wrote that there was "a need in future studies to analyze the relationship between land uses and property values at high ranges of various non-single family land uses" (p. 14).

More recently, Cervero and Duncan (2004) examined the relationship between mixed land use and the land values of 5,364 single-family and 1,734 multifamily parcels that were sold in Santa Clara County, California. They used two stage least squares to regress the value of the parcel on a variety of neighborhood and land use characteristics. The 'neighborhood' was defined as the area within a one-mile radius from the sold parcel. Two stage least squares was utilized to control for the potential endogeneity between land values and land use. They assumed that land uses would impact land values and that land values would impact the types of land uses in the neighborhood.

The authors measured mixed land use with a modified formula of entropy which measured the diversity of jobs in various employment sectors within a one-mile radius of the property transaction.[46] They used the variety of employment sectors in the neighborhood as a proxy for the variety of land uses. They found that a greater diversity of land use activities in a neighborhood was associated with higher land prices. They also found that a greater proportion of housing units that were single-family homes within 1 mile of the parcel was associated with lower land values. Separate models for single-family parcels and multi-family parcels revealed the same results.

Song and Knaap (2003) used a similar measure of land use diversity to test the relationship between mixed use and real estate values. Their analysis included 48,070 housing transactions over a ten year period in Washington County, Oregon. Song and Knaap used an hedonic pricing model to test the effect of land use characteristics on the sale value of each home. In constrast to Cervero and Duncan who used employment data to calculate the diversity of land uses, Song and Knaap used actual land use data. They calculated two different indices of mixed land use based on the census block group in which the home was located. One index included single family dwellings in the mix of uses, as well as multifamily residential, commercial, industrial, and public uses. The second index excluded single family dwellings from the mixed land use variable in order to capture the impact of only non single-family uses.

When using the first measure of mixed land use, Song and Knaap found that a lower diversity of land uses was associated with higher housing prices. They concluded that consumers preferred neighborhoods in which single-family dwellings were dominant. The predominance of single-family homes was indicated by a lower level of diversity. When using the second measure, which did not include single-family homes, they found that greater diversity of land uses was associated with higher prices. From the second measure, they concluded that

[46] Geoghehan et al. (1997) and Acharya and Lewis (2001) also examine the relationship between land use diversity and housing prices with a similar measurement of diversity. However, they are not discussed here as their types of land use are based on data from USGS which classifies uses such as forest, agriculture, wetlands, residential, etc. In the context of smart growth, "mixed land use" most often refers to the diversity of activities such as retail, residential, industrial, etc.

consumers preferred a more even distribution and greater diversity of land uses in neighborhoods where single-family homes did not dominate the landscape. Therefore, the impact of mixed land use on house values was sensitive to the type of land uses which were being measured.

Table 3.3 provides a summary of the empirical literature regarding the relationship between mixed land use and housing prices.

Table 3-3. Review of Relationship Between Mixed Land Use and Housing Prices

Author	Location	Unit of Analysis	Method	Measure of Mixed Land Use	Dependent Variable	Finding
Cao and Cory (1982)	Tucson, AZ	Neighborhoods (n=52)	Ordinary Least Squares	% of land: Multi-Family Commerce Industry Public use	Median value of owner-occupied, single-family units	Positive relationship between proportion of land that was not for single-family use and housing prices
Crecine et al. (1967)	Pittsburgh, PA	Residential transactions	Ordinary Least Squares (separate analysis for each neighborhood)	% of land in block for each zoning category, ie. multi-family, commercial, industrial, etc.	Sale price	No statistically significant relationship
Cervero & Duncan (2004)	Santa Clara County, CA	Individual parcel sales (n=5364 single-family sales; n=1734 multi-family sales)	Two-Stage Least Squares	1) Land use mix (within 1 mile radius) 2) % single family units (within 1 mile radius)	Land value of parcel sales	Positive relationship between mixed land use and land values
Song & Knaap (2003)	Washington County, OR	Real estate transactions (n=48,070)	Hedonic Pricing Model	Land use (entropy) mix	Sale Price	Positive relationship if neighborhood is not dominated by single-family homes. But, neighborhood of single-family use is preferred.
Stull (1975)	Boston SMSA	Suburban Cities (n = 40)	Ordinary Least Squares; Two-Stage Least Squares	% of land devoted to: Multi-Family Commercial use Industrial use Institutional use Vacant	Median value of owner-occupied, single-family units	Consumers preferred single-family homes and small amounts of commercial activiy. Quadratic relationship between % of land for commercial uses and median home value.

There are two important issues noticeable from the review. The first issue is the sensitivity of housing values to the level of diversity among land uses. Song and Knaap (2003), as well as Stull (1975), found that commercial activity lowered housing values if there was a significant mixture of housing, commercial, and other land uses. For example, Stull's study of Boston's suburbs found a negative relationship between commercial land use and housing prices when commercial activities accounted for more than 5% of the suburb's total land use. He found a positive relationship if commercial activities accounted for less than 5% of the suburb's land use. This evidence suggests that neighborhoods with a significant proportion of non-residential land uses may contain a larger supply of affordable units than neighborhoods dominated by residential land uses because of lower demand among housing consumers for housing in neighborhoods with a great diversity of land uses.

Cao and Cory (1982) and Cervero and Duncan (2004) found that a greater diversity of land uses was associated with higher home and land values, respectively. However, Cao and Cory questioned their own results. They asserted that their analyses' level of observation precluded having a wide range of values for their measure of land use activities. Most of their neighborhoods had only small amounts of commercial activity. They questioned whether they would find the same results if more of their observations had a greater proportion of land used for commercial purposes. Cervero and Duncan noted that the county in which they performed their analysis was job-rich and housing-poor (p. 307). There was a significant lack of housing in the county as compared to the number of workers. It is possible that their results are not generalizable to other counties because of the stronger than average demand for housing.

The second issue revealed by the literature review is the lack of research explicitly testing the relationship between mixed land use and the supply of affordable housing for low-income households. There are two identifiable gaps. First, the literature suggests that housing consumers prefer neighborhoods not dominated by non-residential land uses. Therefore, less demand for housing in mixed use neighborhoods may lower prices and, in turn, increase the supply of affordable units. However, no current research tests this hypothesis.

Second, the research by Song and Knaap (2003) indicated that mixed use neighborhoods may be preferred by housing consumers when single-family homes are not included in the analysis. This finding suggests a possible interaction between mixed land use and demand for specific types of housing. Housing consumers may have higher demand for multi-unit structures and attached homes than for single-family homes in neighborhoods of greater land use diversity. Typically, multi-units structures and attached homes are more likely to be affordable for low-income households. Because of the potential for greater demand for these types of units in mixed use neighborhoods, they may be less likely to be affordable. Once again, there is no research which explicitly tests this hypothesis.

3.2.4 Open Space

The fourth principle of smart growth which is of interest to the study of affordable housing for low-income households is the preservation of open space. A previous section reviewed the impact of urban containment, which are policies to preserve open space on the fringes of urban areas, on housing. This section discusses the impact of another form of open space, public parks, on housing costs.

Public parks are likely considered an amenity among housing consumers. Therefore, a park will be associated with higher housing costs in the park's neighborhood because of greater demand for housing. However, a review of the literature reveals two caveats concerning this assumption. First, a park has a localized impact on house values. The distance between the park and a home has significant implications for the effect the park has on the home's value. A park typically only increases the value of homes that are adjacent to or within a block of the park. The additional value that a park creates for a home declines as the walking distance between the two increases. In addition, some studies have shown that houses within 100 feet of a park are not actually higher in value. While the benefit of a park is captured in home values within walking distance, houses too close to a park might be devalued because of its proximity to space that attracts people and activities.

The second caveat regarding parks and their positive relationship to housing prices is that undeveloped land not guaranteed to remain undeveloped does not increase the value of nearby homes. Housing consumers appear to value permanent forms of open space, such as publicly owned parks, more than open space that can be developed in the future.

Weicher and Zerbst (1973) examined the impact of five public parks on prices of single-family dwellings sold between 1965 and 1969 in Columbus, Ohio. They included homes that were the distance of a block or less away from one of the five parks. Using ordinary least squares, the sales price was the dependent variable. The independent variables were the number of rooms, age of the house, and lot size. They used individual dummy variables to indicate whether the house was adjacent to and facing a park, adjacent to and backing onto a park, and adjacent to a park and facing an area of heavy recreational use or park building.

Weicher and Zerbst found that the positive effect of a park on the value of a home was dependent on the location of the house in reference to the park. They found that the sales price of homes adjacent to and facing a public park were of higher value than those homes that were a block away. On average, they sold for $3,434 more than homes a block away. However, they also found that adjacent homes that backed into (faced away from) the park sold for, on average, $1,030 less than homes that were a block away. Homes looking over a heavily used recreational area or a park building had, on average, a price that was $1,057 less than homes that were a block away.

Correll et al. (1978) tested the impact of three greenbelts (a form of urban containment) in Boulder, Colorado, on the price of real estate transactions. They used ordinary least squares with the sales price of individual property transactions within 3200 feet of one of the greenbelts as the dependent variable. They controlled for the age and size of the house. They did not control for neighborhood characteristics because they assumed Boulder to be a fairly homogenous community. Therefore, neighborhood characteristics would be similar for all of the observations.

Correll et al. found that a closer proximity to a greenbelt was associated with a higher sale price. As the distance from the greenbelt increased, the price of the transaction decreased. However, when they analyzed each of the three greenbelts separately, they found mixed results. A closer proximity to one greenbelt was associated with higher prices. For the second greenbelt, the authors found there was a negative relationship between proximity and housing prices. And for the third greenbelt, they found no statistically significant relationship between proximity and prices. The authors hypothesized that the different outcomes for the second and third greenbelts were the result of the fact that these two greenbelts were newer. There had been less time for their presence to be captured in housing prices. There was undeveloped land around the second greenbelt. The authors felt that the positive amenity of the greenbelt would be capitalized into home values once new development occurred close to the greenbelt. Around the third greenbelt were older, owner-occupied homes in a stable neighborhood. Few transactions had taken place. Therefore, the authors predicted that the values of the homes would benefit from the greenbelt once turnover began occur in the neighborhood and more sales took place.

Cheshire and Sheppard (1995) examined the relationship between the amount of open space surrounding a home and its asking price in two British towns. Their sample included 350 properties for sale in Darlington and 490 properties for sale in Reading. Reading had a larger amount of open space that was accessible to the public than Darlington. In contrast, Darlington had a larger supply of "closed" open space which was undeveloped, privately owned land not accessible to the public. To test the relationship between open space and housing prices, they used a hedonic price model which included a wide range of structural and neighborhood characteristics. They measured open space as the proportion of land that was open space within 1 square kilometer of the home. They found that a 1% increase in the proportion of land that was accessible open space was associated with an increase of £83 in the asking price in Darlington and a £50 increase in Reading. Because there was a smaller supply of the amenity in Darlington, it was more highly valued. They found a 1% increase in the proportion of land that was "closed" open space was not statistically significant in Darlington and was associated with a £101 increase in asking prices in Reading. This difference was likely due to the fact that Reading had a smaller supply of "closed" open space and was, therefore, more highly valued.

Acharya and Lewis (2001) did a similar analysis of the relationship between the amount of open space surrounding a home and its value in New Haven County, Connecticut. Their sample included 4,000 homes that had sold in the county from 1995 to 1997. Using a hedonic price model, they controlled for social and economic characteristics of the home's neighborhood, including the race of the population, education level of residents, crime rate, average commute times, and population density. They also controlled for features of the housing unit's structure, such as its size, style, exterior material, and the presence of physical amenities including a basement, attic, decks, and garage. After controlling for these other features, they found that a greater percentage of open space within one mile of the home was associated with a higher sales price for the home. Acharya and Lewis also found a diminishing marginal benefit of open space on housing values. As the proportion of open space surrounding a house increased, the magnitude of its positive impact on housing values decline. Households paid more per unit of open space when there was little open space surrounding the home.

Irwin (2002) analyzed the impact of open space surrounding a home on its value in four Maryland counties. Irwin's research expanded the work of Acharya and Lewis in that she measured the effects of permanently preserved open space separate from the effects of developable open space that was not guaranteed to remain permanently undeveloped. She used a hedonic price model with the sales price of 55,799 sales transactions of single-family homes from 1995 to 1999. She measured the proportion of land within 600 meters that was open space, as well as the proportion of land within 100 meters that was open space. She found that a greater proportion of permanently preserved open space was associated with higher home values. The relationship was of a stronger magnitude at 100 meters than at 600 meters. Irwin found the developable open space was not statistically associated with home values. She concluded that consumers value permanently preserved land more than developable land which may not remain open space.

Geoghegan (2002) also examined the impact of both permanent open space and developable open space on housing values in the same manner as Irwin. She measured the proportion of land within 1600 meters of a home that was either developable or permanent open space. She used a hedonic price model in which the dependent variable was the sales price of 5,599 residential properties in Howard County, Maryland. Her results were similar to those of Irwin in that she found that a greater proportion of permanent open space surrounding a home was associated with higher home values. Developable open space was not associated with home values.

Bolitzer and Netusil (2000) tested the impact of different types of open space on home values. They used a hedonic price model to analyze the sale price of 16,402 single family homes in the city of Portland, Oregon. In their first analysis, they used a single dummy variable to indicate the presence of open space within 1500 feet of a home. They included a second variable indicating the size of the open space. They found having open space within 1500 feet was associated with higher home values and that a greater amount of it increased home values. In a second analysis, they used multiple dummy variables to indicate the presence of public parks, private parks, cemeteries, and golf courses. They found that public parks and golf courses were statistically significant in explaining higher home values. The other types of open space were not significant.

Bolitzer and Netusil did a third analysis to test the impact of distance on the relationship between the open space and house values. They used dummy variables to indicate the presence of open space within a variety of distances from the home. Table 3.4 presents the distance range for each dummy variable, its estimated impact on a home's sales price and level of significance. The estimated impact of each dummy variable is relative to open space at distances greater than 1500 feet from a home. Starting at a distance of 101 feet away from a home, they found that the magnitude of the positive relationship between the presence of open space and a home's value diminished as distance increased. An interesting finding of their research was that open space within 100 feet of a home was not statistically significant in explaining the home's sales price. They concluded that open space too close to a home did not provide positive benefits, and might produce negative externalities, to residents as the space may attract noise and people to be within close proximity to the home.

Table 3-4. Impact of Open Space on Home Values from Bolitzer and Netusil

Dummy Variable (distance)	Estimated Coefficient (Impact on a home's sales price)
Within 100 feet	$ 3,522.80
101 to 400 feet	$ 2,755.36*
401 to 700 feet	$ 1,982.80*
701 to 1000 feet	$ 1,522.09*
1001 to 1300 feet	$ 1,454.59*
1301 to 1500 feet	$ 1,004.16***

*p=.01; ***p=.10
Source: Bolitzer and Netusil (2000, p. 192).

Wu et al. (2004) looked at the relationship among environmental amenities – such as parks, rivers, lakes, and wetlands – development density, and home values within Portland's urban growth boundary. They presented three simultaneous equations in which the price of a home was a function of structural amenities of the home and environmental amenities and density of the surrounding area; the density of the area was a function of housing prices and environmental amenities; and house size was a function of housing prices, density, and environmental amenities. They argued that housing prices would increase with a closer proximity to parks and other positive environmental amenities. Their second and third equations illustrate their argument that development density may increase and home size may decrease in areas of higher housing prices because developers would use land more intensely to be able to produce more housing units in order to achieve greater profits.

Wu et al. applied their model of simultaneous equations to 14,191 residential sales in Multnomah County, Oregon. They found that a closer proximity to parks, lakes, and wetlands was associated with higher home values. In addition, they found that a larger amount of land within a home's zip code that was located within park was associated with higher home values. Wu et al. then found that higher housing prices were associated with greater development density. Higher density was associated with lower housing prices. Therefore, Wu et al. concluded that parks were a positive amenity to housing consumers but do not prefer higher development density to accompany the open space.

Shultz and King (2001) examined the relationship between open space and median house values among census block groups in Tucson, Arizona. They used a hedonic price model to test the relationship. Their research differs from the other research presented in this section because they did not use the price of individual housing units as the dependent variable. Rather, they used aggregate value data from the Census. They measured the distance from each block group's center to different types of open space, including large protected resource areas such as National parks; undeveloped, regional, and neighborhood parks; and public and private golf courses. They then used these distances as independent variables, along with the median number of rooms per housing unit, residential density, and the proportion of land that was industrial, commercial, and vacant.

Shultz and King found that different types of open space had different impacts on housing values. They found that a closer proximity to golf courses, large protected resource areas, and undeveloped parks were associated with higher values. They found that a closer proximity to neighborhood and regional parks was associated with lower values. There are two possible explanations for finding the negative relationship between local parks on home values. First, they may introduce negative externalities to nearby homes, such as noise and a greater likelihood of non-residents coming to the park. Second, the block group may be too big of an area to capture a local park's impact on nearby homes. A number of other studies reviewed in this section illustrate that the impact of parks diminishes as the distance between the park and a home increases.

Roe et al. (2004) used a conjoint analysis to determine the willingness of consumers to pay for the preservation of farmland, as well as their willingness to pay to live near a neighborhood park. A conjoint analysis is a survey in which respondents are asked to choose among a randomized combination of neighborhood and housing attributes that they would prefer if they were moving to a new house. Roe et al.'s respondents were given two hypothetical housing units from which to choose. The two units were each randomly assigned a combination of one of four types of neighborhood designs, one of two density levels, one of six surrounding land uses, one of a variety of commute times, one school quality level, one neighborhood safety level, average neighborhood income, and price. Table 3.5 presents the attributes that were randomly assigned to each potential house.

Table 3-5. Roe et al.'s Housing Attributes and Levels for Conjoint Analysis

Attribute	Level of Attribute
Neighborhood Design	Cul de sac – no neighborhood park Cul de sac – with neighborhood park Grid – no neighborhood park Grid – with neighborhood park
Housing Density	Less dense More dense
Surrounding Land Use	None of the land within 1 mile in agricultural use ½ of the land within 1 mile in agricultural use Most of the land within 1 mile in agricultural use None of the land within 1 mile is permanent cropland ½ of the land within 1 mile is permanent cropland Most of the land within 1 mile is permanent cropland **Note: Agricultural use is land that can become developed in the future. Permanent cropland is land that is dedicated to be undeveloped in the future.
Commute Time	5 to 60 minutes by 5 minute intervals
School Quality	Fair, Average, Good, or Excellent
Neighborhood Safety	Somewhat unsafe, Somewhat safe, Safe, Very safe
Average Household Income in Neighborhood	$35,000 to $70,000 in $5,000 intervals
House Price	$129,000 to $219,000 in $1,000 intervals

Source: Roe, Irwin, and Morrow-Jones (2004, p. 60).

Roe et al. received 1,551 usable surveys from homeowners in Franklin County, Ohio. They used a utility model in which they measured the extent to which consumers were willing to pay more for a certain level of an attribute over another level of the same attribute. They found that respondents were willing to pay for shorter commutes, greater school quality, better safety, more surrounding agricultural land and permanent cropland, and a neighborhood park. These attributes increased the consumers' utility as measured by the extent to which consumers were willing to pay for them. Agricultural land was defined as land that could be developed in the future while permanent cropland was defined as land that was dedicated to being cropland and undeveloped in the future. They found that consumers' willingness to pay for surrounding permanent cropland diminished when there was also developable farmland surrounding the home. They concluded that consumers valued permanent open space, either in the form of permanently preserved cropland or neighborhood parks, to a greater extent when open space was in limited supply.

Table 3.6 summarizes the empirical literature regarding the relationship between open space and housing costs.

Table 3-6. Review of Relationship Between Open Space and Housing Prices

Author	Location	Unit of Analysis	Method	Measure of Open Space	Dependent Variable	Finding
Acharya & Lewis (2001)	New Haven County, CT	Property transactions (n=4,000)	Hedonic Pricing Model	% land that is open space within 1 mile and ¼ mile of house	Sale price	Positive relationship
Cheshire & Sheppard (1995)	Reading and Darlington	Asking price of available property (n=840)	Hedonic Pricing Model	Open space within a 1 square km of transaction	Asking price	Positive relationship
Correll et al. (1978)	Boulder, CO	Property transactions (n=85)	Regression	Number of feet from house to greenbelt	Sale price	Closer proximity was associated with higher prices. But mixed results if greenbelts were analyzed separately
Bolitzer & Netusil (2000)	Portland, OR	Property transactions (n=16,402)	Hedonic Pricing Model	Dummy variables for different types of open space within 1500 feet of house	Sale price	Positive relationship between public parks and golf courses and price of home; but not significant if distance is less than 100 feet
Geoghegan (2002)	Howard County, MD	Residential transactions (n=5,599)	Hedonic Pricing Models	% of land within 1600 meter buffer that is permanent open space and % that is developable open space	Sale price	Positive relationship between permanent open space and price. No relationship between developable open space and price.
Irwin (2002)	Anne Arundel, Howard, Calvert, and Charles counties, MD	Transactions of owner-occupied homes (n=55,799)	Ordinary Least Squares; Instrumental Variables	Proportion of land within 100, 200, 400, and 600 meters of home that is private croplands, private forests, privately owned permanently conserved (not developed) land, public land	Sale price	Positive relationship between forms of open space and house price, except for privately-owned forests.
Roe, Irwin, & Morrow-Jones (2004)	Franklin County, OH	Surveys of individual households (n=1,551)	Conjoint Analysis	Respondents were asked to choose their preferred home from two houses with randomly selected surrounding land use and neighborhood attributes	Willingness to pay for one combination of surrounding land use and neighborhood attributes over another combination	Consumers placed greater value on a greater supply of surrounding agricultural and permanent cropland, as well as neighborhood parks.
Shultz & King (2001)	Tucson, AZ	Census block groups (n=6,277)	Hedonic Pricing Model	Proximity to varying types of open space	Avg. of median value of owner occupied units and median value of capitalized rents for rentals	Mixed results depending on type of open space
Weicher & Zerbst (1973)	Columbus, OH	Property transactions	Ordinary Least Squares	Dummy variables indicating: a) if property was adjacent to and faces park; b) if property is adjacent and backs up to a park c) if property was adjacent to park and facing recreational facilities	Sale price	Positive relationship between price and being adjacent to and facing park
Wu, Adams, and Plantinga (2004)	Portland, OR (Multnomah County)	Residential transactions	Simultaneous Equations	Distance to parks, rivers, lakes, and wetlands	Sale price	Positive relationship

The review of this literature reveals a number of important details regarding this relationship. First, the distance between a home and open space is an important factor in the extent to which housing consumers value the space. Open space is more highly valued at short distances of approximately a block from a home. The research reviewed in this section shows that open space at a distance from 100 feet to 1600 meters was associated with higher housing values. The extent to which the space is valued declines as a home's distance from it increases. This finding has significant implications for research that aggregates the measure of individual home values to an average or median value for a neighborhood. There is the possibility that aggregation of values to the neighborhood level does not adequately capture the impact of open space as the impact may be insignificant throughout the entire neighborhood, but significant in a block or two within the neighborhood. However, in their analysis of block groups in Tucson, Arizona, Shultz and King (2001) determined that the impact of open space could be captured at the block group level.

The second significant detail from the literature is that the type of open space is significant regarding the relationship between the open space and housing values. Permanent open space was found to have a stronger positive impact on housing prices than open space that could be developed in the future. Golf courses were also found to be associated with higher values of nearby homes. Both permanently preserved open space and golf courses were considered a positive amenity among consumers.

Interestingly, the research presents mixed results concerning the relationship between public parks and housing values. On one hand, neighborhood parks provide a positive amenity to neighborhood residents as illustrated by the association between the presence of a neighborhood park and higher home values. On the other hand, the positive benefits are sometimes balanced out by the negative aspects brought by a park to its neighbors. These negative amenities are an increase in noise during public events, as a well as the presence of a greater number of strangers attracted by the park. There is evidence that housing consumers take into account both the positive and negative aspects of a neighborhood park when deciding on the price they are willing to pay for a home. The research found that neighborhood parks are associated with higher values of nearby homes, but with some exceptions. Homes too close to a park or adjacent to an area of the park which attracts a sizable number of people had either lower values than other homes or the relationship between the park and the home's value was statistically insignificant.

The third significant point drawn from the available research is that the marginal benefits of open space decline as the supply of it increases. Consumers are likely to pay a higher price for proximity to a neighborhood park or other types of open space when undeveloped land is scarce in the area than when undeveloped land is abundant. A limited supply of open space increases its value. Therefore, the impact of neighborhood parks on housing costs is partially dependent on the amount of other types of open space accessible to residents.

This third point is pertinent to this research as a region with a successful urban containment policy will have a greater amount of permanently preserved open space than a region with no urban containment policy. On one hand, preserving the amount of undeveloped land on the outskirts of a region may make neighborhood parks less valuable as open space is more abundant in general. On the other hand, urban containment policies preserve land on the fringe of a region by steering new development to within specified urban boundaries. Neighborhood parks, which are a form of open space, within the boundaries will become more valuable as the supply of undeveloped land diminishes as a result of development.

The fourth significant point from the literature review of open space is that there is no research that explicitly tests the relationship between open space and the supply of affordable housing for low-income households. All of the reviewed research uses either median house values of a neighborhood or the individual sales price of recent real estate transactions as the dependent variable. The conclusions of the reviewed research apply to the average house, but does not address the possibility that open space may have different impacts on different types of housing or different segments of the housing market.

3.3 SUMMARY

This chapter reviewed the literature regarding the relationships between urban containment, the four smart growth principles, and housing costs. This chapter also reviewed the relationships between urban containment, the four smart growth principles, and the supply of affordable housing for low-income households. The four smart growth principles were greater density, a variety of housing options, mixed land use, and open space. While there are numerous studies examining the impact of these variables on housing costs in general, there is relatively little research into the impact of them on the supply of housing that is affordable for low-income households. There are a limited number of studies testing the relationship between density and low-income housing and no studies regarding urban containment, mixed land use, and public parks on affordable housing.

While smart growth proponents argue that greater density and mixed land use are likely to improve housing options for low-income households, the literature review does not provide conclusive evidence for these claims. Density has been shown to be associated with lower housing prices. It has also been shown to help relieve pressure on housing prices after growth control or urban containment policies are implemented. However, there is no evidence that greater density improves housing affordability or the supply of affordable housing specifically for low-income households. The opposite relationship has been found instead. Low-income households spend a greater proportion of their income on housing in areas that are denser. Also, housing at the lower end of the market appears to be more expensive in denser areas. The research does not, however, indicate causality between greater density and lower affordability for low-income households. Rather, a strong housing market may become more dense in response to developers building more units within the same space. Simultaneously, a strong housing market decreases the affordability of housing for low-income households.

With regard to mixed land use, there are no studies that directly examine its impact on housing for low-income households. Previous research found that consumers prefer neighborhoods that are predominantly single-family dwellings with only a limited presence of commercial land uses. One study found that commercial activities were associated with lower home values in instances where the commercial activities accounted for more than 5% of the neighborhood's total land use. These findings suggest that there may be less demand for housing in neighborhoods dominated by other uses than residential and, in turn, a greater supply of affordable units.

The literature also provides evidence that public parks within a limited distance are associated with greater home values, with a few exceptions. The exception to the positive relationship between a public park and a home's value is when the home is in close enough proximity to the park to capture the negative externalities, such as a greater number of people attracted to the park, created by it. While there are numerous studies indicating these relationships, there are no studies which examine the relationship between parks and housing that is affordable for low-income households.

The next chapter builds on the evidence found in the literature regarding the relationship among urban containment, the four smart growth principles, and housing costs. It develops a theoretical framework from which testable hypotheses are drawn concerning the impact that that these variables will have the supply of affordable housing.

4.0 THEORETICAL FRAMEWORK

The purpose of this dissertation is to test the relationship between each of four smart growth principles and the supply of affordable housing for low-income households. The four smart growth principles are higher density, a variety of housing options, mixed land use, and open space. An additional component of smart growth is urban containment, a policy intended to limit the outward growth of urban development. Therefore, this research compares the relationship between each of the four smart growth principles and affordable housing in areas that have implemented an urban containment policy with areas that have not. The specific questions addressed by this research are:

- What is the impact of neighborhood density, a variety of housing options, mixed land use, and public parks on the supply of affordable housing for extremely and very low-income households?

- Are these relationships different in metropolitan areas which have implemented a form of urban containment, such as urban growth boundaries or priority funding areas? If so, what are these differences?

This chapter presents the theoretical framework from which hypotheses are drawn to address the research questions. Modeling the impact of the smart growth principles and urban containment on affordable housing requires a theory which connects urban containment to the residential land market and, in turn, to the market for housing. The theoretical framework must then connect the smart growth principles of higher density, a variety of housing options, mixed land use, and open space to supply and demand in the housing market in areas both with and without urban containment policies. This chapter contains eight sections. The first seven sections present the theoretical framework. The last section provides a summary of the hypotheses drawn from the framework.

The first section presents the concept of dividing a general housing market into smaller submarkets, each consisting of housing units of similar characteristics. Units within each submarket are substitutes for one another as they share similar traits desired by consumers. For example, Rothenberg et al. (1991) divided housing markets into high-quality housing units, moderate-quality housing units, and low-quality housing units. Consumers searching for high-quality newer housing will choose their unit from those in the high-quality submarket as opposed to units in the low-quality submarket. While these submarkets are segmented from one another, they are closely connected as shifts in the supply or demand in one submarket will influence the price of housing in other submarkets.

The theoretical framework divides the general housing market into two submarkets. The first submarket is of housing units affordable to low-income households. These units are likely of lower quality than unaffordable units. The second submarket is of housing units unaffordable to low-income households. The quantity of low-quality affordable housing is influenced by what is happening in the unaffordable housing market.

The second section explains the impact of urban containment on prices in the residential land market. As illustrated in Chapter Three, urban containment policies restrict the supply of residential land and, as a result, prices in the residential land market increase. Price increases for residential land have an impact on the housing market.

The third section addresses the significance of higher residential land prices on the housing market and the supply of affordable housing. Land is a significant portion of the total costs of a housing unit. The cost of housing units will increase in the general housing market if there is no reduction in the amount of land consumed by each new housing unit.[47] This section then presents the theoretical impact of urban containment on the two submarkets, which consist of affordable and non-affordable units. Land use controls, such as urban containment, are shown to have a stronger impact on the lower-quality affordable submarket than on the unaffordable submarket (Malpezzi and Green 1996).

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[47] The literature review indicates that the impact of urban containment on housing prices may not be as strong as theoretically predicted. Unlike research testing urban containment's impact on land prices, research testing its impact on housing costs indicates other factors, particularly the strength of the economy, have a stronger influence on housing prices than urban containment.

The fourth section addresses the impact of greater residential density on affordable housing. There are two ways in which greater density may increase the supply of affordable housing. First, greater density increases the supply of housing on a given an area of land. This increase in supply lowers prices. It is assumed that a decrease in the cost of units will result in a greater supply of units affordable to low-income households.

The second reason for the positive relationship between density and affordable housing is that greater density is often achieved by increasing the supply of attached housing units and multi-unit structures. These types of housing are more likely to be found in the affordable housing submarket than in the non-affordable submarket. An increase in these types of units will increase the supply of affordable units.

On the other hand, demand for housing within urban containment boundaries will increase as the supply of housing is restricted outside of the boundaries. This increase in the demand for housing within urban boundaries may increase housing prices to an extent which greater density may not be able to completely off-set through the provision of more units on a given area of land.

The fifth section addresses the impact of a variety of housing options on affordable housing. In this research, a variety of housing options is interpreted as the presence of both small and large multi-unit structures. The relationship between a variety of housing options and the supply of affordable housing is similar to the relationship between density and affordable housing.

The sixth section presents the impact of mixed land use on the supply of affordable units. The literature review in the previous chapter indicated that housing consumers prefer neighborhoods dominated by residential land uses. Less demand for housing in mixed use neighborhoods will lower prices. A decrease in housing prices will allow more units to be affordable for low-income households. This relationship may be different in regions of urban containment. Higher housing prices resulting from urban containment may increase the desirability of mixed use neighborhoods among housing consumers as they search for housing more convenient to employment and other necessities of daily life, such as retail establishments. If demand for housing in mixed use neighborhoods increases, then mixed use will be less likely to be associated with affordable units.

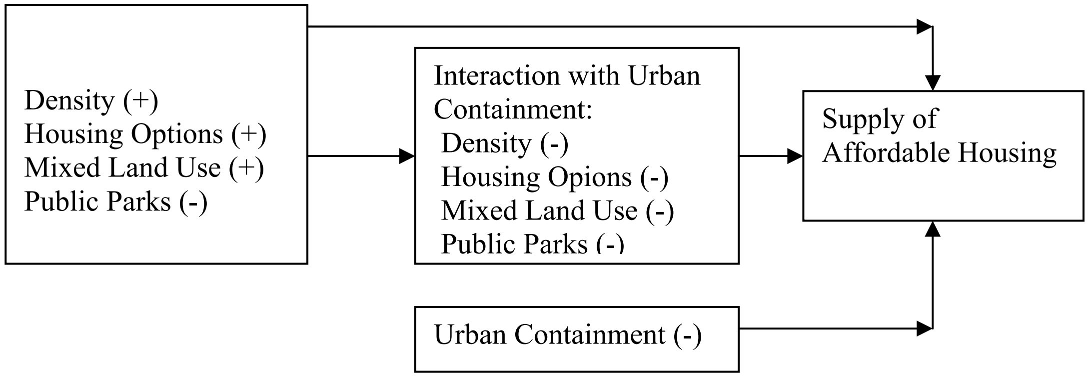
The seventh section addresses the impact of public parks, a specific type of open space, on the supply of affordable housing. Public parks will have an association with a smaller supply of affordable housing units in neighborhoods for two reasons. First, positive amenities provided by public parks will increase demand for housing within neighborhoods with a public park. This higher demand will increase house values.[48] An increase in values is assumed to reduce the supply of affordable units as fewer units would be priced at a level affordable to low-income households. Second, the positive amenities of a park may increase demand for unaffordable, higher-quality housing as higher-income households are willing to pay for living near a park. This demand increase in the unaffordable housing submarket will encourage landlords in the affordable housing submarket to upgrade the quality their units, making them unaffordable to low-income households.

The association between public parks and a smaller supply of affordable units may be stronger in regions of urban containment. Within urban containment boundaries, permanent open space, such as public parks, will become more valuable to residents as undeveloped land is consumed by development. The literature review showed that open space within developed areas is more highly valued when there is less of it. Therefore, in regions of urban containment, the association between public parks and a smaller supply of affordable units will be stronger as demand for housing near public parks will be stronger.

The eighth, and final, section of this chapter provides a summary of the hypotheses drawn from the theoretical framework. Figure 4.1 illustrates the expected relationships. The hypotheses are then tested in Chapter Seven, following the presentation of the research design.

[48] As will be discussed in this chapter, this prediction assumes that all other things, such as perceptions of safety and crime, remain constant. Some parks reduce the perception of a neighborhood's safety and may increase crime. In this case, a public park may have a negative association with housing prices.

Figure 4-1. Impact of Urban Containment and Four Smart Growth Principles on Affordable Housing



Note: Sign in parentheses is expected relationship to supply of affordable housing.

4.1 HOUSING SUBMARKETS

There are two ways to theoretically connect prices in the general housing market to the supply of affordable units for low-income households. The first, and simplest, connection is to assume that an increase in housing prices throughout the housing market will reduce the number of units that remain affordable to low-income households. Assuming incomes do not increase, some units previously affordable to low-income households will become unaffordable if there is a price increase in the general housing market.

The second connection between prices in the general housing market and the supply of affordable housing is through a general theory of housing submarkets. A metropolitan area's housing market is assumed to consist of separate submarkets which differ in quality and price (Grigsby 1963, Chapter 2; Sweeney 1974; Rothenberg et al. 1991, Chapter 3; Galster 1996). The housing units within each submarket are assumed to be substitutes for each other as consumers would not prefer one unit over another within the same submarket as each submarket consists of units of similar characteristics. Therefore, there is potentially a different market for high quality units than for moderate quality or low quality, less expensive units.[49] Affordable units for low-

[49] The discussion in this section focuses on quality differences among housing units to define submarkets. Grisby (1963) also focused on neighborhood based submarkets as neighborhoods typically consist of similar housing units

income households are most likely in the low-quality submarket. A shift in the supply or demand for housing in a higher quality submarket will impact prices, and supply, in the low-quality submarket. This section provides an overview of the relationship between housing submarkets.

Grigsby (1963) was one of the first scholars to divide a single housing market into smaller submarkets and explore the relationship between them. Grisby explained movements in the supply and demand in each submarket as partially a result of exogenous events occurring in other submarkets. For example, new construction of high quality units for higher income households would increase the supply of high quality units. This increase in supply would lower prices in the high quality housing submarket and, in turn, reduce demand for moderate and lower quality units as households move from the moderate quality submarket to the high quality submarket. In turn, prices would decline in the moderate quality and low quality market. On the other hand, a decrease in new construction in the higher quality submarket could have the opposite effect and increase demand in the lower quality submarkets, and therefore increase prices of lower quality units.[50]

Rothenberg et al. (1991, Chapter 8) presented three hypothetical submarkets to theorize the way in which submarkets are interdependent and related to each other. Their three submarkets were of high quality, medium quality, and low quality units. Using these three submarkets, they hypothesized the impact of multiple scenarios on each submarket. These scenarios are useful for this chapter's later sections which present the theoretical impact of urban containment and the four smart growth principles on the supply of affordable housing. Their scenarios included an upgrading scenario in which owners of moderate and low quality housing upgrade their units in response to an exogenous factor which increases demand for high quality

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in terms of type of structure and age. Housing submarkets have also been defined by neighborhoods and school districts as potential residents may place a higher value on a home in a 'desirable' location as compared to a similar home in a 'undesirable' location (Goodman 1981; Goodman and Thibodeau 1998; Bourassa, Hoesli, and Peng 2003); by type of structure as the market for single-family homes may be different from multi-family structures or the market for units with many rooms may be different from the market for units with fewer rooms (Schnare and Struyk 1976; Adair, Berry, and McGreal 1996; Larsen and Sommervoll 2004); or by socio-economic factors, such as race, as housing in minority neighborhoods may be in a different market from housing in white neighborhoods due to discrimination and racial preferences (King and Mieszkowski 1973).

[50] Sweeney (1974), Braid (1981), and Schall (1981) are credited with providing a comprehensive theoretical discussion of the relationship between housing submarkets. Sweeney applies his theory to urban renewal programs which replace low-quality housing with new high quality housing. He argues that prices will decline in higher quality submarkets because of the increase in supply, but will increase in low-quality submarkets as low-quality units are replaced by renewal.

housing. Another scenario was an increasing supply scenario in which new construction increased the supply in the high quality submarket.

Rather than use three hypothetical submarkets, the following discussion will only divide the general housing market into two submarkets, the market for units affordable to low-income households and the unaffordable submarket. Table 4.1 summarizes two scenarios based on Rothenberg et al's hypothetical scenarios. The table presents an initial exogenous event which shifts either the supply or demand in the housing market. It then provides the resulting shifts in supply and demand in the submarkets. In the table, the following symbols are used:

U – Unaffordable submarket

A – Affordable submarket

A significant assumption in this discussion is that the affordable submarket consists predominantly of lower quality units than units in the unaffordable submarket.

Table 4-1. Two Scenarios of Submarkets

Exogenous Shift	**1st Submarket Shift**	**2nd Submarket Shift**
Increasing Demand for unaffordable units as a result of higher incomes	Demand increases in *U*, which increases prices in *U*	Supply decreases in *A*, because landlords will get higher returns by upgrading unit in submarket *A* to be in submarket *U*
Increasing Supply of high-quality units as a result of new construction	Supply increases in *U*, which decreases prices in *U*	Demand for low-quality units will decline as more households are able to afford high quality units. Prices may decline in *A*.

Source: Rothenberg et al (1991, pp. 221-246).

In the first scenario, demand for higher-quality, unaffordable units could shift upward as a result of higher household incomes or an increase in the population that would demand higher-quality housing. An increase in demand results in higher prices in the unaffordable submarket. Higher prices in the unaffordable market, in comparison to the lower-quality affordable submarket, will result in an increase in supply in the unaffordable submarket in two ways. First, new construction will occur in the unaffordable submarket to meet the greater demand. Second, higher prices in the unaffordable market will encourage landlords of affordable units to upgrade the quality of their units. Upgrading of these low-quality units in submarket *A* will reduce the supply of affordable units to low-income households.

In a second scenario, there is an increase in the supply of higher quality units due to new construction. An assumption for this scenario is that the shift in supply is the result of exogenous factors, such as a change in technology or input costs, which increases the supply of higher quality units. The supply increase is assumed not to be a response to greater demand. As supply increases in the unaffordable submarket, prices decline which allows more households to be able to affordable higher-quality units. Therefore, demand for low quality units declines.

There are two potential outcomes in the affordable submarket as a result of greater supply in higher-quality, unaffordable units. First, the supply of affordable units may increase. Prices in the general housing market will decline as supply increases, resulting in more affordable units as some units in the unaffordable submarket would decline in price to an affordable level.

On the other hand, affordable units of the lowest quality may be abandoned and not remain in the market. Prices for the lowest quality units may decline below the point at which income from the unit covers the owner's cost of making the unit available. These units will be removed from the market as owners abandoned them, removing some of the supply of affordable units for low-income households. The potential abandonment of the lowest quality units indicates the final result of an increase in the supply of higher quality, unaffordable units may be ambiguous. If abandonment occurs at a large enough scale, the quality of units in the affordable submarket may improve but their supply would not increase.

These two scenarios provide an illustration of how submarkets may be used to develop a theory of the impact of an exogenous event on the supply of affordable housing for low-income households. The previous examples were relatively simplistic as the general housing market was divided into only two submarkets. These two submarkets were affordable units and unaffordable units. However, there are potentially numerous submarkets within a general housing submarket (Rothenberg et al. 1991, p. 360).

These two submarkets will be used as a tool to theorize about the impact of urban containment, as well as of the four smart growth principles, on the supply of affordable housing. The next section presents the theoretical impact of urban containment on residential land values, a significant input cost to the production of housing. Section 4.3 then extends the discussion to the theoretical impact of higher residential land values on the affordable and unaffordable submarkets of housing.

4.2 URBAN CONTAINMENT AND RESIDENTIAL LAND VALUES

Land value is one of the most influential factors determining the price and supply of housing. The price of a house consists of the cost of land on which the unit sits plus the structural costs of the unit itself. Therefore, the theoretical framework begins with a discussion of the impact of urban containment on the supply and value of developable land for housing. Because land provides for a variety of uses, such as residential, commercial, agricultural, and industrial to name a few, there are separate land markets for each type of use. While these markets are closely connected, the primary land market of interest to this discussion is that of developable, residential land.

Both supply and demand factors determine the price and quantity of land in the residential land market. This section first presents a general model of the residential land market which discusses these factors.[51] The supply of residential land (Q_{LH}^S) is influenced by the price of residential land (P_{LH}), the value of the land if it were used for non-residential purposes (O), such as commercial, industrial, or agricultural uses, topographical constraints (W), such as bodies of water, and growth management mandates (G). An increase in the price of residential land (P_{LH}), relative to other land uses, increases the supply of residential land as landowners will make more of their land available for residential use. Increases in the value of land for non-residential uses (O), relative to the value of residential land, decreases the supply of residential land as landowners will obtain higher prices by using the land for the other uses. Topographical constraints (W) decrease the supply, as do growth management mandates (G) intended to preserve land from development.

The demand for residential land (Q_{LH}^D) is a function of the cost of capital (K), the cost of housing construction (C), environmental amenities associated with the land (A_E), income (Y) and

[51] This model of the residential land market draws primarily from Potepan (1996), as well as from Black and Hoben (1985), Rose (1989), Shilling et al. (1991), and Engle et al. (1992).

the price of residential land (P_{LH}). Demand for residential land will decrease in response to increases in the costs of capital (K) and housing construction (C). Both capital and construction costs are significant inputs in the development of housing. As these costs increase, the quantity of new housing supplied will decline. Therefore, the demand for residential land on which housing would be developed will decline. Demand for residential land will increase with an increase in environmental amenities (A_E) associated with the location of the land. Increases in household income (Y) will also increase the demand for residential land. Greater income among consumers increases their ability to demand more residential land. An increase in the price of residential land (P_{LH}) will decrease the amount of residential land demanded by consumers.

Equations for both the supply and demand functions for residential land can be written as:

Supply: $Q_{Lh}{}^{s} = f\,(P_{LH}, O, W, G)$ (4.1)

Demand: $Q_{Lh}{}^{d} = f\,(K, C, A_E, Y, P_{LH})$ (4.2)

Where: $Q_{Lh}{}^{s}$ is the quantity of residential land supplied; $Q_{Lh}{}^{d}$ is the quantity of residential land demanded; O is the value of land for non-residential use; W is topographical constraints, such as bodies of water and mountains; G is government mandates, such as development restrictions; K is the cost of capital; C is construction costs; A_E is environmental amenities associated with the land; Y is income; and P_{LH} is the price of residential land.

In models of supply and demand, the relationship between quantity and price is endogenous. A change in the price of a good will lead to a change in the quantity supplied, as well as in the quantity demanded. If the price of a good increases, suppliers will produce a greater supply because they can obtain higher prices for it which will lead to greater profits. Consumers, on the other hand, will decrease their demand of the good when its price increases. Meanwhile, a change in either the quantity supplied or demanded of a good will lead to a change in its price. If suppliers increase their production of a good, its price will decline as a greater quantity of the good is available in the market.[52] If consumers reduce their demand for a good, its price will decrease.

This relationship between the price of a good and the quantity supplied and demanded in the market can be applied to the market for residential land. An increase in the price of residential land relative to the price of land for other uses will increase the quantity of land which landowners are willing to make available for residential use. They increase the supply of residential land because they can obtain a higher price for it. For example, an owner of agricultural land has an incentive to provide his land for residential use when residential land is more valuable than agricultural land (Brueckner and Fansler 1983). On the other hand, as landowners increase the supply of residential land, the price of the it will decrease.

On the demand side, consumers demand less residential land as it becomes more expensive. At the same time, as consumers demand a smaller quantity of residential land, the price of land declines.

This theoretical discussion assumes that the market for residential land is in equilibrium. Equilibrium occurs when the quantity supplied is equal to the quantity demanded. Equilibrium in the residential land market can be represented by:

$$Q_{LH}^{S} = Q_{LH}^{D} \tag{4.3}$$

When the market is not in equilibrium, consumers and suppliers of residential land will adjust the quantity that they demand and supply, respectively, to find a point of equilibrium. If the market's price of residential land is too low, the quantity of residential land demanded will be greater than the quantity supplied ($Q_{LH}^{D} > Q_{LH}^{S}$). In this case, there is a shortage of residential land and consumers will bid up its price. In response, landowners will provide a greater supply of residential land as the price of land increases. As the price increases, consumers will decrease their quantity demanded. The quantity supplied will increase while the quantity demanded will decrease until demand equals supply at an equilibrium price. When the quantity of residential land demanded is less than the quantity supplied ($Q_{LH}^{D} < Q_{LH}^{S}$), there is a surplus of residential land. In this case, landowners have supplied too much residential land at too high of a price. The

[52] In a competitive market, suppliers will increase their production only to the quantity level at which the marginal revenue gained from one additional unit of the good is equal to the marginal cost, which is the cost of producing that one additional unit.

price of residential land will decline and landowners will decrease the quantity supplied. As the price declines, consumers will increase the quantity demanded. The quantity supplied will increase and the quantity demanded will decrease until the market is in equilibrium.[53]

Because the price of residential land (P_{LH}) is found in both the equation for the quantity supplied and the quantity demanded, a reduced form function for P_{LH} can be solved when the market is in equilibrium. P_{LH} becomes a function of the variables which influence supply in equation 4.1 and of the variables which influence demand in equation 4.2. This equation can be written as:

$$P_{LH} = f\,(O, W, G, K, C, Y, A_E) \tag{4.4}$$

Equation 4.4 illustrates that a change in the value of any of the supply and demand variables found in equations (4.1) and (4.2) has an impact on the price of residential land.[54]

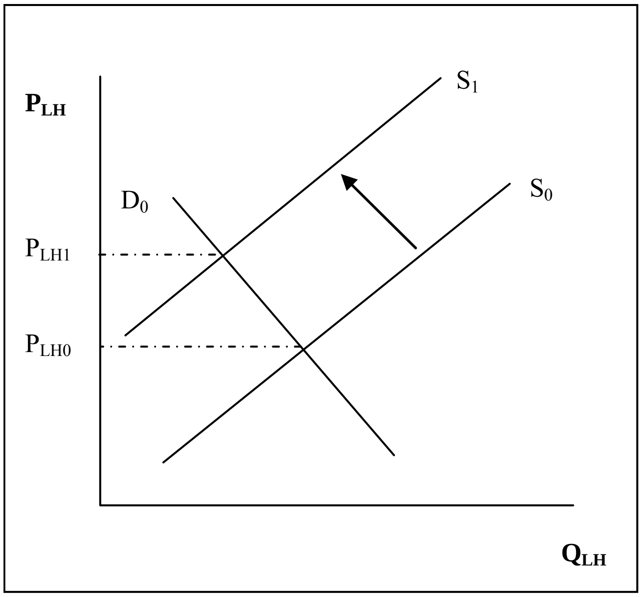
Urban containment policies, a form of government mandate (G) for growth management, limit the supply of developable residential land by introducing restrictions which remove land outside of specified boundaries from the residential land market. Development on land outside the boundaries is either prohibited or is discouraged by the unavailability of public infrastructure. As illustrated in Figure 4.2, urban containment should cause a shift (decrease) in the supply of developable, residential land from S_0 to S_1. The shift in supply will increase the cost of residential land from P_{LH0} to P_{LH1}.

It is theorized that a secondary effect of urban containment policies is an increase in the demand for residential land as a result of amenities created by urban containment (Ellson and McDermott 1987; Shilling, Sirmans, and Guidry 1991; Engle, Navarro, and Carson 1992). The amenity which urban containment may produce is increased certainty of the development approval process. Landowners and developers determine the probability of receiving approval for a planned development when deciding on current and future investments. Urban containment policies create a clear delineation between land which will be developed in the near future from land on which development will be restricted. This delineation provides developers with better information on where future development will be allowed, making them more certain of the land

[53] This is a textbook explanation of market equilibrium. See, for example, Riddell, Shackelford, and Stamos (1990, pp. 153-155) or O'Sullivan (2003, pp. 561-563).
[54] The reduced form is equation is $P_{LH} = \prod_0 + \prod_1 O + \prod_2 W + \prod_3 G + \prod_4 K + \prod_5 C + \prod_6 Y + \prod_7 A_E$ where $\prod$ are the reduced form coefficients. See Gujarati (1995, pp. 653-664) or Pindyck and Rubinfeld (1998, pp. 338-340).

on which residential development will be approved. Greater certainty of the approval process will increase the demand for land among developers (Ellson and McDermott 1987).

Figure 4-2. Supply and Demand of Residential Land with Implementation of Urban Containment

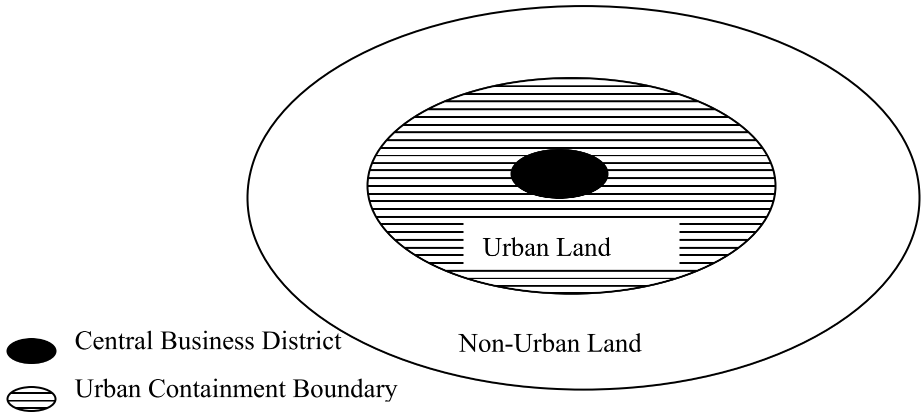


Shilling et al. (1991) used a two-stage least squares estimation of the supply and demand of residential land to test this theory. Their data consisted of residential land values of new single-family homes eligible for FHA-insurance and the total amount of residential land developed for FHA-insured new single-family homes from 1974 to 1976 in 37 states. Their level of analysis was the state. They found that state-level comprehensive land use planning requirements were associated with a greater quantity demanded of residential land for new homes.

4.2.1 Urban Containment and Segmented Residential Land Markets

Another aspect of urban containment policies discussed in the literature review in Chapter Three is that urban containment divides the residential land market into two different segments, the residential land market within the urban containment boundary and the market outside of the boundary. As shown in Figure 4.3, land outside of the urban boundary is referred to as 'non-urban.' Land inside an urban boundary is referred to as 'urban.'

Figure 4-3. Illustration of Segmented Residential Land Market



The implementation of an urban containment policy prevents undeveloped non-urban land, outside of the urban boundary, from becoming residential in the future. Therefore, the supply of residential land in the non-urban area is limited to the supply that already exists. Figure 4.4 provides a graph of supply and demand in the non-urban residential land market (L_{HNU}). Without urban containment, the supply of residential land is represented by S_0. The supply is elastic as it can adjust to changes in price. With the implementation of urban containment, the supply of residential land becomes inelastic. It does not adjust to changes in price because land cannot be developed for residential purposes outside of the urban boundary. Land that is already developed for residential use will likely maintain its current use. Figure 4.4 illustrates the change from an elastic supply to an inelastic supply of residential land by the change in the supply curve from S_0 to S_1. The quantity, as well as the price, of non-urban residential land will not change if all other factors, such as economic and population growth, remain constant.[55]

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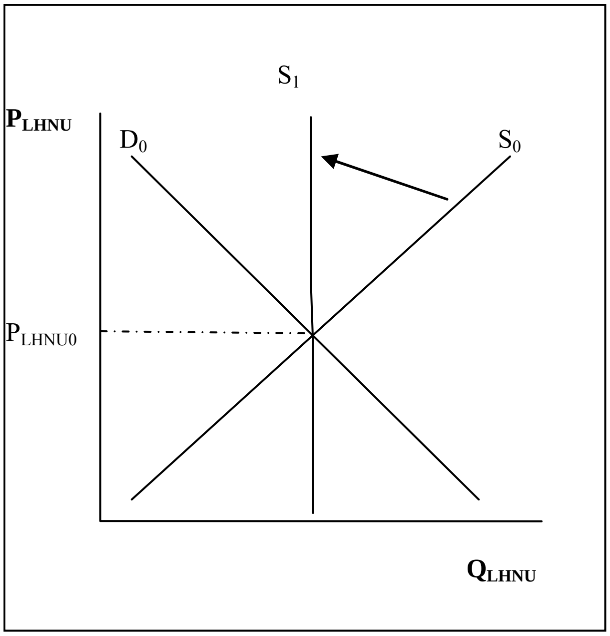
[55] This discussion focuses on the quantity and price of *residential* land, which is land that is currently used (or planned to be used) for residential purposes. The implementation of an urban containment policy will *decrease* the price of *undeveloped* land outside of the urban boundary. Undeveloped land outside of an urban boundary can no longer be developed in the future without a modification to the boundary. This makes undeveloped land outside of the urban boundary less desirable and less valuable than it was before the boundary was established and less valuable than land within the urban boundary (Nelson 1985, 1986; Knaap and Nelson 1992, pp. 42-44).

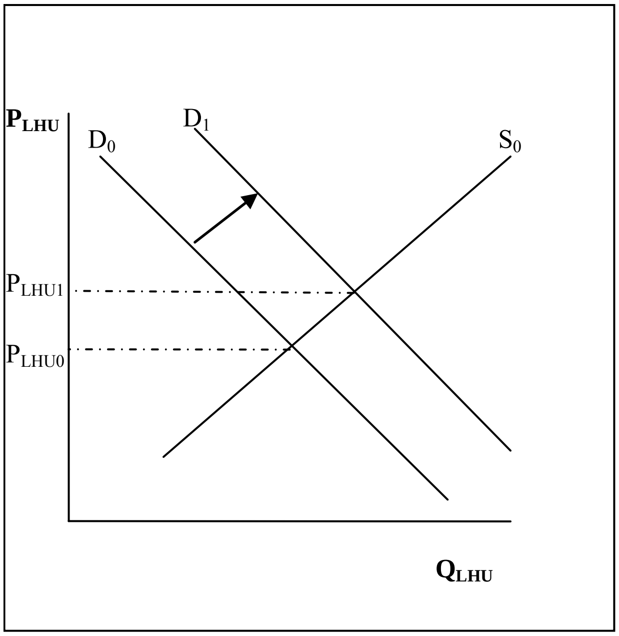
Figure 4-4. Supply and Demand of Non-Urban Residential Land Outside of Urban Boundary



The implementation of an urban containment policy will increase demand for urban residential land, which is located within the urban boundary. Demand will increase because consumers who would otherwise pursue residential land in a location outside of the urban boundary must shift their pursuit of residential land to within the boundary once it is established. This shift in demand is illustrated by the shift from D_0 to D_1 in Figure 4.5. The price of urban residential land will increase from P_{LHU0} to P_{LHU1}.

The discussion regarding the impact of urban containment on residential land values, graphically represented in Figures 4.4 and 4.5, makes two significant assumptions. The first assumption is that the urban containment policy is successful in preventing development outside of urban boundaries established by the policy. If development continues outside of the boundaries, there will likely be little impact on land prices as the policy is not adequately restricting land uses and affecting the supply of residential land (Nelson 1986). Exceptionally large minimum lot sizes, and other zoning restrictions, are typically used to prevent residential development outside of urban boundaries from occurring (Nelson and Dawkins 2004, pp. 9-10). Minimum lot requirements can used to prevent large-scale residential development. Farquhar (1999, p. 9) reports that these minimum lot requirements outside of urban boundaries range from 10 to 230 acres per unit. In Britain, residential development on land within protected greenbelt areas is prevented by restrictions on construction and building improvements. Buildings can only be constructed for agricultural uses (Evans 1991).

Figure 4-5. Supply and Demand of Urban Residential Land Inside of Urban Boundary



The second assumption is that total demand for residential land in the region is flat, or declining. This assumes that there is flat, or declining, population and economic growth. The increase in demand in Figure 4.5 comes from the displaced demand that would, without urban containment, otherwise occur for residential land located outside of the urban boundary. With an increase in overall demand, either through an increase in the region's population or income, there would a larger increase in demand in the urban residential land market. There would also be an increase in the demand for non-urban residential land, which would be illustrated by an upward shift in the demand curve in Figure 4.4.

4.3 URBAN CONTAINMENT AND THE HOUSING MARKET

This section expands the discussion of urban containment from its impact on residential land values to its impact on housing costs and the supply of affordable housing for low-income households. This section first explains the impact of higher residential land costs, the result of urban containment, on the general housing market. The section then explains the increase in demand for housing within urban containment boundaries as consumers who would otherwise buy housing outside of the urban boundaries must shift their demand to housing located inside the boundaries. Finally, the section presents the theoretical impact of urban containment on the supply of affordable housing, delineating the general housing market into affordable and unaffordable submarkets to do so.

This section first provides a general model of supply and demand in a housing market in order to understand the impact of residential land values on the housing market.[56] The supply of housing (Q_H^S) is a function of the cost of materials (C), labor costs (L), the cost of capital (K), government regulations (R), and housing prices (P_H). Producers of housing will decrease their supply of new units when input costs increase. These input costs include construction materials (C), Labor (L), capital (K) and additional expenses associated with government regulations (R). When input costs decline, producers will increase the supply of housing. When the price of housing (P_H) increases, more housing is supplied as producers can obtain greater revenue per unit of housing. When the price of housing (P_H) declines, producers will supply less housing.

Demand for housing (Q_H^D) is a function of the market's demographics (D), income (Y), amenities of the units (A_U), as well as amenities of the surrounding environment (A_E), and housing prices (P_H). Greater household income (Y) will increase the demand for housing. Positive amenities provided by housing units (A_U), as well as by the surrounding environment (A_E), will also increase demand as consumers prefer the positive amenities. Higher prices in the housing market decrease the quantity demanded by consumers. Likewise, lower prices increase the quantity demanded.

Based on the factors which influence supply and demand in the housing market, the functions for each can be written as:

Housing Supply: $Q_H^s = f(C, L, K, R, P_H)$ (4.5)

Housing Demand: $Q_H^d = f(D, Y, A_U, A_E, P_H)$ (4.6)

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[56] The housing literature includes a large number of articles presenting models of supply and demand to explain price differentials among markets. The model presented here is a general model drawn from Ozanne and Thibodeau (1983), Segal and Srinivasan (1985), Malpezzi (1996), Potepan (1996), Jud and Winkler (2002), and Wassmer and Baass (2006).

Where: Q_H^S is the quantity of housing supply; Q_H^D is the quantity of housing demand; C is cost of materials; L is labor costs; R is government regulation; P_H is the price of housing; D is demographics; Y is income; A_U is amenities of the housing units; and A_E is amenities of the surrounding environment.

The price of a housing unit (P_H) is a combination of the cost of the land on which the unit sits and the cost of the structure itself (DiPasquale and Wheaton 1996, Chapter 3). The price of residential land, therefore, is a significant factor in the total cost of housing. The price of housing (P_H) can be written as:

$$P_H = P_S + P_{LH} \qquad (4.7)$$

Where P_S is the price of the structure and P_{LH} is the price of the residential land on which the structure is located. An increase in either P_S or P_{LH} will increase the total price of a housing unit.

Additionally, the cost of a housing unit's structure (P_S) is a combination of input costs for the development of the unit. These input costs include construction materials, labor, and regulation in the form of building codes which require a minimum level of quality. The structural cost of a unit can be written as a function of these input costs:

$$P_S = f\,(C, L, R) \qquad (4.8)$$

If the input costs of construction materials or labor increase, the price of the structure increases. Similarly, an increase in regulation requiring additional inputs to a structure will increase the price of the structure.

An assumption is made that the housing market is in equilibrium where the quantity demanded equals the quantity supplied. If the market were not in equilibrium, both the quantity supplied and quantity demanded would slowly adjust to reach equilibrium. The explanation for these adjustments is the same as that given for equilibrium being assumed in the previous section for the residential land market. If there is a shortage in the housing market, where demand is greater than supply, the excess demand results in an increase of prices. The price increase encourages housing producers to increase the quantity of housing supplied while the higher prices encourage consumers to reduce their quantity demanded. Eventually, the market reaches equilibrium. If there is a surplus in the housing market, where supply is greater than demand, the opposite changes will occur. Prices fall as producers have produced too much housing. As prices fall, consumers increase the quantity demanded and producers decrease the quantity supplied until the market is in equilibrium.

When the housing market is in equilibrium, the following equation can be written:

$$Q_H^S = Q_H^D \quad (4.9)$$

Because price is a factor in both the supply and demand equations, we can obtain a reduce-form function which solves for the price of housing. Therefore, the price of housing (P_H) can be written as:

$$P_H = f\ (C, L, K, R, D, Y, A_U, A_E, O, W, G, P_{LH}) \quad (4.10)$$

This equation illustrates that the price of housing is a function of variables which influence both the supply of and demand for housing. P_{LH} is included in equation 4.10 as it is a component of P_H. P_S is not explicitly included in equation 4.10 as it is a function of C, L, and R, as shown in equation 4.8.

The model represented by equation 4.10 allows us to theorize about the impact of urban containment on the price of housing. Urban containment is a government mandate (G) which was shown in Section 4.2, Figure 4.2, to restrict the supply of developable residential land, increasing its cost. Assuming all other things, such as the type of housing, are kept constant, the price increase for residential land will result in a decrease in the supply of housing units (Knaap and Nelson 1992, p. 72). Higher input costs reduce the quantity of housing produced by suppliers. Figure 4.6 illustrates this decline in housing supply with a shift in the supply curve from S_0 to S_1. The price of housing increases from P_{H0} to P_{H1}.

Theoretically, urban containment could also increase demand for housing by improving the amenities provided by the surrounding environment (A_E) (Knaap and Nelson 1992, pp. 72-74).[57] By preserving undeveloped land and creating more open space in an area, urban containment may improve the quality of life which is associated with the environment. People may prefer to live in places with better environmental amenities. Figure 4.6 illustrates this increase in the demand for housing with a shift in the demand curve from D_0 to D_1. The price of housing increases further from P_{H1} to P_{H2}.

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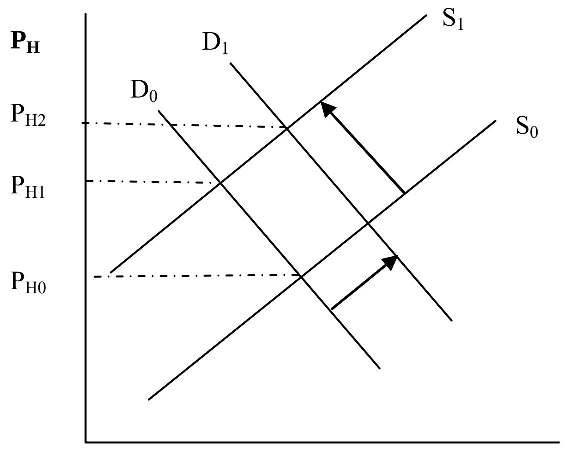
[57] Also see Fischel (1988) for a literature review of the impact of local land use controls on the supply and demand of housing.

Figure 4-6. Supply and Demand of Housing with Implementation of Urban Containment



Source: Knaap and Nelson (1992, p. 72)

The increase in housing prices as a result of urban containment presents potential implications for the supply of affordable housing. A general increase of prices in the housing market will likely decrease the supply of units which are affordable for low-income households. As prices increase, the price of some affordable housing units filters up to unaffordable levels. However, the literature review in Chapter Three showed that the only study specifically testing the link between urban containment and affordable rental units did not find a statistically significant relationship.[58] The relationship between urban containment and the supply of affordable housing will be further explored in Section 4.3.2.

4.3.1 Urban Containment and Segmented Housing Markets

Before discussing the relationship between urban containment and the supply of housing affordable for low-income households, this section explains urban containment's division of the housing market into the urban market located within the urban containment boundaries and the non-urban market located outside of the boundaries. In theory, supply in the non-urban housing

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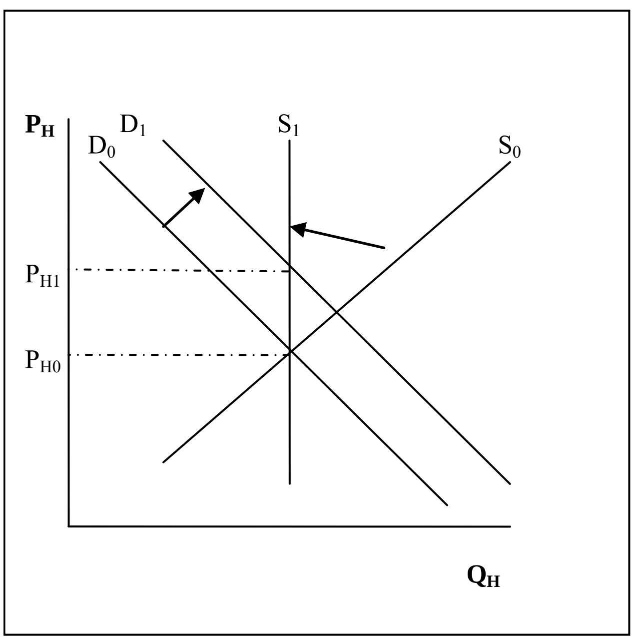
[58] See Pendall (2000).

market will become inelastic as development restrictions prohibit increases in the supply of housing regardless of price changes in the housing market. In reality, some new housing can be developed outside of urban boundaries, but in a limited quantity. [59]

Figure 4.7 illustrates the shift from an elastic supply to an inelastic supply of housing in the non-urban market. The supply curve shifts from S_0 to S_1. Demand for housing will increase in the non-urban housing market. Demand likely increases because of environmental amenities associated with the development restrictions. The literature reviewed in Chapter Three indicated housing consumers value permanent open space in the vicinity of their home (Geoghegan 2002; Irwin 2002; Roe, Irwin, and Morrow-Jones 2004). Residents of housing outside of the urban boundary are, theoretically, guaranteed that undeveloped land surrounding their home will not be developed. This increase in demand in the non-urban housing market is illustrated in Figure 4.7 by the shift in the demand curve from D_0 to D_1. Housing prices will increase in the non-urban housing market. However, the supply will not adjust to greater demand and higher prices, as shown by S_1, because of development restrictions in the non-urban market.

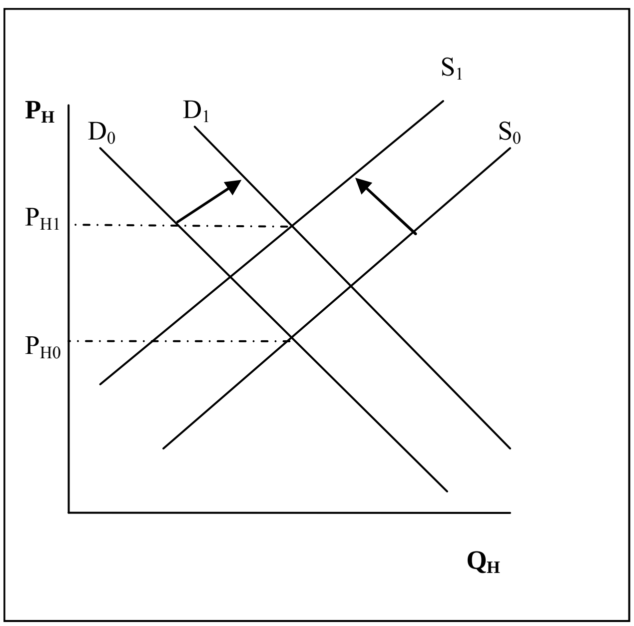
Figure 4-7. Supply and Demand in Non-Urban Housing Market



[59] The supply of housing outside of urban boundaries is not perfectly inelastic. As mentioned previously, a typical policy of urban containment allows new residential development outside of urban boundaries but requires excessively large minimum lot sizes. These large lot requirements, in theory, make the number of new housing units negligible in comparison to new housing within the urban boundaries.

In the urban housing market, a decrease in the supply of housing will occur as a result of higher residential land prices. This shift is illustrated in Figure 4.8 with the supply curve shifting from S_0 to S_1. Demand will shift upward in the urban housing market for two reasons. First, housing consumers who would otherwise prefer housing outside of the urban boundary will have to shift their demand to housing located within the urban boundaries because the supply of housing outside of the urban boundaries is limited to the supply that already exists. Second, amenities attributed to urban containment will increase demand for housing. Within the urban boundaries, the amenities include less sprawl, shorter commute times, and preservation of open space throughout the region (Engle, Navarro, and Carson 1992; Richmond 1997). This increase in demand is illustrated in Figure 4.8 by the shift in the demand curve from D_0 to D_1.

Figure 4-8. Supply and Demand in Urban Housing Market



4.3.2 Urban Containment and Affordable Housing

The theoretical discussion to this point has addressed the impact of urban containment on residential land values and housing prices in the housing market. It has not dealt specifically with its impact on the supply of affordable units for low-income households. The previous sections illustrated that urban containment increases the cost of residential land which then increases the price of housing in the housing market. Assuming household incomes do not increase along with housing prices, the price of some affordable units would filter up to an unaffordable level for low-income households. Therefore, an increase in prices in the general housing market decreases the supply of units affordable for low-income households.

To further consider the impact of urban containment on the supply of affordable housing units for low-income households, we will examine the urban housing market (housing within urban boundaries) and assume that it consists of two inter-related submarkets, one of affordable units for low-income households and one of non-affordable units, as discussed in Section 4.1. An exogenous supply (or demand) shock to the housing market will impact each of the submarkets in a slightly different manner. These exogenous shocks can be a variety of events, including changes in residential land values, constructions costs, government regulations, amenities, and household income. In the case of the implementation of an urban containment policy, the exogenous supply shock is an increase in residential land values.

As discussed in the previous section, restrictions on the supply of residential land will cause a decrease in the supply of housing. The decrease in housing supply will occur in both the affordable and non-affordable housing submarkets.[60] Figures 4.9 and 4.10 illustrate the change in supply within the non-affordable and affordable housing submarkets, respectively, with the shift in the supply curve from S_0 to S_1. This shift in supply will result in rising home prices throughout the market.

In addition to the shift in supply, this section previously presented the theory that urban containment would increase demand in the urban housing market. Demand would increase in both the non-affordable, as well as the affordable, submarkets for two reasons. First, improved amenities created by urban containment policies may increase the demand for housing (Knaap and Nelson 1992, p. 72). Second, the restriction on residential development outside of urban boundaries will increase housing demand in the urban market, both for non-affordable and

[60] It could be argued that greater residential land costs may have a greater initial impact on the supply of housing in the non-affordable housing submarket. Newly produced units are predominantly unaffordable to low-income households and it is the production of new units which would decline as a result of higher land values. Rothenberg et. al (1991), however, argue that increases in input costs impact the supply throughout the entire market. In addition, higher residential land costs would impact the development of subsidized units for low-income households.

affordable housing. This shift in demand throughout the urban housing market is illustrated by the shift from D_0 to D_1 in Figures 4.9 and 4.10.

Figure 4-9. Non-Affordable Housing Submarket

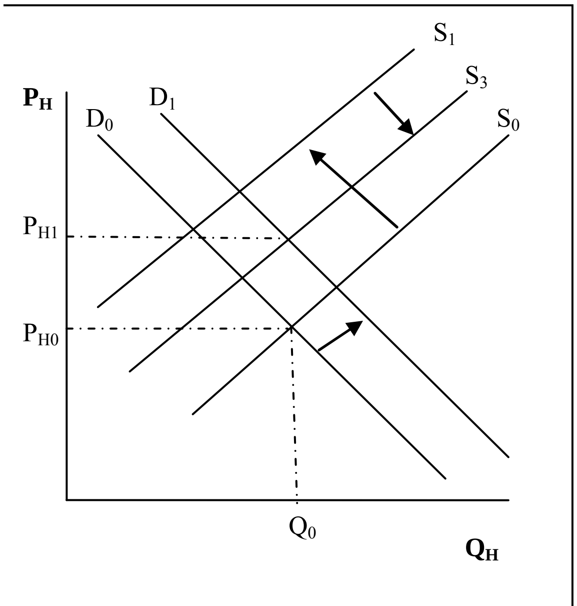
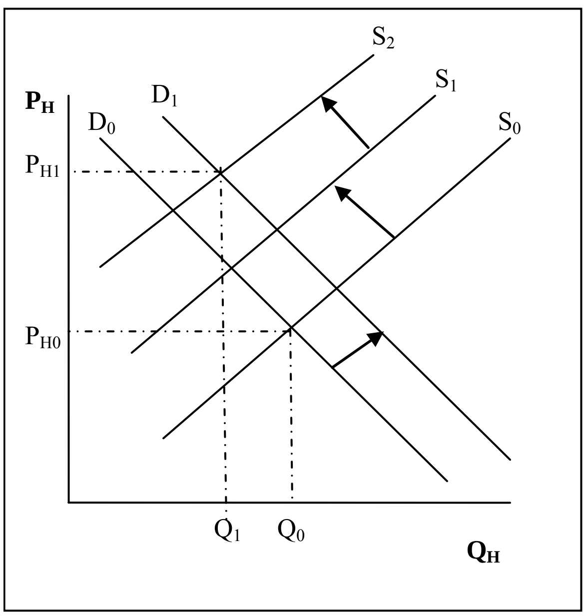


Figure 4-10. Affordable Housing Submarket



For this discussion, we will assume that the affordable housing submarket mostly consists of units that are of lower quality than housing in the non-affordable submarket. Typically, units priced at an affordable level for low-income households are of lower quality because there is a lack of economic incentive among owners of the affordable housing stock to maintain the units at a higher level of quality. Owners of the affordable housing stock will not increase the quality of their units, by increasing their expenditures on maintenance and renovations, without expecting to be able to increase their rents.

An exogenous factor introduced into the housing market, such as an urban containment policy, may provide an incentive for owners of low-quality affordable housing to upgrade their units in quality and price, making them no longer affordable for low-income households. If an increase in prices occurs in the housing market as a result of a reduction in supply or an increase in demand, some owners may improve the quality of their units given that the higher rents they can collect allow them the opportunity to upgrade their units. The upgraded units would be lost from the affordable housing submarket. The units would move from the affordable housing submarket to the non-affordable housing submarket. This additional decrease in the affordable housing supply is represented by the supply shift from S_1 to S_2 in Figure 4.10. Meanwhile, the upgrading of low-quality units would increase the supply of units in the higher quality non-affordable market, as illustrated by a shift from S_1 to S_3 in Figure 4.9.

In summary, figure 4.9 graphically illustrates the theoretical impact of urban containment on prices in the non-affordable housing submarket. The supply curve will initially shift from S_0 to S_1, representing a decrease in supply in response to higher residential land values. However, property owners will respond to higher housing prices by upgrading units in the affordable housing market which were initially of low quality. The movement of units from the affordable submarket to the non-affordable submarket will shift the supply curve of non-affordable units from S_1 to S_3 and partially off-set the loss caused by urban containment. Figure 4.9 shows that the price of housing in the non-affordable submarket will increase from P_{H0} to P_{H1} while the change in quantity is indeterminate.

Figure 4.10 represents the affordable, low-quality housing submarket. The supply curve will initially shift from S_0 to S_1 as a result of higher residential land values. A further decreasing shift in supply from S_1 to S_2 will occur as a result of property owners upgrading their units from the affordable submarket to the unaffordable submarket. Figure 4.10 shows that the quantity of housing in the affordable submarket will decrease from Q_0 to Q_1. Comparing figures 4.9 and 4.10, it is clear that, theoretically, urban containment will have greater consequences on the quantity and price of housing in the lower-quality submarket than on other segments of the housing market.[61]

The units lost from the low quality housing submarket to the non-affordable market are likely the affordable units which are of better quality prior to their upgrading. Owners of the low quality stock will first upgrade the units which require the smallest expense to improve their quality (Rothenberg et al. 1991). By upgrading units which require the minimal level of upgrading costs, owners will maximize their profits. The units requiring extensive rehabilitation in order to achieve higher quality are less likely to be upgraded. The implication of this behavior among property owners is that the units which remain of low-quality and affordable to low-income households are of the lowest quality units. Potentially, the quality of the low-quality submarket declines further.

Additionally, an increase in prices in the affordable submarket will make some of the low-quality units unaffordable to the lowest income households even if the units' quality remains unimproved. A price increase in the affordable submarket decreases the supply of low-income housing to some extent regardless of the quality upgrading of units, assuming the income of low-income households does not increase.

This section presented the theory that the supply of affordable housing is a function of exogenous factors influencing the affordable housing submarket, as well as of prices in the non-affordable submarket. The exogenous factor of interest was an urban containment policy resulting in an increase in residential land values. Similar scenarios are conceivable for changes to any of the explanatory factors of the supply and the demand for housing, including changes in household income, environmental amenities, household composition, construction costs, or government regulation. Therefore, the supply of affordable housing is a function of the variables presented in the discussion of supply and demand in the housing market in equation (4.10). The quantity of affordable housing units for low-income households can be written as:

$$Q_{afford} = f\,(C, L, K, R, D, Y, A_E, A_U, O, W, G, P_{LH}) \qquad (4.11)$$

Where: Q_{afford} is the quantity of affordable units

[61] Malpezzi and Green (1996) provided empirical evidence for this theory. Among metropolitan regions, they found that higher levels of land use restrictions were associated with higher prices in the lowest cost submarket relative to the region's other submarkets. In addition, vacancy rates were lower in the lowest cost/quality submarket in regions with more regulation, indicating a tighter market for the lowest priced submarkets.

4.4 URBAN CONTAINMENT, DENSITY, AND THE HOUSING MARKET

Up to this point in the theoretical discussion, there has been no consideration of the potential changes that may occur in the structural characteristics and type of housing available in the marketplace as a result of urban containment. If the type of housing throughout the market remains consistent, an increase in the cost of residential land increases the cost of housing and decreases the supply of units, particularly for low-income households. However, it is likely that the type of housing in the market and its structural characteristics will change with the implementation of urban containment and higher residential land values. The changes are likely to occur in two ways, both of which reduce the amount of land per unit of housing. First, housing units will become smaller and more multi-unit structures will become available. Second, the physical size of housing units may remain constant, but lot sizes will decline. Either of these changes will increase residential density, which is measured as the number of housing units, households, or residents located on a given area of land. This section explains the reason behind this change in density, as well as its impact on affordable housing.

There are two reasons why urban containment increases residential density. First, greater density is often required by legislative mandate accompanying urban containment policies. Greater density, which increases the amount of development per unit of land, helps to ensure that future growth can be accommodated on land located within the boundaries of urban containment (Nelson and Dawkins 2004, Chapter 6). This accommodation helps to prevent development from occurring outside of the boundaries.

Greater density is also legislated because it is a potential method of countering the negative consequences that urban containment has on housing prices (Knaap and Nelson 1992, pp. 77-80). This chapter previously explained the process through which urban containment increases residential land values which in turn decreases the supply of housing if the type of housing remains constant. This reduction in supply increases prices. By increasing density in urban areas, the supply of housing can be increased. This increase will partially off-set the decrease which occurs as a result of urban containment (Staley, Edgens, and Mildner 1999; Carruthers 2002; Nelson and Dawkins 2004).

State, regional, or county governments which include minimum density targets as part of their urban containment initiatives often do so by requiring local municipalities within their jurisdictions to take steps to increase density (Nelson and Dawkins 2004, Chapter 6). Local governments are encouraged to achieve greater density using a variety of techniques, including allowing smaller lot sizes, accessory apartments in existing homes, zero lot line development (which allows a home to sit along the boundary line of a lot, thereby not placing the home in the middle of yard), and multi-family housing (Atash 1990, p. 240; Smart Growth Network 2002).

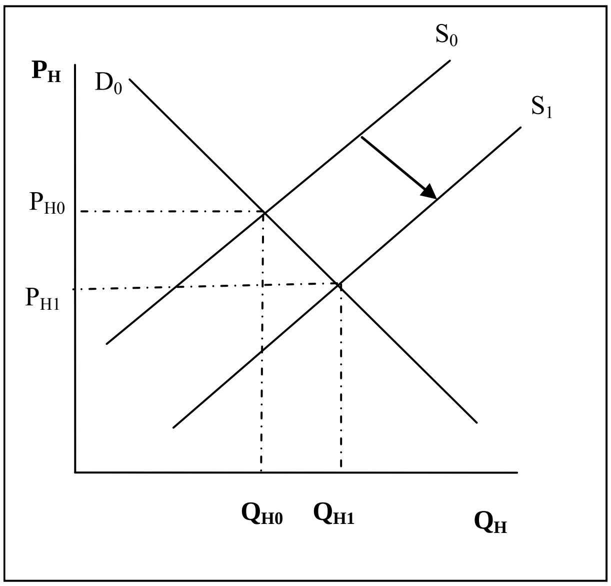
The second reason why residential density increases in response to urban containment is that developers will choose to use less land in relation to other housing inputs, such as materials and labor, in response to higher residential land values (Mills and Hamilton 1989, pp. 126-127; Knaap and Nelson 1992, pp. 73-74; DiPasquale and Wheaton 1996, pp. 79-81). A restriction on the supply of developable residential land increases residential land costs (P_{LH}) relative to the other inputs. To maximize their profits, developers will substitute for the more expensive land, other structural inputs (DiPasquale and Wheaton 1996, pp. 74-78). The substitution away from land results in developers using their land more intensely by building more units per area of land.

Because the cost of a home is equal to the price of the structure plus the price of the land, consumers may be willing to sacrifice the land around their house in response to higher residential land prices (Song and Knaap 2004). They will substitute for land either other structural amenities in their home or non-housing goods which are less expensive (Mills and Hamilton 1989, p. 127). Therefore, consumers demand less land per unit of housing while producers provide less land per unit of housing.

The increase in residential density can be realized in two ways with regard to the housing stock. First, consumers may be willing to sacrifice the size of their yard but maintain the same size home (Song and Knaap 2004). In this situation, residential density increases but the distribution of the sizes and type of homes in the market remain constant. Second, the number of multi-unit structures and townhomes may increase relative to the number of detached single-family homes. Multi-unit structures, such as condominiums and apartment buildings, by their very nature result in higher residential densities (Knaap and Nelson 1992, p. 73).

Greater residential density increases the number of available units in a housing market as there are more units built on any given area of land. In an unregulated environment with no land use restrictions, higher density will be associated with a greater supply of housing units, including affordable units for low-income households. In Figure 4.11, greater residential density shifts the supply curve from S_0 to S_1. As a result, a new equilibrium where the quantity of housing supplied equals the quantity demanded will be reached. The quantity of housing increases from Q_{H0} to Q_{H1} and the price of housing declines from P_{H0} to P_{H1}. A decrease in prices in the housing market will increase the quantity of affordable units for low-income households as some previously unaffordable units would become affordable.

Figure 4-11. Effect of Greater Residential Density on Supply and Demand in a General Housing Market



This explanation for the positive association between density and the supply of affordable housing assumes density is homogenous throughout a single housing market. However, there is not a uniform level of density throughout a single housing market. Within the same housing market some neighborhoods have a large number of units on a given area of land, consisting of small lot homes, multi-unit structures, townhomes, or a variety of each, while other neighborhoods predominantly consist of low-density large lot single-family homes. If consumers have a choice between a neighborhood of higher density or lower density, many economists argue that consumers will choose a lower density neighborhood as consumers prefer low-density single-family homes with yards (DiPasquale and Wheaton 1996, pp. 74; Shultz and King 2001; Song and Knaap 2003). Therefore, there will be less demand for housing in neighborhoods of greater density, lower housing prices, and a greater supply of affordable units.

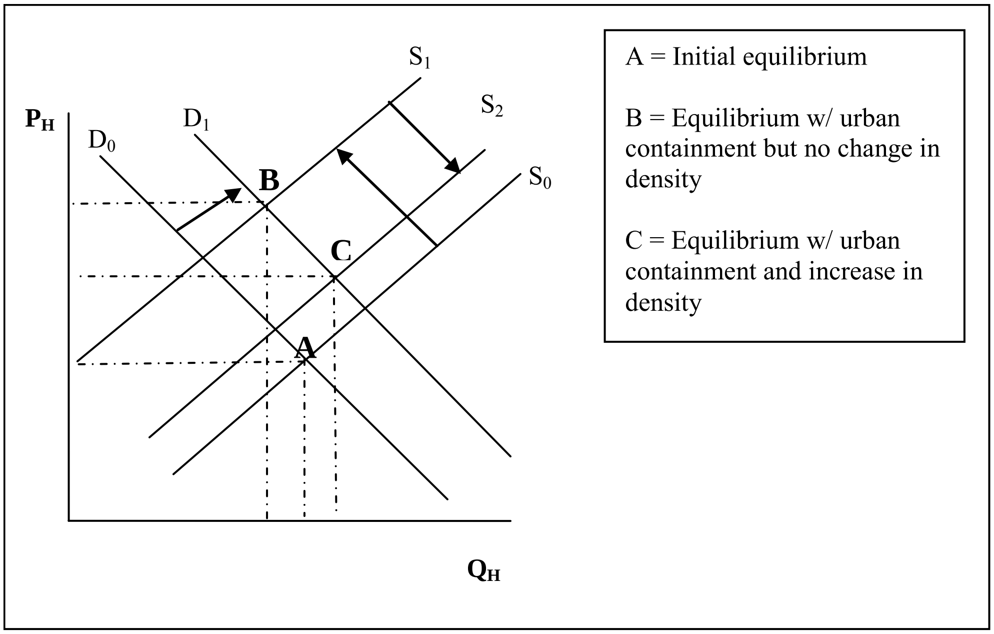
If we view the general housing market as two submarkets presented in Section 4.1, higher density housing may increase the supply of units in the affordable submarket. The types of housing that are higher density are often the most typical type of housing occupied by low-income households. Multi-unit structures, in particular, are more likely to be found in the affordable submarket than in the non-affordable submarket because they are smaller than single-family dwellings. Therefore, an increase in the supply of these types of high-density units is likely to increase the quantity of housing in the affordable submarket.

Density may have no impact on the price and supply of housing in a region with urban containment limiting the supply of residential land. This theoretical discussion focuses on the impact of density within the urban market, or the market for housing located within the urban boundaries of an urban containment policy. Theoretically, density cannot change in locations outside of the boundaries because of restrictions on development.

Figure 4.12 illustrates the shifts in supply and demand in the urban housing market as a result of both urban containment and increases in residential density. The initial equilibrium, where the quantity demanded for housing equals the quantity supplied prior to urban containment, is represented by point A. The beginning of section 4.3 discussed the impact of the implementation of an urban containment policy on the supply and demand for housing within the urban housing market. Keeping density constant, urban containment decreases the supply of housing because of higher residential land values. This decrease is represented in Figure 4.11 by the shift in the supply curve from S_0 to S_1. On the demand side, demand in the urban housing market increases as a result of urban containment (Knaap and Nelson 1992, p. 72). The increase in demand is illustrated in Figure 4.12 by the shift in the demand curve from D_0 to D_1.

The new equilibrium of supply and demand for housing in response to urban containment is represented by point B, keeping density constant. The shift in the equilibrium from point A to point B illustrates that housing prices rise in the urban housing market with the implementation of urban containment policies without a change in residential density. But, density is expected to increase in response to urban containment.

Figure 4-12. Supply and Demand in Urban Housing Market, with Implementation of Urban Containment and Change in Residential Density



The increase in density which is expected as a result of urban containment will partially off-set the decrease in the housing supply (Miller 1986; Staley, Edgens, and Mildner 1999). Greater residential density increases the number of housing units on a given area of land. Therefore, greater residential density shifts the supply curve from S_1 to S_2. In order for housing prices not to rise as a result of urban containment, density would have to increase enough to off-set the loss of housing units from the implementation of urban containment. Point C in Figure 4.12 represents a potential equilibrium point with an increase in the supply of housing as a result of greater residential density. Figure 4.12 illustrates that an increase in residential density will reduce the pressure on housing prices that urban containment may otherwise create.

With this theoretical framework in mind, two hypotheses are tested concerning the relationship among density and the supply of affordable housing in areas with and without urban containment policies.

Hypothesis 1: Greater housing density is associated with a greater supply of affordable units for low-income households.

On the supply side, greater housing density increases the supply of available housing units as there are more units built on any given area of land. An increase in supply lowers prices and increases the supply of affordable units for low-income households. On the demand side, consumers may prefer low-density. Therefore, demand for housing in higher density neighborhoods will be less than in low density neighborhoods.

Hypothesis 2: In regions with urban containment, the association between greater housing density and a greater supply of affordable units for low-income households is weaker than in regions without urban containment.

Higher density within regions of urban containment will not necessarily be associated with a greater supply of affordable units for low-income households for two reasons. First, there are two contradicting forces at work on the supply side of the housing market. This section pointed out that higher density may lower the cost of housing and, in turn, increase the quantity of affordable units through both the reduction in prices, as well as an increase in the supply of the types of housing units most typically found in the affordable housing submarket. However, urban containment policies increase the cost of residential land, a significant input cost for housing (Knaap 1985; Nelson 1985). This increase reduces the supply of housing and increases prices for all types of housing. It is unknown the extent to which higher density will off-set the higher housing prices caused by urban containment.

4.5 URBAN CONTAINMENT, VARIETY OF HOUSING OPTIONS, AND THE HOUSING MARKET

A variety of housing options is the presence of housing types which serve as alternatives to the single-family home, such as townhomes and multi-unit structures. For this research, a variety of housing options is defined solely as the presence of multi-unit structures. Two hypotheses will be tested concerning the relationship between multi-unit structures and the supply of affordable housing for low-income households.

Hypothesis 3: A greater supply of multi-unit structures, a measure of a variety of housing options, is associated with a greater supply of affordable units for low-income households.

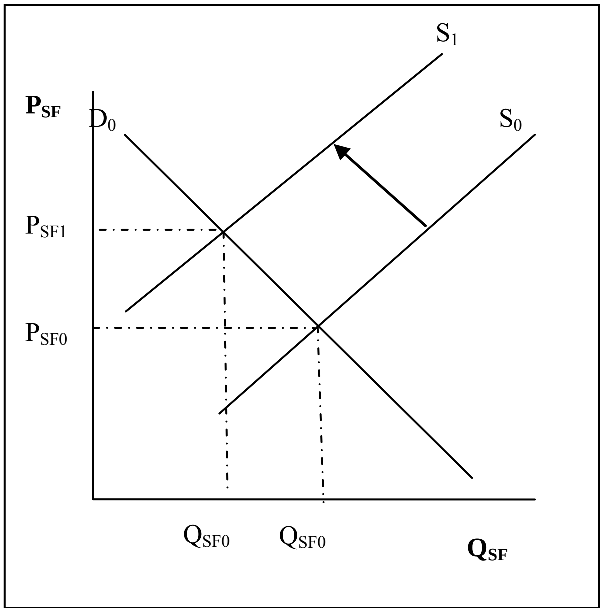
A greater variety of housing options within a neighborhood will increase the supply of affordable units for low-income households for two reasons. Both of the reasons are similar to those explaining the positive relationship between density and affordable housing. The first reason is that multi-unit structures increase the supply of housing units on a given area of land. This increase in supply lowers prices which should make more units affordable. The second reason for the positive relationship is that multi-unit structures are more likely to be in the affordable housing submarket than the non-affordable submarket. An increase in this type of housing will increase supply within the affordable housing submarket.

Hypothesis 4: In regions with urban containment, the association between multi-unit structures and a greater supply of affordable units for low-income households is weaker than in regions without urban containment.

Urban containment may weaken the positive relationship between multi-unit structures and affordable housing. If the housing market is divided into two types of housing, single-family housing and multi-unit structures, urban containment will cause a shift in the supply of both types. Multi-unit structures use land more intensely and efficiently in terms of the number of housing units on a given area of land than single-family homes. Because of higher land costs as a result of urban containment, the production of single-family dwellings may decrease while the production of multi-unit structures may increase to make more efficient and intensive use of land. Figure 4.13 shows the decline in the supply of single-family housing units from S_0 to S_1. The quantity of single family units declines from Q_{SF0} to Q_{SF1} and their price increases from P_{SF0} to P_{SF1}.

A price increase for single-family housing may push households to demand other types of housing as a substitute for single-family units. Figure 4.13 shows a decline in the quantity of single-family homes demanded along the demand curve (D_0) when the supply shifts from S_0 to S_1.

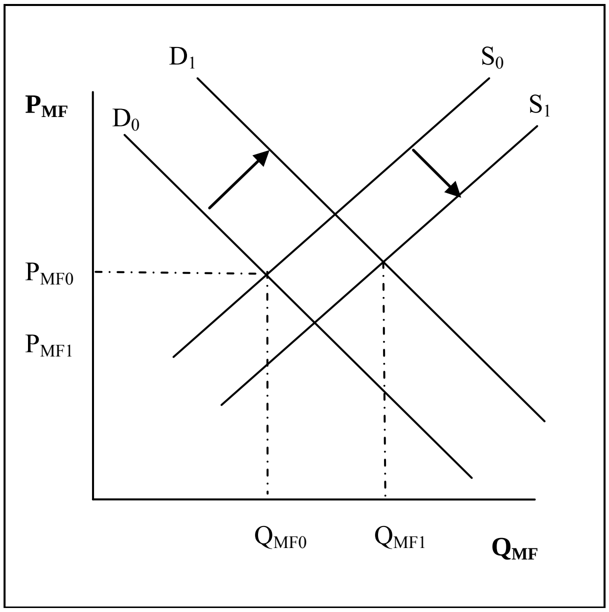
Figure 4-13. Supply and Demand of Single-Family Units



Assuming only two types of housing in the market, single-family units and multi-unit structures, demand for housing in multi-unit structures will increase as consumers will choose it as a substitute for single-family homes. Figure 4.14 shows this change in demand for housing in multi-unit structures with a shift from D_0 to D_1. At the same time, there will be a shift in the supply of housing in multi-unit structures because of higher land costs. This change in supply is illustrated by the shift from S_0 to S_1 in Figure 4.14. A shown in Figure 4.14, the supply of housing in multi-unit structures increases from Q_{MF0} to Q_{MF1}.

While an increase in housing in multi-unit structures is typically expected to increase the supply of affordable units, the positive association may not be as strong in this situation. Demand for housing in multi-unit structures is also increasing. Because of this shift in demand, two things will occur which limit the affordability of multi-unit housing for low-income households. First, households who would otherwise prefer single-family units shift their housing demand to the multi-unit market. Greater demand for housing in multi-units structures will increase the price of these units. Second, higher-income households who, in areas without urban containment, would prefer a single-family unit may demand higher quality amenities in their multi-unit housing as a substitute. These higher quality amenities could include more space, more advanced applicances, and higher quality building products. The inclusion of these amenities would make these units unaffordable for low-income households. For these reasons, the positive relationship between multi-unit structures and the supply of affordable housing will be weaker in areas of urban containment.

Figure 4-14. Supply and Demand of Housing in Multi-Unit Structures



4.6 URBAN CONTAINMENT, MIXED LAND USE, AND THE HOUSING MARKET

There is little theoretical or empirical literature regarding the impact of urban containment on mixed land use. Mixed land use is defined as the diversity of land uses, such as a mixture of commercial, residential, and industrial uses, within a specified geographic area. Among smart growth advocates, the principle of mixed land use is more narrowly defined. Their definition of mixed land use refers to a diversity of activities people typically undertake in daily life within a neighborhood. The activities include employment, retail, entertainment, and professional services that are easily accessible to residents, preferably by walking or public transit (Calthorpe and Fulton 2001, p. 55).[62]

There are two factors which may encourage mixed land use development in areas of urban containment. First, prices rise within the urban boundaries not only for residential land, but also for commercial and industrial land as well. Prices increase for developable land for all uses as development on land outside of the urban boundaries is restricted (Knaap 1985; Nelson 1985, 1986). As in the residential land market, higher commercial and industrial land costs in relation to other inputs of commercial activities, such as construction costs, entice developers to use a greater amount of investment capital in commercial and industrial structures per unit of land. They will substitute structural costs for land costs as the price of land increases.[63] Therefore, the density of commercial activities will increase as land costs increase. This more intense use of land may increase the mix of commercial activities within neighborhoods.

The second factor that will increase the mix of land uses within neighborhoods of urban containment is greater population density. As discussed in Section 4.4, urban containment policies are likely to increase density within urban boundaries. Greater population density provides an incentive for a greater number of stores and other commercial activities to locate in closer proximity to one another.[64] Stores can achieve the same level of revenue from a small geographic area of greater population density as from a larger geographic area of lower density. Assuming that the cost of constructing and operating commercial facilities remains constant, stores draw revenue from a smaller market area when population density is greater.

Mixed land use can only increase if zoning ordinances do not prohibit it. There is a long history, since the early 20th century, in the United States of exclusionary zoning policies which prohibit non-residential land uses from residential neighborhoods (Fischel 2004). Zoning is

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[62] Popular books advocating for smart growth and mixed use neighborhoods do not include industrial uses in the mix. For example, Calthorpe and Fulton (2001) argue that industrial sites and factories should not be part of residential communities, stating that "the low intensity of jobs in light industry and factory areas, the need for frequent truck access, and the scale of buildings do not lend themselves to mixed-use areas. Warehouse facilities and businesses that use toxic materials also need separation into special districts (p. 55)."

[63] See Mills and Hamilton (1989, pp. 97-98) regarding commodity producing firms' substitution of capital expenses (buildings, equipment, etc.) for land as land prices increase. A firm choosing between construction of two similar-sized buildings or one building tall enough to provide the same output as the two buildings will base its decision on the price of land. The firm will also base its decision on the fact that the capital costs of one tall building are likely higher than two smaller buildings. To the extent that savings on land costs exceed the additional capital expense of construction, firms will choose the taller, single building.

[64] For a full explanation, as well as an example, see O'Sullivan (2003, Chapt. 5).

typically adopted as a means to protect homeowners from adjacent land use activities which could lower the value of their property. Zoning typically excludes industrial activities, retail and other commercial activities, as well as multi-unit structures, from neighborhoods of single-family homes. Smart growth advocates claim that zoning must be reformed in order to facilitate mixed use development (Smart Growth Network 2002, p. 4-7; Langdon 2006).

The impact of mixed land use on the price of housing and the supply of affordable units for low-income households is dependent on a number of factors. Most important is the level of demand among housing consumers for mixed land use neighborhoods versus their demand for exclusively residential neighborhoods. The literature review revealed that consumers more highly value housing in neighborhoods with a minimal amount of commercial land use and a high proportion of single family homes than in neighborhoods of high land use diversity (Stull 1975; Song and Knaap 2003).[65] Therefore, we could hypothesize that greater mixed land use is associated with lower housing prices in an unregulated environment and a greater supply of affordable units.

Urban containment, however, may alter the relationship between mixed land use and housing. This chapter has explained that urban containment policies are expected to increase the diversity of land uses, as well as the density and types of housing, found in neighborhoods. Song and Knaap (2003) found that if consumers lived in neighborhoods not dominated by single-family homes, they preferred neighborhoods which had a more even distribution of land uses, including public, commercial, residential, multi-family, and industrial uses without one use dominating over the others. Therefore, consumers are likely in have a higher demand for mixed land use neighborhoods in areas of urban containment.

Another factor increasing the demand for mixed land use neighborhoods in areas of urban containment is the trade-off consumers will make between housing prices and convenience. As urban containment lowers the supply of housing and raises its price, consumers may be more likely to prefer housing whose location helps to decrease commuting and other traveling costs.

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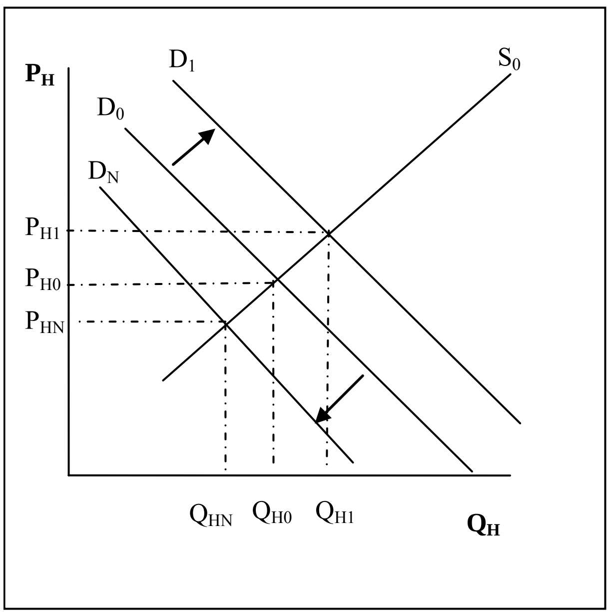
[65] In contrast, Cao and Cory (1982) found a positive relationship between mixed use and housing prices, but concluded that their findings could have been biased. They argued that most of their neighborhoods had only small amounts of commercial activity and, therefore, they could not adequately measure the impact of commercial activity on housing costs where the commercial activity was a significant use of land in the neighborhood. They suggested that their findings would have been different if they could have included neighborhoods which had large proportions of commercial activity in their neighborhoods.

Consumers may increase their demand for housing that is located near land uses that serve their daily needs in term of shopping and employment. Improved access to employment and commercial activities will be considered a positive amenity and increase house prices (Nelson and Dawkins 2004, p. 4). The increase in demand is illustrated by the shift in the demand curve in Figure 4.15 from D_0 to D_1. As a result, the price of housing increases from P_{H0} to P_{H1}. As prices increase, the quantity of housing supplied by producers will increase along the supply curve, S_0.

Figure 4-15. Mixed Land Use Effects on Supply and Demand of Housing in Urban Housing Market



Even while the quantity of housing units supplied may increase, the supply of units affordable to low-income households should decline. First, it can be assumed that some affordable units will simply rise in price to an unaffordable level for low-income households in a neighborhood with a positive mix of land uses. Second, stronger demand for housing units, resulting in higher potential rents for property owners, encourages owners of low-quality, affordable units to upgrade their units. This incentive is especially pertinent if the positive mix of land uses attracts higher income households demanding higher quality units.

On the other hand, a mix of undesirable land uses that produce negative externalities to neighbors, such as dirty and noisy industrial sites and warehouses, would have the opposite effect on demand for housing in these neighborhoods.[66] Demand will be lower for housing in neighborhoods with undesirable land uses. Undesirable land uses include landfills, utility plants, oil refineries, and hazardous waste sites.[67] Therefore, neighborhoods that containment a mix of 'negative' land uses will have lower demand. This decrease in demand is illustrated by a shift in demand curve from D_0 to D_N in Figure 4.15. Prices will decline from P_{H0} to P_{HN}. Therefore, there is likely to be a greater supply of affordable housing for low-income households in neighborhoods with a mix of undesirable land uses.

If the market is divided into the two submarkets of affordable and unaffordable units, there is likely little demand for higher quality, unaffordable units in a neighborhood with a mix of unwanted and undesirable land uses. Units will more likely be of lower-quality at an affordable price level because owners do not have an incentive to upgrade their low-quality units. Additionally, owners of higher quality units do not have an incentive to maintain the high level of quality because of the limited demand.

From this discussion, the hypothesis tested in this research is:

Hypothesis 5: Mixed land use neighborhoods in regions with urban containment are associated with a lower supply of affordable housing units for low-income households.

4.7 OPEN SPACE AND THE HOUSING MARKET

A primary principle of smart growth is the preservation of open space. Open space can be preserved by reserving land for public parks within developed areas, as well as by restricting the use of undeveloped land in outlying, rural areas in metropolitan regions. Urban containment policies intended to preserve land on the outskirts of urban areas have already been presented. This section hypothesizes about the impact of public parks within developed areas on the housing market.

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[66] As stated previously, smart growth advocates often either ignore industrial uses when discussing mixed use or argue that some uses, such as industrial sites and warehouses, should not be part of residential communities.
[67] For a review of the literature regarding the impact of undesirable land uses and negative environmental externalities, see Farber (1998) and Boyle and Kiel (2001).

Public parks influence housing prices and the supply of affordable units for low-income households through factors of both the demand for and supply of housing. There are three reasons that the presence of a public park in a neighborhood may be associated with a smaller supply of affordable units for low-income households. First, public parks present positive amenities, such as access to open space and recreation, to neighborhood residents. Because of these positive amenities, there is a greater demand for housing in close proximity to a public park than for housing without access to a public park (Bolitzer and Netusil 2000; Acharya and Lewis 2001; Shultz and King 2001; Irwin 2002). The greater demand associated with housing near a park increases housing prices. As a result of higher prices, the supply of units affordable to low-income households is smaller.

Second, Wu and Plantinga (2003) hypothesized that a public park may attract higher income households demanding larger lot and more expensive housing than a neighborhood without a public park.[68] The response to greater demand for more expensive housing is easily understood if the two submarkets presented in Section 4.1 are considered. Greater demand for more expensive housing encourages owners of low-quality, affordable housing to upgrade their units if they can obtain greater profits by improving the quality of their units. This upgrading of units from the low-quality, affordable housing submarket to the unaffordable submarket reduces the supply of affordable units and increases the supply in the unaffordable submarket.

Third, a greater proportion of land reserved for public parks reduces the amount of land available for housing, which increases residential land costs and reduces the housing supply. Therefore, a greater proportion of land reserved for public parks is associated with a lower supply of housing, particularly housing that is affordable for low-income households, if density remains constant.

It needs to be noted that in some instances public parks may be responsible for negative externalities which lower adjacent property values. The literature review in Chapter Two indicated that extremely close proximity to a public park, particularly to an area of a park which attracts a large number of strangers, may be associated with lower home values. Another factor which may result in a negative relationship between home values and a public park is the type of

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[68] Wu and Plantinga (2003) argued that there are opportunities for low-income households to reside near a park if the open space is in the central city. This result is due to the fact that higher-income households must weigh the benefit of living a further distance from the CBD, where the cost per unit of housing and land is cheaper, against the benefit of living near a park in the central city.

activity that occurs in the park. Some parks attract the homeless, serve as a location for a drug market, or provide a place for criminals to commit crime.[69] Therefore, public parks may lower housing values if residents have a poor perception of safety within the park.[70]

Based on both the demand and supply effects of public parks, and assuming that public perception of safety is kept constant, the following hypothesis is tested:

Hypothesis 6: A greater proportion of land in public parks is associated with a lower supply of affordable housing for low-income households.

As a result of urban containment, the amount of open space within urban containment boundaries will decrease for two reasons. First, the purpose of urban containment is to develop land located within pre-determined boundaries and on land that would otherwise be skipped over in favor of further outlying, more rural areas (Nelson and Duncan 1995, p. 73; Nelson et al. 2004). As new development is steered or required to be within the urban boundaries, open space within the boundaries declines faster than it would without an urban containment policy.

The second reason for the decrease in open space within urban boundaries is that the value of developable land increases in response to urban containment. As the value of developable land increases inside the urban boundaries, land owners have a greater incentive to make their land available for development. They cannot realize the greater value of their land until they are willing to sell it for development (or develop it themselves).[71]

The literature review in Chapter Three indicated that as the amount of undeveloped and private open space surrounding a home declines, public parks will become more highly valued as an amenity among residents. Demand for housing in close proximity to public parks will

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[69] For example, see the numerous newspaper articles (such as Hansel (2006) and Hennessey (2006)) describing the recent closing of Huntridge Circle Park in Las Vegas after a homeless man stabbed and killed another homeless man in the park . The park had become an infamous haven for the homeless (Kulin 2006).

[70] On the other hand, public parks surrounded by properties of low value may receive less maintenance than parks surrounded by higher valued properties. For example, see a recent article in the New York Times concerning "two" parks within Prospect Park in Brooklyn (Brick 2004). There is likely a complex relationship among adjacent housing values, the maintenance level of the park, and the public's perception of safety within the park. There is a possibility that the value of adjacent homes influences the perception of safety of the park.

[71] Nelson (2000, p. 47) stated that a primary assumption of urban containment policies is that "undeveloped land inside the urban boundary will come on-line in sufficient amounts and at appropriate times to sustain development." However, he then suggested that this assumption has not been tested. There is a possibility that landowners will hold onto their undeveloped land for speculative purposes, expecting to receive even more value for the land in the future, rather than make it available in a timely manner.

increase even further. The greater demand for public parks in areas of urban containment will create an even stronger association between them and higher housing prices and, in turn, a smaller supply of affordable housing than in areas without containment policies. The following hypothesis is tested:

Hypothesis 7: In regions of urban containment, the association between a greater proportion of land in public parks and a smaller supply of affordable housing is stronger than in regions without urban containment.

4.8 SUMMARY OF HYPOTHESES

This chapter presented the theoretical framework from which to draw hypotheses concerning the research questions of the dissertation. The two primary research questions are:

- What is the impact of neighborhood density, a variety of housing options, mixed land use, and public parks on the supply of affordable housing for extremely and very low-income households?

- Are these relationships different in metropolitan areas which have implemented a form of urban containment, such as urban growth boundaries or priority funding areas, from areas which have no such policy? If so, what are these differences?

In summary, this chapter first provided a discussion of the housing market in terms of two submarkets, those of unaffordable units and affordable units for low-income households. The chapter then theorized about the impact of urban containment on residential land values and, in turn, on housing values. Policies restricting the supply of developable land will increase land values. Because land values are a significant component of the housing market, housing prices will increase as a result. Additionally, the supply of affordable units will decline. The chapter then theorized about the impact of density, housing options, mixed land use, and public parks in two different environments, an environment without urban containment and an environment with urban containment, on the supply of affordable housing for low-income households. Based on the theoretical framework provided in this chapter, the following hypotheses are tested in the following chapters:

Hypothesis 1: Greater housing density is associated with a greater supply of affordable units for low-income households.

Hypothesis 2: In regions with urban containment, the association between greater housing density and a greater supply of affordable units for low-income households is weaker than in regions without urban containment.

Hypothesis 3: A greater supply of multi-unit structures, a measure of the variety of housing options, is associated with a greater supply of affordable units for low-income households.

Hypothesis 4: In regions with urban containment, the association between multi-unit structures and a greater supply of affordable units for low-income households is weaker than in regions without urban containment.

Hypothesis 5: Mixed land use neighborhoods in regions with urban containment are associated with a lower supply of affordable housing units for low-income households.

Hypothesis 6: A greater proportion of land in public parks is associated with a lower supply of affordable housing for low-income households.

Hypothesis 7: In regions of urban containment, the association between a greater proportion of land in public parks and a smaller supply of affordable housing is stronger than in regions without urban containment.

Chapter Five presents the research design utilized to test these hypotheses. It first discusses the potential quasi-experimental research designs which could be used. It then continues with the rationale for choosing an "untreated control group with pre-test and post-test" non-equivalent control group research design.

Chapter Six continues the presentation of the research design by describing the process by which appropriate regions were selected to represent areas with urban containment and areas without such a policy. Chapter Seven provides the analyses of these hypotheses.

5.0 RESEARCH DESIGN

This chapter presents the research design used to test the seven hypotheses presented in the previous chapter. The purpose of this research is two-fold. First, it is to test the relationship between four specific smart growth principles on the supply of affordable housing for low-income households. The second purpose is to test the hypothesis that the implementation of urban containment policies, which restrict development in outlying areas, alters the relationship between smart growth principles and affordable housing. The four smart growth principles of interest to this research are greater density, a greater variety of housing options for all income groups, greater mixed land use rather than segregated land uses, and the preservation of open space and public parks.

A modified quasi-experimental research design is used to test the relationships among the smart growth principles and affordable housing, as well as the impact of urban containment policies on these relationships. A quasi-experimental design recognizes that a true experimental design, isolating the impact of a specific treatment on an outcome, is not possible (Cook and Campbell 1979; Reichardt and Mark 1998). The 'quasi-experiment' in this research is the comparison of the relationships found among smart growth and affordable housing in a region of urban containment with the relationships found in a region without urban containment. An urban containment policy is the treatment given to one group with its findings then compared to the findings of the control group.

The first section of this chapter reviews the threats to validity, or threats to the "truthfulness", of research findings. The potential threats to accurate results and appropriate conclusions are threats to the internal, external, statistical, and construct validity of the research. Internal validity is the extent to which the research design is able to accurately assess the relationship between a treatment variable (Cook and Campbell 1979, p. 38). External validity is the extent to which generalizations can be made from the research population to other populations in different settings and at different times (Reichardt and Mark 1998, p. 198). Statistical validity refers to the extent to which appropriate inferences are made regarding the covariation between a cause and effect based on adequate statistical methods evidence (Cook and Campbell 1979, p. 37; Bickman, Rog, and Hedrick 1998, p. 11). Construct validity is the extent to which the variable measures used in the research reflect the ideas expressed in the theory or is the research measuring what it says it is measuring (Cook and Campbell 1979, p. 38; Trochim 2001, p. 22 & p. 69). The potential threats to each form of validity are discussed.

The second section presents the strengths and weaknesses of potential research designs. Two primary designs for conducting research are the experiment and quasi-experiment. An experiment can be performed when subjects can be randomly assigned to receive a specified treatment which is of interest to the researcher. Random assignment ensures that other variables which differentiate subjects from one another are randomly present in both the treatment group receiving a treatment and the control group. Therefore, differences in outcome between the treatment and control groups can be more confidently attributed to the treatment. Quasi-experiments are a group of research designs utilized when random assignment is not possible. There are multiple quasi-experiment research designs from which to choose. The chapter concludes with a quasi-experiment design that is utilized in this research.

5.1 THREATS TO VALIDITY

Validity refers to the 'truthfulness' of research findings. Cook and Campbell (1979, p. 37) wrote that the "concepts of validity and invalidity refer to the best available approximation to the truth or falsity of propositions."[72] Cook and Campbell refer to four types of validity – internal, external, statistical, and construct – which the research must try to protect in order to obtain approximately truthful conclusions. Threats to validity refer to the possibility that incorrect inferences or conclusions can be made as a result of a researcher not considering every plausible alternative explanation for the observed outcomes.

[72] Also see Shadish, Cook, and Campbell (2003, Chapters 2 & 3) for a similar discussion regarding validity.

5.1.1 Internal Validity

Internal validity is the extent to which approximately truthful inferences are made regarding the co-variation between a causation variable and an outcome variable (Cook and Campbell 1979, p. 50; Shadish, Cook, and Campbell 2003, p. 53). Threats to internal validity create the misperception that event A causes outcome B, when in reality another factor is explaining outcome B. Shadish, Cook, and Campbell (2003, p. 55) identify nine potential threats to internal validity.

The first threat is history. History is the threat that another event has occurred that affects the outcome variable, but has not been captured by the research design (Reichardt and Mark 1998, p. 200; Trochim 2001, p. 183). One example of the history threat to internal validity is economic growth. Stronger growth is a significant factor influencing the supply and demand for housing. Economic growth increases demand for housing which increases housing prices, as well as potentially reduces the supply of affordable housing for low-incomes households. If economic growth occurs in a region with urban containment, but does not occur in a comparative region without urban containment, urban containment will inaccurately be associated with the increase in housing prices and decrease in supply of affordable units.

The second threat to internal validity is maturation, which is the threat that "naturally occurring changes over time could be confused with a treatment effect" (Shadish, Cook, and Campbell 2003, p. 55). In this research, the outcome of interest is the supply of affordable housing for low-income households. One potential natural effect on the supply of affordable housing could be the ageing of the housing stock. Older units are more likely a source of affordable units than newer units. Some regions have an older housing stock than other regions. If an older region has no urban containment policy, but has a larger supply of affordable housing units than a newer region with an urban containment policy, then the lack of an urban containment policy may be inaccurately credited with a greater supply of affordable units.

The third threat to internal validity is instrumentation, which is the possibility that the measurement instrument changed between the pre-test and post-test. For example, the method of collecting housing cost data may be different between the time affordable housing is measured prior to urban containment and the time affordable housing is measured after urban containment is implemented. In this research, the measurement instrument does not change. Therefore, there is no threat of instrumentation.

The fourth threat is statistical regression. The threat of statistical regression is the likelihood that extreme values will regress toward the mean value (Reichardt and Mark 1998, p. 202). For example, students with lower than average pre-test scores have a probability of achieving post-test scores closer to the average without any intervention. If students with low pre-test scores were assigned to the treatment group, and post-tests showed improvement, the treatment could inaccurately be determined to be effective in increasing scores, when actually the students were simply regressing to the mean. This threat is not too serious in this research as both the control and treatment groups consist of neighborhoods representing a wide range of affordable housing supplies.

The fifth threat is ambiguous temporal precedence. In attempting to determine cause and effect, the 'cause' event must occur before the 'effect'. Correlation studies are a classic example of research which illustrates covariance between a cause variable and an outcome variable, yet without a research design indicating that the cause variable changed first, there is no evidence of causation. On the other hand, some correlation studies allow for conclusions regarding causation, because the other direction of causation (the outcome causes a change in the 'cause' variable) is implausible (Shadish, Cook, and Campbell 2003, p. 55).

The sixth threat to internal validity is selection, which is the threat that there are "systemic differences over conditions in respondent characteristics that could also cause the observed effect" (Shadish, Cook, and Campbell 2003, p. 55). In other words, subjects receiving the treatment are in some way different from those not receiving treatment. For example, a region which has adopted an urban containment policy may be more progressive in social policy than a region which has not adopted an urban containment policy. In turn, it might be the case that a more socially progressive region will be more likely to adopt affordable housing strategies than other regions not as progressive.

The seventh threat is attrition, which is the fact that subjects in an experiment or quasi-experiment occasionally drop out of the research project (Shadish, Cook, and Campbell 2003, p. 59). This is a threat to internal validity as the treatment and control groups of the research design will be composed of different subjects at the time of the pre-test from the time of the post-test (Cook and Campbell 1979, p. 53). This attrition could result in the researcher attributing the impact of the treatment variable to a change in the outcome variable when the outcome was actually a result of a change in the membership of the treatment and control groups. This threat is not present in this research as the level of analysis will be neighborhoods, none of which are dropped during the analysis.

The eighth threat to internal validity is testing, which is the possibility that exposures to a test will affect the results of subsequent tests. One example is testing for the impact of a tutoring program. If students are given a pre-test prior to tutoring and post-test after tutoring, they may do better on the post-test simply because the students had already taken a similar test. Once again, this threat is not present in this research.

The final threat to internal validity is that the other threats do not need to operate separately. If they operate simultaneously, “the net bias depends on the direction and magnitude of each individual bias plus whether they combine additively or multiplicatively” (Shadish, Cook, and Campbell 2003, p. 61). For example, a selection-history additive threat is the possibility that selection bias is present in the selection of treatment and control groups, while at the same time the difference between the two groups also is a cause of the groups experiencing a different history. Selecting a region with urban containment as a treatment group may be selection bias because regions with urban containment may be more sensitive to environmental quality. At the same time, regions with a better environment may experience stronger economic growth by attracting more new businesses than regions with poor environmental policy.

5.1.2 External Validity

External validity is the extent to which research findings can be generalized to other settings, times, persons, and treatment variations (Cook and Campbell 1979, p. 73; Trochim 2001, p. 42; Shadish, Cook, and Campbell 2003, p. 86). Cook and Campbell (1979, p. 73-74) identify three common threats to external validity. They are the interaction between the selection of subjects and treatment, the interaction of the research setting and treatment, and the interaction of history and treatment. Shadish, Cook, and Campbell (2003, p. 87) later added three more threats, which include context-dependent mediation, the interaction between the causal relationship with different measures of the outcome, and the interaction between the causal relationship with different subtleties of the same treatment.

The first threat to external validity is the interaction of the selection of subjects and treatment. Is there something different about the test subjects included in the research that make them different from the general population? Does this difference influence the effect of the treatment? For example, if the research focuses on the impact of urban containment policies on the relationship between the four smart growth principles and affordable housing in the neighborhoods of Portland, Oregon, can we assume that urban containment would have the same impact in New York City? New York's neighborhoods may be significantly different in terms of their density, the type of housing available, and the supply of affordable housing. This difference between the neighborhoods of Portland and New York City may make conclusions regarding Portland not generalizable to New York.[73]

The second threat to external validity is the interaction between the setting and the treatment is the second threat. Can results from one setting be generalized to another setting? For example, can results from metropolitan regions be generalized to rural areas? Or, can results from the largest metropolitan regions be generalized to the smallest?

The third threat is the interaction between history and the treatment. Can the results be generalized to a different point in time? Cook and Campbell (1979, p. 74) argue that research findings cannot be logically extrapolated from the present time to the future. Replicating the research over different points in time can reduce this threat.

The fourth threat is the interaction of the causal relationship over different variations of a similar treatment (Shadish, Cook, and Campbell 2003, p. 87). For example, there is a range of potential urban containment policies, including urban growth boundaries or urban service areas which were described earlier. One type of urban containment policy may have a different impact than another type. Therefore, external validity is weakened when the research examines only one type of urban containment policy.

The fifth threat to external validity is the interaction of the causal relationship with different measures of the outcome. An outcome variable can often be measured in multiple ways. For example, affordable housing can be measured as the quantity of units that are

[73] The groups in this research are regions. However, the level of analysis is the neighborhood. Therefore, the subjects within each group are neighborhoods. This is explained in more detail in Section 5.3.2.

affordable for low-income households. Or, affordable housing can be measured as the proportion of low-income households that are able to occupy a housing unit for which they pay a reasonable proportion of their income.[74] These two outcome measures may lead to different results as units that might be counted as affordable to low-income households are not necessarily occupied by low-income households.

The sixth, and final, threat to external validity is context-dependent mediation, which is the threat that a mediating variable which enables the treatment variable to reflect a causal relationship with the outcome can differ among different settings. This threat is similar to the threat that research results cannot necessarily be generalized to other settings. But this threat is more specific as it refers specifically to mediating variables between the treatment and the outcome. For example, there is the possibility that an older housing stock may be associated with a greater supply of affordable housing for low-income households in one region, but not in another. Or, multi-family units may be more strongly associated with affordable units in one region than in another.

5.1.3 Construct Validity

Construct validity is "the degree to which inferences can legitimately be made from the operationalizations in a study to the theoretical constructs on which those operationalizations are based" (Trochim 2001, p. 69). Cook and Campbell (1979, p. 38) defined construct validity as the "approximate validity with which we can make generalizations about higher-order constructs from research operations." In other words, is the research measuring what it says it is measuring?

Threats to construct validity are typically the result of there being multiple measures which can potentially be used to define the same concept. Has the researcher used the appropriate measure (or measures) of the construct? A mismatch between the variable in the research and the concept presented in theory is a significant threat. Additional threats to construct validity are the result of a mismatch between the settings and persons presented in theory and those chosen in the research design. Shadish, Cook, and Campbell (2003, p. 73)

[74] It is explained in the second chapter that a "reasonable" cost is typically assumed to be 30% of household income.

summarized a number of threats to construct validity. Four of these threats are listed in table 5.1.[75]

Table 5-1. Threats to Construct Validity

Threat	Definition
Inadequate Explication of Constructs	Mismatch between the operations of the research design and constructs of theory under study
Mono-Operation Bias	Using only one operationalization of a construct
Monomethod Bias	Using only one method for each operationalization, such as one method of providing treatment or one method of recording outcome
Confounding Constructs with Levels of Constructs	Limited levels of the construct may have been studied

Source: Shadish, Cook, and Campbell (2003, pp. 72-79).

The first threat to construct validity is inadequate explication of constructs. This threat occurs when there is a mismatch between the operations of the research and the theoretical constructs under study. In this research, urban containment policies are assumed to successfully prevent new development from occurring outside of specified boundaries. But, if an urban containment policy included in this research is not keeping development away from the urban fringe, then the research may be mis-labeling a policy as urban containment when it should not be.

The second threat to construct validity is mono-operation bias. This occurs when there is only one operationalization for a construct which can be measured in multiple ways. The single measure underrepresents the theoretical construct of interest (Shadish, Cook, and Campbell 2003, p. 75). Multiple measures of the same construct reduce this threat. For example, there are a variety of potential methods of measuring the extent of mixed land use. Mixed land use can be defined as the diversity of all types of land uses; the diversity of population-serving land uses, such as entertainment, health services, and retail; or simply the balance between jobs and residents without including the diversity of the types of jobs. The measure of mixed land use may influence the conclusions regarding the relationship between mixed land use and the supply of affordable housing. A greater mix of land uses may be associated with a greater supply of

[75] The remaining threats to construct validity are primarily threats caused by the behavior of the research participants or researcher. The research design, in the next chapter, will explain that census tracts rather than individuals are the unit of observations. Census tracts do not exhibit behaviors as those presented by individuals.

affordable units if the mix includes industrial sites and warehouses which lower demand for adjacent housing. In contrast, a greater mix of land uses may be associated with a smaller supply of affordable units if the mix is limited to uses which bring positive amenities to adjacent or nearby residents. Therefore, this research uses two measures of mixed land use. One measure is of the mix of all types of land uses. The second measure is the balance between "population-serving" jobs and residents.

The third threat is mono-method bias. This occurs when the treatment is provided in a single manner. For example, if a research project is testing the impact of tutoring on student achievement the researcher should realize that there are multiple methods of providing tutoring. In the same way, there are multiple methods of implementing urban containment. The states of Oregon and Washington require municipalities and counties to implement urban growth boundaries. In contrast, Maryland requires its municipalities and counties to designate priority funding areas, which are a form of urban service areas. These differences will be more fully explored in the next chapter.

The fourth threat to construct validity is that there may be different levels of the construct (Shadish, Cook, and Campbell 2003, p. 76). For example, Oregon has a top-down approach in growth management in that the state gives final approval to urban containment boundaries drawn by local municipalities, counties, and the Portland Metro. Additionally, development outside of the boundaries is prohibited by zoning restrictions. Therefore, urban containment policies in Oregon are strong. In contrast, the state of Maryland does not have final approval authority over the size of urban containment boundaries established by the state's municipalities and counties. Additionally, development is allowed outside of the boundaries as long as state money is not used for the infrastructure. Therefore, urban containment policies are likely weaker in Maryland than in Oregon. The research includes both the Portland region and Baltimore region in an attempt to capture these differences.

5.1.4 Statistical Validity

Statistical validity is the extent to which appropriate inferences are made about the cause and affect relationship between two variables based on statistical methods and evidence (Cook and

Campbell 1979, p. 37). It refers to the accuracy of two statistical inferences which are made in most research, whether the cause and affect variables covary and how strongly they covary (Shadish, Cook, and Campbell 2003, p. 42). Shadish, Cook, and Campbell identified nine threats to statistical validity.

Table 5.2 summarizes these nine threats. The threats to statistical validity can be addressed through appropriate data screening, selection of observations, variable measurements, and statistical tests.

Table 5-2. Threats to Statistical Validity

Threat	Definition
Low Statistical Power	Poor ability of test to detect relationships that exist between variables. Low power increases the probability that a statistical test will fail to reject a null hypothesis which should be rejected
Violated Assumptions of Statistical Tests	Violations of statistical test assumptions can lead to inaccurate conclusions about the significance of relationships among variables
Fishing and the Error Rate Problem	Repeated tests in an attempt to find statistical significance among variables may artificially inflate statistical significance and the probability of Type I Error (concluding there is a relationship when there is not)
Unreliability of Measures	Measurement error weakens the accuracy of statistical tests
Restriction of Range of Variable Values	Small range of values weakens the relationship between two variables. Small ranges can lead to incorrect statistical conclusions regarding significance of relationships
Unreliability of Treatment Implementation	An inconsistent implementation of treatment can lead to inconsistent conclusions about covariation between two variables
Extraneous Variance in the Experimental Setting	Extraneous factors influencing the outcome, but not specifically measured will increase the error of the statistical tests
Heterogeneity of Units	Variation in the characteristics of research subjects (units) can increase the error variance of the statistical tests if these characteristics are correlated with the outcome.
Inaccurate Effect Size Estimation	Covariance estimates can be inaccurate when effect size is poorly measured. Outliers can create a non-normal distribution of a variable which can drastically reduce effect sizes.

Source: Cook and Campbell (1979, pp. 39-50) and Shadish, Cook, and Campbell (2003, pp. 45-52).

In summary, Section 5.1 presented the potential threats to the validity of research findings. The threats are classified into four broad categories of validity, which are internal, external, construct, and statistical. These threats decrease the researcher’s ability to make accurate inferences regarding the covariance between two variables; generalize the findings to other settings, places, or times; generalize from the research variables to theoretical constructs; and make accurate inferences regarding the statistical significance of relationship between two variables.

5.2 RESEARCH DESIGNS

There are a number of research designs available to assist in pursuing approximately truthful inferences regarding relationships between two or more variables. Each research design has it own strengths and weaknesses in addressing the variety of threats to validity presented in Section 5.1. This section reviews some of the potential research designs.

5.2.1 Randomized Experiment Research Design

A randomized experiment is one in which subjects are randomly assigned to either a treatment or control group. The treatment group is then given the 'treatment' which the researcher wants to study. The treatment group is comparable to the control group because of random assignment (Boruch 1998, p. 162).[76] A randomized experiment reduces the threats to validity because it reduces the plausibility of an alternative explanation for observed differences in outcome between the treatment and control groups (Shadish, Cook, and Campbell 2003, p. 247).

For this research, however, a random experiment was not possible. The research in this dissertation uses the implementation of an urban containment policy as the treatment. Urban containment is never implemented in randomly chosen places. There are economic and social structures, such as political will, which make urban containment policies possible and prevent random assignment.

[76] This is not to be confused with random selection, which is the selection of samples from a population on a random basis. Random assignment refers to randomly assigning the treatment to some members of the sample after the sample has already been chosen (Trochim 2001, p. 196; Shadish, Cook, and Campbell 2003, p. 248).

5.2.2 Quasi-Experimental Designs

This research employs a quasi-experimental research design which recognizes that subjects cannot be randomly assigned to treatment and non-treatment groups. The most common quasi-experimental approaches to research are nonequivalent control group designs.[77] These designs utilize two groups of subjects, a control group and a treatment group. The groups are nonequivalent because the subjects are not randomly assigned. Therefore, the two groups are not as comparable in a quasi-experiment as in a true experiment with random assignment. The threats to validity need to be explicitly considered in light of the fact that the groups are less likely to share similar characteristics than in a randomized experiment.

Table 5.3 compares four alternative quasi-experiment nonequivalent control group designs discussed in this section and the random experiment. The table includes the strengths and weaknesses of each design, as well as the practical concerns of each design as they relate to this research.

Table 5-3. Quasi-Experimental Nonequivalent Control Group Research Designs

Research Design	Notation	Strengths	Weakness	Practical Concerns
Randomized Experiment	O X O O O	Reduces threats to internal validity; Statistically unbiased estimates of effects	Design is rarely realistic	**Urban Containment cannot be randomly assigned**
Untreated Control Group Design with Pretest and Posttest	O X O - - - - - - O O	Addresses non-random assignment of treatment	Without careful attention to selection of groups, threats to internal validity are not eliminated	**Finding appropriately matched groups to reduce the threats to internal validity**
Untreated Control Group Design with Pretest Measures at More than One Time	O O X O - - - - - - - - O O O	Improves internal validity		**Lack of data**
Reversed Treatment Nonequivalent Control Group Design with Pretest and Postest	O X O - - - - - - - O X- O	Can provide stronger evidence of causation than other designs; Improves internal validity; Improves construct validity	No control group receiving no treatment. Therefore, interpretation is difficult when change in the outcome variable is in the same direction	**Difficult to find a treatment that is explicitly the opposite of an urban containment policy**
Switching Replication	O X O O O O X O	Improves internal validity, especially the threat of maturation and history	Requires the removal of treatment from 1st group or the assumption that treatment loses its impact prior to treatment being applied to 2nd group	Lack of data

Note: O is test of outcome; X is treatment; - - - - - - indicates non-random groups (no random assignment of treatment).
Sources: Cook and Campbell (1979) and Shadish, Cook and Campbell (2003).

[77] The other common types of quasi-experimental designs are interrupted time-series.

5.2.2.1 Untreated Control Group Design with Pretest and Posttest

One of the most frequently used nonequivalent control group research design is the "untreated control group with pretest and posttest" design (Cook and Campbell 1979, p. 103). In this design, both the control and treatment groups receive a pre-test. The pre-test measures the initial differences between the two groups. The treatment group then receives the treatment, while the control group does not. A post-test is then given to the two groups to measure the differences between the two groups after the treatment. The commonly used notation to illustrate this design is:

Treatment Group:	O_1	X	O_2
	- - - - - -	- - - - - -	- - - - - -
Control Group:	O_1		O_2

Where O_1 is the pre-test, X is the treatment, O_2 is the post-test, and the dashed line (- -) indicates that the groups are not randomly formed (Cook and Campbell 1979, p. 104).

Some common threats to validity are not eliminated by the "untreated control group with pretest and posttest" design. There are still threats to internal validity, including the possibility the two groups will mature at different rates, as well as experience a different history between the pre-test and post-test. Additionally, regression to the mean will occur if one of the groups initially consists of members who were chosen based on being not close to the average observation. Because random assignment of the treatment to the observed units does not occur in a quasi-experimental design, it is more probable that the treatment group may differ from the control group in terms of maturation and history than in a randomized experimental design. The researcher must pay more careful attention to listing the threats to internal validity and choosing groups specifically to reduce these threats (Cook and Campbell 1979).

5.2.2.2 Untreated Control Group Design with Pretest Measures at More than One Time Interval

An alternative nonequivalent control group design is the "untreated control group design with pretest measures at more than one time interval" (Cook and Campbell 1979, p. 117). The notation for this design is:

Treatment Group:	O_1	O_2	X	O_3
- - - - - - - - - - - - - -				
Control Group:	O_1	O_2		O_3

Where O_1 is the first pre-test, O_2 is the second pre-test, X is the treatment, O_3 is the post-test, and the dashed line (---) indicates that the groups are not randomly selected.

This research design takes two pretests prior to the treatment intervention, which in this research is urban containment. The advantage of two pre-tests is that they provide the researcher with the ability to determine if the outcomes were changing between the two groups prior to treatment. If there is a change in the outcome from O_1 to O_2 in one group, but not the other, then a conclusion can be made that the groups are growing apart without the treatment. If there is no change in the outcome from O_1 to O_2 in either group or there is a similar change in both groups, then the threat of different rates of maturation between the two groups is reduced.

A second advantage of two pre-tests is that if there is anything atypical in the first pre-test, it can be identified in the second pre-test. Results from O_2 can be compared to results on O_1 to ensure that one of the two pre-tests did not result in unexplainable high or low results. If there were only one pretest, the possibility that the pretest outcome was an anomaly because of its timing or of another reason increases the threat the outcome results of the posttest will differ from the pretest only because of regression to the mean. Earlier, regression to the mean was identified as the probability that extreme values among multiple observations will have a tendency to move towards the average of all the values. Therefore, a pre-test which has an abnormally high or low value combined with a posttest which captures regression to the mean may indicate that the treatment is statistically significant when it actually may not be significant. Two pre-tests assist in eliminating this potential threat.

5.2.2.3 Reversed Treatment Nonequivalent Control Group Design with Pretest and Posttest

A third type of nonequivalent control group quasi-experimental research design is the "reversed treatment nonequivalent control group design with pretest and posttest" (Cook and Campbell 1979, p. 124). The notation for this design is:

Treatment Group:	O_1	X	O_2
Reverse Treatment Group:	O_1	X -	O_2

Where O_1 is the pre-test, X is the treatment, X- is a treatment that is expected to have the reverse impact from the primary treatment, and O_2 is the post-test.

The purpose of this design is to apply the treatment to one group and the exact opposite of the treatment to the other group. For example, if an urban containment policy is the treatment (X) then an urban expansion policy is the opposite of the treatment (X-). The finding that X has the exact opposite impact on the posttest outcomes than X- provides stronger proof of causation than other designs. Using both the treatment and the reversed treatment forces the researcher to more accurately define the treatment as an opposite can also be tested. This more exact nature of operationalizing the theoretical constructs improves construct validity (Cook and Campbell 1979, p. 125; Shadish, Cook, and Campbell 2003, p. 147).

Another benefit of using a reversed treatment control group is that it improves internal validity. The threats of maturation and history to internal validity are reduced (Shadish, Cook, and Campbell 2003, p. 148). Maturation in one group can explain a difference in outcome between two groups if the direction of change is the same but at a different magnitude of change. But maturation cannot explain one group's outcome moving in one direction and the other group's outcome moving in the other direction from the initial pretest (Cook and Campbell 1979, p. 125). Therefore, if opposite treatments are used on the two groups and the two groups' outcomes move in different directions from the pretest, maturation is not threat. The threat of history is reduced in the same manner. It is unlikely that an event will occur which influences one group in one direction and yet influence the other group in the exact opposite direction.

A significant drawback of the reversed treatment research design is the lack of a control group receiving no treatment at all (Shadish, Cook, and Campbell 2003, p. 148). If changes in the outcome variable occur in the same direction for both treatment groups, the results are not interpretable. In this situation, it remains unknown whether the treatments had an impact on the outcome because there is no outcome from a control group without treatment for comparison.

5.2.2.4 Switching Replication

A fourth type of quasi-experimental nonequivalent control group research design is the "untreated control group design with dependent pretest and posttest samples using switching replications" (Shadish, Cook, and Campbell 2003, p. 137 & p. 146). In this design, two groups are given the pretest which is then followed by the introduction of the treatment to one group. A second pretest is then conducted, after which the treatment is removed from the first treatment group and applied to the other group. A posttest is then conducted. The notation for this research design is:

Treatment Group 1:	O_1	X	O_2		O_3
	- - - - - - - - - - - - - -				
Treatment Group 2:	O_1		O_2	X	O_3

Where O_1, O_2, and O_3 are the tests, X is the treatment, and the dashed line (----) indicates that the groups are not a result of random assignment.

This type of research design has two research phases. The first phase occurs between the first and second tests. It is a controlled quasi-experiment in which one group receives the treatment while the other group doesn't. The second phase is the removal of the treatment from the first treatment group and the introduction of the treatment to the second group. This design rules out the threat of maturation as the threat can be detected if one group continues to grow apart from the other even after both groups received the treatment. The design also allows the researcher to examine the impact of treatment at different time intervals and, presumably, under different contexts because of the time differences. This reduces the threat of unrecognized history influencing the researcher's conclusions of statistical significance between the treatment and the outcome.

5.3 SELECTED RESEARCH DESIGN

The quasi-experimental research design utilized in this research is the "untreated control group with pretest and posttest" described in Section 5.2.2.1. This quasi-experimental design is modified in this research in that it is not testing whether or not the 'treatment' of urban containment directly impacts the dependent variable, which is the supply of affordable housing. Rather, a primary hypothesis of this research is that urban containment impacts the relationships between smart growth principles, which are independent variables, and the dependent variable of affordable housing.

There are a number of reasons why the other potential research designs were not utilized in this research. First, places cannot be randomly assigned to receive an urban containment policy. There are political, economic, and environmental factors which influence whether an area will adopt an urban containment policy. For example, a place in which the political process is influenced by environmentalists will be more likely to adopt an urban containment policy than a place where there is little public influence among environmentalists. Or, a region which has sensitive environmental assets to protect is more likely to consider the use of urban containment than a region with few easily identifiable assets. Because random assignment cannot occur, a randomized experiment is not possible.

The "untreated control group design with pretest measures at more than one time interval" was not chosen because of lack of data. A research design with more than one pretest, or multiple tests over a long period of time, requires longitudinal data which covers a significant period of time. However, there is a limit to the availability of historical data concerning affordable housing which is comparable over time. As will be discussed later, a significant source of data is the Census and the level of analysis is the census tract. Prior to 1990, not all counties within the chosen cases were dis-aggregated into census tracts. In addition, some housing cost data for vacant housing units was not readily available in Census data prior to 1990. This lack of availability made multiple pre-tests difficult.[78]

[78] The sources of data will be discussed in a later section. The Metropolitan American Housing Survey (M-AHS) also provides longitudinal housing data for select metropolitan regions. But this data cannot be used for three reasons. First, the survey was re-sampled in 1995. Post-1995 surveys should be compared to pre-1995 surveys with caution as they contain different samples. Second, the smallest level of geography at which data can be aggregated in the M-AHS is the zone. The zone is an area of approximately 100,000 housing units. The level of analysis in this research is the neighborhood and zones are much larger than a typical neighborhood. Third, the variables in the M-AHS that would measure the smart growth principles of open space and mixed land use were slightly changed in 1997. For example, in the question "are there any businesses or institutions, such as stores, restaurants, schools, or hospitals within 300 ft. of this building," 300 ft. was changed to ½ a block. I do not know how much this change resulted in respondents giving different answers.

The reverse treatment research design is not feasible for this research. It requires the introduction of a policy that is the exact opposite of urban containment. There are no clear, explicit policies of urban expansion from which to choose as the reverse treatment. Most explicit policies to guide urban growth are to contain urban development from extending into rural areas, rather than expanding urban development. Therefore, the use of a reverse treatment for this research is not realistic. Advocates for urban containment argue that the expansion of urban development into rural areas is partially the result of a lack of planning, implicit policies supporting urban expansion, and no attempts to contain development. Therefore, it is more realistic and appropriate to use a research design which compares a treatment group with urban containment to control group without similar policies.

The switching replication research design is also not feasible. It requires the removal of treatment. However, once urban containment policies are implemented, they are rarely withdrawn or removed. If treatment cannot be removed, Shadish, Cook, and Campbell (2003, p. 146) suggested that researchers assume that the treatment introduced to the first group loses its effect in the second phase of the research when the treatment is introduced to the second group. However, urban containment is unlikely to lose its significance over time.

5.3.1 Treatment and Control Groups

Treatment and control groups for the "untreated control group design with pretest and posttest" were delineated by metropolitan regions. Regions with a region-wide urban containment policy were considered as potential treatment groups. Urban containment in a single county, or a single municipality, has a different type of impact than a region-wide policy. Local urban containment policies may limit the supply of residential land and push up residential land prices, locally. But, developers will move development to adjacent jurisdictions without land use restrictions (Levine 1999). Therefore, local urban containment policies will not have as strong of an impact on the regional housing market as regional policies, particularly if households can easily move to other jurisdictions.

Appropriate control groups were chosen based on their comparability to the treatment groups with the exception of urban containment. The "untreated control group with pretest and posttest" research design does not adequately address threats to internal validity without careful consideration of other potential explanations. In a quasi-experimental research design, subjects are not randomly assigned to a treatment or a control group. Therefore, the groups could differ from one another in other characteristics which explain a difference in outcomes. To improve the validity of this research, the choice of treatment and control groups should ensure that the groups share similar characteristics with the exception of the treatment. The selection of control and treatment groups is discussed in further detail in Chapter 6.

5.3.2 Unit of Analysis

The neighborhood, defined by census tract, is the unit of analysis or level of observation for testing the relationships among the smart growth principles and the supply of affordable housing in both the treatment and control groups. There are three reasons why this level of analysis was chosen. First, the neighborhood serves as the "basic building block of urban form" (Song and Knaap 2004, p. 215). Residents experience the environment of their neighborhood every day and make their residential location decisions partially based on this environment.

The second reason to use the neighborhood as the unit of analysis is that aggregation of data to a larger level of geography eliminates the variability of the data. Measuring density, the variety of housing options, mixed land use, and open space at the municipal level assumes that each variable's value is similar within all areas of the municipality. The same is true if the variables are measured at the regional level. As the size of the geographic unit of observation increases, the ability of the research design to capture the variations in both the independent variables and the dependent variable decreases.

The third reason for this unit of analysis is that data constraints prevent analyses at a geographic level smaller than the census tract. Adequate housing cost data from the U.S. Census, which is utilized in this research, are not available at smaller geographies. Cost data is not available at the block level, which is the smallest level of aggregation for Census data. At the 2nd smallest level, which is the block group consisting of multiple blocks, data are available only in situations where there are enough housing units to calculate rents of renter-occupied units and values of owner-occupied units without violating the Census Bureau's confidentiality standards.[79]

5.4 SUMMARY

This chapter presented the potential research designs available for testing this dissertation's hypotheses. Each research design has its own strengths and weaknesses in terms of addressing the four broad categories of the threats to validity, as well as being a practical and feasible design to conduct.

After exploring the strengths, weaknesses, and practical concerns with each design, the "untreated control group design with pretest and posttest" was chosen as the design for this research. However, this research uses a modified quasi-experimental research design as its primary purpose is to test the impact of urban containment on the relationships among the four smart growth principles and the supply of affordable housing, rather than to test urban containment's direct impact on the supply of affordable housing.

The chapter then defined the treatment and control groups, as well as the unit of observation within the groups, that will be utilized in the research design. The treatment is urban containment. The treatment groups will consist of neighborhoods within a region of urban containment, while the control groups will consist of neighborhoods in regions with no region-wide urban containment policy. This research design allows for a comparison of the impact of urban containment on the relationships between each of the four smart growth principles and the supply of affordable housing by comparing their relationships in a region with urban containment to a region without such a policy.

The next chapter will explain the rationale for the regions chosen for this research. It will then compare the treatment regions with the control regions in terms of their economic growth patterns, growth management policies, affordable housing policies, and housing market.

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[79] See the U.S. Census Bureau's (1994) Geographic Areas Reference Manual.

6.0 SELECTION OF TREATMENT AND CONTROL GROUPS

Chapter Five presented alternative research designs which could be utilized to test the hypotheses of this research. The chapter concluded that the research design appropriate for this research is the "untreated control group design with pretest and posttest." The 'treatment' in this research is a regional urban containment policy and the unit of analysis is the neighborhood.

This chapter continues the presentation of the research design by discussing the selection of the treatment and control groups. The first section describes the criteria by which treatment and control groups were selected. Because a quasi-experimental research design does not eliminate the threat that the treatment and control groups differ in a way which influences their outcome, the researcher runs the risk of concluding that a difference in outcome may be the result of treatment when in actuality there is some other explanation. To reduce this risk, the groups must be selected so as to ensure they are as similar as possible, with the exception of the treatment variable.

The treatment and control groups were chosen in two steps. In the first step, two regions with region-wide urban containment policies were chosen. To ensure that urban containment policies were applied thoughout the region, only regions located in states *mandating* urban containment policies were considered. For this reason, the selection of potential urban containment regions was limited to the states of Oregon, Washington, Maryland and Tennessee.[80] Because of the limited diversity among the choices for urban containment regions, only two were chosen. The neighborhoods of the two chosen regions provided two treatment groups.

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[80] As explained later in the chapter, Tennessee's growth management legislation was passed in 1998 and urban containment boundaries did not need to be implemented until 2000. Therefore, regions in Tennessee were not a practical option for this research.

In the second step, each treatment group was then paired with a control group consisting of neighborhoods of a region which had as many similar characteristics to the treatment group as possible, with the exception of a region-wide urban containment policy. This selection process resulted in two pairs of metropolitan regions. Each pair consists of a treatment region and a control region and is analyzed separately.

The second and third sections of this chapter provide descriptive information regarding the two pairs of regions selected for this research. The first pair consists of the metropolitan regions of Portland and Seattle. The neighborhoods of Portland are the treatment group as the region was one of the first to implement a region-wide urban containment policy with the establishment of urban growth boundaries in 1979. The neighborhoods of Seattle are the control group as the Seattle region did not have an urban containment policy until the mid-1990's. Counties throughout Washington State began to implement urban growth boundaries in the early and mid-1990's in response to the state's Growth Management Acts of 1990 and 1991.

The second pair of treatment and control groups consists of the metropolitan regions of Baltimore and Philadelphia. In response to Maryland's Smart Growth Act of 1997, every county and municipality in the state established priority funding areas (PFAs). PFAs are boundaries outside of which state money for infrastructure, such as water and sewer systems, is restricted. PFAs serve as an urban containment policy as they discourage new development outside of the predetermined boundaries. Therefore, the neighborhoods of Baltimore are the treatment group. The neighborhoods of Philadelphia serve as the control group as there is no region-wide urban containment policy in the Philadelphia region.

6.1 CRITERIA FOR SELECTION

The selection of appropriate treatment and control groups is explicitly related to improving the internal and external validity of the research. Cook and Campbell (1979, p. 104-105) discussed two threats to internal validity that are not overcome in an "untreated control group pretest posttest" design without careful designation of subjects into the control and treatment groups.

Threats to internal validity can make a treatment seem effective when in actuality the treatment is ineffective, or vice versa.

The two significant threats to internal validity not overcome by the untreated control group design are history and maturation. The treatment group may experience an event that is different from the control group, which could influence the dependent variable. If these events are not taken into consideration, the researcher could inappropriately conclude that the treatment was responsible for the change. To reduce this threat to validity, the treatment and control groups paired in this research are chosen based on their comparability to one another in their characteristics, such as their economic growth patterns, climate, and location.

The selection of treatment and control groups was also a means to improve external validity which is the ability to generalize the findings of the current research to other settings and times. To improve the external validity of the research, two different pairs of treatment and control groups were chosen. Each pair consists of a treatment region and a control region and is analyzed separately. The pairs were chosen so that there were three differences between the two pairs. The three differences were:

1. Different variation of an urban containment policy.
2. One pair is located on the east coast and one on the west coast of the United States, representing two different parts of the country.
3. One pair experienced large population and economic growth during the 1990's while the other pair experienced greater growth in the 1980's and stagnant growth in the 1990's.

Using two different pairs allows for a comparison of the findings using two different urban containment policies, in two different settings, and in two different economies.

6.1.1 Selection of Treatment Groups

Across the United States, Nelson and Dawkins (2004, p. 16) identified 131 examples of growth management plans which included an urban containment framework. These examples were of regional, county, or city governments adopting an urban containment policy to reduce growth in outlying, undeveloped areas. However, unless urban containment is required by the state, urban containment policies are not typically found throughout an entire metropolitan region.

A single jurisdiction adopting an urban containment policy may simply push development to other areas of the region that have not yet implemented urban containment or other growth restrictions. There is empirical evidence that growth restrictions redistribute new development, but have little overall effect on the supply and price of housing throughout the region. Schwartz, Hansen, and Green (1981) compared two neighboring communities in California, Petulma and Rohnert Park. Petulma implemented strict growth control measures while Rohnert Park had no similar constraints. They found that increases in housing prices were not significantly different between each community. But, the growth in building permits was significantly higher in Rohnert Park. The authors concluded that housing price increases did not differ between the two communities partially because the development prohibited by Petulma was displaced to other communities, including Rohnert Park. Housing in Rohnert Park served as a substitute for housing in Petulma.[81]

Elliot (1981) examined local growth controls by comparing their impact on housing prices in situations where neighboring communities had similar growth controls to situations where neighboring communities had no growth controls. He studied local growth controls in California from 1969 to 1976. He found that housing price increases were significantly higher in growth control communities that were neighbors to other growth control communities than in growth control communities that were neighbors to localities with no growth controls. In unregulated housing markets, which are regions with few growth controls, he found insignificant differences in price increases between growth control and no growth control communities. His findings provided evidence that additional development in communities without growth control measures would absorb the development prohibited in a neighboring community with growth control.

Levine's (1999) study of local growth controls in 490 California jurisdictions found growth control measures, particularly zoning and maximum density requirements, were

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[81] If the communities were not perfect substitutes for each other, the results could have been different. If housing (or other characteristics) of Petulma were significantly different and more highly valued than those of Rohnert Park, prices would have increased faster in Petulma than in Rohnert Park. The supply would have remained restricted, but the demand would have been more inelastic (less of a decline in demand in response to the increase in price) because households would have seen a benefit to living in Petulma over Rohnert Park.

associated with a decline in the production of new housing units. However, the study found that urban growth boundaries, a form of urban containment, were not statistically significant in explaining the number of new housing units. He concluded urban growth boundaries did not reduce development, particularly the supply of housing. Even though growth boundaries were not statistically significant in his analyses, Levine's research provided evidence that local growth controls have the potential to limit the supply of housing locally, but not impact the supply of housing in surrounding communities with no growth control.

Because of these findings, only metropolitan regions in which urban containment policies are region-wide were considered as potential treatment groups. Individual local urban containment polices may have little impact on the metropolitan region overall unless they are implemented throughout the region. Growth management requirements from the state are most often responsible for region-wide implementation of urban containment. Therefore, the selection of regions to serve as the treatment groups begins by examining states which have urban containment requirements as part of their growth management strategies.

Nelson and Dawkins (2004, p. 29) identified nine states which have state-wide growth management legislation that mandates planning on the part of local jurisdictions and counties. They called these nine states "planning mandate" states because they require local jurisdictions to plan, provide statewide planning guidelines which local plans must follow, and require vertical consistency which mandates that local plans be consistent with state plans or state-wide goals.[82] The nine states were Arizona, California, Delaware, Florida, Hawaii, Maryland, Oregon, Tennessee, and Washington.

Of the nine states, Pendall et al. (2002, p. 7) identified three that require urban containment policies of local governments or counties throughout the state. The three states they identified were Oregon, Tennessee, and Washington.[83] The metropolitan regions of these states can be considered to have region-wide urban containment policies as most counties or local jurisdictions must designate urban growth boundaries, outside of which new development is restricted. Maryland can be added to this list of states requiring region-wide urban containment

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[82] Nelson and Dawkins acknowledge that identifying states with planning and growth management requirements is difficult. For example, Carlson and Mathur (2004, p. 16) listed 12 states with state-wide growth management legislation which requires local or county planning.

[83] Staley and Mildner (1999) identified the same three states.

policies as they require every county to designate priority funding areas into which state infrastructure funds are steered. This is a form of urban containment.

Tennessee was not considered as a potential source of treatment groups as the state's Growth Policy Law, requiring urban growth boundaries of large cities, was not legislated until 1998.[84] Counties were not required to submit their comprehensive plans, including their designated urban growth boundaries, until 2000. Therefore, data from the 2000 Census would not capture any impact of Tennessee's growth management act. Only metropolitan regions located in Oregon, Washington, and Maryland were considered as potential treatment groups.

The other five states identified as "planning mandate" states by Nelson and Dawkins were not considered as states with potential treatment groups for a variety of reasons. Hawaii was not considered because it is unique from other states in that it consists of a series of islands, naturally limiting the amount of land available for development. Sprawl is limited in Hawaii "in a way that is not possible in other states" (Nelson and Dawkins 2004, p. ix).

Regions in Arizona and Delaware were not considered as potential treatment groups because the states do not require urban containment policies. Arizona, as a result of its Growing Smarter Act of 1998 and its Growing Smarter Plus Act of 2000, requires all large or fast-growing communities to create a comprehensive plan which is approved by voters every ten years (Johnson, Jordan, and Salkin 2002, p. 35). These plans must include designated growth areas but do not need to include boundaries outside of which development is prevented.[85] The requirement of urban growth boundaries was rejected by Arizona voters in 2000 (Myers and Puentes 2001; Johnson, Jordan, and Salkin 2002). Delaware also requires counties to submit comprehensive land use plans, but does not require specific urban containment policies.

For the reasons just discussed, metropolitan regions in Oregon, Washington, and Maryland were considered as potential treatment groups because urban containment policies can be found throughout these regions as a result of state legislation. Of these states, Oregon was chosen because it has the oldest state mandated urban containment policy, adopted in 1973. In response to the state legislation, urban growth boundaries were established in the Portland region in 1979, making them one of the first region-wide urban containment policies for a major U.S.

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[84] For a summary of every state's current activities in growth management, see Johnson, Jordan, and Salkin's (2002) *Planning for Smart Growth: 2002 State of the States*.
[85] See the Arizona Department of Commerce about the Growing Smarter Legislation at http://www.azcommerce.com/CommAsst/GrowSmart/Growing+Smarter+Legislation.htm.

metropolitan region. Therefore, the neighborhoods of Portland were chosen as a treatment group.

The neighborhoods of the Baltimore region in the state of Maryland were chosen as the second treatment group. The Baltimore region was chosen for two reasons. First, even though it is relatively new, Maryland's growth management legislation has quickly become one of the most influential and most often discussed within the smart growth movement. The title of the 1997 legislation was called the "Smart Growth Act" and brought national attention to the smart growth movement as it was supported by then Governor Parris Glendening, a prominent supporter of smart growth (Daniels 2001; Cohen 2002; Glendening 2002).

The second reason for choosing the Baltimore region is that Maryland's Smart Growth Act requires counties to designate priority funding areas (PFA), which are a different form of urban containment than urban growth boundaries. PFAs are similar to urban service areas, which are boundaries outside of which state money for infrastructure, such as water and sewer systems, cannot be spent. The lack of infrastructure discourages new development. Unlike Oregon's urban growth boundaries, PFAs do not completely restrict development outside of their borders. New development may occur outside of PFAs so long as infrastructure costs are covered by private interests.

Using two treatment groups, each with slightly different forms of urban containment, improves the external validity of the research. Chapter Five presented the idea that external validity is threatened by the possibility that a research treatment can take different forms. One form of urban containment may have a different impact than another, which reduces the ability of the researcher to generalize from one urban containment policy to another. By testing the impact of both urban growth boundaries and priority funding areas, this threat to validity is reduced.

6.1.2 Selection of Control Groups

The criterion for selecting a metropolitan region as a control group to match with a treatment group was that the region share as many similar characteristics as possible to the treatment region, with the exception of the urban containment policy. Choosing treatment and control groups with similar characteristics improves the internal validity of the research because it reduces the chance that other factors, separate from the treatment, are responsible for the different outcomes that might occur between the two groups.

The first characteristic necessary to be similar between the treatment and control groups of each pair was population and economic growth. One of the most significant influences on the housing market, and the supply of affordable housing, is changes in the region's population or economy. Growth in the number of households, as well as an increase in household income, increases the demand for housing. Greater demand for housing increases prices and decreases the supply of affordable units for low-income households. An on-going and inconclusive debate within the urban containment literature is to what extent an increase in housing prices is attributable to a change in income or population growth and to what extent an increase in prices is attributable to urban containment (Phillips and Goodstein 2000; Downs 2002).

Two other similar characteristics between the treatment and control groups were climate and geographic location. These two characteristics are closely related to population growth as cities and metropolitan areas in the South and West regions of the U.S. experienced great gains in population over the past fifteen years while those in the North and Midwest have lost residents (Fulton et al. 2001; Glaeser and Shapiro 2001; Berube and Katz 2006, p. 35). Nine of the ten fastest-growing cities in the U.S. from 1990 to 2000 were located in California, Texas, Arizona, and Nevada (Glaeser and Shapiro 2001). In general, these fast growing regions have warmer, or at least milder, climates than slower growing and declining regions.

Another shared characteristic of the treatment and control groups were topographical constraints on growth. Metropolitan areas adjacent to oceans, lakes, mountains, or deserts may have natural restrictions on the growth of sprawl and the supply of housing (Rose 1989; Lang 2002). Nature serves as a mechanism of urban containment without the need for an explicit policy. Therefore, a region with topographical restrictions on the outward spread of development would not make an appropriate control group to a treatment group, as the control group has a permanent constraint on the form of its outward growth.

Construction costs were also required to be similar in both the treatment and control groups of both pairs. The cost of labor and materials is a significant input cost in the development of new housing. Higher costs reduce the supply of housing. Regions with higher input costs are likely to have a tighter housing market, in terms of higher prices and lower supply, as compared to regions with lower construction costs.

A final threat to the internal validity of the research is that either the treatment or control group has more progressive affordable housing policies than the other region. A region with more progressive regional policies, requiring local jurisdictions to reduce barriers to affordable housing, could likely have a more even distribution of affordable units among the region's neighborhoods. However, few metropolitan regions have an affordable housing strategy which addresses the need for low-income housing throughout the entire region. The later sections will discuss the regional strategies for affordable housing in each region representing the treatment and control groups. None of the regions *require* the adoption of affordable housing policies at the local level. Therefore, the regional affordable housing strategies are typically limited in scope and effect. However, some localities *within* the selected regions have mandatory affordable housing requirements.

Based on the threats to internal validity discussed in this section, a region was chosen as a control group to each treatment group. The neighborhoods of the Seattle region were chosen as the control group to treatment group neighborhoods in Portland, while the neighborhoods of the Philadelphia region were chosen as the control group to the treatment group of neighborhoods in Baltimore. Section 6.2 compares the Portland and Seattle regions, while Section 6.3 does the same for Baltimore and Philadelphia.

6.2 PORTLAND AND SEATTLE

The metropolitan region of Seattle was chosen as the control group to the Portland region.[86] Both regions are located in the fast-growing northwest region of the United States, share similar climates, experienced similar economic growth patterns, and are the largest metropolitan areas of their respective states. Section 6.2.1 presents data that addresses the potential threats to internal

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[86] The geographic definition of each region is based on O.M.B. designated boundaries as of 2000.

validity discussed in the previous section. The data illustrates the similar growth patterns of the two regions.

Sections 6.2.2 and 6.2.3 present a description of the growth management techniques adopted in the regions of Portland and Seattle, respectively. Urban growth boundaries were implemented in Portland in 1979. Almost fifteen years later, Seattle did the same. Because both regions eventually received the "treatment" of urban containment, the research design of the Portland/Seattle analysis is slightly modified from the "untreated control group with pretest and posttest" design that was selected for this research in Chapter Five. The research design for Portland/Seattle can be written as:

Portland Region:	X	O_1	X	O_2
- - - - - - - - - - - - - - - - - -				
Seattle Region:		O_1	X	O_2

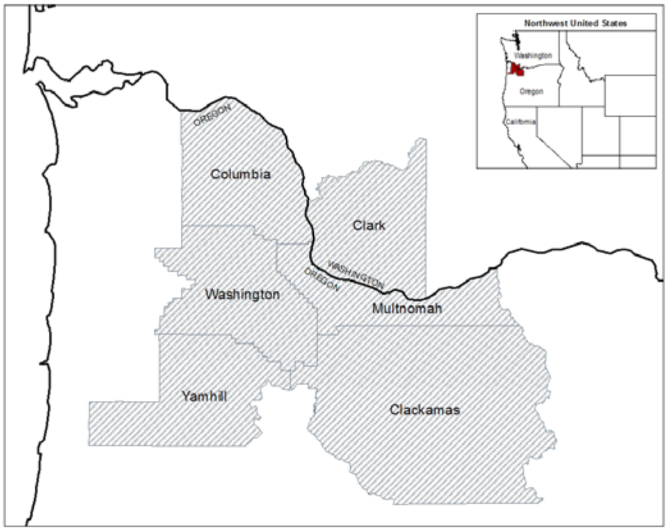
Where X is the treatment of urban containment (urban growth boundaries), O_1 is the test in 1990, and O_2 is the test in 2000.

The concept is still similar to the "untreated control group with pretest and posttest" research design. In O_1, we would expect to find different relationships among the smart growth principles and affordable housing between Portland and Seattle as only Portland had urban growth boundaries. In O_2, we would expect to find similar relationships among smart growth principles and affordable housing because both regions had urban growth boundaries. If there are significant (or insignificant) differences between Portland and Seattle in both 1990 and 2000, illustrating that the relationships had not changed, we can conclude that urban growth boundaries do not change the relationships between the smart growth principles and affordable housing.

6.2.1 Comparison of Regions

Portland is the largest metropolitan region of Oregon, while Seattle is the largest region of Washington State. As shown in Figure 6.1, the Portland region includes the counties of Clackamas, Columbia, Multnomah, Washington, and Yamhill in Oregon and Clark County in the state of Washington. With the exception of Clark, all counties and their municipalities throughout Portland received a mandate in 1973 to develop comprehensive plans addressing state-wide land use goals and including urban growth boundaries.

Figure 6-1. Portland Region



As shown in Figure 6.2, the Seattle region includes the counties of King, Snohomish, and Island in Washington State. The state's Growth Management Acts of 1990 and 1991 require most municipalities and counties to establish urban growth boundaries.

Figure 6-2. Seattle Region

Both Portland and Seattle experienced similar economic growth over the past twenty years. Both regions recovered from a stagnant economy during the 1980's to experience strong growth in jobs and household income during the 1990's. Table 6.1 shows the growth in income and jobs during the previous two decades.

Table 6-1. Economic Growth, 1980 to 2000

	Median Household Income[a]			Number of Jobs		
Region	**1980**	**1990**	**2000**	**1980**	**1990**	**2000**
Portland	$ 42,194	$ 41,658 (-1.3%)	$ 47,077 (13.0%)	620,954	756,324 (21.8%)	968,429 (28.0%)
Seattle	$ 47,270	$ 48,544 (2.7%)	$ 52,804 (8.8%)	815,306	1,086,190 (33.2%)	1,271,126 (17.0%)

a. Constant dollars (1999). Number in parentheses is percent change from previous decade.
Source: U.S. Census.

During the 1980's, Seattle's median household income increased by only 2.7% while Portland's median income declined by 1.3%, adjusted for inflation. Household income growth did not occur in either region despite a 33.2% increase in the number of jobs in Seattle and a 21.8% increase in Portland. Of the Portland region's 135,000 additional jobs, approximately 25,000 were in health and education, 24,000 in professional services, and 22,000 in retail. Of Seattle's 271,000 additional jobs during this time period, 44,000 were in the retail sector, 39,000 in professional services, and 35,000 in manufacturing.[87]

The 1990's brought strong economic growth, and higher household income, to both regions. Median household income increased by 8.78% in Seattle and by 13.01% in Portland, adjusted for inflation. During the 1990's, both regions saw an increase of jobs in higher-paying employment sectors, including the sectors of professional and scientific services, information, health, and education. Figure 6.2 lists the industry sectors which created, and lost, the greatest number of new jobs between 1990 and 2000.

The computer industry grew significantly in the Seattle region and was a significant driver of higher-paying employment.[88] Of the 185,000 additional jobs created in the Seattle region, 62,000 were in the scientific, professional (other than health and education) sectors,

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[87] Employment figures have been rounded to the nearest thousand.
[88] Jobs in computer and software development are categorized as employment in the 'information' and 'scientific, professional' sectors.

43,000 were in health, education, and social services, 36,500 were in the information sector, and 31,000 were in retail. At the same time, 37,000 jobs were lost in manufacturing and 8,000 were lost in the industries of natural resources such as forestry.

Table 6-2. Industries of Greatest Job Growth and Decline, 1990 to 2000

Seattle		**Portland**	
Job Growth		***Job Growth***	
Scientific, Professional	62,000	Health, Education, and Social Services	41,000
Health, Education, and Social Services	43,000	Scientific, Professional	38,000
Information	36,500	Retail	26,000
Retail	31,000	Construction	23,000
Job Loss		***Job Loss***	
Manufacturing	- 37,000	Natural Resource Industries	- 5,000
Natural Resource Industries	- 8,000		

Source: U.S. Census.

Of the 212,000 additional jobs in the Portland region, 41,000 were in health, education, and social services, 38,000 were in the scientific and professional sector, 26,000 in retail, and 23,000 in construction.[89] Employment in the natural resource industries declined by more than 5,000 jobs during the 1990's.

Table 6.3 provides data on population and household growth for both the Portland and Seattle regions. During the 1980's, Seattle experienced greater population growth than Portland. From 1980 to 1990, Seattle added approximately 381,000 residents for a 23.1% increase. Meanwhile, Portland's population increased by 182,000 residents, or by 13.6%. In terms of households, Seattle's growth was also stronger than that of Portland. Portland added approximately 80,000 households, for a growth rate of 15.7%, while Seattle added approximately 175,000 households, for growth of 27.6%.

Portland's population growth rate doubled in the 1990's and was similar to the growth of the Seattle region. While Seattle's population growth remained similar to the previous decade with another 381,000 residents added in the 1990's, Portland added 402,500 residents for an

[89] The Census' industry classifications were significantly modified between the 1990 and 2000 Census. The comparison between 1980 and 1990 is based on sectors as defined by the SIC. The comparison between 1990 and 2000 is based on sectors as defined by NAICS, the newer classification system. While 1990 figures could be re-categorized from SIC to NAICS classifications, it was less clear if a re-classification of 1980 figures would be reliable and, therefore, was not attempted.

increase of 26.6%. In terms of households, both regions added a similar number of households in the 1990's. The Seattle region gained 153,000 households, while Portland added 152,000.

Table 6-3. Population and Household Growth, 1980 to 2000

Region	Population			Households		
	1980 Population	1990 Population	2000 Population	1980 Households	1990 Households	2000 Households
Portland	1,333,572	1,515,452 (13.6%)	1,918,009 (26.6%)	509,845	590,049 (15.7%)	742,381 (25.8%)
Seattle	1,651,517	2,033,156 (23.1%)	2,414,616 (18.8%)	634,900	810,460 (27.6%)	963,957 (18.9%)

Note: Number in parentheses is percent change from previous decade.
Source: U.S. Census.

Because the regions had similar population growth during the 1990's, this variable should not explain any differences we may find between the two regions in terms of affordable housing in the 2000 analysis. However, Seattle likely had a somewhat stronger housing market in 1990 given that the number of new residents and new households in Seattle were more than double the number in Portland during the 1980's.

Table 6.4 provides data on construction costs in both regions. The R.S. Means Company produces an annual index of construction costs for 162 major U.S. and Canadian cities. The index is based on a scale in which 100 equals the average material and installation costs among 30 major U.S. cities. A city with a score higher than 100 has construction costs higher than the average while a score lower than 100 indicates construction costs lower than the average.

Table 6-4. Construction Cost Index for Portland and Seattle

Region	1990	1995	2000
Portland	101.0	105.2	106.0
Seattle	101.6	107.2	105.7

Source: R.S. Means Company, Inc.

In 1990, the construction cost index was 101.0 for Portland and 101.6 for Seattle. Therefore, construction costs in Portland were 1% higher than the average of major cities, while Seattle's costs were 1.6% higher. During the 1990's, both regions became more expensive in terms of construction costs in comparison to other cities. In 2000, Portland's costs were 6% higher than the average of major cities and Seattle's costs were 5.7% higher. Because the index scores are similar in both regions, constructions costs are not a factor in altering the outcome of the neighborhood-level analysis.

6.2.2 Background to Portland

Oregon is one of the first of few state governments to take a strong leading role in growth management (Gale 1992; Howe 1993; Nelson and Duncan 1995). In 1973, the Oregon state legislature created the Land Conservation and Development Commission (LCDC) to review comprehensive plans required of the state's cities and counties. Local municipalities were given the responsibility for developing and maintaining their comprehensive plans in accordance to goals established by LCDC. Counties were responsible for planning in their unincorporated areas.

The state, through LCDC, gave the final approval of all plans in a "top-down" system of control. Plans that were not initially accepted by the state were required to be revised until they were acknowledged (Knaap 1994, p. 13). By the end of 1974, LCDC adopted 14 initial planning goals required to be addressed by each comprehensive plan. Plans were required to address the following goals (Howe 1993, p. 64):

1. *Citizen Participation* – To ensure the opportunity for citizens to be involved in all phases of the planning process
2. *Land Use Planning* – To establish a land use planning process and policy framework which emphasizes an adequate factual basis for land use decisions
3. *Agricultural Lands* – To preserve and maintain agricultural lands
4. *Forest Lands* – To protect the State's forest economy consistent with sound resource management and to provide for recreational opportunities and agriculture
5. *Open spaces, scenic, and historic areas* – To conserve open space and protect natural and scenic resources
6. *Air, water, and land resources quality* – To maintain and improve the quality of the air, water, and land resources of the state
7. *Areas subject to natural disasters and hazards* – To protect life and property from natural disasters and hazards
8. *Recreational needs* – To satisfy the recreational needs of residents and visitors
9. *Economic development* – To provide adequate opportunities for a variety of economic activities through the state

10. *Housing* – To provide for the housing needs of citizens

11. *Public facilities and services* – To plan and develop a timely, orderly, and efficient arrangement of public facilities and services that serve as a framework for urban and rural development

12. *Transportation* – To provide and encourage a safe, convenient, and economic transportation system

13. *Energy conservation* –To conserve energy

14. *Urbanization* – To provide for an orderly and efficient transition from rural to urban land use

By the end of 1977, five additional goals were added by LCDC to protect the environmental resources associated with the state's coastline and waterways (Howe 1993, p. 64; Department of Land Conservation and Development 2000).

The impetus behind Oregon's growth management legislation was the protection of the natural resources of the Willamette River Valley in the face of growing development (Abbott 1997, p. 28). The Willamette Valley stretches for almost 100 miles south of Portland and includes a majority of the state's population, the state's three largest cities, as well as the state's most prime farmland (Howe 1993, p. 62; Abbott 2002, p. 211). The late 1960's and 1970's brought an economic boom to the region through its newly established electronics industry (Abbott 1997, p. 14). During these two decades, Oregon's population grew twice as fast as the national rate and much of the growth was captured in the Willamette River Valley. From 1950 to 1980, the state's population grew from 1.5 million to 2.6 million while the proportion living in the Willamette Valley increased from 65.3% to 67.9% (Knaap and Nelson 1992, p.18). At the same time, the valley produces about half of the state's agricultural products. The land of the Willamette Valley accounts for 83% of the Oregon's prime farmland and produces 48% of the state's agricultural products (Knaap and Nelson 1992, p. 131).

As population grew, farmers in the valley along with environmentalists feared that sprawl similar to that found in California would overtake the natural environment of the Willamette Valley. Farmers were concerned that urban development would ruin their livelihood by disrupting their agricultural production with scattered residential subdivisions (Abbott 2002, p. 211). Meanwhile, environmentalists were concerned with the impact of population growth on the loss of land and environmental amenities of the valley. At the same time, economic growth was being fueled by the development of the electronics industry which was bringing new young professionals to the state, and particularly to the Willamette Valley. Abbot (1997, p. 20) contended that these new professionals were attracted to the region not only by jobs, but also by its environmental amenities and outdoor opportunities. These new professionals, along with their employers, also had an interest in protecting the environment. As a result, farmers, environmentalists, young professionals, and other businessmen formed a strong coalition to protect the natural resources of the valley on one hand and yet not stifle economic development on the other (Knaap and Nelson 1992, p. 125).[90]

The comprehensive nature of Oregon's planning goals makes the state's growth management legislation one the most innovative in the U.S. (Howe 1993). The wide-ranging goals are the result, as well as a cause, of the broad coalition supporting the state's growth management laws. Farmers have consistently supported growth management in the Willamette Valley to protect their income and way of life, which is represented by the goal to preserve farmland (goal #3). Environmentists support the goals pertaining to the preservation of land and natural resources. Developers support growth management to the extent that it provides easily identified rules for development and hastens the approval process. Downtown businesses support growth management to the extent that it promotes development and revitalization of the central city (Leo 1998).

The primary feature of Oregon's growth management legislation is the urban growth boundary (Abbott 2002, p. 213). The primary purpose of the urban growth boundary is to achieve goal #14 of urbanization, which is "to provide for an orderly and efficient transition from rural to urban land use to accommodate urban population and urban employment inside urban growth boundaries, to ensure efficient use of land, and to provide for livable communities" (Department of Land Conservation and Development 2005). The urbanization guideline requires cities, counties, and in the case of Portland, regional government to establish and maintain urban growth boundaries (UGB) outside of which urban development is prohibited. To set the boundary lines of the UGBs, government units must consider the projected needs for housing, employment, and public facilities based on a twenty year population forecast.

UGBs, by designating the location of future development, are closely related to a number of the other goals in addition to the goal of planned and controlled urbanization. Table 6.5 lists the LCDC goals that UGBs can help to achieve. They include the preservation of farmland,

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[90] For readings on political culture and the politics of coalition-building for Oregon's growth management legislation, see Abbott (1997; 2002), Leo (1998), and Durant, Thomas, and Haynes (1993). For a discussion of the political divisions during the passage and implementation of the 1973 land use bill, see Knaap (1994).

preservation of open space, and the orderly and efficient placement of infrastructure. The UGBs preserve agricultural land (goal #3) and open spaces (goal #5) by prohibiting development outside of the urban boundaries.

Table 6-5. Goals of which Urban Growth Boundaries are a Tool to Acheive

Goal	Definition	How UGB Achieves Goal
#3 – Agricultural Lands	To preserve and maintain agricultural lands	Prohibits development on farmland outside of boundaries
#5 – Open Spaces and Scenic Areas	To conserve open space and protect natural and scenic resources	Prohibits development on undeveloped land outside of boundaries
#11 – Public facilities and services	To plan and develop a timely, orderly, and efficient arrangement of public facilities and services that serve as a framework for urban and rural development	Development occurs in a more contiguous manner, reducing infrastructure costs.
#14 – Urbanization	To provide for an orderly and efficient transition from rural to urban land use	Land must first be developed within the boundaries. Incremental expansions of the boundaries occur as

Source: Howe (1993, p. 64) and Abbott (2002, p. 214).

With the establishment of UGBs, public facilities and infrastructure are developed and operated in a more efficient manner (goal #11) for two reasons. First, public infrastructure will be expanded in an orderly fashion as the boundaries prohibit large-scale development on the rural fringe which would otherwise occur. New development occurs within closer proximity to current development and existing infrastructure. This closer proximity reduces the distance and cost of expensive public infrastructure extensions (Nelson and Duncan 1995).

The second reason that UGBs help to achieve more efficient infrastructure is by increasing density. Chapter Four provided an explanation for greater development density in response to an urban containment policy, including urban growth boundaries. Urban growth boundaries restrict the supply of developable land. As a result, the price of developable land increases. Developers then choose to invest more capital in structures per unit of land. This results in an increase in density. Greater population density means that there are more people per unit of infrastructure, making more efficient use of it.

As a result of Oregon's growth management legislation, the Portland Metro adopted and implemented their initial UGB in 1979. The Portland Metro is unique in that it is responsible for designating and implementing an urban growth boundary that surrounds the City of Portland and twenty-six of its suburban municipalities. Typically, growth boundaries are implemented by local jurisdictions or counties to control local growth rather than in a regionally unified manner (Abbott 2002, p. 214). The Portland Metro is the only regional organization in Oregon to be responsible for a UGB. Throughout the remainder of the state, UGBs are implemented by each local municipality and county. The Metro's UGB covers portions of Clackamas, Multnomah, and Washington counties. The other two Oregon counties of the Portland region, Columbia and Yamhill, oversee UGBs within their borders independent of the Portland Metro. Meanwhile, Clark County, located in Washington State, did not establish UGBs until 1994 in response to that state's Growth Management Acts in 1990 and 1991.

State level oversight of comprehensive planning led to smaller UGBs and higher density than localities would have implemented on their own (Howe 1993, p. 66; Knaap 1994, p. 13-14). LCDC, the state agency given the responsibility for approving or rejecting local plans, was unwilling to accept plans which the agency considered to include too much land and minimal density requirements within the urban growth boundaries. Many times, LCDC sided with environmental organizations who wanted small growth boundaries rather than municipalities who wanted larger boundaries in which to place future development (Knaap 1994). LCDC was able to enforce smaller boundaries and higher densities by rejecting local plans and, as a result, withholding state funds or threatening to temporarily suspend local land use powers until local plans were determined to be in compliance with LCDC's goals and criteria.

6.2.2.1 Affordable Housing Policy

Meeting the housing needs of the state's citizens (goal #10) is a significant planning goal of Oregon's growth management legislation (Toulan 1994). LCDC states that for localities to achieve this goal:

> Buildable lands for residential use shall be inventoried and plans shall encourage the availability of adequate numbers of needed housing units at price ranges and rent levels which are commensurate with the financial capabilities of Oregon households and allow for flexibility of housing location, type, and density (Department of Land Conservation and Development 2005, Goal 10).

Table 6.6 lists four significant affordable housing policies established by the state and Portland Metro to achieve the housing goal since the implementation of urban growth boundaries in 1979.

Table 6-6. Affordable Housing Policies of Portland Metro

Policy (Year)	Purpose	Requirement	Reason Policy was Established
Metropolitan Housing Rule (1981)	"Assure opportunity for the provision of adequate numbers of needed housing units and efficient use of land within the Metropolitan Portland urban growth boundary."	Minimum density requirements for local municipalities within Portland Metro's jurisdiction: 6 largest cities – 10 units per net buildable acre; Moderate sized cities – 8 units per net buildable acre; Smallest communities – 6 units per net buildable acre.	Local jurisdictions were not adequately addressing the state's housing goal in their initial comprehensive plans required by the state.
Regional Framework Plan (1997)	Reemphasize need for affordable housing throughout the region.	Establishment of the Affordable Housing Technical Advisory Committee (H-TAC) to discuss potential solutions to affordable housing problem.	Strong growth in housing prices during the early 1990's. Median house value grew more than twice as fast as median household income.
Regional Affordable Housing Strategy (2000)	Identify strategies to address the affordable housing problem.	Estimated fair-share housing allocations for each municipality within the jurisdiction of the Portland Metro. No requirements for municipalities to adopt them.	Municipalities were reluctant to address affordable housing issues.
Title 7 of Urban Growth Management Functional Plan (2001)	Encourage municipalities to adopt strategies to increase supply of affordable housing.	Required municipalities to submit reports to Portland Metro regarding their progress in addressing affordable housing. Adoption of specific strategies is voluntary.	Municipalities were reluctant to address affordable housing issues.

Source: (Knaap and Nelson 1992, p. 79; Portland Metro 2000, 2004).

One of the earliest problems in the Portland region regarding growth management and affordable housing was the reluctance among local municipalities to address the state's housing goal. Frustrated by local jurisdictions submitting initial comprehensive plans that were then rejected by LCDC because they included low-density zoning which would exclude housing for low-income households, the state passed the Metropolitan Housing Rule (MHR) in 1981 (Knaap and Nelson 1992, p. 78; Toulan 1994, pp. 102-105). The most important aspect of the MHR is its minimum density requirements for each municipality within the Portland Metro's jurisdiction. The minimum density requirement is six, eight, or ten units per net buildable acre depending on the size of the municipality (Portland Metro 2000, 2004).[91] Another important aspect of the MHR is that also requires the Portland Metro to take steps to ensure that 50% of the new housing built in the urban portions of Multnomah, Washington, and Clackamas Counties be attached single-family or multi-family housing (Portland Metro 2004).

The MHR is credited as one reason for the success of Portland's growth management system, particularly with regard to the public acceptance of the urban growth boundaries (Toulan 1994; Leo 1998). If the implementation of urban growth boundaries increased housing prices, households would have a legitimate complaint against them. By increasing housing density and the supply of multi-family units, housing could remain affordable for most households even though the amount of land available for development was restricted. Hale (1991) argued that from 1985 to 1989 the Metropolitan Housing Rule's density requirements increased the number of housing units allowed on available land from 129,000 units to 240,950 units.

The second important result of the housing rule is that local politicians who were opposed to multi-family housing for political purposes could accept smaller housing units without taking personal responsibility (Hale 1991, p. 14; Leo 1998, p. 372). Local officials could approve multi-family units and, at the same time, explain to disgruntled constituents that the state forced their decision to do so. Knowing that all municipalities faced the same rule also reduced local opposition to multi-family housing.

In 1997, the Portland Metro adopted a Regional Framework Plan which reemphasized the need for affordable housing throughout the metropolitan area as the affordability of housing in the region declined. As will be described in Section 6.2.4, Portland's housing market was strong in the early 1990's as a result of a booming economy. Portland's housing market was becoming over-priced for the median household and losing affordable housing for lower-income households. The median value of a home grew more than twice as fast as median household income (U.S. Census Bureau 2000).

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[91] The minimum density requirements for specific cities and urban portions of Clackamas, Multnomah, and Washington Counties can be found on page 21 (Chapter One – Land Use) of the Metro's Regional Framework Plan (2004) or in Knaap and Nelson (1992, p. 79).

The Regional Framework Plan called for the creation of the Affordable Housing Technical Advisory Committee (H-TAC) to bring local government representatives, developers, businesses, and affordable housing advocates together to discuss solutions to the growing affordable housing problem (Portland Metro 2004). H-TAC published the Regional Affordable Housing Strategy (RAHS) in 2000, providing an analysis of the need for affordable housing, as well as a detailed list of strategies that could be implemented at the regional and local levels to satisfy that need (Portland Metro 2000). The RAHS estimated the fair-share of affordable housing each municipality was expected to attempt to attain. The estimates were based on each municipality's current population, current housing stock, and future projected growth.[92]

Based on recommendations from H-TAC, affordable housing production goals and strategies to reach them were added in Title 7 of the Metro's Urban Growth Management Functional Plan (UGMFP) (Portland Metro 2004). Title 7 requires municipalities within the Metro's jurisdiction to submit progress reports to Metro regarding their progress in addressing affordable housing needs. Each jurisdiction is required to consider strategies for increasing the supply of affordable units for low-income households. The strategies include (Portland Metro 2004, pp. 42-45; 2005):

- Density bonuses
- No-net-loss housing policies
- Inclusionary housing policies
- Transfer of development rights
- Examine zoning codes for ways to reduce development costs
- Review regulatory constraints, discrepancies in planning and zoning codes, local permitting or approval processes
- Review parking requirements for ways to reduce development costs

Despite the efforts of H-TAC, there is evidence of a lack of will among local jurisdictions to adopt these affordable housing strategies. Municipalities only must "consider adopting a voluntary affordable housing production goal and a list of specific affordable housing strategies and tools" to meet the goal (Portland Metro 2004). Municipalities must meet density and multi-family housing requirements established by the Metropolitan Housing Rule, but no other strategies are mandated. The only requirement of Title 7 is that jurisdictions provide an

[92] For specific affordable housing targets for each municipality see page 18 of the Regional Affordable Housing Strategy report.

explanation why any of the strategies recommended by H-TAC and Metro were not adopted. However as of the end of 2003, 14 out of 27 jurisdictions had not complied with the requirement to submit a progress report regarding their consideration of these affordable housing strategies (Portland Metro 2004). Without legislation requiring to do so, local municipalities have been slow to address the affordable housing goals on their own.

6.2.3 Background to Seattle

Washington's Growth Management Acts of 1990 and 1991 require comprehensive planning among counties and their municipalities. The planning mandate applies to counties with a 20% population growth rate from 1980 to 1990 or those with a population greater than 50,000 residents and a 17% growth rate (Weitz 1999, p. 114). Currently, sixteen counties in the state are required to have comprehensive plans and another ten counties have them voluntarily (DeGrove 1994, p. 238; Weitz 1999, p. 114).

Comprehensive plans of both municipalities and counties are required to include thirteen primary goals. Many of these goals complement one another with a unified aim to preserve open space and other environmental resources, ensure efficient and orderly extensions of infrastructure, and manage the balance between economic growth and environmental protection. The goals are (Washington Research Council 2001, p. 2):

1. *Urban growth* – Encourage development in urban areas where adequate public facilities and services exist or can be provided in an efficient manner

2. *Reduce sprawl* – Reduce the inappropriate conversion of undeveloped land into sprawling, low-density development

3. *Transportation* – Encourage efficient multi-modal transportation systems that are based on regional priorities and coordinated with county and city comprehensive plans

4. *Housing* – Encourage the availability of affordable housing to all economic segments of the population, promote a variety of residential densities and housing types, and encourage preservation of existing housing stock

5. *Economic development* – Encourage economic development throughout the state that is consistent with comprehensive plans, promote economic opportunity for all citizens, and encourage growth in areas experiencing insufficient economic growth, all within the capacities of the state's natural resources, public services, and public facilities

6. *Property rights* – Private property shall not be taken for public use without just compensation having been made.

7. *Permits* – Applications for both sate and local governments should be processed in a timely and fair manner to ensure predictability

8. *Natural resource industries* – Maintain and enhance natural resource-based industries, including productive timber, agricultural, and fisheries industries. Encourage the conservation of productive forest lands and productive agricultural lands, and discourage incompatible uses

9. *Open space and recreation* – Encourage the retention of open space and development of recreational opportunities

10. *Environment* – Protect the environment and enhance the state's high quality of life, including air and water quality, and the availability of water

11. *Citizen participation and coordination* – Encourage the involvement of citizens in the planning process and ensure coordination between communities and jurisdictions to reconcile conflicts

12. *Public facilities and services* – Ensure that public facilities and services necessary to support development shall be adequate at the time the development is available for occupancy

13. *Historic preservation* – Identify and encourage the preservation of lands, sites, and structures, that have historical or archaeological significance

Washington's Growth Management Act was the result of concerns among the state's citizens, particularly those living in urban areas of the Puget Sound region, regarding population growth, urban development, and the loss of natural resources. The state's population more than doubled from 2.4 million to 4.9 million residents from 1950 to 1990, with much of that growth captured by the Puget Sound region, particularly the Seattle metropolitan area (Staley and Gilroy 2001, p. 12). After a recession during the late 1970's and the early 1980's, the late 1980's brought a resurgence of urban growth in the metropolitan area of Seattle. The growth was captured not only in the city of Seattle, but was felt in the suburbs which were fast becoming home to large corporate campuses, such as Microsoft (Fulton et al. 2006, p. 27). At the same time, Seattle lies within the Puget Sound Region which is an area known for its environmental amenities and natural resources of forests and water life.

The goals of Washington's Growth Management Act were heavily drawn from Oregon's experience, particularly with regard to protection of the state's natural resources while planning for and managing economic development and growth (DeGrove 1994). Table 6.7 compares the states of Washington and Oregon with regard to growth management.

Table 6-7. Comparison of Growth Management between Washington and Oregon

	Washington	***Oregon***
Year Passed	1990/1991	1973
Form of Urban Containment	Urban Growth Area (same as Urban Growth Boundary)	Urban Growth Boundary
Year Urban Containment Implemented in Region of Interest to this Research	1995 (Seattle)	1979 (Portland)
Enforcement Approach	Bottom-Up	Top-Down
Housing Goal Required in Comprehensive Plans	Yes	Yes
Minimum Density Requirements	Minimum density established by Growth Management Hearing Boards of the Seattle Region is 4 units per buildable acre.	Minimum densities of 6, 8, to 10 units per buildable acre in Portland Region. Established by Metropolitan Housing Rule.

Source: (Gale 1992; Dawkins and Nelson 2003; Futurewise 2005).

A significant tool required by Washington's Growth Management Act is the designation of urban growth areas, outside of which urban development is prohibited.[93] The Puget Sound Regional Council provides the following summary of the urban growth area:

> Urban growth areas must be designated by counties, in consultation with municipalities. There areas are to accommodate 20 years of growth, based on projections provided by the Washington State Office of Financial Management (OFM). Urban growth area designations are to be reviewed every 10 years. No annexations are allowed beyond designated growth areas (Puget Sound Regional Council 2005).

Urban growth areas are closely related to a number of the state's growth management goals, including the goals to reduce sprawl (goal #2), encourage development where adequate infrastructure exists and ensure that public facilities and services are available to serve development prior to the time of occupation (goals #1 and #12), encourage the retention of open space (goal # 9), and encourage the availability of a wide range of housing densities and types to meet the needs for all income groups (goal #4). Section 36.70A.110, "Comprehensive plans –

[93] In Washington State, this tool is called an urban growth area. In Oregon, the tool is called an urban growth boundary. They each refer to the same concept.

Urban growth areas," of the state's growth management legislation explicitly links each of these goals to urban growth areas.

Urban growth areas encourage development in areas with adequate infrastructure because the state requires urban growth areas to first be located where infrastructure and development already exist. The urban growth areas can then include land that is expected to be provided with public infrastructure in the future. The state mandate includes a stipulation that development cannot actually occur in locations within the urban growth area until public services and infrastructure are ensured to be available at the time the development is occupied.[94]

Urban growth areas are also expected to assist local jurisdictions in meeting the housing goal. The state requires that comprehensive plans permit a range of housing densities within urban growth areas to accommodate housing needs for current and future households. However, there are few specific guidelines pertaining to actual density targets which localities are expected to achieve.

Dawkins and Nelson (2003) refer to Washington's growth management system as a "bottom-up" approach in which local governments have a great degree of authority over their comprehensive plans. Unlike Oregon's Land Conservation and Development Commission (LCDC), there is no state level agency with the authority to impose rigid standards and reject local plans (Gale 1992, p. 426-427; Fulton 1999, p. 19). The state's Department of Community Development is able to review and comment on local plans, but does not determine if they are out of compliance. At the time of submission, plans are assumed to be in compliance with state requirements until they are challenged by an interested third-party.

The Growth Management Acts created three regional Growth Management Hearing Boards to hear complaints filed by third-party organizations or individuals regarding municipal and county comprehensive plans. After a complaint is filed, it is the responsibility of these regional hearing boards to then determine if a plan is in compliance with the growth management laws. If a municipality's or county's plan is determined to be out of compliance, the state is able to withhold certain streams of revenue, particularly resources which are distributed by the state from the gas tax, liquor taxes, and sales tax (Gale 1992).

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[94] This requirement is concurrency, which was modeled after Florida's growth management legislation. The concurrency requirement is applicable to roads, sewers, and water supply (DeGrove 1994, p. 239).

Amendments to the Growth Management Acts, passed in 1997, have given more control to local and county governments over their plans. Prior to 1997, complainants only had to illustrate to a Growth Management Hearing Board that there was a "preponderance of evidence" that a locality's comprehensive plan was out of compliance of state goals. The 1997 amendments modified the growth management legislation to require complainants to show that a locality's plans and development regulations are "clearly erroneous" in order to have them judged as out of compliance of state goals. This is higher standard of review which makes it more difficult for interested parties, such as environmental organizations, to challenge a locality's comprehensive plans (Black 1998).

6.2.3.1 Affordable Housing Policy

Counties and local municipalities are required to include a housing element in their comprehensive plans, providing a blueprint for achieving affordable housing for all income groups. The housing element must include:[95]

1. An analysis and inventory of existing and projected housing needs that identifies the number of housing units necessary to manage projected growth;

2. A statement of goals, policies, objectives, and mandatory provisions for the improvement, and development of housing, including single-family residences;

3. Identification of sufficient lands for housing, including all types of housing such as government-assisted housing, housing for low-income families, manufactured housing, multifamily housing, and group homes; and

4. Adequate provisions for existing and projected needs of all economic segments of the community.

Counties and local jurisdictions are responsible for addressing in their plans a 'fair' distribution of affordable housing for low-income households throughout the county based on projections of future population and job growth (Washington Research Council 1998, p. 22-23). A significant factor influencing each county's projection is the definition of affordability. However, the state does not mandate a specific definition of "affordability" nor does it specify a

[95] From the Revised Code of Washington (RCW), Section 36.70A.070, "Comprehensive plans – Mandatory Elements."

definition of “low-income” households. Counties are free to adopt their own definition of affordability, as well choose the level of income at which they want to focus their housing affordability efforts (Washington Research Council 1998).

In its comprehensive plan’s housing element, King County which includes the City of Seattle focuses on the housing needs of very low-income households with income less than 50% of the area’s median, as well as low-income households with income of 50% to 80% of the area’s median. King County expects its jurisdictions to plan for at least 17% of their housing units to be affordable to low-income households and 24% to be affordable for very low-income households (King County 2004, Chapter 2, p. 35). To achieve this goal, King County suggests that jurisdictions adopt density bonuses for developers who include affordable housing in their new developments; reduce impact fees for the development of housing units that service low-income households; and expedite review plans for housing developments which serve low and moderate-income households (King County 2004, Chapter 2, pp. 37-38).

The housing element of Snohomish County’s comprehensive plan focuses on the distribution of affordable housing units for low/moderate-income households. The county defines a household as having a “housing need” if its income is less than 95% of the median income and it is spending more than 30% of its income on housing (Washington Research Council 1998, p. 25). The county calculates the total number of households that currently have, and are expected to have in the future, “housing needs” in the county. It then allocates this total number of “housing needs” to local jurisdictions to achieve a “fair-share” distribution of affordable housing. The purpose of this allocation is to ensure that low-income housing is not concentrated in any one jurisdiction.

Snohomish County’s fair share housing allocation for “housing need” households is based on three primary factors (Snohomish County Tomorrow 2005, Executive Summary, p. 2). These factors are:

1. The existing need in each jurisdiction and the county.

2. The proportion of low-income jobs within or adjacent to the jurisdiction as compared to the countywide proportion. The fair-share allocation is adjusted upward for a jurisdiction which has a greater than average proportion of low-income jobs.

3. The proportion of low cost housing units in each jurisdiction’s total housing stock as compared to the countywide average. Jurisdictions with a smaller proportion of low cost housing in comparison to other jurisdictions are given an increase in their fair-share

allocation, while jurisdictions with a larger than average proportion are given a decrease in their allocation.[96]

The county recommends, but does not mandate, specific tools to increase the supply of affordable units. These strategies include reviewing parking, sidewalk, and curb requirements which may result in more expensive housing than necessary, reducing impact fees, streamlining the approval process to reduce costly delays in approval, and reviewing land use regulations to make sure they do not impede higher density and mixed use development (Snohomish County Tomorrow 1994, 2005).

Despite the autonomy among counties regarding their affordable housing policies, there is one "regional" policy which may have an impact on the supply of housing, and the supply of affordable housing for lower income households. Two regional Growth Management Hearing Boards have established a minimum acceptable density for new development within urban growth areas. The Central Puget Sound and Western Washington Growth Management Hearing Boards, which combined cover the three counties of the Seattle Metropolitan Statistical Area, have established a minimum density of four single-family dwellings per net buildable acres (Futurewise 2005, p. 3). Densities below this minimum are not considered urban and therefore not acceptable within the urban growth areas. This minimum density is not as high as Portland's Metropolitan Housing Rule which requires jurisdictions to try to achieve densities of six, eight, or ten units per net buildable acre and likely has less impact on the supply of affordable housing than Portland's rule.

6.2.4 Housing Affordability in Portland and Seattle

Section 6.2.2 and 6.2.3 reviewed the state growth management mandates regarding urban growth boundaries, as well as affordable housing policies, in the metropolitan regions of Portland and Seattle, respectively. The sections first described each state's growth management legislation and their requirement for local jurisdictions to designate urban growth boundaries. Urban

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[96] For specific allocations for each jurisdiction, as well as details of the methodology for calculating the fair-share allocation, see the *2025 Fair Share Housing Allocation* report published by Snohomish County Tomorrow (2005).

growth boundaries are one of the most significant aspects to growth management in both states and, in turn, in both regions.

The sections then provided a review of each region's policies regarding affordable housing for low-income households. The planning organization for the Portland region has a 'regional' requirement that all jurisdictions consider voluntarily adopting specific strategies to increase the supply of affordable housing. The jurisdictions must report to the Portland Metro their progress in considering the various strategies, even though not all jurisdictions have done so. Additionally, the Portland Metropolitan Housing Rule requires localities to have density targets of six, eight, or ten units per acre. In contrast, there are no regional requirements for affordable housing strategies in the Seattle region with the exception of a density minimum for new development of four units per acre established by the regional growth management hearing boards.

This section compares six measures of housing affordability within both regions from 1990 to 2000. Table 6.8 lists these six measures which include three for renter households and three for homeowner households. The first measure is the median gross rent for rental units, but this does not indicate affordability without a comparison to income. The second measure is the ratio of median gross rent to median income for renter households. The third measure is the ratio of the percentage change in median gross rent to the percentage change in median household income for renter households during this same time period. This ratio captures the growth of rental costs relative to the growth in household incomes for renter households. The fourth measure is the median home value for owner-occupied housing units. The fifth measure is the ratio of median home value to median income for homeowner households for homeowner households. The sixth measure is the ratio of the percentage change in median home values to the percentage change in median household incomes from 1990 to 2000 for homeowners.

As shown in Table 6.8, the median gross rent to median income ratio did not significantly change in either region for renter households from 1990 to 2000. In 1990, Portland's ratio of median gross rent to median household income was .169. This value means that the median renter household spent 16.9% of its income on rental costs. By 2000, Portland's median gross rent to median household income ratio was .171 indicating only a minor increase as the median renter household was spending 17.1% of its income on rental costs. In the Seattle, the ratio only increased from .171 to .172 in the same time period.

Table 6-8. Housing Affordability in Portland and Seattle

	1990 Portland	1990 Seattle	2000 Portland	2000 Seattle
Rental Units				
Median Rent	$ 436	$ 514	$ 672	$ 758
Ratio of Median Rent to Median Income for Renter Households	.169	.171	.171	.172
Ratio of Percentage Change in Median Rent to Percentage Change in Median Household Income, 1990 to 2000, for Renter Households	NA	NA	1.04	1.03
Owner-Occupied Units				
Median Value	$ 72,563	$ 135,763	$ 170,000	$ 223,100
Ratio of Median Home Value to Median Income, 1990 and 2000, for Homeowner Households	2.34	3.76	3.61	4.23
Ratio of Percentage Change in Median Home Value to Percentage Change in Median Household Income, 1990 to 2000, for Homeowner Households	NA	NA	2.59	1.39

Note: "Rent" is gross rent which includes utility costs. Figures are not adjusted for inflation.
Source: U.S. Census.

From 1990 to 2000, the ratio of the percentage change in median gross rent to percentage change in median household income for renter households was not significantly different between Portland and Seattle. The ratio was 1.04 in Portland and 1.03 in Seattle. This indicates that rental costs increased 4% and 3% faster than income in each region, respectively.

The ratio of median home value to median household income for owner-occupied housing units tells a different story. In both 1990 and 2000, median home value relative to median household income was higher in Seattle than in Portland. But from 1990 to 2000, home values grew significantly faster relative to income in Portland than in Seattle. In 1990, the ratio of the median home value-to-median household income was 2.34 in Portland as compared to 3.76 in Seattle. This comparison indicates that Seattle's median house was 3.76 times higher in value than the median household's income and 2.34 times higher in Portland. By 2000, the ratio increased from 2.34 to 3.61 in the Portland region, which was a 54.3% increase. It increased from 3.76 to 4.23 in the Seattle region during the same time period, which was a 12.5% increase.

The ratio of the percentage change in median home value to percentage change in median household income for homeowner households was much higher in Portland than in Seattle. During the 1990's, Portland was experiencing a much tighter housing market in home ownership opportunities that Seattle. In Portland, the ratio was 2.59, indicating that the increase in the median home value was 159% higher than the increase in median household income. Meanwhile, the ratio in Seattle was 1.39 indicating that the median home value in Seattle increased only 39% faster than household income.

While these measures provide insight into changes in housing affordability for the median household, changes in affordability may vary for different income groups, particularly for low-income households. To measure affordability for low-income households, a gap ratio can be used to measure the number of affordable units to the number of low-income households. Because rental units are the most important component of the housing stock for extremely low-income and very low-income households, this analysis focuses on the rental market. The value of the ratio can be interpreted as the proportion of low-income renters who would be able to occupy an affordable unit if all of the units were available to them. A ratio with a value less than 1 signifies that there are more low-income renter households than affordable rental units. Similarly, a ratio with a value greater than 1 indicates there are more affordable units than renter households.

Table 6.9 provides the gap ratio for extremely low-income, very low-income, and low-income renter households.[97] The table also includes the number of renter households in each income category, as well as the number of rental units affordable to them. In 1990, the gap ratio for extremely low-income renter households was .49 in both regions. These ratios mean that of the renter households earning less than 30% of the area's median income only 49% would be

[97] Section 2.1 defines these income categories, as well as provides the definition of 'affordable' units. Following the example in Table 2.3, the income categories in Table 6.9 are cumulative. Extremely low-income, very low-income, and low-income households have income less than 30%, 50%, and 80% of the area median income, respectively. Affordable housing is housing that costs less than 30% of household income. An affordable rental unit for a given income category is a unit whose gross rental cost is less than 30% of the highest possible income for that income category.

able to occupy an 'affordable' rental unit if all of them were available. In 2000, this ratio had dropped to .36 in Portland, for a 26.5% decline, and to .48 in Seattle, for only a 2.0% decline.

Table 6-9. Supply of Affordable Rental Units to Number of Low-Income Renter Households[a]

	Portland Region			Seattle Region		
	1990	**2000**	**% Change**	**1990**	**2000**	**% Change**
Extremely Low-Income						
Gap Ratio	.49	.36	-26.5%	.49	.48	-2.0%
# of renter households	54,822	64,678	18.0%	73,286	93,969	28.2%
# of affordable rental units	26,698	23,105	-13.5%	35,606	45,382	27.5%
Very Low-Income						
Gap Ratio	1.29	1.13	-12.4%	1.21	1.13	-6.6%
# of renter households	97,664	117,397	20.2%	133,042	172,246	29.5%
# of affordable rental units	125,577	133,240	6.1%	161,606	194,805	20.5%
Low-Income						
Gap Ratio	1.33	1.38	3.8%	1.31	1.15	-12.2%
# of renter households	154,006	184,919	20.1%	217,858	260,972	19.8%
# of affordable rental units	205,540	237,367	15.5%	285,397	301,041	5.5%

a. Income categories are cumulative.
Source: U.S. Census.

The gap ratio is influenced by both a change in the number of low-income renter households, as well as a change in the supply of affordable housing units. In Portland, the gap ratio for extremely low-income renter households declined because the number of extremely low-income renter households increased by 9,856, or 18%, while the number of affordable rental units declined by 3,593, or 13.5%. In contrast, Seattle also had an increase in the number of extremely low-income renter households by 28.2%, or by 20,683 households, but the region also had a 27.5% increase in the number of rental units affordable to extremely low-income renter households.

Why did the number of affordable rental units for extremely low-income renter households increase in Seattle, but decline in Portland? One plausible explanation is the extraordinary strength of the housing market in Portland during the 1990's. While both Seattle and Portland experienced strong economic growth and little change in affordability of rental units to the median income household, the value of owner occupied units relative to income increased much greater in Portland than in Seattle. In Section 4.1, the theoretical framework suggests that strong increases in housing prices in the general housing market give owners of low-quality housing, which is more likely affordable than higher-quality housing, an incentive to upgrade their units. If this occurs, affordable housing is lost for low-income households. Extremely low-income renter households in Portland were the only income group to see a decline in the number of rental units affordable to them from 1990 to 2000.

The gap ratio also declined for very low-income renter households (those with incomes less than 50% of the area's median). The ratio of affordable rental units to very low-income renter households declined from 1.29 to 1.13, or by 12.4%, in Portland and from 1.21 to 1.13, or by 6.6%, in Seattle. This decline occurred despite an increase in the number of affordable rental units for very-low income households in both regions. Portland experienced an increase in the number of affordable rental units for very low-income households by 6.1%, or 7,663 rental units. However, the number of very low-income renter households increased by 20.2%, or 19,733. In contrast, Seattle experienced a much greater increase in the number of affordable rental units for very low-income renter households. The number of very low-income rental units increased by 33,199 units, or 20.5%. The number of very-low income renter households increased by 39,204 households, or 29.5%.

The growth in affordable rental units for very low-income renter households was smaller in Portland than in Seattle. Once again, this smaller growth may be the result of Portland's expensive homeownership market, encouraging landlords to upgrade their low-quality units. Such a strong housing market may also make it less likely for units to be converted to rental units, and particularly low-income rental units. Absentee-owners of housing units may find it more profitable to sell the units as owner-occupancy opportunities than to keep them for rentals.

The broadest definition of "low-income" includes all households whose income is below 80% of the area median income. From 1990 to 2000, the ratio of affordable rental units to the number of low-income renter households increased from 1.33 to 1.38, or 3.8%, in Portland. In contrast, the ratio declined from 1.31 to 1.15, or 12.2%, in Seattle.

In both regions, the number of affordable units to low-income households increased. The supply increased by 15.5%, or 31,827 units, in Portland and by 5.5%, or 15,644 units, in Seattle. This difference between the two regions is interesting in that Seattle had greater growth than Portland in the number of rental units affordable to extremely low-income and very low-income renter households, yet had smaller growth than Portland in the number of affordable rental units to all low-income renter households. In Seattle, the decline in the ratio between the number of affordable rental units and the number of low-income renter households was the result of large growth in the number of low-income households. The number of low-income renter households increased by 19.8%, or 43,114, in Seattle as compared to the increase in affordable rental units by 15,644 units.

In summary, this comparison of housing affordability between the regions of Portland and Seattle indicate that Portland experienced a greater loss in housing affordability during the 1990's than Seattle. While affordability in the rental market remained fairly constant for the median renter households in both regions, values in the homeownership market grew much faster for the median household in Portland. The supply of affordable rental units for very low-income and extremely low-income renters is of primary importance to this research. Portland saw a much larger decline in the number of affordable rental units relative to the number of extremely low-income and very low-income renter households than Seattle.

6.2.5 Summary of Portland and Seattle

Table 6.10 provides a summary of the most important comparisons between Portland and Seattle made in Section 6.2. Urban growth boundaries were established in the Portland region in 1979 while they were not established throughout the Seattle region until 1995. This difference in the timing of the urban containment policies makes the two regions potential comparative regions regarding the impact of urban containment policies. *For fifteen years, Portland had an urban containment policy while the Seattle region did not.*

In comparison to the Seattle region, Portland experienced a greater growth rate in jobs and household income during the 1990's. Not unexpectedly, Portland also experienced a greater decline in affordability than Seattle during this time period, particularly with regard to home ownership opportunities.

Of significant importance to this research is the change in each region's ability to meet the housing needs of extremely low-income and very low-income renter households. In both regions, the gap between the number of affordable units and the number of extremely low-income and very low-income renter households increased. However, the actual number of affordable rental units only declined for extremely low-income renter households in Portland. The gap increased for very low-income renter households in both regions, as well as for extremely low-income renter households in Seattle, because of a large increase in the number of low-income renter households rather than a decline in the number of affordable units.

Table 6-10. Summary Comparison of Portland and Seattle Regions

	Portland	Seattle
Urban Containment Policy	Urban growth boundaries required in 1973, implemented in 1979	Urban growth boundaries required in 1990/91, fully implemented in region in 1995
Regional Affordable Housing Strategy	1. Metropolitan Housing Rule, minimum density targets of 6-8-10 units per acre 2. Regional Affordable Housing Strategy requires jurisdiction to voluntarily consider strategies to increase affordable housing, but no mandates to implement strategies	1. Minimum density of 4 units per acre 2. Counties/jurisdictions independently address affordable housing in comprehensive plans
Economic Growth	Stagnant growth in 1980's, strong growth in 1990's.	Stagnant growth during most of 1980's, strong growth beginning in late 1980's. Strong growth in 1990's, but growth rate in jobs and income not as high as Portland.
Change in Regional Affordability from 1990 to 2000	1. Little change in rental market 2. Strong decrease in affordability of home ownership	1. Little change in rental market 2. Moderate decrease in affordability of home ownership
Change in Supply of Affordable Rental Units for Low-Income Households from 1990 to 2000	1. Decline in affordable rentals for extremely low-income renters 2. Increase in affordable rentals for very low- and low-income renters	Increase in affordable rentals for all income segments of low-income households (extremely low-, very low-, and low)

6.3 BALTIMORE AND PHILADELPHIA

This section presents the other pair of regions for the analysis. The Philadelphia metropolitan region was chosen as the control group to the Baltimore region which represents the treatment group. Both regions are located on the eastern coast of the United States, share similar climates, and have experienced similar growth patterns over the past twenty years. Section 6.3.1 reviews the growth patterns of both regions.

Sections 6.3.2 and 6.3.3 provide a description of the growth management mandates that affect the regions of Baltimore and Philadelphia, respectively. In 1997, priority funding areas were established throughout the Baltimore region in response to Maryland's Smart Growth Act. The purpose of priority funding areas is to reduce urban sprawl by directing investment away from the outer fringes of urban areas and toward existing places. Therefore, priority funding areas are a form of urban containment. Meanwhile, the Philadelphia metropolitan region does not have a region-wide policy of urban containment. This difference between the two regions regarding urban containment policies make them appropriate for an "untreated control group with pretest and posttest" research design with the urban containment policy representing the "treatment." The research design for Baltimore/Philadelphia can be written as:

Baltimore Region:	O_1	X	O_2
- - - - - - - - - - - - - -			
Philadelphia Region:	O_1		O_2

Where X is the treatment of urban containment (priority funding areas), O_1 is the test in 1990, and O_2 is the test in 2000.

6.3.1 Comparison of Regions

Located within Maryland's Chesapeake Bay area, the Baltimore metropolitan region is home to slightly more than 2.5 million people. In addition to Baltimore City, the region includes the Maryland counties of Anne Arundel, Baltimore, Carroll, Hartford, Howard, and Queen Anne's. Figure 6.3 provides a map of the Baltimore region.

Figure 6-3. Baltimore Region

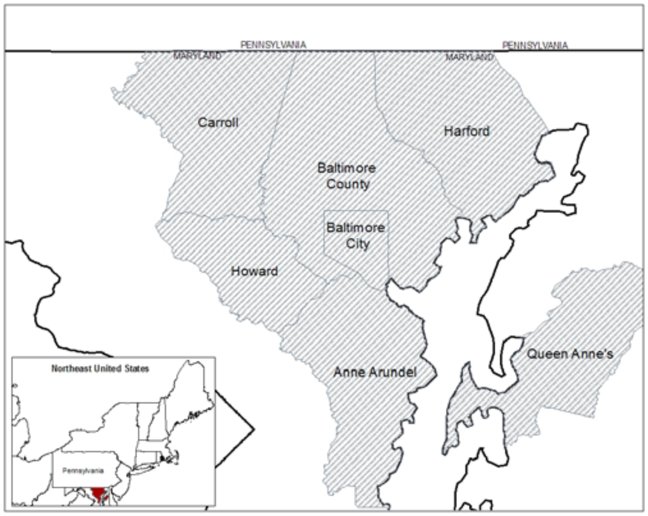

Figure 6.4 provides a map of the Philadelphia region. It includes nine counties in two states, Pennsylvania and New Jersey.

Figure 6-4. Philadelphia Region

Economic growth was significant in both regions during the 1980's as illustrated by the growth rates in median household income and employment from 1980 to 1990. Table 6.11 presents this data. From 1980 to 1990, median household income grew by 14.8% and 15.8% in the regions of Baltimore and Philadelphia, respectively. The job growth rate was 20.9% and

15.7% in Baltimore and Philadelphia, respectively. The number of jobs increased in the Baltimore region by 209,000 and in the Philadelphia region by 322,000.

Table 6-11. Economic Growth, 1980 to 2000

	Median Household Income[a]			Number of Jobs		
Region	**1980**	**1990**	**2000**	**1980**	**1990**	**2000**
Baltimore	$43,148	$49,515 (14.8%)	$49,938 (0.8%)	1,005,202	1,215,300 (20.9%)	1,248,344 (2.7%)
Philadelphia	$41,237	$47,752 (15.8%)	$47,536 (-0.4%)	2,039,023	2,359,428 (15.7%)	2,361,552 (0.1%)

a. Constant dollars (1999). Number in parentheses is percent change from previous decade.
Source: U.S. Census.

As shown in Table 6.12, the employment sectors which grew the most in each region from 1980 to 1990 were professional services; finance, insurance, and estate; retail; and health services. Meanwhile, both regions saw a significant loss in manufacturing jobs. Baltimore's manufacturing sector lost 31,000 jobs, for a 17.5% decline, and Philadelphia's manufacturing sector lost 96,000 jobs, for a 19.7% decline.

Table 6-12. Industries of Greatest Job Growth and Decline, 1980 to 1990

Baltimore		Philadelphia	
Job Growth		***Job Growth***	
Professional Services	47,000	Professional Services	86,000
Finance, Insurance, Real Estate	31,000	Health	65,000
Retail	31,000	Retail	57,000
Health	30,000	Finance, Insurance, Real Estate	53,000
Job Loss		***Job Loss***	
Manufacturing	- 31,000	Manufacturing	- 96,000

Source: U.S. Census.

The economic growth of both regions slowed dramatically during the 1990's. Table 6.11 shows that Baltimore's median household income grew by only .85%, while Philadelphia's median household income declined slightly by .45%. Job growth was also stagnant during this time period as the number of jobs increased in the Baltimore region by 2.72% and in the Philadelphia region by 0.09%.

Table 6.13 lists the industries that experienced the greatest growth, as well as decline, from 1990 to 2000. Both regions continued to see a decline in the manufacturing sector. The Baltimore region lost 40,000 jobs, for a 28.2% decline, while the region of Philadelphia lost another 96,000 jobs in manufacturing, for a 25.3% decline. To replace manufacturing, both regions saw a large increase in the number of professional and scientific jobs, as well as gains in employment within the health and education sectors.

Table 6-13. Industries of Greatest Job Growth and Decline, 1990 to 2000[98]

Baltimore		**Philadelphia**	
Job Growth		***Job Growth***	
Scientific, Professional	42,000	Scientific, Professional	77,000
Health, Education, and Social Services	39,000	Health, Education, and Social Services	57,000
Job Loss		***Job Loss***	
Manufacturing	- 40,000	Manufacturing	- 96,000

Source: U.S. Census.

Table 6.14 provides data regarding population and household growth in the Baltimore and Philadelphia regions. From 1980 to 1990, the population growth rate in the Baltimore region was 8.3%. This growth rate was much higher than the 2.9% population growth rate in the Philadelphia region. In absolute terms, the Baltimore region's population grew by approximately 183,000 residents while the Philadelphia region's population grew by 141,100.

Table 6-14. Population and Household Growth, 1980 to 2000

Region	**Population**			**Households**		
	1980 Population	**1990 Population**	**2000 Population**	**1980 Households**	**1990 Households**	**2000 Households**
Baltimore	2,199,531	2,382,172	2,552,994	765,770	879,968	974,359
Absolute Change[a]		182,641	170,822		114,198	94,391
Percent Change[a]		8.3%	7.2%		14.9%	10.7%
Philadelphia	4,781,494	4,922,175	5,100,931	1,662,905	1,798,667	1,915,187
Absolute Change[a]		140,681	178,756		135,762	116,520
Percent Change[a]		2.9%	3.6%		8.2%	6.5%

a. Change from previous decade.
Source: U.S. Census.

[98] Because of changes in industry classifications, this table is not comparable to Table 6.12. See the footnote in Section 6.2.1.

From 1990 to 2000, the Baltimore region added 171,000 residents for a gain of 7.2% while the Philadelphia region added 179,000 residents for a gain of 3.6%. Even though the regions had similar population growth in absolute terms, the growth rate was higher in the Baltimore region because of its smaller size in comparison to the Philadelphia region. We might suspect that the housing market was stronger in the Baltimore region than the Philadelphia region as population growth in the Baltimore region was much larger relative to the region's size.

The number of new households, however, is a more important factor in influencing the housing market than the number of additional residents. An interesting note is that while the Baltimore region added a greater number of residents from 1980 to 1990, the Philadelphia region experienced a larger absolute increase in the number of new households. The number of households in the Baltimore region increased by 114,000, or 14.9%. In comparison, the number of households in the Philadelphia region increased by 136,000 or 8.2%.

From 1990 to 2000, the Philadelphia region continued to add a greater number of new households in absolute numbers. Despite smaller population growth, the Philadelphia region added 23,000 more new households than the Baltimore region. The number of households in the Philadelphia region increased by 117,000 households, or 6.5%. The Baltimore region added 94,000 households for an increase of 10.7%. Although the Philadelphia region experienced greater growth in the number of households in absolute terms, Baltimore's growth was higher relative to its size.

During both the 1980's and 1990's, Baltimore experienced greater growth rates than the Philadelphia region. This greater growth relative to the region's size, particularly with regard to the number of households, indicates that housing was likely less affordable in the Baltimore region than the Philadelphia region. An increase in the number of households increases the demand for housing units. Therefore, the Baltimore was likely experiencing greater demand for housing units, relative to the region's size, than the Philadelphia region.

Another important factor concerning housing affordability is the construction costs of housing. Table 6.15 provides the R.S. Means' Construction Cost Index for both regions for 1990, 1995, and 2000. The index illustrates that constructions costs in Baltimore are significantly lower than construction costs in Philadelphia. In 1990, Baltimore's construction costs were 96.1% of the average of major cities. By 2000, costs were 91.0% of the average. In contrast, Philadelphia's construction costs were 7.2% higher than the average of major cities in 1990. During the 1990's, Philadelphia's costs rose faster relative to the average city. In 2000, costs were 11.9% higher than the average of major cities. The higher construction costs in Philadelphia could lead to lower housing affordability in the Philadelphia region as compared to the Baltimore region even though the Baltimore region experienced greater population and household growth rates.

Table 6-15. Construction Cost Index

Region	**1990**	**1995**	**2000**
Baltimore	96.1	91.2	91.0
Philadelphia	107.2	111.6	111.9

Source: R.S. Means Company, Inc.

These variables – economic growth, population growth, and construction costs – impact each region's housing market and housing affordability. Each of these factors was reviewed in this section. Housing affordability will be compared between the two regions in Section 6.3.4. The next two sections provide a description of growth management and affordable housing policies, which may impact housing affordability, in each region.

6.3.2 Background to Baltimore

With the passage of its Smart Growth Act in 1997, the state of Maryland came to be considered an exemplary example of smart growth and growth management (Cohen 2002, p. 293). The Act's primary purpose is to provide incentives to developers and other private citizens to not pursue urban development in rural areas. Five significant components of the Act, which will be discussed, make Maryland's growth management legislation one of the few to rely on incentive-based policies rather than land use regulations to limit sprawl (Cohen 2002, p. 305; Knaap and Schmidt-Perkins 2006, p. 10).

There were two significant concerns which led to the Smart Growth Act.[99] The first concern was the decline of Maryland's central places, particularly in regard to population loss from the City of Baltimore, in relation to newer suburbs and rural areas. From 1970 to 1995, the city of Baltimore lost 24% of its population, or 213,000 people (Schneider 1999, p. 64). Meanwhile, a 1997 article in *Planning* magazine reported that Baltimore's suburbs experienced a population growth rate of 67% in the previous 25 years, while Washington D.C.'s Maryland suburbs grew by 72% (Lambrecht and Martin 1997, p. 13).

The second concern was the pollution of the Chesapeake Bay, which is 195 miles long with a width that ranges from 4 to 30 miles. Its watershed is 64,000 square miles, making it one the most significant on the east coast (Cohen 2002, p. 296). As early as 1983, the U.S. Environmental Protect Agency issued a report warning about the growing pollutants to the Chesapeake Bay from nutrients and other chemical contaminants (Chesapeake Bay Program 2007). The deforestation and loss of wetlands surrounding the Bay increases the concentration of nutrients and other pollutants in the Bay, resulting in the overabundance of algae and depletion of certain fish and other species.[100]

While other growth management states, such as Oregon and Washington, chose to use regulation to affect local behavior regarding land use, the state of Maryland took a different route and offered incentives to change the public's behavior. The state's Governor at the time insisted that new growth management legislation could not rely on regulation. He feared there would be too many opponents to any proposal that increased state oversight and control of local land use issues (Frece 2005, p. 115). He felt that any legislation creating state-level land use regulation would be defeated.

The Governor recognized that the state could influence the location of new development and the pattern of growth by how and where the state spent its money (Frece 2005, p. 109). He believed that developers responded to financial incentives which would improve their bottom-

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[99] The Smart Growth Act was an extension of a previous state attempt to control sprawl, preserve open space, and protect the Chesapeake Bay from environmental pollution. The previous attempt was the Maryland Economic Growth, Resource Protection, and Planning Act of 1992. For a description of this Act, see Appendix A.

[100] For an introduction to the sources of pollution to the Chesapeake Bay and the pollution's effects see information from the Chesapeake Bay Program at www.chesapeakebay.net. The Chesapeake Bay Program was founded in 1983 as a partnership between the state of Maryland, state of Pennsylvania, Washington D.C., and the Environment Protection Agency to address the concerns regarding pollution of the Chesapeake Bay (Chesapeake Bay Program 1983).

line. Therefore, if state money was available to assist with new development only within specific areas, developers would develop in those areas. To this end, the Smart Growth Act included five components. These five components are (Daniels 2001, pp. 274-275; Cohen 2002):[101]

1. *Priority Funding Areas* – Priority growth areas designated by counties and local jurisdictions, outside of which state money cannot be used to pay the costs of infrastructure supporting new development.

2. *Brownfields Redevelopment Program* – Funds the cleanup and redevelopment of industrial sites that have been contaminated with hazardous waste.

3. *Jobs Creation Tax Credit* – Income tax credits available to business owners who create at least 25 jobs in a Priority Funding Area.

4. *Live Near Your Work Program* – Incentive in the form of a grant of at least $3,000 to people who purchase homes in older neighborhoods and near their jobs.

5. *Rural Legacy Program* – Funds to buy environmentally sensitive land and development rights to farmland in rural areas outside of priority funding areas.

Among the five components, the cornerstone of Maryland's Smart Growth Act is the mandate for counties and local governments to establish priority funding areas (PFA) (Office of Smart Growth 2005, p. 3). A PFA is an urban boundary outside of which state money for infrastructure, such as water and sewer service, is not to be spent. The purpose of the PFA is to control sprawl by controlling the location of new development. Like urban growth boundaries or urban service areas, PFAs are an attempt to control development patterns and preserve open space on the outer fringes of metropolitan areas by steering development inward to places that already have public services or have plans for public services to be offered in the near future (Knaap 2001).

Unlike urban growth boundaries, new development is not prohibited outside of PFAs. Rather, new development is allowed outside of PFAs as long as private developers or applicable local governments are willing to absorb the costs of the infrastructure needed to support the new development without state assistance (Cohen 2002, p. 303). The PFAs fit well with the Governor's desire to create an incentive-based growth management program which did not

[101] Priority funding areas are discussed in detail in this dissertation. For details of the other four components, see Daniels (2001) and Cohen (2002).

regulate a change in land use behavior, but encouraged private developers to change from their current sprawl-like development patterns in rural areas to facilitate development in areas suitable (and designated) for growth. The lack of state money for infrastructure outside of PFAs serves as a dis-incentive for private developers to pursue development on rural land that is not included within PFA boundaries.

Each county and its local jurisdictions are required to designate PFAs in their comprehensive plans. All existing municipalities are automatically designated as a PFA, as well as areas designated for revitalization by the Maryland Department of Housing and Community Development, enterprise zones designated by the federal government, and areas located inside the beltways of Baltimore and Washington, D.C. (Cohen 2002, p. 302). Additional lands are then designated as PFAs by each county and its local jurisdictions for future development. These additional lands can be included in PFAs based on current and future land use, as well as current or future water and sewer service (Maryland Department of Planning 1997, p. 5).

Similar to the growth management legislation in the states of Oregon and Washington, Maryland's Smart Growth Act attempts to preserve open space and protect the environment without disrupting or threatening economic growth in the state. Governor Glendening (2002, p. 1493), a strong advocate and supporter of the Smart Growth Act, wrote:

> Maryland's Smart Growth plan is not a no-growth or even slow-growth program. Instead, it recognizes the inevitability and value of growth to the Maryland economy…. The Smart Growth program, however, attempts to minimize the adverse effects of growth by channeling it to those areas of the state where existing or planned infrastructure and services are in place to support it.

The Maryland Department of Planning (MDP) provides guidelines regarding appropriate residential densities within PFAs, as well as consistency between PFAs and local infrastructure capacity (Maryland Department of Planning 1997; Cohen 2002). MDP created multiple PFA classifications, each of which having a suggested minimum average residential density. Table 6.16 provides these recommendations. MDP then requires the size of local PFAs to be determined based on these suggested densities and land capacity. MDP writes that the amount of land included in PFAs be "based on an analysis of the capacity of land areas available for development, including in-fill and redevelopment; and an analysis of the land areas needed to satisfy demand for development at densities consistent with the Master Plan" (Maryland Department of Planning 1997, p. 27).[102]

Table 6-16. Recommended Residential Densities and Planning Requirements by Maryland Planning Department (MPD)

Location of Priority Funding Area	MPD Recommendation
Existing municipality	Average residential density of at least 2 units per acre
Existing community[a]	Average residential density of at least 2 units per acre Has public water or sewer service. PFAs with only water service are typically rural and slow-growth areas and cannot receive state funds which increase the growth capacity of the community, except for in-fill and limited development.
Outside of existing community	Average residential density of at least 3.5 units per acre; Be part of planned water and sewer service area as outlined in an approved 10-year Water and Sewer Plan.

a. Community which is not incorporated, but citizens of the county typically recognize it as a distinct entity.
Source: Maryland Department of Planning (1997; 1998).

The state does not have final approval authority over local comprehensive plans and PFA designations. Rather, MDP reviews each county's plan and PFA designations in terms of consistency with current water and sewer plans, the state's residential density recommendations, and expected population growth. MDP then gives "comment" on all or part of the submitted plan to which it does not agree, but the Department cannot reject plans or mandate changes to them. Porter (1999, p. 4) contends that without enforceable oversight from the state, counties have an incentive to designate as much of their land as possible (if the land is included in a sewer and water service plan) in order to not diminish their access to state funds. If counties designate PFAs which include a more than ample supply of developable land needed for future economic

[102] Initially, an analysis of land capacity and future demand was only required of counties when they designated PFAs outside of existing municipalities. In 2006, this standard became required of all local governments (Maryland Department of Planning and Maryland Department of the Environment 2006).

and population growth, then PFAs would have little impact on the housing market and the supply of affordable housing.

Porter (1999) argues that Maryland's smart growth legislation, particularly the priority funding area component and its relation to the location of new development, is implemented inconsistently across counties because of the limited state control. Recent evidence from 1000 Friends of Maryland (2002) support this contention. 1000 Friends of Maryland reviewed the proportion of land designated as a PFA in each of the state's counties. They found a wide fluctuation among the counties. For example, 23.6% of Carroll County's land is included in PFAs and less than half of the county's new housing units over the next 20 years are expected to be located within them (1000 Friends of Maryland 2002, p. 9). In contrast, Howard County has designated 40% of its land as PFAs and expects more than 80% of its new housing units over the next 20 years to be located within them (1000 Friends of Maryland 2002, p. 17).

Development is not prohibited outside of PFAs (Knaap 2001, p. 11). Rather, the only restriction is that state money cannot be used to pay for the necessary infrastructure of the development. Where there is strong development pressure because of strong housing demand, local governments and private developers can provide public infrastructure with their own financing. MDP data show there is a wide range among Maryland's counties with regard to the proportion of housing that is built outside of PFAs. From 1997 to 2004, the percentage of residential single-family parcels improved by more than $1,000 which were outside of PFAs ranged from 13.0% in Prince George's County to 85.8% in Garrett County (Maryland Department of Planning 2007).

Table 6.17 provides the percentage of improved single-family residential parcels which were outside of the PFAs in each county of the Baltimore region. The percentage ranged from 20.0% in Baltimore County to 45.6% in Queen Anne's County, indicating that more than half of improved single-family parcels in each county were within a PFA.[103]

The percentage of improved (developed) residential land area which was outside of a PFA, however, is a different story. In terms of land area, the percentage of improved land which was outside of a PFA ranged from 70.3% in Howard County to 83.0% in Queen Anne's County. When compared to the proportion of improved residential parcels that were outside of PFAs, it is

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[103] Baltimore City, in its entirety, is a PFA. Therefore, all improved parcels in the city were within a PFA.

clear the size of improved parcels were much larger outside of PFAs than within them. While less than half of the improved parcels were outside of PFAs throughout the region, they accounted for more than three-quarters of the improved residential land area.

Table 6-17. Improved Single-Family Residential Parcels from 1997 to 2004

County	Percent of Improved Parcels Which Were Outside of PFA	Percent of Improved (Developed) Land Area Which Was Outside of PFA[b]
Anne Arundel	30.6%	74.8%
Baltimore City[a]	0%	0%
Baltimore County	20.0%	74.7%
Carroll	37.4%	80.6%
Hartford	20.9%	77.1%
Howard	23.6%	70.3%
Queen Anne's	45.6%	83.0%

a. All of Baltimore City is a PFA. Therefore, it is not possible for any improvement of parcels to occur outside of its PFA.
b. Land area measures in acres.
Source: Maryland Department of Planning (2007).

6.3.2.1 Affordable Housing Policy

There are no components specific to affordable housing within Maryland's Smart Growth Act. Frece (2005, p. 130) argued that insufficient attention to housing issues, particularly to "workforce" housing affordable to moderate income residents, is a flaw of the state's smart growth legislation. He presented the fear that redevelopment in older communities, which is a goal of the PFA component of the legislation, has the potential to displace older residents with not enough income to afford their current housing if prices increase. In an earlier article, Governor Glendening (2002, pp. 1497-1498) expressed the same fear. He argued that state policy must be careful to protect working families from the high cost of housing. Targeting funds into areas that are already developed could result in gentrification of older neighborhoods at the cost of housing affordability for lower-income households.

6.3.3 Background to Philadelphia

In contrast to the Baltimore region, Philadelphia does not have a region-wide urban containment policy. The Philadelphia region lies within two states, Pennsylvania and New Jersey.[104] Because both of these states have weak growth management legislation, there is no consistent urban containment policy throughout the metropolitan area.

Pennsylvania recently enacted "Growing Smarter" land use bills in 1999 to promote municipal cooperation in the development of comprehensive plans and land use planning (PADCNR 2000). There are three significant pieces of the legislation in terms of comprehensive planning. First, the legislation provides technical assistance to jurisdictions who wish to undergo a comprehensive planning process. To assist local governments with their planning process, the Governor's Center for Local Government is charged with the responsibility of identifying best land use practices and policies which can be adopted by local governments. In addition, the Act appropriated money from the state budget to be used specifically for providing assistance to jurisdictions completing a comprehensive plan. In 2000, the amount of money available to assist local planning was $3.6 million which represented the first time the state had appropriated funding for such a purpose (PADCNR 2000).

The second significant component of the Act is that it gives authority to municipalities and counties to work together on comprehensive plans, or a multi-jurisdictional plan, in order to create planning consistency among adjacent jurisdictions (Denworth 2002, Introduction). The tools available to jurisdictions creating multi-jurisdictional plans include the sharing of taxes or revenues and fees, combining specific plans for commercial and industrial development, and transferring development rights from jurisdictions that want to preserve open space to jurisdictions that need and want additional growth.

The third potentially significant component is that jurisdictions are encouraged to identify designated growth areas, as well as rural areas. Designated growth areas should currently be served by public infrastructure or planned to be served in the future. Meanwhile, public infrastructure and urban development are expected to be prohibited from designated rural areas (Denworth 2002, pp. i-ii). This is a policy of urban containment.

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[104] See Figure 6.4.

But in a recently completed national survey, Nelson and Dawkins (2004) found only two Pennsylvania jurisdictions with urban containment policies in the Philadelphia metropolitan region. They were Bucks County and Delaware Valley. Nelson and Dawkins categorized each of these jurisdictions as having a 'weak-accommodating' form of urban containment which they define as "urban growth boundaries or urban service limits (that) do little to manage development outside these boundaries, thus facilitating the proliferation of low-density suburban and exurban development" (Nelson and Dawkins 2004, p. 53). This weak form of urban containment is due to the fact that comprehensive plans in Pennsylvania are advisory in nature and non-binding. Therefore, these urban containment policies have little impact on the housing market and affordable housing.

Pennsylvania's Growing Smarter legislation is a weak version of state-level growth management. There are no requirements for local jurisdictions to submit comprehensive plans or to designate urban growth areas. Comprehensive planning is voluntary, advisory in nature, and non-binding. In addition, there is no state legislation allowing local zoning decisions to be challenged based on their inconsistency with a locality's comprehensive plan (Pennsylvania Economy League et al. 2003, p. 22).

Albeit slightly stronger than Pennsylvania, New Jersey's growth management legislation is also weak regarding policies of urban containment. New Jersey's state legislature passed the New Jersey State Planning Act and Fair Housing Act in 1985. The Planning Act created a commission to oversee the writing and implementation of a new state plan. The goals of the state plan include (Epling 1993, p. 99; NJDCA 2006):

- Revitalization of the state's cities and towns
- Conserve natural resources and systems
- Promote economic growth and development
- Protect the environment
- Provide public services at a reasonable cost
- Provide housing at reasonable cost
- Preserve historical and cultural areas
- Ensure integrated planning statewide among local governments, counties, and the state

There are two significant components of New Jersey's Planning Act. First, the state was required to develop a State Development and Redevelopment Plan to identify areas for future growth. The Plan divides the state into five types of "planning areas," which are based on the urban/rural nature of the area. The planning areas are defined as "distinct geographic and economic units within the state and serve as an organizing framework for application of the Statewide policies of the State Plan" (NJCDA 2006, 'Planning Areas'). The five types of planning areas are (NJDCA 2006):

- *Metropolitan Planning Areas* – Includes a variety of communities that range from large urban centers to small towns. The communities of this type of planning area have strong ties to major metropolitan centers.

- *Suburban Planning Areas* – Generally located adjacent to more densely developed Metropolitan Planning Areas. Typically identified by more dispersed patter of predominantly low-density development.

- *Fringe Planning Areas* – Predominantly rural landscapes that are not prime agricultural or environmentally sensitive land, with scattered small communities and free-standing residential, commercial, and industrial development.

- *Rural Planning Areas* – Large masses of cultivated or open land surrounding rural concentrated centers of population, including large contiguous areas of farmland.

- *Environmentally Sensitive Planning Areas* – Large contiguous areas with valuable ecosystems, geological features, and wildlife habitats particularly in the Delaware Bay and other estuary areas, as well as coastal areas.

The primary purpose of designating the five different planning areas in the state plan is to identify areas for urban-scale development and other areas, particularly rural farmland and environmentally sensitive areas, for protection from development (DeGrove 1994, p. 233). To that end, the Planning Act requires that the state's capital improvement plan, including planned investments in public infrastructure and facilities, focus on development within existing communities and urban centers in metropolitan and suburban planning areas. The state's infrastructure plans are to be consistent with the goal of promoting economic development, while revitalizing existing communities and preserving rural and environmentally sensitive areas (Gale 1992, p. 432; Epling 1993, pp. 99-100).

The second important component of the New Jersey Plan is that local jurisdictions were required to negotiate with the state through a process called "cross-acceptance" when a local plan was in conflict with the State Development and Redevelopment Plan. Cross-acceptance is defined as "a process of comparison of planning policies among governmental levels with the purpose of attaining compatibility between local, county, and state plans" (DeGrove 1992, p. 38). The product of this process is a written statement specifying areas of agreement and disagreement between the local or county level plan and the state plan. Through this process counties and their local jurisdictions determine whether they can accommodate the growth that is projected for their jurisdiction in the state plan.

Despite the cross-acceptance process, the Planning Act's comprehensive planning requirements for local governments are weak for three reasons. First, comprehensive plans are recommended, but not mandated at the county or local level (Gale 1992, p. 434; Godschalk 2000, p. 17). A plan is only required of the state. Second, local plans are not required to be consistent with the state's plan. Disagreements between a county or local plan and the state plan do not need to be resolved in the cross-acceptance process. Third, the state Planning Act contains weak requirements and standards for local plans with regard to compact development, preservation of open space, and affordable housing (Fainstein 2000, pp. 459-460). Fainstein argued that these lax requirements were necessary to entice local jurisdictions to participate in the planning process because their participation is not a mandate, yet they weaken the impact of the comprehensive plans. While observing New Jersey's planning system, Fainstein concluded that implementation of local plans is half-hearted and the free market continues to dictate the location of land uses.

6.3.3.1 Affordable Housing Policies

There are no affordable housing policies for low-income households in Pennsylvania which impact the Philadelphia metropolitan region. However, affordable housing receives special consideration in the New Jersey portion of the Philadelphia region. Given the debate over growth management's impact on housing costs, it is ironic that New Jersey's growth management legislation was partially a result of the Mt. Laurel legal cases in which the state Supreme Court ordered state's municipalities to plan for and provide a "fair-share" of affordable housing for low-income households (Bollens 1993, p. 153-154). In response, the state passed both the 1985 Planning Act and the 1985 Fair Housing Act. The history leading to the Fair

Housing Act, because it is a component of the growth management legislation in New Jersey, is reviewed.

In 1975, a New Jersey court ruled that the zoning practices of a Philadelphia suburb, Mount Laurel, were in violation of the state constitution (Hughes and Vandoren 1990, pp. 99-100; Calavita, Grimes, and Mallach 1997, p. 115). The court ruled that exclusionary zoning codes, which prohibited housing types that are affordable to low and moderate income households, negatively affected the general welfare of the citizens of the state and municipal actions which conflict with general welfare were unconstitutional. As part of the ruling, the state Supreme Court ruled that municipalities have a constitutional responsibility to provide opportunities for the construction of affordable housing within their jurisdiction (Meck, Retzlaff, and Schwab 2003, p. 32). But, the 1975 ruling did not provide oversight to ensure that the suburb modified its regulatory practices. Without the oversight, the suburb made no efforts to follow the court ruling (Calavita, Grimes, and Mallach 1997, p. 115).

In 1983, the suburb of Mount Laurel was sued again regarding their coding practices. This time, the court made a much stronger ruling, now known as Mount Laurel II, which was to impact every municipality in the state. The court decided that every municipality had a responsibility to ensure that the general welfare of citizens was not inhibited. To this end, every municipality was expected to provide the opportunity to have its "fair-share" of affordable housing within its jurisdiction.

The court determined each municipality's fair-share obligations for affordable housing based on a state growth plan which had been written in the 1970's (Epling 1993, p. 98). The state plan divided the state into growth areas, limited growth areas, and agricultural, conservation, pinelands, and coastal zone areas. The initial purpose of the state plan was to promote growth in growth areas while preserving agricultural and environmentally sensitive areas. The courts made the decision that the communities within growth areas would have to absorb the bulk of the share of new affordable housing for low-income households since those were the locations where the state expected growth to occur (Buchsbaum 1985, pp. 65-66).

The court demanded that local jurisdictions modify their zoning regulations and other ordinances to improve the probability that affordable housing would become available. To enforce their rule, they instituted the "builder's remedy" which stated that developers could bring suit against municipalities in order to gain development approval. The state's courts can grant zoning relief or building permits to developers willing to set aside at least 20% of new units for low to moderate income households (households making less than 50% and 80% of area median income, respectively). Within 2 ½ years of the 1983 court ruling, 90 suits had been brought against local jurisdictions by developers (Calavita, Grimes, and Mallach 1997, p. 116).

To remove the judicial oversight of local planning and affordable housing allocation, the state legislation passed the Fair Housing Act along with the State Planning Act which has already been described.[105] The Fair Housing Act created the state's Council on Affordable Housing (COAH) to provide municipalities with potential relief from the judicial process and the "builder's remedy." COAH was given two significant responsibilities to oversee the state's municipalities' progress toward affordable housing goals.

COAH first significant responsibility is to determine a fair-share allocation of affordable housing among municipalities. To do so, COAH was directed to divide the state into regions and determine the affordable housing needs for low and moderate households for each region. The initial fair-share allocation of affordable housing needs was based on the present need, as well as prospective need that would be required in the future based on population projections, in each housing region (Meck, Retzlaff, and Schwab 2003, p. 35). The regional need was then evenly allocated across municipalities so each one was expected to achieve the same proportion of affordable units through a modification of their zoning practices.[106]

COAH's second significant responsibility is to review and approve housing elements and fair share plans that are voluntarily submitted by local municipalities. COAH provides certification to municipal housing plans which adequately address the fair-share affordable housing goals, as well explain the local methods that will be utilized to achieve the goals. To receive certification, municipal housing plans can include a variety of techniques to achieve their fair allocation of affordable housing, including density bonuses, inclusionary zoning practices,

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[105] New Jersey Fair Housing Act, (N.J.S.A. 52:27 D-301). The Act explicitly states that one of its purposes is to, at the recommendation of the courts, reduce the role of the judiciary and increase the role of the Legislature in affordable housing allocations.

[106] The allocation methodology has since been significantly modified. Jurisdictions who have already received certification from COAH must update their plans within 10 years in a "3rd" round of allocations. The new allocation calculation is based on a "growth share" methodology which requires 1 affordable housing unit for every 8 new units built within the municipality. This ensures that growing municipalities incorporate affordable housing into their growth. Jurisdictions who have not yet received certification, but are seeking it, must submit a housing plan which addresses the initial fair-share housing allocations which are explained in the text. Then, they must address the new "growth share" allocation and how they will achieve 1 affordable unit for every 8 new units. For details of this new methodology, see Retzlaff (2003) and the COAH Handbook (COAH 2006).

rehabilitation of sub-standard units, or payments by developers to subsidize affordable units (COAH 2006, Chapter 8).

Municipalities receiving certification from COAH are protected from potential lawsuits brought against them by developers under the Mount Laurel II's "builder's remedy" ruling. The recent COAH Handbook clearly states to municipalities that the incentive for receiving certification is protection from litigation and greater autonomy over their land use decisions without judicial involvement. The Handbook states:

> If you choose to take part in the COAH process, you will have the opportunity to provide affordable housing using an increased array of options, while maintaining control of land use rather than being subject to directives of the Court as a result of litigation concerning affordable housing (COAH 2006, p. 16).

Out of 566 municipalities, 211 have received certification from COAH and another 73 were in the process of filing housing plans (COAH 2004, p. 4).

A unique component of the New Jersey's Fair Housing Act is the Regional Contribution Agreement (RCA). Using a RCA, a 'sending' municipality may pay other municipalities to take up to 50% of the sending municipality's affordable housing obligations. The fee paid by the sending municipality is $35,000 per unit (COAH 2006, p. 65). Receiving municipalities who agree to take on additional affordable housing obligations receive this money spend on affordable housing, as well as administrative costs. From its inception in 1985 to the end of 2003, COAH has approved more than 48,000 additional affordable housing units throughout the state, 8,650 of which where through RCAs (COAH 2004, p. 5).

6.3.4 Housing Affordability in Baltimore and Philadelphia

Sections 6.3.2 and 6.3.3 presented the growth management legislation and affordable housing policies which impact the two regions of Baltimore and Philadelphia. Section 6.3.2 discussed the Maryland Smart Growth Act of 1997 which requires every county in the Baltimore region to implement priority funding areas, a form of urban containment which restricts state infrastructure spending to areas designated for growth. There are no affordable housing policies either at the state or regional level which impact the Baltimore region.

Section 6.3.3 presented Philadelphia as the control region to Baltimore. There is no strong growth management legislation in Pennsylvania requiring urban containment policies of local juridictions. In New Jersey, there is a state-level plan which divides the state into five types of planning areas in an effort to steer state infrastructure money to metropolitan and existing suburban areas. However, there are no requirements for local planning or urban containment policies to pursue the state's goals at the local level.

With regard to affordable housing policies, Pennsylvania has no state or regional policies which influence the Philadelphia region. On the other hand, New Jersey has made strong efforts to ensure local municipalities modify their zoning codes and other regulation to achieve a fair-share of affordable housing with their jurisdiction.

This section compares housing affordability between the Baltimore and Philadelphia regions in both 1990 and 2000. Table 6.18 presents six measures of affordability, three for renter-occupied housing units and three for owner-occupied units. These are the same six measures used in the comparison of housing affordability between the regions of Portland and Seattle in Section 6.2.4.

In both regions of Baltimore and Philadelphia, rental units became slightly more affordable, relative to income, during the 1990's. In 1990, the median gross rent was 16% of the median household income in the Baltimore region and 17.4% of median household income in the Philadelphia region. During the 1990's this ratio of median rent to median household income declined. In 2000, median gross rent was 15% of median household income in the Baltimore region and 16.4% of median household income in the Philadelphia region. In both regions, the ratio of the percentage change in median gross rent to the percentage change in median household income was .77. This measure indicates that rental costs increased 77% as much as income for the median household in both regions from 1990 to 2000.

From 1990 to 2000, owner-occupied units for the median household in the Philadelphia region became more affordable. In comparison, there was little change in affordability of owner-occupied units in the Baltimore region. In 1990, the ratio of the median value of owner occupied units to median household income was 2.78 and 2.87 in the regions of Baltimore and Philadelphia, respectively. The median home value was fairly similar relative to median household income in each region. The ratio indicates that, in the Baltimore region, the median home's value was 2.78 times greater than the income of the median household. In the

Philadelphia region, the median home was 2.87 times greater in value than the median household's income. In 2000, the ratio of median value to median household income was smaller in both regions, but the decrease was more significant in the Philadelphia region. In the Philadelphia region, the ratio declined from 2.87 to 2.55. In the Baltimore region, the ratio declined from 2.79 to 2.70.

Table 6-18. Housing Affordability in Baltimore and Philadelphia

	1990 Baltimore	1990 Philadelphia	2000 Baltimore	2000 Philadelphia
Rental Units				
Median Rent	$ 492	$ 514	$ 626	$ 648
Ratio of Median Rent to Median Income for Renter Households	.160	.174	.150	.164
Ratio of Percentage Change in Median Rent to Percentage Change in Median Household Income, 1990 to 2000, for Renter Households	NA	NA	.77	.77
Owner-Occupied Units				
Median Value	$ 102,543	$ 101,934	$ 134,900	$121,200
Ratio of Median Home Value to Median Income, 1990 and 2000, for Homeowner Households	2.78	2.87	2.70	2.55
Ratio of Percentage Change in Median Home Value to Percentage Change in Median Household Income, 1990 to 2000, for Homeowner Households	NA	NA	.89	.56

Note: "Rent" is gross rent which includes utility costs. Figures are not adjusted for inflation.
Source: U.S. Census.

The ratio of the percentage increase in median home value to percentage change in median household income was .89 in the Baltimore region and .56 in the Philadelphia region. This ratio indicates that the increase in the median home value was 89% of the increase in median household income in the Baltimore region and only 56% of the increase in the median household income in the Philadelphia region. These ratios indicate that, relative to income growth, the growth in home values was slower in the Philadelphia region.

The previous six measures compare each region's housing costs to the region's income for the median household. Therefore, the ratios tell us little about the changes in affordability or in the supply of affordable housing for low-income households. Once again, a gap ratio of the number of affordable rental units to the number of low-income renter households was calculated for extremely low-, very low-, and low-income renter households.[107] The gap ratio can be interpreted as the percentage of renter households within the specified income group that could find an affordable rental unit if all of the units were available to them. Table 6.19 provides the gap ratio, as well as the number of affordable units and number of renter households, for each income category. A discussion of the table's results will be followed by an explanation of possible reasons for its results.

Table 6-19. Supply of Affordable Rental Units to Number of Low-Income Renter Households[a]

	Baltimore Region			Philadelphia Region		
	1990	**2000**	**% Change**	**1990**	**2000**	**% Change**
Extremely Low-Income						
Gap Ratio	.56	.77	37.2%	.39	.53	35.2%
# of renter households	86,054	104,819	21.8%	151,293	182,577	20.7%
# of affordable rental units	48,016	80,249	67.1%	59,053	96,366	63.2%
Very Low-Income						
Gap Ratio	1.13	1.25	10.1%	0.89	1.14	29.0%
# of renter households	138,501	170,670	23.2%	238,000	288,188	21.1%
# of affordable rental units	157,148	213,224	35.7%	210,930	329,419	56.2%
Low-Income						
Gap Ratio	1.25	1.19	-4.6%	1.24	1.20	-3.0%
# of renter households	216,703	242,688	12.0%	359,180	411,573	14.6%
# of affordable rental units	270,073	288,642	6.9%	445,360	495,117	11.2%

a. Income categories are cumulative.
Source: U.S. Census.

In both the Baltimore and Philadelphia regions, the number of affordable rental units, relative to the number of extremely low-income renter households, increased between 1990 and 2000. In 1990, the ratio for the Baltimore region was .56. By 2000, the ratio had increased to .77. This ratio indicates that in 2000, 77% of extremely low-income renter households in the Baltimore region would have been able to occupy an affordable rental unit if all of the units

[107] Once again, these are households whose income is less than 30%, 50%, and 80% of the area's median income.

would have been available. The reason for the increase in the ratio for the Baltimore region was a significant increase in the number of affordable rental units to extremely low-income households. The number of affordable rental units increased by 67.1%, or by 32,200 units. This increase was more than likely partially the result of a stagnant economy during the 1990's. In contrast, the number of extremely low-income renters by increased by only 21.8%, or by 18,800 households.

There was also a significant increase in the ratio of affordable rental units to the number of extremely low-income renters in the Philadelphia region. From 1990 to 2000, the ratio increased from .39 to .53 in the Philadelphia region. This ratio indicates that, in 2000, only 53% of extremely low-income renter households would have been able to occupy an affordable rental unit if all of them were available. The number of affordable rental units for extremely low-income households increased by 63.2%, or by 37,300 units. Meanwhile, the number of extremely low-income renters increased by 20.7%, or by 31,300 households.

Both regions also had an increase in the number of affordable rental units relative to the number of very low-income renter households. In the Baltimore region, the ratio of affordable rental units to the number of very low-income renter households increased from 1.13 to 1.41. In the Philadelphia region, the ratio increased from .89 to 1.14. In both regions, an increase in the number of affordable units explains the improvement in this ratio. In the Baltimore region, the number of affordable rental units increased by 56,100 units, or 35.7%. Meanwhile, the number of very low-income households increased by only 32,200 or by approximately 23.2%. In the Philadelphia region, similar changes occurred. The number of affordable rental units increased by 118,500 units, or 56.2%, but the number of very-low income renters increased by only 50,200, or by 21.1%.

The broadest category of low-income households, those making less than 80% of the area median income, is the only category for which the supply of affordable rental units did not grow faster than the number of renter households. As a result, the ratio of affordable units to the number of low-income renter households declined. The gap ratio declined slightly from 1.25 to 1.19 in the Baltimore region and from 1.24 to 1.20 in the Philadelphia region. The number of affordable rental units for low-income renter households increased by 6.9%, or by 18,600 units, in the Baltimore region and by 11.2%, or by 49,800 units, in the Philadelphia region. However, the number of low-income renter households increased by a greater amount. In the Baltimore region, the number of low-income renter households increased by 12.0%, or by 26,000 households. In the Philadelphia region, the number of low-income renters increased by 14.6%, or 52,400 households.

The most significant difference between the two regions with regard to affordable housing is the supply of affordable rental units relative to the number of extremely low-income and very low-income renter households. In 2000, 77% of extremely low-income renters in the Baltimore region could have occupied an affordable unit if all of the affordable units were available to them. In comparison, only 53% of similar renters in the Philadelphia region could have occupied an affordable unit. A similar comparison can be made with regard to affordable rental units for very low-income renters. In the Baltimore region there were 1.25 affordable units for every very low-income renter household. In comparison, there were 1.14 affordable units for every very low-income renter household in Philadelphia.[108]

Table 6.20 presents the proportion of the housing stock in each region that was affordable rental units for extremely low-income, very low-income, and low-income renter households. As compared to the Philadelphia metropolitan region, the Baltimore region had a higher proportion of units which was affordable rental units for each income category in both 1990 and 2000. This higher proportion explains the greater supply of affordable rental units in the Baltimore region relative to the number of low-income renters.

From 1990 to 2000, the proportion of the Baltimore region's housing stock which was affordable rental units for extremely low-income households increased from 5.1% to 7.7%. In the Philadelphia region the proportion increased from 3.1% to 4.7%. A similar increase occurred in both regions regarding the proportion of the housing stock that was affordable rentals for very low-income households. In the Baltimore region, the proportion of units that was affordable rentals for very low-income households increased from 16.7% to 20.3%. In the Philadelphia region, this proportion increased from 10.9% to 16.1%.

The proportion of the housing stock that was affordable rental units for the highest income category for low-income households did not increase in both regions. In the Baltimore region, the proportion of units which were affordable rental units for low-income households

[108] This is, once again, assuming that all affordable units are actually available to very low-income households. This assumption is unrealistic as many units are occupied by households of higher income, yet the measure provides a useful tool for comparison between two regions.

slightly declined from 28.8% to 27.5% between 1990 and 2000. The proportion increased in the Philadelphia region from 23.0% to 24.2%.

Table 6-20. Proportion of Housing Units that were Affordable Rentals, 1990 and 2000

	Baltimore Region		Philadelphia Region	
	1990	**2000**	**1990**	**2000**
Total housing units	938,979	1,048,046	1,932,499	2,047,843
Percentage affordable rentals for extremely low-income renter households	5.1%	7.7%	3.1%	4.7%
Percentage affordable for very low-income renter households	16.7%	20.3%	10.9%	16.1%
Percentage affordable for low-income renter households	28.8%	27.5%	23.0%	24.2%

Source: U.S. Census.

The affordability data do not provide information on the quality or size of the housing units in each region. There is the possibility that Baltimore has a greater supply of affordable rental units relative to the number of lowest income households because of lower quality or smaller size among housing units in the Baltimore region as compared to the Philadelphia region. Census data do not provide information on the quality of housing units, but do provide limited data on unit size.

Census data do not provide evidence that the Baltimore region's housing stock is significantly different from the Philadelphia region's stock in terms of size. Table 6.21 provides the proportion of housing stock in each region that was in multi-units structures of more than 2 units, more than 5 units, and more than 10 units. Units in multi-unit structures, particularly in large structures, are apartments which are smaller in size than single-family homes. The table reveals that the Baltimore region had a slightly higher proportion of its housing stock in multi-unit structures than the Philadelphia region. For example, 18.8% of the Baltimore region's housing stock was in structures in five or more units, while 15.3% of the Philadelphia region's housing stock was in similar structures. This measure indicates that the Baltimore region may have a higher proportion of affordable rental units because the region has a larger proportion of its housing stock in multi-unit structures.

Table 6-21. Proportion of Housing Stock in Multi-Unit Structures, 2000

Region	Percentage of housing stock in structures of 2 or more units	Percentage of housing stock in structures of 5 or more units	Percentage of housing stock in structures of 10 or more units
Baltimore	25.3%	18.8%	13.3%
Philadelphia	24.9%	15.3%	11.7%

Source: U.S. Census.

Another measure of housing sizes in a metropolitan region is the proportion of the housing stock which has four or more bedrooms. The measure indicates that the Philadelphia region had a slightly higher proportion of larger housing units than the Baltimore region. This measure differed slightly between the two regions as 21.4% of the Baltimore region's housing stock consisted of units with four or more bedrooms while 22.7% of Philadelphia's housing stock consisted of units with four or more bedrooms (U.S. Census Bureau 2000) .

There are two other possible explanations for the smaller relative supply of affordable rental units in the Philadelphia region as compared to the Baltimore region. First, as shown earlier in Table 6.15, constructions costs are significantly higher than the national average in Philadelphia while Baltimore construction costs are lower than the national average. These higher costs could have significant influence on the supply of new housing units and, in turn, may increase the price of housing in all segments of the housing market.

Second, table 6.22 indicates that the vacancy rate increased in the Baltimore region but not in the Philadelphia region from 1990 to 2000. The vacancy rate in the housing market increased from 6.3% to 7.1% in the Baltimore region. During the same time period, the vacancy rate slightly declined in the Philadelphia region from 6.8% to 6.5%. Despite the Baltimore region's greater growth rate in households and population (see Table 6.14), the vacancy rate increased while it slightly declined in the Philadelphia region. This measure is an indicator that there might have been less upward pressure on housing prices in the Baltimore region than the Philadelphia region.

Table 6-22. Vacancy Rates, 1990 and 2000

Region	1990	2000
Baltimore	6.3%	7.1%
Philadelphia	6.8%	6.5%

Source: U.S. Census.

6.3.5 Summary of Baltimore and Philadelphia

Table 6.23 summarizes the comparison made between the regions of Baltimore and Philadelphia in Section 6.3. The similarities between the two regions make them appropriate cases from which neighborhoods of the Philadelphia region serve as a control group without urban containment while the neighborhoods of the Baltimore region serve as the treatment group with urban containment. An urban containment policy was implemented, in the form of priority funding areas, in every municipality and county in the Baltimore region as a result of Maryland's Smart Growth Act of 1997. In contrast, there is no consistent urban containment policy throughout the Philadelphia region.

Table 6-23. Summary Comparison of Baltimore and Philadelphia Regions

	Baltimore	Philadelphia
Urban Containment Policy	Priority funding areas in every municipality and county throughout the region	No
Regional Affordable Housing Strategy	No	None in Pennsylvania. Municipal fair-share housing plans are certified by COAH, but the process is optional.
Economic Growth	Stagnant growth in number of jobs and household income during 1990's	Stagnant growth in number of jobs and household income during 1990's
Change in Regional Affordability from 1990 to 2000	1. Small increase in affordability in rental market 2. Small increase in affordability in home ownership market	1. Small increase in affordability in rental market 2. Small (but larger than Baltimore) increase in affordability in home ownership market
Change in Supply of Affordable Rental Units for Low-Income Households from 1990 to 2000	Increase	Increase

There are no regional affordable policies throughout either region. The state of Maryland did not specifically address affordable housing in their Smart Growth legislation. In the Philadelphia region, the state of Pennsylvania has no affordable housing policies which it requires of local or county governments. The state of New Jersey encourages municipalities to submit a fair-share housing plan to COAH detailing their plans to increase their share of low-income housing units. Participation in this process is voluntary, but municipalities submit plans to receive protection from the judicial system which has the power to overrule local zoning codes which exclude affordable units for low-income households. Municipalities which are certified by COAH may have a higher proportion of units which are affordable for low-income households. This possibility is controlled with a dummy variable which is discussed in a later section.

There was little economic growth and housing affordability improved in both regions during the 1990's. The improvement in affordability was similar in each region for renter occupied units. For owner-occupied units, affordability significantly improved in the Philadelphia region, but not in the Baltimore region. Despite the implementation of priority funding areas in the Baltimore region, both regions experienced an increase in the supply of affordable rental units relative to the number of extremely low-income and very low-income renter households. The Baltimore region's supply of affordable rental units, relative to the need among extremely low-income and very low-income households, was greater than the supply in the Philadelphia region.

6.4 SUMMARY

The purpose of this chapter was to explain the selection of the treatment and control groups for the "untreated control group with pretest and posttest" research design presented in Chapter Five. This chapter began by discussing the selection criteria for the groups. The selection was based heavily on the desire to improve the internal and external validity of the research. To improve internal validity, the treatment and control groups were chosen on the basis that they shared as many similar characteristics as possible with the exception of urban containment. To improve external validity, two pairs of treatment and control groups were chosen. The treatment group in each pair represented a different form of urban containment policy, in a different region of the U.S, in a different economic environment.

The first pair of treatment and control group is the metropolitan regions of Portland and Seattle. Urban growth boundaries were implemented in the Portland region in 1979 while they were not established throughout the Seattle region until fifteen years later. The second pair is the metropolitan regions of Baltimore and Philadelphia. Priority funding areas were implemented throughout the Baltimore region in 1997. There are no region-wide urban containment policies in the Philadelphia region.

The next chapter presents a linear regression model used to test the hypotheses presented in Chapter Four concerning the impact of urban containment on the relationships among the smart growth principles and affordable housing. The chapter presents the model and data used to test the hypotheses, as well as the findings.

7.0 MODEL AND RESULTS

Chapter Four presented seven hypotheses concerning the relationships among four smart growth principles and the supply of affordable housing, as well as the impact of urban containment on these relationships. Chapter Five then presented the threats to research validity and potential research designs to reduce these threats. After considering the practical weaknesses of some of the designs, the chapter presented the "untreated control group design with pretest and posttest" as the research design which would be used to test the seven hypotheses. Chapter Six presented the selection of the regions used as treatment and control groups in this research.

This chapter describes the regression model, variables, and data used to test the hypotheses of this research, as well as the findings from the model. Linear regression is used to test the association of housing density, a variety of housing options, mixed land use, and public parks with the supply of affordable rental units for extremely low-income and very low-income households. The regressions include interaction variables which represent the interaction of urban containment policies with each smart growth principle to capture their combined impact on the supply of affordable units.

The analyses are conducted using data from two different periods of time, 1990 and 2000. Table 7.1 summarizes the urban containment status for each region by year. As presented in the previous chapter, two pairs of regions are included in the analyses. In the pair of Portland and Seattle, Portland maintained a regional urban containment policy in both 1990 and 2000, while Seattle did not implement region-wide urban containment until the mid-1990's. The interaction variables represent the Portland region. In the pair of Baltimore and Philadelphia, neither region had urban containment policies in 1990, but an urban containment policy was required of counties in the Baltimore region beginning in 1997. The interaction variables represent the Baltimore region.

Table 7-1. Urban Containment Status by Region and Year

	Portland	Seattle	Baltimore	Philadelphia
1990	Urban Growth Boundaries	None	None	None
2000	Urban Growth Boundaries	Urban Growth Boundaries	Priority Funding Areas	None

The analyses of two different time periods provide a means by which to test the impact of urban containment on the relationships between each smart growth principle and affordable housing. In the study of Portland and Seattle, we would expect to find the interaction variables of Portland and smart growth principles significant in 1990, but not in 2000. In 1990, urban growth boundaries were present in the Portland region, but were not yet implemented in Seattle. A statistically significant interaction variable indicates that a relationship between a smart growth principle and affordable housing is different in Portland than it is in Seattle. In 2000, urban growth boundaries were present throughout both regions. Therefore, there would be no statistically significant interaction variables.

In the study of Baltimore and Philadelphia, we would expect to find the interaction variables of Baltimore and smart growth principles statistically significant in 2000, but not in 1990. In 2000, an urban containment policy was required of Baltimore's counties while Philadelphia had no such policy. In 1990, neither region had an urban containment policy required throughout the region. Therefore there would be no statistically significant interaction between the Baltimore region and smart growth principles in 1990.

The first five sections of this chapter present the model and data used for the regression analyses. The first section presents the regression model. The model is static in that it does not test for changes in four the smart growth variables themselves and the resulting change in the supply of affordable units. The static model, used for two different time periods, simply tests whether the relationship between each of the four smart growth variables and affordable housing is similar in each time period.

The second section presents the operationalization and method of measurement for each independent variable and the dependent variable. Independent variables represent the four smart growth principles of density, a variety of housing options, mixed land use, and public parks, as well as other control variables which impact the supply of affordable housing for low-income households. The dependent variables are the proportion of housing that are affordable rental units for extremely low-income and very low-income renter households.

The third section discusses the sources of data that are used to measure the independent and dependent variables. The fourth section provides the descriptive statistics for the neighborhoods of each region. The fifth section presents transformations applied to the data in order to meet the assumptions of a linear regression model.

The last two sections present the results of the regression analyses. The sixth section discusses the findings regarding the relationship between eah of the four smart growth principles and the proportion of housing that is affordable to extremely low-income households. The seventh section provides the results when the dependent variable is changed from the proportion of housing that is affordable rentals for extremely low-income households to the proportion that is affordable for very low-income households.

7.1 MODEL

To examine the relationships among the smart growth principles and the supply of affordable housing and the impact of urban containment on these relationships, a neighborhood-level model is utilized. The model can be written as:

$$Q_{afford} = f\,(D, A_U, A_E, R) \qquad (7.1)$$

Where Q_{afford} is the supply of affordable housing; D is the racial composition of the neighborhood; A_U is amenities of the housing unit; A_E is amenities of the surrounding environment (neighborhood); and R is local government regulation.

This neighborhood-level model was derived from the theoretical framework presented in Chapter Four. Equation (4.11) of Chapter Four presented the supply of affordable housing as a function of variables which influence both the supply of and demand for housing. It is:

$$Q_{afford} = f\ (C, L, K, R, D, Y, A_E, A_U, O, W, G, P_{LH}) \quad (7.2)$$

Where Q_{afford} is the supply of affordable housing; C is cost of construction; L is labor cost; K is the cost of capital; R is local regulation; D is the demographics of the neighborhood; Y is median household income; A_U is amenities of the housing unit; A_E is amenities of the surrounding environment (neighborhood); O is the value of non-residential land; W is topographical constraints; G is growth management mandates; and P_{LH} is the price of residential land.

Equation 7.1 was derived from the theoretical framework which argued the exogenous factors influencing supply and demand in the housing market also influence the supply of housing in the affordable, low-quality submarket for low-income households.[109] The neighborhood level model presented in the equation does not include regional level variables which would be consistent among all neighborhoods of the individual regions. The costs of capital, labor, and construction; regional amenities, such as climate and location within the U.S.; and regional regulation would not vary significantly across neighborhoods within each region. These regional variables are addressed through the selection of appropriate treatment groups and their control groups, which were presented in Sections 6.2 and 6.3.

It is inappropriate to concretely determine causation from this model. For two reasons, the model simply tests for associations between each of the independent variables and the supply of affordable housing. First, the model is static in that it does not include changes in the independent variables or in the supply of affordable units over time. Given the pretest and posttest research design, the model tests for associations at two "points in time." Second, the model does not account for potential endogeneity between the independent and dependent variables. The model assumes a one-way relationship between each of the four smart growth variables – density, multi-unit structures, mixed land use, and open space – and the supply of affordable units. The model does not allow for the possibility that the supply of affordable housing may impact the four smart growth variables. For example, the model ignores the possibility that developers may have an easier approval process for multi-unit structures in neighborhoods that already have a large supply of affordable units as compared to neighborhoods dominated by high-quality, expensive single-family homes (and little affordable

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[109] See Section 4.2.2.

housing). There may be more opposition to multi-unit structures in the neighborhood dominated by expensive, single-family homes.

7.2 OPERATIONALIZATION AND MEASUREMENT OF VARIABLES

This section describes the variables which are used in the model to test the hypotheses concerning the relationships among the four smart growth principles and the supply of affordable housing. Section 7.2.1 discusses the measurement of the dependent variable, which is the proportion of housing units in a neighborhood that are affordable for low-income households. Section 7.2.2 then presents the operationalization and measures of the four smart growth principles of density, a variety of housing options, mixed land use, and neighborhood open space in the form of public parks. The other independent variables included in the model are presented in Section 7.2.3. Section 7.3 then provides a description of the data sources used to measure the dependent and independent variables.

7.2.1 Dependent Variable

The dependent variable, Q_{afford}, is represented by two measures of affordable housing. The first measure is of the proportion of the housing stock that is affordable rental units for extremely low-income households.[110] The "extremely low-income" definition of affordable housing is a narrow definition as it represents a small fraction of the total housing market. Table 7.2 shows the average proportion of the housing stock among neighborhoods in each region that is affordable rentals for extremely low-income households, as well as the average proportion that is affordable rentals for very low-income households. In 2000, only 3.7% of the housing stock in the average Portland neighborhood was affordable rentals for extremely low-income households, 4.8% in the average Seattle neighborhood, 9.1% in the average Baltimore neighborhood, and

[110] As discussed earlier in Chapter Two, Section 2.1, these are rental units whose gross rent is less than 30% of 30% of the area median income.

4.8% in the average Philadelphia neighborhood. Because these units are such a small portion of the housing market, it may be hard to capture the impacts that smart growth principles have on their supply.

Table 7-2. Average Proportion of Housing Stock (among neighborhoods) that are Affordable Rentals[a] in 2000

	Region			
	Portland	**Seattle**	**Baltimore**	**Philadelphia**
Percentage affordable to extremely low-income households	3.7%	4.8%	9.1%	4.8%
Percentage affordable to very low-income households	18.6%	19.1%	21.4%	16.2%

a. Adjusted for physical adequacy using adequacy factors calculated from the American Housing Survey.
Source: U.S. Census and American Housing Survey.

The second measure of the dependent variable is the proportion of the housing stock that is affordable rental units for very low-income households.[111] A greater proportion of housing is affordable at this income level. In 2000, 18.6% of the housing stock in the average Portland neighborhood was affordable rentals for very low-income households, 19.1% in the average Seattle neighborhood, 21.4% in Baltimore neighborhoods, and 16.2% in the average Philadelphia neighborhood.

There are three important details of these two measures of affordable housing which must be discussed. First, this research examines the supply of affordable rental units. Rental units are the most important segment of the housing market for low-income households, particularly for those households whose income is less than 50% of the area median income. While some extremely low- and very low-income households own their home, it is unclear how these households can purchase a home in the unsubsidized housing market without assistance from either family or friends. It is possible that a number of these households purchased their homes while their income was higher.

The second detail is that the number of affordable rental units is calculated from Census data. The Census reports the number of units in various ranges of rents. For example, Census

[111] As discussed earlier in Chapter Two, Section 2.1, these are rental units whose gross rent is less than 30% of 50% of the area median income.

data report the number of rental units whose rents are from $0 to $99, $100 to $149, $150 to $199, and so on. These cost ranges do not necessarily coincide with the "cut-off" rental cost that is affordable. For example, the highest affordable rent to extremely low-income households may be $375, which would lie in the range of $350 to $399 reported in the Census data. To calculate the number of affordable units, 100% of the units in each rent range whose upper limit is lower than the affordable limit are added to a proportion of units in the rent range in which the affordable rent limit is located.

Table 7.3 provides an example of this calculation. In this example, the highest rent considered 'affordable' to extremely low-income households is $375. The number of units below this affordable cut-off is found by adding the number of units in each rent range up to $350 plus a proportion of the units in the range which includes $375. The proportion of affordable units in the final range is found by (affordable limit – lower bound of range) / (upper bound of range – lower bound of range).

Table 7-3. Sample Exercise - County Affordable Units Using U.S. Census Data

Rent Range (per month)	# of Units	% Affordable	Affordable Supply at $375
0 to $99	20	100%	20
$100 to $149	20	100%	20
$150 to $199	20	100%	20
$200 to $249	20	100%	20
$250 to $299	20	100%	20
$300 to $349	20	100%	20
$350 to $399[a]	20	51% (($375 - $350)/($399 - $350))	10
Total Affordable Supply			**130**

a. Affordable units in this rent range = number of units * proportion with gross rent < $375 per month.

The third important detail in calculating the number of affordable units is the three specific delineations which can be used to define the supply of units for low-income households. The affordable housing stock for low-income households can be divided into three different measures. They are (HUD 2005, pp. 39-40):

- *Affordability* – Housing units that are affordable to low-income households, regardless if the units are vacant or occupied.

- *Availability* – Housing units that are affordable to a low-income household, based on their cost, and are either occupied by a low-income household or vacant. This measure is sometimes used as units affordable to low-income households are often occupied by higher income households.

- *Adequacy* – Housing units that are affordable, available, and are in adequate physical condition for occupants.

The supply of rental units for low-income households, in this research, is defined as those units that are *affordable* and *adequate*, and includes those units not necessarily available at the time of the data collection. This research includes in its calculation of affordable units those units whose rents are affordable but currently occupied by higher-income households. While these units are not available at the time-period of the data collection, they have the potential to be available to low-income households without a change to the units' quality or adequacy.

Inadequate units are not included in the measure of supply. From a public policy perspective, units that are affordable based solely on price should not be considered an appropriate supply of affordable housing if they are unsafe for potential occupants. Rental units of lower cost are more likely to be inadequate in terms of their physical condition than those units with higher rents.

The U.S. Census does not include variables from which to estimate the physical condition of housing units. Therefore, the Census data are adjusted based on adequacy factors calculated from the Metropolitan American Housing Survey (M-AHS), a data source described in the next section. The M-AHS calculates an "adequacy" variable ranging from 1 to 3 to identify occupied housing units as adequate, moderately inadequate, or severely inadequate. A housing unit is considered moderately or severely inadequate if it fails specific quality standards in terms of plumbing, heating, electricity, physical upkeep, and physical condition of public areas of the structure (HUD 2005, pp. 79-80)

Adjustment factors were estimated for each metropolitan region based on the proportion of units in designated rental cost categories that were physically adequate. The rental cost categories for which adequacy factors were calculated are larger ranges than the rental cost categories found in the Census. These factors were then applied to the number of rental units in each of the Census' rental categories. Table 7.4 provides an example. If 80% of rental units with rents less than $300 were physically adequate, according to the M-AHS, then the adequacy factor of .8 was applied to the number of rental units to each of the census's rental cost categories up to $300.[112]

Table 7-4. Sample Exercise - Adjusting Census Data for Physical Adequacy of Units

Rent Range	Rental units counted by Census	M-AHS Adequacy Factor for rental units less than $300	Adequacy-Adjusted number of rental units
< $99	100	.80	80
$100 – $149	75	.80	60
$150 - $199	200	.80	160
$200 - $249	100	.80	80
$250 - $299	150	.80	120
Total	625		500

A caveat to the adequacy factor is that it likely over-estimates the proportion of adequate units, particularly among lower cost units. The M-AHS does not determine the physical adequacy of vacant units. Therefore, vacant units are not included in the adequacy factor. It is probable that unoccupied units are more likely than occupied units to be physically inadequate. The actual adequacy factors can be found in Appendix B.

7.2.2 Smart Growth Variables

The smart growth principles represent A_E, amenities of the neighborhood, in the regression model represented by equation 7.1. These independent variables are housing density, a variety of housing options, mixed land use, and open space defined as public parks. Housing density is measured as the number of housing units per square mile of land. For a more accurate measure of density, water and the amount of land estimated to be in parks is not included in the denominator.

A variety of housing options is measured as the proportion of housing that is in multi-unit structures. Two variables represent multi-unit structures in the model. The first variable is the

[112] The Census uses rental cost categories in increments of $50 for lower cost rental units. However, the M-AHS has a limited sample size for small ranges of rent. For more accurate estimates of the adequacy factor, larger rental cost categories had to be used.

percentage of total housing units that are in structures of 2 to 4 units. The second variable is the percentage of units that are in structures of 5 or more units.

Mixed land use is measured using employment data from the Census Transportation Planning Package (CTPP). Employment data is used to measure mixed land use because the two options for land use data are not appropriate. The first option for land use data is to use parcel-level data for each property in every neighborhood. However, coding for land use among parcels differ not only among regions, but among counties and jurisdictions within those regions. I want to measure mixed land use from data which is standardized across each of the four metropolitan regions. Standardized data makes for more appropriate comparisons across regions.

The second option for land use data is the USGS' National Land Cover Dataset (NLCD). The NLCD provides land cover data, but classifies land cover into 21 categories which include low intensity residential development, high intensity residential development, commercial/industrial development, forest, and grasslands.[113] These categories do not differentiate commercial developments which may be industrial in nature, such as manufacturing, from other commercial development such as retail and entertainment. Therefore, I want to use data which provides more detailed classifications of land use.

Two different measures for mixed land use are used in two different models. In the first model, mixed land use is represented by an index of the diversity of employment and residential activity within each neighborhood. This diversity index is calculated using a common formula found in the transportation and land use literature. It accounts for both the number of residents residing in the neighborhood, as well as the number of employees who work in the neighborhood in various employment sectors. The index is calculated as (Ewing, Pendall, and Chen 2002; Krizek 2003; Song and Knaap 2003; Cervero and Duncan 2004; Song and Knaap 2004):[114]

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[113] For a complete list of land cover categories, see www.epa.gov/mrlc/classification.html.

[114] Ewing, Pendall, and Chen (2002) and Cervero and Duncan (2004) also use CTPP employment data rather than land use data. Song and Knaap (2003; 2004) use land use data from the Portland Metro's Regional Land Information System. Geoghegan, Wainger, and Bockstael (1997), as well as Acharya and Lewis (2001), use a similar index using land cover data.

$$D = - \sum P_i * \ln(P_i) / \ln(J) \quad (7.3)$$

Where: D is the index of mixed land use

P_i is the proportion people in activity *i* where activity *i* is:

agricultural employment; construction employment; manufacturing employment; wholesale employment; retail employment; transportation, warehouse, and utility employment; information industry employment; finance, insurance, and real estate employment; professional, scientific, management employment; education, health, and social services employment; arts and entertainment employment; other services employment; public administration employment; armed forces employment; people residing in census tract.

J is the total number of activities

The index ranges from 0 to 1, with 1 indicating an equal mix of job types and residents. 0 indicates an area of single use.

For 2000, CTPP employment data by type of industry are available at the census tract level within all four metropolitan regions. In 1990, CTPP data are available at the census tract level for the Portland region while data are reported for transportation analysis zones (TAZ) in the regions of Seattle, Baltimore, and Philadelphia. TAZ boundaries are designated by the metropolitan planning organization of each region and do not necessarily coincide with the boundaries of census tracts. They do, however, coincide with census blocks. In order to allocate TAZ data to census tracts, census blocks were assigned to their appropriate TAZ. TAZ level employment data was then allocated to each block in the TAZ proportional to the percentage of the TAZ's land area that was in the block. Employment data for census blocks was then aggregated to the census tract level.

The diversity index does not differentiate between activities providing positive amenities from those producing negative amenities. A mix of residential, retail, and entertainment land uses which provide positive amenities could have the same diversity score as a mix of residential, manufacturing, and warehousing land uses (Krizek 2003, p. 274). This is a drawback to the diversity index as a measure of mixed land use.

Smart growth advocates generally define mixed land use as a mix of positive amenities serving the population, such as entertainment, retail establishments, and food services. Popular books advocating for smart growth and mixed land use neighborhoods do not include industrial uses in the mix. Calthorpe and Fulton (2001) argue that industrial sites and factories should not be part of residential communities, stating that "the low intensity of jobs in light industry and factory areas, the need for frequent truck access, and the scale of buildings do not lend themselves to mixed-use areas. Warehouse facilities and businesses that use toxic materials also need separation into special districts" (p. 55).

A second measure of mixed land use, included in a second set of analyses, is a measure of balance between the number of "population-serving" jobs in a neighborhood and the number of residents (Ewing, Pendall, and Chen 2002; Cervero and Duncan 2004). "Population serving" jobs in this research are defined as employment in retail; finance and insurance, real estate; education, health, social services; and arts, entertainment, and food services.

The purpose of using this measure is two-fold. First, it includes only activities which are more likely to provide positive amenities to neighborhood residents as opposed to a mix of all types of land uses. Second, the measure captures the balance between all population-service jobs and residents as opposed to a diversity index which may underestimate an actual mix of jobs and residents. For example, if a neighborhood consists of 100 residents and 100 population-serving jobs then there is an equal balance. If in this same neighborhood, these 100 jobs are within only one of the four population-serving employment categories listed above, then a diversity index would indicate an unequal mix of land uses.

The formula for the balance between population-serving jobs and residents for each neighborhood is (Cervero and Duncan 2004):

$$\text{Balance} = 1 - (\text{Abs}(S - P) / (S + P)) \qquad (7.4)$$

Where: S is the number of "population-serving" jobs in the neighborhood
P is the number of residents residing in the neighborhood

The measure ranges from a value of 0 to 1, with 1 indicating a neighborhood which has an equal balance between population-serving jobs and residents. A score of 0 indicates that the neighborhood is dominated by one or the other. However, a score of 0 does not indicate which of the variables (residents or population-serving jobs) are dominant in the neighborhood.

The presence of open space, in the form of public parks, is measured as the proportion of neighborhood land which is a park. Data from the NLCD designates land use into 21 different categories, including "urban/recreational grasses" which the USGS defines as vegetation planted in developed settings. This category is used as a proxy for neighborhood parks. While this excludes park land categorized as forests or other types of shrubs and land cover, this seems to be the most appropriate category which allows for comparisons across regions.

To capture the impact of urban containment on the relationships among smart growth principles and the supply of affordable housing, interaction variables are included in the model in which neighborhood housing density, multi-unit structures, mixed land use, and public parks are interacted with a dummy variable representing the treatment region of each pair.

A statistically significant interaction variable indicates that a relationship is either weaker or stronger in the treatment region than in the control region. In the analyses of Baltimore and Philadelphia, the treatment region is Baltimore. A change in the statistical significance of the interaction variables from 1990 to 2000 indicates the Baltimore's priority funding areas created a change in the relationships among smart growth principles at the neighborhood level and affordable housing.

In the analyses of Portland and Seattle, Portland is the treatment region. A statistically significant interaction variable in 1990 indicates that the smart growth variable had a different impact on affordable housing in Portland than in Seattle. In 1990, only Portland had urban growth boundaries. But in 2000, both regions had them. If the interaction variables change from being statistically significant in 1990 to being insignificant in 2000, it can be determined that urban growth boundaries modify the smart growth principles' impact on the supply of affordable housing. When both regions have urban growth boundaries, we would expect no statistically significant interaction variables because the each region has similar policies with regard to urban containment.

7.2.3 Control Variables

Table 7.5 lists the control variables, as well as the smart growth and interaction variables, included in the model. The table also provides the category from equation (7.1) which each variable represents, the variable's data source, and its expected relationship to the supply of affordable housing.

On the demand side, the vacancy rate signals the preference for housing in the neighborhood. A higher vacancy rate, indicating less demand, is expected to be associated with a greater proportion of units being affordable rentals for low-income households. The racial diversity of the neighborhood may also be an influence on demand. However, the relationship between the minority population and the supply of affordable units is unknown. Demand for housing in increasingly diverse neighborhoods may decline among those who prefer homogeneous neighborhoods, resulting in more affordable units. On the other hand, there are other potential residents who may prefer diverse neighborhoods and, therefore, demand may increase.

Table 7-5. Independent Variables

Variable	Expected Effect	Description	Data Source
Smart Growth Variables			
Density	+	$Amenity_E$ – Supply and Demand	U.S. Census Bureau
Mixed Use -	+	$Amenity_E$ – Supply and Demand	Census Transportation Planning Package (CTPP)
% Land that is Public Park	-	$Amenity_E$ - Demand	U.S. Geological Survey (USGS)
% 2 to 4 units in structure	+	$Amenity_U$ – Supply and Demand	U.S. Census Bureau
% 5 or more units in structure	+	$Amenity_U$ – Supply and Demand	U.S. Census Bureau
Smart Growth Variables Interaction w/ Region (R)			
Density * R	-	$Amenity_E$ – Supply and Demand	U.S. Census Bureau
Mixed Use * R	-	$Amenity_E$ – Supply and Demand	Census Transportation Planning Package (CTPP)
Public Park * R	-	$Amenity_E$ - Demand	U.S. Geological Survey (USGS)
% 2 to 4 units in structure * R	-	$Amenity_U$ – Supply and Demand	U.S. Census Bureau
% 5 or more units in structure* R	-	$Amenity_U$ – Supply and Demand	U.S. Census Bureau
Other Controls			
% Vacant	+	$Amenity_U$ and $Amenity_E$ – Demand	U.S. Census Bureau
% Built 20 or more years ago	+	$Amenity_U$ – Supply	U.S. Census Bureau
% of rooms with 4 or more bedrooms	-	$Amenity_U$ – Supply and Demand	U.S. Census Bureau
% Subsidized Units	+	Supply	HUD
% Minority	Unknown	Demographic – Demand	U.S. Census Bureau
"Place" dummies	Unknown	Regulation and taxes – Supply	U.S. Census Bureau, MABLE-GEOCORR
Regional Dummy	Unknown	Regional Supply/Demand Factors	U.S. Census Bureau, MABLE-GEOCORR

Note: A_E = neighborhood amenity and A_U = unit amenity.

On the supply side, a greater proportion of units that are subsidized for households with low-income will be associated with a greater supply of affordable units. The proportion of units which receive Federal housing subsidies from a public housing agency is used to represent subsidized units.[115] Another supply-side influence on affordable units is local regulation, local taxes, and the availability of public infrastructure, such as access to sewer and water systems.

[115] Subsidized housing owned and operated by non-public housing agencies, such as local non-profits, is not included in this measure due to data limitations. There were a large number of these units which did not have specific addresses or census tracts reported.

Including accurate measures of these variables for every jurisdiction for four large metropolitan regions is a difficult task. To capture these local influences on the supply of affordable housing in neighborhoods, dummy variables representing each 'place' as defined by the U.S. Census Bureau are included in the model. It should be noted that the dummy variables represent both incorporated places with actual governments, as well as census defined places which are clusters of population within a named community even though there may be no locally incorporated government to represent it.[116]

Two additional housing amenities are included in the model, in addition to the smart growth variables of density and multi-unit structures. The proportion of housing with 4 or more bedrooms is included in the model to capture the average size of homes in the neighborhood. A greater proportion of homes with four or more bedrooms is expected to be associated with a smaller supply of affordable units for low-income households. The second variable is the age of the housing stock. An older housing stock is likely to be associated with a greater supply of affordable units. Most units provided in the private market for low-income households have filtered down to lower income households over time. They are not new. To capture the age of the neighborhood's housing stock, the proportion of units which are more than 20 years old is included in the model.

Finally, a region dummy variable is included to account for any differences between the two regions in each pair. This dummy variable captures any differences between the regions not captured by the "place" dummy variables. The region dummy variable represents the 'treatment' region. In the Portland and Seattle analysis, the dummy variable is equal to one if the neighborhood is in the region of Portland. In the Baltimore and Philadelphia analysis, the region dummy variable is equal to one if the neighborhood is in the region of Baltimore.

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[116] For more details on census defined places, see the U.S. Census Bureau's *Geographic Areas Reference Manual* (1994, Chapter 9).

7.3 SOURCES OF DATA

The sources of data are listed in Table 7.6. The U.S. Decennial Census provides population and housing data for a variety of geographic units, nationwide. This research uses data from the Census' Summary File 3, sample data from 1/6 of the U.S. population, to measure the minority population, housing costs (to determine the proportion of units that are affordable rentals), and other variables of the neighborhood housing stock.

Table 7-6. Sources of Data

Data Source	Purpose
U.S. Decennial Census, 1990 and 2000	Neighborhood variables for density; multi-unit structures; control variables.
U.S. Census Bureau's Census Tract Relationship File	Allocate 2000 data to 1990 census tracts.
Census Transportation Planning Package, 1990 and 2000	Measures of mixed land use.
Metropolitan American Housing Surveys	Adequacy factors for supply of affordable rental units.
USGS National Land Cover Dataset	Measure proportion of land in parks.
HUD – A Picture of Subsidized Housing, 1998	Measure proportion of units that are subsidized by public housing agency.

The U.S. Census Bureau's Census Tract Relationship File is used to allocate 2000 census data to 1990 census tracts.[117] Census tracts are small geographic units for which census data are reported. They typically range in size from 2,500 to 8,000 residents. Between census surveys, tract boundaries may be adjusted depending on changes in the population. A region experiencing population growth may have a number of its tracts split into additional tracts. Similarly, places experiencing population decline may have multiple tracts merged together. Because the analysis examines data from both 1990 and 2000, the relationship file was used to allocate 2000 census tract data to 1990 census tract boundaries in order to have consistent boundaries. The relationship file provides a weight, based on the proportion of each 2000 tract's

[117] This file can be found at the Census Bureau's website, http://www.census.gov/geo/www/relate/rel_tract.html.

population that would have been in a different tract based on 1990 boundaries. These weights were used to allocate each census variable from 2000 tracts to 1990 tracts.

The Census Transportation Planning Package (CTPP) provides the data necessary for calculating the diversity index and the balance between population-serving jobs and residents. The CTPP includes detailed data regarding the level and types of employment of both residents and non-residents within census tracts, block groups, or transportation analysis zones (TAZ) depending on the region. The data are tabulated by the U.S. Census Bureau from the Decennial Census for the U.S. Department of Transportation. CTPP employment data are available by industry type. Therefore, it is possible to know how many jobs for each industry are located within a geographic area.

CTPP data from 1990 are not available for rural counties. The counties within the chosen metropolitan regions for which 1990 CTPP data were not available were dropped from the analysis. However, the dropped counties represent only a small portion of each region's total population. The counties removed from the analysis, along with the proportion of their region's population that they represent, are listed in Table 7.7.

Table 7-7. Counties without CTPP Data[a]

Baltimore Region	Philadelphia Region	Portland Region	Seattle Region
Queen Anne's (1.6%)	Salem (1.3%)	Columbia (2.3%) Yamhill (4.4%)	Island (3.0%)

a. Percentage in parenthesis is percentage of region's population in county.

The supply of affordable units for low-income households is adjusted for quality based on adequacy data from the Metropolitan American Housing Survey (M-AHS). The M-AHS is a series of longitudinal surveys taken of individual housing units, and their residents, by the U.S. Census Bureau for HUD. The M-AHS focuses on a revolving set of metropolitan areas every year. There are approximately 15 metropolitan areas covered by this survey, each of which is surveyed every 4 to 6 years.[118] Unlike most large surveys, the M-AHS does not follow households, but rather includes the same *housing units* in each survey year. The dataset includes

[118] Due to budgetary constraints at HUD and the U.S. Census Bureau, the Metropolitan AHS is undergoing evaluation and the cycle of surveys has fluctuated over time.

a variable which identifies each housing unit as being physically adequate, moderately inadequate, or severely inadequate based on its own criteria. This adequacy variable was used to estimate the proportion of rental units in various price ranges that were physically adequate for occupancy.

The proportion of neighborhood land in public parks is measured using data from the U.S. Geological Survey's (USGS) National Land Cover Data Set (NLCD). The NLCD designates land use into 21 different categories. It is one of the few datasets that provides standardized land use data for the entire nation. One of the 21 categories is "urban/recreational grasses" which is used as a proxy for parks. The proportion of land in this category for each census tract was calculated by using GIS software which joined NLCD data with census tract boundaries.

There are two threats to the validity of using this dataset. First, the data is best used when applied to regional analyses rather than smaller levels of geography. The NLCD estimates of land use are based on sample data which provide a greater degree of accuracy at larger levels of geography. Second, the land use category of "urban/recreational" grasses excludes parkland that is classified as forest, shrubs, or other types of natural land uses. Therefore, the amount of land which is in public parks is likely to be underestimated, particularly in areas which have large amounts of open space which have other natural ground covering.

Despite these limitations, the NLCD is used as there are few other alternatives. The NLCD provides land use data that is standardized across the four metropolitan regions included in this research. Other alternatives do not provide uniform information across different regions. One alternative is to collect land use data from the regional organizations in each metropolitan area. Unfortunately, not all regional planning organizations maintain this data. Among those regional organizations that do maintain land use data, they do not use uniform definitions of land use. In addition, each organization has collected its data at a different point in time. The lack of standardization makes it difficult to assess the comparability of land use data among regional planning organizations.

The proportion of housing subsidized by a local public housing authority is provided by the U.S. Department of Housing and Urban Development. The data are available in a dataset occasionally released by HUD, titled *A Picture of Subsidized Housing*. This dataset provides geographic and socioeconomic data for all federally subsidized housing for low-income households. It includes units funded their public housing authorities, including rental vouchers and certificates, as well as units owned and managed by private organizations. Only units provided through public housing authorities are included in this research as many privately operated units are missing the identification of their census tract.

7.4 DESCRIPTIVE STATISTICS

Prior to using the model presented in Section 7.1 to test the relationships among the four smart growth principles and the supply of affordable housing, the descriptive statistics for each region are presented. This section presents two tables of descriptive statistics, one table for each pair of treatment and control groups. Table 7.8 provides the mean and standard deviation for each variable at the census tract level for both 1990 and 2000 in the regions of Portland and Seattle.

Table 7-8. Descriptive Statistics, Census Tracts in Portland and Seattle[a]

	Portland – 1990 (n=328)		Seattle – 1990 (n=405)		Portland – 2000 (n=328)		Seattle – 2000 (n=405)	
Variable	Mean	Std Deviation	Mean	Std Deviation	Mean	Std Deviation	Mean	Std Deviation
% Rentals for 30% AMI	4.7	7.8	4.7	8.9	3.7*	6.4	4.8	7.5
% Rentals for 50% AMI	20.6	15.8	18.1	16.9	18.6*	14.8	19.1*	16.0
HU per square mile	1816.6	1909.8	2081.3	2666.8	2041.7*	1987.0	2326.5*	2951.2
Mixed Use (D)	.35	.22	.31	.24	.39*	.19	.38*	.20
% Park	1.8	3.3	1.4	2.8	1.8[b]	3.2	1.4[b]	2.8
% 2 - 4 units	7.9	6.8	6.2	6.0	8.0	6.4	6.1	5.6
% 5 or more units	19.1	20.3	23.6	23.6	21.4*	21.0	25.6*	23.6
% Vacant	5.0	4.3	5.2	6.	5.6*	3.4	4.4*	3.2
% More than 20 years old	60.2	27.0	56.5	25.4	69.9*	22.0	66.3*	20.7
% Four or more bedrooms	17.0	9.4	20.2	12.8	17.3	10.7	21.0*	12.9
% Subsidized	4.6	9.2	4.0	9.7	3.8[b]	6.8	3.3[b]	7.7
% Minority Population	9.8	11.5	13.4	15.0	16.9*	11.4	22.0*	15.6

a. * indicates difference between 1990 and 2000 is statistically significant below the .05 level of significance, using paired sample t-test.
b. Indicates that the paired sample t-test was not performed as the same data was used for 1990 and 2000.

On average, the proportion of housing units that were affordable rentals for extremely low-income households declined in Portland neighborhoods from 1990 to 2000. The average proportion of units that were affordable rental units in each neighborhood declined from 4.7% to 3.7%. A paired samples t-test indicates that this decline among census tracts in the Portland region was statistically significant below the .000 level of significance. In contrast, the change in the average proportion of affordable rentals for extremely low-income households was not statistically significant in Seattle neighborhoods. On average, the proportion of affordable rentals for extremely low-income households slightly increased from 4.7% to 4.8%.

Regarding affordable rental units for very low-income households, a similar difference between Portland and Seattle neighborhoods was found. On average, the proportion of units that were affordable rental units for very low-income households declined from 20.6% to 18.6% among neighborhoods in Portland. Once again this decline was found to be statistically significant at the .000 level of significance using a paired samples t-test. In contrast, the average proportion of affordable rentals for very low-income households slightly increased in Seattle's neighborhoods. The average proportion increased from 18.1% to 19.1%. The difference was statistically significant below the .000 level of significance.

Table 7.8 also shows that average neighborhood density is higher in the Seattle region than in the Portland region, with density increasing in both regions from 1990 to 2000. In Portland, the average housing density among census tracts increased from 1,817 units to 2,042 units per square mile. In Seattle, housing density increased from an average of 2,081 units per square mile to 2,346. In both regions, these increases were statistically significant at the .000 level of significance.

Neighborhoods of the Portland region have, on average, a greater proportion of units in multi-unit structures of 2 to 4 units than the Seattle region, but Seattle has a greater proportion in multi-unit structures of 5 or more units. In Portland, the proportion of units in structures of 2 to 4 units slightly increased, on average, from 7.9% to 8.0%. In Seattle, the proportion slightly declined, on average, from 6.2% to 6.1%. Neither of these changes is statistically significant. In contrast, neighborhoods of both regions on average experienced an increased in the proportion of units in structures of 5 or more units. The average proportion among neighborhoods in the Seattle region increased from 23.6% to 25.6%, while the average proportion among neighborhoods in the Portland region increased from 19.1% to 21.4%.

The average degree of mixed land use was higher among the Portland region's neighborhoods than the Seattle region in 1990. But both regions' neighborhoods experienced a statistically significant increase in the diversity of land use between 1990 and 2000, with Seattle's neighborhoods experiencing a greater increase. From 1990 to 2000, the average degree of mixed use among the Portland region's neighborhoods increased from .35 to .39. It increased from .31 to .38 in the Seattle region. The increase in Seattle was greater than in Portland, bringing both regions to have a similar average degree of mixed use among neighborhoods in 2000.

The average housing vacancy rate among neighborhoods increased in the Portland region, but decreased in the Seattle region. The average vacancy rate among Portland's neighborhoods increased from 5.0% to 5.6%. The increase was statistically significant below the .01 level of significance. This finding was somewhat surprising, given that Portland experienced a decline in the proportion of units that were affordable rentals for extremely low- and very low-income housing units. A higher vacancy rate could signal a decrease in the strength of the housing market, which could increase the supply of affordable units. However, these descriptive statistics reveal that despite Portland's slight increase in vacancies, the supply of affordable rental units, as a percentage of the market, declined. Therefore, we could hypothesize that the increase in vacancy rates is not necessarily an indicator of the strength of the low-end of the housing market, but is an indicator of the home ownership or more expensive housing market.

In Seattle, vacancy rates declined from an average of 5.2% to 4.4% among the region's neighborhoods. The change was statistically significant below the .01 level of significance. This was also surprising given that, on average, the proportion of affordable rental units increased. Once again, the vacancy rate as an indicator of the overall housing market may not capture well the market for affordable units for low-income households.

Regarding the other independent variables in the model, the average size of housing units among neighborhoods in both regions slightly increased. From 1990 to 2000, the average proportion of units with four or more bedrooms increased slightly from 17.0% to 17.3% in the Portland region and from 20.2% to 21.0% in the Seattle region. Only the increase in Seattle was statistically significant. On average, the neighborhoods of the Portland region have an older housing stock than the Seattle region. In 2000, 69.9% of the housing stock was more than 20 years old in the average Portland neighborhood versus 66.3% of the housing stock in the average Seattle neighborhood. Both regions saw a statistically significant increase in the proportion of units that were more than 20 years old from 1990 to 2000. This was not unexpected as housing is a durable good, which lasts a significant amount of time once it is built. In any given year, the number of new units is minimal compared to the existing housing stock.

The neighborhoods of the Portland and Seattle regions saw a substantial increase in the proportion of residents who were minorities between 1990 and 2000. On average, the minority population increased from 9.8% to 16.9% of the population in the average Portland neighborhood. In the Seattle region, the proportion of minorities increased from 13.4% to 22.0% of the population in the average neighborhood. In both regions, the increase in the proportion of minorities was statistically significant. The increase in the minority population was not led by an increase in the number of African-Americans, but rather by an increase in other minorities such as Asians and Pacific Islanders. The proportion of African-Americans in both the Portland and Seattle regions remained constant at 3% and 4%, respectively.[119]

Table 7.9 provides the same descriptive statistics for the neighborhoods of the Philadelphia and Baltimore regions. On average, the proportion of housing units that were affordable rentals for extremely low-income renters increased in the neighborhoods of both regions from 1990 to 2000. In the Baltimore region, the average proportion among neighborhoods increased from 6.0% of the housing stock to 9.1%. In neighborhoods of the Philadelphia region, the average proportion increased from 3.1% to 4.8%. The increase was statistically significant in both regions below the .01 level of significance.

The supply of affordable rental units for very low-income households, as a proportion of the housing stock, also increased among neighborhoods of both regions. The average proportion of affordable rentals for very low-income households increased from 17.3% to 21.4% of the housing in the average neighborhood of the Baltimore region. In neighborhoods of the Philadelphia region, the average proportion increased from 10.6% to 16.2%. The increase was statistically significant in both regions below the .01 level of significance.

With regard to housing density and multi-unit structures, there was little statistically significant change in the neighborhoods of either region. While housing density declined slightly in the average neighborhood for both regions, the decline was not statistically significant. Similarly, changes in the proportion of housing in structures of 2 to 4 units and in structures of five or more units were not statistically significant among neighborhoods in the

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[119] Author's calculation from U.S. Census.

Baltimore region. Among neighborhoods of the Philadelphia region, there was no statistically significant change in the proportion of housing in structures of 5 or more units. However, the average proportion of housing in structures of 2 to 4 units increased slightly from an average of 9.4% to 9.6% among the Philadelphia region's neighborhoods.

Mixed land use, as measured by the diversity index, between the neighborhoods of both regions is relatively similar. In 1990, the Baltimore region's neighborhoods had an average score on the diversity index of .36 while the Philadelphia region's neighborhoods had an average score of .35. The average diversity index among the Baltimore region's neighborhoods declined from .36 to .34. In contrast, it increased in the Philadelphia region's neighborhoods from .35 to .37. Both of these changes were statistically significant.

Table 7-9. Descriptive Statistics, Census Tracts in Baltimore and Philadelphia[a]

	Baltimore – 1990 (n=564)		**Philadelphia – 1990 (n=1215)**		**Baltimore – 2000 (n=564)**		**Philadelphia – 2000 (n=1215)**	
Variable	Mean	Std Deviation	Mean	Std Deviation	Mean	Std Deviation	Mean	Std Deviation
% Rentals for 30% AMI	6.0	11.1	3.1	6.6	9.1*	12.3	4.8*	7.4
% Rentals for 50% AMI	17.3	17.1	10.6	11.4	21.4*	17.9	16.2*	14.3
HU per square mile	3162.4	3700.5	3312.8	4245.7	3151.6	3549.3	3289.1	4119.0
Mixed Use (D)	.36	.21	.35	.22	.34*	.19	.37*	.18
% Park	4.2	6.6	2.4	4.4	4.2[b]	6.6	2.4[b]	4.4
% 2 - 4 units	7.9	9.8	9.4	9.2	7.6	9.1	9.6*	8.8
% 5 or more units	15.7	19.9	14.4	17.8	16.1	19.1	14.4	17.1
% Vacant	6.4	6.1	6.4	5.9	8.0*	8.2	6.6	6.8
% More than 20 years old	69.2	26.4	75.6	23.8	77.0*	21.9	82.7*	19.3
% Four or more bedrooms	18.7	14.3	23.0	17.0	20.3*	15.7	23.6*	16.9
% Subsidized	5.8	13.6	3.1	8.1	5.7[b]	14.0	3.1[b]	8.4
% Minority Population	28.7	34.3	22.1	31.0	36.5*	34.8	28.4*	31.6

a. * indicates difference between 1990 and 2000 is statistically significant below .05 level of significance using paired sample t-test.
b. The paired sample t-test was not performed as the same data was used for 1990 and 2000.

With regard to the other independent variables, the average proportion of housing units that are more than 20 years old increased from 69.2% to 77.0% in the average neighborhood in the Baltimore region and from 75.6% to 82.7% in the average neighborhood in the Philadelphia region. The average proportion of units with four or more bedrooms also increased among the neighborhoods in each region. The average proportion increased from 18.7% to 20.3% among neighborhoods in the Baltimore region and from 23.0% to 23.6% among neighborhoods in the Philadelphia region.

The average size of minority population among each region's neighborhoods, as a proportion of total population, increased in both regions. From 1990 to 2000, the average proportion of minorities increased from 28.7% to 36.5% among neighborhoods of the Baltimore region. Among neighborhoods of the Philadelphia region, the average proportion increased from 22.1% to 28.4%.

7.5 MODEL ASSUMPTIONS

A linear regression is utilized to estimate equation (7.1) in which the dependent variable is the proportion of housing units that are affordable rentals for low-income households. Therefore, the data must meet certain assumptions of a linear regression. This section reviews the extent to which the data meet those assumptions, as well as the transformations that were applied to the initial data.

Prior to testing the data, a small number of observations were removed from the analyses. Census tracts in which more than half of the housing stock was subsidized by a public housing agency were excluded. These tracts, particularly those in which the vast majority of housing consists of subsidized units, are more likely identified as public housing communities. The majority of units in these neighborhoods are affordable for low-income households because they are subsidized specifically for low-income households. Neighborhood characteristics or housing features are irrelevant to the affordability of these units. Nine census tracts in the regions of Portland and Seattle and twenty-two tracts in the regions of Baltimore and Philadelphia were dropped, accounting for 1.2% of all census tracts in each analysis.

The first assumption tested is that there are linear relationships between the dependent variable and each independent variable. However, scatterplots revealed that not all of these relationships are linear. A common method of improving the linearity of a regression model is to transform the dependent variable, independent variable, or both. Any transformation to a variable does not alter its relationships with other variables as all observations are transformed in the same manner (Mertler and Vannatta 2002, p. 31).

A box-cox model was utilized to find a transformation of the dependent variable that provided for the best fitting model. A box-cox transformation transforms either the dependent variable, specified independent variables, or both using the formula (Davidson and Mackinnon 1993, p. 483):

$$y = (y^{\lambda} - 1) / \lambda \qquad (7.5)$$

The box-cox transforms variable (y) using multiple values of λ, which typically range from -2 to 2. The model allows for a maximum-likelihood estimation to test which transformation of variable (y) provides the best fitting model (Pindyck and Rubinfeld 1998, pp. 277-279). The box-cox model is a popular tool as it allows for an easy comparison of the fit among different potential transformations of variables. If $\lambda = 0$, the variables under question are transformed by their log. When $\lambda = 1$, the transformed variables are similar to their initial non-transformed variables.

In every analysis, the box-cox model found that neither the log transformation ($\lambda = 0$) nor the lack of transformation ($\lambda = 1$) of the dependent variable was the best solution to addressing the non-linearity of the model. The results illustrated that the ideal transformation would be a box-cox transformation where λ was something other than 0 or 1. However, a drawback of transformations where λ does not equal 0 or 1 is that the regression results are difficult to interpret.

Because interpretability of the results was important, the log of the proportion of units that were affordable rentals was used as the dependent variables in the regression analyses. When the dependent variable is transformed by its log, the coefficients of each independent variable are interpreted as the proportional increase in the dependent variable given a one unit increase in the independent variable. Because a number of observations had a value of 0 for the proportion of affordable rental units, and the log of 0 is undefined, the transformation applied to the dependent variable was:

$$y = \log (y + 1) \qquad (7.6)$$

Scatterplots show that this transformation of the dependent variable improved the linearity of the relationships between the dependent and independent variables.

The results of the box-cox model with the best transformation are reported in Appendix D, as well as the log-likelihood estimations for the best fitting model, the log-linear model ($\lambda = 0$), and the linear model ($\lambda = 1$). The box-cox model found only one group of analyses for which no transformation was a better fitting model than a log transformation of the dependent variable. The analysis limited to the central city of each region for the supply of units affordable to very low-income households was a better fitting model with no transformation. For this reason, the central city analysis for very low-income rental units uses the proportion of units affordable to very low-income households as the dependent variable rather than the log of the variable.

The second assumption of regression analysis is that there is no exact linear relationship between two or more independent variables, or no multicollinearity. If two or more independent variables have a perfectly linear correlation, regression coefficients cannot be determined. If two or more independent variables have a strong linear correlation (but not perfect), regression coefficients can be determined but their standard errors are large. Large standard errors create wider confidence intervals of the coefficient and, therefore, less accuracy both in terms of the coefficient itself, as well as its statistical significance (Gujarati 1995, p. 322).

The first step to detect multicollinearity was to explore pair-wise correlations among the independent variables. The correlations were measured, separately, for each of the four regions. The full correlation matrices for each region are located in Appendix D. [120] Of particular concern is the potentially strong correlation between residential density and the proportion of housing in multi-unit structures.[121] Multi-unit structures, particularly apartment buildings with 5 or more units, concentrate more housing units on a given area of land than single-family housing units. Therefore, multi-unit structures are believed to have a strong correlation with residential density.

Table 7.10 provides the correlations between residential density and multi-unit structures in each region in the years 1990 and 2000. To explore the differences between two different

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[120] Correlations range in value from -1 to 1. Correlations of -1 and 1 indicate an exact linear relationship between two variables. 0 indicates no linear relationship. Typically, a strong pair-wise correlation greater than .8 or less than -.8 indicates a serious threat of multicollinearity (Gujarati 1995, p. 335).

[121] Initially, the proportion of the population that was African-American and the proportion that was minority were both included in the model. The correlations between these two variables presented a severe threat of multicollinearity. The correlation ranged in value from .812 in the Seattle region in the year 2000 to .998 in the Baltimore region in the year 1990. The African-American variable was dropped from the final analysis. See Appendix J for further details.

sizes of multi-unit structures, correlations are provided for the linear relationship between density and the proportion of housing in structures of 2 to 4 units, as well as for the relationship between density and the proportion of housing in structures of 5 or more units. Surprisingly, these linear relationships are not as strong as expected.

Small multi-unit structures of 2 to 4 units were more strongly correlated with density in the regions of Baltimore and Philadelphia than in the regions of Portland and Seattle. In 2000, the correlation was .537 in Baltimore and .436 in Philadelphia. The correlation was .298 in Portland and .166 in Seattle. Similar correlations were found in 1990.

Table 7-10. Correlations of Housing Density and Multi-Unit Structures

Year	Region	Correlation of density and % units in structures of 2 – 4 units	Correlation of density and % units in structures of 5 or more units
1990	Portland	.271***	.539***
	Seattle	.194***	.583***
	Baltimore	.454***	.106**
	Philadelphia	.426**	.155**
2000	Portland	.298***	.525***
	Seattle	.166***	.607***
	Baltimore	.537***	.119**
	Philadelphia	.436***	.161***

Note: ** Significant at 5%. *** Significant at 1%.

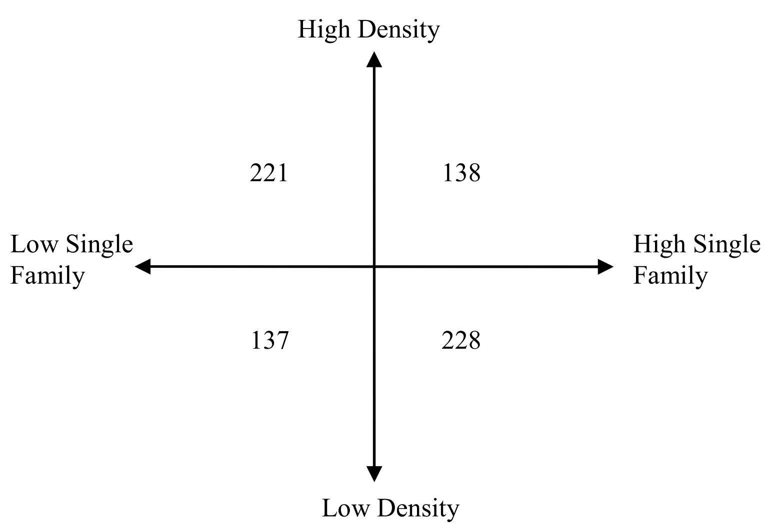
Larger multi-unit structures of 5 or more units were more strongly correlated with density in Portland and Seattle than in the regions of Baltimore and Philadelphia. In 2000, the correlation was .525 and .607 in the regions of Portland and Seattle, respectively. Surprisingly, the correlation between density and multi-units structures of 5 more units in the regions of Baltimore and Philadelphia were much lower. In 2000, the correlation was .119 and .161 in the regions of Baltimore and Philadelphia, respectively.

The correlations between multi-unit structures and housing density were not as strong as expected. We would expect a neighborhood consisting of multi-unit structures to be denser than a neighborhood of single-family units. There are at least two explanations for these weaker than expected correlations. First, housing density for each neighborhood is measured as the number of dwelling units divided by total land area. The measure does not differentiate between developed land area and undeveloped land area. The only land area not included in the total amount within the neighborhood is land included in public parks. Neighborhoods consisting of single-family units with little space between them may be just as dense as neighborhoods consisting of multi-unit structures separated by undeveloped land.

The second potential explanation for the lower than expected correlations is that multi-unit structures may be more likely to be located in neighborhoods with other land uses. While neighborhoods dominated by single-family units may be exclusively residential, neighborhoods with a larger proportion of housing in multi-unit structures may include other land uses, such as commercial activities, that prevent land from being used for housing. This land is still included in the denominator for density. The correlations in Appendix D provide some evidence for this explanation. In 2000, the correlation between the proportion of housing in structures of 5 or more units and the index of mixed land use was .550 in Portland, .551 in Seattle, .202 in Baltimore, and .295 in Philadelphia. All of these correlations were statistically significant at the .01 level.

These two explanations lead to the conclusion that there could be neighborhoods with a high proportion of single-family units and high density, as well as neighborhoods with a high proportion of multi-unit structures and low density. Figure 7.1 provides a matrix in which the census tracts of Portland and Seattle are categorized by the proportion of single-family units and housing density.

Figure 7-1. Single-Family Dwellings by Housing Density (Portland and Seattle)

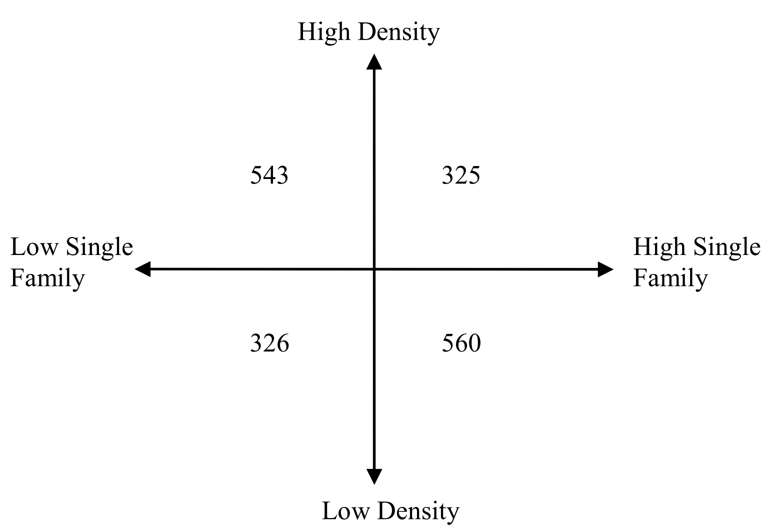


Note: Number is count of census tracts in each quadrant.

Census tracts with a proportion of single-family units greater than the median among the region's tracts are categorized as "high single-family" while those with a proportion lower than the median are categorized as "low single-family." Tracts with housing density greater than the median density among the region's tracts are categorized as "high density" while those with density lower than the region's median are categorized as "low density." Of 724 census tracts, there were 138 tracts with a high proportion of single-family dwellings and high density. There were 137 tracts with a low proportion of single-family dwellings and low density. There were 221 census tracts with a low proportion of single-family units and high density and 228 tracts with a high proportion of single-family units and low density.

Figure 7.2 is the same matrix, but for the regions of Baltimore and Philadelphia. The matrix indicates that in there are neighborhoods with both a high proportion of single-family units and high density, as well as neighborhoods with a high proportion of non single-family housing and low density. Of 1,754 census tracts, there were 325 with a high proportion of single-family dwellings and also high density. There were 326 census tracts with a low proportion of single-family homes and low density. There were 543 tracts with low proportion of single-family homes and high density and another 560 census tracts with low density and a high proportion of single-family units.

Figure 7-2. Single-Family Dwellings by Housing Density (Baltimore and Philadelphia)



Note: Number is count of census tracts in each quadrant.

A strong correlation between two independent variables is a sufficient condition for multicollinearity, but is not always necessary when there are more than two independent variables in a model (Gujarati 1995, p. 336). There may be a linear relationship between multiple variables not captured by pair-wise correlations. Therefore, variance inflation factors (VIF) were obtained for the independent variables as a second test of multicollinearity. The VIF measures the extent to which the variance of an independent variable's coefficient is increased as a result of the variable's correlation with other independent variables (Gujarati 1995, p. 328). The variance of an independent variable's coefficient is:

$$\mathrm{Var}(b_{xi}) = \frac{\sigma^2}{\mathrm{Var}(x_i)} * \frac{1}{(1 - r^2_{xi})} \tag{7.7}$$

Where b_{xi} is the estimated regression coefficient of x_i, x_i is the independent variable in question, and r^2_{xi} is the resulting R^2 of x_i regressed on all other independent variables. R^2 is the proportion of the variance of x_i explained by the other independent variables. The VIF is $1 / (1 - r^2_{xi})$, the second part of equation 7.7. As r^2_{xi} increases, the VIF increases for x_i. In other words, a greater proportion of variance in x_i that can be explained by x_i's relationship to other independent variables leads to a greater VIF. Typically, a VIF greater than 10 is considered a severe problem and a score greater than 5 is considered a potential problem (Mertler and Vannatta 2002, p. 169; Gujarati 1995, p. 339).

The VIF scores are presented in Table 7.11. For the analysis of Portland and Seattle, there are two variables which may cause some concern of multicollinearity. First, the interaction variable of Portland with the index of mixed land use has a VIF of 9.92 and 11.32 in 1990 and 2000, respectively. It is likely that the correlation between mixed land use and the proportion of housing in structures of 5 or more units is partially responsible for the large VIF.[122] These high scores indicate that the performance of this interaction variable should be closely watched as variables are added into and removed from the model.

The second concern is the variable representing multi-unit structures with five or more units. The VIF for the interaction of Portland with multi-unit structures of 5 or more units was 6.98 and 7.18 in 1990 and 2000, respectively. VIF scores for multi-unit structures of 5 or more

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[122] When structures of 5 or more units are removed from the analysis, the VIF for the interaction of Portland and mixed land use declines to 6.06 and 7.43 in 1990 and 2000, respectively.

units (without the interaction) were 6.11 and 5.79 in 1990 and 2000, respectively. These scores do not indicate a definite and severe threat of multicollinearity, but do indicate the potential for multicollinearity. Because of this concern, structures of 5 or more units are dropped from an additional analysis for Portland and Seattle.

Table 7-11. Variance Inflation Factors for Independent Variables

Variable	Portland/Seattle 1990 Analysis	Portland/Seattle 2000 Analysis	Baltimore/Phila. 1990 Analysis	Baltimore/Phila. 2000 Analysis
Smart Growth				
Density	3.56	3.52	3.16	3.17
Mixed Land Use[a]	4.12	3.37	2.08	2.51
% Park	2.72	2.75	2.51	2.52
Units in Structure				
% 2-4 Units	3.51	3.81	3.04	2.99
% => 5 Units	6.11	5.79	2.34	2.30
Interaction Variables[b]				
Density	4.93	5.11	4.80	5.15
Mixed Land Use[a]	9.92	11.32	5.84	7.14
% Park	3.03	3.00	3.35	3.37
Units in Structure				
% 2-4 Units	5.66	6.60	3.89	3.99
% => 5 Units	6.98	7.18	2.93	3.24
Other Variables				
% Vacant	1.26	1.45	1.99	2.44
% > 20 yrs. Old	3.28	2.50	2.45	2.32
% => 4 bedrooms	2.49	2.85	1.85	2.10
% Subsidized	1.88	1.81	1.51	1.50
% Minority Pop.	1.92	1.82	2.46	3.19
Region Dummy	4.95	8.22	8.08	9.82

a. Diversity index as presented in Section 7.2.2.
b. Smart growth variables interacted with either Portland or Baltimore.

Table 7.11 indicates the analysis of the Baltimore and Philadelphia regions contains one variable which poses a potential threat of multicollinearity. This variable is the interaction of the Baltimore region and mixed land use. The VIF scores for this interaction variable are 5.84 and 7.14 in 1990 and 2000, respectively. There are two reasons I do not believe this VIF should be cause for concern. First, a VIF between 5 and 10 only suggests potential multicollinearity. Second, Appendix D indicates that mixed land use is only weakly correlated with any of the other independent variables in the regions of Baltimore and Philadelphia.

The third significant assumption of linear regression is homoskedasticity, or a constant variance of the error term across observations. In addition, the error term is assumed to be random across observations and normally distributed. Constant variance of the errors indicates that they are not related to any of the model's independent variables or to the predicted value of the dependent variable. A typical violation of homoskedasticity occurs when the regression residuals among observations increase as the predicted value of the dependent variable increases.[123] For the analyses in this research, the plotted residuals against the predicted values of the dependent variable reveal a strong likelihood that the assumption of homoskedasticity is violated. Rather than constant variance of errors, there is heteroskedasticity or non-constant variance of errors. A selection of scatterplots from the initital regressions is in the appendix.

When heteroskedasticity is present, the estimates of the coefficients for the independent variables may still be unbiased and consistent. They are not necessarily incorrect estimators of the true value of the coefficient. However, the variance of the coefficients is not efficient, meaning that the variance of the coefficient is not kept to a minimum. The t-statistic used for hypothesis testing is not accurate when variance is not kept to a minimum. Therefore, wrong conclusions can be drawn regarding the significance of variables when the homoskedasticity assumption is not met.

To address the lack of homoskedasticity, a procedure of robust standard errors was utilized.[124] This procedure, included in STATA and other statistical software packages, provides a correction for heteroskedasticity using robust variance estimates obtained from a procedure developed by Huber and White.[125] Stock and Watson (2007) argue this procedure has become commonplace in applied econometrics as heteroskedasticity is more common among data than homoskedasticity. A benefit of robust standard errors is that they provide more accurate estimates of standard errors when heteroskedasticity is present, but do not provide incorrect standard errors when heteroskedasticity is not a threat (Stock and Watson 2003, Chapter 4).

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[123] Another example is increasing errors as the value of an independent variable increases.

[124] Appendix H provides regression results for Ordinary Least Squares with standard errors, assuming homoskedasticity.

[125] A second method of correcting for heteroskedasticity is weighted least squares (WLS). WLS is used to give a lower weight to observations whose error terms are the highest and a higher weight to observations whose error terms are small. However, appropriate use of WLS requires the pattern of heteroskedasticity to be known. Because the independent variables identified as heteroskedastic changed from model to model throughout these analyses, the procedure of robust standard errors was used rather than WLS.

Now that the variables, measurements, data sources, and assumptions of the regression model have been reviewed, the next two sections present the model's findings. Section 7.6 presents the results when the proportion of affordable rental units for extremely low-income households is regressed on the four smart growth variables, as well as on the other control variables. The level of analysis is the neighborhood as defined by census tracts. Section 7.6.1 examines the same dependent variable, but includes only the neighborhoods within the central city of each region. In Section 7.7, the dependent variable is broadened to include the proportion housing that is affordable rental units for very low-income households. Section 7.7.1 examines this relationship only in the central city of each region.

7.6 ANALYSIS OF EXTREMELY LOW-INCOME RENTAL UNITS

Table 7.12 provides the regression results for the supply of affordable rental units for extremely low-income households in the regions of Portland and Seattle for 1990 and 2000. There are a total for four regressions. For reasons which will become apparent, Models 1 and 2 exclude the variables for multi-unit structures. In model 1, mixed land use is measured as the diversity index which includes all types of employment and residential activity in the neighborhood. In model 2, mixed land use is measured as the balance between population-serving jobs and residents. Models 3 and 4 are the full models which include all variables. Mixed land use is measured by the diversity index of all types of activities in model 3 and by the balance between population-serving jobs and residents in model 4. All of the models explained a significant proportion of the variation among neighborhoods in the proportion of housing that was affordable rental units for extremely low-income households. Among the four models, the Adjusted-R^2 ranged from .65 to .70.

Table 7-12. Regression Coefficients, Portland and Seattle, Extremely Low-Income Rental Units (n=724)

	Multi-Unit Structures Excluded				***Full Model – All Variables***			
	Model 1		**Model 2**		**Model 3**		**Model 4**	
	1990	**2000**	**1990**	**2000**	**1990**	**2000**	**1990**	**2000**
Smart Growth Variables								
Residential Density (1,000 dwelling units / square mile)	.027**	.027***	.024**	.024***	-.000	.017	-.000	.015
Mixed Land Use								
Diversity of all uses	.352**	.581***			-.024	.436**		
Balance of pop. serving jobs to residents			.349**	.482***			.061	.373**
% of land in parks	.003	.008	.005	.010	-.001	.008	-.001	.009
Units in Structure								
% of housing in structures of 2 - 4 Units					.019***	.021***	.018***	.021***
% of housing in structures of 5 or more units					.009***	.004**	.008***	.004**
Interactions								
Residential Density * Portland (1,000 d.u.(s) / square mile)	-.003	-.000	-.004	-.007	-.000	-.001	.000	-.002
Mixed Use * Portland								
Diversity * Portland	-.186	-.237			-.235	-.220		
Servbal * Portland			-.162	-.162			-.112	-.121
% of land in parks * Portland	-.042	-.041***	-.044**	-.044***	-.034	-.041***	-.035	-.043***
% of housing in structures of 2 - 4 Units * Portland					-.005	-.005	-.006	-.004
% of housing in structures of 5 or more units * Portland					-.001	-.002	-.002	-.003
Other Variables								
% of housing that is vacant	.004	.010	.004	.013**	.006	.014**	.006	.016***
% of housing stock that is 20 or more years old	.011***	.005***	.011***	.005***	.013***	.006***	.012***	.006***
% of housing with 4 or more bedrooms	-.024***	-.022***	-.024***	-.022***	-.017***	-.017***	-.017***	-.017***
% of housing that is subsidized	.070***	.076***	.070***	.076***	.066***	.075***	.066***	.074***
% of population that is minority	.006**	.005***	.006**	.004***	.004**	.004**	.004**	.004**
Portland City	-.169	-.167	-.162	-.155	-.175	-.185**	-.199	-.179
Seattle City	-.280**	-.103	-.267**	-.102	-.342***	-.166	-.336***	-.163
Portland Region	.000	-.145	-.013	-.186**	.065	-.118	.032	-.159**
Constant	.653***	.783***	.730***	.873***	.381***	.564***	.394***	.630***
R-squared	0.70	0.73	0.70	0.73	0.72	0.74	0.72	0.74
Adjusted R-Squared	0.65	0.69	0.65	0.69	0.67	0.70	0.67	0.70

Note: ** significant at 5%; *** significant at 1%. Dependent variable: ln(% of all units that are affordable rentals for extremely low-income households). Interpretation of coefficients is the relative change in the dependent variable given a 1-unit change in the independent variable.

The purpose for the first two models is to highlight the statistical significance of residential density prior to the inclusion of multi-unit structures. In models 1 and 2, residential density was associated with a greater proportion of affordable rentals for extremely low-income renters. In both 1990 and 2000, an increase in residential density by 1,000 dwelling units per square mile was associated with 2.7% and 2.4% increase in the proportion of affordable rental units in models 1 and 2, respectively.[126] These results change when variables for multi-unit structures are included in models 3 and 4.

In the full models 3 and 4, residential density was not statistically significant. The only smart growth variables to be consistently statistically significant in models 3 and 4 were multiple housing options as measured by the proportion of housing units in multi-unit structures. In 1990, Model 3 indicates that an increase of .01 in the proportion of units in structures of 2 to 4 units was associated with a 1.9% increase in the proportion of affordable rental units. A similar increase in the proportion of housing in structures of 5 or more units was associated with a .9% increase in the proportion of affordable rentals. Similar relationships were found in 2000. A .01 increase in the proportion of units in structures of 2 to 4 units was associated with a 2.1% increase in the proportion of affordable rental units and a similar increase in the proportion of units in structures of 5 or more units was associated with a .4% increase in the proportion of affordable rental units.

There are two possible explanations for the lack of statistical significance of the density variable when multi-unit structures are included in the analysis. First, there is the possibility that multi-unit structures and residential density are too strongly correlated to include both in the model. The correlations and variance inflation factors (VIF) presented in the previous section did not definitively indicate severe multicollinearity, but indicated that a potential threat exists.[127] Additional models were analyzed without the variable for structures of 5 or more units. The results are presented in Table 7.13.

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[126] One square mile is equivalent to 640 acres. Therefore, an increase in density by 1,000 units per square mile is equivalent to an increase of 1.5625 units per acre. The regression coefficient would be larger if housing density was measured in 10,000 units per square mile or smaller if measured as units per acre. However, the statistical significance of the variable would not change.

[127] Eigenvalues is another method of diagnosing multicollinearity. From these eigenvalues, a condition index can be used to determine if multicollineaity is a threat to a regression. The condition index for the regression is 17.59, which is considered a moderate threat by some statisticians (See SPSS Results Coach, Gujarati 1995, p. 338).

Comparing models 5 and 6 in Table 7.13 to models 3 and 4 in Table 7.12, we find that residential density is once again positive and statistically significant in explaining the proportion of affordable rental units. These results indicate that collinearity between structures of 5 or more unts and residential density may make the results regarding density from models 3 and 4 less reliable.

Table 7-13. Regression Coefficients, Portland and Seattle, Extremely Low-Income Rental Units, Without 5-or-more Unit Structures (n=724)

	Model 5		Model 6	
	1990	**2000**	**1990**	**2000**
Smart Growth Variables				
Residential Density (1,000 dwelling units / square mile)	.030***	.031***	.027***	.029***
Mixed Land Use				
Diversity of all uses	.329	.564***		
Balance of pop. serving jobs to residents			.330**	.468***
% of land in parks	.005	.011	.007	.013
Units in Structure				
% of housing in structures of 2 - 4 Units	.018***	.021***	.018***	.021***
% of housing in structures of 5 or more units				
Interactions				
Residential Density * Portland (1,000 d.u.(s) / square mile)	-.006	-.007	-.007	-.013
Mixed Use * Portland				
Diversity * Portland	-.212	-.279		
Servbal * Portland			-.168	-.189
% of land in parks * Portland	-.043**	-.045***	-.046**	-.048***
% of housing in structures of 2 - 4 Units * Portland	-.006	-.006	-.006	-.006
% of housing in structures of 5 or more units * Portland				
Other Variables				
% of housing that is vacant	.006	.014**	.006	.017***
% of housing stock that is 20 or more years old	.011***	.005***	.010***	.005***
% of housing with 4 or more bedrooms	-.021***	-.018***	-.021***	-.019***
% of housing that is subsidized	.070***	.075***	.070***	.075***
% of population that is minority	.004	.005***	.004	.005**
Portland City	-.183	-.190**	-.179	-.173
Seattle City	-.330***	-.167	-.319***	-.167
Portland Region	.023	-.116	.005	-.167**
Constant	.576***	.619***	.603***	.707***
R-squared	0.70	0.74	0.71	0.74
Adjusted R-Squared	0.66	0.70	0.66	0.70

Note: ** significant at 5%; *** significant at 1%. Dependent variable: ln(% of all units that are affordable rentals for extremely low-income households). Interpretation of coefficients is the relative change in the dependent variable given a 1-unit change in the independent variable.

The second explanation for density's lack of statistical significance in the complete models 3 and 4 is that the type of housing is more significant in explaining the supply of affordable rental units than density. Holding the type of housing constant, greater residential density itself was not associated with a greater supply of affordable rental units. This is a significant finding as it provides evidence that policies meant specifically to promote residential density may have little impact on affordable housing unless specific attention is paid to the type of housing available in the market. Reducing lot sizes to increase density, without similar changes to the size of homes or the type of structures built, may have little impact on housing for low-income households.

Mixed land use is the only smart growth variable which provided mixed results among the models. As measured by the diversity index of all activities, mixed land use was not statistically significant in 1990 in models 3 or 5. In 2000, the diversity index was statistically significant.

There is no obvious explanation for mixed land use's association with a greater proportion of affordable rental units in 2000, but not in 1990. One possible explanation is that high home values in a strong housing market may make home buyers risk-adverse to purchasing a home in a location in which they may have little control over adjacent land uses. A homebuyer making a large investment in a home may want assurances that adjacent land uses do not cause a threat, in the form of negative externalities, to the home's value. This aversion may reduce demand for housing in mixed use neighborhoods. Both Portland and Seattle experienced strong growth in home values during the 1990's.[128]

The balance of population-serving jobs to residents, the second measure of mixed land use, performed in a slightly different yet similar manner. With one exception, the 'balance' measure of mixed land use was statistically significant and positive in both 1990 and 2000. A more even balance between population-serving jobs and residents was associated with a greater supply of affordable units in all models except for model 4 in 1990. This finding was unexpected. I suspected that the 'balance' measure of mixed land use, which only includes land uses likely to provide positive amenities, was less likely to be associated with a greater supply of affordable units than the diversity index of all land uses (which includes land uses that produce both positive and negative externalities).

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[128] See Table 6.8. From 1990 to 2000, the median home value in the Portland region increased from 2.34 to 3.76 times the median household's income. The median home value in the Seattle region increased from 3.61 to 4.23 times the median household's income.

Of primary interest to this research is the statistical significance of the interaction variables representing the interaction of Portland's urban growth boundaries with each smart growth variable. These interaction variables provided two interesting results, neither of which gave evidence that urban containment altered the relationship between the smart growth principles and the supply of affordable housing. The first interesting result was no change in the interaction variables' statistical significance between 1990 and 2000.[129] Only Portland had urban growth boundaries in 1990. Therefore, I expected interaction variables to be significant in 1990 but not in 2000. Because this change in significance did not occur, the findings do not support the hypothesis that region-wide urban containment policies change the relationship between the smart growth principles and affordable housing.

The second interesting result was the different relationship between public parks and affordable housing in the Portland region as compared to Seattle. The negative and statistically significant coefficient for the interaction of Portland and public parks indicates a negative relationship between the proportion of land in public parks and the proportion of affordable rental units in the Portland region. There was no statistically significant relationship between parks and affordable rental units in the Seattle region. These findings indicate that public parks may be more highly valued as a neighborhood amenitity in Portland than in Seattle.

Only three of the control variables were statistically significant in the expected direction in all models for 1990 and 2000. First, an older housing stock in the neighborhood was associated with a greater proportion of housing that was affordable rental units for extremely low-income households. Second, a greater proportion of units with four or more bedrooms was associated with a smaller proportion of affordable rental units. Third, a greater proportion of units in the neighborhood subsidized by a public housing authority was associated with a greater proportion of affordable rental units.

Two other control variables were not consistently significant. A higher vacancy rate and a greater proportion of minorities were associated with a greater proportion of affordable rental units. The vacancy rate was statistically significant in 2000 in five of the six models, but not significant in 1990. The proportion of minorities was consistently significant in 2000. In 1990, the proportion of minorities was significant in all models except for models 5 and 6.

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[129] In models 3 and 4, the interaction of Portland and public parks was negative and statistically significant in 2000 but not in 1990. However, the other models indicate this interaction to be significant in both 1990 and 2000.

Similar analyses were undertaken for the regions of Philadelphia and Baltimore. Table 7.14 provides the results. Once again, models 1 and 2 exclude the variables for multi-unit structures. The Adjusted R^2 for the four models ranged from .62 to .69. Unlike the analysis of extremely low-income rental units in the regions of Portland and Seattle, multicollinearity was not a concern in models 3 and 4 as indicated by the low VIF scores presented earlier.

Unlike the Portland and Seattle analysis, the relationship between residential density and the proportion of affordable rental units was consistently significant and positive in models 1 and 2 and models 3 and 4 for the regions of Baltimore and Philadelphia. Among the four models, an increase in residential density by 1,000 units per square mile was associated with at least a 2% increase in the proportion of affordable rental units.

The relationship between multi-unit structures and the proportion of affordable rental units in the Baltimore and Philadelphia regions was dependent on the size of the structures. An increase of .01 in the proportion of units in structures of 2 to 4 units was associated with a 1.2% increase in the proportion of units that were affordable rentals in 1990 and a 1.9% increase in the proportion of affordable rental units in 2000. Contrary to expectations, the variable for structures of 5 or more units was not statistically significant.[130] These results indicate that large multi-unit structures were not associated with affordable rentals for extremely low-income households as they were in the Portland and Seattle analysis.

The variable measuring public parks was statistically significant and negative in 1990 and 2000 for all models. This result was expected as the positive amenity provided by public parks was expected to increase demand for housing while the preservation of land in parks was expected to decrease the supply of housing. The magnitude of this negative relationship increased from 1990 to 2000. For example, Model 3 indicates that an increase of .01 in the proportion of land in parks was associated with a 1.2% decrease in the proportion of affordable rental units in 1990 and with a 2.1% decrease in the proportion of affordable rental units in 2000.

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[130] Appendix I provides results for regressions which exclude the variable for residential density. When density is excluded, the variable for units in structures of 5 or more units remains statistically insignificant.

Table 7-14. Regression Coefficients, Baltimore and Philadelphia, Extremely Low-Income Rental Units (n=1757)

	Multi-Unit Structures Excluded				***Full Model – All Variables***			
	Model 1		**Model 2**		**Model 3**		**Model 4**	
	1990	**2000**	**1990**	**2000**	**1990**	**2000**	**1990**	**2000**
Smart Growth Variables								
Residential Density (1,000 dwelling units / square mile)	.024***	.027***	.022***	.026***	.024***	.021***	.021***	.020**
Mixed Land Use								
Diversity of all uses	.221**	.153			.270**	.039		
Balance of pop. serving jobs to residents			.028	.019			.065	-.074
% of land in parks	-.013***	-.022***	-.013***	-.021***	-.012***	-.021***	-.012***	-.021***
Units in Structure								
% of housing in structures of 2 - 4 Units					.012***	.019***	.012***	.020***
% of housing in structures of 5 or more units					-.003	.001	-.002	.001
Interactions								
Residential Density * Baltimore (1,000 d.u.(s) / square mile)	.023	-.009	.018	-.015	.011	-.017	.008	.023
Mixed Use * Baltimore								
Diversity * Baltimore	.314	.223			.320	.220		
Servbal * Baltimore			.214	.027			.235	.033
% of land in parks * Baltimore	.009	.021***	.009	.021***	.011	.025***	.011	.025***
% of housing in structures of 2 - 4 Units * Baltimore					.013**	.005	.012**	.005
% of housing in structures of 5 or more units * Baltimore					.001	.003	.000	.003
Other Variables								
% of housing that is vacant	.027***	.024***	.029***	.026***	.025***	.021***	.027***	.022***
% of housing stock that is 20 or more years old	.002	.002	.002**	.002	.000	.001	.001	.001
% of housing with 4 or more bedrooms	-.003***	-.011***	-.003***	-.011***	-.004***	-.010***	-.004***	-.010***
% of housing that is subsidized	.056***	.046***	.057***	.047***	.056***	.042***	.057***	.043***
% of population that is minority	.006***	.007***	.005***	.006***	.006***	.006***	.005***	.006***
Baltimore City	.124	.511***	.135	.537***	.033	.382***	.040	.402***
Philadelphia City	.049	.176**	.061	.180**	.003	.102	.018	.107
Baltimore Region	.147	.117	.228***	.194**	.067	.114	.155**	.187**
Constant	.132	.648***	.172**	.727***	.199**	.632***	.230***	.670***
R-squared	0.68	0.72	0.68	0.71	0.70	0.73	0.69	0.73
Adjusted R-Squared	0.63	0.67	0.62	.067	0.65	0.69	0.64	0.69

Note: ** significant at 5%; *** significant at 1%. Dependent variable: ln(% of all units that are affordable rentals for extremely low-income households). Interpretation of coefficients is the relative change in the dependent variable given a 1-unit change in the independent variable.

The one smart growth variable that showed inconsistent results was of mixed land use. In 1990, a greater diversity index was positive and statistically significant. The diversity index includes land use activities which may provide negative externalities to residents. Examples include industrial activities, warehouses, utilities, or other less desirable land uses. These types of land uses lower home values and could increase the proportion of units that are affordable for low-income households. The diversity index was not statistically significant in 2000. The balance between population-serving jobs and residents was not statistically significant in either 1990 or 2000.

Comparing the coefficients of the interaction variables in models 3 and 4, we find that the statistical significance of two interactions changed from 1990 to 2000. Only one of these changes provided limited evidence that urban containment may influence the relationship between any of the smart growth principles and affordable housing. First, the interaction between Baltimore and the proportion of housing in structures of 2 to 4 units was positive and statistically significant in 1990, indicating that the positive relationship between structures of 2 to 4 units and affordable rental units was of a stronger magnitude in the Baltimore region as compared to the Philadelphia region. In 2000, the interaction variable was not statistically significant, indicating that structures of 2 to 4 units were no longer more strongly associated with affordable housing in the Baltimore region after priority funding areas were implemented.

This may finding may indicate that the positive relationship between these multi-unit structures of 2 to 4 units and affordable rental units became weaker in the Baltimore region after the implementation of priority funding areas as compared to the relationship prior to urban containment. Admittedly, stronger evidence would be provided for the hypotheses had the interaction variable been negative and statistically significant in 2000. This would have indicated that the positive relationship between structures of 2 to 4 units and affordable housing was weaker in the Baltimore region than in the Philadelphia region after the implementation of urban containment in Baltimore.

Unfortunately, an alternative explanation is plausible. It could be that the relationship between structures of 2 to 4 units and affordable rental units no longer differed between the two regions in 2000 because of some other event which occurred in one region, but not the other, between 1990 and 2000. During this time period, the Baltimore region's population growth rate was twice that of the Philadelphia region. It is possible that this greater growth in population resulted in greater growth in the demand for housing in multi-unit structures in Baltimore as compared to Philadelphia, thereby weakening the positive relationship between structures of 2 to 4 units and the supply of affordable units in Baltimore.

The second change in significance of an interaction variable was unexpected. This unexpected change from 1990 to 2000 was of the interaction of public parks and the Baltimore region. In 1990, the interaction was not statistically significant. Therefore, the negative relationship between parks and affordable rental units was similar in both regions. In 2000, the interaction variable was positive and statistically significant. In models 3 and 4 for 2000, the coefficients for the interaction were .025. These coefficients indicate that the negative relationship between public parks and affordable rental units was stronger in the Philadelphia region as compared to the Baltimore region. Further analysis indicates that the relationship was not statistically significant in the Baltimore region.[131] This result was unexpected as it was hypothesized that urban containment policies would increase the value of parks within developed areas which, in turn, would increase the magnitude of the negative association between parks and affordable housing in the Baltimore region as compared to the Philadelphia region.

Among the control variables, a higher vacancy rate, a greater proportion of units subsidized by a public housing authority, and a greater proportion of population that was a minority, were each associated with a greater proportion of affordable rental units for extremely low-income households. A greater proportion of units with four or more bedrooms was associated with a smaller proportion of affordable rental units.

7.6.1 Analysis of Extremely Low-Income Rental Units in the Central City

Urban containment policies, such as urban growth boundaries and priority funding areas, push new commercial and housing development, as well as housing demand, back into the inner city

[131] In model 3, the 95% confidence interval for the public parks (non-interaction) variable is -.0324 to -.0101 and the confidence interval for the interaction variable is .0114 to .0391. In model 4, the confidence interval for public parks is -.0321 to -.0010 and the interval for the interaction variable is .0111 to .0393. Additional regressions switching the interaction variables to represent an interaction between the Philadelphia region and the smart growth variables indicated that the relationship between parks and affordable housing was not statistically significant in Baltimore.

(Nelson et al. 2004). For this reason, a second set of analyses were limited to the central city neighborhoods of each metropolitan region. Table 7.15 provides the results from the analysis of extremely low-income rental units in the central cities of Portland and Seattle. Models 1 thru 4 explained from 67% to 74% of the variation in the proportion of housing that was affordable rental units among the central city neighborhoods.

Once again, Models 1 and 2 exclude multi-unit structures from the regression. There are two important variables to highlight from them. Similar to the regional analysis, residential density was statistically significant when the variables for multi-unit structures were excluded. In 1990 and 2000, model 1 indicates that an increase in residential density by 1,000 units per square mile was associated with a 2.6% increase in the proportion of affordable rental units. The only model, among those excluding multi-unit structures, in which density was not significant was model 2 in 1990. Second, mixed land use was also statistically significant in models 1 and 2. An increase in mixed land use was associated with a greater proportion of affordable rental units. This relationship was consistently significant in both 1990 and 2000, as well as for either measure of mixed land use.

Models 3 and 4, once again, included variables for the proportion of housing in structures of 2 to 4 units and in structures of 5 or more units. The proportion of housing in structures of 2 to 4 units was positive and statistically significant in both 1990 and 2000, with a .01 increase in the proportion of housing in these structures associated with a 2.0% to 2.6% increase in the proportion of affordable rental units. The proportion of housing in structures of 5 or more units was positive and statistically significant in 1990, but not in 2000.

When multi-unit variables were included in models 3 and 4, two interesting changes occurred to the significance of other variables. The first interesting change was that residential density was no longer statistically significant, with one exception. The second interesting change was that the measures of mixed land use also became statistically insignificant, with the exception of model 4 in 2000.

Table 7-15. Central City, Regression Coefficients, Portland and Seattle, Extremely Low-Income Rental Units (n=241)

	Multi-Unit Structures Excluded				*Full Model – All Variables*			
	Model 1		**Model 2**		**Model 3**		**Model 4**	
	1990	**2000**	**1990**	**2000**	**1990**	**2000**	**1990**	**2000**
Smart Growth Variables								
Residential Density (1,000 dwelling units / square mile)	.026**	.026**	.015	.022**	-.034	.021	-.028	.020**
Mixed Land Use								
Diversity of all uses	.743**	.732***			-.323	.471		
Balance of pop. serving jobs to residents			.608***	.678***			-.118	.512**
% of land in parks	.000	-.004	.005	-.003	-.001	-.005	-.003	-.004
Units in Structure								
% of housing in structures of 2 - 4 Units					.020***	.024***	.019***	.023***
% of housing in structures of 5 or more units					.020***	.005	.018***	.005
Interactions								
Residential Density * Portland (1,000 d.u.(s) / square mile)	.037	.027	.029	.012	.044	.005	.030	.003
Mixed Use * Portland								
Diversity * Portland	.444	-.060			.653	-.381		
Servbal * Portland			.267	.012			.485	-.058
% of land in parks * Portland	-.021	-.024	-.021	-.026	.002	-.012	.005	-.017
% of housing in structures of 2 - 4 Units * Portland					-.003	-.005	-.001	-.006
% of housing in structures of 5 or more units * Portland					-.005	.003	-.003	.001
Other Variables								
% of housing that is vacant	.024	.001	.037**	.008	.017	.006	.018	.007
% of housing stock that is 20 or more years old	.010**	.005	.010***	.006	.016***	.005	.015***	.006
% of housing with 4 or more bedrooms	-.027**	-.026***	-.029***	-.027***	-.018***	-.016***	-.016***	-.018***
% of housing that is subsidized	.050***	.061***	.050***	.060***	.043***	.057***	.042***	.056***
% of population that is minority	.007***	.009***	.007***	.009***	.008***	.009***	.008***	.010***
Portland City	-.356	-.368**	-.247	-.375***	-.239	-.211	-.150	-.283**
Constant	.341	.768**	.465	.737	-.340	.340	-.393	.322
R-squared	0.70	0.72	0.69	0.74	0.75	0.75	0.75	0.75
Adjusted R-Squared	0.68	0.71	0.67	0.72	0.73	0.73	0.73	0.74

Note: ** significant at 5%; *** significant at 1%. Dependent variable: ln(% of all units that are affordable rentals for extremely low-income households). Interpretation of coefficients is the relative change in the dependent variable given a 1-unit change in the independent variable.

When the variables for multi-unit structures were included in models 3 and 4, multicollinearity was a concern. The correlations between structures of 5 or more units and density, as well as between structures of 5 or more units and mixed land use, were stronger among central city census tracts than they were among all census tracts in the region. The correlations are shown in Table 7.16. In 2000, the correlation between structures of 5 or more units and density was .580 and .668 in the regions of Portland and Seattle, respectively. The correlation between structures of 5 or more units and mixed land use was .634 and .711 in the regions of Portland and Seattle, respectively.

Table 7-16. Correlations for Cities of Portland and Seattle

Year	City	Correlation of % units in structures of 5 or more units and density	Correlation of % units in structures of 5 or more units and mixed land use (diversity index)
1990	Portland Seattle	.576*** .639***	.639*** .705***
2000	Portland Seattle	.580*** .668***	.634*** .711***

Note: ** Significant at 5%. *** Significant at 1%. See Appendix D, Tables 9 & 10 for complete 1990 correlation matrices for tracts in the central cities.

Because of these high correlations, another analysis was conducted excluding structures of 5 or more units. Table 7.17 provides the results. Once again, model 5 measures mixed land use as the diversity index of all land use types and model 6 measures it as the balance between population-serving jobs and residents. After structures of 5 or more units were removed from the analysis, three interesting changes occurred in the remaining coefficients. First, the coefficients for residential density were again positive and statistically significant, as in models 1 and 2, indicating greater residential density was associated with a greater proportion of affordable rental units. Second, mixed land use was also again associated with a greater proportion of affordable rental units. Both of these changes were likely the result of removing multicollinearity from the model by dropping the variable for structures of 5 or more units.

The third interesting change after structures of 5 or more units were removed from the analysis was that the pattern of statistical significance of structures of 2 to 4 units changed. A greater proportion of housing in structures of 2 to 4 units was associated with a greater proportion of affordable rental units in 2000, but was no longer significant in 1990. In model 5, a .01 increase in the proportion of housing in these structures was associated with a 2.2% increase in the proportion of affordable rental units in 2000. The coefficient in model 6 was similar.[132]

Table 7-17. Central City, Regression Coefficients, Portland and Seattle, Extremely Low-Income Rental Units, Without 5-or-more Unit Structures (n=241)

	Model 5		Model 6	
	1990	**2000**	**1990**	**2000**
Smart Growth Variables				
Residential Density (1,000 dwelling units / square mile)	.028**	.033***	.019**	.030***
Mixed Land Use				
Diversity of all uses	.731**	.696***		
Balance of pop. serving jobs to residents			.612**	.638***
% of land in parks	.005	.002	.009	.002
Units in Structure				
% of housing in structures of 2 - 4 Units	.015	.022***	.015	.020***
% of housing in structures of 5 or more units				
Interactions				
Residential Density * Portland (1,000 d.u.(s) / square mile)	.037	.025	.029	.010
Mixed Use * Portland				
Diversity * Portland	.343	-.145		
Servbal * Portland			.177	-.020
% of land in parks * Portland	-.021	-.027	-.021	-.029
% of housing in structures of 2 - 4 Units * Portland	-.001	-.005	.003	-.004
% of housing in structures of 5 or more units * Portland				
Other Variables				
% of housing that is vacant	.028	.008	.039**	.014
% of housing stock that is 20 or more years old	.009***	.004	.010***	.005
% of housing with 4 or more bedrooms	-.024***	-.021***	-.026***	-.022***
% of housing that is subsidized	.051***	.060***	.050***	.059***
% of population that is minority	.006**	.008***	.005**	.009***
Portland City	-.326**	-.304	-.266	-.339**
Constant	.221	.556	.342	.541
R-squared	0.70	0.74	0.70	0.75
Adjusted R-Squared	0.69	0.72	0.68	0.73

Note: ** significant at 5%; *** significant at 1%. Dependent variable: ln(% of all units that are affordable rentals for extremely low-income households). Interpretation of coefficients is the relative change in the dependent variable given a 1-unit change in the independent variable.

There were no significant interaction variables in either 1990 or 2000. This result provides evidence that urban containment policies, which Portland but not Seattle had in 1990,

[132] The proportion of units in structures of 2 to 4 units and the proportion in structures of 5 or more units were not significantly correlated, see Appendix D, Tables 9 and 10.

do not alter the relationships between the smart growth principles and affordable rental units in the central city.

Three control variables were consistently significant in the expected manner. A greater proportion of units with four or more bedrooms was associated with a smaller proportion of affordable rental units. A greater proportion of subsidized units was associated with a greater proportion of affordable rental units. And, a greater proportion of minorities was also associated with a greater supply of affordable units.

Two other control variables were sporadically significant. A greater proportion of units that were more than 20 years old was associated with a greater supply of affordable rental units in 1990, but not 2000. A higher vacancy rate was associated with a greater supply of affordable rental units in models 2 and 6 in 1990, but in not other models.

Table 7.18 provides the results for the analysis of rental units affordable for extremely low-income households in the central cities of Baltimore and Philadelphia. Results for models 1 and 2, without multi-unit structures, were similar to those found in models 3 and 4, with multi-unit structures. Therefore, this discussion highlights models 3 and 4. Unlike the analysis of the cities of Portland and Seattle, multicollinearity was not a threat.[133]

As in the regional analysis, residential density was statistically significant in all models. In model 3, an increase in density by 1,000 units per square mile was associated with a 2.7% increase in the proportion of affordable rental units in 1990 and a 1.9% increase in 2000. In model 4, a similar increase in density was associated with a 1.9% and 1.8% increase in the proportion of affordable units in 1990 and 2000, respectively.

Another similarity between the central city and regional analyses is the statistical significance of structures of 2 to 4 units. A .01 increase in the proportion of units in structures of 2 to 4 units was associated with a 1.4% increase in the proportion of affordable rental units in 1990 and a 2.0% increase in 2000. Multi-unit structures of 5 or more units were not consistently significant.

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[133] Correlations among the independent variables are in Appendix D, Tables 11 and 12. The highest VIF for the variables included in Table 7.19 is 5.20. Also, similar results to those presented here are obtained when structures of 5 or more units are excluded.

Table 7-18. Central City, Regression Coefficients, Baltimore and Philadelphia, Extremely Low-Income Rental Units (n=529)

	Multi-Unit Structures Excluded				***Full Model – All Variables***			
	Model 1		**Model 2**		**Model 3**		**Model 4**	
	1990	**2000**	**1990**	**2000**	**1990**	**2000**	**1990**	**2000**
Smart Growth Variables								
Residential Density (1,000 dwelling units / square mile)	.025**	.024***	.019**	.024***	.027***	.019**	.019***	.018**
Mixed Land Use								
Diversity of all uses	.545**	.133			.768***	.059		
Balance of pop. serving jobs to residents			.100	.091			.219	.016
% of land in parks	-.029***	-.044***	-.031***	-.045***	-.028***	-.043***	-.032***	-.043***
Units in Structure								
% of housing in structures of 2 - 4 Units					.014***	.020***	.013***	.020***
% of housing in structures of 5 or more units					-.006***	.000	-.004	.000
Interactions								
Residential Density * Baltimore (1,000 d.u.(s) /square mile)	.036***	-.013	.032***	-.019	.030***	-.012	.029***	-.018
Mixed Use * Baltimore								
Diversity * Baltimore	.418	.303			.280	.282		
Servbal * Baltimore			.330	-.007			.267	-.023
% of land in parks * Baltimore	.038***	.045***	.041***	.046***	.037***	.048***	.041***	.048***
% of housing in structures of 2 - 4 Units * Baltimore					-.003	-.009	-.004	-.009
% of housing in structures of 5 or more units * Baltimore					.003	.003	.001	.004
Other Variables								
% of housing that is vacant	.029***	.026***	.034***	.027***	.027***	.024***	.032***	.025***
% of housing stock that is 20 or more years old	.000	.000	.000	-.000	-.002	.001	-.001	.001
% of housing with 4 or more bedrooms	.002	-.008***	.001	-.009***	.001	-.010***	-.001	-.010***
% of housing that is subsidized	.047***	.034***	.049***	.035***	.047***	.032***	.049***	.032***
% of population that is minority	.006***	.007***	.005***	.007***	.006***	.007***	.005***	.007***
Baltimore City	.018	.393**	.092	.525***	.109	.482***	.153	.589***
Constant	.158	1.041	.388	1.124	.210	.787	.420	.832
R-squared	0.64	0.58	0.63	0.58	0.66	0.61	0.64	0.61
Adjusted R-Squared	0.63	0.57	0.62	0.57	0.65	0.60	0.63	0.60

Note: ** significant at 5%; *** significant at 1%. Dependent variable: ln(% of all units that are affordable rentals for extremely low-income households). Interpretation of coefficients is the relative change in the dependent variable given a 1-unit change in the independent variable.

A third similarity between the central city and regional analyses of Baltimore and Philadelphia is the relationship between mixed land use and the supply of affordable rental units. A greater diversity of all land uses was associated with a greater proportion of affordable rental units in 1990, but not in 2000. In 2000, the diversity index was not statistically significant. The balance between population-serving jobs and residents was not significant in either 1990 or 2000.

A fourth similarity between the central city and regional analyses is the negative and statistically significant relationship between the proportion of land in public parks and the proportion of units that were affordable rental units. Model 3 indicates that an increase of .01 in the proportion of land in public parks was associated with a 2.8% decline in the proportion of affordable rental units in 1990 and a 4.3% decline in 2000. This negative relationship was of greater magnitude in the central cities compared the regions as a whole. This difference in magnitude is not surprising as the central cities would be more built-up than other areas of the region. Therefore, permanent open space would likely be valued more in the central city than elsewhere.

There were only two statistically significant interaction variables. The first interaction provides no evidence that urban containment policies influence the relationship between the smart growth variables and affordable housing in the central city. The positive and statistically significant interaction between Baltimore and public parks indicates, at the very least, the negative relationship between parks and affordable housing was of a smaller magnitude in Baltimore than in Philadelphia.[134] This interaction was significant in both 1990 and 2000. Therefore, the implementation of priority funding areas in Baltimore in 1997 is not a cause of this interaction.

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[134] Or, the relationship was not statistically significant in Baltimore. The confidence intervals do not allow for an exact determination. In model 3 for 1990, the 95% confidence interval for public parks was -.0451 to -.0108 and the confidence interval for the interaction between Baltimore and public parks was .0174 to .0571. In model 4 for 1990, the confidence interval for public parks was -.0491 to -.0151 and for the interaction of Baltimore and public parks was .0216 to .0612. In model 3 for 2000, the 95% confidence interval for public parks was -.0628 to -.0225 and for the interaction of Baltimore and public parks was .0252 to .0702. In model 4 for 2000, the confidence interval for public parks was -.0634 to -.0223 and for the interaction variable was .0252 to .0713. Separate regressions in which the interaction variables were switched from an interaction with Baltimore to an interaction with Philadelphia indicated that public parks were not statistically significant in Baltimore.

The second statistically significant interaction provides very limited evidence that the implementation of priority funding areas in Baltimore altered the relationship between the smart growth principles and the supply of affordable housing in the central city. The positive and statistically significant coefficient for the interaction of Baltimore and housing density in 1990 indicates that the positive relationship between residential density and affordable housing was stronger in the city of Baltimore than in the city of Philadelphia. In 2000, this interaction was no longer statistically significant. This finding provides limited evidence that the positive association between density and affordable housing may have become weaker in Baltimore after the implementation of priority funding areas as compared to prior their implementation.

Three of the control variables were statistically significant in both 1990 and 2000. A higher vacancy rate, the proportion of units subsidized by a public housing authority, and the proportion of population that was a minority were each associated with a greater proportion of housing being affordable rental units for extremely low-income households. The proportion of housing units that contained four or more bedrooms was not statistically significant in 1990. In 2000, the variable was negative and statistically significant.

The next section expands the definition of affordable housing to include a greater portion of the housing market. As discussed in Section 7.2.1, rental units affordable to very low-income households include a greater proportion of the housing market than rental units affordable to extremely low-income households.

7.7 ANALYSIS OF VERY LOW-INCOME RENTAL UNITS

Table 7.19 provides the results of the analyses for very low-income rental units in the regions of Portland and Seattle. The models explained a greater percentage of the variation of affordable very low-income rental units than the previous models did for extremely low-income rental units. For models 1 and 2 without the multi-unit variables, the adjusted R^2 ranged from .70 in 1990 to .74 in 2000.

Table 7-19. Regression Coefficients, Portland and Seattle, Very Low-Income Rental Units (n=724)

	Multi-Unit Structures Excluded				*Full Model – All Variables*			
	Model 1		**Model 2**		**Model 3**		**Model 4**	
	1990	**2000**	**1990**	**2000**	**1990**	**2000**	**1990**	**2000**
Smart Growth Variables								
Residential Density (1,000 dwelling units / square mile)	.052***	.034***	.046**	.032***	-.037***	-.020***	-.029***	-.018**
Mixed Land Use								
Diversity of all uses	.587***	.528***			-.426**	-.030		
Balance of pop. serving jobs to residents			.568***	.456***			-.187	.082
% of land in parks	.010	.014	.013	.015	.000	.004	-.002	.003
Units in Structure								
% of housing in structures of 2 - 4 Units					.043***	.039***	.043***	.040***
% of housing in structures of 5 or more units					.024***	.017***	.023***	.017***
Interactions								
Residential Density * Portland (1,000 d.u.(s) / square mile)	-.003	.042	-.003	.027	.018	-.002	.019	.006
Mixed Use * Portland								
Diversity * Portland	-.038	.225			.091	-.237		
Servbal * Portland			-.212	.175			-.021	-.115
% of land in parks * Portland	-.016	-.015	-.018	-.019	.004	-.003	.005	-.003
% of housing in structures of 2 - 4 Units * Portland					-.004	.004	-.000	.003
% of housing in structures of 5 or more units * Portland					-.009***	.001	-.008**	.000
Other Variables								
% of housing that is vacant	-.012***	-.021***	-.012**	-.017***	-.006	-.014**	-.007**	-.015***
% of housing stock that is 20 or more years old	.010***	.005***	.010***	.005***	.015***	.008***	.014***	.008***
% of housing with 4 or more bedrooms	-.042***	-.045***	-.043***	-.045***	-.025***	-.028***	-.025***	-.028***
% of housing that is subsidized	.021***	.018***	.022***	.018***	.011***	.011***	.011***	.011***
% of population that is minority	.008***	.011***	.009***	.011***	.005***	.008***	.005***	.008***
Portland City	-.187**	-.288***	-.149	-.266***	-.264***	-.286***	-.277***	-.294***
Seattle City	-.339***	-.079	-.323***	-.082	-.443***	-.213***	-.461***	-.212***
Portland Region	.059	-.150	.091	-.105	.160**	-.006	.159***	-.053
Constant	2.481***	2.734***	2.537***	2.806***	1.700***	2.016***	1.686***	2.007***
R-squared	0.74	0.77	0.74	0.78	0.85	0.86	0.85	0.86
Adjusted R-Squared	0.71	0.74	0.70	0.74	0.81	0.84	0.82	0.84

Note: ** significant at 5%; *** significant at 1%. Dependent variable: ln(% of all units that are affordable rentals for extremely low-income households). Interpretation of coefficients is the relative change in the dependent variable given a 1-unit change in the independent variable.

The initial models without multi-unit variables once again indicate a positive relationship between residential density and the proportion of affordable very low-income rental units. In comparison to the previous analysis of extremely low-income units, the coefficient of density is of a greater magnitude for very low-income units. In model 1, an increase in density by 1,000 units per square mile was associated with a 5.2% increase in the proportion of affordable units in 1990 and a 3.4% increase in 2000. The initial models 1 and 2 also indicate a positive relationhip between mixed land use and the proportion of affordable rental units.

Once again, variables for multi-unit structures were included in models 3 and 4. In contrast to the analyses for extremely low-income rental units, there was a sizable difference in the adjusted R^2 between the initial models without the multi-unit variables and those with the multi-unit variables. For model 3, the adjusted R^2 was .81 in 1990 and .84 in 2000. For model 4, the adjusted R^2 was .82 and .84 in 1990 and 2000, respectively.

There were two significant changes from models 1 and 2 to models 3 and 4. First, the relationship between density and the proportion of affordable rental units was statistically significant and negative, rather than positive, in models 3 and 4. Holding the proportion of housing in multi-unit structures constant, an increase in density was associated with a decrease in the proportion of affordable units. Second, the variables for mixed land use became statistically insignificant. The only exception is that of the diversity index in 1990 (model 3). In this case, the coefficient for the diversity measure of mixed land use was significant and negative.

In models 3 and 4, one interaction variable provided evidence that urban containment policies may alter the relationship between multi-unit structures and affordable housing. The positive association between structures of 5 or more units and the proportion of affordable rental units was weaker in the Portland region as compared to the Seattle region in 1990. There was no difference between the two regions regarding this relationship in 2000. Only Portland had urban growth boundaries throughout the region in 1990 while both regions had urban growth boundaries in 2000. This difference in urban growth boundaries could explain the negative and significant interaction in 1990.

Table 7.20 provides the results for models 5 and 6, which exclude structures of 5 or more units. These structures were excluded from the analysis because of the potential threat of multicollinearity discussed in Section 7.5. There are four interesting differences in models 5 and 6 from models 3 and 4. First, the adjusted R^2 declines by a noticeable degree. For model 5, the

Adjusted R^2 was .76 in 1990 and .78 in 2000. In comparison, model 3 had an Adjusted R^2 of .81 in 1990 and .84 in 2000. Including structures of 5 or more units in the model explained a greater proportion of the variation in a neighborhood's supply of affordable housing. This finding indicates that these structures are significant in explaining the supply of affordable rental units.[135]

Table 7-20. Regression Coefficients, Portland and Seattle, Very Low-Income Rental Units, Without 5-or-more Unit Structures (n=724)

	Model 5		Model 6	
	1990	**2000**	**1990**	**2000**
Smart Growth Variables				
Residential Density (1,000 dwelling units / square mile)	.059***	.044***	.054***	.041***
Mixed Land Use				
Diversity of all uses	.549***	.512***		
Balance of pop. serving jobs to residents			.537***	.446***
% of land in parks	.015	.020**	.018	.021**
Units in Structure				
% of housing in structures of 2 - 4 Units	.043***	.040***	.043***	.039***
% of housing in structures of 5 or more units				
Interactions				
Residential Density * Portland (1,000 d.u.(s) / square mile)	-.016	.024	-.016	.012
Mixed Use * Portland				
Diversity * Portland	-.176	.070		
Servbal * Portland			-.284	.065
% of land in parks * Portland	-.020	-.024**	-.022	-.028**
% of housing in structures of 2 - 4 Units * Portland	-.003	.000	-.002	.002
% of housing in structures of 5 or more units * Portland				
Other Variables				
% of housing that is vacant	-.007	-.011	-.007	-.008
% of housing stock that is 20 or more years old	.010***	.005***	.010***	.005***
% of housing with 4 or more bedrooms	-.035***	-.038***	-.036***	-.038***
% of housing that is subsidized	.021***	.017***	.021***	.017***
% of population that is minority	.004**	.010***	.005**	.010***
Portland City	-.236***	-.351***	-.213***	-.334***
Seattle City	-.445***	-.184**	-.426***	-.183**
Portland Region	.081	-.120	.086	-.107
Constant	2.176***	2.408***	2.227***	2.479***
R-squared	0.79	0.81	0.79	0.81
Adjusted R-Squared	0.76	0.78	0.76	0.79

Note: ** significant at 5%; *** significant at 1%. Dependent variable: ln(% of all units that are affordable rentals for extremely low-income households). Interpretation of coefficients is the relative change in the dependent variable given a 1-unit change in the independent variable.

[135] Further evidence for this point is found in Appendix G. The proportion of very low-income rental units was regressed on each smart growth principle, individually. The R^2 for the proportion of very low-income rental units regressed on the proportion of housing in structures of 2 to 4 units and on structures of 5 or more units was .63 and .67 in 1990 and 2000, respectively. In comparison, the R^2 for the proportion of very low-income rental units regressed on residential density was .22 and .20 in 1990 and 2000, respectively.

Second, residential density was once again positive and statistically significant in models 5 and 6. One possible explanation for the change in density's relationship to the supply of affordable housing is the linear relationship between structures of 5 or more units and density, which makes the results of models 3 and 4 unreliable. The reason for potentially unreliable coefficients and significance levels for density in models 3 and 4 was discussed in Section 7.5.

Third, mixed land use was once again positive and statistically significant in models 5 and 6, as it was in models 1 and 2 but not in models 3 and 4. There are two possible explanations for these changes in the statistical significance of mixed land use. First, a linear relationship between mixed land use and structures of 5 or more units may make the results of models 3 and 4 unreliable.

The second explanation for the change in statistical significance of mixed land use is that there may be an interaction effect between mixed land use and large multi-unit structures not captured by the model. There may be different preferences for mixed land use in neighborhoods of multi-unit housing than in neighborhoods of single-family dwellings. Similarly, there may be different demand for multi-unit housing in neighborhoods of mixed land use than in neighborhoods that are exclusively residential. Housing consumers may have greater demand for single-family dwellings in exclusively residential neighborhoods, but greater demand for housing in structures of 5 or more units in neighborhoods with a diversity of land uses. These interactions may influence the coefficients for both mixed land use, as well as for structures of 5 or more units, when they are both included in the model.[136]

The fourth difference in models 5 and 6 from models 3 and 4 is the positive and statistically significant coefficient for public parks in 2000 in models 5 and 6. This coincides with a negative and statistically significant interaction variable between Portland and public parks. These findings indicate that the relationship between parks and affordable very low-income rental units differed between the regions of Portland and Seattle in 2000. The relationship was positive in Seattle. The relationship was, at the very least, weaker in Portland as

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[136] An attempt was made to include an interaction variable between mixed land use and the proportion of housing in structures of 5 or more units. However, there was a clear threat of multicollinearity and the results were questionable.

compared to Seattle. Additional analyses indicated that the relationship was statistically insignificant in the Portland region.[137]

With one exception, the control variables were statistically significant in the expected manner. A greater proportion of housing that was more than 20 years old, a greater proportion of units subsidized by a public housing authority, and a greater proportion of minorities were associated with a greater proportion of units being affordable rental units for very low-income households.[138] A greater proportion of units with 4 or more bedrooms was associated with a smaller proportion of affordable rental units.

Table 7.21 provides the results of the analyses of very low-income rental units in the regions of Philadelphia and Baltimore. Without the variables for multi-unit structures, the adjusted R^2 in models 1 and 2 was .65 and .67 in 1990 and 2000, respectively. With the variables for multi-unit structures, the adjusted R^2 for models 3 and 4 were .70 and .74 in 1990 and 2000, respectively.

In models 1 and 2 without multi-unit structures, there were two similarities between the analyses for extremely low-income rental units in the regions of Philadelphia and Baltimore and the analyses of very low-income rental units. First, there was a positive association between residential density and the proportion of housing affordable for very low-income renters. In model 1, an increase in density by 1,000 units per square mile was associated with a 2.7% increase in the proportion of very low-income rental units in 1990 and a 1.7% increase in 2000.

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[137] In model 5, the 95% confidence intervals were .0032 to .0362 for public parks and -.0456 to -.0031 for the interaction of Portland and public parks. In model 6, the confidence intervals were .0042 to .0373 for public parks and -.0491 to -.0067 for the interaction of Portland and public parks. In additional regressions, the interaction variables were switched from the interaction of Portland with the smart growth variables to the interaction of Seattle with the smart growth variables. The results of these regressions indicated that the relationship between public parks and the supply of very low-income rental units was statistically insignificant in the region of Portland and the same relationship was positive and significant in Seattle.

[138] Earlier versions of the model included an additional variable for the African-American population. However, the African-American variable was strongly correlated with the minority variable. This strong correlation produced conflicting signs of the coefficients and the results were unreliable. The variable for African-Americans was dropped from the analysis. See the Appendix for further details.

Table 7-21. Regression Coefficients, Baltimore and Philadelphia, Very Low-Income Rental Units (n=1757)

	Multi-Unit Structures Excluded				***Full Model – All Variables***			
	Model 1		**Model 2**		**Model 3**		**Model 4**	
	1990	**2000**	**1990**	**2000**	**1990**	**2000**	**1990**	**2000**
Smart Growth Variables								
Residential Density (1,000 dwelling units / square mile)	.027***	.017**	.024***	.013	.014	-.003	.012	-.007
Mixed Land Use								
Diversity of all uses	.392***	.714***			.181	.187		
Balance of pop. serving jobs to residents			.249**	.338***			.063	-.080
% of land in parks	-.020***	-.020***	-.021***	-.020***	-.024***	-.021***	-.024***	-.021***
Units in Structure								
% of housing in structures of 2 - 4 Units					.025***	.030***	.025***	.030***
% of housing in structures of 5 or more units					.009***	.011***	.009***	.012***
Interactions								
Residential Density * Baltimore (1,000 d.u.(s) / square mile)	.011	.013	.010	.009	.013	.012	.011	.010
Mixed Use * Baltimore								
Diversity * Baltimore	-.123	-.219			.043	-.027		
Servbal * Baltimore			-.159	-.125			-.044	.023
% of land in parks * Baltimore	.016**	.021***	.017**	.021***	.023***	.028***	.023***	.028***
% of housing in structures of 2 - 4 Units * Baltimore					.004	-.005	.004	-.005
% of housing in structures of 5 or more units * Baltimore					.005**	.004	.005**	.003
Other Variables								
% of housing that is vacant	.022***	.009	.024***	.011**	.007	.007	.008	.009
% of housing stock that is 20 or more years old	.007***	.009***	.007***	.008***	.008***	.009***	.008***	.009***
% of housing with 4 or more bedrooms	-.018***	-.026***	-.018***	-.027***	-.014***	-.021***	-.014***	-.021***
% of housing that is subsidized	.030***	.025***	.031***	.026***	.023***	.015***	.024***	.016***
% of population that is minority	.007***	.007***	.006***	.006***	.007***	.006***	.006***	.006***
Baltimore City	.116	-.109	.123	-.082	-.136	-.234**	-.126	-.212
Philadelphia City	.103	.095	.119	.090	.064	0.14	.073	.019
Baltimore Region	.413***	.264**	.427***	.217***	.400***	.273***	.443***	.260***
Constant	1.182***	1.629***	1.234***	1.849***	.916***	1.397***	.936***	1.488***
R-squared	0.70	0.72	0.70	0.72	0.74	0.78	0.74	0.78
Adjusted R-Squared	0.65	0.67	0.65	0.67	0.70	0.74	0.70	0.74

Note: ** significant at 5%; *** significant at 1%. Dependent variable: ln(% of all units that are affordable rentals for extremely low-income households). Interpretation of coefficients is the relative change in the dependent variable given a 1-unit change in the independent variable.

Second, there was a negative association between a greater proportion of land in public parks and the proportion of affordable very low-income rental units in the Philadelphia region. In model 1, a .01 increase in the proportion of land in parks was associated with a 2.0% decline in the proportion of very low-income rental units in 1990 and 2000. The interaction of parks and Baltimore was statistically significant and positive. This finding indicates that parks, at the very least, had a weaker negative association with the proportion of affordable units in the Baltimore region as compared to Philadelphia. The negative coefficient for parks is discussed further in this section.

In models 1 and 2, there is one significant difference between the analyses for extremely low-income rental units and the analyses for very low-income rental units presented in this section. The association between mixed land use and the proportion of very low-income rental units was positive. This association was statistically significant in 1990 and 2000 for both measures of mixed land use.

As shown in models 3 and 4, two significant changes occurred when multi-unit structures were added to the model. First, housing density was no longer statistically significant in explaining the proportion of affordable rental units for very low-income households, but was significant in the earlier analysis of extremely low-income rental units. These findings indicate greater residential density, as compared to the type of housing available, is not as predictable in its impact on affordable housing.[139]

Second, mixed land use became statistically insignificant. Mixed land use may have lost its significance because of an interaction between mixed land use and structures of 5 or more units. As discussed previously, there may be a greater demand for mixed land use neighborhoods among consumers of housing in large multi-unit structures as compared to consumers of single-family homes. This interaction may influence the coefficient and significance of mixed land use.[140]

Three smart growth variables were consistently statistically significant among models 3 and 4. First, a greater proportion of land in public parks was associated with a smaller proportion of affordable rental units for very low-income households in the Philadelphia region.

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[139] Removing the variable for structures of 5 or more units did not alter the statistical significance of density. Additionally, removing the variable for structures of 2 to 4 units did not alter the statistical significance of density.
[140] When structures of 5 or more units are removed from the model, mixed land use becomes positive and statistically significant (similar to models 1 and 2).

This relationship was expected as public parks were hypothesized to provide positive amenities which increase demand for housing. Greater demand would raise prices and decrease the proportion of affordable rental units for very low-income households. Parks may also increase the demand for more expensive housing, which would entice property owners to upgrade their units, making them unaffordable. However, the interaction between Baltimore and public parks was positive and statistically significant. Combined with the negative coefficient for the public park variable without an interaction, we can conclude that the relationship between public parks and affordable rental units was "less negative" in the Baltimore region than in the Philadelphia region.[141]

The two other significant smart growth variables were the proportion of units in structures of 2 to 4 units and the proportion in structures of 5 or more units. A greater proportion of housing in either of these structures was associated with an increase in the proportion of affordable rental units for very low-income households. The results for multi-unit structures were more consistent in this analysis than in the previous analysis for extremely low-income rental units. In the previous analysis, only multi-unit structures of 2 to 4 units were statistically significant in explaining the variation in the proportion of rental units for extremely low-income households.

The interaction of the Baltimore region and multi-unit structures of 5 or more units changed in statistical significance between 1990 and 2000, providing limited evidence that the implementation of Baltimore's priority funding areas may weaken the positive relationship between multi-unit structures and affordable housing. The interaction was positive and statistically significant in 1990, when neither region had an urban containment policy. This finding indicates that the positive relationship between structures of 5 or more units and the proportion of very low-income rental units was stronger in the Baltimore region than in the Philadelphia region. In 2000, after the implementation of priority funding areas throughout the

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[141] For model 3 in 1990, the 95% confidence interval for public parks is -.0353 to -.0133 and for the interaction of Baltimore with public parks is .0094 to .0368. For model 4 for 1990, the confidence interval for public parks is -.0355 to -.0131 and the interaction of Baltimore with public parks is .0096 to .0374. For model 3 in 2000, the confidence interval for public parks is -.0312 to -.0110 and for the interaction of Baltimore with public parks is .0146 to .0415. For model 4 in 2000, the confidence interval for public parks is -.0307 to -.0104 and for the interaction of Baltimore with public parks is .0143 to .0414. Switching the interaction variables to represent the interaction between Philadelphia, rather than Baltimore, and the smart growth variables, indicated that the relationship between parks and affordable very low-income rental units is insignificant in the Baltimore region.

Baltimore region, the difference between the two regions was no longer significant. This change could be the result of priority funding areas. But it could also be that the strength of the relationship increased in the Philadelphia region to equal that found in Baltimore.

With the exception of the vacancy rate, all of the control variables were statistically significant and had the expected relationship with the proportion of affordable rental units. A greater proportion of older units, a greater proportion of units subsidized by a public housing authority, and a larger proportion of minorities were each associated with a greater proportion of rental units affordable to very low-income households. A greater proportion of units containing four or more bedrooms was associated with a smaller proportion of affordable rental units.

7.7.1 Analysis of Very Low-Income Rental Units in the Central City

A similar analysis was limited to neighborhoods within the central city of each region. As discussed in Section 7.5, the previous analyses transformed the dependent variable by its log in order to create a better fitting linear model as determined by the Box-Cox procedure. For very low-income rental units in the central cities, the Box-Cox procedure identified a linear model as the best fitting model. For that reason, the dependent variable in the following analysis of very low-income rental units in central cities is not transformed and is the percentage of housing units in each neighborhood that are affordable rentals for very low-income households.

Table 7.22 provides the results for the central cities of Portland and Seattle. Once again multi-unit structures were excluded from models 1 and 2. The Adjusted R^2 for model 1 was .70 and .71 in 1990 and 2000, respectively. The Adjusted R^2 for model 2 was .66 and .69 in 1990 and 2000, respectively.

The only two statistically significant smart growth variables in models 1 and 2 were residential density and mixed land use. Each of them had a positive association with the proportion of affordable rental units for very low-income households. These findings are similar to those found in the regional analysis of very low-income rental units.

Table 7-22. Central City, Regression Coefficients, Portland and Seattle, Very Low-Income Rental Units (n=241)

	Multi-Unit Structures Excluded				*Full Model – All Variables*			
	Model 1		**Model 2**		**Model 3**		**Model 4**	
	1990	**2000**	**1990**	**2000**	**1990**	**2000**	**1990**	**2000**
Smart Growth Variables								
Residential Density (1,000 dwelling units / square mile)	1.335***	.875***	.942***	.669***	-.480	-.432	-.383	-.214
Mixed Land Use								
Diversity of all uses	25.719***	17.821***			-5.116	-12.917**		
Balance of pop. serving jobs to residents			21.581***	15.311***			.778	1.947
% of land in parks	-.069	.435	.058	.409	-.166	-.167	-.193	-.101
Units in Structure								
% of housing in structures of 2 - 4 Units					.410***	.507***	.390***	.448***
% of housing in structures of 5 or more units					.594***	.546***	.553***	.454***
Interactions								
Residential Density * Portland (1,000 d.u.(s) / square mile)	.658	.469	.700	.315	.790	.180	.689	-.054
Mixed Use * Portland								
Diversity * Portland	3.788	11.953			5.597	13.050		
Servbal * Portland			-5.413	1.453			-1.972	-1.021
% of land in parks * Portland	-.363	-.953	-.374	-.929	.444	.214	.504	.193
% of housing in structures of 2 - 4 Units * Portland					.311**	.063	.345**	.130
% of housing in structures of 5 or more units * Portland					-.138	-.072	-.082	.029
Other Variables								
% of housing that is vacant	-.195	-.645	.179	-.211	-.435	-.578	-.434	-.670
% of housing stock that is 20 or more years old	.054	.083	.065	.104	.233***	.168***	.227***	.164***
% of housing with 4 or more bedrooms	-.564***	-.765***	-.657***	-.815***	-.304***	-.300***	-.291***	-.294***
% of housing that is subsidized	.573***	.556***	.577***	.571***	.346***	.303***	.336**	.277***
% of population that is minority	.122**	.119**	.089	.099**	.134***	.168***	.135***	.175***
Portland City	-1.157	-7.263***	1.295	-4.029	.330	-3.834	-1.497	-.999
Constant	10.301	16.100**	14.984	17.115	-8.801***	-2.285	-9.535**	-4.984
R-squared	0.71	0.72	0.68	0.70	0.87	0.86	0.87	0.86
Adjusted R-Squared	0.70	0.71	0.66	0.69	0.86	0.85	0.86	0.85

Note: ** significant at 5%; *** significant at 1%. Dependent Variable: % of units that are affordable rentals for very low-income households.

Variables for multi-unit structures were added to models 3 and 4. The Adjusted R^2 for models 3 and 4 was significantly higher than those found in models 1 and 2, indicating that multi-unit structures are important variables for explaining the supply of affordable units. Models 3 and 4 explained 86% and 85% of the variation in the proportion of affordable rental units for very low-income households in 1990 and 2000, respectively.

The only smart growth variables to be consistently significant in models 3 and 4 were the proportion of units in structures of 2 to 4 units and in structures of 5 or more units. Residential density became statistically insignificant after the inclusion of multi-unit structures in the model. Mixed land use also became statistically significant, with one exception in which the diversity index was negative in 2000.

One interaction changed in significance from 1990 to 2000 in an unexpected direction in models 3 and 4. First, the positive coefficient in 1990 of the interaction between Portland and multi-unit structures of 2 to 4 units indicates that the positive relationship between these small multi-unit structures and affordable rental units was stronger in the central city of Portland than in the central city of Seattle. The interaction was not significant in 2000. This will be discussed further after models 5 and 6.

Models 5 and 6 exclude the variable for structures of 5 or more units. The results of these models are in Table 7.23. As expected from previous analyses, density and mixed land use became statistically significant. These results further indicate structures of 5 or more units influence the statistical significance of density and mixed land use.

The models which exclude large multi-unit structures had an Adjusted R^2 that is significantly lower than the models which include them. Models 5 and 6 explained from 71% to 73% of the variation in the proportion of affordable rental units. This is significantly lower than the 86% and 85% of the variation explained by models 3 and 4. Once again, this finding indicates that structures of 5 or more units are an important variable for explaining the supply of affordable rental units.

No interaction variables provided evidence that urban containment policies influence the relationship between the smart growth principles and the supply of affordable housing. One interaction was statistically significant, which was the same significant interaction found in models 3 and 4. In 1990, the interaction of Portland and structures of 2 to 4 units was positive and statistically significant. In 2000, it was not significant. This finding is contrary to the hypothesis that multi-unit structures would have a weaker positive relationship to affordable housing in regions of urban containment. The coefficient of the interaction was positive, indicating a stronger relationship in 1990, when only Portland had a region-wide urban containment policy.

Table 7-23. Central City, Regression Coefficients, Portland and Seattle, Very Low-Income Rental Units, Without 5-or-more Unit Structures (n=241)

	Model 5		Model 6	
	1990	**2000**	**1990**	**2000**
Smart Growth Variables				
Residential Density (1,000 dwelling units / square mile)	1.388***	.988***	1.022***	.804***
Mixed Land Use				
Diversity of all uses	26.209***	17.662***		
Balance of pop. serving jobs to residents			22.496***	15.718***
% of land in parks	.030	.526	.167	.506
Units in Structure				
% of housing in structures of 2 - 4 Units	.272	.302	.263	.229
% of housing in structures of 5 or more units				
Interactions				
Residential Density * Portland (1,000 d.u.(s) /square mile)	.641	.444	.708	.324
Mixed Use * Portland				
Diversity * Portland	-2.607	8.549		
Servbal * Portland			-10.369	-1.928
% of land in parks * Portland	-.268	-1.011	-.297	-.995
% of housing in structures of 2 - 4 Units * Portland	.369**	.107	.479**	.313
% of housing in structures of 5 or more units * Portland				
Other Variables				
% of housing that is vacant	-.088	-.494	.226	-.084
% of housing stock that is 20 or more years old	.037	.063	.050	.079
% of housing with 4 or more bedrooms	-.505***	-.677***	-.595***	-.715***
% of housing that is subsidized	.570***	.536***	.569***	.541***
% of population that is minority	.079	.113**	.048	.092**
Portland City	-2.489	-7.100**	-2.098	-5.865**
Constant	8.268	12.962	12.887**	14.611**
R-squared	0.75	0.74	0.73	0.73
Adjusted R-Squared	0.73	0.72	0.71	0.71

Note: ** significant at 5%; *** significant at 1%. Dependent Variable: % of units that are affordable rentals for very low-income households.

Table 7.24 provides the results for the analysis of very low-income rental units in the central cities of Baltimore and Philadelphia. Among all of the analyses in this research, this analysis was the weakest. Excluding multi-unit structures, model 1 had an adjusted R^2 of .59 and .42 in 1990 and 2000, respectively. Model 2 had an adjusted R^2 of .57 and .39 in 1990 and 2000, respectively.

Table 7-24. Central City, Regression Coefficients, Baltimore and Philadelphia, Very Low-Income Rental Units (n=529)

	Multi-Unit Structures Excluded				*Full Model – All Variables*			
	Model 1		**Model 2**		**Model 3**		**Model 4**	
	1990	**2000**	**1990**	**2000**	**1990**	**2000**	**1990**	**2000**
Smart Growth Variables								
Residential Density (1,000 dwelling units / square mile)	.239	.112	.129	-.016	.070	-.282**	-.023	-.346**
Mixed Land Use								
Diversity of all uses	12.515***	20.749***			8.698***	7.067		
Balance of pop. serving jobs to residents			6.652**	10.778***			3.093	1.231
% of land in parks	-.271**	-.347**	-.346***	-.425**	-.302***	-.328**	-.350***	-.339**
Units in Structure								
% of housing in structures of 2 - 4 Units					.308***	.405***	.304***	.409***
% of housing in structures of 5 or more units					.135***	.241***	.152***	.261***
Interactions								
Residential Density * Baltimore (1,000 d.u.(s)/ square mile)	.881***	.706**	.866***	.579**	1.090***	.796***	1.070***	.724***
Mixed Use * Baltimore								
Diversity * Baltimore	-.084	-4.667			3.827	-1.245		
Servbal * Baltimore			-.998	-6.165			2.462	-3.524
% of land in parks * Baltimore	.287**	.252	.362**	.318	.407***	.443**	.457***	.465***
% of housing in structures of 2 - 4 Units * Baltimore					.032	-.075	.023	-.076
% of housing in structures of 5 or more units * Baltimore					.043	.095	.035	.099
Other Variables								
% of housing that is vacant	.248***	.040	.323***	.120	.070	.124	.131	.165
% of housing stock that is 20 or more years old	-.036	-.003	-.035	-.034	.046	.176	.055	.170
% of housing with 4 or more bedrooms	-.026	-.136***	-.054	-.194***	-.029	-.152***	-.047	-.167***
% of housing that is subsidized	.500***	.586***	.526***	.614***	.426***	.425***	.447***	.442***
% of population that is minority	.103***	.125***	.086***	.096***	.108***	.110***	.093***	.094***
Baltimore City	2.485	.712	2.516	1.311	-2.147	-2.479	-1.258	-1.757
Constant	5.171	10.719	9.036	19.769**	-4.082	-8.097	-1.811	-5.013
R-squared	0.60	0.43	0.58	0.40	0.67	0.59	0.66	0.59
Adjusted R-Squared	0.59	0.42	0.57	0.39	0.66	0.58	0.65	0.57

Note: ** significant at 5%; *** significant at 1%. Dependent Variable: % of units that are affordable rentals for very low-income households.

In models 1 and 2, three consistent patterns among the smart growth variables were revealed. First, residential density was not statistically significant. However, the interaction of density and Baltimore was positive and statistically significant. These findings indicate that density was not associated with the proportion of affordable very low-income rental units in the city of Philadelphia, but was associated with affordable rental units in the city of Baltimore. This is a different result from the regional analysis for Baltimore and Philadelphia, where there was a positive association between density and affordable units in both regions.

The second consistent pattern is mixed land use was associated with a greater proportion of affordable very low-income rental units. This finding is similar to the regional analysis of very low-income units. This relationship was also found for extremely low-income rental units in the central cities.

The third consistent pattern was the negative relationship between public parks and the supply of affordable very low-income rental units. A greater proportion of land in public parks was associated with a smaller proportion of affordable rental units. But the positive and statistically significant coefficient of the interaction between Baltimore and public parks in 1990 indicates the relationship between parks and the proportion of affordable very low-income rental units differed between the central cities of Philadelphia and Baltimore. In Baltimore, the relationship was, at the very least, not as strongly negative as compared to Philadelphia or it was not significant in 1990. This will be further discussed regarding models 3 and 4.

Models 3 and 4 present the results when multi-unit structures are included in the analysis. These models performed better than models 1 and 2. Model 3 had an adjusted R^2 of .66 and .58 in 1990 and 2000, respectively. Model 4 had an adjusted R^2 of .65 and .57 in 1990 and 2000, respectively.

Models 3 and 4 provide further evidence that multi-unit structures are important in explaining the supply of affordable housing. As in other analyses, a greater proportion of housing in structures of 2 to 4 units, as well as in structures of 5 or more units, was associated with a greater proportion of affordable very low-income rental units.

Residential density behaved in an interesting manner when multi-unit structures were included in the model. It was not significant in 1990, but was negative and significant in

2000.[142] This result is different from the regional analysis where density was not significant in models 3 and 4. The interaction between Baltimore and density was statistically significant and positive. These findings indicate that, similar to models 1 and 2, greater density was associated with a greater proportion of affordable very low-income rental units in the city of Baltimore, but not in the city of Philadelphia.

Another similarity between models 3 and 4 and models 1 and 2 is the relationship between parks and affordable housing. A greater proportion of land in public parks was associated with a smaller proportion of affordable rental units. The interaction between Baltimore and public parks was positive and statistically significant. The positive interaction indicates that the negative relationship between parks and affordable rental units for very low-income households is not as negative in the city of Baltimore as in the city of Philadelphia. We cannot conclude that the relationship between parks and affordable housing in Baltimore is positive.[143]

One difference between models 3 and 4 from models 1 and 2 is the significance of mixed land use. Unlike in models 1 and 2, the diversity index was statistically significant in only one instance in models 3 and 4. In 1990, an increase in the diversity index was associated with an increase in the proportion of affordable rental units. As discussed previously, this is possibly the result of an interaction between mixed land use and the proportion of housing in structures of 5 or more units.

From models 3 and 4, the analysis of very low-income rental units in the central cities of Baltimore and Philadelphia does not provide support for the hypothesis that the implementation of urban containment policy in Baltimore changed the relationship between the smart growth variables and affordable housing. There were no changes in the statistical significance of any of the interaction variables from 1990 to 2000.

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[142] The low correlations between residential density and multi-unit structures in the central cities of Baltimore and Philadelphia provide evidence that multicollinearity is not an issue in these models. See Appendix D, Tables 11 and 12.

[143] For model 3 in 1990, the 95% confidence interval for public parks was -.5276 to -.0754 and the confidence interval for the interaction of Baltimore with public parks was .1342 to .6798. For model 4 in 1990, the confidence interval for public parks was -.5737 to -.0754 and the confidence interval for the interaction of Baltimore with public parks was .1765 to .7375. For model 3 in 2000, the confidence interval for public parks was -.6076 to -.0488 and for the interaction of Baltimore with public parks was .1041 to .7824. For model 4 in 2000, the confidence interval for public parks was -.6278 to -.0508 and for the interaction of Baltimore with public parks was .1130 to .8177.

In comparison to the other analyses of this research, fewer control variables were statistically significant. A greater proportion of units subsidized by a public housing authority was associated with a greater proportion of affordable very low-income rental units. A greater proportion of minorities was also associated with a greater proportion of affordable rental units. A greater proportion of units with four or more bedrooms was associated with a greater proportion of affordable units only in 2000, but not in 1990.

7.8 SUMMARY

This chapter presented analyses of the impact of four smart growth principles on the supply of affordable rental units for extremely low-income and very low-income households. The four smart growth principles were residential density, a variety of housing options measured as the proportion of units in multi-unit structures, mixed land use, and public open space in the form of public parks. Included in these analyses were interaction variables to test the impact urban containment policies may have on the relationship between each smart growth principle and affordable housing.

After discussing the model, the measurement of variables, data sources, and assumptions for a regression analysis, this chapter's last two sections provided results from four different analyses. The first analysis was of extremely low-income rental units among neighborhoods of the paired regions of Portland and Seattle, as well as among neighborhoods of the paired regions of Baltimore and Philadelphia.

The second analysis, of extremely low-income rental units, was limited to the neighborhoods of each region's central cities. The purpose of comparing regional results with those of the central city was to idenfity significant differences in the impact of smart growth variables, or their interaction with urban containment, on affordable housing for low-income households. There were no discernible differences in the patterns of behavior among variables when comparing the region and the central city analyses.

The third and fourth analyses broadened the definition of affordable housing to include affordable rental units for very low-income households whose income is higher than extremely low-income households. There were two differences between these analyses and the previous two. First, the models were better able to explain the supply of very low-income rental units as compared to extremely low-income units. This was determined by comparing the adjusted R^2 of the models. This is not too suprising as extremely low-income rental units are a very tiny portion of the rental market. Therefore, it is more difficult to capture changes in this segment of the market.

The second difference between the analyses is the strong explanatory power of multi-unit structures for very low-income rentals as compared to extremely low-income rentals. For every analysis, models 1 and 2 excluded multi-unit structures while models 3 and 4 included them. When multi-unit structures were included, the adjusted R^2 increased by a greater magnitude in the analyses for very low-income units. These changes in the adjusted R^2 indicated the importance of multi-unit structures, particularly those with 5 or more units, on the supply of very low-income units.

The purpose of the analyses in this chapter was to test the seven hypotheses presented in Chapter 4 concerning the relationship between smart growth and the supply of affordable units. Rather than summarizing those results here, the concluding chapter summarizes the analyses' findings in relation to each of the seven hypotheses drawn from the theoretical framework.

8.0 CONCLUSION AND POLICY IMPLICATIONS

The purpose of this research was to answer the two primary questions proposed in the introduction. These two questions were:

- What is the relationship between four smart growth principles – specifically neighborhood density, a variety of housing options, mixed land use, and public open space – and the supply of affordable housing for extremely and very low-income households?

- Are these relationships different in metropolitan areas which have implemented a form of urban containment, such as urban growth boundaries or priority funding areas, from areas which have no such policy? If so, what are these differences?

This research did not test the direct impact of urban containment on the supply of affordable housing, but rather tested the impact of urban containment on the relationship between each of four smart growth principles and the supply of affordable housing. Therefore, this research does not address the question of whether urban containment reduces the supply of affordable housing. Rather, the objective of this research was to test whether urban containment, by restricting the availability of land on the urban fringe, altered the impact of residential density, a variety of housing options, mixed land use, and public open space on the supply of affordable housing.

A quasi-experimental research design was utilized to allow for a comparison of the impact of the four smart growth principles in neighborhoods within a region of urban containment to neighborhoods in a region without urban containment. Interaction variables of the urban containment region with each smart growth principle were included in the analyses to capture differences between the two regions.

I chose two pairs of regions for this research. The first pair included Portland and Seattle. Portland implemented urban growth boundaries in 1979, approximately 15 years prior to Seattle. Therefore, the region of Portland had urban containment boundaries in 1990 while Seattle did not. By 2000, both regions had a region-wide urban containment policy in the form of urban growth boundaries.

The second set of comparison regions included Baltimore and Philadelphia. Neither region had urban containment in 1990. Priority funding areas were implemented throughout the Baltimore region in 1997. Therefore, there was a region-wide urban containment policy in Baltimore, but not in the Philadelphia region, in 2000.

The analyses were performed at two different points in time, in 1990 and 2000. If the hypothesis that urban containment alters the relationship between each smart growth variable and the supply of affordable housing is accurate, we would expect to find the interaction variables statistically significant when only a single region of each pair had urban containment. There would be no statistical significance of the interaction variables when both regions had similar policies.

Table 8.1 summarizes the urban containment policy for each region as of 1990 and 2000, the expected change in the statistical significance of the interaction variables between the two time periods, and the strength of the research findings supporting these expected changes. In the Portland/Seattle analyses, I hypothesized that the interaction variables would be significant in 1990 and not in 2000. I found only weak evidence for this hypothesis. Only one interaction variable, representing multi-unit structures of 5 or more units, changed in statistical significance in the expected manner. This result is discussed in more detail in the next section.

In the Baltimore/Philadelphia analyses, I hypothesized that the interaction variables would not be significant in 1990, but would be significant in 2000 after the implementation of priority funding areas throughout the Baltimore region. While the statistical significance of some of the interaction variables changed, their change in significance did not occur in a manner I had expected. Details of these changes are the following section.

This chapter is divided into three sections. The first section summarizes the research findings as they apply to each hypothesis presented in Chapter Four. The second section discusses the policy implications of the findings. Finally, the third section presents limitations to this current study and suggests future research to address these limitations.

Table 8-1. Expected Changes in Significance of Interaction Variables and Evidence

	1990	2000
Portland	Urban Growth Boundaries	Urban Growth Boundaries
Seattle	None	Urban Growth Boundaries
Expected Change in Interaction Variables of Portland and Smart Growth Principles	Change from statistically significant to not statistically significant	
Evidence for the Expected Changes in Significance of Interaction Variables	Weak – only structures of 5 or more units	
Baltimore	None	Priority Funding Areas
Philadelphia	None	None
Expected Change in Interaction Variables of Baltimore and Smart Growth Principles	Change from not statistically significant to statistically significant	
Evidence for the Expected Changes in Significance of Interaction Variables	Weak – only multi-unit structures, and not in expected manner	

8.1 FINDINGS AND THE SEVEN HYPOTHESES

The theoretical framework in Chapter Four presented seven hypotheses regarding the impact of the four smart growth principles of housing density, a variety of housing options, mixed land use, and open space (in the form of public parks) on the supply of affordable housing in regions with and without urban containment. This section summarizes the findings from Chapter Seven in terms of the seven hypotheses.

Table 8.2 summarizes the strength of the evidence from the analyses in the previous chapter for each of the seven hypotheses. The evidence was strongest for the hypotheses concerning the positive association between multi-unit structures and the supply of affordable units. The evidence was moderate to strong for a positive relationship between residential density and affordable units. The evidence was weak for a negative relationship between land in public parks and the supply of affordable units.

Table 8-2. Hypotheses and Strength of Evidence

Hypothesis	Strength of Evidence
1. Greater housing density is associated with a greater supply of affordable units for low-income households.	Moderate
2. In regions with urban containment, the association between greater housing density and a greater supply of affordable units for low-income households is weaker than in regions without urban containment.	No Evidence
3. A greater supply of multi-unit structures, a measure of the variety of housing options, is associated with a greater supply of affordable units for low-income households.	Strong
4. In regions with urban containment, the association between multi-unit structures and a greater supply of affordable units for low-income households is weaker than in regions without urban containment.	Weak
5. Mixed land use neighborhoods in regions with urban containment are associated with a lower supply of affordable housing units for low-income households.	No Evidence
6. A greater proportion of land in public parks, a form of open space, is associated with a lower supply of affordable housing for low-income households.	Weak
7. In regions of urban containment, the association between a greater proportion of land in public parks and a smaller supply of affordable housing is stronger than in regions without urban containment.	No Evidence

The evidence that any of the smart growth variables interacted with urban containment to alter their relationship to the supply of affordable units was mostly non-existent. The analyses provided no evidence that there was an interaction between urban containment and density, mixed land use, or public parks. The only evidence of an interaction was between urban containment and multi-unit structures, with weak evidence that multi-unit structures have a weaker positive association with affordable housing in regions of urban containment. The remainder of this section discusses each of the seven hypotheses, individually.

Hypothesis 1: Greater housing density is associated with a greater supply of affordable units for low-income households.

There are two points from which to conclude the analyses provided moderate evidence that greater housing density was associated with a greater supply of affordable units. First, the coefficient for density was positive and statistically significant in the analyses for Portland and Seattle, as long as structures of 5 or more units were excluded from the model. When large multi-unit structures were included in the model, the association between density and affordable housing became either statistically insignificant or negative.

Second, density was positive and statistically significant in Baltimore and Philadelphia in the analyses of *extremely* low-income rental units. This was true in both the regional, as well as the central city, analyses.

The results are slightly different for *very* low-income units in Baltimore and Philadelphia. Greater density was associated with a greater proportion of very low-income rental units in the regions of Baltimore and Philadelphia as long as multi-unit structures were not included in the model. Density was not significant for very low-income rental units when multi-unit structures were included. Among the central cities of Baltimore and Philadelphia, only in the city of Baltimore was there a positive relationship between density and very low-income rental units.

Hypothesis 2: In regions with urban containment, the association between greater housing density and a greater supply of affordable units for low-income households is weaker than in regions without urban containment.

The analyses did not provide evidence for this hypothesis. Between 1990 and 2000, there were no changes in the statistical significance of either the interaction variable for Portland and density or the interaction variable for Baltimore and density. Therefore, urban containment did not alter the association between density and affordable housing. If urban containment did have an impact on this relationship, the interaction variable for Portland and density would have been significant in 1990 when only Portland had a region-wide urban containment policy. The interaction variable for Baltimore and density would have been significant in 2000 when Baltimore had a region-wide urban containment policy.

Hypothesis 3: ***A greater supply of multi-unit structures, a measure of the variety of housing options, is associated with a greater supply of affordable units for low-income households.***

The analyses provided strong evidence for a positive relationship between multi-unit structures and affordable housing. There are three important findings to support this hypothesis. First, the positive relationship between structures of 2 to 4 units and affordable housing was consistently positive for both extremely low-income, as well as very low-income, rental units throughout all four regions, as well as in the central cities of Baltimore and Philadelphia.

Second, the relationship between structures of 5 or more units and affordable *extremely* low-income units was positive in one pair of regions. A greater proportion of units in multi-unit structures of 5 or more units were associated with a greater proportion of affordable *extremely* low-income rental units in the regions of Portland and Seattle, but not in the regions of Baltimore and Philadelphia. There is no obvious explanation for the lack of statistical significance in the Baltimore and Philadelphia regions. One possible explanation is that, as a proportion of the housing stock, there is less housing in these multi-unit structures in Philadelphia and Baltimore as compared to Portland and Seattle. In 2000, the proportion of housing in these structures was 19% in Baltimore, 15% in Philadelphia, 21% in Portland, and 27% in Seattle. Because there is always some demand for housing in multi-unit structures among higher income households, a smaller relative supply of these units in a region may reduce their association with affordability for *extremely* low-income renters in that region.

The positive relationship between multi-unit structures of 5 or more units and affordable *very* low-income rental units was consistently significant throughout all four regions, as well as in their central cities. It is not surprising that multi-unit structures of 5 or more units are more consistently significant in explaining the supply of *very* low-income rentals as compared to *extremely* low-income rentals. Extremely low-income rental units are a much smaller fraction of the market as units must have a much lower price to be considered ‘affordable’ for extremely low-income households than for very low-income households. It is likely that changes in the type of housing available are likely to more strongly impact very low-income units, because they are a larger portion of the overall housing stock, than extremely low-income units.

The third important finding regarding multi-unit structures is the significant explanatory power that structures of 5 or more units have in explaining the supply of *very* low-income rental units among neighborhoods. In Portland and Seattle, removing structures of 5 or more units from the analyses lowered the adjusted R^2 of the models by as much as .07 in the regional analysis and by as much as .15 in the central city analysis. The adjusted R^2 represents the proportion of the variation in the supply of affordable units that is explained by the independent variables. Therefore, the model does a better job of explaining the supply of very low-income rental units when structures of 5 or more units are included.

Hypothesis 4: In regions with urban containment, the association between multi-unit structures and a greater supply of affordable units for low-income households is weaker than in regions without urban containment.

Support for this hypothesis was weak as there were only one analysis which provided evidence for it. There was a weaker relationship between structures of 5 or more units and affordable *very* low-income rental units in the Portland region as compared to the Seattle region when only Portland had urban growth boundaries. After Seattle implemented urban growth boundaries, this difference was no longer significant. This is the only interaction variable, throughout this research, which performed in its hypothesized manner.

This result was not replicated for *extremely* low-income units in the Portland and Seattle regions. As mentioned previously, the small size of the *extremely* low-income rental housing stock, relative to the overall size of the market, likely makes it difficult to capture the interaction affect of urban containment on the relationship between multi-unit structures and the supply of affordable extremely low-income rental units.

A second finding from this research provided some further evidence, albeit limited, for the hypothesis that urban containment alters the relationship between multi-unit structures and the supply of affordable housing. The positive impact of multi-unit structures in the Baltimore region may have become weaker after the implementation of priority funding areas there. The interaction variables indicated that, prior to priority funding areas in the Baltimore region, the relationship between structures of 2 to 4 units and *extremely* low-income rental units, as well as the relationship between structures of 5 or more units and *very* low-income rental units, were stronger in the Baltimore region as compared to Philadelphia. After priority funding areas were established, the relationships were no longer stronger in Baltimore and were similar to those found in Philadelphia. This change in the Baltimore region could have been the result of urban containment pushing demand for housing into developed areas and areas designated for development. As demand for housing increases in developed and other designated areas, demand will increase for housing in multi-unit structures as well as for single-family dwellings. Therefore, the strong association between multi-unit structures and affordable units may decline.

On the other hand, there is an alternative explanation for this change. The population growth rate, of residents and of households, was higher in the Baltimore region as compared to the Philadelphia region during the 1990's. The growth rate in terms of residents was 7.2% in Baltimore as compared to 3.6% in Philadelphia. In terms of households, the growth rate was 10.7% in Baltimore and 6.5% in Philadelphia. This stronger growth in Baltimore may have increased the demand for all types of housing relative to Philadelphia, including for housing in multi-unit structures. This increase in demand may explain why the relationship between multi-unit structures and affordable housing was no longer stronger in Baltimore, as compared to Philadelphia, by 2000.

Hypothesis 5: Mixed land use neighborhoods in regions with urban containment are associated with a lower supply of affordable housing units for low-income households.

The analyses did not provide evidence for this hypothesis. The direction and statistical significance of the interaction variables for mixed land use did not change in the expected manner between 1990 and 2000 in either the analyses for Portland and Seattle or in the analyses for Philadelphia and Baltimore.

There are two issues regarding my two measures of mixed land use, the diversity index of all land uses and the balance of population-serving jobs to residents, which may have influenced my lack of significant findings. First, I used employment and population data to estimate the diversity of land use within each neighborhood. Land use data were not used because of the lack of standardization of data for various land use categories at the neighborhood level among the four metropolitan regions of Portland, Seattle, Baltimore, and Philadelphia. Using my measure, I assume that the amount of land used by a particular activity is strongly correlated with the number of employees employed by that activity. But using employment and population data does not exactly capture the amount of land used for different activities as many residents, or employees of a particular industry, may be concentrated within a small area of land relative to the land area of the neighborhood or may be widely spread throughout. The mixture of employees and residents within a neighborhood may not be the best measure of mixed land use as the measure masks the possibility that housing consumers are more sensitive to the amount of land which is consumed by particular activities than the number of employees that are employed by those activities.

A second issue with regard to my two measures of mixed land use is that a neighborhood dominated by one land use has a low index score, while a neighborhood with an even distribution of land uses has an index score of 1. However, a low score does not indicate which land use dominates the neighborhood. It may be dominated by residential use or by a specific industry. A score somewhere between 0 and 1 does not specify the type of land uses within the mix. To address this issue and to select only land uses which residents would more likely view as a positive amentity in their neighborhood, the balance of population-serving jobs and residents includes only employment in retail, finance and insurance, real estate, education, health, social services, arts, entertainment, and food services.

Hypothesis 6: A greater proportion of land in public parks, a form of open space, is associated with a lower supply of affordable housing for low-income households.

The analyses provided only weak evidence that a greater proportion of land in public parks was associated with a lower supply of affordable housing. The results indicate that this relationship was dependent on the region. First, only in Philadelphia was the relationship between public parks and affordable units consistently negative and statistically significant, for both extremely low-income and very low-income rental units. With only one exception, the interaction of Baltimore and parks indicated that this negative relationship was either weaker or non existent in Baltimore.[144] Second, there was a negative relationship between public parks and *extremely* low-income rental units in the region of Portland but not in Seattle.

One potential explanation for the weak support for this hypothesis from my analyses is my measure of public parks. Using the neighborhood, defined by census tracts, as the level of analysis, my analyses precludes finding a negative relationship between public parks and the supply of affordable housing within smaller distances such as a block. The literature review in Chapter Three indicated that public parks have their greatest impact on home values at closer distances smaller than a census tract. This limitation to my research is further discussed in Section 8.3.

Hypothesis 7: In regions of urban containment, the association between a greater proportion of land in public parks and a smaller supply of affordable housing is stronger than in regions without urban containment.

The analyses did not provide evidence for this hypothesis. The direction and statistical significance of the interaction variables for public parks did not change in the expected manner between 1990 and 2000 in either the analyses for Portland and Seattle or in the analyses for Philadelphia and Baltimore.

It was hypothesized that the negative relationship between public parks and the supply of affordable housing would be stronger in areas of urban containment because of the reduction of open space within urban containment boundaries. Open space should decline within these boundaries because development is prohibited, or discouraged, outside of them. As open space declines, land preserved as public parks would be more valuable as an amenity to housing consumers. Hypothetically, people would be willing to pay more for housing near a public park, reducing the supply of affordable units near the park, as open space declines. However, the findings do not support this hypothesis. It may be that the preservation of open space outside of urban containment boundaries serves as a substitute for open space within them. Alternatively, my measure of public parks at the neighborhood level, once again, prevents capturing the impact of urban containment on the relationship between public parks and affordable housing within closer distances.

[144] As mentioned in Chapter 7's footnotes, results from an interaction of Philadelphia and parks, rather than Baltimore and parks, indicated that parks were not statistically significant in Baltimore.

8.2 IMPLICATIONS

Smart growth has received a growing amount of attention in recent years among diverse groups of people, including planners, environmentalists, politicians, academics, and others. Typically, these groups see smart growth as a means to protect the environment and preserve open space rather than to address social issues such as affordable housing. But recently, smart growth proponents have begun to pay more attention to ways in which the smart growth principles can be applied to social concerns, such as housing.[145]

The primary purpose of this research was to test claims that specific smart growth principles can increase the supply of affordable housing for low-income households. It tested the impact of four principles – greater housing density, a variety of housing options, mixed land use, and open space in the form of public parks – on affordable housing. To date, there have been few empirical studies of these relationships. Given the popularity of the smart growth principles in recent years, it is imperative that research address this gap and this research begins to do so. The results of this research have implications for public policy, specifically as it pertains to urban planning, growth management, and attempts to curb sprawl.

The first policy implication is the necessity among planners and growth management advocates to give greater consideration to the types of housing developed as they encourage greater residential density to reduce sprawl. Growth management states such as Oregon and Washington encourage, if not mandate, greater residential density as a means to increase the supply of housing for households with limited income while at the same time preserve open space. This research's finding that residential density is consistently statistically significant and positive when multi-unit structures are not explicitly included in the model provides evidence that greater residential density, without regard to the type of housing, is associated with a greater supply of affordable rental units.

This research, however, also suggests a more reliable and stronger source of affordable units than greater residential density in general is the presence of multi-unit structures. When variables to measure the presence of multi-unit structures are included in the model, they are

[145] For example, see the Smart Growth Network (2001), Arigoni (2001), and Downs (2004).

positive and statistically significant in almost every case. The significance of the variable for residential density becomes less reliable.

It is not difficult to see how an increase in residential density may not be associated with an increase in the supply of affordable units. Song and Knaap (2004) found in Portland that residents sacrificed the size of their yards in response to higher land costs and growth management mandates, thereby increasing residential density. However, residents did not change their preferences regarding the size of their single-family, detached homes. Reducing lot sizes may increase density, but does not necessarily increase the supply of affordable housing for low-income households if new housing units themselves not only remain single-family dwellings, but grow in size.[146,147]

As local municipalities and counties develop and update their comprehensive plans, there should not only be a discussion of residential density in general, but also of the type of housing as well. A variety of housing types are associated with not only higher density, but also with a greater supply of affordable housing. Multi-unit structures and attached homes, such as townhomes, by the nature of their design increase density as they concentrate more housing units on any given area of land. This is especially true for large multi-unit structures. At the same time, this research consistently found that a greater supply of housing in multi-unit structures was associated with a greater supply of affordable rental units.

An example of a growth management policy which gives specific attention to the type of housing, in addition to density in general, is found in Portland's Metropolitan Housing Rule (MHR). The housing rule was passed in 1981, two years after Portland implemented its urban growth boundary. Not only does the MHR require municipalities to plan for specific density targets, but it requires them to "allow the opportunity" for half of all newly developed housing units to be in multi-unit structures (Portland Metro 2000, p. 30; 2004, p. 21). But this type of policy is rare.

Individual municipalities are likely to have an adversity to multi-unit housing, which explains why few local comprehensive plans specifically state the type of housing which should

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[146] Song and Knaap (2004) provide evidence that this is the case in Washington County of the Portland Region.
[147] The Portland Metro's Housing Advisory Technical Committee (H-TAC) concluded that developers have historically built housing below allowable densities because of demand in the housing market for lower density. The committee concluded that, in some places, zoning in the Portland region allows for higher density than the market will bear (Portland Metro 2000, pp. 30-31).

be encouraged to achieve higher density and few local policies requiring multi-unit structures exist. Municipalities have a financial interest in allowing the development of new housing which attracts higher income households. Higher income households provide a greater tax base and are more likely to 'pay their own way' in terms of public services they consume (Hamilton 1975). New, high quality single-family dwellings are more likely to attract the type of household which benefit the municipality, financially, than multi-family units (Orfield 2002). Many municipalities, for these reasons, implement restrictions which prevent affordable, multi-unit housing (Advisory Commission on Regulatory Barriers to Affordable Housing 1991).

For this reason, state or regional authority must be used to encourage municipalities to increase production of multi-unit structures within their jurisdictions. A mandate from a higher level of government, which is uniformly enforced across local jurisdictions, would improve the probability of an increase in multi-unit structures for two reasons. First, jurisdictions could be required to implement zoning which permits more multi-unit structures. Second, a jurisdiction may be more likely to approve multi-unit structures if it knows other jurisdictions are also approving the development of multi-unit structures. Without this knowledge, a jurisdiction may be fearful that it will experience an increase in multi-unit structures while another jurisdiction is approving only single-family homes for higher income households.

One such example of the state encouraging multi-unit structures is Portland's Metropolitan Housing Rule. It was the result of legislation by the state of Oregon requiring the Portland Metro to establish such a rule. However, local jurisdictions fiercely protect their control over land use decisions within their borders. In most areas of the country, there is little political support allowing the state or regional authorities to impose specific land use laws on municipalities (Downs 2004).

A second policy implication is that state, regional and local policies specific to the supply of affordable housing are necessary within the smart growth movement. If proponents of smart growth are to be proponents of affordable housing, they cannot rely solely on smart growth principles tested in this research. The only smart growth principle reliably associated with a greater supply of affordable units was a variety of housing options as measured by the proportion of housing in multi-unit structures. In addition, the results of this research can only be used to determine association and not causation. The results do not provide conclusive evidence that multi-unit structures *cause* an increase in affordable housing. This limitation will be further discussed in Section 8.3.

To truly provide a variety of housing options for low-income households, smart growth advocates must support policies which are specific to increasing the supply of affordable units. Such policies include[148]:

- Density bonuses which allow developers to build housing densities greater than typically allowed if they set aside of portion of their units for low-income households;
- Inclusionary zoning, as opposed to exclusionary zoning, which requires new housing developments to include a proportion of units affordable to low-income households;
- Relaxation of building codes and excessive zoning which increases the cost of housing;
- Support of Housing Trust Funds which create dediciated streams of funding for affordable housing units from government revenue or private philanthropy.

Unfortunately, affordable housing for low-income households is rarely, if ever, at the forefront of smart growth.[149] As discussed in Section 2.3.1, smart growth advocates are slower to adopt affordable housing policies than they are to adopt mechanisms by which to preserve open space and combat sprawl. There are a number of reasons for the slow adoption of affordable housing policies. First, homeowners prefer to not have affordable housing adjacent o their own home. Their fear is that low-income housing lowers the value of their home. The impact of this fear is significant in that the home is a significant asset among most homeowners. This fear might not prevent people from supporting policies for affordable housing, as long as the housing is not located in their own neighborhood.[150]

The second reason for the slow adoption of affordable housing policies is the economic incentive for local municipalities to prohibit affordable housing in order to protect their tax base.

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[148] For details of programs like these, see Meck, Retzlaff, and Schwab (2003). For inclusionary zoning, see Porter (2004) and Brown (2001).
[149] For this reason, these policies were not the focus of study in this research.
[150] This phenonmenon is commonly called NIMBY, "not in my backyard."

Prohibiting affordable housing within a jurisdiction keeps out low-income households, who bring a net loss to municipalities' budgets. Low income households are likely to consume more local public expenditures than the local tax revenue they provide.

To overcome local objections to affordable housing policies, they need to be required of local municipalities by the state. An example is New Jersey's Council on Affordable Housing (COAH) which requires jurisdictions to adopt methods to achieve their "fair-share" of housing for low-income households. Municipalities are free to choose from a variety of methods, including those listed above. Participation is voluntary among municipalties, but those choosing to submit an affordable housing plan to COAH are exempt from lawsuits concerning their zoning practices.[151]

However, there can be strong opposition to state or regional affordable housing policies. For example, political pressure pushed Oregon's state legislature to prohibit Portland's regional planning organization (Portland Metro) from requiring municipalities to meet specific affordable housing goals. At best, Portland Metro could only make suggestions to municipalities regarding strategies to increase the supply of affordable units. Adoption of any specific strategy or affordable housing goal by a municipality is voluntary.

A third implication is that growth management advocates are not incorrect when they argue greater density, and changes in the type of housing, may help to alleviate the potentially adverse affects of urban containment policies on affordable housing. This is particularly true for changes in the type of housing. The hypotheses of this research were that urban containment policies would weaken the positive associations between affordable housing and density, as well as between affordable housing and multi-unit structures. But other than weak evidence that urban containment may weaken the positive association between multi-unit structures and affordable units, there is no support for these hypotheses. Therefore, advocates of urban containment policies to curb sprawl should be equally supportive of an increase in the diversity of housing types, and greater housing density, if they are not to exacerbate the shortage of affordable units for extremely low-income and very low-income households.

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[151] COAH is discussed further in Section 6.3.3.1.

8.3 LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

There are limitations to this research that should be explored in future studies. The first limitation is that the current model tested for *association*, but not *causation*, between the four smart growth principles and the supply of affordable housing. For example, a strong positive association was found between the proportion of housing in multi-unit structures and the proportion of affordable units. But the model does not allow for the interpretation that multi-unit structures *cause* affordable units. The present research was a "point in time" analysis at two different points in time, the years 1990 and 2000. The independent variables were measured at the same point in time as the dependent variable. Therefore, the analysis does not adequately capture causation. It does not measure the independent variables at a point in time *prior* to the measure of the dependent variables nor did it measure changes in the independent variables leading up to the measure of the dependent variable. In order to determine causation, changes in the independent variables must occur prior to changes in the dependent variable.

There is a possibility that a large number of affordable housing units in a neighborhood *cause* multi-unit structures. Zoning restrictions prohibit, or at least make unlikely, the development of multi-unit structures in neighborhoods or municipalities dominated by unaffordable single-family homes. As discussed elsewhere, homeowners have an aversion to types of adjacent land uses they fear may lower their home's value. One such aversion is to multi-unit structures. Therefore, there is the possibility that additional multi-unit structures are more likely to be developed in neighborhoods with fewer unaffordable owner-occupied homes and a greater supply of affordable rental units already.

The same reverse causation pattern may also exist between the other smart growth principles and the supply of affordable housing. Neighborhoods with a large supply of affordable housing, and low-income households, may present fewer barriers to developers who want to develop new high-density housing or alternative land uses, such as commercial structures. Once again, neighborhoods with a larger number of affordable rental units may also have fewer homeowners to organize against greater residential density or alternative land uses.

To control for the potentially endogenous relationship between affordable housing and the smart growth variables, a lagged model could be utilized in future research. The four smart growth variables – density, multi-unit structures, mixed land use, and public parks – could be measured at a point in time prior to the measure of the dependent variable – affordable housing. For example, the smart growth variables could be measured as of 1980. The dependent variable would be the supply of affordable housing in 1990. This is the first step in setting up an appropriate lagged model in which the dependent variable lags behind the independent variables.

Additional independent variables could be included to make the model dynamic over time rather than static at one point in time. The additional variables should measure the change in each smart growth principle during the decade prior to the measure of the dependent variable. To continue the example given in the previous paragraph, the additional independent variables would be the change in each smart growth variable from 1980 to 1990, as well as the supply of affordable housing in 1980. Therefore, the supply of affordable housing in 1990 would be a function of the supply in 1980 and changes in the smart growth variables from 1980 to 1990.[152]

A second limitation of this research is that additional affordable housing is likely to be located in neighborhoods that already have affordable housing, regardless of residential density, mixed land use, or parks, because of public policies regarding subsidized housing. Therefore, my analysis may find little significance regarding the impact of the smart growth variables. HOPE VI, HOME, and other subsidized housing programs typically provide new affordable housing where affordable housing already exists. This occurs for two reasons. First, political battles over the placement of subsidized housing often prevent these units from being developed in neighborhoods with unaffordable, single-family homes occupied by homeowners. The reason for this aversion to subsidized units on the part of homeowners has been previously discussed. Homeowners do not want land uses or housing types in their neighborhood that may lower values. They also do not want low-income households consuming public services for which the higher income homeowners pay. Therefore, affordable housing may attract other subsidized, affordable housing investments as those investments are more likely to be rejected in higher-income neighborhoods with a more costly housing stock.

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[152] The lagged model is appropriate for the analyses of Portland/Seattle and Baltimore/Philadelphia in both 1990 and 2000. The lagged model would still allow me to test the impact of urban containment on the relationships between each smart growth principle and affordable housing. However, extending the analyses of Portland/Seattle beyond 2000 to 2010 would not be useful as both regions woulds still have urban growth boundaries as they did in 2000. A lagged model to 2010 would be beneficial for Baltimore and Philadelphia as more time would have passed between the time of Baltimore's establishment of priority funding areas and the analysis.

The second reason new affordable housing units are likely located in neighborhoods which already have affordable units is a result of the goals among agencies developing affordable housing. Section 2.1.2.2 explained the growing importance of the non-profit sector in the provision of affordable housing for low-income households. Community Development Corporations (CDCs) are playing a growing role in the development of affordable housing as the Federal government takes less direct responsibility. Through state and regional housing agencies and intermediary organizations, CDCs have access to public money, such as Community Development Block Grants (CDBG), HOME, and LIHTC funds. At the same time, CDCs have kept their initial mission of addressing problems created by urban decline, specifically in low-income neighborhoods. CDCs attempt to revitalize their neighborhoods through housing and other investments. Therefore, CDC investments in affordable housing are made in low-income neighborhoods which likely have a stock of affordable units.[153]

A third limitation of this research is it assumed the urban containment policies were effective and functioned in the expected manner. There is evidence in the literature for this assumption. While no policy is perfect, Maryland's public infrastructure spending was successfully re-directed to priority funding areas (Daniels 2001; Maurer, Forsyth, and Whipple 2001); Portland's urban growth boundaries increased development density and directed a sizable proportion of new housing to older urban neighborhoods and other locations within urban growth boundaries (Nelson and Moore 1996; Song and Knaap 2004); and Seattle's urban growth areas decreased development in farming areas in favor of development within urban growth boundaries (Fulton et al. 2006).

A potential avenue of research is to measure the extent to which regional urban containment policies actually change land use patterns, particularly with regard to the consumption of undeveloped land on the urban fringe. A study could then explore the relationship between the change in the consumption of undeveloped land and the supply of affordable housing for low-income households.

A fourth limitation is this research did not address the location of affordable housing relative to the location of jobs for low-income households. Many metropolitan regions have a spatial mismatch between jobs and housing as low wage jobs are often not easily accessible from

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[153] There is the possibility that some of the affordable housing stock that already exists in these low-income communities in which CDCs work is of inadequate quality.

neighborhoods which have a supply of low-income housing (Kasarda 1990; Coulton, Leete, and Bania 1999).[154] One argument receiving growing attention within the realm of smart growth is the extent to which neighborhoods with greater density, mixed land uses, and access to public transportation reduce commuting costs for households. The Center for Transit Oriented Development (2007, p. 7) reports that families living in neighborhoods with a greater diversity of land uses, greater residential density, and transit services spend 9% of their income on transportation as compared to 19% spent by the average family. Presumably, these lower transportation costs are the result of access to employment and daily necessities without the required expenditures of a car.[155] Therefore, households may achieve financial gains if they live in a compact, mixed use neighborhood with public transportation. On the other hand, Haas et al. (2007, p. 54) report that expenditures on housing are higher in these types of neighborhoods for some metropolitan regions.

There has been no research regarding the combination of transportation affordability and the supply affordable housing, as they pertain specifically to extremely and very low-income households, in neighborhoods of greater density and mixed land use. If compact, mixed use neighborhoods do reduce commuting costs, then low-income households living in those neighborhoods may be better off even if these neighborhoods do not have a greater number of affordable units. Low-income households would be able to spend more of their income on housing as they spend less on transportation. A future avenue of research is to explore the impact of compact and mixed use neighborhoods on commuting patterns and transportation costs for low-income households.

A fifth potential limitation is the level at which data was aggregated for the analysis. This limitation is especially pertinent to public parks. The literature review indicated the impact of public parks on housing values declines as the distance between the two increases. Using the

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[154] This line of reasoning stems from Kain's (1968) spatial mis-match hypothesis in which he argued unemployment among African-Americans was exacerbated by their segregation in neighborhoods of inner cities as jobs were decentralizing to the suburbs. He found that a greater distance between a workplace and the nearest residential concentration of African-Americans was statistically significant in explaining a lower proportion of workers within the workplace who were African-American. He attributed some of his findings to transportation barriers, housing segregation, and discrimination in the labor market. Since his article, numerous studies have been published regarding the spatial mis-match hypothesis as it pertains to race. For two reviews, see Holzer (1991) and Ihlanfeldt and Sjoquist (1998).

[155] Also see the Housing & Transportation Affordability Index being developed by the Brookings Institution and the Center for Transit Oriented Development at http://www.brookings.edu/metro/umi/ctod_page.htm.

census tract as the level of analysis may not adequately capture the impact of public parks on the supply of affordable units. Parks may have an impact within a few blocks, but maybe not within an entire tract. This would be especially true for census tracts which cover a large area of land. Therefore, the variable for public parks may not be providing the best estimates for the relationship between them and affordable units. Additionally, the model did not capture distance from the park. It captured the amount park space relative to the census tract's size.

Despite these limitations, this research provides a better understanding of the complexities regarding the impact of four specific smart growth principles on the supply of affordable housing for low-income households. While a number of rhetorical claims have been made about the benefits of smart growth on the housing opportunities for low-income households, few of these claims were empirically tested prior to this research.

Appendix A

MARYLAND'S ECONOMIC GROWTH, RESOURCE PROTECTION, AND PLANNING ACT OF 1992

Maryland's 1992 Economic Growth, Resource Protection, and Planning Act required local governments and counties throughout Maryland to devise comprehensive plans addressing seven "visions" for the state's future with regard to population growth and protection of the state's natural resources. The Act required that localities incorporate the following visions into their plans (Maryland Department of Planning 2005; Frece 2005, pp. 106-107):

- Development is concentrated in suitable areas
- Sensitive Areas are protected – "sensitive areas" must include habitats for endangered species, floodplains, steep slopes, and streams and stream buffers
- In rural areas, growth is directed to existing population centers and resource areas are protected
- Stewardship of the Chesapeake Bay and the land is a universal ethic
- Conservation of resources, including a reduction in resource consumption is practiced
- Economic growth is encouraged and regulatory mechanisms are streamlined in a manner to achieve the other visions
- Funding mechanisms are addressed to achieve these visions

The 1992 Act designated little responsibility to the state in growth management policies (Cohen 2002, p. 300). Local governments were free to identify their own "sensitive areas" and use their own discretion in establishing standards for site location of new development. In addition, there was no mandate for a state-level comprehensive plan. The state had two roles. First, the state would comment on local comprehensive plans with recommendations on the identification of sensitive areas and site development. Local jurisdictions, however, were not required to include the state's recommendations in their final plans. The second role of the state was to ensure that public expenditures were consistent with local plans. State funds could be used to facilitate new development only if the proposed development was consistent with the comprehensive plan of the development's local government. Additionally, the state could not approve public works or transportation projects unless the projects were consistent with local plans (Maryland Department of Planning 2005).

Maryland's 1992 Planning Act was criticized for not strengthening the state's control or influence over local land use decisions. Because of continued local control over land use decisions, the planning act was seen as ineffective in adequately directing growth and revitalizing older neighborhoods (Cohen 2002, p. 301). Supporters, however, saw the preservation of local autonomy as a strong point of the 1992 Act as legislation giving stronger authority to the state had been rejected in the past (Porter 1999, p. 2). One of the most significant outcomes of the 1992 Act was the seven "visions" for future growth which were outlined by the state. These visions served as the foundation for the Smart Growth Act which was passed five years later to improve Maryland's growth management efforts (Frece 2005, p. 107).

Appendix B

ADEQUACY FACTORS FOR PHYSICAL CONDITION OF HOUSING UNITS

Tables B-1 and B-2 provide adequacy factors indicating the percentage of rental units that were in acceptable physical condition as reported by the M-AHS. The total supply of rental units in each price range, reported by the U.S. Census, was multiplied by these factors in order to estimate the number of units that were not only affordable, but also physically adequate. For each region, separate factors were estimated for the central city and the rest of the region.

Table B-1. 1990 Adequacy Factors

Rent Range	Portland, Central City	Portland, Rest of Region	Seattle, Central City	Seattle, Rest of Region	Baltimore, Central City	Baltimore, Rest of Region	Phila., Central City	Phila., Rest of Region
Less than $300	80.4%	88.5%	89.5%	98.2%	82.1%	94.7%	72.4%	87.9%
$300 to $449	93.8%	95.8%	93.0%	95.9%	81.9%	93.9%	84.4%	91.5%
$450 to $599	96.3%	96.8%	93.5%	95.2%	84.1%	93.6%	88.1%	93.3%

Source: Metropolitan American Housing Surveys, 1989 (Philadelphia), 1990 (Portland), 1991 (Seattle & Baltimore).

Table B-2. 2000 Adequacy Factors

Rent Range	Portland, Central City	Portland, Rest of Region	Seattle, Central City	Seattle, Rest of Region	Baltimore, Central City	Baltimore, Rest of Region	Phila., Central City	Phila, Rest of Region
Less than $400	87.0%	96.7%	85.4%	88.9%	84.6%	92.3%	82.0%	94.2%
$400 to $599	90.1%	93.3%	88.7%	89.3%	88.0%	90.1%	90.8%	93.7%
$600 to $799	92.7%	93.4%	90.0%	87.4%	86.9%	91.6%	83.4%	88.1%

Source: Metropolitan American Housing Surveys, 1998 (Baltimore), 1999 (Philadelphia), 2002 (Portland), 2004 (Seattle)

Appendix C

MAPS OF MIXED LAND USE

The following maps, beginning on the next page, provide a graphic presentation of the two measures of mixed land use. The diversity index ranges from a score of 0 to 1, with 0 indicating a neighborhood with only one land use. A score of 1 indicates a neighborhood with an equal mix of land uses. The second measure is the balance between population-serving employment and the number of residents in each neighborhood. A score of 0 indicates a neighborhood that is completely residential with no ‘population-serving’ activities or, alternatively, has no residents.

Figure C-1. Diversity Index by Census Tract, Portland, 2000

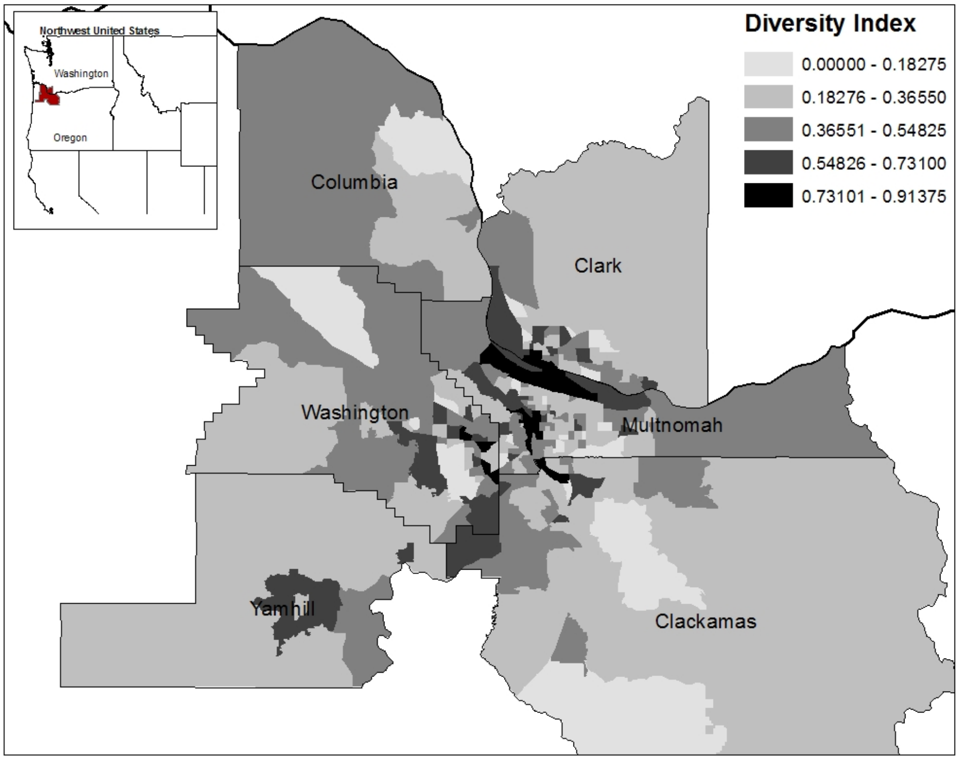


Figure C-2. Balance of 'Population-Serving' Jobs to Residents by Census Tract, Portland, 2000

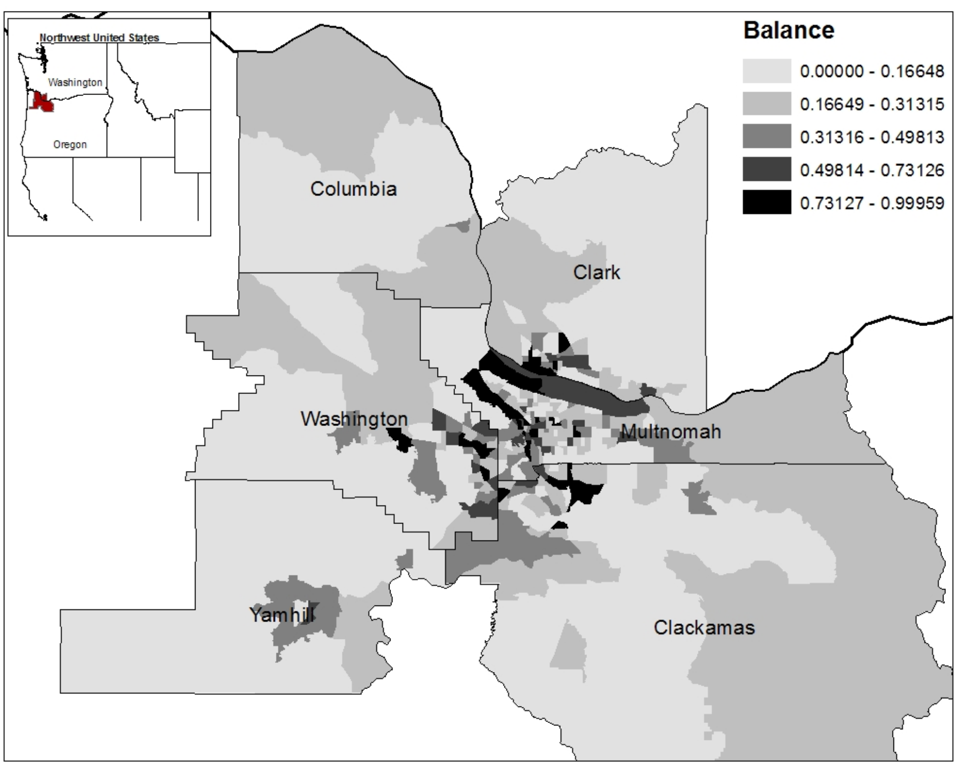


Figure C-3. Diversity Index by Census Tract, Seattle, 2000

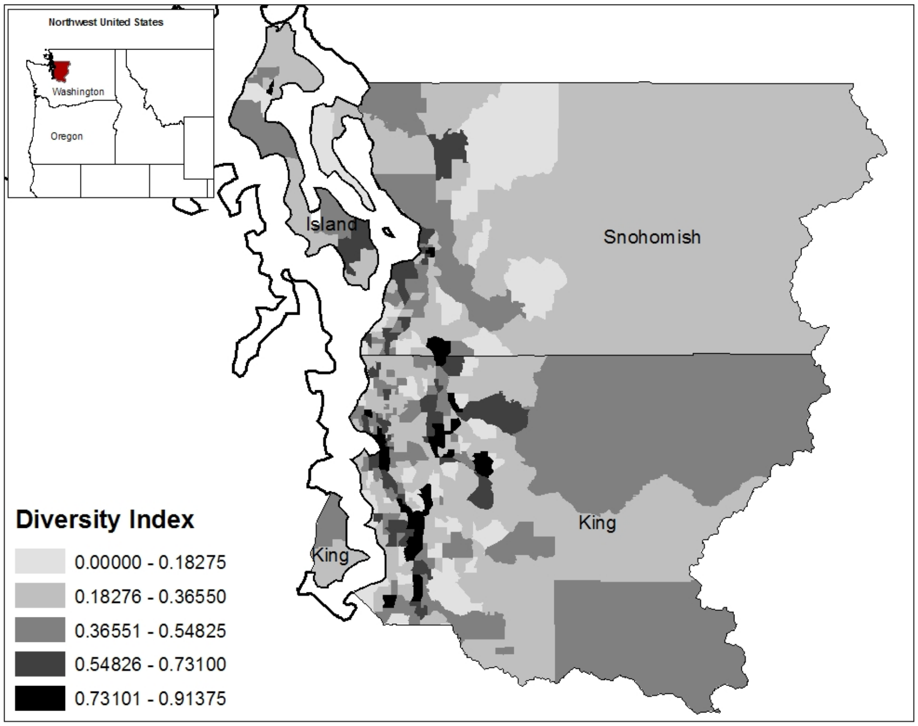


Figure C-4. Balance of 'Population-Serving' Jobs to Residents by Census Tract, Seattle, 2000

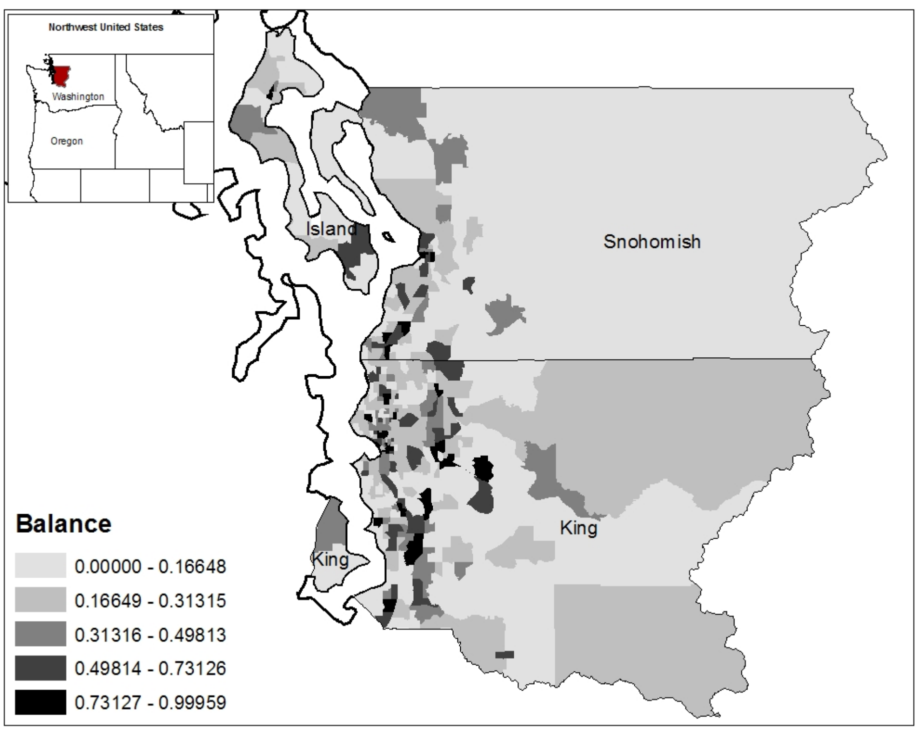


Figure C-5. Diversity Index by Census Tract, Baltimore, 2000

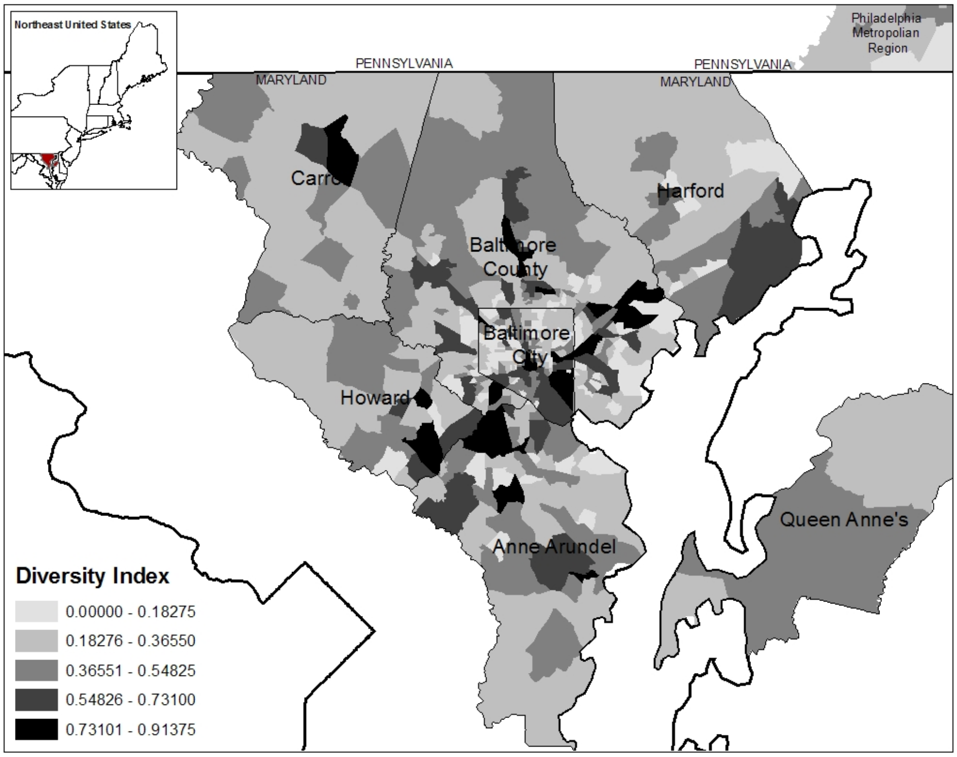


Figure C-6. Balance of 'Population-Serving' Jobs to Residents by Census Tract, Baltimore, 2000

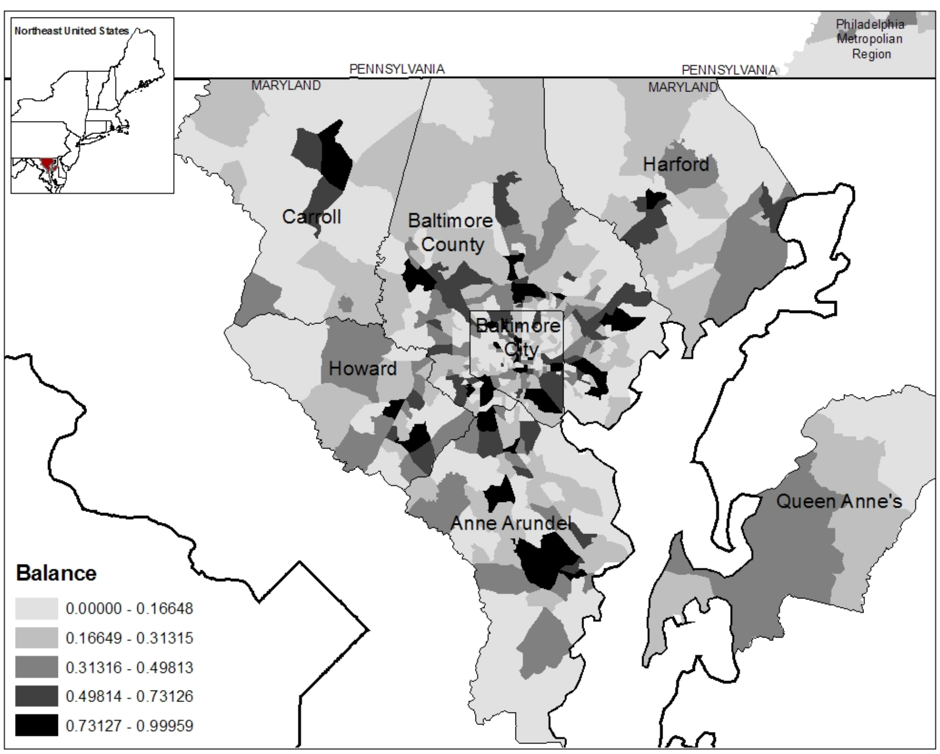
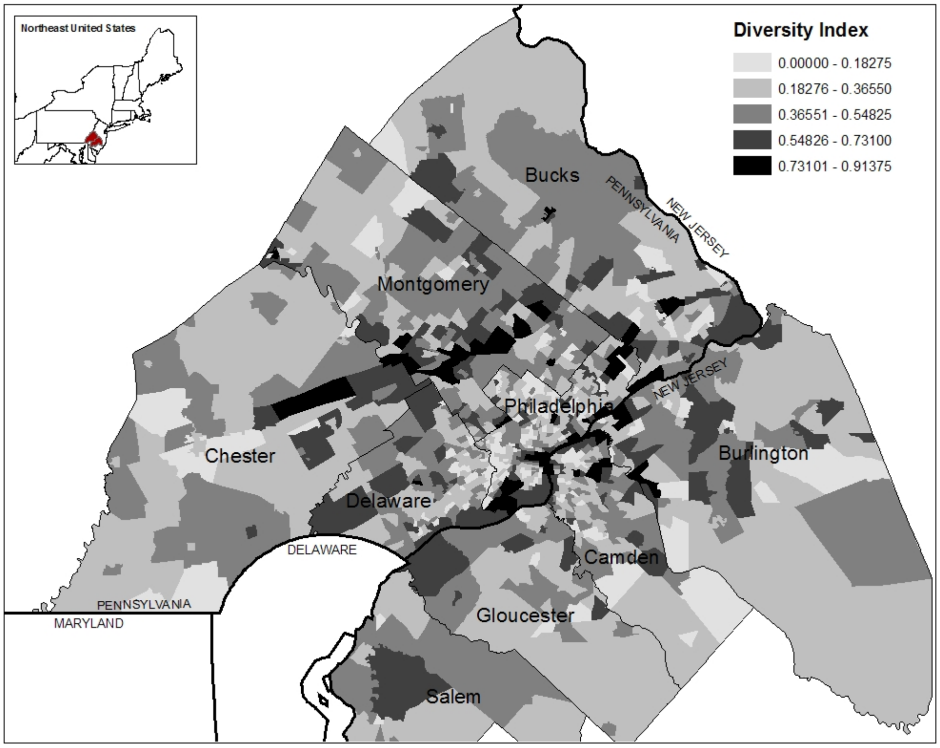
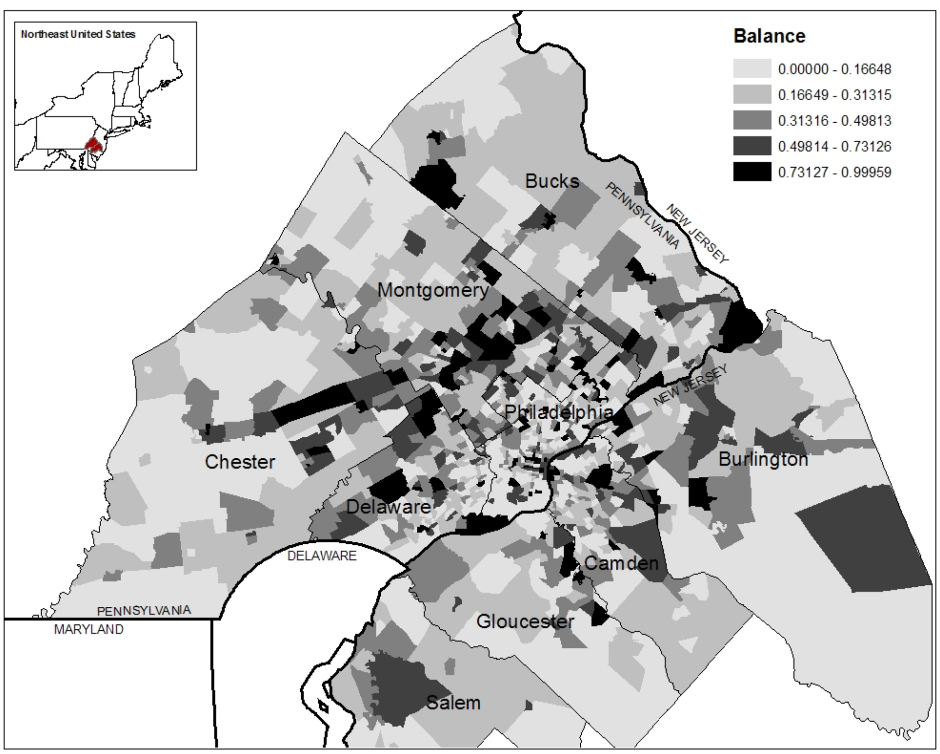


Figure C-7. Diversity Index by Census Tract, Philadelphia, 2000



C-7. Balance of 'Population-Serving' Jobs to Residents by Census Tract, Philadelphia, 2000



Appendix D

CORRELATION MATRICES BY REGION AND YEAR

Table D-1. Correlations for Portland in 2000 (n=325)

	Density (100 d.u./squ. mile)	mixed land use index with all industries included	balance of service jobs and residents	% of land in parks	% of housing in structures of 2 - 4 units	% of housing in structures of 5 or more units	vacancy rate all units	% units built before 1970	% units with four or more bedrooms	% units subsidized by federal funds - public housing agencies	% population that is minority	% population that is black
Density (100 d.u./square mile)	1	.067	.262**	-.026	.298**	.525**	-.025	.426**	-.384**	.368**	.252**	.176**
mixed land index with all industries included	.067	1	.838**	.117*	.245**	.550**	.307**	.093	-.358**	.231**	.015	.019
balance of service jobs and residents	.262**	.838**	1	.151**	.283**	.584**	.209**	.132*	-.363**	.280**	-.015	-.036
% of land in parks	-.026	.117*	.151**	1	.139*	.001	.091	.074	-.161**	.093	.082	.010
% of housing in structures of 2 - 4 units	.298**	.245**	.283**	.139*	1	.290**	.028	.300**	-.496**	.367**	.290**	.204**
% of housing in structures of 5 or more units	.525**	.550**	.584**	.001	.290**	1	.257**	.004	-.525**	.386**	.185**	.049
vacancy rate all units	-.025	.307**	.209**	.091	.028	.257**	1	-.071	-.313**	.044	.136*	.117*
% before 1970	.426**	.093	.132*	.074	.300**	.004	-.071	1	-.235**	.245**	.258**	.335**
% units with four or more bedrooms	-.384**	-.358**	-.363**	-.161**	-.496**	-.525**	-.313**	-.235**	1	-.399**	-.336**	-.139*
% of units subsidized by federal funds - public housing agencies	.368**	.231**	.280**	.093	.367**	.386**	.044	.245**	-.399**	1	.453**	.413**
% population that is minority	.252**	.015	-.015	.082	.290**	.185**	.136*	.258**	-.336**	.453**	1	.814**
% population that is black	.176**	.019	-.036	.010	.204**	.049	.117*	.335**	-.139*	.413**	.814**	1

** Correlation is significant at the 0.01 level 2-tailed. * Correlation is significant at the 0.05 level 2-tailed.

Table D-2. Correlations for Seattle in 2000 (n=399)

	Density (100 d.u./squ. mile)	mixed land use index with all industries included	balance of service jobs and residents	% of land in parks	% of housing in structures of 2 - 4 units	% of housing in structures of 5 or more units	vacancy rate all units	% units built before 1970	% units with four or more bedrooms	% units subsidized by federal funds - public housing agencies	% population that is minority	% population that is black
Density (100 d.u./square mile)	1	.167**	.218**	-.073	.166**	.607**	.053	.348**	-.389**	.332**	.139**	.195**
mixed land index with all industries included	.167**	1	.856**	.169**	.241**	.551**	.407**	.059	-.475**	.246**	.090	.061
balance of service jobs and residents	.218**	.856**	1	.126*	.258**	.530**	.248**	.099*	-.434**	.262**	.131**	.105*
% of land in parks	-.073	.169**	.126*	1	.031	.130**	-.008	.125*	-.118*	-.015	.131**	.060
% of housing in structures of 2 - 4 units	.166**	.241**	.258**	.031	1	.260**	.051	.207**	-.459**	.283**	.159**	.198**
% of housing in structures of 5 or more units	.607**	.551**	.530**	.130**	.260**	1	.309**	.066	-.636**	.397**	.289**	.220**
vacancy rate all units	.053	.407**	.248**	-.008	.051	.309**	1	-.073	-.349**	.159**	.028	.055
% before 1970	.348**	.059	.099*	.125*	.207**	.066	-.073	1	-.215**	.141**	.199**	.246**
% units with four or more bedrooms	-.389**	-.475**	-.434**	-.118*	-.459**	-.636**	-.349**	-.215**	1	-.371**	-.257**	-.252**
% of units subsidized by federal funds - public housing agencies	.332**	.246**	.262**	-.015	.283**	.397**	.159**	.141**	-.371**	1	.494**	.482**
% population that is minority	.139**	.090	.131**	.131**	.159**	.289**	.028	.199**	-.257**	.494**	1	.812**
% population that is black	.195**	.061	.105*	.060	.198**	.220**	.055	.246**	-.252**	.482**	.812**	1

** Correlation is significant at the 0.01 level 2-tailed. * Correlation is significant at the 0.05 level 2-tailed.

Table D-3. Correlations for Baltimore in 2000 (n=548)

	Density (100 d.u./squ. mile)	mixed land use index with all industries included	balance of service jobs and residents	% of land in parks	% of housing in structures of 2 - 4 units	% of housing in structures of 5 or more units	vacancy rate all units	% units built before 1970	% units with four or more bedrooms	% units subsidized by federal funds - public housing agencies	% population that is minority	% population that is black
Density (100 d.u./square mile)	1	-.273**	-.155**	.047	.537**	.119**	.645**	.513**	-.448**	.273**	.512**	.500**
mixed land index with all industries included	-.273**	1	.801**	.040	-.056	.202**	-.071	-.131**	-.004	.033	-.274**	-.290**
balance of service jobs and residents	-.155**	.801**	1	.065	-.040	.266**	-.080	-.088*	-.041	.080	-.155**	-.177**
% of land in parks	.047	.040	.065	1	.017	.033	.069	.349**	-.295**	.019	.154**	.150**
% of housing in structures of 2 - 4 units	.537**	-.056	-.040	.017	1	.042	.541**	.459**	-.291**	.288**	.405**	.400**
% of housing in structures of 5 or more units	.119**	.202**	.266**	.033	.042	1	.027	-.194**	-.372**	.297**	.147**	.105*
vacancy rate all units	.645**	-.071	-.080	.069	.541**	.027	1	.421**	-.322**	.315**	.551**	.554**
% before 1970	.513**	-.131**	-.088*	.349**	.459**	-.194**	.421**	1	-.498**	.055	.341**	.360**
% units with four or more bedrooms	-.448**	-.004	-.041	-.295**	-.291**	-.372**	-.322**	-.498**	1	-.258**	-.359**	-.350**
% of units subsidized by federal funds - public housing agencies	.273**	.033	.080	.019	.288**	.297**	.315**	.055	-.258**	1	.362**	.360**
% population that is minority	.512**	-.274**	-.155**	.154**	.405**	.147**	.551**	.341**	-.359**	.362**	1	.993**
% population that is black	.500**	-.290**	-.177**	.150**	.400**	.105*	.554**	.360**	-.350**	.360**	.993**	1

** Correlation is significant at the 0.01 level 2-tailed. * Correlation is significant at the 0.05 level 2-tailed.

Table D-4. Correlations for Philadelphia in 2000 (n=1208)

	Density (100 d.u./squ. mile)	mixed land use index with all industries included	balance of service jobs and residents	% of land in parks	% of housing in structures of 2 - 4 units	% of housing in structures of 5 or more units	vacancy rate all units	% units built before 1970	% units with four or more bedrooms	% units subsidized by federal funds - public housing agencies	% population that is minority	% population that is black
Density (100 d.u./square mile)	1	-.282**	-.158**	-.076**	.436**	.161**	.444**	.464**	-.410**	.195**	.509**	.473**
mixed land index with all industries included	-.282**	1	.793**	.038	-.018	.295**	-.114**	-.166**	.032	-.008	-.287**	-.308**
balance of service jobs and residents	-.158**	.793**	1	.081**	.014	.310**	-.086**	-.102**	.039	.007	-.191**	-.205**
% of land in parks	-.076**	.038	.081**	1	-.035	.011	-.075**	.136**	-.028	-.017	.006	.017
% of housing in structures of 2 - 4 units	.436**	-.018	.014	-.035	1	.157**	.393**	.408**	-.422**	.247**	.361**	.329**
% of housing in structures of 5 or more units	.161**	.295**	.310**	.011	.157**	1	.076**	-.067*	-.292**	.195**	.051	.013
vacancy rate all units	.444**	-.114**	-.086**	-.075**	.393**	.076**	1	.330**	-.335**	.328**	.678**	.638**
% before 1970	.464**	-.166**	-.102**	.136**	.408**	-.067*	.330**	1	-.385**	.146**	.390**	.363**
% units with four or more bedrooms	-.410**	.032	.039	-.028	-.422**	-.292**	-.335**	-.385**	1	-.224**	-.323**	-.267**
% of units subsidized by federal funds - public housing agencies	.195**	-.008	.007	-.017	.247**	.195**	.328**	.146**	-.224**	1	.413**	.412**
% population that is minority	.509**	-.287**	-.191**	.006	.361**	.051	.678**	.390**	-.323**	.413**	1	.959**
% population that is black	.473**	-.308**	-.205**	.017	.329**	.013	.638**	.363**	-.267**	.412**	.959**	1

** Correlation is significant at the 0.01 level 2-tailed. * Correlation is significant at the 0.05 level 2-tailed.

Table D-5. Correlations for Portland in 1990 n=325

	Density (100 d.u./squ. mile)	mixed land use index with all industries included	balance of service jobs and residents	% of land in parks	% of housing in structures of 2 - 4 units	% of housing in structures of 5 or more units	vacancy rate all units	% units built before 1970	% units with four or more bedrooms	% units subsidized by federal funds - public housing agencies	% population that is minority	% population that is black
Density (100 d.u./square mile)	1	.285**	.336**	-.025	.271**	.539**	.114*	.434**	-.338**	.350**	.284**	.199**
mixed land index with all industries included	.285**	1	.880**	.189**	.337**	.631**	.197**	.318**	-.411**	.320**	.171**	.109*
balance of service jobs and residents	.336**	.880**	1	.142*	.276**	.609**	.133*	.245**	-.395**	.260**	.056	.004
% of land in parks	-.025	.189**	.142*	1	.078	.002	-.010	.096	-.134*	.109*	-.016	-.052
% of housing in structures of 2 - 4 units	.271**	.337**	.276**	.078	1	.289**	.068	.250**	-.369**	.352**	.292**	.190**
% of housing in structures of 5 or more units	.539**	.631**	.609**	.002	.289**	1	.251**	.074	-.510**	.398**	.120*	.043
vacancy rate all units	.114*	.197**	.133*	-.010	.068	.251**	1	.060	-.263**	.250**	.471**	.491**
% before 1970	.434**	.318**	.245**	.096	.250**	.074	.060	1	-.101	.211**	.387**	.345**
% units with four or more bedrooms	-.338**	-.411**	-.395**	-.134*	-.369**	-.510**	-.263**	-.101	1	-.405**	-.099	-.003
% of units subsidized by federal funds - public housing agencies	.350**	.320**	.260**	.109*	.352**	.398**	.250**	.211**	-.405**	1	.447**	.396**
% population that is minority	.284**	.171**	.056	-.016	.292**	.120*	.471**	.387**	-.099	.447**	1	.953**
% population that is black	.199**	.109*	.004	-.052	.190**	.043	.491**	.345**	-.003	.396**	.953**	1

** Correlation is significant at the 0.01 level 2-tailed. * Correlation is significant at the 0.05 level 2-tailed.

Table D-6. Correlations for Seattle in 1990 n=399

	Density (100 d.u./squ. mile)	mixed land use index with all industries included	balance of service jobs and residents	% of land in parks	% of housing in structures of 2 - 4 units	% of housing in structures of 5 or more units	vacancy rate all units	% units built before 1970	% units with four or more bedrooms	% units subsidized by federal funds - public housing agencies	% population that is minority	% population that is black
Density (100 d.u./square mile)	1	.281**	.338**	-.065	.194**	.583**	.022	.388**	-.334**	.287**	.205**	.208**
mixed land index with all industries included	.281**	1	.887**	.222**	.313**	.646**	.073	.226**	-.400**	.349**	.207**	.139**
balance of service jobs and residents	.338**	.887**	1	.140**	.288**	.620**	.064	.216**	-.373**	.353**	.180**	.117*
% of land in parks	-.065	.222**	.140**	1	.040	.135**	.006	.102*	-.113*	.000	.084	.057
% of housing in structures of 2 - 4 units	.194**	.313**	.288**	.040	1	.259**	.024	.248**	-.437**	.296**	.262**	.244**
% of housing in structures of 5 or more units	.583**	.646**	.620**	.135**	.259**	1	.126*	.082	-.569**	.442**	.223**	.175**
vacancy rate all units	.022	.073	.064	.006	.024	.126*	1	-.048	-.309**	.122*	.065	.121*
% before 1970	.388**	.226**	.216**	.102*	.248**	.082	-.048	1	-.183**	.133**	.301**	.273**
% units with four or more bedrooms	-.334**	-.400**	-.373**	-.113*	-.437**	-.569**	-.309**	-.183**	1	-.369**	-.199**	-.193**
% of units subsidized by federal funds - public housing agencies	.287**	.349**	.353**	.000	.296**	.442**	.122*	.133**	-.369**	1	.514**	.442**
% population that is minority	.205**	.207**	.180**	.084	.262**	.223**	.065	.301**	-.199**	.514**	1	.879**
% population that is black	.208**	.139**	.117*	.057	.244**	.175**	.121*	.273**	-.193**	.442**	.879**	1

** Correlation is significant at the 0.01 level 2-tailed. * Correlation is significant at the 0.05 level 2-tailed.

Table D-7. Correlations for Baltimore in 1990 (n=549)

	Density (100 d.u./squ. mile)	mixed land use index with all industries included	balance of service jobs and residents	% of land in parks	% of housing in structures of 2 - 4 units	% of housing in structures of 5 or more units	vacancy rate all units	% units built before 1970	% units with four or more bedrooms	% units subsidized by federal funds - public housing agencies	% population that is minority	% population that is black
Density (100 d.u./square mile)	1	-.177**	-.102*	.045	.454**	.106*	.415**	.449**	-.392**	.277**	.504**	.499**
mixed land index with all industries included	-.177**	1	.874**	.097*	-.044	.168**	.156**	-.021	-.040	.025	-.195**	-.203**
balance of service jobs and residents	-.102*	.874**	1	.097*	-.023	.235**	.151**	-.003	-.070	.082	-.124**	-.135**
% of land in parks	.045	.097*	.097*	1	.033	.028	-.039	.347**	-.290**	.001	.107*	.110**
% of housing in structures of 2 - 4 units	.454**	-.044	-.023	.033	1	-.002	.381**	.390**	-.232**	.216**	.369**	.368**
% of housing in structures of 5 or more units	.106*	.168**	.235**	.028	-.002	1	.282**	-.193**	-.351**	.316**	.121**	.103*
vacancy rate all units	.415**	.156**	.151**	-.039	.381**	.282**	1	.084*	-.210**	.225**	.342**	.334**
% before 1970	.449**	-.021	-.003	.347**	.390**	-.193**	.084*	1	-.406**	-.023	.250**	.263**
% units with four or more bedrooms	-.392**	-.040	-.070	-.290**	-.232**	-.351**	-.210**	-.406**	1	-.218**	-.246**	-.251**
% of units subsidized by federal funds - public housing agencies	.277**	.025	.082	.001	.216**	.316**	.225**	-.023	-.218**	1	.380**	.378**
% population that is minority	.504**	-.195**	-.124**	.107*	.369**	.121**	.342**	.250**	-.246**	.380**	1	.998**
% population that is black	.499**	-.203**	-.135**	.110**	.368**	.103*	.334**	.263**	-.251**	.378**	.998**	1

** Correlation is significant at the 0.01 level 2-tailed. * Correlation is significant at the 0.05 level 2-tailed.

Table D-8. Correlations for Philadelphia in 1990 (n=1208)

	Density (100 d.u./squ. mile)	mixed land use index with all industries included	balance of service jobs and residents	% of land in parks	% of housing in structures of 2 - 4 units	% of housing in structures of 5 or more units	vacancy rate all units	% units built before 1970	% units with four or more bedrooms	% units subsidized by federal funds - public housing agencies	% population that is minority	% population that is black
Density (100 d.u./square mile)	1	-.081**	-.056	-.076**	.426**	.155**	.465**	.414**	-.369**	.198**	.478**	.456**
mixed land index with all industries included	-.081**	1	.868**	.050	.106**	.251**	.051	.114**	-.041	.089**	-.138**	-.154**
balance of service jobs and residents	-.056	.868**	1	.077**	.076**	.251**	.040	.090**	.010	.066*	-.106**	-.111**
% of land in parks	-.076**	.050	.077**	1	-.036	.012	-.079**	.126**	.014	-.018	-.027	-.016
% of housing in structures of 2 - 4 units	.426**	.106**	.076**	-.036	1	.075**	.385**	.333**	-.365**	.216**	.339**	.316**
% of housing in structures of 5 or more units	.155**	.251**	.251**	.012	.075**	1	.277**	-.085**	-.272**	.183**	.020	.007
vacancy rate all units	.465**	.051	.040	-.079**	.385**	.277**	1	.151**	-.240**	.297**	.587**	.568**
% before 1970	.414**	.114**	.090**	.126**	.333**	-.085**	.151**	1	-.272**	.099**	.297**	.285**
% units with four or more bedrooms	-.369**	-.041	.010	.014	-.365**	-.272**	-.240**	-.272**	1	-.205**	-.224**	-.200**
% of units subsidized by federal funds - public housing agencies	.198**	.089**	.066*	-.018	.216**	.183**	.297**	.099**	-.205**	1	.397**	.389**
% population that is minority	.478**	-.138**	-.106**	-.027	.339**	.020	.587**	.297**	-.224**	.397**	1	.968**
% population that is black	.456**	-.154**	-.111**	-.016	.316**	.007	.568**	.285**	-.200**	.389**	.968**	1

** Correlation is significant at the 0.01 level 2-tailed. * Correlation is significant at the 0.05 level 2-tailed.

Table D-9. Correlations for City of Portland in 1990 (n=124)

	Density (100 d.u./squ. mile)	mixed land use index with all industries included	balance of service jobs and residents	% of land in parks	% of housing in structure s of 2 - 4 units	% of housing in structures of 5 or more units	vacancy rate all units	% units built before 1970	% units with four or more bedrooms	% units subsidized by federal funds - public housing agencies	% population that is minority	% population that is black
Density (100 d.u./square mile)	1	.106	.290 **	-.227 *	.093	.576 **	.095	.105	-.349 **	.329 **	.037	.010
mixed land index with all industries included	.106	1	.817 **	.067	.266 **	.636 **	.274 **	-.002	-.359 **	.220 *	.000	-.024
balance of service jobs and residents	.290 **	.817 **	1	-.007	.172	.593 **	.108	-.041	-.360 **	.208 *	-.154	-.159
% of land in parks	-.227 *	.067	-.007	1	-.146	-.227 *	-.125	-.022	-.021	-.023	-.105	-.139
% of housing in structures of 2 - 4 units	.093	.266 **	.172	-.146	1	.178 *	.167	.114	-.186 *	.231 **	.276 **	.193 *
% of housing in structures of 5 or more units	.576 **	.636 **	.593 **	-.227 *	.178 *	1	.268 **	-.203 *	-.514 **	.402 **	-.022	-.045
vacancy rate all units	.095	.274 **	.108	-.125	.167	.268 **	1	.124	-.241 **	.479 **	.787 **	.786 **
% before 1970	.105	-.002	-.041	-.022	.114	-.203 *	.124	1	.091	-.006	.293 **	.273 **
% units with four or more bedrooms	-.349 **	-.359 **	-.360 **	-.021	-.186 *	-.514 **	-.241 **	.091	1	-.333 **	.014	.081
% of units subsidized by federal funds - public housing agencies	.329 **	.220 *	.208 *	-.023	.231 **	.402 **	.479 **	-.006	-.333 **	1	.502 **	.465 **
% population that is minority	.037	.000	-.154	-.105	.276 **	-.022	.787 **	.293 **	.014	.502 **	1	.975 **
% population that is black	.010	-.024	-.159	-.139	.193 *	-.045	.786 **	.273 **	.081	.465 **	.975 **	1

** Correlation is significant at the 0.01 level 2-tailed. * Correlation is significant at the 0.05 level 2-tailed.

Table D-10 Correlations for City of Seattle in 1990 (n=117)

	Density (100 d.u./squ. mile)	mixed land use index with all industries included	balance of service jobs and residents	% of land in parks	% of housing in structure s of 2 - 4 units	% of housing in structures of 5 or more units	vacancy rate all units	% units built before 1970	% units with four or more bedrooms	% units subsidized by federal funds - public housing agencies	% population that is minority	% population that is black
Density (100 d.u./square mile)	1	.242 **	.392 **	-.217 *	-.060	.639 **	.376 **	-.018	-.445 **	.197 *	-.110	-.032
mixed land index with all industries included	.242 **	1	.815 **	.053	.068	.705 **	.451 **	-.354 **	-.647 **	.404 **	.072	.014
balance of service jobs and residents	.392 **	.815 **	1	-.054	.048	.696 **	.393 **	-.340 **	-.534 **	.419 **	.061	.009
% of land in parks	-.217 *	.053	-.054	1	-.100	-.066	-.182 *	.039	-.015	-.130	-.016	-.086
% of housing in structures of 2 - 4 units	-.060	.068	.048	-.100	1	-.028	.101	-.080	-.208 *	.097	.207 *	.215 *
% of housing in structures of 5 or more units	.639 **	.705 **	.696 **	-.066	-.028	1	.565 **	-.447 **	-.741 **	.460 **	.029	.007
vacancy rate all units	.376 **	.451 **	.393 **	-.182 *	.101	.565 **	1	-.185 *	-.500 **	.496 **	.396 **	.496 **
% before 1970	-.018	-.354 **	-.340 **	.039	-.080	-.447 **	-.185 *	1	.430 **	-.315 **	-.081	.039
% units with four or more bedrooms	-.445 **	-.647 **	-.534 **	-.015	-.208 *	-.741 **	-.500 **	.430 **	1	-.425 **	-.141	-.104
% of units subsidized by federal funds - public housing agencies	.197 *	.404 **	.419 **	-.130	.097	.460 **	.496 **	-.315 **	-.425 **	1	.572 **	.486 **
% population that is minority	-.110	.072	.061	-.016	.207 *	.029	.396 **	-.081	-.141	.572 **	1	.870 **
% population that is black	-.032	.014	.009	-.086	.215 *	.007	.496 **	.039	-.104	.486 **	.870 **	1

** Correlation is significant at the 0.01 level 2-tailed. * Correlation is significant at the 0.05 level 2-tailed.

D-11. Correlations for City of Baltimore (n=187)

	Density (100 d.u./squ. mile)	mixed land use index with all industries included	balance of service jobs and residents	% of land in parks	% of housing in structures of 2 - 4 units	% of housing in structures of 5 or more units	vacancy rate all units	% units built before 1970	% units with four or more bedrooms	% units subsidized by federal funds - public housing agencies	% population that is minority	% population that is black
Density (100 d.u./square mile)	1	-.270 **	-.216 **	-.364 **	.230 **	-.030	.341 **	-.052	.046	.149 *	.189 **	.177 *
mixed land index with all industries included	-.270 **	1	.856 **	.099	-.131	.260 **	.227 **	-.115	-.258 **	.088	-.379 **	-.387 **
balance of service jobs and residents	-.216 **	.856 **	1	.076	-.101	.293 **	.181 *	-.227 **	-.153 *	.192 **	-.297 **	-.304 **
% of land in parks	-.364 **	.099	.076	1	-.177 *	-.146 *	-.175 *	.173 *	-.195 **	-.108	-.074	-.065
% of housing in structures of 2 - 4 units	.230 **	-.131	-.101	-.177 *	1	-.002	.303 **	-.045	.353 **	.179 *	.153 *	.146 *
% of housing in structures of 5 or more units	-.030	.260 **	.293 **	-.146 *	-.002	1	.190 **	-.510 **	-.112	.370 **	.014	.002
vacancy rate all units	.341 **	.227 **	.181 *	-.175 *	.303 **	.190 **	1	-.187 *	.129	.189 **	.165 *	.155 *
% before 1970	-.052	-.115	-.227 **	.173 *	-.045	-.510 **	-.187 *	1	-.048	-.639 **	-.220 **	-.217 **
% units with four or more bedrooms	.046	-.258 **	-.153 *	-.195 **	.353 **	-.112	.129	-.048	1	-.035	.173 *	.174 *
% of units subsidized by federal funds - public housing agencies	.149 *	.088	.192 **	-.108	.179 *	.370 **	.189 **	-.639 **	-.035	1	.317 **	.314 **
% population that is minority	.189 **	-.379 **	-.297 **	-.074	.153 *	.014	.165 *	-.220 **	.173 *	.317 **	1	.999 **
% population that is black	.177 *	-.387 **	-.304 **	-.065	.146 *	.002	.155 *	-.217 **	.174 *	.314 **	.999 **	1

** Correlation is significant at the 0.01 level 2-tailed. * Correlation is significant at the 0.05 level 2-tailed.

D-12. Correlations for City of Philadelphia (n=342)

	Density (100 d.u./squ. mile)	mixed land use index with all industries included	balance of service jobs and residents	% of land in parks	% of housing in structures of 2 - 4 units	% of housing in structures of 5 or more units	vacancy rate all units	% units built before 1970	% units with four or more bedrooms	% units subsidized by federal funds - public housing agencies	% population that is minority	% population that is black
Density (100 d.u./square mile)	1	-.225 **	-.140 **	-.362 **	.174 **	.111 *	.275 **	.141 **	-.151 **	.047	.224 **	.223 **
mixed land index with all industries included	-.225 **	1	.811 **	.027	-.044	.398 **	.044	-.154 **	-.058	.148 **	-.346 **	-.371 **
balance of service jobs and residents	-.140 **	.811 **	1	.103	-.021	.352 **	.018	-.164 **	.043	.139 **	-.283 **	-.281 **
% of land in parks	-.362 **	.027	.103	1	-.091	.007	-.216 **	-.170 **	-.104	-.053	-.182 **	-.153 **
% of housing in structures of 2 - 4 units	.174 **	-.044	-.021	-.091	1	.031	.326 **	-.069	.044	.132 *	.215 **	.212 **
% of housing in structures of 5 or more units	.111 *	.398 **	.352 **	.007	.031	1	.241 **	-.390 **	-.115 *	.215 **	-.104	-.094
vacancy rate all units	.275 **	.044	.018	-.216 **	.326 **	.241 **	1	-.029	.139 **	.279 **	.463 **	.456 **
% before 1970	.141 **	-.154 **	-.164 **	-.170 **	-.069	-.390 **	-.029	1	.024	-.103	.129 *	.130 *
% units with four or more bedrooms	-.151 **	-.058	.043	-.104	.044	-.115 *	.139 **	.024	1	.003	.167 **	.181 **
% of units subsidized by federal funds - public housing agencies	.047	.148 **	.139 **	-.053	.132 *	.215 **	.279 **	-.103	.003	1	.320 **	.313 **
% population that is minority	.224 **	-.346 **	-.283 **	-.182 **	.215 **	-.104	.463 **	.129 *	.167 **	.320 **	1	.954 **
% population that is black	.223 **	-.371 **	-.281 **	-.153 **	.212 **	-.094	.456 **	.130 *	.181 **	.313 **	.954 **	1

** Correlation is significant at the 0.01 level 2-tailed. * Correlation is significant at the 0.05 level 2-tailed.

Appendix E

BOX-COX MODELS

The following regressions provide the box-cox transformation of the dependent variable (% of units that are affordable rental units) that provides for the best fitting model. Throughout these tables:

- 'D' is the diversity index as the measure of mixed land use;
- 'Servbal' is the balance of population-serving jobs to residents as the second measure of mixed land use;
- 'hu-sqmi' is the number of housing units per square mile;[156]
- Theta is the constant in the box-cox transformation: $y = (y^{\theta} - 1) / \theta$.

[156] The coefficients in the tables reported in Chapter Seven are based on housing density being measured in the 100s of housing units per square mile. For comparability, multiply the coefficients for housing density reported in the appendix by 100.

1990 Portland and Seattle Regions – Extremely Low-Income Rental Units

WITH DIVERSITY INDEX AS MIXED LAND USE

```
                                                  Number of obs   =        724
                                                  LR chi2(98)     =     844.72
Log likelihood = -1338.008                        Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afe1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |  -.1247489   .0387214    -3.22   0.001    -.2006414   -.0488563
------------------------------------------------------------------------------

Estimates of scale-variant parameters
------------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+----------------------------------------------
Notrans      |
     hu_sqmi |  -6.54e-06     0.285    0.593          1
           D |  -.0863189     0.411    0.522          1
   perc_park |  -.0017084     0.043    0.836          1
    unit_2t4 |   .0160875    12.955    0.000          1
      unit_5 |   .0073952    17.138    0.000          1
 husqmi_Plnd |  -1.01e-06     0.002    0.962          1
      D_Plnd |   -.139712     0.516    0.473          1
perpark_Plnd |  -.0246391     4.813    0.028          1
unit2t4_Plnd |  -.0028625     0.243    0.622          1
  unit5_Plnd |  -.0012657     0.244    0.622          1
    vac_rate |   .0047174     2.156    0.142          1
       b1970 |   .0109404    99.683    0.000          1
    four_bdr |  -.0161027    55.552    0.000          1
   per_subsd |   .0513404   144.755    0.000          1
     per_min |   .0033525     4.440    0.035          1
---------------------------------------------------------
---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -1520.7397       365.46           0.000
theta =  0      -1343.5104        11.00           0.001
theta =  1      -2004.3972      1332.78           0.000
---------------------------------------------------------
```

WITH “BALANCE” MEASURE OF MIXED LAND USE

Log likelihood = -1339.0747

Number of obs =	724
LR chi2(98) =	842.59
Prob > chi2 =	0.000

adjpre_afe1	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
/theta	-.1191315	.0384986	-3.09	0.002	-.1945874	-.0436757

Estimates of scale-variant parameters

	Coef.	chi2(df)	P>chi2(df)	df of chi2
Notrans				
hu_sqmi	-4.11e-06	0.116	0.733	1
servbal	.0235706	0.035	0.852	1
perc_park	-.0018233	0.050	0.824	1
unit_2t4	.0163509	13.363	0.000	1
unit_5	.0067472	15.842	0.000	1
husqmi_Plnd	3.88e-06	0.034	0.854	1
servbal_Plnd	-.0735291	0.166	0.684	1
perpark_Plnd	-.0266564	5.785	0.016	1
unit2t4_Plnd	-.0040973	0.518	0.472	1
unit5_Plnd	-.0020825	0.762	0.383	1
vac_rate	.0048198	2.218	0.136	1
b1970	.0106566	96.090	0.000	1
four_bdr	-.0160488	54.454	0.000	1
per_subsd	.0517624	144.298	0.000	1
per_min	.0034228	4.537	0.033	1

Test H0:	Restricted log likelihood	LR statistic chi2	P-Value Prob > chi2
theta = -1	-1524.9533	371.76	0.000
theta = 0	-1344.1405	10.13	0.001
theta = 1	-2004.0505	1329.95	0.000

1990 Portland and Seattle Central Cities – Extremely Low-Income Rental Units

```
WITH DIVERSITY INDEX AS MEASURE OF MIXED LAND USE
                                                  Number of obs   =        241
                                                  LR chi2(16)     =     334.89
Log likelihood = -552.6287                        Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afe1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |   .1276758   .0509242     2.51   0.012     .0278662    .2274855
------------------------------------------------------------------------------

Estimates of scale-variant parameters
-------------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+-----------------------------------------------
Notrans      |
     hu_sqmi |  -.0000465     4.903    0.027          1
           D |  -.3703738     0.982    0.322          1
   perc_park |   .0038542     0.040    0.841          1
    unit_2t4 |   .0214348     5.805    0.016          1
      unit_5 |   .0261103    36.072    0.000          1
 husqmi_Plnd |   .0000554     2.465    0.116          1
      D_Plnd |    .873635     2.962    0.085          1
perpark_Plnd |   -.005477     0.049    0.825          1
unit2t4_Plnd |  -.0028375     0.062    0.803          1
  unit5_Plnd |  -.0070951     1.656    0.198          1
    vac_rate |   .0173737     1.349    0.245          1
       b1970 |   .0198546    32.493    0.000          1
    four_bdr |   -.019419    11.998    0.001          1
   per_subsd |   .0596107    51.649    0.000          1
     per_min |   .0096529    10.328    0.001          1
placec~59000 |  -.2929515     2.299    0.129          1
       _cons |  -.6531368
-------------+-----------------------------------------------
      /sigma |   .5822403
-------------------------------------------------------------

---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -705.55131       305.85           0.000
theta =  0      -555.59913         5.94           0.015
theta =  1      -723.96843       342.68           0.000
---------------------------------------------------------
```

WITH “BALANCE” MEASURE OF MIXED LAND USE

	Number of obs	=	241
	LR chi2(16)	=	335.36
Log likelihood = -552.39294	Prob > chi2	=	0.000

adjpre_afe1	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
/theta	.126431	.0506075	2.50	0.012	.0272421	.2256199

Estimates of scale-variant parameters

	Coef.	chi2(df)	P>chi2(df)	df of chi2
Notrans				
hu_sqmi	-.0000399	4.139	0.042	1
servbal	-.1244987	0.150	0.698	1
perc_park	.0021231	0.012	0.912	1
unit_2t4	.0203941	5.339	0.021	1
unit_5	.0243385	37.692	0.000	1
husqmi_Plnd	.0000366	1.216	0.270	1
servbal_Plnd	.6153706	2.193	0.139	1
perpark_Plnd	-.0006227	0.001	0.979	1
unit2t4_Plnd	-.0004174	0.001	0.970	1
unit5_Plnd	-.0044024	0.881	0.348	1
vac_rate	.0191696	1.685	0.194	1
b1970	.0193781	32.255	0.000	1
four_bdr	-.0178639	10.523	0.001	1
per_subsd	.0582246	49.803	0.000	1
per_min	.0101295	11.367	0.001	1
placec~59000	-.1683272	1.002	0.317	1
_cons	-.7191668			
/sigma	.5804977			

Test H0:	Restricted log likelihood	LR statistic chi2	P-Value Prob > chi2
theta = -1	-706.39914	308.01	0.000
theta = 0	-555.34461	5.90	0.015
theta = 1	-724.99493	345.20	0.000

2000 Portland and Seattle Regions – Extremely Low-Income Rental Units

```
WITH DIVERSITY INDEX AS MEASURE OF MIXED LAND USE

                                                Number of obs   =        724
                                                  LR chi2(98)     =     916.35
Log likelihood = -1272.1964                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afe1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |  -.0107319   .0391646    -0.27   0.784    -.0874931    .0660292
------------------------------------------------------------------------------

Estimates of scale-variant parameters
----------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+--------------------------------------------
Notrans      |
     hu_sqmi |   .0000187     2.713    0.100          1
           D |   .5132556    14.324    0.000          1
   perc_park |   .0086327     1.052    0.305          1
    unit_2t4 |   .0219021    18.628    0.000          1
      unit_5 |   .0032929     3.604    0.058          1
 husqmi_Plnd |  -8.20e-06     0.162    0.687          1
      D_Plnd |  -.4231326     6.628    0.010          1
perpark_Plnd |   -.041359    13.251    0.000          1
unit2t4_Plnd |   -.006325     0.901    0.342          1
  unit5_Plnd |  -.0009004     0.143    0.705          1
    vac_rate |   .0133809     5.576    0.018          1
       b1980 |   .0057384    24.768    0.000          1
    four_bdr |  -.0162048    51.924    0.000          1
   per_subsd |   .0729392   210.004    0.000          1
     per_min |   .0045275     8.991    0.003          1

---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -1492.5075       440.62           0.000
theta =  0      -1272.2342         0.08           0.784
theta =  1      -1809.2031      1074.01           0.000
---------------------------------------------------------
```

WITH “BALANCE” MEASURE OF MIXED LAND USE

Number of obs =	724
LR chi2(98) =	916.67
Log likelihood = -1272.0357 Prob > chi2 =	0.000

adjpre_afe1	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
/theta	-.0044555	.0391988	-0.11	0.910	-.0812837	.0723727

Estimates of scale-variant parameters

	Coef.	chi2(df)	P>chi2(df)	df of chi2
Notrans				
hu_sqmi	.0000158	1.970	0.160	1
servbal	.4347687	14.146	0.000	1
perc_park	.0111298	1.750	0.186	1
unit_2t4	.0232058	20.995	0.000	1
unit_5	.0038837	5.217	0.022	1
husqmi_Plnd	-6.37e-06	0.101	0.750	1
servbal_Plnd	-.2603305	2.460	0.117	1
perpark_Plnd	-.0467273	16.848	0.000	1
unit2t4_Plnd	-.0091292	1.964	0.161	1
unit5_Plnd	-.0025669	1.206	0.272	1
vac_rate	.0153869	7.495	0.006	1
b1980	.0056428	23.669	0.000	1
four_bdr	-.0162473	51.629	0.000	1
per_subsd	.0736455	210.235	0.000	1
per_min	.0045873	9.115	0.003	1

Test H0:	Restricted log likelihood	LR statistic chi2	P-Value Prob > chi2
theta = -1	-1494.0834	444.10	0.000
theta = 0	-1272.0422	0.01	0.909
theta = 1	-1803.8056	1063.54	0.000

2000 Portland and Seattle Cities – Extremely Low-Income Rental Units

```
WITH DIVERSITY INDEX AS MEASURE OF MIXED LAND USE
                                                  Number of obs   =        241
                                                  LR chi2(16)     =     331.11
Log likelihood = -503.33976                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afe1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |   .1117987   .0556857     2.01   0.045     .0026568    .2209407
------------------------------------------------------------------------------

Estimates of scale-variant parameters
--------------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+------------------------------------------------
Notrans      |
     hu_sqmi |   .0000236     1.914    0.166          1
           D |   .5775835     2.190    0.139          1
   perc_park |  -.0062959     0.131    0.717          1
    unit_2t4 |   .0267772     9.169    0.002          1
      unit_5 |   .0069614     3.231    0.072          1
 husqmi_Plnd |   9.85e-06     0.109    0.742          1
      D_Plnd |  -.3496541     0.516    0.473          1
perpark_Plnd |  -.0125919     0.324    0.569          1
unit2t4_Plnd |  -.0067939     0.346    0.556          1
  unit5_Plnd |   .0024639     0.249    0.618          1
    vac_rate |   .0060147     0.152    0.696          1
       b1980 |   .0063681     3.056    0.080          1
    four_bdr |  -.0175914    10.654    0.001          1
   per_subsd |   .0729148    71.085    0.000          1
     per_min |   .0109667    18.503    0.000          1
placec~59000 |  -.2451901     1.856    0.173          1
       _cons |   .2182072
-------------+------------------------------------------------
      /sigma |   .5182159
--------------------------------------------------------------

---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -629.30422       251.93           0.000
theta =  0      -505.24676         3.81           0.051
theta =  1      -671.49042       336.30           0.000
---------------------------------------------------------
```

WITH “BALANCE” MEAURE OF MXED LAND USE

```
                                                  Number of obs   =        241
                                                  LR chi2(16)     =     340.91
Log likelihood = -498.43821                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afe1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |   .1386986   .0547012     2.54   0.011     .0314861     .245911
------------------------------------------------------------------------------

Estimates of scale-variant parameters
------------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+----------------------------------------------
Notrans      |
     hu_sqmi |   .0000225     1.865    0.172           1
     servbal |   .7048898     6.035    0.014           1
   perc_park |  -.0054548     0.095    0.758           1
    unit_2t4 |   .0257711     8.103    0.004           1
      unit_5 |   .0068479     3.738    0.053           1
 husqmi_Plnd |   3.81e-06     0.017    0.896           1
servbal_Plnd |  -.0658214     0.032    0.858           1
perpark_Plnd |  -.0182986     0.669    0.413           1
unit2t4_Plnd |  -.0077449     0.453    0.501           1
  unit5_Plnd |   .0006763     0.025    0.874           1
    vac_rate |   .0086247     0.329    0.567           1
       b1980 |   .0078414     4.427    0.035           1
    four_bdr |  -.0194633    12.547    0.000           1
   per_subsd |   .0758063    73.475    0.000           1
     per_min |   .0121679    21.480    0.000           1
placec~59000 |  -.3180983     4.016    0.045           1
       _cons |   .1454404
-------------+----------------------------------------------
      /sigma |   .5286052
------------------------------------------------------------

---------------------------------------------------------
   Test         Restricted      LR statistic      P-Value
    H0:       log likelihood        chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -631.72681       266.58           0.000
theta =  0      -501.43146         5.99           0.014
theta =  1      -662.41373       327.95           0.000
---------------------------------------------------------
```

1990 Baltimore and Philadelphia Regions – Extremely Low-Income Rental Units

WITH DIVERSITY INDEX AS MEASURE OF MIXED USE

Number of obs = 1757
LR chi2(261) = 1822.04
Log likelihood = -2914.8401   Prob > chi2 = 0.000

adjpre_afe1	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
/theta	-.3249222	.0279756	-11.61	0.000	-.3797532	-.2700911

Estimates of scale-variant parameters

	Coef.	chi2(df)	P>chi2(df)	df of chi2
Notrans				
hu_sqmi	.0000199	26.261	0.000	1
D	.1700051	8.171	0.004	1
perc_park	-.0090623	11.226	0.001	1
unit_2t4	.0076824	21.549	0.000	1
unit_5	-.0020371	7.687	0.006	1
husqmi_B	-3.23e-06	0.168	0.682	1
D_B	.163022	2.334	0.127	1
perpark_B	.0088198	4.928	0.026	1
unit2t4_B	.0068489	6.542	0.011	1
unit5_B	.0004623	0.162	0.687	1
vac_rate	.0154938	51.263	0.000	1
b1970	.0005739	1.064	0.302	1
four_bdr	-.0037513	25.476	0.000	1
per_subsd	.0318509	311.064	0.000	1
per_min	.0034081	58.837	0.000	1
Baltimore	.1101204	4.085	0.043	1

Test H0:	Restricted log likelihood	LR statistic chi2	P-Value Prob > chi2
theta = -1	-3136.3439	443.01	0.000
theta = 0	-2994.5849	159.49	0.000
theta = 1	-5022.5328	4215.39	0.000

WITH "BALANCE" MEASURE OF MIXED LAND USE

```
                                                  Number of obs   =       1757
                                                  LR chi2(261)    =    1805.63
Log likelihood = -2923.0449                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afe1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |  -.3317877   .0280663   -11.82   0.000    -.3867965   -.2767788
------------------------------------------------------------------------------

Estimates of scale-variant parameters
----------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+--------------------------------------------
Notrans      |
     hu_sqmi |   .0000181    22.129    0.000           1
     servbal |   .0287553     0.284    0.594           1
   perc_park |  -.0089381    10.914    0.001           1
    unit_2t4 |    .007818    22.442    0.000           1
      unit_5 |  -.0016315     4.981    0.026           1
    husqmi_B |  -5.08e-06     0.427    0.513           1
   servbal_B |   .1288875     1.846    0.174           1
   perpark_B |   .0089313     5.061    0.024           1
   unit2t4_B |   .0064248     5.786    0.016           1
     unit5_B |   .0002689     0.055    0.815           1
    vac_rate |   .0164521    58.743    0.000           1
       b1970 |   .0008714     2.491    0.114           1
    four_bdr |  -.0037066    24.869    0.000           1
   per_subsd |   .0319895   315.477    0.000           1
     per_min |   .0030376    48.488    0.000           1
   Baltimore |   .1563979    11.686    0.001          1
---------------------------------------------------------
---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1       -3139.979       433.87           0.000
theta =  0      -3005.7237       165.36           0.000
theta =  1      -5030.7262      4215.36           0.000
---------------------------------------------------------
```

1990 Baltimore and Philadelphia Central Cities – Extremely Low-Income Rental Units

WITH DIVERSITY INDEX AS MEASURE OF MIXED LAND USE

```
                                                  Number of obs   =        529
                                                  LR chi2(16)     =     580.37
Log likelihood = -1266.5232                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afe1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |    .134598   .0389512     3.46   0.001     .0582551    .2109409
------------------------------------------------------------------------------

Estimates of scale-variant parameters
-------------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+-----------------------------------------------
Notrans      |
     hu_sqmi |   .0000296    11.793    0.001          1
           D |   .9343447    19.385    0.000          1
   perc_park |  -.0309617     9.849    0.002          1
    unit_2t4 |    .016831    15.960    0.000          1
      unit_5 |  -.0068944    10.286    0.001          1
    husqmi_B |   .0000449     7.222    0.007          1
         D_B |   .3811558     1.330    0.249          1
   perpark_B |   .0418155    11.445    0.001          1
   unit2t4_B |  -.0033149     0.235    0.628          1
     unit5_B |   .0037527     1.232    0.267          1
    vac_rate |   .0344027    40.150    0.000          1
       b1970 |  -.0031224     1.597    0.206          1
    four_bdr |   .0015208     0.284    0.594          1
   per_subsd |   .0624993   174.971    0.000          1
     per_min |   .0073381    52.035    0.000          1
placeco~4000 |   .0521074     0.053    0.818          1
       _cons |   .1991287
-------------+-----------------------------------------------
      /sigma |   .7043844
-------------------------------------------------------------

---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2        Prob > chi2
---------------------------------------------------------
theta = -1      -1551.1331       569.22           0.000
theta =  0       -1272.185        11.32           0.001
theta =  1      -1573.8453       614.64           0.000
---------------------------------------------------------
```

WITH “BALANCE” MEASURE OF MIXED LAND USE

Number of obs	=	529
LR chi2(16)	=	551.20
Prob > chi2	=	0.000

Log likelihood = -1281.1067

adjpre_afe1	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
/theta	.1332584	.0396089	3.36	0.001	.0556264	.2108903

Estimates of scale-variant parameters

	Coef.	chi2(df)	P>chi2(df)	df of chi2
Notrans				
hu_sqmi	.0000194	5.231	0.022	1
servbal	.2810259	2.060	0.151	1
perc_park	-.0360149	12.730	0.000	1
unit_2t4	.0164253	14.465	0.000	1
unit_5	-.004763	4.905	0.027	1
husqmi_B	.0000436	6.691	0.010	1
servbal_B	.3311802	1.166	0.280	1
perpark_B	.0469642	13.757	0.000	1
unit2t4_B	-.0043025	0.377	0.539	1
unit5_B	.0025068	0.529	0.467	1
vac_rate	.0406873	55.595	0.000	1
b1970	-.0021762	0.739	0.390	1
four_bdr	-.0002914	0.010	0.921	1
per_subsd	.0646691	177.794	0.000	1
per_min	.0056997	32.398	0.000	1
placeco~4000	.1195308	0.333	0.564	1
_cons	.4510948			
/sigma	.7225886			

Test H0:	Restricted log likelihood	LR statistic chi2	P-Value Prob > chi2
theta = -1	-1559.3425	556.47	0.000
theta = 0	-1286.4824	10.75	0.001
theta = 1	-1581.4797	600.75	0.000

2000 Baltimore and Philadelphia Regions – Extremely Low-Income Rental Units

WITH DIVERSITY INDEX AS MEASURE OF MIXED LAND USE

```
                                                  Number of obs   =       1757
                                                  LR chi2(261)    =    2214.03
Log likelihood = -3718.5369                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afe1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |  -.0596505   .0225048    -2.65   0.008     -.103759    -.015542
------------------------------------------------------------------------------

Estimates of scale-variant parameters
-------------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+-----------------------------------------------
Notrans      |
     hu_sqmi |   .0000198    13.538    0.000           1
           D |    .028907     0.078    0.780           1
   perc_park |  -.0199781    29.920    0.000           1
    unit_2t4 |   .0176861    57.717    0.000           1
      unit_5 |   .0006718     0.431    0.512           1
    husqmi_B |  -.0000179     2.566    0.109           1
         D_B |   .2022971     1.494    0.222           1
   perpark_B |    .023768    19.581    0.000           1
   unit2t4_B |   .0043471     1.218    0.270           1
     unit5_B |   .0022926     1.901    0.168           1
    vac_rate |   .0185776    45.190    0.000           1
       b1980 |   .0010674     1.447    0.229           1
    four_bdr |  -.0092866    75.948    0.000           1
   per_subsd |   .0370239   230.559    0.000           1
     per_min |   .0056948    73.032    0.000           1
   Baltimore |   .1151365     2.046    0.153           1
---------------------------------------------------------
---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -4356.8143      1276.55           0.000
theta =  0      -3722.1166         7.16           0.007
theta =  1      -5051.2909      2665.51           0.000
---------------------------------------------------------
```

WITH “BALANCE” MEASURE OF MIXED LAND USE

```
                                                  Number of obs   =       1757
                                                  LR chi2(261)    =    2212.03
Log likelihood = -3719.5387                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afe1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |  -.0610621   .0225037    -2.71   0.007    -.1051685   -.0169556
------------------------------------------------------------------------------

Estimates of scale-variant parameters
-------------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+-----------------------------------------------
Notrans      |
     hu_sqmi |   .0000189    12.788    0.000          1
     servbal |  -.0729517     0.903    0.342          1
   perc_park |   -.019553    28.613    0.000          1
    unit_2t4 |   .0179124    59.420    0.000          1
      unit_5 |   .0010545     1.065    0.302          1
    husqmi_B |  -.0000228     4.398    0.036          1
   servbal_B |   .0377038     0.082    0.774          1
   perpark_B |    .023657    19.390    0.000          1
   unit2t4_B |   .0043599     1.231    0.267          1
     unit5_B |   .0025696     2.395    0.122          1
    vac_rate |   .0194773    51.087    0.000          1
       b1980 |   .0010113     1.302    0.254          1
    four_bdr |  -.0093155    76.630    0.000          1
   per_subsd |   .0372351   233.401    0.000          1
     per_min |   .0052979    67.050    0.000          1
   Baltimore |   .1796064     8.057    0.005          1
---------------------------------------------------------
---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -4356.3974      1273.72           0.000
theta =  0      -3723.2917         7.51           0.006
theta =  1      -5055.2601      2671.44           0.000
---------------------------------------------------------
```

2000 Baltimore and Philadelphia Central Cities – Extremely Low-Income Rental Units

```
WITH DIVERSITY INDEX AS MEASURE OF MIXED USE
                                                  Number of obs   =        529
                                                  LR chi2(16)     =     533.67
Log likelihood = -1573.2554                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afe1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |   .3331999   .0405374     8.22   0.000      .253748    .4126519
------------------------------------------------------------------------------

Estimates of scale-variant parameters
-------------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+-----------------------------------------------
Notrans      |
     hu_sqmi |   .0000187     1.665    0.197          1
           D |    .286764     0.470    0.493          1
   perc_park |  -.0668586    17.305    0.000          1
    unit_2t4 |   .0367848    29.508    0.000          1
      unit_5 |   .0018705     0.273    0.601          1
    husqmi_B |    .000011     0.146    0.702          1
         D_B |   .4912766     0.643    0.423          1
   perpark_B |   .0794069    15.471    0.000          1
   unit2t4_B |  -.0113877     1.020    0.313          1
     unit5_B |   .0077934     1.768    0.184          1
    vac_rate |    .047711    37.855    0.000          1
       b1980 |  -.0030706     0.193    0.661          1
    four_bdr |  -.0133187     7.724    0.005          1
   per_subsd |   .0764616   106.738    0.000          1
     per_min |   .0137868    52.690    0.000          1
placeco~4000 |   .6127628     2.825    0.093          1
       _cons |   1.136637
-------------+-----------------------------------------------
      /sigma |   1.147706
-------------------------------------------------------------

---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -2075.9929      1005.48           0.000
theta =  0      -1607.3244        68.14           0.000
theta =  1      -1700.3227       254.13           0.000
---------------------------------------------------------
```

WITH “BALANCE” MEASURE OF MIXED LAND USE

```
                                                  Number of obs   =        529
                                                  LR chi2(16)     =     531.37
Log likelihood = -1574.4077                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afe1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |   .3315439   .0405338     8.18   0.000     .2520991    .4109887
------------------------------------------------------------------------------

Estimates of scale-variant parameters
-------------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+-----------------------------------------------
Notrans      |
     hu_sqmi |   .0000169     1.468    0.226           1
     servbal |   .1582709     0.264    0.607           1
   perc_park |   -.067944    17.651    0.000           1
    unit_2t4 |   .0366093    29.154    0.000           1
      unit_5 |   .0020627     0.361    0.548           1
    husqmi_B |  -1.16e-06     0.002    0.967           1
   servbal_B |  -.1652241     0.113    0.737           1
   perpark_B |   .0812401    16.071    0.000           1
   unit2t4_B |  -.0110696     0.962    0.327           1
     unit5_B |   .0099115     2.950    0.086           1
    vac_rate |   .0507021    45.695    0.000           1
       b1980 |  -.0033954     0.236    0.627           1
    four_bdr |  -.0145876     9.382    0.002           1
   per_subsd |   .0769798   107.443    0.000           1
     per_min |   .0126867    50.776    0.000           1
placeco~4000 |    .829285     6.662    0.010           1
       _cons |   1.266488
-------------+-----------------------------------------------
      /sigma |   1.146144
-------------------------------------------------------------

---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -2076.4867      1004.16           0.000
theta =  0      -1608.1469        67.48           0.000
theta =  1       -1702.159       255.50           0.000
---------------------------------------------------------
```

1990 Portland and Seattle Regions – Very Low-Income Rental Units

WITH DIVERSITY INDEX AS MIXED LAND USE

Log likelihood = -2100.3995		
Number of obs	=	724
LR chi2(99)	=	1498.36
Prob > chi2	=	0.000

adjpre_afv1	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
/theta	.3765551	.028402	13.26	0.000	.3208882	.432222

Estimates of scale-variant parameters

	Coef.	chi2(df)	P>chi2(df)	df of chi2
Notrans				
hu_sqmi	-.0000531	4.180	0.041	1
D	-.7842471	7.434	0.006	1
perc_park	.0199723	1.314	0.252	1
unit_2t4	.1003168	102.166	0.000	1
unit_5	.0665166	263.553	0.000	1
husqmi_Plnd	.0000331	0.529	0.467	1
D_Plnd	.0133196	0.001	0.976	1
perpark_Plnd	-.0238698	1.008	0.315	1
unit2t4_Plnd	.0192237	2.273	0.132	1
unit5_Plnd	-.0158924	8.538	0.003	1
vac_rate	-.0169804	6.263	0.012	1
b1970	.0343485	206.024	0.000	1
four_bdr	-.052194	123.458	0.000	1
per_subsd	.0479456	34.036	0.000	1
per_min	.0140094	17.526	0.000	1
Portl	.2395738	2.765	0.096	1

Test H0:	Restricted log likelihood	LR statistic chi2	P-Value Prob > chi2
theta = -1	-3018.2817	1835.76	0.000
theta = 0	-2186.0725	171.35	0.000
theta = 1	-2312.9184	425.04	0.000

WITH “BALANCE” MEASURE OF MIXED LAND USE

Log likelihood = -2104.4303	Number of obs	=	724
	LR chi2(99)	=	1490.29
	Prob > chi2	=	0.000

adjpre_afv1	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
/theta	.3811757	.0284755	13.39	0.000	.3253647	.4369867

Estimates of scale-variant parameters

	Coef.	chi2(df)	P>chi2(df)	df of chi2
Notrans				
hu_sqmi	-.0000382	2.203	0.138	1
servbal	-.2749245	1.056	0.304	1
perc_park	.0152947	0.755	0.385	1
unit_2t4	.100379	99.094	0.000	1
unit_5	.0634181	259.125	0.000	1
husqmi_Plnd	.0000405	0.823	0.364	1
servbal_Plnd	-.1945012	0.254	0.614	1
perpark_Plnd	-.0221799	0.855	0.355	1
unit2t4_Plnd	.0190742	2.180	0.140	1
unit5_Plnd	-.0147962	8.439	0.004	1
vac_rate	-.0176181	6.506	0.011	1
b1970	.0336056	197.406	0.000	1
four_bdr	-.0526771	121.459	0.000	1
per_subsd	.0482721	33.229	0.000	1
per_min	.0140996	17.083	0.000	1
Portl	.2223289	2.702	0.100	1

Test H0:	Restricted log likelihood	LR statistic chi2	P-Value Prob > chi2
theta = -1	-3022.9476	1837.03	0.000
theta = 0	-2191.6377	174.41	0.000
theta = 1	-2313.5083	418.16	0.000

1990 Portland and Seattle Central Cities – Very Low-Income Rental Units

WITH DIVERSITY INDEX AS MEASURE OF MIXED LAND USE

```
                                                  Number of obs   =        241
                                                  LR chi2(16)     =     472.94
Log likelihood = -768.94117                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afv1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |   .6203045   .0531017    11.68   0.000     .5162271    .7243819
------------------------------------------------------------------------------

Estimates of scale-variant parameters
-------------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+-----------------------------------------------
Notrans      |
     hu_sqmi |  -.0001492     5.067    0.024          1
           D |  -2.080686     3.054    0.081          1
   perc_park |  -.0842318     1.906    0.167          1
    unit_2t4 |   .1691318    32.936    0.000          1
      unit_5 |   .1630907   118.220    0.000          1
 husqmi_Plnd |   .0002003     3.196    0.074          1
      D_Plnd |   1.442382     0.811    0.368          1
perpark_Plnd |   .1845481     5.539    0.019          1
unit2t4_Plnd |   .0635756     3.030    0.082          1
  unit5_Plnd |  -.0413004     5.565    0.018          1
    vac_rate |  -.0911399     3.657    0.056          1
       b1970 |   .0582995    27.630    0.000          1
    four_bdr |  -.1113567    37.330    0.000          1
   per_subsd |   .0812428    11.484    0.001          1
     per_min |   .0378163    15.603    0.000          1
placec~59000 |   .4804972     0.614    0.433          1
       _cons |   1.296465
-------------+-----------------------------------------------
      /sigma |   1.845115
-------------------------------------------------------------

---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -1200.4799       863.08          0.000
theta =  0      -840.47296       143.06          0.000
theta =  1      -791.73083        45.58          0.000
---------------------------------------------------------
```

WITH “BALANCE” MEASURE OF MIXED LAND USE

Number of obs = 241
LR chi2(16) = 470.35
Log likelihood = -770.23505
Prob > chi2 = 0.000

adjpre_afv1	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
/theta	.6271051	.0528968	11.86	0.000	.5234293	.730781

Estimates of scale-variant parameters

	Coef.	chi2(df)	P>chi2(df)	df of chi2
Notrans				
hu_sqmi	-.0001115	3.091	0.079	1
servbal	-.2129761	0.041	0.839	1
perc_park	-.0951491	2.323	0.127	1
unit_2t4	.1657495	30.500	0.000	1
unit_5	.1530632	117.949	0.000	1
husqmi_Plnd	.0001874	2.976	0.085	1
servbal_Plnd	-.4555041	0.113	0.736	1
perpark_Plnd	.1999599	6.514	0.011	1
unit2t4_Plnd	.0728253	3.938	0.047	1
unit5_Plnd	-.0280672	3.347	0.067	1
vac_rate	-.0988256	4.165	0.041	1
b1970	.0567445	25.689	0.000	1
four_bdr	-.109028	35.163	0.000	1
per_subsd	.0817897	11.021	0.001	1
per_min	.0391642	15.810	0.000	1
placec~59000	.7651491	1.931	0.165	1
_cons	1.021497			
/sigma	1.893964			

Test H0:	Restricted log likelihood	LR statistic chi2	P-Value Prob > chi2
theta = -1	-1206.9871	873.50	0.000
theta = 0	-843.85578	147.24	0.000
theta = 1	-792.40897	44.35	0.000

2000 Portland and Seattle Regions – Very Low-Income Rental Units

WITH DIVERSITY INDEX AS MEASURE OF MIXED LAND USE

```
                                                  Number of obs   =        724
                                                  LR chi2(99)     =    1626.57
Log likelihood = -2008.5908                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afv1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |    .411284   .0258975    15.88   0.000     .3605259    .4620421
------------------------------------------------------------------------------

Estimates of scale-variant parameters
----------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+--------------------------------------------
Notrans      |
     hu_sqmi |  -.0000416     3.401    0.065          1
           D |   -.310089     1.094    0.296          1
   perc_park |   .0137568     0.683    0.409          1
    unit_2t4 |     .11349   116.355    0.000          1
      unit_5 |   .0628011   263.984    0.000          1
 husqmi_Plnd |   4.19e-06     0.010    0.920          1
      D_Plnd |  -.2607694     0.336    0.562          1
perpark_Plnd |  -.0271269     1.459    0.227          1
unit2t4_Plnd |   .0138934     1.070    0.301          1
  unit5_Plnd |  -.0021581     0.194    0.659          1
    vac_rate |  -.0373908    11.081    0.001          1
       b1980 |   .0236008   101.544    0.000          1
    four_bdr |  -.0578644   151.138    0.000          1
   per_subsd |   .0558252    41.711    0.000          1
     per_min |   .0237382    60.878    0.000          1
       Portl |   -.138094     0.613    0.434          1
---------------------------------------------------------
---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -3008.0053      1998.83           0.000
theta =  0      -2127.2572       237.33           0.000
theta =  1      -2230.0539       442.93           0.000
---------------------------------------------------------
```

WITH “BALANCE” MEASURE OF MIXED LAND USE

Log likelihood = -2010.0807

Number of obs	=	724
LR chi2(99)	=	1623.59
Prob > chi2	=	0.000

adjpre_afv1	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
/theta	.4116	.0259245	15.88	0.000	.3607888	.4624112

Estimates of scale-variant parameters

	Coef.	chi2(df)	P>chi2(df)	df of chi2
Notrans				
hu_sqmi	-.0000348	2.447	0.118	1
servbal	.1071684	0.214	0.644	1
perc_park	.0118862	0.510	0.475	1
unit_2t4	.1130089	114.726	0.000	1
unit_5	.06077	261.595	0.000	1
husqmi_Plnd	.0000166	0.176	0.675	1
servbal_Plnd	-.2905239	0.697	0.404	1
perpark_Plnd	-.0252857	1.258	0.262	1
unit2t4_Plnd	.0132834	0.974	0.324	1
unit5_Plnd	-.0023145	0.254	0.614	1
vac_rate	-.0410411	13.694	0.000	1
b1980	.023207	98.192	0.000	1
four_bdr	-.0573667	148.211	0.000	1
per_subsd	.0548578	40.055	0.000	1
per_min	.0243843	63.899	0.000	1
Portl	-.1684919	1.532	0.216	1

Test H0:	Restricted log likelihood	LR statistic chi2	P-Value Prob > chi2
theta = -1	-3008.7377	1997.31	0.000
theta = 0	-2128.6736	237.19	0.000
theta = 1	-2231.032	441.90	0.000

2000 Portland and Seattle Cities – Very Low-Income Rental Units

WITH DIVERSITY INDEX AS MEASURE OF MIXED LAND USE

```
                                                  Number of obs   =        241
                                                  LR chi2(16)     =     504.91
Log likelihood = -730.5449                        Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afv1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |   .5352792   .0461955    11.59   0.000     .4447377    .6258208
------------------------------------------------------------------------------

Estimates of scale-variant parameters
-------------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+-----------------------------------------------
Notrans      |
     hu_sqmi |  -.0000722     2.991    0.084           1
           D |  -2.138121     4.940    0.026           1
   perc_park |    -.02939     0.477    0.490           1
    unit_2t4 |   .1440673    41.409    0.000           1
      unit_5 |   .1011544    88.170    0.000           1
 husqmi_Plnd |  -3.26e-06     0.002    0.964           1
      D_Plnd |   1.223165     1.033    0.310           1
perpark_Plnd |   .0376855     0.485    0.486           1
unit2t4_Plnd |   .0278461     0.971    0.324           1
  unit5_Plnd |  -.0012773     0.011    0.916           1
    vac_rate |  -.1059491     7.727    0.005           1
       b1980 |    .032983    13.379    0.000           1
    four_bdr |  -.0971828    49.016    0.000           1
   per_subsd |   .0619352    10.976    0.001           1
     per_min |    .037089    34.190    0.000           1
placec~59000 |  -.8539329     3.750    0.053           1
       _cons |   3.026647
-------------+-----------------------------------------------
      /sigma |   1.267364
-------------------------------------------------------------

---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -1173.7323       886.37           0.000
theta =  0      -799.54547       138.00           0.000
theta =  1      -772.52699        83.96           0.000
---------------------------------------------------------
```

WITH "BALANCE" MEAURE OF MXED LAND USE

Number of obs =	241
LR chi2(16) =	499.72
Prob > chi2 =	0.000

Log likelihood = -733.13683

adjpre_afv1	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
/theta	.5295772	.0457923	11.56	0.000	.4398259	.6193285

Estimates of scale-variant parameters

	Coef.	chi2(df)	P>chi2(df)	df of chi2
Notrans				
hu_sqmi	-.0000334	0.729	0.393	1
servbal	.3671602	0.296	0.586	1
perc_park	-.0160338	0.145	0.704	1
unit_2t4	.1330664	35.837	0.000	1
unit_5	.0838875	79.196	0.000	1
husqmi_Plnd	-.0000206	0.088	0.767	1
servbal_Plnd	-.268548	0.094	0.759	1
perpark_Plnd	.0235049	0.194	0.659	1
unit2t4_Plnd	.0311717	1.289	0.256	1
unit5_Plnd	.009476	0.867	0.352	1
vac_rate	-.1275096	12.254	0.000	1
b1980	.0315842	12.430	0.000	1
four_bdr	-.0962023	48.574	0.000	1
per_subsd	.0568544	9.401	0.002	1
per_min	.0382705	36.235	0.000	1
placec~59000	-.5482886	2.102	0.147	1
_cons	2.61415			
/sigma	1.25963			

Test H0:	Restricted log likelihood	LR statistic chi2	P-Value Prob > chi2
theta = -1	-1177.5969	888.92	0.000
theta = 0	-801.97372	137.67	0.000
theta = 1	-776.48518	86.70	0.000

1990 Baltimore and Philadelphia Regions – Very Low-Income Rental Units

WITH DIVERSITY INDEX AS MEASURE OF MIXED LAND USE

```
                                                  Number of obs   =       1757
                                                  LR chi2(261)    =    2541.86
Log likelihood = -5004.4856                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afv1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |    .249444   .0189458    13.17   0.000      .212311     .286577
------------------------------------------------------------------------------

Estimates of scale-variant parameters
-------------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+-----------------------------------------------
Notrans      |
     hu_sqmi |   .0000216     5.493    0.019          1
           D |   .3810813     7.258    0.007          1
   perc_park |  -.0376893    34.110    0.000          1
    unit_2t4 |    .042837   115.349    0.000          1
      unit_5 |   .0157333    78.955    0.000          1
    husqmi_B |   .0000443     5.584    0.018          1
         D_B |   .0282838     0.012    0.911          1
   perpark_B |   .0366783    15.035    0.000          1
   unit2t4_B |   .0153588     5.769    0.016          1
     unit5_B |   .0079888     8.543    0.003          1
    vac_rate |   .0124607     5.985    0.014          1
       b1970 |   .0118398    77.962    0.000          1
    four_bdr |  -.0181596   101.001    0.000          1
   per_subsd |   .0476632   138.604    0.000          1
     per_min |   .0121928   130.502    0.000          1
   Baltimore |   .5576388    18.532    0.000          1
---------------------------------------------------------
---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -6697.9683      3386.97           0.000
theta =  0      -5089.1495       169.33           0.000
theta =  1      -5740.6788      1472.39           0.000
---------------------------------------------------------
```

WITH “BALANCE” MEASURE OF MIXED LAND USE

	Number of obs = 1757
	LR chi2(261) = 2532.61
Log likelihood = -5009.1116	Prob > chi2 = 0.000

adjpre_afv1	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
/theta	.2470739	.0189534	13.04	0.000	.2099259	.2842219

Estimates of scale-variant parameters

	Coef.	chi2(df)	P>chi2(df)	df of chi2
Notrans				
hu_sqmi	.0000181	3.949	0.047	1
servbal	.139357	1.179	0.278	1
perc_park	-.0375907	33.951	0.000	1
unit_2t4	.0429646	116.789	0.000	1
unit_5	.0162632	85.040	0.000	1
husqmi_B	.0000405	4.802	0.028	1
servbal_B	-.1072931	0.227	0.634	1
perpark_B	.0372016	15.506	0.000	1
unit2t4_B	.0144722	5.155	0.023	1
unit5_B	.0079441	8.432	0.004	1
vac_rate	.0145568	8.331	0.004	1
b1970	.0123217	85.734	0.000	1
four_bdr	-.0180905	100.294	0.000	1
per_subsd	.0484835	143.964	0.000	1
per_min	.0114623	119.754	0.000	1
Baltimore	.6257576	32.966	0.000	1

Test H0:	Restricted log likelihood	LR statistic chi2	P-Value Prob > chi2
theta = -1	-6698.302	3378.38	0.000
theta = 0	-5092.1816	166.14	0.000
theta = 1	-5747.9606	1477.70	0.000

1990 Baltimore and Philadelphia Central Cities – Very Low-Income Rental Units

WITH DIVERSITY INDEX AS MEASURE OF MIXED LAND USE

```
                                                  Number of obs   =        529
                                                  LR chi2(16)     =     553.90
Log likelihood = -1793.4709                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afv1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |   .5824978   .0435775    13.37   0.000     .4970874    .6679082
------------------------------------------------------------------------------

Estimates of scale-variant parameters
-------------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+-----------------------------------------------
Notrans      |
     hu_sqmi |   .0000444     2.693    0.101          1
           D |   2.287063    11.683    0.001          1
   perc_park |  -.1133662    13.176    0.000          1
    unit_2t4 |   .1018718    55.970    0.000          1
      unit_5 |   .0356814    27.085    0.000          1
    husqmi_B |     .00023    18.521    0.000          1
         D_B |   1.013324     0.944    0.331          1
   perpark_B |   .1345845    11.938    0.001          1
   unit2t4_B |  -.0161557     0.551    0.458          1
     unit5_B |   .0048578     0.207    0.649          1
    vac_rate |   .0246398     2.146    0.143          1
       b1970 |   .0199729     6.498    0.011          1
    four_bdr |  -.0158212     3.055    0.081          1
   per_subsd |    .105825    61.511    0.000          1
     per_min |   .0310499    89.924    0.000          1
placeco~4000 |    .431038     0.359    0.549          1
       _cons |   .3126412
-------------+-----------------------------------------------
      /sigma |   2.224877
-------------------------------------------------------------

---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -2660.5825      1734.22           0.000
theta =  0      -1900.4466       213.95           0.000
theta =  1      -1834.0136        81.09           0.000
---------------------------------------------------------
```

WITH "BALANCE" MEASURE OF MIXED LAND USE

```
                                                  Number of obs   =        529
                                                  LR chi2(16)     =     535.56
Log likelihood = -1802.6415                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afv1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |   .5702233   .0438937    12.99   0.000     .4841932    .6562535
------------------------------------------------------------------------------

Estimates of scale-variant parameters
-------------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+-----------------------------------------------
Notrans      |
     hu_sqmi |   .0000198     0.594    0.441          1
     servbal |   .6803552     1.317    0.251          1
   perc_park |  -.1224271    16.004    0.000          1
    unit_2t4 |   .0978248    53.504    0.000          1
      unit_5 |   .0391918    35.061    0.000          1
    husqmi_B |   .0002151    17.341    0.000          1
   servbal_B |   .7292477     0.618    0.432          1
   perpark_B |   .1429923    13.992    0.000          1
   unit2t4_B |  -.0188549     0.778    0.378          1
     unit5_B |   .0020144     0.037    0.847          1
    vac_rate |   .0394543     6.001    0.014          1
       b1970 |    .021691     7.938    0.005          1
    four_bdr |  -.0199406     5.012    0.025          1
   per_subsd |   .1073487    64.944    0.000          1
     per_min |   .0260435    71.123    0.000          1
placeco~4000 |   .6520357     1.062    0.303          1
       _cons |   .9539083
-------------+-----------------------------------------------
      /sigma |   2.187131
-------------------------------------------------------------

---------------------------------------------------------
   Test         Restricted      LR statistic      P-Value
    H0:       log likelihood        chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -2660.9759      1716.67           0.000
theta =  0      -1904.2892       203.30           0.000
theta =  1      -1844.7028        84.12           0.000
---------------------------------------------------------
```

2000 Baltimore and Philadelphia Regions – Very Low-Income Rental Units

WITH DIVERSITY INDEX AS MEASURE OF MIXED LAND USE

```
                                                  Number of obs   =       1757
                                                  LR chi2(261)    =    2874.36
Log likelihood = -5412.7279                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afv1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |   .3642967   .0186057    19.58   0.000     .3278302    .4007632
------------------------------------------------------------------------------

Estimates of scale-variant parameters
---------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+-------------------------------------------
Notrans      |
     hu_sqmi |  -.0000136     1.311    0.252          1
           D |   .4172222     3.346    0.067          1
   perc_park |  -.0425213    27.819    0.000          1
    unit_2t4 |   .0721952   189.791    0.000          1
      unit_5 |   .0327341   195.218    0.000          1
    husqmi_B |   .0000595     5.793    0.016          1
         D_B |  -.2166555     0.351    0.553          1
   perpark_B |   .0623369    27.587    0.000          1
   unit2t4_B |  -.0058169     0.449    0.503          1
     unit5_B |   .0138873    14.177    0.000          1
    vac_rate |   .0172099     8.088    0.004          1
       b1980 |   .0202311   103.524    0.000          1
    four_bdr |  -.0356297   213.359    0.000          1
   per_subsd |   .0513085   101.055    0.000          1
     per_min |   .0163284   121.596    0.000          1
   Baltimore |   .5214608     8.602    0.003          1
---------------------------------------------------------
---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -7718.5186      4611.58           0.000
theta =  0      -5607.8031       390.15           0.000
theta =  1      -5914.9444      1004.43           0.000
---------------------------------------------------------
```

WITH “BALANCE” MEASURE OF MIXED LAND USE

```
                                                  Number of obs   =       1757
                                                  LR chi2(261)    =    2873.83
Log likelihood = -5412.9925                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afv1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |   .3659525    .018623    19.65   0.000     .3294521     .402453
------------------------------------------------------------------------------

Estimates of scale-variant parameters
-------------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+-----------------------------------------------
Notrans      |
     hu_sqmi |  -.0000205     3.060    0.080          1
     servbal |   -.178907     1.103    0.294          1
   perc_park |  -.0413926    26.033    0.000          1
    unit_2t4 |   .0739218   197.177    0.000          1
      unit_5 |   .0350801   220.840    0.000          1
    husqmi_B |   .0000563     5.439    0.020          1
   servbal_B |  -.1699775     0.339    0.561          1
   perpark_B |   .0624502    27.369    0.000          1
   unit2t4_B |  -.0068689     0.622    0.430          1
     unit5_B |   .0133897    13.064    0.000          1
    vac_rate |   .0198398    10.954    0.001          1
       b1980 |   .0201191   101.574    0.000          1
    four_bdr |  -.0357211   212.481    0.000          1
   per_subsd |   .0526035   105.098    0.000          1
     per_min |   .0152679   111.520    0.000          1
   Baltimore |   .4916786    12.241    0.000          1
---------------------------------------------------------

---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -7719.7298      4613.47           0.000
theta =  0      -5609.3993       392.81           0.000
theta =  1      -5912.5943       999.20           0.000
---------------------------------------------------------
```

2000 Baltimore and Philadelphia Central Cities – Very Low-Income Rental Units

WITH DIVERSITY INDEX AS MEASURE OF MIXED LAND USE

```
                                                  Number of obs   =        529
                                                  LR chi2(16)     =     481.43
Log likelihood = -1882.1423                       Prob > chi2     =      0.000
```

adjpre_afv1	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
/theta	.5794777	.047673	12.16	0.000	.4860403	.6729151

Estimates of scale-variant parameters

	Coef.	chi2(df)	P>chi2(df)	df of chi2
Notrans				
hu_sqmi	-.000059	4.314	0.038	1
D	1.196553	2.085	0.149	1
perc_park	-.1143276	12.948	0.000	1
unit_2t4	.1174585	72.831	0.000	1
unit_5	.0595457	66.657	0.000	1
husqmi_B	.0001563	7.630	0.006	1
D_B	.1976134	0.027	0.870	1
perpark_B	.1331503	11.196	0.001	1
unit2t4_B	-.037647	2.839	0.092	1
unit5_B	.0135331	1.356	0.244	1
vac_rate	.0414298	7.495	0.006	1
b1980	.0462058	11.143	0.001	1
four_bdr	-.0550744	31.520	0.000	1
per_subsd	.0935272	45.230	0.000	1
per_min	.0290827	59.615	0.000	1
placeco~4000	-.0718309	0.010	0.920	1
_cons	.8060396			
/sigma	2.266962			

Test H0:	Restricted log likelihood	LR statistic chi2	P-Value Prob > chi2
theta = -1	-2852.3203	1940.36	0.000
theta = 0	-1981.697	199.11	0.000
theta = 1	-1915.41	66.54	0.000

WITH “BALANCE” MEASURE OF MIXED LAND USE

```
                                                  Number of obs   =        529
                                                  LR chi2(16)     =     478.36
Log likelihood = -1883.6771                       Prob > chi2     =      0.000

------------------------------------------------------------------------------
 adjpre_afv1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
      /theta |   .5732552   .0476651    12.03   0.000     .4798334     .666677
------------------------------------------------------------------------------

Estimates of scale-variant parameters
----------------------------------------------------------
             |      Coef.  chi2(df)  P>chi2(df)    df of chi2
-------------+--------------------------------------------
Notrans      |
     hu_sqmi |  -.0000701     6.777    0.009          1
     servbal |  -.1262319     0.044    0.834          1
   perc_park |  -.1123659    12.771    0.000          1
    unit_2t4 |   .1166691    73.754    0.000          1
      unit_5 |   .0628624    82.258    0.000          1
    husqmi_B |   .0001342     6.249    0.012          1
   servbal_B |  -.3845242     0.161    0.688          1
   perpark_B |   .1333331    11.502    0.001          1
   unit2t4_B |  -.0380042     2.976    0.084          1
     unit5_B |   .0141689     1.582    0.209          1
    vac_rate |   .0495064    11.854    0.001          1
       b1980 |   .0441937    10.526    0.001          1
    four_bdr |  -.0567183    35.011    0.000          1
   per_subsd |   .0955614    48.255    0.000          1
     per_min |   .0248158    51.225    0.000          1
placeco~4000 |   .1748145     0.079    0.779          1
       _cons |   1.468571
-------------+--------------------------------------------
      /sigma |   2.229133
----------------------------------------------------------

---------------------------------------------------------
   Test         Restricted     LR statistic      P-Value
    H0:       log likelihood       chi2       Prob > chi2
---------------------------------------------------------
theta = -1      -2848.5664      1929.78           0.000
theta =  0      -1980.8175       194.28           0.000
theta =  1      -1917.9127        68.47           0.000
---------------------------------------------------------
```

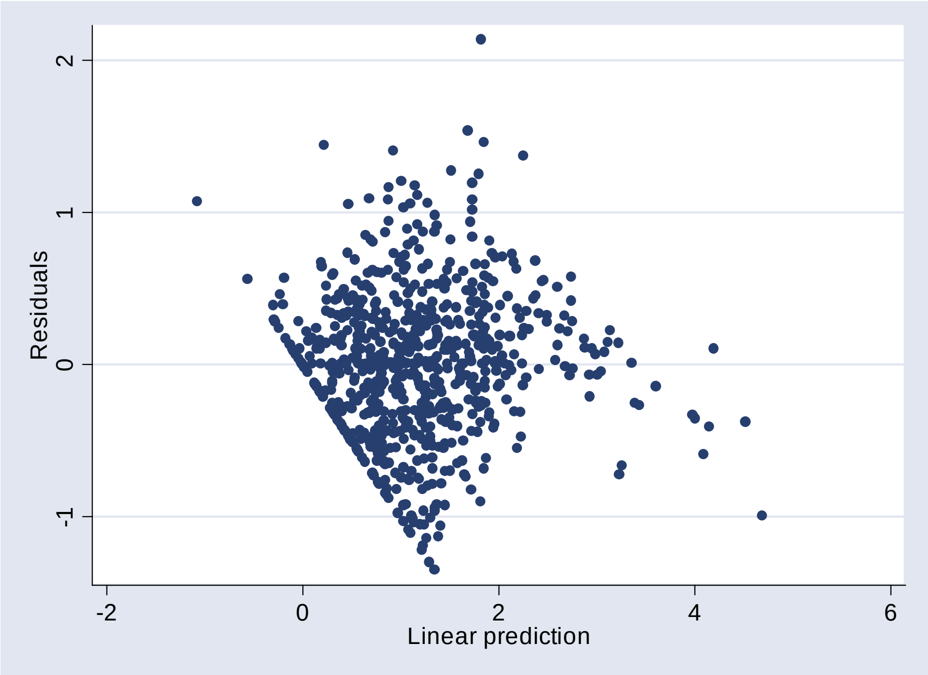
Appendix F

RESIDUALS

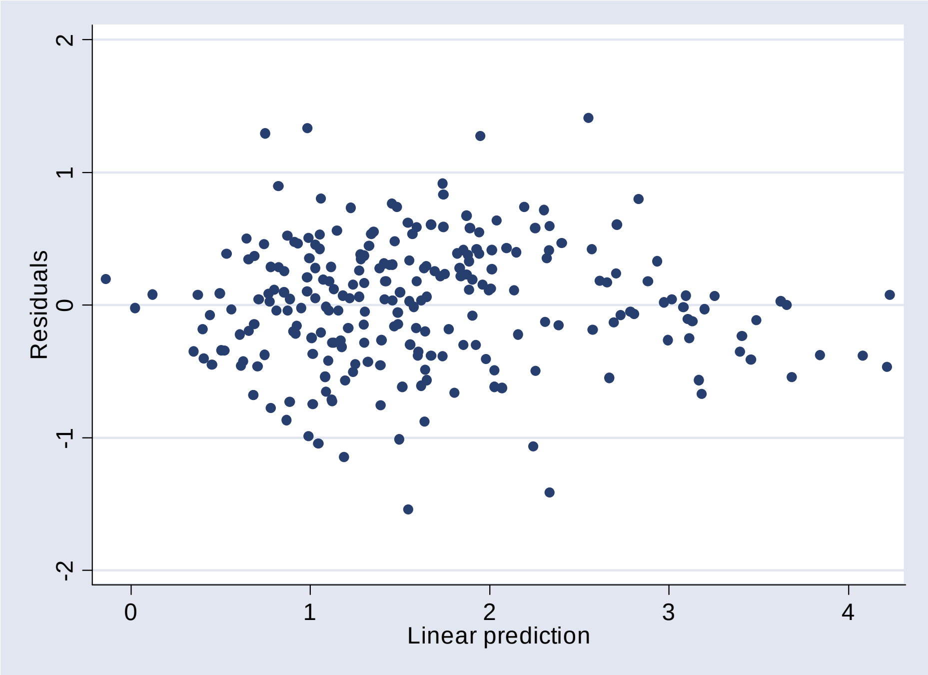
On the following pages are scatterplots of the residuals from the initial regression models. The dependent variable is the log of the proportion of affordable rental units for extremely low-income and very low-income households. The scatterplots indicate that heteroskedasticity, non-constant variance of the error term, is present. To deal with this violation of ordinary least squares, robust standard errors were utilized in STATA.

The scatterplots show a similar pattern among all models, therefore only select scatterplots are shown. All scatterplots are from the analysis of model 3, in which mixed land use is measured by the diversity index.

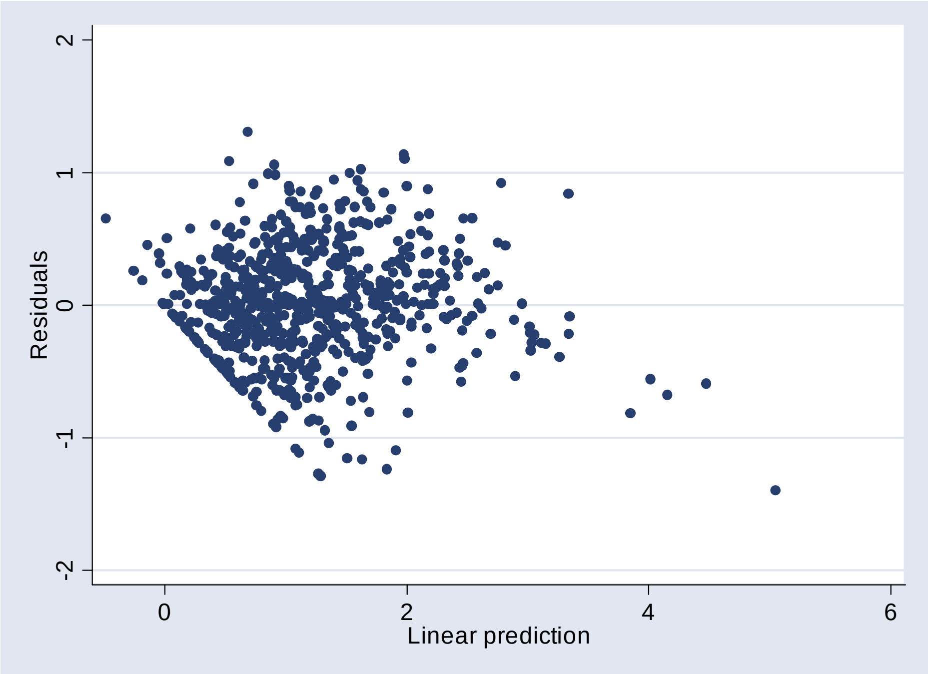
1990 Portland and Seattle Regions – Extremely Low-Income Rental Units



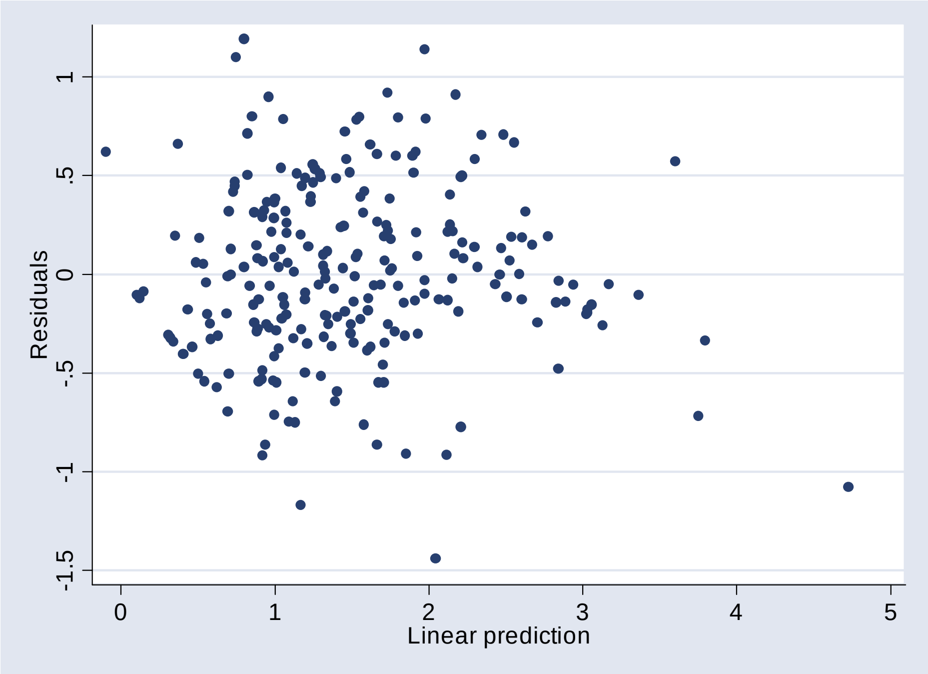
1990 – Seattle and Portland Central Cities – Extremely Low-Income Rental Units



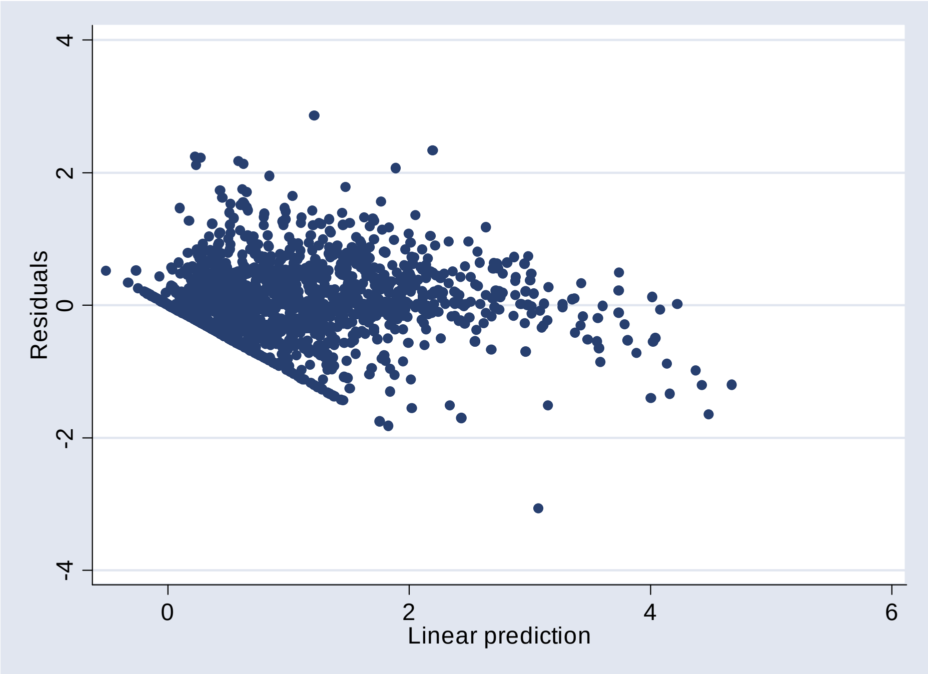
2000 – Seattle and Portland Regions – Extremely Low-Income Rental Units



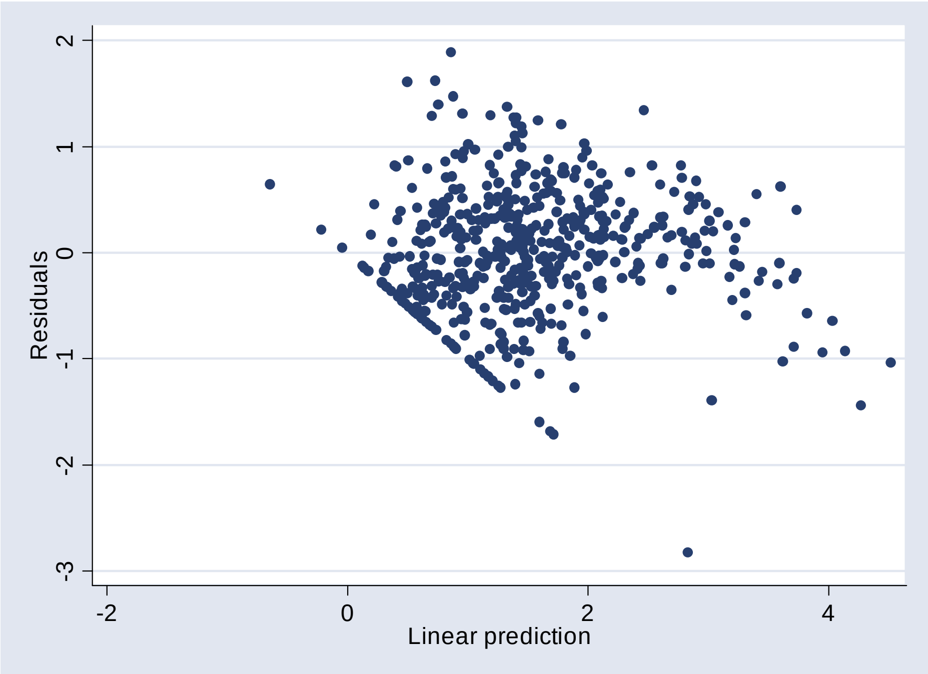
2000 Portland and Seattle Central Cities – Extremely Low-Income Rental Units



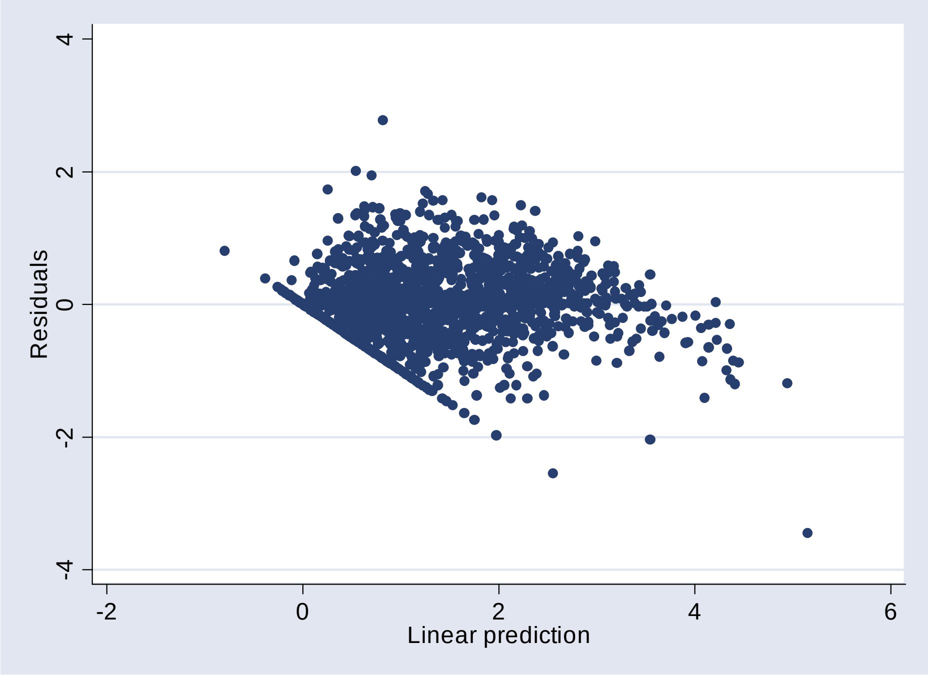
1990 Baltimore and Philadelphia Regions – Extremely Low-Income rental Units



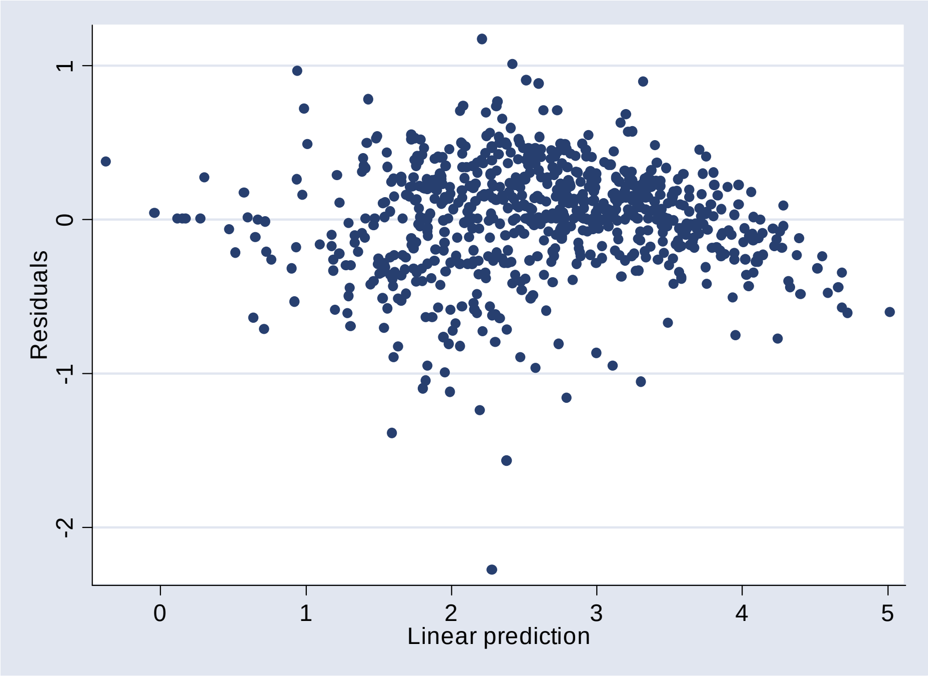
1990 Baltimore and Philadelphia Central Cities – Extremely Low-Income Rental Units



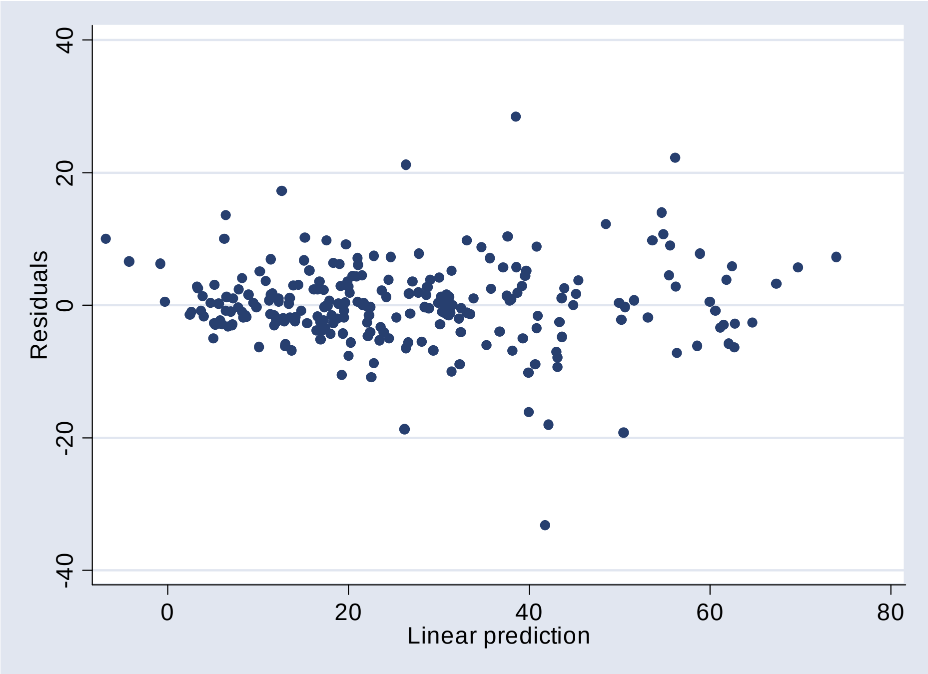
2000 Baltimore and Philadelphia Regions – Extremely Low-Income Rental Units



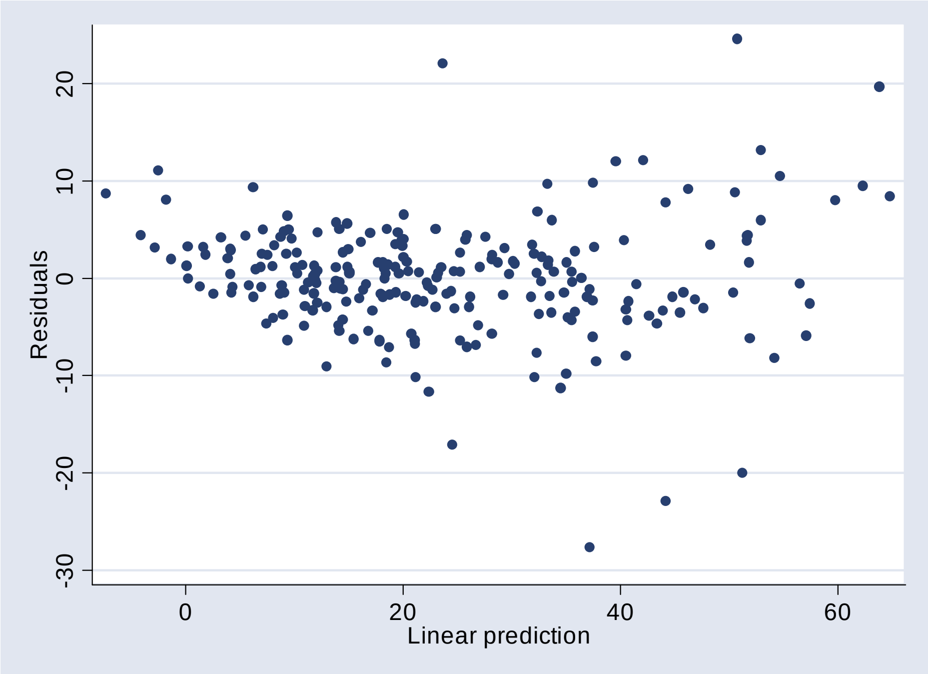
1990 Portland and Seattle Regions – Very Low-Income Rental Units



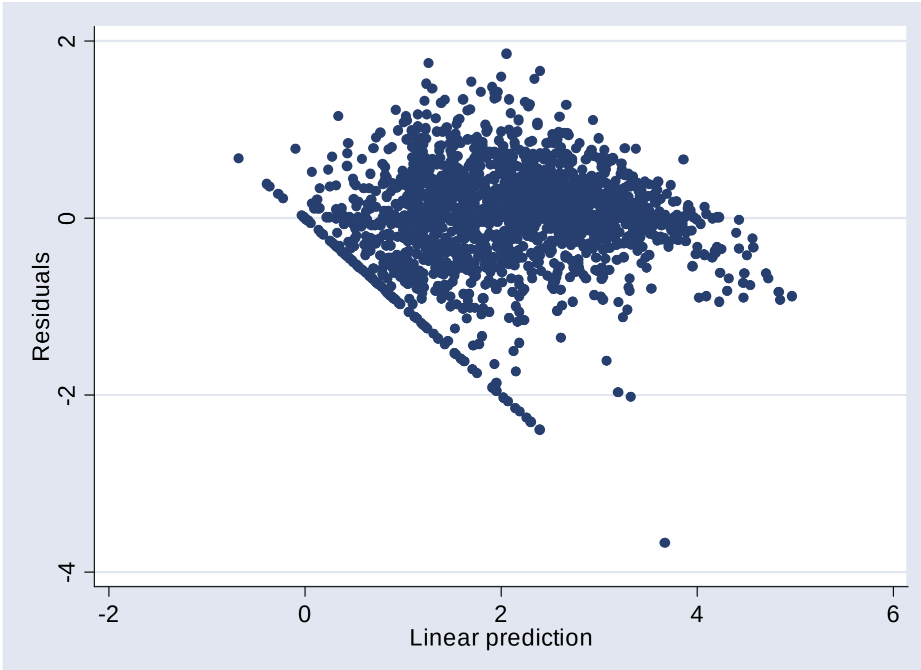
1990 Portland and Seattle Central Cities – Very Low-Income Rental Units



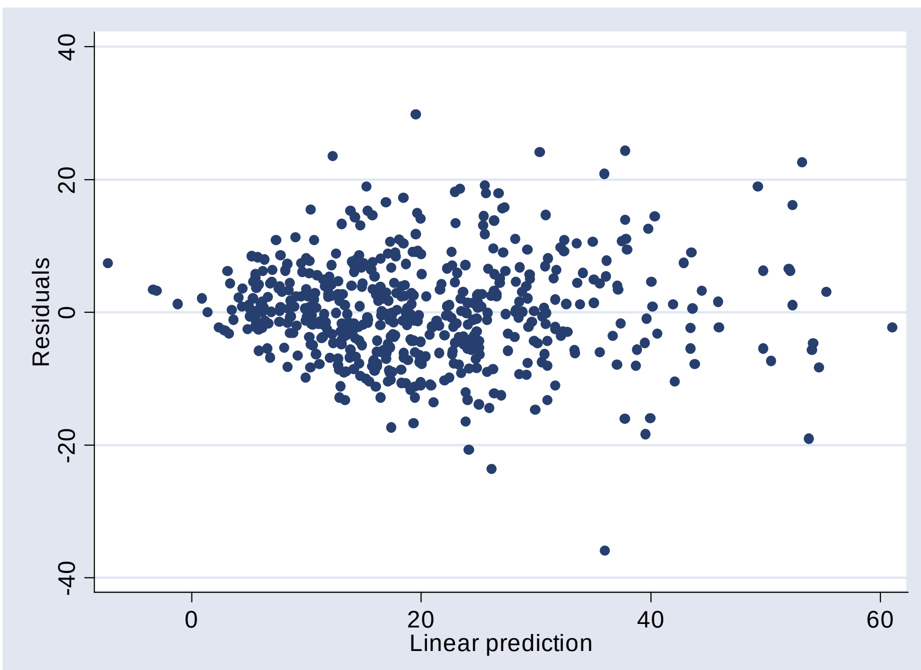
2000 Portland and Seattle Central Cities – Very Low-Income Rental Units



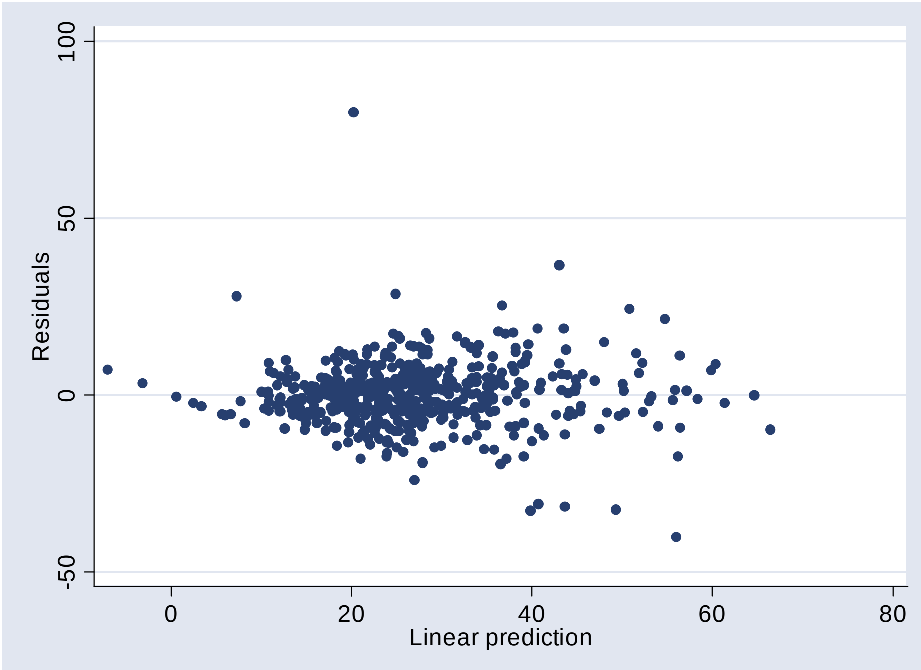
1990 Baltimore and Philadelphia Regions – Very Low-Income Rental Units



1990 Baltimore and Philadelphia Central Cities – Very Low-Income Rental Units



2000 Baltimore and Philadelphia Central Cities – Very Low-Income Rental Units



Appendix G

SIMPLE REGRESSION MODELS OF SMART GROWTH VARIABLES

1990 Portland and Seattle Regions – Extremely Low-Income Rental Units

	(1)	(2)	(3)	(4)	(5)
hu_sqmi[a]	0.000 (5.53)***				
husqmi_Plnd	0.000 (1.68)				
D		1.697 (7.90)***			
D_Plnd		-0.273 (0.82)			
servbal			1.674 (8.02)***		
servbal_Plnd			-0.508 (1.64)		
unit_2t4					0.053 (7.37)***
unit_5					0.018 (8.84)***
unit2t4_Plnd					-0.007 (0.63)
unit5_Plnd					-0.003 (0.78)
perc_park				0.027 (1.51)	
perpark_Plnd				-0.035 (1.54)	
Portland Dummy	0.028 (0.31)	0.118 (1.11)	0.176 (2.14)**	0.151 (1.97)**	0.195 (2.49)**
Constant	0.843 (13.42)***	0.610 (9.22)***	0.755 (14.12)***	1.088 (21.30)***	0.397 (8.02)***
Observations	724	724	724	724	724
R-squared	0.17	0.16	0.15	0.01	0.34

a. Housing Density measured as units per square mile.
** significant below .05 level; *** significant below .01 level
Number in parentheses is t-test statistic.

2000 Portland and Seattle Regions – Extremely Low-Income Rental Units

	(1)	(2)	(3)	(4)	(5)
hu_sqmi[a]	0.000 (5.25)***				
husqmi_Plnd	0.000 (1.40)				
D		1.993 (9.07)***			
D_Plnd		-0.641 (1.89)			
servbal			1.683 (8.11)***		
servbal_Plnd			-0.480 (1.63)		
unit_2t4					0.052 (8.24)***
unit_5					0.018 (13.21)***
unit2t4_Plnd					-0.004 (0.44)
unit5_Plnd					-0.005 (1.73)
perc_park				0.031 (2.23)**	
perpark_Plnd				-0.033 (1.64)	
Portland Dummy	-0.244 (2.93)***	0.033 (0.26)	-0.076 (0.84)	-0.142 (2.05)**	-0.071 (1.00)
Constant	1.017 (16.70)***	0.541 (6.59)***	0.804 (13.06)***	1.242 (26.14)***	0.511 (10.80)***
Observations	724	724	724	724	724
R-squared	0.18	0.17	0.19	0.02	0.41

a. Housing Density measured as units per square mile.
** significant below .05 level; *** significant below .01 level.
Number in parentheses is t-test statistic.

1990 Baltimore and Philadelphia Regions – Extremely Low-Income Rental Units

	(1)	(2)	(3)	(4)	(5)
hu_sqmi[a]	0.000 (10.31)***				
husqmi_B	0.000 (4.30)***				
D		0.316 (2.60)***			
D_B		-0.048 (0.19)			
servbal			0.096 (0.81)		
servbal_B			0.173 (0.75)		
unit_2t4					0.043 (14.45)***
unit_5					0.005 (3.48)***
unit2t4_B					0.015 (3.38)***
unit5_B					0.004 (1.69)
perc_park				-0.020 (4.39)***	
perpark_B				0.026 (3.56)***	
Baltimore Dummy	0.217 (3.75)***	0.388 (3.94)***	0.324 (4.24)***	0.302 (5.13)***	0.249 (4.42)***
Constant	0.517 (15.55)***	0.703 (14.90)***	0.788 (19.93)***	0.860 (29.46)***	0.333 (10.06)***
Observations	1757	1757	1757	1757	1757
R-squared	0.24	0.04	0.03	0.04	0.29

a. Housing Density measured as units per square mile.
** significant below .05 level; *** significant below .01 level.
Number in parentheses is t-test statistic.

2000 Baltimore and Philadelphia Regions – Extremely Low-Income Rental Units

	(1)	(2)	(3)	(4)	(5)
hu_sqmi[a]	0.000 (10.65)***				
husqmi_B	0.000 (4.19)***				
D		-0.578 (3.49)***			
D_B		0.284 (0.95)			
servbal			-0.337 (2.55)**		
servbal_B			0.093 (0.36)		
unit_2t4					0.058 (16.72)***
unit_5					0.006 (3.67)***
unit2t4_B					0.016 (2.73)***
unit5_B					0.005 (1.86)
perc_park				-0.027 (4.93)***	
perpark_B				0.054 (6.22)***	
Baltimore Dummmy	0.228 (3.47)***	0.307 (2.60)***	0.384 (4.25)***	0.242 (3.78)***	0.340 (5.18)***
Constant	0.808 (20.12)***	1.400 (20.93)***	1.290 (27.10)***	1.252 (39.50)***	0.546 (14.19)***
Observations	1757	1757	1757	1757	1757
R-squared	0.30	0.04	0.04	0.05	0.36

a. Housing Density measured as units per square mile.
** significant below .05 level; *** significant below .01 level.
Number in parentheses is t-test statistic.

1990 Portland and Seattle Regions – Very Low-Income Rental Units

	(1)	(2)	(3)	(4)	(5)
hu_sqmi[a]	0.000 (5.17)***				
husqmi_Plnd	0.000 (0.92)				
D		2.188 (10.78)***			
D_Plnd		-0.325 (1.18)			
servbal			2.162 (12.83)***		
servbal_Plnd			-0.675 (2.79)***		
unit_2t4					0.073 (17.03)***
unit_5					0.026 (26.50)***
unit2t4_Plnd					-0.010 (1.56)
unit5_Plnd					-0.008 (3.65)***
perc_park				0.051 (2.52)**	
perpark_Plnd				-0.026 (1.17)	
Portland Dummy	0.237 (2.27)**	0.286 (2.66)***	0.375 (4.36)***	0.299 (3.85)***	0.479 (6.38)***
Constant	2.156 (27.99)***	1.827 (24.86)***	2.013 (33.74)***	2.421 (42.93)***	1.450 (27.21)***
Observations	724	724	724	724	724
R-squared	0.22	0.27	0.25	0.04	0.63

a. Housing Density measured as units per square mile.
** significant below .05 level; *** significant below .01 level.
Number in parentheses is t-test statistic.

2000 Portland and Seattle Regions – Very Low-Income Rental Units

	(1)	(2)	(3)	(4)	(5)
hu_sqmi[a]	0.000 (5.21)***				
husqmi_Plnd	0.000 (1.50)				
D		2.127 (9.79)***			
D_Plnd		-0.403 (1.28)			
servbal			1.856 (10.06)***		
servbal_Plnd			-0.320 (1.28)		
unit_2t4					0.069 (15.98)***
unit_5					0.025 (22.75)***
unit2t4_Plnd					-0.000 (0.06)
unit5_Plnd					-0.003 (1.77)
perc_park				0.055 (3.66)***	
perpark_Plnd				-0.028 (1.45)	
Portland Dummy	-0.037 (0.37)	0.173 (1.24)	0.106 (1.06)	0.074 (0.99)	0.085 (1.12)
Constant	2.305 (32.56)***	1.818 (19.08)***	2.081 (29.72)***	2.536 (48.71)***	1.578 (31.59)***
Observations	724	724	724	724	724
R-squared	0.20	0.18	0.20	0.02	0.67

a. Housing Density measured as units per square mile.
** significant below .05 level; *** significant below .01 level.
Number in parentheses is t-test statistic.

1990 Baltimore and Philadelphia Regions – Very Low-Income Rental Units

	(1)	(2)	(3)	(4)	(5)
hu_sqmi[a]	0.000 (12.45)***				
husqmi_B	0.000 (2.92)***				
D		0.500 (3.44)***			
D_B		-0.425 (1.66)			
servbal			0.236 (1.72)		
servbal_B			-0.124 (0.54)		
unit_2t4					0.067 (15.79)***
unit_5					0.014 (8.55)***
unit2t4_B					-0.003 (0.60)
unit5_B					0.004 (1.88)
perc_park				-0.027 (4.23)***	
perpark_B				0.050 (5.62)***	
Baltimore Dummy	0.335 (4.91)***	0.580 (5.36)***	0.464 (5.48)***	0.275 (4.24)***	0.479 (6.72)***
Constant	1.538 (36.38)***	1.763 (30.28)***	1.875 (39.91)***	2.000 (58.17)***	1.119 (24.72)***
Observations	1757	1757	1757	1757	1757
R-squared	0.28	0.04	0.04	0.05	0.43

a. Housing Density measured as units per square mile.
** significant below .05 level; *** significant below .01 level.
Number in parentheses is t-test statistic.

2000 Baltimore and Philadelphia Regions – Very Low-Income Rental Units

	(1)	(2)	(3)	(4)	(5)
hu_sqmi[a]	0.000 (11.36)***				
husqmi_B	0.000 (2.32)**				
D		-0.100 (0.56)			
D_B		-0.008 (0.03)			
servbal			-0.074 (0.53)		
servbal_B			0.102 (0.42)		
unit_2t4					0.071 (20.60)***
unit_5					0.018 (13.01)***
unit2t4_B					-0.014 (2.59)***
unit5_B					0.005 (1.98)**
perc_park				-0.019 (2.60)***	
perpark_B				0.054 (5.39)***	
Baltimore Dummy	0.169 (2.40)**	0.251 (2.26)**	0.221 (2.56)**	0.068 (1.07)	0.402 (5.66)***
Constant	2.006 (45.03)***	2.431 (33.99)***	2.416 (47.51)***	2.440 (70.41)***	1.450 (32.74)***
Observations	1757	1757	1757	1757	1757
R-squared	0.24	0.01	0.01	0.03	0.48

a. Housing Density measured as units per square mile.
** significant below .05 level; *** significant below .01 level.
Number in parentheses is t-test statistic.

Appendix H

OLS REGRESSION OUTPUT (NON-ROBUST STANDARD ERRORS)

1990 Portland and Seattle Regions – Extremely Low-Income Rental Units

Source	SS	df	MS
Model	419.254162	99	4.23489053
Residual	166.486634	624	.266805503
Total	585.740796	723	.810153245

Number of obs	724
F(99, 624)	15.87
Prob > F	0.0000
R-squared	0.7158
Adj R-squared	0.6707
Root MSE	.51653

ln1adjpre_~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hu_sqmi	-5.36e-06	.0000154	-0.35	0.728	-.0000356	.0000249
D	-.024401	.1712673	-0.14	0.887	-.360731	.311929
perc_park	-.0008449	.0103983	-0.08	0.935	-.0212647	.019575
unit_2t4	.0186288	.005709	3.26	0.001	.0074176	.0298401
unit_5	.0090894	.0022263	4.08	0.000	.0047175	.0134613
husqmi_Plnd	-7.11e-06	.0000273	-0.26	0.794	-.0000607	.0000464
D_Plnd	-.2529432	.266796	-0.95	0.343	-.77687	.2709836
perpark_Plnd	-.0335419	.0141498	-2.37	0.018	-.0613288	-.005755
unit2t4_Plnd	-.0049682	.0075848	-0.66	0.513	-.019863	.0099266
unit5_Plnd	-.0006495	.0032356	-0.20	0.841	-.0070034	.0057045
vac_rate	.0059802	.0040542	1.48	0.141	-.0019814	.0139418
b1970	.0125133	.0013273	9.43	0.000	.0099068	.0151197
four_bdr	-.0169346	.002642	-6.41	0.000	-.0221229	-.0117463
per_subsd	.06601	.0047644	13.85	0.000	.0566538	.0753662
per_min	.0043072	.0019907	2.16	0.031	.0003979	.0082166
Portl	.0653105	.0858762	0.76	0.447	-.1033309	.2339519

1990 Portland and Seattle Central Cities – Extremely Low-Income Rental Units

Source	SS	df	MS
Model	165.707581	16	10.3567238
Residual	55.3400856	224	.247053954
Total	221.047666	240	.921031943

Number of obs	241
F(16, 224)	41.92
Prob > F	0.0000
R-squared	0.7496
Adj R-squared	0.7318
Root MSE	.49705

ln1adjpre_~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hu_sqmi	-.0000342	.0000178	-1.93	0.055	-.0000692	7.74e-07
D	-.3230696	.3186365	-1.01	0.312	-.9509781	.304839
perc_park	-.0011919	.016336	-0.07	0.942	-.0333839	.031
unit_2t4	.019643	.0074937	2.62	0.009	.0048758	.0344101
unit_5	.0198961	.0035194	5.65	0.000	.0129606	.0268315
husqmi_Plnd	.0000438	.0000301	1.46	0.146	-.0000154	.000103
D_Plnd	.6533863	.4311791	1.52	0.131	-.1963	1.503072
perpark_Plnd	.0023065	.0208941	0.11	0.912	-.0388677	.0434806
unit2t4_Plnd	-.0028575	.0097253	-0.29	0.769	-.0220223	.0163073
unit5_Plnd	-.0051469	.0046888	-1.10	0.274	-.0143866	.0040928
vac_rate	.0166836	.0127001	1.31	0.190	-.0083433	.0417105
b1970	.0158428	.0028685	5.52	0.000	.01019	.0214955
four_bdr	-.017636	.0046694	-3.78	0.000	-.0268376	-.0084345
per_subsd	.0431607	.0063103	6.84	0.000	.0307255	.055596
per_min	.0077001	.0025355	3.04	0.003	.0027037	.0126965
placec~59000	-.2394255	.164561	-1.45	0.147	-.5637112	.0848602
_cons	-.3403847	.265578	-1.28	0.201	-.8637356	.1829662

2000 Portland and Seattle Regions – Extremely Low-Income Rental Units

Source	SS	df	MS
Model	362.396649	99	3.66057222
Residual	128.503873	624	.205935695
Total	490.900523	723	.67897721

Number of obs	724
F(99, 624)	17.78
Prob > F	0.0000
R-squared	0.7382
Adj R-squared	0.6967
Root MSE	.4538

ln1adjpre_~e	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
hu_sqmi	.0000173	.0000124	1.39	0.165	-7.13e-06	.0000417
D	.4356436	.1633408	2.67	0.008	.1148794	.7564079
perc_park	.0080562	.0091834	0.88	0.381	-.0099779	.0260903
unit_2t4	.0210008	.005573	3.77	0.000	.0100568	.0319448
unit_5	.003601	.0018798	1.92	0.056	-.0000904	.0072924
husqmi_Plnd	-7.52e-07	.000023	-0.03	0.974	-.000046	.0000444
D_Plnd	-.2204276	.2476857	-0.89	0.374	-.7068259	.2659708
perpark_Plnd	-.0406476	.012366	-3.29	0.001	-.0649316	-.0163636
unit2t4_Plnd	-.0046622	.0074075	-0.63	0.529	-.0192088	.0098844
unit5_Plnd	-.00185	.0026952	-0.69	0.493	-.0071428	.0034428
vac_rate	.0139498	.0061731	2.26	0.024	.0018272	.0260725
b1980	.0057541	.001247	4.61	0.000	.0033053	.0082029
four_bdr	-.0166061	.0023773	-6.99	0.000	-.0212746	-.0119377
per_subsd	.0745898	.0046066	16.19	0.000	.0655434	.0836361
per_min	.0044585	.0016433	2.71	0.007	.0012313	.0076856
Portl	-.117963	.0972032	-1.21	0.225	-.3088481	.072922

2000 Portland and Seattle Central Cities – Extremely Low-Income Rental Units

Source	SS	df	MS
Model	138.942496	16	8.683906
Residual	47.0796882	224	.210177179
Total	186.022184	240	.775092434

Number of obs	241
F(16, 224)	41.32
Prob > F	0.0000
R-squared	0.7469
Adj R-squared	0.7288
Root MSE	.45845

ln1adjpre_~e	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
hu_sqmi	.0000215	.000015	1.43	0.155	-8.15e-06	.000051
D	.4714725	.3443018	1.37	0.172	-.2070123	1.149957
perc_park	-.004706	.0153672	-0.31	0.760	-.0349888	.0255767
unit_2t4	.0236823	.0077315	3.06	0.002	.0084465	.0389181
unit_5	.0048786	.0033718	1.45	0.149	-.0017659	.011523
husqmi_Plnd	5.19e-06	.0000264	0.20	0.844	-.0000468	.0000572
D_Plnd	-.3807875	.4283708	-0.89	0.375	-1.22494	.4633647
perpark_Plnd	-.0115634	.0195499	-0.59	0.555	-.0500886	.0269618
unit2t4_Plnd	-.0047003	.0101938	-0.46	0.645	-.0247883	.0153877
unit5_Plnd	.0033243	.0043174	0.77	0.442	-.0051837	.0118323
vac_rate	.0057914	.0136232	0.43	0.671	-.0210545	.0326374
b1980	.0052119	.0032105	1.62	0.106	-.0011148	.0115387
four_bdr	-.0164786	.0046505	-3.54	0.000	-.025643	-.0073143
per_subsd	.0570095	.0066631	8.56	0.000	.0438792	.0701398
per_min	.0093779	.0022121	4.24	0.000	.0050187	.0137371
placec~59000	-.2114058	.1588899	-1.33	0.185	-.524516	.1017043
_cons	.3396148	.3381893	1.00	0.316	-.3268247	1.006054

1990 Baltimore and Philadelphia Regions – Extremely Low-Income Rental Units

Source	SS	df	MS		
Model	1118.96533	261	4.28722347	Number of obs =	1757
Residual	483.932091	1495	.323700395	F(261, 1495) =	13.24
				Prob > F =	0.0000
Total	1602.89742	1756	.912811741	R-squared =	0.6981
				Adj R-squared =	0.6454
				Root MSE =	.56895

ln1adjpre_~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hu_sqmi	.0000236	5.94e-06	3.98	0.000	.000012	.0000353
D	.2696829	.0911132	2.96	0.003	.0909597	.4484062
perc_park	-.0119522	.0041442	-2.88	0.004	-.0200812	-.0038233
unit_2t4	.0119142	.0025304	4.71	0.000	.0069507	.0168777
unit_5	-.0025537	.0011262	-2.27	0.024	-.0047629	-.0003445
husqmi_B	.0000109	.000012	0.90	0.367	-.0000128	.0000345
D_B	.3199978	.1635338	1.96	0.051	-.0007823	.6407778
perpark_B	.0108633	.0060923	1.78	0.075	-.001087	.0228135
unit2t4_B	.0128884	.0040976	3.15	0.002	.0048507	.0209261
unit5_B	.0006277	.0017619	0.36	0.722	-.0028284	.0040838
vac_rate	.0247389	.0032842	7.53	0.000	.0182967	.031181
b1970	.0003041	.0008528	0.36	0.721	-.0013686	.0019769
four_bdr	-.0037191	.001129	-3.29	0.001	-.0059336	-.0015045
per_subsd	.0559821	.0025144	22.26	0.000	.05105	.0609142
per_min	.0055589	.0006726	8.26	0.000	.0042395	.0068783
Baltimore	.0672402	.0832473	0.81	0.419	-.0960537	.230534

1990 Baltimore and Philadelphia Central Cities – Extremely Low-Income Rental Units

Source	SS	df	MS		
Model	347.077244	16	21.6923277	Number of obs =	529
Residual	177.533716	512	.346745539	F(16, 512) =	62.56
				Prob > F =	0.0000
Total	524.61096	528	.993581363	R-squared =	0.6616
				Adj R-squared =	0.6510
				Root MSE =	.58885

ln1adjpre_~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hu_sqmi	.0000271	7.12e-06	3.80	0.000	.0000131	.0000411
D	.7681248	.1757785	4.37	0.000	.4227889	1.113461
perc_park	-.0279586	.0081737	-3.42	0.001	-.0440167	-.0119004
unit_2t4	.0136584	.0034951	3.91	0.000	.0067918	.020525
unit_5	-.0057758	.0017878	-3.23	0.001	-.0092882	-.0022635
husqmi_B	.00003	.0000138	2.18	0.030	2.94e-06	.000057
D_B	.2801548	.2759553	1.02	0.310	-.2619891	.8222988
perpark_B	.0372242	.0102384	3.64	0.000	.0171097	.0573387
unit2t4_B	-.0031098	.0057097	-0.54	0.586	-.014327	.0081075
unit5_B	.0025394	.0028194	0.90	0.368	-.0029996	.0080785
vac_rate	.0273187	.0044471	6.14	0.000	.0185818	.0360556
b1970	-.0019671	.0020568	-0.96	0.339	-.0060078	.0020736
four_bdr	.0005787	.0023764	0.24	0.808	-.0040899	.0052474
per_subsd	.0467644	.0034238	13.66	0.000	.040038	.0534907
per_min	.0059914	.0008296	7.22	0.000	.0043616	.0076212
placeco~4000	.1086355	.18808	0.58	0.564	-.2608679	.478139
_cons	.2098402	.2249552	0.93	0.351	-.2321086	.651789

2000 Baltimore and Philadelphia Regions – Extremely Low-Income Rental Units

Source	SS	df	MS
Model	1403.74929	261	5.37834976
Residual	511.510892	1492	.342835719
Total	1915.26018	1753	1.09256143

Number of obs =	1757
F(261, 1492) =	15.69
Prob > F =	0.0000
R-squared =	0.7329
Adj R-squared =	0.6862
Root MSE =	.58552

ln1adjpre_~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hu_sqmi	.0000207	6.32e-06	3.27	0.001	8.27e-06	.000033
D	.0392427	.1213758	0.32	0.747	-.1988426	.277328
perc_park	-.021235	.0042716	-4.97	0.000	-.0296141	-.012856
unit_2t4	.0192542	.0027136	7.10	0.000	.0139313	.0245772
unit_5	.0008489	.0012017	0.71	0.480	-.0015084	.0032062
husqmi_B	-.0000173	.0000131	-1.32	0.188	-.000043	8.46e-06
D_B	.2201135	.1945067	1.13	0.258	-.1614221	.6016492
perpark_B	.025255	.0062929	4.01	0.000	.0129111	.0375988
unit2t4_B	.0053676	.0046211	1.16	0.246	-.0036969	.0144321
unit5_B	.0025515	.0019535	1.31	0.192	-.0012804	.0063833
vac_rate	.020744	.0032178	6.45	0.000	.0144321	.0270559
b1980	.0011105	.0010426	1.07	0.287	-.0009346	.0031555
four_bdr	-.0095153	.0012198	-7.80	0.000	-.0119079	-.0071226
per_subsd	.0423902	.0026399	16.06	0.000	.037212	.0475685
per_min	.0063208	.0007728	8.18	0.000	.004805	.0078366
Baltimore	.1144996	.0945047	1.21	0.226	-.0708765	.2998758

2000 Baltimore and Philadelphia Central Cities – Extremely Low-Income Rental Units

Source	SS	df	MS
Model	296.964125	16	18.5602578
Residual	189.479457	510	.371528348
Total	486.443582	526	.924797684

Number of obs =	529
F(16, 510) =	49.96
Prob > F =	0.0000
R-squared =	0.6105
Adj R-squared =	0.5983
Root MSE =	.60953

ln1adjpre_~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hu_sqmi	.0000186	7.62e-06	2.45	0.015	3.66e-06	.0000336
D	.0585952	.2217895	0.26	0.792	-.3771383	.4943288
perc_park	-.0426364	.0084102	-5.07	0.000	-.0591593	-.0261136
unit_2t4	.0202494	.0035423	5.72	0.000	.0132902	.0272086
unit_5	.000066	.0018982	0.03	0.972	-.0036634	.0037953
husqmi_B	-.0000121	.0000151	-0.80	0.421	-.0000417	.0000175
D_B	.2822748	.3252689	0.87	0.386	-.3567569	.9213066
perpark_B	.0477091	.0106111	4.50	0.000	.0268622	.068556
unit2t4_B	-.0092904	.0059701	-1.56	0.120	-.0210193	.0024386
unit5_B	.0026715	.0031045	0.86	0.390	-.0034277	.0087707
vac_rate	.0238754	.0040446	5.90	0.000	.0159292	.0318215
b1980	.0010217	.0037001	0.28	0.783	-.0062477	.0082911
four_bdr	-.0098327	.0025133	-3.91	0.000	-.0147704	-.0048951
per_subsd	.0319336	.0036306	8.80	0.000	.0248009	.0390664
per_min	.0070098	.0009836	7.13	0.000	.0050774	.0089422
placeco~4000	.4822691	.1920558	2.51	0.012	.1049512	.8595871
_cons	.7869241	.3798133	2.07	0.039	.040733	1.533115

1990 Portland and Seattle Regions – Very Low-Income Rental Units

Source	SS	df	MS		
Model	534.643767	99	5.40044209	Number of obs =	724
Residual	95.2717043	624	.152679013	F(99, 624) =	35.37
Total	629.915471	723	.87125238	Prob > F =	0.0000
				R-squared =	0.8488
				Adj R-squared =	0.8248
				Root MSE =	.39074

ln1adjpre_~v	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hu_sqmi	-.0000372	.0000117	-3.19	0.001	-.00006	-.0000143
D	-.4260089	.1295587	-3.29	0.001	-.6804328	-.171585
perc_park	.0004433	.007866	0.06	0.955	-.0150037	.0158904
unit_2t4	.0433972	.0043187	10.05	0.000	.0349162	.0518782
unit_5	.0244984	.0016841	14.55	0.000	.0211912	.0278056
husqmi_Plnd	.0000177	.0000206	0.86	0.392	-.0000228	.0000582
D_Plnd	.0914714	.2018235	0.45	0.651	-.304864	.4878068
perpark_Plnd	.0036349	.0107039	0.34	0.734	-.0173851	.0246549
unit2t4_Plnd	-3.88e-06	.0057377	-0.00	0.999	-.0112713	.0112636
unit5_Plnd	-.0086969	.0024476	-3.55	0.000	-.0135035	-.0038904
vac_rate	-.0063595	.0030669	-2.07	0.039	-.0123822	-.0003368
b1970	.0145985	.0010041	14.54	0.000	.0126268	.0165702
four_bdr	-.0250364	.0019986	-12.53	0.000	-.0289612	-.0211116
per_subsd	.0107947	.0036041	3.00	0.003	.003717	.0178723
per_min	.0047246	.0015059	3.14	0.002	.0017673	.0076819
Portl	.1604757	.0649629	2.47	0.014	.0329034	.288048

1990 Portland and Seattle Central Cities – Very Low-Income Rental Units

Source	SS	df	MS		
Model	65242.0077	16	4077.62548	Number of obs =	241
Residual	10069.8412	224	44.9546484	F(16, 224) =	90.71
Total	75311.849	240	313.799371	Prob > F =	0.0000
				R-squared =	0.8663
				Adj R-squared =	0.8567
				Root MSE =	6.7048

adjpre_afv	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hu_sqmi	-.0004802	.0002396	-2.00	0.046	-.0009523	-8.12e-06
D	-5.116013	4.298203	-1.19	0.235	-13.5861	3.354072
perc_park	-.1663005	.2203629	-0.75	0.451	-.6005499	.267949
unit_2t4	.4101586	.101085	4.06	0.000	.2109594	.6093577
unit_5	.5942952	.047475	12.52	0.000	.5007404	.68785
husqmi_Plnd	.0007898	.0004054	1.95	0.053	-9.14e-06	.0015887
D_Plnd	5.596633	5.816331	0.96	0.337	-5.865092	17.05836
perpark_Plnd	.4440117	.2818479	1.58	0.117	-.1114009	.9994243
unit2t4_Plnd	.3105791	.1311883	2.37	0.019	.0520581	.5691001
unit5_Plnd	-.1376387	.0632483	-2.18	0.031	-.2622766	-.0130009
vac_rate	-.4348763	.1713159	-2.54	0.012	-.7724733	-.0972793
b1970	.2329988	.0386947	6.02	0.000	.1567466	.309251
four_bdr	-.3035935	.0629871	-4.82	0.000	-.4277165	-.1794704
per_subsd	.3460523	.0851226	4.07	0.000	.1783088	.5137957
per_min	.1339583	.034202	3.92	0.000	.0665596	.2013571
placec~59000	.3300111	2.219823	0.15	0.882	-4.044396	4.704418
_cons	-8.801119	3.582478	-2.46	0.015	-15.86079	-1.741449

2000 Portland and Seattle Regions – Very Low-Income Rental Units

```
     Source |       SS       df       MS              Number of obs =     724
-------------+------------------------------           F( 99,   624) =   39.27
       Model |  485.242326    99  4.90143763           Prob > F      =  0.0000
    Residual |  77.8801777   624  .124807977           R-squared     =  0.8617
-------------+------------------------------           Adj R-squared =  0.8398
       Total |  563.122504   723    .7788693           Root MSE      =  .35328

------------------------------------------------------------------------------
ln1adjpre_~v |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     hu_sqmi |  -.0000197   9.68e-06    -2.03   0.043    -.0000387   -6.55e-07
           D |  -.0296799   .1271599    -0.23   0.816     -.279393    .2200332
   perc_park |   .0037541   .0071492     0.53   0.600    -.0102853    .0177936
   unit_2t4 |   .0394047   .0043385     9.08   0.000     .0308848    .0479245
      unit_5 |   .0170991   .0014634    11.68   0.000     .0142254    .0199729
 husqmi_Plnd |  -2.04e-06   .0000179    -0.11   0.910    -.0000372    .0000332
      D_Plnd |  -.2367058   .1928218    -1.23   0.220    -.6153641    .1419525
perpark_Plnd |  -.0031758   .0096269    -0.33   0.742    -.0220807    .0157292
unit2t4_Plnd |   .0039423   .0057667     0.68   0.494    -.0073821    .0152667
  unit5_Plnd |   .0010716   .0020982     0.51   0.610    -.0030489     .005192
    vac_rate |  -.0138031   .0048057    -2.87   0.004    -.0232405   -.0043657
       b1980 |   .0082737   .0009708     8.52   0.000     .0063673    .0101801
    four_bdr |   -.028084   .0018507   -15.17   0.000    -.0317184   -.0244497
   per_subsd |   .0109757   .0035862     3.06   0.002     .0039332    .0180182
     per_min |   .0081131   .0012793     6.34   0.000     .0056007    .0106254
       Portl |  -.0056216   .0756721    -0.07   0.941    -.1542245    .1429813
```

2000 Portland and Seattle Central Cities – Very Low-Income Rental Units

```
      Source |       SS       df       MS              Number of obs =     241
-------------+------------------------------           F( 16,   224) =   89.70
       Model |  55015.4202    16  3438.46376           Prob > F      =  0.0000
    Residual |  8586.37798   224  38.3320446           R-squared     =  0.8650
-------------+------------------------------           Adj R-squared =  0.8554
       Total |  63601.7982   240  265.007492           Root MSE      =  6.1913

------------------------------------------------------------------------------
  adjpre_afv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     hu_sqmi |  -.0004316   .0002028    -2.13   0.034    -.0008313   -.0000319
           D |  -12.91739   4.649727    -2.78   0.006     -22.0802    -3.75459
   perc_park |  -.1665834   .2075308    -0.80   0.423    -.5755459    .2423791
    unit_2t4 |   .5069836   .1044126     4.86   0.000     .3012271    .7127401
      unit_5 |   .5456501   .0455352    11.98   0.000     .4559178    .6353823
 husqmi_Plnd |   .0001795   .0003566     0.50   0.615    -.0005231    .0008822
      D_Plnd |   13.05026   5.785063     2.26   0.025     1.650152    24.45037
perpark_Plnd |   .2141734   .2640173     0.81   0.418    -.3061019    .7344487
unit2t4_Plnd |   .0629339   .1376652     0.46   0.648    -.2083506    .3342185
  unit5_Plnd |  -.0718722    .058306    -1.23   0.219    -.1867705    .0430262
    vac_rate |  -.5784376   .1839782    -3.14   0.002     -.940987   -.2158881
       b1980 |   .1678584   .0433577     3.87   0.000     .0824172    .2532995
    four_bdr |  -.3004039   .0628042    -4.78   0.000    -.4241666   -.1766412
   per_subsd |   .3029389   .0899836     3.37   0.001     .1256163    .4802615
     per_min |   .1680433   .0298741     5.63   0.000     .1091731    .2269135
placec~59000 |  -3.834018   2.145776    -1.79   0.075    -8.062508    .3944723
       _cons |  -2.285027   4.567179    -0.50   0.617    -11.28516    6.715105
```

1990 Baltimore and Philadelphia Regions – Very Low-Income Rental Units

Source	SS	df	MS
Model	1561.05261	261	5.98104449
Residual	534.55652	1495	.35756289
Total	2095.60913	1756	1.19339928

Number of obs = 1757
F(261, 1495) = 16.73
Prob > F = 0.0000
R-squared = 0.7449
Adj R-squared = 0.7004
Root MSE = .59797

ln1adjpre_~v	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hu_sqmi	.0000136	6.24e-06	2.19	0.029	1.40e-06	.0000259
D	.1813473	.0957604	1.89	0.058	-.0064916	.3691863
perc_park	-.0242774	.0043555	-5.57	0.000	-.032821	-.0157338
unit_2t4	.0249734	.0026594	9.39	0.000	.0197568	.0301901
unit_5	.0085208	.0011837	7.20	0.000	.0061989	.0108426
husqmi_B	.0000127	.0000126	1.00	0.317	-.0000121	.0000375
D_B	.0428056	.1718748	0.25	0.803	-.2943357	.379947
perpark_B	.0231367	.006403	3.61	0.000	.0105769	.0356965
unit2t4_B	.0040795	.0043066	0.95	0.344	-.0043681	.0125272
unit5_B	.0046195	.0018518	2.49	0.013	.0009872	.0082519
vac_rate	.0068729	.0034517	1.99	0.047	.0001021	.0136436
b1970	.0081694	.0008962	9.12	0.000	.0064114	.0099275
four_bdr	-.0138672	.0011866	-11.69	0.000	-.0161948	-.0115397
per_subsd	.0232575	.0026426	8.80	0.000	.0180738	.0284412
per_min	.0066217	.0007069	9.37	0.000	.005235	.0080084
Baltimore	.4003207	.0874933	4.58	0.000	.2286981	.5719432

1990 Baltimore and Philadelphia Central Cities – Very Low-Income Rental Units

Source	SS	df	MS
Model	65198.8238	16	4074.92649
Residual	31792.9643	512	62.0956335
Total	96991.7881	528	183.696568

Number of obs = 529
F(16, 512) = 65.62
Prob > F = 0.0000
R-squared = 0.6722
Adj R-squared = 0.6620
Root MSE = 7.8801

adjpre_afv	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hu_sqmi	.000069	.0000953	0.72	0.469	-.0001182	.0002562
D	8.698221	2.35229	3.70	0.000	4.076893	13.31955
perc_park	-.3015368	.1093817	-2.76	0.006	-.5164289	-.0866447
unit_2t4	.3076239	.0467724	6.58	0.000	.2157344	.3995134
unit_5	.1346139	.0239248	5.63	0.000	.087611	.1816168
husqmi_B	.0010898	.0001843	5.91	0.000	.0007278	.0014518
D_B	3.826719	3.692868	1.04	0.301	-3.428319	11.08176
perpark_B	.4070075	.1370121	2.97	0.003	.1378324	.6761826
unit2t4_B	.0320113	.0764073	0.42	0.675	-.1180992	.1821217
unit5_B	.0431852	.0377298	1.14	0.253	-.0309391	.1173095
vac_rate	.0695243	.0595123	1.17	0.243	-.0473939	.1864426
b1970	.0464743	.0275238	1.69	0.092	-.0075991	.1005478
four_bdr	-.0289768	.031801	-0.91	0.363	-.0914533	.0334997
per_subsd	.4257352	.0458171	9.29	0.000	.3357226	.5157478
per_min	.1078312	.0111017	9.71	0.000	.0860208	.1296417
placeco~4000	-2.146594	2.51691	-0.85	0.394	-7.091336	2.798147
_cons	-4.081946	3.010379	-1.36	0.176	-9.99616	1.832268

2000 Baltimore and Philadelphia Regions – Very Low-Income Rental Units

Source	SS	df	MS
Model	1528.1169	261	5.85485402
Residual	437.449361	1492	.293196623
Total	1965.56626	1753	1.12125856

Number of obs	1757
F(261, 1492)	19.97
Prob > F	0.0000
R-squared	0.7774
Adj R-squared	0.7385
Root MSE	.54148

ln1adjpre_~v	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hu_sqmi	-3.46e-06	5.84e-06	-0.59	0.554	-.0000149	8.00e-06
D	.1873644	.1122454	1.67	0.095	-.0328112	.4075399
perc_park	-.0210926	.0039503	-5.34	0.000	-.0288414	-.0133438
unit_2t4	.0297666	.0025095	11.86	0.000	.0248441	.0346892
unit_5	.011492	.0011113	10.34	0.000	.009312	.0136719
husqmi_B	.0000119	.0000121	0.98	0.327	-.0000119	.0000357
D_B	-.0268283	.1798751	-0.15	0.881	-.3796632	.3260067
perpark_B	.028046	.0058195	4.82	0.000	.0166308	.0394613
unit2t4_B	-.0047388	.0042735	-1.11	0.268	-.0131214	.0036438
unit5_B	.0035064	.0018065	1.94	0.052	-.0000372	.0070501
vac_rate	.0073038	.0029757	2.45	0.014	.0014668	.0131409
b1980	.009007	.0009642	9.34	0.000	.0071157	.0108982
four_bdr	-.0206684	.001128	-18.32	0.000	-.0228811	-.0184558
per_subsd	.0151811	.0024413	6.22	0.000	.0103924	.0199698
per_min	.0061046	.0007146	8.54	0.000	.0047028	.0075064
Baltimore	.2731229	.0873956	3.13	0.002	.1016915	.4445543

2000 Baltimore and Philadelphia Central Cities – Very Low-Income Rental Units

Source	SS	df	MS
Model	63658.9059	16	3978.68162
Residual	44286.3488	510	86.8359781
Total	107945.255	526	205.219115

Number of obs	527
F(16, 510)	45.82
Prob > F	0.0000
R-squared	0.5897
Adj R-squared	0.5769
Root MSE	9.3186

adjpre_afv	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
hu_sqmi	-.000282	.0001164	-2.42	0.016	-.0005108	-.0000533
D	7.066605	3.390743	2.08	0.038	.4050613	13.72815
perc_park	-.3282075	.1285756	-2.55	0.011	-.5808105	-.0756045
unit_2t4	.4048269	.0541544	7.48	0.000	.2984338	.51122
unit_5	.2413929	.0290204	8.32	0.000	.1843787	.298407
husqmi_B	.0007963	.0002304	3.46	0.001	.0003435	.001249
D_B	-1.245384	4.972747	-0.25	0.802	-11.01497	8.524205
perpark_B	.443259	.1622242	2.73	0.007	.1245491	.7619689
unit2t4_B	-.0751631	.0912709	-0.82	0.411	-.2544763	.10415
unit5_B	.095239	.047462	2.01	0.045	.0019939	.1884841
vac_rate	.1242713	.0618348	2.01	0.045	.0027891	.2457535
b1980	.1759151	.0565682	3.11	0.002	.0647797	.2870505
four_bdr	-.1521843	.038423	-3.96	0.000	-.2276712	-.0766975
per_subsd	.4252271	.0555049	7.66	0.000	.3161807	.5342735
per_min	.1099231	.0150374	7.31	0.000	.0803803	.139466
placeco~4000	-2.479479	2.936171	-0.84	0.399	-8.247958	3.289
_cons	-8.097296	5.806628	-1.39	0.164	-19.50515	3.310558

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Appendix I

REGRESSION MODELS WITH HOUSING DENSITY EXCLUDED

The analysis in Chapter Seven provided mixed results for the impact of residential density. Below are the same regression models as those presented in Chapter Seven, but with housing density excluded from the model.

1990 Portland and Seattle Regions – Extremely Low-Income Rental Units.

```
Regression with robust standard errors                Number of obs =     724
                                                       F( 66,   626) =       .
                                                       Prob > F      =       .
                                                       R-squared     =  0.7156
                                                       Root MSE      =  .51587

------------------------------------------------------------------------------
             |               Robust
ln1adjpre_~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           D |  -.0084527   .2176915    -0.04   0.969    -.4359466    .4190413
   perc_park |  -.0000324   .0158774    -0.00   0.998    -.0312119    .0311471
    unit_2t4 |   .0187714   .0056776     3.31   0.001      .007622    .0299208
      unit_5 |   .0086279   .0025043     3.45   0.001       .00371    .0135458
      D_Plnd |  -.2293226   .3446777    -0.67   0.506    -.9061872    .4475419
unit2t4_Plnd |  -.0053463   .0085492    -0.63   0.532    -.0221349    .0114422
  unit5_Plnd |  -.0010157   .0034721    -0.29   0.770    -.0078341    .0058027
perpark_Plnd |  -.0341439   .0223766    -1.53   0.128    -.0780862    .0097983
    vac_rate |   .0060718   .0043546     1.39   0.164    -.0024795    .0146231
       b1970 |     .01232   .0013336     9.24   0.000     .0097012    .0149388
    four_bdr |  -.0169504   .0029568    -5.73   0.000     -.022757   -.0111439
   per_subsd |    .065831   .0057797    11.39   0.000      .054481     .077181
     per_min |   .0044025   .0021933     2.01   0.045     .0000953    .0087096
       Portl |   .0602761   .0914708     0.66   0.510    -.1193507     .239903
```

1990 Portland and Seattle Central Cities – Extremely Low-Income Rental Units

Regression with robust standard errors

Number of obs	= 241
F(15, 225)	= 78.28
Prob > F	= 0.0000
R-squared	= 0.7455
Root MSE	= .50003

ln1adjpre_~e	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
D	-.1017493	.3949838	-0.26	0.797	-.8800899	.6765914
perc_park	.0048283	.0282652	0.17	0.865	-.05087	.0605267
unit_2t4	.0194564	.0070892	2.74	0.007	.0054868	.0334261
unit_5	.015534	.0041778	3.72	0.000	.0073015	.0237666
D_Plnd	.4989654	.5398279	0.92	0.356	-.5647996	1.56273
perpark_Plnd	-.0038231	.0342928	-0.11	0.911	-.0713991	.063753
unit2t4_Plnd	-.0026487	.0110881	-0.24	0.811	-.0244985	.019201
unit5_Plnd	-.0014057	.0057313	-0.25	0.806	-.0126996	.0098883
vac_rate	.0149616	.0146049	1.02	0.307	-.0138182	.0437415
b1970	.0140044	.0028396	4.93	0.000	.0084088	.0195999
four_bdr	-.0167569	.0051815	-3.23	0.001	-.0269673	-.0065465
per_subsd	.0431551	.0061873	6.97	0.000	.0309627	.0553474
per_min	.0084008	.0025181	3.34	0.001	.0034387	.0133629
placec~59000	-.1534893	.1514761	-1.01	0.312	-.4519826	.1450039
_cons	-.314051	.2861064	-1.10	0.274	-.8778417	.2497398

2000 Portland and Seattle Regions – Extremely Low-Income Rental Units

Regression with robust standard errors

Number of obs	724
F(66, 626)	.
Prob > F	.
R-squared	0.7372
Root MSE	.454

ln1adjpre_~e	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
D	.3840997	.1718554	2.24	0.026	.0466169	.7215825
perc_park	.0050003	.0122803	0.41	0.684	-.0191153	.0291158
unit_2t4	.0201804	.005694	3.54	0.000	.0089987	.0313621
unit_5	.005184	.0015524	3.34	0.001	.0021356	.0082325
D_Plnd	-.2306481	.2596049	-0.89	0.375	-.74045	.2791537
perpark_Plnd	-.0379364	.0146764	-2.58	0.010	-.0667574	-.0091154
unit2t4_Plnd	-.0034398	.0081584	-0.42	0.673	-.0194609	.0125813
unit5_Plnd	-.0023452	.002462	-0.95	0.341	-.0071799	.0024895
vac_rate	.0132753	.0063792	2.08	0.038	.000748	.0258026
b1980	.0060741	.0012555	4.84	0.000	.0036085	.0085397
four_bdr	-.0166088	.002236	-7.43	0.000	-.0209998	-.0122179
per_subsd	.0754805	.0070818	10.66	0.000	.0615735	.0893875
per_min	.0040016	.0018011	2.22	0.027	.0004647	.0075384
Portl	-.1144521	.0971259	-1.18	0.239	-.3051841	.0762799

2000 – Portland and Seattle Central Cities – Extremely Low-Income Rental Units

Regression with robust standard errors

Number of obs	241
F(14, 226)	44.99
Prob > F	0.0000
R-squared	0.7433
Root MSE	.45964

ln1adjpre_~e	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
D	.290814	.3004039	0.97	0.334	-.3011367	.8827647
unit_2t4	.0231727	.0072917	3.18	0.002	.0088042	.0375412
unit_5	.0079776	.0026735	2.98	0.003	.0027094	.0132459
perc_park	-.0126504	.0185297	-0.68	0.495	-.0491634	.0238627
D_Plnd	-.3469055	.3956405	-0.88	0.382	-1.126522	.4327105
unit2t4_Plnd	-.0042374	.0107212	-0.40	0.693	-.0253636	.0168888
unit5_Plnd	.0024776	.003101	0.80	0.425	-.003633	.0085881
perpark_Plnd	-.0038543	.0212772	-0.18	0.856	-.0457813	.0380727
vac_rate	.0057818	.0191325	0.30	0.763	-.0319192	.0434827
b1980	.0063824	.003593	1.78	0.077	-.0006977	.0134626
four_bdr	-.0168223	.0048877	-3.44	0.001	-.0264536	-.0071909
per_subsd	.0587551	.0085736	6.85	0.000	.0418607	.0756496
per_min	.0087216	.002018	4.32	0.000	.0047451	.0126981
placec~59000	-.2100397	.1533861	-1.37	0.172	-.5122894	.0922101
_cons	.3411923	.4025111	0.85	0.398	-.4519622	1.134347

1990 Baltimore and Philadelphia Regions – Extremely Low-Income Rental Units

```
Regression with robust standard errors                 Number of obs =    1757
                                                       F(137,  1497) =       .
                                                       Prob > F      =       .
                                                       R-squared     =  0.6929
                                                       Root MSE      =  .57345

------------------------------------------------------------------------------
             |               Robust
ln1adjpre_~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           D |   .2038891   .1090637     1.87   0.062    -.0100449    .4178231
   perc_park |  -.0145504   .0044241    -3.29   0.001    -.0232284   -.0058723
    unit_2t4 |   .0130797   .0030325     4.31   0.000     .0071313    .0190282
      unit_5 |  -.0020008   .0014478    -1.38   0.167    -.0048408    .0008391
         D_B |   .2772412   .1913625     1.45   0.148    -.0981258    .6526083
   perpark_B |   .0099679   .0065873     1.51   0.130    -.0029534    .0228893
   unit2t4_B |   .0130763   .0060096     2.18   0.030     .0012881    .0248645
    unit5_B |   .0004339    .002093     0.21   0.836    -.0036716    .0045393
    vac_rate |    .027243   .0046871     5.81   0.000      .018049    .0364371
       b1970 |   .0010598   .0009138     1.16   0.246    -.0007326    .0028523
    four_bdr |   -.004232   .0010892    -3.89   0.000    -.0063686   -.0020954
   per_subsd |   .0563949    .004261    13.24   0.000     .0480367     .064753
     per_min |   .0057703   .0009587     6.02   0.000     .0038897    .0076508
   Baltimore |   .0845323   .0812248     1.04   0.298    -.0747941    .2438587
```

1990 Baltimore and Philadelphia Central Cities – Extremely Low-Income Rental Units

```
Regression with robust standard errors                 Number of obs =     529
                                                       F( 14,   514) =   65.60
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.6384
                                                       Root MSE      =  .60752

------------------------------------------------------------------------------
             |               Robust
ln1adjpre_~e |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           D |   .5623375   .2467803     2.28   0.023     .0775154     1.04716
   perc_park |   -.037743    .008428    -4.48   0.000    -.0543006   -.0211854
    unit_2t4 |   .0141975    .003688     3.85   0.000     .0069521     .021443
      unit_5 |  -.0048117   .0021683    -2.22   0.027    -.0090715   -.0005518
         D_B |   .1673168   .3280505     0.51   0.610    -.4771679    .8118015
   perpark_B |   .0373611   .0100776     3.71   0.000     .0175628    .0571594
   unit2t4_B |  -.0009957   .0056481    -0.18   0.860    -.0120919    .0101006
    unit5_B |   .0011093   .0028899     0.38   0.701    -.0045682    .0067868
    vac_rate |   .0340145   .0057722     5.89   0.000     .0226746    .0453545
       b1970 |  -.0010264   .0027874    -0.37   0.713    -.0065025    .0044497
    four_bdr |  -.0022881   .0023543    -0.97   0.332    -.0069133    .0023371
   per_subsd |   .0479527   .0052554     9.12   0.000     .0376279    .0582775
     per_min |   .0058449    .000972     6.01   0.000     .0039353    .0077546
placeco~4000 |   .3327816   .1551859     2.14   0.032      .027905    .6376582
       _cons |   .3818828   .2864115     1.33   0.183    -.1807983     .944564
```

2000 Baltimore and Philadelphia Regions – Extremely Low-Income Rental Units

Regression with robust standard errors

Number of obs = 1757
F(137, 1494) = .
Prob > F = .
R-squared = 0.7310
Root MSE = .58723

ln1adjpre_~e	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
D	-.0587383	.1493745	-0.39	0.694	-.3517443	.2342676
perc_park	-.02355	.0059675	-3.95	0.000	-.0352555	-.0118445
unit_2t4	.0205422	.00378	5.43	0.000	.0131275	.0279569
unit_5	.0015847	.001544	1.03	0.305	-.0014438	.0046133
D_B	.3127606	.2304667	1.36	0.175	-.1393121	.7648333
perpark_B	.0271448	.0071328	3.81	0.000	.0131535	.0411361
unit2t4_B	.0039622	.0059998	0.66	0.509	-.0078066	.0157311
unit5_B	.0019029	.0023197	0.82	0.412	-.0026473	.0064532
vac_rate	.0218063	.00611	3.57	0.000	.0098212	.0337914
b1980	.0015382	.0012018	1.28	0.201	-.0008192	.0038957
four_bdr	-.0098622	.001167	-8.45	0.000	-.0121514	-.007573
per_subsd	.0421087	.0045874	9.18	0.000	.0331102	.0511072
per_min	.006467	.0011905	5.43	0.000	.0041318	.0088022
Baltimore	.0740834	.103456	0.72	0.474	-.1288509	.2770177

2000 Baltimore and Philadelphia Central Cities – Extremely Low-Income Rental Units

Regression with robust standard errors

Number of obs = 529
F(14, 512) = 63.49
Prob > F = 0.0000
R-squared = 0.6058
Root MSE = .61195

ln1adjpre_~e	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
D	-.1120979	.293407	-0.38	0.703	-.6885277	.464332
perc_park	-.0493587	.0098994	-4.99	0.000	-.0688072	-.0299103
unit_2t4	.0212858	.0043502	4.89	0.000	.0127393	.0298323
unit_5	.0013464	.0024127	0.56	0.577	-.0033936	.0060865
D_B	.4027275	.3744904	1.08	0.283	-.3329993	1.138454
perpark_B	.05366	.0108105	4.96	0.000	.0324216	.0748983
unit2t4_B	-.0099016	.0059396	-1.67	0.096	-.0215706	.0017674
unit5_B	.0017573	.0034075	0.52	0.606	-.0049371	.0084516
vac_rate	.0257512	.0067598	3.81	0.000	.0124708	.0390316
b1980	.0021352	.0073553	0.29	0.772	-.012315	.0165854
four_bdr	-.0113014	.0022969	-4.92	0.000	-.0158138	-.0067889
per_subsd	.0317564	.0055962	5.67	0.000	.0207621	.0427507
per_min	.0069354	.00141	4.92	0.000	.0041654	.0097055
placeco~4000	.3473308	.1430669	2.43	0.016	.0662603	.6284012
_cons	.8633169	.7437226	1.16	0.246	-.5978064	2.32444

1990 Portland and Seattle Regions – Very Low-Income Rental Units

Regression with robust standard errors

Number of obs =	724
F(66, 626) =	.
Prob > F =	.
R-squared =	0.8460
Root MSE =	.39362

ln1adjpre_~v	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
D	-.3265822	.1959659	-1.67	0.096	-.7114124	.058248
perc_park	.0057961	.0122629	0.47	0.637	-.0182853	.0298775
unit_2t4	.044229	.0056241	7.86	0.000	.0331847	.0552733
unit_5	.0213511	.0023198	9.20	0.000	.0167955	.0259066
D_Plnd	.0633128	.2567321	0.25	0.805	-.4408476	.5674732
perpark_Plnd	-.0014245	.0153406	-0.09	0.926	-.0315498	.0287009
unit2t4_Plnd	-.0013991	.0065311	-0.21	0.830	-.0142246	.0114264
unit5_Plnd	-.006989	.0026078	-2.68	0.008	-.0121102	-.0018678
vac_rate	-.0064438	.0033024	-1.95	0.051	-.012929	.0000413
b1970	.0138663	.0010864	12.76	0.000	.0117329	.0159997
four_bdr	-.0253836	.0028042	-9.05	0.000	-.0308902	-.0198769
per_subsd	.0103583	.0036442	2.84	0.005	.003202	.0175145
per_min	.0053032	.0015134	3.50	0.000	.0023313	.0082752
Portl	.1638011	.0712244	2.30	0.022	.0239334	.3036687

1990 Portland and Seattle Central Cities – Very Low-Income Rental Units

Regression with robust standard errors

Number of obs =	241
F(14, 226) =	112.79
Prob > F =	0.0000
R-squared =	0.8632
Root MSE =	6.7518

adjpre_afv	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
D	-2.191513	5.741918	-0.38	0.703	-13.50606	9.12303
perc_park	-.0880899	.414216	-0.21	0.832	-.9043093	.7281296
unit_2t4	.4028136	.0897034	4.49	0.000	.2260515	.5795756
unit_5	.53373	.0600602	8.89	0.000	.4153803	.6520796
D_Plnd	1.825815	7.179405	0.25	0.799	-12.32132	15.97295
perpark_Plnd	.3693	.4740693	0.78	0.437	-.5648611	1.303461
unit2t4_Plnd	.3239589	.145695	2.22	0.027	.0368645	.6110532
unit5_Plnd	-.0520708	.07203	-0.72	0.470	-.1940071	.0898654
vac_rate	-.4728701	.2803204	-1.69	0.093	-1.025246	.0795057
b1970	.2155233	.0503325	4.28	0.000	.1163423	.3147043
four_bdr	-.2940902	.0628549	-4.68	0.000	-.4179469	-.1702335
per_subsd	.3532992	.1324073	2.67	0.008	.0923885	.6142099
per_min	.1434589	.0406567	3.53	0.001	.0633443	.2235735
placec~59000	2.495924	1.834286	1.36	0.175	-1.118566	6.110413
_cons	-8.893974	4.581767	-1.94	0.053	-17.92242	.1344719

2000 Portland and Seattle Regions – Very Low-Income Rental Units

```
Regression with robust standard errors                 Number of obs =     724
                                                       F( 66,   626) =       .
                                                       Prob > F      =       .
                                                       R-squared     =  0.8604
                                                       Root MSE      =  .35438

------------------------------------------------------------------------------
             |               Robust
ln1adjpre_~v |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           D |   .0287724   .1259335     0.23   0.819    -.2185308    .2760757
   perc_park |   .0072453   .0057589     1.26   0.209    -.0040638    .0185543
    unit_2t4 |   .0403406   .0037093    10.88   0.000     .0330565    .0476247
      unit_5 |   .0152962   .0011027    13.87   0.000     .0131307    .0174618
      D_Plnd |  -.2144131   .2015329    -1.06   0.288    -.6101755    .1813494
perpark_Plnd |  -.0062014   .0080942    -0.77   0.444    -.0220965    .0096938
unit2t4_Plnd |   .0024843    .005822     0.43   0.670    -.0089488    .0139174
  unit5_Plnd |    .001451   .0017086     0.85   0.396    -.0019042    .0048063
    vac_rate |  -.0129696    .005564    -2.33   0.020    -.0238959   -.0020432
       b1980 |   .0078784   .0009995     7.88   0.000     .0059157    .0098412
    four_bdr |  -.0280763   .0022831   -12.30   0.000    -.0325597   -.023593
   per_subsd |   .0098971   .0032694     3.03   0.003     .0034769    .0163173
     per_min |   .0086525   .0012852     6.73   0.000     .0061287    .0111763
       Portl |  -.0130974   .0862561    -0.15   0.879    -.1824838     .156289
```

2000 Portland and Seattle Central Cities – Very Low-Income Rental Units

```
Regression with robust standard errors                 Number of obs =     241
                                                       F( 14,   226) =   91.45
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.8620
                                                       Root MSE      =  6.2318

------------------------------------------------------------------------------
             |               Robust
  adjpre_afv |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
           D |  -9.348954   5.528355    -1.69   0.092    -20.24267     1.54476
   perc_park |  -.0123757   .3569845    -0.03   0.972    -.7158193     .691068
    unit_2t4 |   .5138528   .0919758     5.59   0.000     .3326131    .6950925
      unit_5 |   .4832716   .0493983     9.78   0.000     .3859315    .5806117
      D_Plnd |   11.16664   6.776155     1.65   0.101    -2.185887    24.51916
perpark_Plnd |   .0667704   .3944164     0.17   0.866    -.7104336    .8439743
unit2t4_Plnd |   .0587102   .1259384     0.47   0.642    -.1894534    .3068738
  unit5_Plnd |  -.0302614   .0608766    -0.50   0.620    -.1502198    .0896969
    vac_rate |  -.5888984   .3619256    -1.63   0.105    -1.302079    .1242818
       b1980 |   .1508932   .0535386     2.82   0.005     .0453946    .2563918
    four_bdr |  -.2940768   .0523069    -5.62   0.000    -.3971483   -.1910052
   per_subsd |     .27848   .1187359     2.35   0.020     .0445091     .512451
     per_min |   .1787333   .0377037     4.74   0.000     .1044375    .2530291
placec~59000 |  -3.134765    1.80652    -1.74   0.084    -6.694541    .4250113
       _cons |  -2.707813   5.655543    -0.48   0.633    -13.85215    8.436526
```

1990 Baltimore and Philadelphia Regions – Very Low-Income Rental Units

```
Regression with robust standard errors                 Number of obs =    1757
                                                       F(137,  1497) =       .
                                                       Prob > F      =       .
                                                       R-squared     =  0.7432
                                                       Root MSE      =  .59958
```

ln1adjpre_~v	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
D	.1433837	.1179137	1.22	0.224	-.08791	.3746773
perc_park	-.025734	.0057428	-4.48	0.000	-.0369988	-.0144691
unit_2t4	.0255789	.0034927	7.32	0.000	.0187277	.03243
unit_5	.0088037	.0016343	5.39	0.000	.005598	.0120095
D_B	-.0017735	.1869336	-0.01	0.992	-.368453	.364906
perpark_B	.0219656	.0069825	3.15	0.002	.0082691	.0356622
unit2t4_B	.0045905	.0043525	1.05	0.292	-.0039472	.0131281
unit5_B	.0045905	.0021433	2.14	0.032	.0003863	.0087947
vac_rate	.0086057	.0045597	1.89	0.059	-.0003382	.0175497
b1970	.0086178	.0012218	7.05	0.000	.0062211	.0110145
four_bdr	-.0142087	.0013838	-10.27	0.000	-.0169231	-.0114942
per_subsd	.0235718	.0037672	6.26	0.000	.0161822	.0309613
per_min	.0067408	.0008516	7.92	0.000	.0050704	.0084112
Baltimore	.417972	.0937645	4.46	0.000	.2340482	.6018958

1990 Baltimore and Philadelphia Central Cities – Very Low-Income Rental Units

```
Regression with robust standard errors                 Number of obs =     529
                                                       F( 14,   514) =   68.96
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.6394
                                                       Root MSE      =  8.2493
```

adjpre_afv	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
D	7.94965	2.616059	3.04	0.002	2.810167	13.08913
perc_park	-.3107279	.1089653	-2.85	0.005	-.5248	-.0966558
unit_2t4	.2920264	.0541917	5.39	0.000	.185562	.3984908
unit_5	.1274529	.0314265	4.06	0.000	.0657127	.189193
D_B	-1.433766	4.247948	-0.34	0.736	-9.779242	6.91171
perpark_B	.2240507	.1351329	1.66	0.098	-.04143	.4895314
unit2t4_B	.1007688	.0806164	1.25	0.212	-.0576092	.2591469
unit5_B	.0377932	.0529916	0.71	0.476	-.0663135	.1418999
vac_rate	.167248	.0749774	2.23	0.026	.0199481	.3145479
b1970	.046968	.0387048	1.21	0.225	-.0290711	.1230072
four_bdr	-.0540066	.0276832	-1.95	0.052	-.1083927	.0003794
per_subsd	.4494893	.0737539	6.09	0.000	.3045932	.5943854
per_min	.1034563	.0127881	8.09	0.000	.0783329	.1285798
placeco~4000	6.951529	2.216753	3.14	0.002	2.596518	11.30654
_cons	-3.556874	3.996582	-0.89	0.374	-11.40852	4.294772

2000 Baltimore and Philadelphia Regions – Very Low-Income Rental Units

Regression with robust standard errors

Number of obs	= 1757
F(137, 1494)	= .
Prob > F	= .
R-squared	= 0.7773
Root MSE	= .54129

ln1adjpre_~v	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
D	.2021913	.144582	1.40	0.162	-.081414	.4857966
perc_park	-.0206323	.0051407	-4.01	0.000	-.0307161	-.0105485
unit_2t4	.0294763	.0028303	10.41	0.000	.0239245	.0350281
unit_5	.0113522	.0013888	8.17	0.000	.0086279	.0140765
D_B	-.0778379	.1915523	-0.41	0.685	-.453578	.2979021
perpark_B	.0269275	.0066492	4.05	0.000	.0138847	.0399703
unit2t4_B	-.0038383	.0042867	-0.90	0.371	-.0122468	.0045703
unit5_B	.003805	.0025882	1.47	0.142	-.0012719	.0088819
vac_rate	.0077232	.0043893	1.76	0.079	-.0008867	.016333
b1980	.0089353	.001328	6.73	0.000	.0063305	.0115402
four_bdr	-.0206865	.0013343	-15.50	0.000	-.0233038	-.0180693
per_subsd	.0152561	.0028481	5.36	0.000	.0096693	.0208428
per_min	.0060312	.0008881	6.79	0.000	.0042891	.0077733
Baltimore	.2938401	.0951082	3.09	0.002	.1072803	.4803998

2000 Baltimore and Philadelphia Central Cities – Very Low-Income Rental Units

Regression with robust standard errors

Number of obs	= 529
F(14, 512)	= 55.93
Prob > F	= 0.0000
R-squared	= 0.5793
Root MSE	= 9.4175

adjpre_afv	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
D	9.125313	5.882068	1.55	0.121	-2.430646	20.68127
perc_park	-.2137475	.1339466	-1.60	0.111	-.4769001	.049405
unit_2t4	.3851986	.0687902	5.60	0.000	.2500528	.5203443
unit_5	.2235358	.0502851	4.45	0.000	.1247452	.3223264
D_B	-6.694902	7.04963	-0.95	0.343	-20.54466	7.154859
perpark_B	.2593007	.1608928	1.61	0.108	-.0567906	.5753919
unit2t4_B	-.0231087	.0906211	-0.26	0.799	-.2011436	.1549263
unit5_B	.1169425	.0635407	1.84	0.066	-.00789	.241775
vac_rate	.1513941	.0972483	1.56	0.120	-.0396606	.3424488
b1980	.1659872	.0911034	1.82	0.069	-.0129953	.3449697
four_bdr	-.1441824	.030794	-4.68	0.000	-.2046806	-.0836842
per_subsd	.4362048	.0979624	4.45	0.000	.243747	.6286625
per_min	.1038704	.0178271	5.83	0.000	.0688471	.1388938
placeco~4000	4.192436	2.114236	1.98	0.048	.0387911	8.346081
_cons	-9.790416	9.171656	-1.07	0.286	-27.80912	8.228293

Appendix J

A NOTE ABOUT THE VARIABLE FOR AFRICAN-AMERICANS

Two independent variables for minorities were included in initial models for this research. The first variable was the proportion of the population that was minority. The second variable was the proportion of the population that was African-American. The purpose for including both measures was to capture differences which may exist in the explanatory power and statistical significance between the variable for all minorities and a variable for African-Americans. The high correlation between these two variables, however, made it necessary to drop of the variables. The variable for African-Americans was dropped from the analysis.

The correlations between the proportion of the population that was minority and the proportion that was African-American are shown in Table J-1. The correlations range from .812 in Seattle (2000) to .998 in Baltimore (1990).

Table J-1. Correlations of Proportions of Population Minority and African-American

	Portland Region	**Seattle Region**	**Baltimore Region**	**Philadelphia Region**
1990	.953***	.879***	.998***	.968***
2000	.814***	.812***	.993***	.959***

In the analyses for very low-income rental units in Portland and Seattle, I included both proportions in the model simultaneously. A greater proportion of minorities was associated with a larger proportion of affordable rental units. A greater proportion of African-Americans was associated with a smaller proportion of affordable units. I decided the most plausible explanation for these contradictory findings is the strong correlation between these two proportions.

When only one of these variables at a time was included, both variables were positive. When the African-American variable was dropped from the regressions, the minority variable was still positive and significant in both 1990 and 2000. When the minority variable was dropped from the regression, the African-American variable became positive and statistically significant in 2000, but not statistically significant in 1990. Therefore, it was likely the collinearity between the two variables which caused the contradictory findings when both variables were included at the same time.

In analyses of very low-income rental units in the regions of Baltimore and Philadelphia, the same results were found when the variable for minorities and the variable for African-Americans were included simultaneously in the model. The coefficient for minorities was positive and statistically significant and the coefficient for African-Americans was negative and statistically significant. When each is included separately, each variable is positive and statistically significant.

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