Urban Intensification in Seattle: A Data System, Policy Evaluation and Market Analysis

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Abstract

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This dissertation uses three related essays to examine the policies and processes influencing urban intensification within the City of Seattle from 2000 to 2012. I begin by constructing a toolbox-type planning support system (PSS) capable of generating parcel-level land use change data. Using data from this system, I then analyze the conformance of housing unit growth to the spatial patterns forecast by the City's Urban Village strategy. The third component builds a statistical model of low-rise redevelopment for the purpose of understanding the factors associated with increased redevelopment risk. More specifically I find that:

- Using open source software and publically available data a tool-box type planning support system (PSS) can be created that allows for flexible analysis of changes to land use within dense urban areas. Termed the Land Use Change Identification and Analysis (LUCIA) system, this tool can export raw data for external use, create analytical tables and produce two- and three-dimensional visualizations of land use change.

- Overall, the Urban Villages have met housing unit growth targets for the 2000 to 2012 period. The smaller and less dense Hub and Residential Urban Villages

have led the way. From a relative standpoint, non-Urban Village areas have grown nearly as fast as the areas within the Urban Villages, calling into question the efficacy of the strategy in concentrating growth. Finally, breaking growth down by unit type shows that areas experiencing growth through a mix of housing types greatly exceeded targets; those heavily dependent on a single type of unit for growth did not.

- In general, larger lots, smaller homes and greater potential gains in overall density are the biggest drivers of higher redevelopment risk for existing single family homes in Seattle's Lowrise zones. Neighborhood factors and option values do play a moderate, but nuanced role. Priming effects show a consistent, positive relationship with redevelopment. Finally, the redevelopment process itself is shown to vary over both space and time, suggesting that intensification policies should be flexible and attempt to take advantage of the locational variations in the market.

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DEDICATION

to my dear wife, Erin

Chapter 1

OVERVIEW OF PAPERS

Over the past thirty years, growth management policies have become commonplace across the United States (Weitz 1999; 2012) as well as in other developed countries such as Australia (McKenzie 1997), South Korea (Dawkins & Nelson 2002) and Switzerland (Gennaio et al. 2009). The most universal goal of these policies is the containment of low density, peripheral growth. As a compliment to restraining outward expansion, growth management regimes also develop plans that seek to foster the intensification of existing urban areas through infill and redevelopment. Along with these policy measures, changes in demographics (Pitkin & Myers 2008), economic costs (Glaeser & Shapiro 2003) and consumer preferences (Nelson et al. 2004) all suggest that demand for dense, urban locations is increasing. As a result, a better understanding of the urban intensification process and its related policies is called for.

At the same time, the ability of planners to collect, manage and analyze geospatial data has grown many-fold due to advances in computing hardware and software such as GPS, GIS and planning support systems (PSS). As data has become increasingly cheap and available, so, too, have calls to improve on existing processes and policies via quantitative analysis. Many government offices and departments have been asked to justify their expenses and, often, their very existence with this new found power of analysis (Seasons 2003). For planning, this means a renewed interest in asking and an increased ability to answer the question: “Is planning working?” In short, given the necessary data and analytical tools along with a changing climate of governance, the evaluation of existing and proposed plans is again becoming a critical issue in urban planning.

The expansion of data availability and computational capacity also means that complex market processes once reducible only to anecdotal evidence may now be analyzed to a greater degree than ever before. As a result, policy-makers can better draft plans that are able to forge symbiotic relationships with market forces, when desirable, as well as offer proactive instead of reactive corrections to market failures. For the private sector, an increased understanding of property market dynamics should lead to more resource efficient development and greater competitive pressure for urban locations.

It is in this combined space –understanding urban intensification through the convergence of data analysis, policy evaluation and market processes –that the research questions in this dissertation arise. The overarching question asks how policy and market forces interact to create urban intensification. From this, both policy- and market-specific angles are pursued. The fundamental policy question that I ask revolves around evaluating the efficacy of Seattle's Urban Village strategy in meeting housing growth goals. Since most housing growth within the City of Seattle occurs through redevelopment, a second line of inquiry approaches the question of urban intensification from the market standpoint by analyzing the determinants of residential redevelopment.

More specifically, these questions are:

1. How well has the Urban Village strategy met housing unit growth forecasts? Do results differ by village type or location? How do growth totals within the villages compare to those outside village boundaries?

2. What factors impact the probability of a detached, single family home redeveloping into a more dense low-rise residential use? Does the low-rise redevelopment process vary over time and space?

Prior to directly addressing these two empirical questions, I first take a step back to develop a toolbox-type planning support system (PSS) capable of generating the urban land use change data necessary to do so.

The remainder of this dissertation is organized into three related, but stand-alone papers. The first discusses the development of a basic data framework for deriving, analyzing and visualizing previous changes to land use within dense urban settings. In the second and third papers I use the data system constructed in the first to answer the two empirical questions asked above. Figure 1.1 shows a graphical overview of the research process, highlighting the somewhat circuitous approach in which the data development process became a necessary first step prior to answering the two initial research questions. A summary of each of the three papers followed by a brief conclusion is given below. Full papers and their appendices follow this introductory chapter.

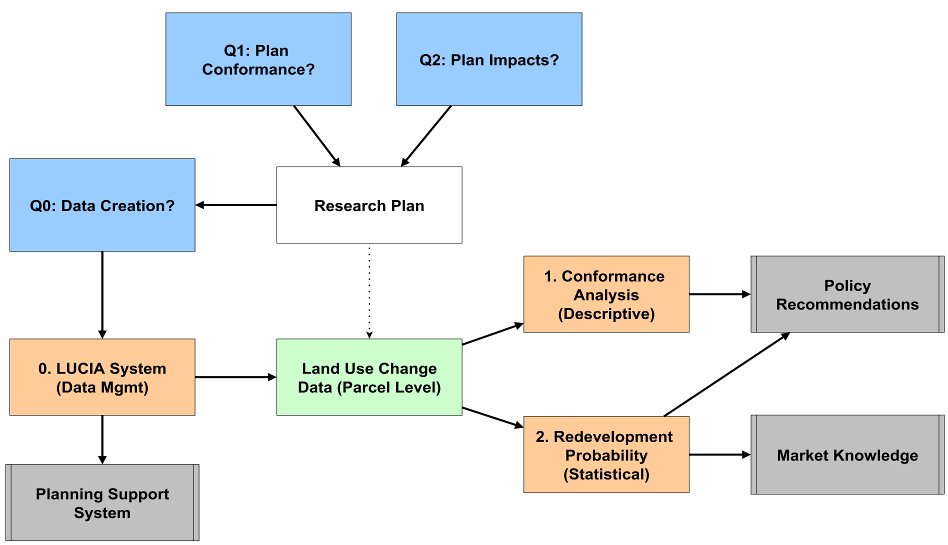

Figure 1.1: Research Process

Part I: Developing a Data System

A review of the existing state of planning support systems (PSS) shows that practicing planners rarely use the large, detailed forecasting models that have been developed, despite the extensive time, money and effort invested in them (Vonk et al. 2005; Geertman & Stillwell 2009). This reflective research suggests that existing models may be too complex and that planners do not feel that they have the necessary skills to use them (Brommelstroet 2010). At the same time, ex post planning evaluation continues to be one of the most neglected steps of the general planning process (Laurian et al. 2010). One of the reasons most often cited for the lack of evaluation and monitoring is poor data availability (Seasons 2003). Building off of these two deficiencies, I outline a basic data framework that can be used as a simple, yet powerful, toolbox-type planning support system (PSS) to collect, analyze and visualize a variety of information on past land use changes. Natural uses for this PSS are to assist with ex post planning evaluation efforts or to analyze market processes.

To show the functionality of this type of support tool, named a Land Use Change Identification and Analysis (LUCIA) system, I develop an example for the City of Seattle over the 2000 to 2012 time period. This example illustrates the LUCIA system's ability to create comparisons of land use change across various dimensions (change type, use type, change time and structure sizes). Additional output includes raw data available for use in more complex statistical analyses, basic cross-tabulated tables and two- and three-dimensional visualizations. To enhance the external validity of this approach, the LUCIA system requires only: 1) basic data already produced by most large metropolitan areas across the developed world; and 2) a pair of open source software platforms –R and GEOS –to process GIS operations, create basic summary statistics and generate visualizations. As the LUCIA system developed in this paper shows, simple, flexible planning support tools can be developed using existing data and readily available software. These tools can fit seamlessly with planners' existing knowledge and skill base as well as produce clear and easily understood results. From an evaluation standpoint, the contribution of poor data availability to hurdles in ex post planning evaluation can hopefully be reduced.

Part II: Evaluating Housing Growth

In the second paper, I use data created by the LUCIA system to test the extent to which the Seattle Urban Village (UV) strategy has met its housing unit growth goals from 2000 to 2012. Growth totals are analyzed on absolute and relative growth metrics. Monitoring actual growth in comparison to targets is a critical planning activity because many other public decisions are based on these growth targets –future infrastructure investments and public transit routing, as examples. Additionally, the Urban Village strategy has the expressed goal of concentrating higher density growth within the spatially-delineated villages while protecting the low-density character of surrounding residential neighborhoods. As a result, relative growth within the villages as compared to the city as a whole is an important metric to track over time and space. In doing so, we may ask if the strategy is indeed focusing growth, or if city-wide growth has simply exceeded expectations.

Results of this conformance-based analysis show that, overall, the urban villages have exceeded housing unit growth targets over the study period. Across village types the less dense Residential (RUV) and Hub Urban Villages (HUV) have led the way in housing growth compared to forecasts, while growth in denser Urban Center Villages (UCV) has languished. In looking at relative growth, non-urban village areas have grown nearly as fast as urban villages, suggesting that goals of concentrating growth are not necessarily being met city-wide. An analysis of variations in growth within and outside of UV boundaries over time highlights the importance that real estate market cycles and trends play in the location and form of urban growth. Finally, breaking growth down by unit type, villages that have grown through a mix of different unit types (apartments, condominiums, townhomes and single family dwellings) are more likely to have met and exceeded growth targets than those whose growth came primarily from one type of development activity.

Part III: Analyzing Redevelopment Probability

In the third paper I examine the market side of the urban intensification equation. More specifically, using data from the LUCIA system I develop a duration (survival) model to examine the probability of detached single family homes within the city's Lowrise (LR) zones redeveloping to new low-rise residential structures. Duration models are particularly well suited for this type of study since they allow for longitudinal data analysis when independent variables change values over time.

The results of this study also highlight the importance of net present value (NPV) theory in explaining redevelopment risk. All else equal, I find that the properties most likely to redevelop are those with low lot coverage (small home, large lot), flat topography, and large differences between the current floor-to-area ratio (FAR) and the allowable FAR under the existing zoning. A number of neighborhood variables, such as land use mix, overall neighborhood density and demographic variables, are shown to exert low to moderately significant influences on redevelopment probability. Stronger influences come from priming effects –those variables that measure the level of recent redevelopment occurring in the neighborhood of the properties at risk for redevelopment.

In terms of option values, measures of localized price trends show little impact on redevelopment risk, however, positive deviations from price expectations are positively related to low-rise redevelopment. The limited impact of price trends represents a result that conflicts with the deterrent effect found in other research (Bulan et al. 2009). Rationale, both theoretical and methodological, for this counter-intuitive result are given and indicate that more research should be focused on option values for redevelopment in a dense urban area, as opposed to the traditional focus on new growth in suburban settings (Cunningham 2006; Towe et al. 2008).

Additional models are developed that measure the temporal and spatial variations in the relationships between dependent variables and redevelopment risk. The results here suggests that the impact of most factors are relatively constant over time. However, lower income and higher rental areas began as negative drivers of redevelopment but gradually became positive over time, capturing the gentrification activity occurring in some of Seattle's traditionally lower priced neighborhoods. I also divide the city into three submarkets and estimate separate models for these areas. This analysis shows that large lot size plays a much larger role in the higher density and more expensive central submarket, while income and land use mix hold more importance in the northern part of the city. Finally, in the relatively less expensive southern reaches of Seattle low-rise redevelopment appears to be more contagious, meaning that redevelopment is primarily drawn to areas already experiencing similar growth.

In addition to the specific empirical results, this paper is the first to use duration analysis to analyze redevelopment in a densely developed urban area. Previous uses of this technique in a land use setting have focused on subdivision development in low-density, peripheral areas of metropolitan regions. Overall, these findings of this component of my research indicate that redevelopment is a highly contextual phenomenon and that knowledge of localized trends and processes could make planning for urban intensification more successful.

Conclusion

The results of this work offer findings and recommendations across methodological, policy and market contexts. In terms of methodologies, the LUCIA framework and functional example show that tools for planning support need not be highly complex in order to assist in answering critical planning questions. In fact, using open source software and data publically available in most metropolitan areas, a flexible system to identify, analyze and visualize urban land use change data can be created. Additionally, I show that duration models, to date a method used primarily in suburban land use change analysis, can be adapted to analyze redevelopment in a highly dynamic urban environment. Through temporal interactions and spatial submarketing, heterogeneities –both temporal and spatial –in the relationships between redevelopment and relevant co-variates can also be identified and measured.

From a policy perspective, Seattle's Urban Village strategy is meeting the housing growth targets set forth in the comprehensive plan. As forecasts are due to be updated in 2014, past plan performance is important information for medium- and long-range planning activities. However, when looked at from a relative perspective, areas outside of the urban villages are growing nearly as fast as those within, calling into the question the efficacy of the program in concentrating growth. Also, this analysis shows that areas that intensify though a mix of unit types have systematically experienced higher growth-to-target ratios than areas wholly dependent on a single type of growth. This suggests that, in terms of housing unit growth, a mix of structural and tenure types may be important to driving neighborhood growth levels.

Finally, a number of market-based findings and resulting policy recommendations stem from this work. First, the analysis of housing unit growth over time highlights the importance that real estate cycles (and trends) have on urban growth. Planners involved in forecasting and plan evaluation need to consider these cycles in performing their related analyses. Next, the analysis of redevelopment probability shows, through the confirmation of the NPV theory, the importance of profitability in determining the likelihood of redevelopment. As small homes on large lots in areas with the greatest potential density are most likely to redevelop, new plans aimed at encouraging urban intensification should focus on neighborhoods that meet these criteria.

As the changing influence of income and rental rates attest, the redevelopment process also changes over time. In the case of Seattle over the 2003 to 2012 period, the data suggests that the latter half of this period was characterized by an increase in redevelopment in lower income/higher rental neighborhoods –characteristics consistent with gentrification. These temporal evolutions indicate that urban intensifications plans should remain flexible to be able to adapt to the changing fundamentals of the market.

Space also matters in explaining low-rise redevelopment. Areas within the central regions of Seattle are much more heavily influenced by lot size and density differences than those in the north and south. In the south end, redevelopment activity is more likely in areas already seeing similar growth types, while in the north, local demographics and proximity to mixed uses exert greater forces on redevelopment than elsewhere in the city. The knowledge that redevelopment is spatially contextual as well as information as to what factors are more important where both mean that intensification plans can be most efficient if varied by neighborhood. In other words, for best effect, the incentives of a plan like the Urban Village strategy could be neighborhood (or at least submarket) specific so as to best harness the power of the market in reaching growth goals.

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Chapter 2

PART I. THE LAND USE CHANGE IDENTIFICATION AND ANALYSIS (LUCIA) SYSTEM: A TOOL FOR SUPPORTING QUANTITATIVE PLAN EVALUATION

Abstract

Over the past two decades Planning Support Systems (PSS) and related tools have steadily evolved from a narrow focus on land use forecasting and simulation to much broader endeavors. The majority of this work, however, remains focused on the process of plan creation and evaluation of potential alternatives. A similar trend is evident in the planning evaluation literature, in which ex ante evaluation (forecasting and scenario planning) dominates while efforts to measure the ongoing performance and the ultimate efficacy of plans (ex post evaluation) languishes. This research seeks to address both these gaps by providing a general framework for developing a toolbox-type PSS aimed at identifying, measuring and analyzing past land use changes at the parcel level. Termed a Land Use Change Identification and Analysis (LUCIA) system, its applicability is shown via an example evaluation of housing unit growth targets in one of the City of Seattle's Urban Villages.

Introduction

The gathering, storing, analysis and interpretation of information is fundamental to the planning process (Branch 1998). Information in its various forms is used by the planner for multiple activities including, but not limited to, plan creation, plan enforcement, plan evaluation, and, increasingly, communication with stakeholders and the public at large. As the availability, sheer volume and demand for increasingly complex information has steadily grown a number of technological innovations have permeated the everyday activities of planning professionals. Geographic Information Systems (GIS) present the most important and ubiquitous change to the way that planners manage spatially referenced data and information. Other internet-based advances such as open data sources, collaborative planning software and crowd-sourcing have also increased the flow of information both to and from planning organizations. One particular set of information frameworks that have arisen to address the specific needs of planners are Planning Support Systems (PSS) (Klosterman 1997; Geertman & Stillwell 2003).

This recent influx of information and the technological capabilities to manage it offer an incredible opportunity to enhance all facets of the urban planning process. While the ability to forecast and simulate future land use and transportation patterns have grown incredibly over the last 20 years (Klosterman 1999; Waddell 2002; Gaunt & Jackson 2003; Sun et al. 2009), similar improvements in the ability to accurately monitor and evaluate the outcomes of plan implementation (ex post evaluation) have been much more modest. In fact, the literature on plan monitoring and ex post evaluation suggests that the lack of necessary information remains one of causes of the failure to evaluate plans (Seasons 2003; Laurian et al. 2010). In this paper, I address this shortfall by presenting a highly flexible method (a toolbox-type PSS) for providing planners with land use change data that can be used to evaluate a subset of common urban planning objectives and, ideally, further the capacity of plan monitoring and ex post evaluation.

This paper begins by discussing the definition, evolution and current state of Planning Support Systems (PSS). Next, I present a brief overview of plan evaluation and monitoring centered around quantitative, ex post evaluation. The third section of the paper describes a generalizable information framework for identifying, measuring, analyzing and visualizing land use change at the parcel level, with a particular focus on use for plan evaluation. Here I present a system that tracks changes to urban form across a number of dimensions including: 1) parcel geometry (lot splits, lot combinations, etc.); 2) land use (apartment, condominium, retail, etc.); 3) structural size and density (building square foot, number of living units, etc.); and 4) change process (new development, conversion, etc.). To demonstrate the applicability of this tool, termed a Land Use Change Identification and Analysis (LUCIA) system, I conclude the paper with an example analysis of housing unit changes in one of the City of Seattle's Urban Villages.

Background

Planning Support Systems (PSS)

The term "Planning Support System" can trace its beginning back to an Urban and Regional Information Systems Association (URISA) conference in the late 1980s (Batty 2003). Harris (1989) was the first to add this term to the lexicon of urban planning literature. Since that time, research and development of Planning Support Systems (PSS) has grown rapidly, including dozens of scholarly articles and four edited volumes dedicated to the topic (Brail & Klosterman 2001; Geertman & Stillwell 2003; Brail 2008; and Geertman & Stillwell 2009).

Throughout the development and expansion of PSS, its exact definition has evolved. Early efforts to define PSS focused on all-encompassing systems in which complex models, such as spatial equilibrium, cellular automata and other simulation and forecasting systems, served as the central feature (Harris 1989; Densham 1991; Kammeier 1999). Many of these holistic models have been developed, thoroughly described in the academic literature and successfully employed in planning practice. A decade ago, a review study conducted by the U.S. Environmental Protection Agency (EPA) found more than 20 of these large land use/transportation forecasting models in existence (Gaunt & Jackson 2003). Some of the most common are UrbanSim (Waddell 2002), WhatIf? (Klosterman 1999), LEAM (Sun et al 2009; Deal & Pallathucheril 2009) and

SLEUTH (Silva & Clarke 2002). These large, complex modeling systems remain the most common form of PSS discussed in the academic literature.

Although land use and transportation forecasting models remain the dominant form of PSS, the breadth of what constitutes a PSS has slowly expanded over time to include models and systems aimed at other planning functions. Examples include research and development on PSS for public participation in planning (Geertman 2002; Snyder 2003; Khaila & Kytta 2009), ecological and environmental modeling (Bonfatti et al. 2003; Besio & Quadrelli 2009) as well as more specialized pursuits aimed at tourism (Johnson & Sieber 2009) and motor vehicle safety (Levine 2009). In short, the collection of PSS in the literature is expanding in scope from its initial and narrowly defined parameters.

There are two unifying components of all Planning Support Systems. The first is the ability to improve the information handling of a particular set or sets of data used in the planning process (Geertman & Stillwell 2009). The second unifying component is that all PSS are developed and used to address a particular planning task or collection of tasks. This focus on the planning process –often described as a rational, forward-looking activity (Klosterman 2009) –is a key component of what separates PSS from a more simplified and generalized GIS (Geertman & Stillwell 2003). Under these very generic boundaries, a wide variety of models and related systems fall into this domain. In fact, as Geertman and Stillwell (2003) note, PSS may vary based on their goals, aims, functional capabilities, content, structure, technology and look and feel.

Task and technique are two particularly useful dimensions over which to classify PSS. (Klosterman & Pettit 2005). Task refers to the specific planning question, problem or objective that is being addressed by the PSS. Technique, on the other hand, describes the manner in which the PSS gathers or process data to transforms it into usable information in the planning process. Categorization along these lines can help bring order to the rapidly expanding universe of Planning Support Systems.

PSS tasks can range from grandiose –forecasting future development patterns –to very utilitarian –aiding in aggregating public responses –to everything in between. It is the task and the available data and computing environment that determine the ultimate design or technique that the system will use. In terms of technique, most of the large, complex modeling systems such as UrbanSim, WhatIf? and others are developed around simulation methods that use either agent-based modeling or cellular automata to produce forecasts. These forecasts often consist of population, employment or land use change estimates and are aggregated at various geographic levels from individual parcels to census block groups and up to larger areas such as traffic analysis zones (TAZ) or forecast analysis zones (FAZ). Systems utilizing cellular automata usually produce forecasts for equally-sized and spaced raster or grid areas, the spatial scale of which vary by the model's computational power and underlying data resolution. Other simpler PSS may analyze and/or visualize existing datasets for collaboration and visioning purposes, compile inputs from various stakeholders into a database or create very specialized spatial and non-spatial estimates and forecasts depending on the specific task of the PSS.

PSS and the Practitioner

Despite the great promise that PSS hold for the planning practice and the extensive resources applied toward developing PSS in academic circles, the actual adoption of planning support systems by practitioners remains sporadic. To examine the under-utilization of PSS, Geertman and Stillwell (2009) have developed a three-fold approach. In this approach, the relationship of PSS to potential users is examined based on the instruments in the PSS (instrument approach), the user's specific characteristics (user approach) and method of information diffusion regarding the PSS itself (transfer approach). They find evidence in the literature suggesting that PSS suffer from deficiencies across all three approaches.

Empirical research directed at assessing causes for the limited use of PSS have found a number of key “bottlenecks” to the adoption of PSS (Vonk et al. 2005). These include poor awareness of the existence of usable systems, insufficient experience with these systems and overall lack of intention to use such systems (Vonk et al. 2005). From this work conducted in the Netherlands, it appears that planners either are not aware of PSS or are hesitant due to limitations (real or perceived) in their ability to properly use them. These findings support Geertman and Stillwell’s consideration of both transfer and user approaches to examine hurdles in the adoption of PSS. Additional survey research in this direction has identified the desire for more transparency in the PSS inputs, outputs and models, more user-friendliness and more flexibility in the PSS design. These user demands are critical hurdles to implementation created by the PSS instruments themselves (Brommelstroet 2010).

Overall, the majority of resources aimed at developing and maintaining PSS are focused on large-scale, complex models used to forecast and simulate land use and transportation outcomes. Incredible progress in the development of these models has been achieved, however, their diffusion to practicing planners has proven difficult. Surveys of practitioners suggest that planners actually desire less complex, more transparent and more easy to use systems. Simply put, urban growth and change is a very complex phenomena for which researchers and developers have created equally complex models to explain this process. The complexity of these large-scale is, therefore, unavoidable. Practicing planners, who operate under constant resource and political constraints (Seasons 2003), may recognize and appreciate this complexity, however, the demands of their position often require more practical and pragmatic tools to improve their daily work. What the reflective research on PSS adoption suggests is that more research and development aimed at smaller, toolbox-type PSS (Batty 2003) could help bridge the gap between the development and ultimate implementation and daily use of Planning Support Systems. In no way are these toolbox-type systems a replacement for the large-scale models, but rather should be seen as a compliment to these existing, complex PSS.

Evaluation of Urban Planning Policies

The evaluation of existing policies forms a key component of the urban planning process (Branch 1998). In fact, as Alexander and Faludi (1989) suggest, the very credibility of the entire profession rests on the ability to properly measure the effectiveness of the planning process. Regrettably, however, research on plan evaluation finds that thorough ex post plan evaluation is the exception and not the rule in general practice (Calkins 1979; Talen 1996; Seasons 2003; Laurian et al. 2010). This section explores the issue of plan evaluation and its deficiencies.

As there is no one type of urban plan, there is also no one type of plan evaluation. Evaluation can vary over a number of metrics or characteristics. First, plan evaluation can occur during the planning process (ex ante), while the plan is being carried out (plan monitoring) or after the completion of the plan (ex post)[1] (Talen 1996; Baer 1997). Depending on the point in the process at which the evaluation occurs, the method(s) of evaluation will differ. In an ideal situation, evaluation criteria are developed contemporaneously with the plan itself (Kaiser et al. 1995; Oliveira & Pinho 2010), though often in practice plans are evaluated based on criteria developed at a later time and/or are evaluated by individuals or groups not involved in the original plan creation process.

Ex ante evaluation is the most common form of plan evaluation. A major component of ex ante evaluation involves the comparison of a number of forecasts or scenarios to determine which ones support larger goals and objectives. This form of evaluation also occurs when local government planners must gauge the direct compliance of their plans to broader state or federal requirements.

Conversely, the on-going monitoring and the ex post evaluation of plans receive much less attention in general planning practice (Oliveira & Pinho 2010). There are number of reasons cited to explain this shortcoming. The most common include the

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[1] This may also be referred to a “post-hoc” or “retrospective” evaluation (Waldner 2004)

lack of resources –monetary and time –to do so, insufficient skills and data (Talen 1996) as well as organizational cultures that do not place an emphasis on evaluation (Seasons 2003). Calkins (1979) goes so far as to suggest that because proper ex post planning evaluation can bring accountability, certain agencies are disincentivized to undertake evaluation in order to avoid scrutiny.

As with any kind of evaluation, the choice of metrics or indicators is important. Indicators may be large aggregate metrics, somewhat moderately aggregated or finely disaggregated (Oliveira & Pinho 2010). The type of indicator(s) used in planning evaluation should ideally be tailored to the plan itself (Branch 1998). For instance, quantitative measures are only truly meaningful for plans that have goals and objectives that are measurable in a numeric fashion. Less quantifiable plans will require a qualitative, contextual approach to evaluation. In developing an evaluation method or metric, consideration should also be given to the credibility of the potential results, the feasibility given available resources and the level to which the results will be understood by parties not directly involved in the evaluation process (Kaiser et al. 1995).

Finally, plans can also be measured based on their performance or conformance. Plan performance is measured by how well the plan operates as a guiding set of regulations and policies. This type of evaluation examines the output of the planning process –the plan itself –to judge if the plan is indeed functioning as envisioned (Laurian et al. 2010). Measuring plan performance can also involve a larger, more normative assessment in which the plan is examined to determine if it has bettered the community or not (Waldner 2004). Due to the inherent subjectivity of this type of performance-based analysis results can be difficult to reach and/or compare across time and space.

Conformance, on the other hand, examines the outcome(s) of the plan to see if it matches the goals and objectives originally desired (Oliveira & Pinho 2010). For instance, if a plan has the objective of adding X number of affordable housing units in area Y over time period Z, then a measure of the actual growth in units over that time could be used to the judge the conformance of the actual results to the intended outcomes. Like indicators, the choice of a performance- or conformance-based measure (or some combination of the two) depends on the type of plan being evaluated.

In sum, the planning evaluation literature agrees on two things. First, ex post planning evaluation, while incredibly important to the overall process, is notoriously lacking in everyday practice. And, second, plan evaluation methods and metrics need to be designed specifically for the plan being evaluated and should be carried out before, during and after plan implementation.

An Opportunity for PSS

Planning has ridden a wave of changes in governing theory and paradigms shifts since the mid-1950s. From hyper-rational planning of the 1950s and 1960s to the backlash and focus on communication in the 1970s and 1980s, to a time of fragmentation and specialization more recently, the direction of planning has never been clear (Geertman 2006). In a hopeful call to arms, Beauregard (1990) suggests that planners could regain relevance by focusing their efforts around a better understanding of the physical city building process and the relationships and mechanisms that drive it. Twenty years later, Oliveira and Pinho (2010) report that such a change is occurring and that urban form is again becoming the focus of the planning profession. At the same time, governments have, for better or worse, adopted the corporate model of fiscal management in which all spending and resource use must be validated by concrete evidence of efficacy and cost-effectiveness (Seasons 2003). In such an environment, thorough and comprehensive planning evaluation can go a long way in validating the planning profession and ensuring that the necessary resources are continually available in order to properly shape our collective futures.

Overall on-going monitoring and ex post plan evaluation is lacking in every-day practice. Interestingly, a survey of the Planning Support System literature finds that most of the energy and resources are put towards simulation or forecasting studies and/or systems aimed at facilitating public input; both activities which commonly fall under the ex ante evaluation typology. Given these gaps in the current work, an opportunity for PSS exists in aiding planners with on-going plan monitoring and the ex post evaluation of plans.

Many urban plans, goals and objectives call for specific quantitative changes in terms of land use, however, most metrics used to measure the conformance of these plans are available at spatial and temporal scales insufficient for quality evaluation. As a result, the purpose of the methodology presented in this paper is to develop a toolbox-like Planning Support System that can provide planners with a wide variety of information regarding past changes to land use in their jurisdictions. This research provides a flexible PSS able to generate and visualize land use changes for any given spatial extent over any given time frame across a number of dimensions, such as use type, quantity of change and type of change process. The remainder of this paper outlines a general framework, termed the Land Use Change Identification and Analysis (LUCIA) system, for doing so and provides an example using data from the City of Seattle.

Methodology

There are essentially two unavoidable hurdles in any attempt to create a widely generalizable methodology for measuring land use change. First, data availability, quality and specific collection and recording methods vary widely across planning jurisdictions, meaning that specific models developed in one area may not necessarily translate well to others. In other words, the external validity of any given solution to this problem may be quite limited. Second, urban planning policies often have numerous goals and objectives that can rarely be characterized by a single set of indicators or data. I begin this section by outlining how this research addresses these two concerns. Afterwords, a discussion of the general framework, the data requirements and the specific analytical steps of the LUCIA system is presented.

Data Integrity and External Validity

Although geographic information systems (GIS) are decades old and data computation and storage is incredibly cheap, data quality and availability issues still exist. Within the U.S., most major metropolitan areas have well-developed GIS data at the parcel level as well as relevant property information (generally from county assessor's offices) that can be linked to individual parcels. This parcel level data usually includes, at a minimum, information on land use designation, lot size and a variety of data on the structural characteristics of the property. Moving to smaller and more rural jurisdictions, availability and resource constraints (lack of expensive GIS software) may inhibit the data collection exercises necessary to maintain accurate and up-to-date spatial datasets.

In developing a toolbox-type PSS that can be used across multiple jurisdictions, a bigger issue is the conformity of data collection and storage processes. In most U.S. states (Maryland and Florida as exceptions) there is no central depository of parcel-level data and data storage schema may vary at the county or municipality level. Within the U.S. context, a national level parcel database has been proposed and the feasibility of doing so examined (U.S. Dept. of H.U.D. 2013) but the closest thing to its realization has been the development of extensive and proprietary databases by commercial vendors such as CoreLogic and DataQuick.[2] Outside of the U.S. a number of countries, including Australia, Belgium, Germany and South Korea have developed functional national level parcel databases (Schutzberg 2008).

Differences in data collection and storage schematics can create considerable headaches for local planners hoping to adapt an existing PSS to their particular jurisdiction or

[2]For an example, see CoreLogic's ParcelPoint product at www.corelogic.com/ products/ parcelpoint.aspx

area of study. To address this, the Land Use Change Identification and Analysis (LUCIA) system developed in this paper is presented as a broad framework or process that can be adapted to the particular local level. To enhance the external validity of the method, the LUCIA system uses a set of basic data fields and structures that are widely available across counties in the United States and in developed nations around the world. Using basic, ubiquitous data fields limits the necessity for additional data collection, a process that can be expensive and time consuming. Further, the example LUCIA system presented here is developed using R[3] and GEOS[4], two open source software platforms capable of advanced statistical and geospatial analysis as well as two- and three-dimensional mapping. Developing the LUCIA system with open source software commonly used across a wide variety of academic disciplines illustrates the flexibility and accessibility of the LUCIA framework.

Quantitative Focus

The myriad of potential evaluation indicators makes creating a unified quantitative evaluation framework a difficult exercise, or perhaps even an impossible or undesirable one. As Laurian et al. (2010) suggest, a comprehensive evaluation plan should contain theoretical, quantitative and qualitative components. The research presented here focuses on providing a support tool for generating the data that is likely to be necessary in the quantitative/analytical portion of a hypothetical holistic evaluation framework. As there are many potential data to collect and analyze, the question necessarily arises reqarding what data are needed and how a planning support system can best provide these data.

As Beauregard (1990) suggests, the central, unifying thread of planning's many sub-disciplines is the city-building process. Recognizing this, the process I develop here focuses on identifying and analyzing changes to the physical urban form of the

[3]The R Project for Statistical Computing. See www.r-project.org for more information

[4]Geometry Engine: Open Source. See http:// trac.osgeo.org/ geos/ for more information

city over time at the finest spatial scale, the property lot or parcel. By doing so, this process allows users to answer a number of questions regarding changes to the physical structure of the city. To be most useful, this process is flexible both spatially and temporally, as well as able to provide more than counts of housing units or construction permits, for example. A complete list of the goals of the LUCIA system are to:

- Provide analysis at the elemental or parcel level
- Provide analysis over any user defined spatial extent
- Provide analysis over a variety of temporal extents
- Provide analysis over multiple dimensions of land use change
- Output raw data for further analysis
- Output a set of simple analytical tables based on user demands
- Allow for two- and three-dimensional visualization of the data

In short, the goal is to develop a toolbox-type PSS that can answer the question:

> "What changes to the built environment occurred in area X over time period Y broken down by category(s)/characteristic(s) Z?",

where X is any spatial extent (within the jurisdiction in question), Y is any time period (within the bounds of the available data) and Z is a set of dimensions such as land use type, change type and actual physical characteristics. An example of such a question might be: How many existing single family homes were converted to multi-family dwellings in the Oak Park neighborhood from 2005 to 2009? A secondary objective of this system is to produce flexible data analysis and visualization outputs.

Using the terminology of Klosterman and Pettit (2005), it is helpful to define the task and the technique of the LUCIA system. The central task is to provide parcel level information on land use changes in a flexible, yet highly detailed manner. The basic technique of the LUCIA system is one of data aggregation, data analysis and geospatial visualization of existing land use changes. This is primarily a descriptive exercise. The LUCIA instance developed in this paper is designed specifically for ex post plan evaluation, but other related planning functions could benefit from the products of the LUCIA system as well.

In the remainder of this paper I presents an overview of the LUCIA system. In terms of the existing literature on planning support systems, the LUCIA system expands on the parcel-based GIS models (PBGIS) currently developed in order to provide more flexibility and user-controlled analysis and visualization (Moudon & Hubner 2000). It is not intended to be an all-encompassing forecasting model, but rather a small, transparent and intuitive tool aimed at converting existing data into useful information on past land use changes. Within the planning evaluation framework (Laurian et al. 2010), this system is an atheoretical tool focused on creating the information necessary to answer existing questions as well as to provide the stimulus to generate more focused future inquiries.

General Model Overview

Figure 2.1 shows a general overview of the LUCIA system. The remainder of this section discusses the functionality of each of the individual components. In discussing the LUCIA system, I refer to a hypothetical user-defined spatial extent, X, and temporal extent, Y. An example would be a given neighborhood or special planning zone (X) and a given time frame of interest (Y), say, 2005 to 2009. These two inputs to the model are shown in the upper right hand corner of Figure 2.1.

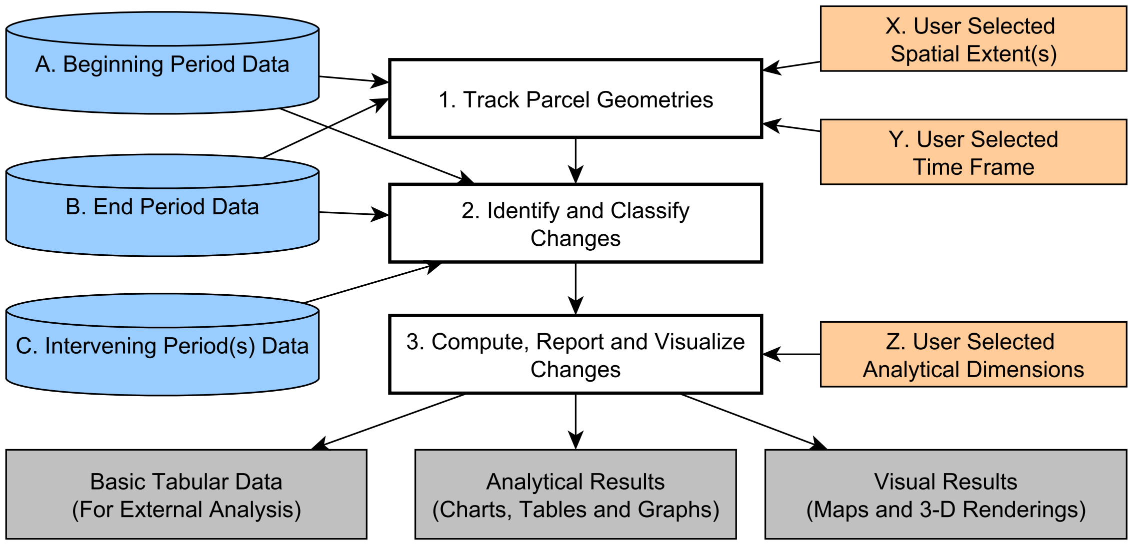


Figure 2.1: LUCIA Process Overview

Data

As noted above, data quality, availability and congruency all present problems when attempting to utilize an existing PSS or other urban model in a new jurisdiction or study area. The LUCIA system described in this paper seeks to limit these issues by relying on a standard set of data types and fields commonly found in jurisdictions across the U.S. and abroad. This use of ubiquitous data greatly increases the transferability of the system. The specific data required are listed in Table 2.1 and discussed more fully below. Some data objects are required for the LUCIA system to function, others are optional and help create improved data resolution or more options for analytical and visual output. These data enter the general LUCIA framework as inputs in the upper left portion of Figure 2.1 under the “Beginning Period Data”, “End Period Data” and “Intervening Period(s) Data” items.

Table 2.1: LUCIA Data Requirements

Data Description	**Importance**	**Type**
Parcel Level GIS Polygons with PIN[5]	Required	Spatial
Land Use Classification	Required	Tabular
Lot Size	Required	Tabular[6]
Structural Size	Required	Tabular
Structural Year Built	Required	Tabular
Number of Living/Commercial Units	Required	Tabular
Structural Footprint	Optional	Spatial
Structural Number of Stories	Optional	Tabular
Zoning	Optional	Tabular/Spatial

- Parcel GIS Polygons: Polygons of individual parcels (property tax lots) form the base spatial dataset of the LUCIA system. These parcel polygons are overlaid and spatially joined via the process introduced in step 1 below. The tabular data attached to the spatial polygons requires only a single parcel identification number field (PIN) that can be linked to the subsequent tabular data that follows. The usual considerations of spatial GIS data, such as projection and coordinate systems, apply here as well.

- Land Use Classifications: Each parcel in the study area (X) must have a land use designation for both the beginning and the end period. Ideally, these classifications will arise from the same typological system. If not, conversions need to be made. Classification systems can be as aggregate or as finely disaggregate as the user desires.

[5]Parcel Identification Number

[6]This may be calculated from the GIS file

- Lot Sizes: Parcel lot size measurements are helpful in tracking parcel geometry changes. This data can be provided in a tabular format or calculated directly using the parcel polygon file(s).

- Structure Size: A measure of the structural size of any building on the property is a necessary input for the LUCIA system.

- Structure Year Built: A variable indicating when a structure(s), if any, was built is also required.

- Number of Living/Commercial Units: To analyze changes in the density of use for a given parcel, the number of functional living or lease-able (in the case of commercial uses) units is required.

- Structure Footprint: Spatial data indicating the structural footprint of the building on the individual parcels is a desired, but optional, data source for the LUCIA system. In the absence of this data, floor-to-area ratios (FARs) can be used to approximate building bulk in the two- and three-dimensional visualizations.

- Structure Number of Stories: Structural height or an indicator of the number of stories of the structure, if any, is a useful data point for the three-dimensional visualization process. This field is not required as a value can be roughly approximated based on total square foot and lot size.

- Zoning Classification: Zoning classifications are also an optional input to the LUCIA system. Zoning classifications allow for additional analysis and visualization but is not required.

At a minimum, each of the necessary data fields are required from the beginning and the end time period. In our example using time period Y, this would require data from both 2005 and 2009. The intervening period data are an optional data source that can improve the accuracy of the LUCIA system, especially in terms of assigning exact time stamps to various land use changes. For example, if a structure was converted from a single family residence to a multi-family rental unit, intervening period data can help pinpoint the exact time that change took place. In the case of new buildings, the year built variable will usually be able to locate the identified change in time. Again, the intervening year data are optional.

Step 1: Track Parcel Geometry

The first step in identifying changes to urban land use is to track changes in parcel geometry over time. There are two central reasons for doing so. First, if parcel numbering systems and parcel boundaries were completely static, this step would be unnecessary. They are not, and in the case of changing urban land use parcels that undergo changes to their geometry are more likely to also see changes to their land use. In other words, instances of parcel boundary changes are indicators of growth and change. In order to properly measure changes over time, the LUCIA system must make a direct comparison between what used to exist on a given spatial geometry and what currently exists.

A second reason for tracking changes to parcel boundaries is the fact that parcelization structures can determine the type of land use changes that are possible and/or more likely to occur in a given area. For example, an existing neighborhood composed primarily of small 5,000 square foot lots that are individually owned will present problems to developers looking to build large apartment, condominium or retail/office structures since lot assemblage (plottage) can be a time consuming and expensive process. On the other hand, converting an area of large lot industrial parcels to densely developed townhomes may prove more difficult due to the lack of existing right-of-ways and other costs associated with land subdivision. Parcelization may, in part, guide future development and understanding and tracking its relationship to past changes is one of the useful data products that can be generated by the LUCIA system.

Changes to parcel geometry over time can take many forms. Six of the most common are shown in Figure 2.2 and discussed below. In Figure 2.2, black, solid boundaries represent the original parcel boundaries at the beginning of the time frame and red, dashed lines represent the new boundaries at the end of the study period. The dashed lines are slightly elevated to allow for visualization. Note that other, more exotic, changes may occur in areas undergoing complete parcel realignments, however, these are rare occurrences.[7] These change types are:

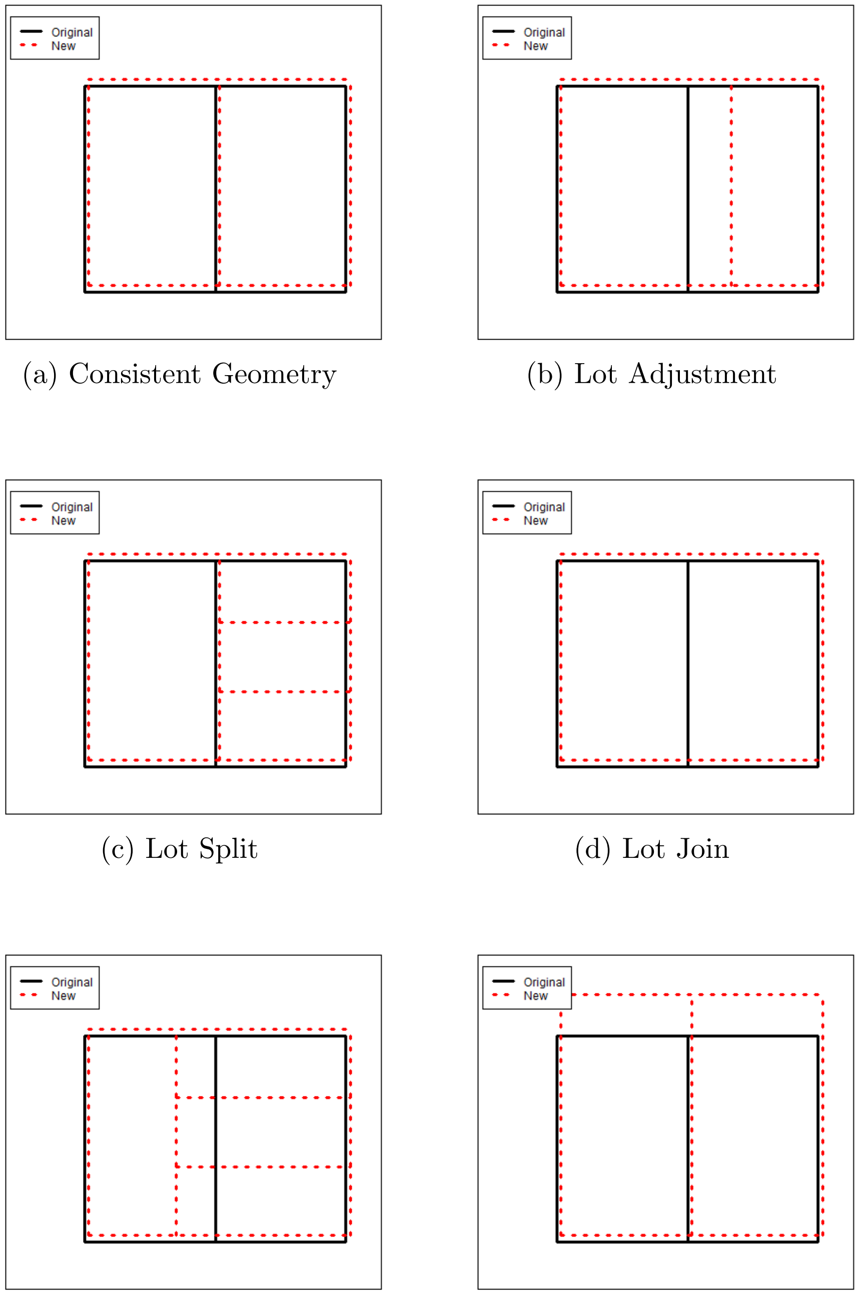
- (a) Consistent Geometry: Parcel boundaries have not changed over time. In most areas of the city not undergoing major development activities consistent parcel geometry is the predominant form of change (or lack thereof).

- (b) Lot Adjustment: Contiguous parcels may mutually agree (if more than one owner) to shift the location of a shared boundary(s). In the figure, the right hand parcel gains size at the direct expense of the left hand lot.

- (c) Lot Split: The right hand lot is split into three, smaller and equally-sized lots. Lot splits in suburban areas often involve traditional land subdivision followed by single family home development. In developed urban areas, lot splits are often followed by townhome, rowhouse or other small multi-family developments.

- (d) Lot Join: In many areas, existing parcels are too small to accommodate the desired development. In these instances, lot joins are common. In the example, the two parcels are combined to create a single, larger lot. Lot joins often precede large apartment, condominium, office and mixed use development.

[7] In a test on the entire City of Seattle these six change types explain 99.85% of changes to all parcels in the City from 2000 to 2012.



(a) Consistent Geometry

(b) Lot Adjustment

(c) Lot Split

(d) Lot Join

(e) Lot Split and Adjustment

(f) Lot Expansion

Figure 2.2: Potential Changes to Parcel Geometry

- (e) Lot Split and Adjustment: Lot splits may also be accompanied by changes to existing and surrounding lot boundaries. Changes like this are most common when a developer is able to purchase two or more contiguous lots and perform adjustments in order to create the maximum number of small lots out of the given geometry of contiguous parcels that they may own.

- (f) Lot Expansion/Contraction: In areas undergoing changes to land use patterns, existing right-of-ways may not be necessary or sufficient to support the current transportation infrastructure. In the example given, the right-of-way to the top of the two parcels has been vacated and that land brought within the boundaries of the existing parcels. A similar process may occur if land is needed for right-of-way expansion and is taken via eminent domain proceedings. In an eminent domain situation, the lots would be contracting and the top boundary (dashed) would shift below the original boundary (solid).

A critical component of the parcel geometry tracking step (1) is to assign links between parcels over the two selected time frames. In the case of consistent parcels (a), boundary changes (b) and lot expansions/contractions (f) parcel identification numbers have not changed over time. This represents a direct one-to-one relationship between parcel geometry and identification numbers from initial to ending period. More complex changes to parcel geometry such as lot splits (c), lot joins (d) and a combination of the two (e) involve one-to-many, many-to-one or many-to-many relationships over time. To manage these types of relationships, the LUCIA system employs a parent-child linking approach.[8] An example, using a lot split, is given in Figure 2.3.

In this example, parcel identification numbers (PINs) in the initial time period

[8]This process combines the some features of the snapshot approach developed by Armstrong (1988, cited in An & Brown 2009) and the space-time model created by Langran and Chrisman (1988).

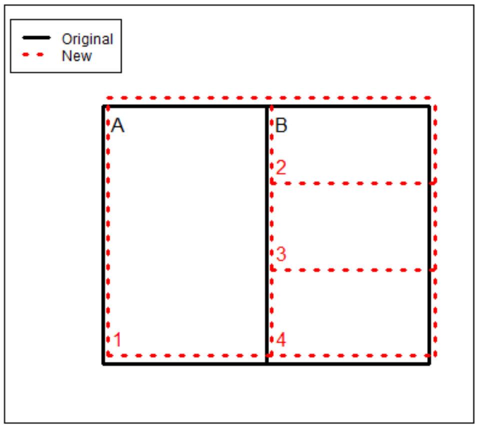
(original) are given as letters (A & B) and those for the ending time period (new) as numbers (1 through 4). Parcel A does not undergo any change to its parcel geometry over time and its relationship with parcel 1 in the ending time period is a one-to-one relationship. As a result, the parent/child of parcel A is parcel 1, and vice versa. Parcel B, on the other hand, has been split into three new parcels (2, 3 & 4) between the two time periods. The parent/child field for the new parcels links back to the original parcel (B), while the parent/child field for the original parcel (B) only links to one of the new parcels in order to maintain the data integrity of that field. In practice, which of the multiple new parcels to link to can be controlled via a simple rule system such as linking to the largest of the new parcels or the first one alphabetically or numerically.[9] This linking process ensures two things: 1) that land uses existing at the initial time period are compared directly to land uses in the same geographic extent in the end period; and 2) that in the case of lot splits, lot joins and more complex changes to lot geometries any changes to land use in terms of size, units and other quantitative measures are not double counted.

Changes in parcel geometry are determined by overlaying the parcel polygons from the beginning and the end year data. A rule-based categorization scheme then places the relationship between the intersecting geometries into one of the change categories. For instance, an end year parcel that overlays three beginning year parcels represents a lot join. Conversely, one beginning year parcel intersected by three end year parcels is a lot split. Some measure of difference between lot boundaries is due purely to data corrections or changes in projections and, therefore, a parameter must be entered to indicate lot line changes not indicative of a true parcel change.[10]

In sum, the purpose of step 1 is to assign a parcel geometry change type (no change, lot split, etc.) and to link parcels that have undergone changes over the time

[9]Note that in some jurisdictions one of the newly created lots may maintain the original parcel number and therefore offers a clear choice in linking procedures.

[10]In the example that follows this parameter is set to 10%.



Parcel Period	Parcel ID	Parent/Child
Original	A	1
Original	B	2
New	1	A
New	2	B
New	3	B
New	4	B

Figure 2.3: Example of Parcel Linking Method

period(s).

Step 2: Identify and Classify Land Use Changes

The second step in the LUCIA system identifies and classifies changes in land use over the selected time period. Changes are identified in a two-step process. First, the required and optional tabular data identified in Table 2.1 are appended to the beginning and end period parcel polygons using the parcel identification number as a link. Second, the actual changes from the beginning period to the end period are calculated to create a number of change-related fields. Here, too, a rule-based classification system is applied to categorize the land use changes into a discrete set of change dimensions.

In cases where lot boundaries have changed and new parcels have been created, the linking procedure described above is employed to ensure that additions and subtractions of units or building sizes are not double counted. Changes in land use can be classified over three separate dimensions: 1) by land use designation; 2) by changes to physical characteristics of the property; and 3) by the type of change itself. If intervening period data is available a fourth dimension, time, can also be used to classify land use changes.

Changes to land use designations are the most obvious dimension of land use change. Examples of this type of change include new apartment construction (converting vacant land to an apartment use), a conversion of a building from office use to retail use or the demolition of a single family residence and construction of a new condominium building. A particular user of the LUCIA system could utilize any number of land use designation breakdowns, depending on the level of disaggregation in their particular data.

Changes to land use may also be examined in regards to the actual differences in the physical structures. For example, many planning goals and objectives are focused on impacting the number of housing units or the number of jobs (a correlate of structural size) in targeted areas. The LUCIA system allows a user to identify and measure changes in living units and building square footage. Other potential measures such as renovations, parking spaces and impervious surfaces may be of interest in given studies and could also be analyzed within the LUCIA framework.

The third dimension of land use change concerns the method used to facilitate the change in use. In other words, did the land use change result from a demolition and a new development (redevelopment) or simply the conversion of an existing structure from one use to another? The land use succession literature (Andrews 1971; Bourne 1971) provides some guidance when classifying change types. Using this work, I have developed six different categories of change types to track in my implementation of the LUCIA system:

- Demolition - change from an improved structure to vacant land

- New Development - change from vacant land to a new improved structure

- Redevelopment - change from one structure to a completely new structure[11]
- Conversion - change in the primary use of the structure[12]
- Expansion/Contraction - change in the size of the structure[13]
- Densification - No change in use or in size, but an increase of units/occupants due to a change in density within the structure

If intervening year data is available, then land use changes across the three previous dimensions may also be broken down by time. The resolution of this temporal analysis will depend on the temporal resolution of the intervening period data.

To summarize, the second step of the LUCIA process compares property characteristics from the beginning and ending time periods to determine the change, if any, in land use and in the physical characteristics as well as the manner in which the change occurred (new building, expansion, etc.). If the time period being studied is sufficiently long and intervening period data are available, this process can also add temporal stamps to the land use changes.

Step 3: Compute, Report and Visualize Changes

The third step of the LUCIA process takes the change information developed in step 2 and produces three separate types of output. The first is the raw data created in step 2. An example of what this raw data might look like is shown in Table 2.2. In this example, records and fields have been suppressed for space considerations and

[11]In highly urbanized areas, the distinction between Redevelopment and a two-step process of Demolition and then New Development is differentiated solely by the time frame of the study. On a long enough time frame, most urban parcels in the private land market will follow Demolition with New Development.

[12]Note that Conversion may be paired with Expansion/Contraction and that the modeler should determine which one is of more concern for the particular study in question.

[13]Ibid.

are indicated by '...'s. This example has been constructed to illustrate the maximum number of potential change scenarios and it is unlikely that any given area of 150 parcels we would expect see this variety of change over the short, four-year time frame being used in this example.

The second output from the LUCIA system is a set of analytical table(s) cross tabulating the various changes to land use across a combination of user-selected dimensions (Z). Finally, the third type of output of the LUCIA system are maps, GIS shapefiles and three-dimensional visualizations of land use changes over the area (X), the time period (Y) and across the specific dimensions of interest (Z). Examples of these cross-tabular analyses and two- and three-dimensional visualizations are given in the fully developed LUCIA example that follows.

Table 2.2: Example of Change Data

Beg PIN	**End PIN**	**Geo. Change Type**	**Beg Land Use**	....	**End Land Use**	....	**Use Change**	**Net Units**	**Net Size**	**Change Type**	**Change Time**
1	1	None	Retail	....	Retail	....	None	0	0	None	0
2	2a	Split	Land	....	Single Family	....	Land to SFR	+1	+1,500	New Constr.	2006
2	2b	Split	Land	....	Single Family	....	Land to SFR	+1	+1,650	New Constr.	2006
3	3	None	Single Family	....	Multi-Family	....	SFR to MFR	+1	0	Densification	2008
4	4	Lot Adj	Retail	....	Office	....	Retail to Office	+2	0	Conversion	2005
5	5	Lot Adj	Office	....	Office	....	None	+3	+2,000	Expansion	2005
6	6	None	Land	....	Land	....	None	0	0	None	0
7	7a	Split	Industrial	....	Retail	....	Ind. to Retail	+1	0	Conversion	2008
7	7b	Split	Industrial	....	Retail	....	Ind. to Retail	+1	0	Conversion	2008
8	8.9	Join	Single Family	....	Apartment	....	SFR to Apt	+45	+35,000	Redevelopment	2007
9	8.9	Join	Single Family	....	Apartment	....	SFR to Apt	0	0	Redevelopment	2007
...	...	...	...	....	...	....	...	...	...	...	...
...	...	...	...	....	...	....	...	...	...	...	...
149	149	None	Single Family	....	Land	....	SFR to Land	-1	-980	Demolition	2005
150	150	None	Single Family	....	Retail	....	SFR to Retail	0	0	Conversion	2008

LUCIA Example

To demonstrate the functionality of the LUCIA system, I have developed a prototype using data from the City of Seattle, located in King County, WA. In the example that follows I examine changes in housing units in Seattle's 12th Avenue Urban Village, a highly urbanized area just east of the downtown core. The location and the boundaries of this Urban Village are shown in Figure 2.4.

The 12th Avenue Urban Village is one of 41 Urban Villages defined by the City of Seattle. These spatially delineated villages are part of an Urban Villages planning strategy that the city adopted in 1994 and has been using ever since. The villages exist in a three-level hierarchy: 1) Urban Center Villages (UCVs) the largest and densest; 2) Hub Urban Villages (HUV); and 3) Residential Urban Villages (RUV). A fourth category, Manufacturing-Industrial Centers are reserved for the city's two largest industrial areas and do not fit into the hierarchy. UCVs and HUVs receive individual housing and employment forecasts, while only housing growth targets are forecast for RUVs. The 12th Avenue Village is an Urban Center Village and is considered part of the First/Capitol Hill Urban Center.

To show the functionality of the LUCIA system, I calculate the actual change in housing units in the 12th Avenue Village over the 2000 to 2012 period. I also conduct a number of additional analyses to take a deeper look into land use change in the 12th Avenue Village by breaking housing unit growth down by year, land use, change process type and size of development. Finally, I illustrate housing unit change using two- and three- dimensional maps and renderings produced by the LUCIA system.

Seattle LUCIA System

The LUCIA framework presented above is intended to be a broad description capable of being utilized in any jurisdiction or context that possesses the minimum data requirements (see Table 2.1). To operationalize this system in a particular location

Figure 2.4: Location Map

a computing environment and a number of other specific parameters must be set. The parameters used to create a LUCIA system for the City of Seattle are described below.

The LUCIA system could be developed in any number of computer languages and/or software packages so long as spatial analysis and three-dimensional plotting are available. I have used the R statistical language to create this Seattle LUCIA system (R Development Core Team 2013). In its basic installation, R does not possesses the necessary geostatistical packages to perform the required analyses. Through use of the `maptools` (Bivand & Lewin-Koh 2013), `sp` (Pebesma & Bivand 2005), `rgeos` (Bivand & Rundel 2013) and `rgl` (Adler & Murdoch 2013) packages, however, R can produce the mapping and three-dimensional visualization show in Figures 2.6 to 2.7 below.[14]

[14]Note, that the functions for plotting .shp files into the RGL viewer are user-created and are available from the author upon request.

The use of the `rgeos` package, which allows for basic geometric and geospatial data analysis such as area calculation, clipping and buffering, requires the use of the GEOS (Open Source Geometry Engine) platform as well. ESRI's ArcGIS software was used to produce the base boundaries files for the 12th Avenue Urban Village and City of Seattle, but is not used in the actual LUCIA system.

Data for the Seattle LUCIA system comes from King County. Current property characteristic data (tabular) are available for download from the King County Assessor's Website.[15] The King County GIS Center provides free downloads of current parcel polygons from its website.[16] Historic data from 2009 to 2012 were collected by the author over that time period. Data prior to 2009 were gathered from the University of Washington Map Library collection or from Runstad Center for Real Estate Studies data archives. Data are available from these sources back to the year 2000. As a result, the study time period for the Seattle LUCIA system runs from 2000 to the end of year 2012.[17]

The LUCIA framework provides the ability to categorize land use changes across a number of dimensions including land use, size of structure and change type. The specific typology that each of these dimensions (or variables) can take is dependent on the local data and/or the specific desires or needs of the analyst or modeler. For instance, King County divides land uses into over 150 different categories. This fine of a classification system is likely too detailed for meaningful analysis in most cases. As a result, a subjective decision must be made by the analyst/modeler as to a whether or not to use this system or to create a more aggregated typology. For the purposes of this example, I have chosen to use the following land use categories (only those relating to housing) in this version of the Seattle LUCIA system: 1) Apartment; 2) Condominium; 3) Small Multi-Family (2-4 Units); 4) Single Family Detached;

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[15]http://www.kingcounty.gov/Assessor.aspx

[16]http://www.kingcounty.gov/operations/GIS.aspx

[17]Note that intervening year data for 2002 and 2003 is missing.

and 5) Townhome. Finally, the LUCIA system is designed to return information on both changes to housing units and to building sizes. The Seattle LUCIA system, as currently set up, returns information on both of these figures, however, the example presented here focuses on housing units only.

In terms of the X, Y and Z framework presented in the methodology section and Figure 2.1, the boundaries of the 12th Avenue Urban Village represent the spatial extent (X), the years 2000 to 2012 represent the user defined temporal extent (Y) and the various dimensions of change (land use, change type, change size and timing of change) represent the characteristics of interests (Z).

LUCIA Tabular Results

I begin by presenting a variety of tabular results generated by the LUCIA system. In each case, the results show the breakdown of changes in housing units over a number of categories in one of the dimensions discussed above (by parcel change type, by time, by land use, by change type and by size). Five different statistics are created for each category:

1. The number of parcels losing housing units
2. The total number of housing units lost
3. The number of parcels gaining housing units
4. The total number of housing units gained
5. The total net change in housing units

The purpose of the tabular analysis that follows is to highlight the capabilities of the LUCIA system and not to perform an in-depth analysis of trends in the 12th

Avenue Village or draw any causal inferences as to the drivers of growth in this neighborhood.

Table 2.3 begins by illustrating the changes in housing units based on changes to parcel geometry. The largest volume of housing unit changes occur on parcels that have not changed shape over the study time period. We can also see from this analysis that parcel joins result in large apartment or condominium structures, while parcel splits often engender small single family or townhome developments.

Table 2.3: Change in Housing Units by Parcel Change Type

	# with Loss	Units Lost	# with Gain	Units Gained	Net Change
Consistent	25	46	29	722	676
Join	0	0	3	92	92
Lot Adjustment	1	1	0	0	-1
Split	7	12	46	46	34
Totals	33	59	78	860	801

Table 2.4 shows the breakdown of housing units changes in the 12th Avenue Urban Village over time, categorized by year. As this table suggests, unit loss is fairly small and consistent over time, whereas unit gains are lumpy and categorized by a few large developments scattered over the time period.

Next, we look at the changes by land use type. Table 2.5 shows that the vast majority of housing units gained in the 12th Avenue Village came in the form of apartment units, while the primary form of lost or demolished units were single family detached and small multiple family units. These results are what can be expected in an inner city neighborhood that is undergoing some measure of urban infill and overall increase in density.

Not surprisingly, when we look at changes based on change type (Table 2.6) we see that most new units are the result of new construction, either in the form of a tear-down and subsequent development (redevelopment) or with new construction on an existing vacant site (new development). Additionally, looking at changes by the

Table 2.4: Change in Housing Units by Year

	# with Loss	Units Lost	# with Gain	Units Gained	Net Change
2000	1	-2	4	124	122
2001	7	-7	7	98	91
2002	2	-2	3	147	145
2003	0	0	5	28	28
2004	1	-1	2	2	1
2005	0	0	9	17	17
2006	3	-5	9	24	19
2007	11	-22	13	107	85
2008	1	-1	6	6	5
2009	2	-3	16	135	132
2010	3	-7	2	8	1
2011	0	0	0	0	0
2012	2	-9	2	164	155
2013	0	0	0	0	0
Totals	33	-59	78	860	801

Table 2.5: Change in Housing Units by Land Use

	# with Loss	Units Lost	# with Gain	Units Gained	Net Change
Apartment	2	-12	16	672	660
Condominium	0	0	7	126	126
Multi-Fm.	12	-28	7	12	-16
Single Fm. Det.	19	-19	2	4	-15
Townhome	0	0	46	46	46
Totals	33	-59	78	860	801

size of the change (Table 2.7), we see that developments with more than 25 units accounted for 645 of the 801 (81%) total net units gained in the 12th Avenue Village.

The Seattle LUCIA system can also create cross tabulated analyses of any two of the five separate analyses shown in Tables 2.3 to 2.7. Table 2.8 shows one example where total units changes by change type are cross-tabulated by time. In this table, we can see that most of the conversion activity in the 12th Avenue Village occurred during the 2003 to 2006 period when real estate prices were at record highs. More

Table 2.6: Change in Housing Units by Process of Change

	# with Loss	Units Lost	# with Gain	Units Gained	Net Change
Conversion	1	-1	7	53	52
Demolition	18	-28	0	0	-28
Densification	3	-4	9	15	11
Expansion	0	0	0	0	0
New Constr..	0	0	21	312	312
Redevelopment	11	-26	41	480	454
Totals	33	-59	78	860	801

Table 2.7: Change in Housing Units by Magnitude of Change

	# with Loss	Units Lost	# with Gain	Units Gained	Net Change
1 to 4	31	-45	60	72	27
5 to 24	2	-14	10	143	129
25 to 99	0	0	6	414	414
100 to 120	0	0	2	231	231
Totals	33	-59	78	860	801

recent growth has been sporadic and generally in the form of new construction or redevelopment.

Visualizing the Results

In addition to the variety of flexible analytical capabilities shown above, the LUCIA system can output and display two- and three-dimensional maps and renderings. The direct exporting of .shp files, commonly used in GIS applications, is also available. Figure 2.5a shows the basic parcel layout of the 12th Avenue Urban Village as of the end of the year 2000. In Figure 2.5b, the location of the new housing units gained over the 2000 to 2012 period is shown, broken down by development size. Any set of information displayed or analyzed in Tables 2.3 to 2.8 can be shown in a map format and/or export as .shp files for use in external GIS software.

Table 2.8: Change in Housing Units by Change Process by Year

	Conv.	Demo.	Dens.	Exp.	New Constr.	Redev.	Totals
2000	0	0	0	0	99	23	122
2001	0	-7	4	0	66	28	91
2002	0	-2	0	0	78	69	145
2003	25	0	1	0	2	0	28
2004	0	-1	0	0	2	0	1
2005	12	0	0	0	5	0	17
2006	16	-2	0	0	0	5	19
2007	-1	-10	0	0	3	93	85
2008	0	0	0	0	0	5	5
2009	0	0	1	0	4	127	132
2010	0	-6	5	0	0	2	1
2011	0	0	0	0	0	0	0
2012	0	0	0	0	53	102	155
Totals	52	-28	11	0	312	454	801

(a) 12th Avenue Parcels, 2000 (b) New Housing Units by Size, 2000 to 2012

Figure 2.5: LUCIA Mapping Options, 12th Ave UV Example

The LUCIA system can also show spatial features in three dimensions, helping to visualize bulk and approximate building sizes.[18] In Figure 2.6, a section of the village is shown as of the year 2000. In Figure 2.7, a smaller portion of the village is shown, with the structures containing new housing units highlighted. Parcel lines from the maps in Figure 2.5b are drawn for orientation. This image is a snapshot of the three-dimensional output from the `rgl` viewer in R. A user of the system can zoom and navigate around this environment to observe these changes from any angle or magnification.

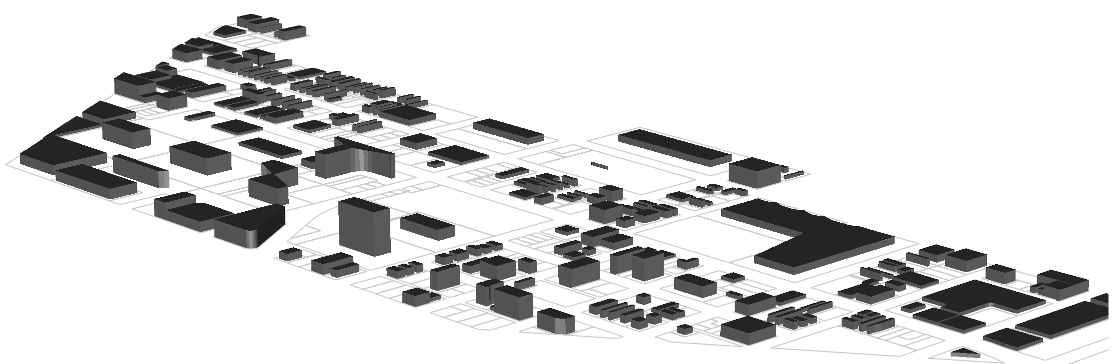


Figure 2.6: 3-D View as of 2000

[18] Note that in this Seattle LUCIA system, buildings are drawn to an accurate overall bulk (height and footprint based on building sizes and stories) and placed at the center of the parcel polygon. These three-dimensional figures do not represent actual building design or placement.

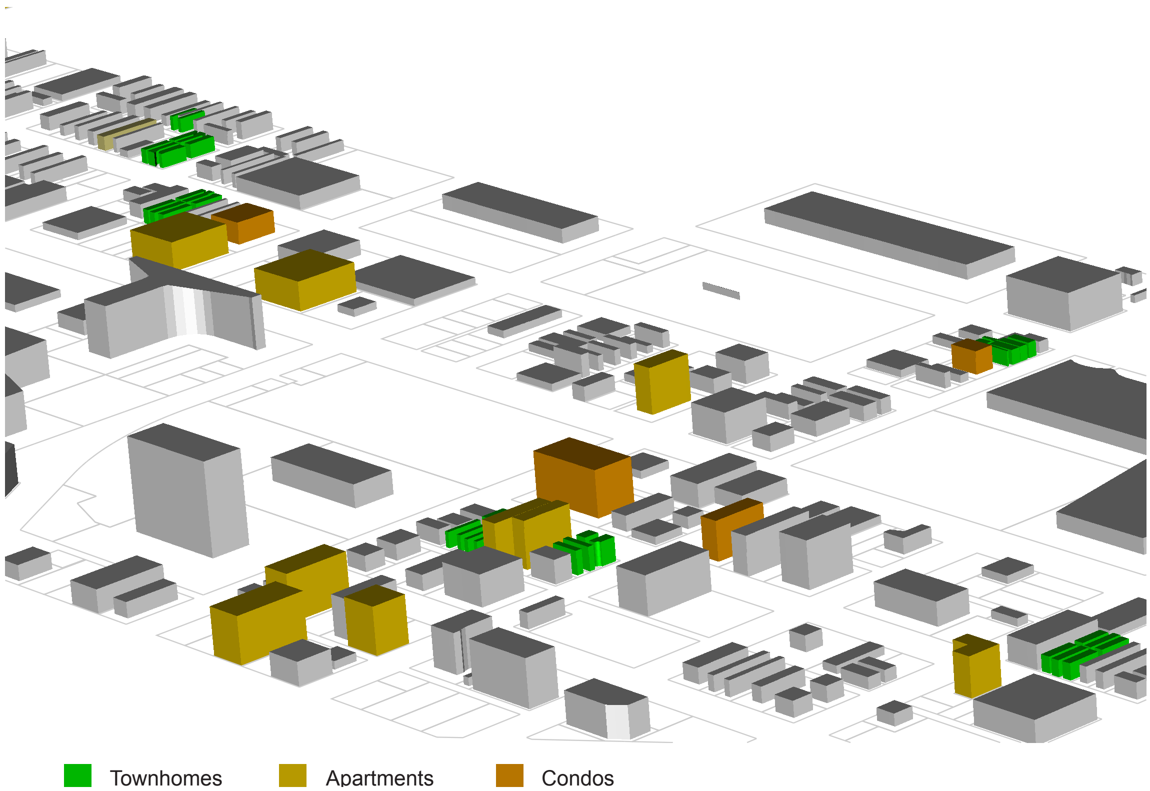


Figure 2.7: 3-D View as of 2012, New Housing Units Highlighted

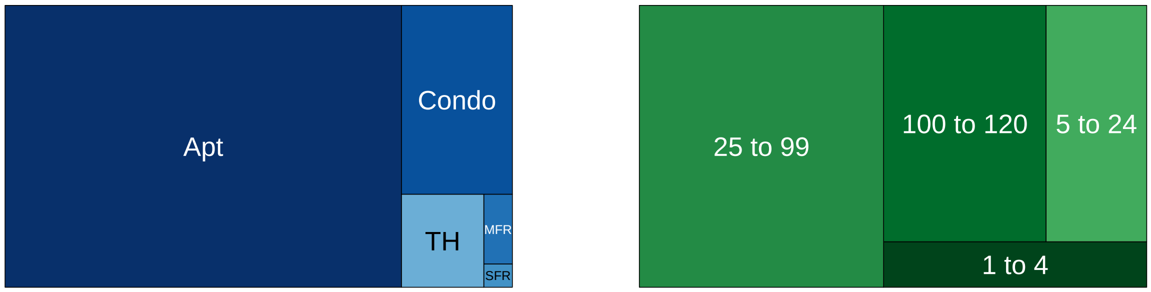
Plan Evaluation with the LUCIA System

As the literature notes, the ex post evaluation of plans is a critical step in the planning process and one that too often is ignored. One factor contributing to this deficiency is the lack of adequate data with which to properly evaluate planning outcomes. The products of the LUCIA system offer an opportunity to fill this void in the case of plans that proscribe some form of land use change.

The Seattle Urban Village (UV) strategy is one such plan. A response to the State's Growth Management Act (GMA) of 1991, the UV strategy seeks to focus urban growth within existing high density areas, the urban villages. Each village has separate housing unit growth forecasts, updated every ten years. By using the LUCIA system, the existing analysis done by the city (Seattle DPD Data Warehouse 2013) can be expanded to include net changes as opposed to simple permit counts as well as the addition of context to the analysis by examining housing unit growth over a variety of dimensions.

Interpolating the revolving 20-year housing unit growth forecasts from the 1994 and 2004 comprehensive plan updates shows that an additional 440 housing units were targeted for the 12th Avenue Urban Village over the 2000 to 2012 time period. As Tables 2.3 to 2.8 above illustrate, the village gained nearly twice that many housing units, 860, over this time period. From an evaluation standpoint, actual growth could be considered conforming to the planned growth for the area, if exceeding totals is a desired occurrence. The LUCIA system allows for consideration of the number of housing units lost (59) and, therefore, can examine net growth in units. Subtracting out the loss of the 59 demolished units, net housing unit growth in the urban village reduces down to a gain of 801 units, still much higher than forecast for this period.

This growth can be examined across a number of dimensions. In Figure 2.8a, we see that most growth in the 12th Avenue Urban Village has come in the form of apartment buildings, with condos making up the second most commonly added unit type. Over three-fourths of the growth in units is located in developments of at least 25 units in size (Figure 2.8b). While the existing UV strategy forecasts do not break growth targets down into unit type and size, it is possible that related planning goals and objectives seek to maintain certain balances of housing unit types and development sizes. The data output from the LUCIA system can further evaluation of these additional objectives. Finally, as planning has increasingly become more open to public engagement, the two- and three-dimensional outputs of the LUCIA system can help facilitate information exchange between planning officials and the general public.



(a) Units Gained by Use

(b) Units Gained by Size of Development

Figure 2.8: Housing Unit Change Dimensions

Conclusions and Future Research

Planning support systems have shown consistent growth in the academic literature over the past two decades, with most of the work being directed at large-scale land use and transportation simulation and forecasting models. While this level of complexity is often necessary in developing accurate forecasts, she adoption of these models by practicing planners, however, has been less than encouraging (Vonk et al. 2005). Research into the causes for the poor diffusion of PSS technology suggest that planners often do not know about existing models, or when they do, feel that the models are too complex and not transparent enough to be useful in everyday planning practice (Brommelstroet 2010).

The ex post evaluation of existing plans, while considered an important component of the planning process, is often avoided or ignored due to limited resources, administrative culture or lack of data (Seasons 2003). This research presents one option to addressing issues of data availability for ex post plan evaluation dealing with land use change. A tool-box type planning support framework, the land use change identification and analysis (LUCIA) system, has been constructed to offer a flexible, user-friendly system for analyzing land use change. In direct contrast to much of the

PSS literature, this model is merely descriptive, not predictive, and it operates at the parcel scale allowing for the level of detail often necessary to evaluate plans in highly urbanized areas. The LUCIA system was first described as a general framework that can be applied to any geographic area or context where a standard set of data exists. To shows its potential use, a specific LUCIA system for the City of Seattle was developed and presented.

Developing this system shows that reasonable data requirements exist in order to create a system capable of producing base data for additional analysis, providing tabular analysis and presenting two- and three-dimensional data visualization. The Seattle LUCIA is programmed in open source software and uses data readily available to the public.

The existing large-scale PSS models have a place in urban planning and are likely to gain acceptance over time as planners become more comfortable with using these complex models. Certainly, they hold great promise for long range planning. Planners could also benefit from smaller and simpler tools to help them properly analyze and visualize existing data, not to mention aid in the ex post plan evaluation process. The LUCIA framework presented here offers an example of how existing data combined with open source software can present a usable and transparent spatial analysis tool.

The current version of the Seattle LUCIA system is a first generation prototype. Some future improvements include using building footprint, remotely sensed and/or contour data to improve the three-dimensional building renderings and adding in building permit data to show the likely changes in the near future. Another supplement could be the addition of real estate transaction and value information to provide planners and other users with indicators of market activity and potential changes in highest and best use.

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Chapter 3

PART II: AN EX POST EVALUATION OF HOUSING GROWTH UNDER SEATTLE'S URBAN VILLAGE STRATEGY

Abstract

The comprehensive Growth Management Act (GMA) enacted by the State of Washington in the early 1990s calls for intensification of existing urban areas as an alternative to continued low-density, peripheral growth. In response to the GMA, the City of Seattle developed and implemented an Urban Village strategy. Composed of 41 spatially-delimited villages targeted for intensification, the program is generally lauded as a success. From a strict plan evaluation standpoint, however, the merits of the Urban Village strategy remain largely unknown. This research applies a conformance-based, ex post plan evaluation analysis on housing unit growth in the urban villages to provide measures of the efficacy of this strategy. Using LUCIA, a planning support system, to derive detailed statistics on housing unit growth I find that, in aggregate, the urban villages have exceeded targeted levels of housing unit growth for the 2000 to 2012 time period. In terms of relative housing growth, differences between areas inside and outside of the urban village boundaries appear to be little affected by the strategy, calling into question the efficacy of the UV strategy in concentrating growth.

Introduction

Washington, like many states during the 1990s, passed a Growth Management Act (GMA) aimed at focusing future development into existing urban areas as opposed to continued low-density expansion often characterized as "sprawl." For municipalities on the fringe of the Puget Sound region, the GMA meant the imposition of an urban growth area (UGA) boundary in or near their community along with a host of other regulations aimed at managing new, greenfield growth. In the more centralized areas of the metropolitan region like the cities of Seattle, Tacoma and Bellevue –those with little remaining vacant land –the GMA necessitated planning to accommodate the growth now targeted for these existing, densely developed areas.

In response to the GMA and to calls for more vibrant urban places the City of Seattle implemented an Urban Village (UV) strategy in the mid-1990s. This program remains in effect today. The primary goal of the UV strategy is to purposefully direct growth into delineated, higher density areas –the urban villages. A secondary objective is to protect the surrounding single family residential areas from intensification and its potential externalities (City of Seattle 2004). Although the program has been in place for nearly 20 years and has generally been considered successful (Fox 2010), on-going evaluation of its actual performance in meeting its stated goals is lacking.

In other words, there exists no deep, quantitative evaluation of the Urban Village strategy, as planning practice suggests should occur (Alexander & Faludi 1989; Baer 1997; Branch 1998) and which the plan itself mandates (City of Seattle 2004). This lack of direct evaluation of the Urban Villages strategy, however, comes as no surprise. As the planning literature clearly demonstrates, thorough ex post evaluation of planning outcomes is commonly absent from most urban planning practice. (Calkins 1979; Talen 1996b; Laurian et al. 2010). The causes of this systemic shortcoming are many fold, ranging from economic and technical to political and strategic. (Talen 1996a; Seasons 2003).

As Waldner (2004) and Alexander (2009) note, plans can vary widely in the degree to which they can be adequately evaluated. The outcomes of strictly physical plans (changes in housing, parks, road miles, etc.) are more easily assessed in a quantitative framework than plans imbued with social goals as well (such as raising resident quality of life). Seattle's Urban Village (UV) strategy, while offering a number of wide ranging goals, does propose discrete, quantifiable changes to the physical built environment and, therefore, is a good candidate for empirical ex post plan evaluation. This paper uses a conformance-based measure of ex post plan evaluation to test the efficacy of the UV strategy in meeting one of its stated objectives: concentrating housing unit growth.

Past published analyses of the UV strategy by city officials have been engaged only sporadically and have used highly aggregated census data to measure changes to the built environment in and around the villages (City of Seattle 2003). Internal data maintained by the city does monitor housing unit growth over time by village, however, a number of shortcoming exist in this data (City of Seattle 2013). First, existing growth figures are based on permit data and do not account for net changes in overall units (ignores demolition). This data also does not account for market vacancy rates when comparing housing unit figures to forecasts for households. Finally the relative growth of villages is not compared against overall growth in the city.

Drawing on the Planning Support System (PSS) literature, this paper expands the capability of analysis with a Land Use Change Identification and Analysis (LUCIA) system that measures and analyzes land use changes at the parcel level (Krause 2013). The LUCIA system allows for the identification of changes in housing units across a number of dimensions including type of units added or lost (apartment, condo, townhome, etc.), mechanism for adding units (new construction, conversion, etc.), size of units and time of change (by year).

This paper begins by discussing plan evaluation theory, methods and empirical evidence from the literature. The second section presents some background of the Urban Village (UV) strategy and the types of goals and objectives it proscribes for the future. Following this, an overview of the study area, the data used and the LUCIA system are given. The fourth section presents the results of the evaluation. The paper concludes with an overview of the findings and suggestions for further research.

Background

The Evaluation of Urban Planning

Plan evaluation can occur at any step during the life of a plan. More specifically, plans can be evaluated during the plan development stage (ex ante), while the plan is being used (monitoring) or after the period of time in which the implemented plan has been applied (ex post). Ex ante evaluation involves two main exercises: 1) Determining if a proposed plan meets the requirements of higher level plans and/or existing enabling legislation; and 2) Comparing the merits of a number of alternative plan scenarios against an agreed upon set of goals and objectives. This second form of ex ante evaluation may include intensive data collection, complex simulation studies and extensive input from stakeholders and the public at large (Kaiser et al. 1995). In short, ex ante evaluation is a major component of the basic plan-making process. As a result, it is no surprise that the ex ante form of plan evaluation is the most common type (Oliveira & Pinho 2010).

As Harris said, “Planners make plans” (1989, p. 86), and once a plan is complete there are inevitably more plans to be made. For this reason and a number of others (discussed below), the on-going monitoring of plans and the thorough ex post evaluation of plans after their useful implementation is complete occurs much less frequently than ex ante evaluation (Oliveira & Pinho 2010). It is this type of evaluation –monitoring and ex post –that are the focus of this paper. For simplicity sake, I will lump them together under the term “ex post evaluation.” This term will refer to any evaluation that occurs after the plan has been produced and enacted, either legislatively or administratively. Under this definition, an ex post evaluation could occur sixty days after a new parking plan has been introduced or sixty years after a comprehensive plan has been enacted.

The feedback gained from the ex post evaluation of plans is a key information source in the planning process (Branch 1998). Despite this, over thirty years of research into the ex post evaluation of urban plans overwhelming suggests that comprehensive plan monitoring and evaluation is notorious absent in practice (Calkins 1979; Talen 1996a; Seasons 2003; Laurian et al. 2010). The causes for this shortcoming range widely, however, the consequences of it may threaten the very legitimacy of the planning process (Alexander & Faludi 1989). The remainder of this section examines what forms ex post evaluation can take, why it often fails, how it can succeed and why ex post evaluation is important to the health of the planning profession.

Conformance vs. Performance

Ex post evaluation can take a conformance or performance approach (Talen 1996a; Laurian et al. 2010). Waldner (2004) has termed these two approaches Little E (conformance) and Big E (performance). Conformance-based evaluation entails comparing the actual results of a plan with the proposed changes. Talen (1996a) presents an example of a conformance-based evaluation when she compares the siting of new parks in Pueblo, CO with the plans for new park placement. Conformance-based approaches seek to answer the following question: How well does what occurred match up to what was planned?

Conformance based approaches appear simple enough –compare A to B –but do maintain some complexities. The most difficult aspect of conformance-based evaluation is determining how much of the actual outcome is a direct of product of the plan and how much occurred through the market or other factors. In setting up his Planning Monitor system, Calkins (1979) breaks all change down into planned changed, forecast change and unplanned changed. In other words, there is some measure of change that is expected to happen regardless of the plan (forecast change), some measure that the plan is designed to create (planned change) and the remainder which is a result of an unknown process that has occurred between the plan implementation and the time of evaluation. In the linear algebraic formulas that Calkins derives, these breakdowns of change function wonderfully, however, in reality is it much more difficult to separate changes to the built environment into these simple categories.

Evaluation by conformance may also seek to compare actual results against either the planned change or against a hypothetical situation in which no plan was enacted, also known as a null scenario (Baer 1997). Similar to the issue of dividing up change into planned, forecast and unplanned, comparing actual results to a hypothetical null scenario can be incredibly difficult in a situation where a number of factors influence a very dynamic system (the city). Both of these suggested comparison approaches suffer from the inability to assign causal impacts to planning interventions (Waldner 2004), no small task in a highly complex environment such as a major urban area. This issue of causality remains a major impediment in efforts to single out the effects of plans through a conformance-based evaluation approach.

However, even when causality cannot be properly established, conformance-based ex post evaluation remains a worthwhile planning exercise. No land use plan being evaluated is a stand-alone document, but rather each exists as one component of a larger set of interrelated planning activities. As a result, deviations from planned change may easily propagate throughout the entire system of plans. For example, significantly greater employment growth in a given section of a city, say a port facility, whether directly related (causally) to the economic development plan or not will still have consequences for other related plans, such as transportation, public utilities and housing programs. In short, establishing a direct causal link between observed changes and plans is the gold standard in conformance-based plan evaluation; however, the timely identification of deviations from plans, causal or not, can contribute greatly to the overall city- or region-wide planning process.

Performance-based, or Big E, evaluation asks a broader set of questions: Was the plan used in the manner in which it was designed (Laurian et al. 2010)?; or Did the results of the plan create a better community (Waldner 2004)? The first of these questions seeks to determine if the plan, as a guiding document, engendered the decision-making processes as envisioned. Was the plan consulted during the process and were the regulations and incentives of the plan important considerations of the decision-makers? This form of evaluation accepts that uncertainty and exogenous forces may render highly objective goals impossible to meet and, instead, attempts to measure if the plan itself helped shape decision making (Mastop & Faludi 1997). Retreating to more subjective (and possibly normative) comparisons is not without its difficulties. Recognizing this, Alexander and Faludi (1989) develop a many-step evaluation process aimed at combining some measure of objective, conformance-based evaluation with more subjective and contextual performance-based measures. While often cited, this comprehensive approach does not appear to have been used in its entirety in any existing, published evaluation study.

The second form of performance-based evaluation inquires after a highly normative answer; whether or not the plan improves the area in which the planning occurs. Overall, evaluating plans that have a contextual and/or normative goal can prove difficult or impossible (Alexander 2009). However, if specific indicators aimed at measuring the normative quality of 'improvement' can be created, then a realistic evaluation framework may be developed. As a result, the use of indicators has become a common practice in studies seeking to evaluate the performance of a plan(s) in terms of its overall impact on the community (Oliveira & Pinho 2010).

Why Evaluation is Lacking and How to Make it Less So

As continuously noted by urban planning scholars, ex post evaluation in planning practice is systematically lacking (Calkins 1979; Talen 1996a; Seasons 2003; Laurian et al. 2010). A number of reasons for this exist. The first set of factors hindering ex post evaluation are resource-based. Simply put, planners do not have the time and/or the budget to adequately evaluate existing and previously implemented plans (Seasons 2003). In an era of shrinking governmental budgets and hiring freezes, this lack of time and financial resources with which to evaluate plans is a significant hurdle. A related, resourced-based issue is that despite the prevalence of Geographic Information Systems (GIS) and cheap computer storage and computing power, many planners still lack the necessary data to properly perform planning evaluations (Talen 1996a; Seasons 2003). A sub-field of GIS, termed Planning Support Systems (PSS), have arisen to help fill this gap, however, the diffusion of PSS technology from academic development to practical use has, unfortunately, been somewhat minimal (Vonk et al. 2005). In short, resource constraints in the form of time, money and data shortages plague the ex post evaluation of plans.

Outside of resource constraints, other organizational and political factors may hinder efforts to evaluate plans. With evaluation comes accountability (Calkins 1979) and many planning organizations may see a critical evaluation of their previously implemented and current plans as an attack on their credibility. If the outcomes of evaluations are uncertain, the process is expensive and may lead to a diminished view of the organization whose plans are being evaluated, it is easy to see how evaluation can become increasing dis-incentivized (Waldner 2004). The planning process and the operation of a planning organization are highly politicized actions and in the battle for resources and influence with decision-makers no evaluation may prove to be better than an unfavorable one.

Even in the presence of necessary resources and in an organization willing to do so, plan evaluation may still prove difficult due to the plan itself. As the scope of traditional urban planning has expanded, so to has the type of plans being generated. Common planning products such as land use and transportation plans often offer very clear goals in terms of objective and measurable metrics. Conversely, plans aimed at enhancing sustainability, protecting cultural resources or furthering human development, as examples, are not so easily quantified and are more difficult to accurately evaluate. As a result, some plans are more amenable to evaluation than others (Seasons 2003), and those most amenable generally concern direct, measurable changes to the built environment.

Resource shortages, organizational or political factors and the plans themselves all contribute the lack of ex post plan evaluation in practice. The biggest avenue for improvement in this direction has come from the realization that ex post evaluation criteria and requirements should be established during the plan development stage (Talen 1996a). Explicitly including the type of evaluation and the manner with which it must occur into the plan itself can help eliminate a number of issues once the plan is implemented. When evaluation is written into the plan, organizational budgeting must account for evaluation ahead of time, rather that relegating it to an activity that is undertaken only during times of budgetary surplus. As such, staff time will be allocated for evaluation and the necessary data can be gathered and compiled over time (or a method to do so can be created). Including evaluation requirements directly in the plan also allows outside groups and stakeholders to apply pressure (legal, if necessary) to planning organizations to undertake evaluations even when these organizations are disincentivized to do so. Finally, by setting up evaluative criteria and processes at the time of the plan, the method of evaluation can be directly tailored to meet the intended goals and objectives of the plan originators as opposed to being created by an outside party many years (or decades) afterwards. Similarly, developing an evaluation framework during the planning process will force planners to produce plans that are more amenable to evaluation. In Alexander's (2009) terms, this means creating plans with very specific, positive (objective and measurable) teleologies as opposed to those with normative and instrumental (more subjective) ones.

At a smaller scale, technology may also help improve the field of ex post evaluation. As mentioned above, an ever expanding set of planning specific data generation, analysis and visualization models have been developed both academic and commercially to help enhance the ability of planners to do their jobs. Termed Planning Support Systems (PSS), these models vary widely from complex simulation software, to technology aimed at increasing public participation and even small, tool-box type models and systems with very focused functionalities. While full-fledged adoption by practicing planners has been limited (Vonk et al. 2005; Geertman & Stillwell 2009), the increasing availability of data and the improved user-friendliness of PSS speak to great potential in this area (Klosterman & Pettit 2005). Technology, in the form of increased dissemination of public information, including the specifics of plans, enables a much wider variety of interested groups and individuals to access and analyze plans and data. This movement towards more open access to government data and the political pressure that it can create has the potential to force the hand of organizations reluctant to evaluate and/or help shape forthcoming plans to be more conducive to future evaluations.

Moving from specifics to a more general sense, plan evaluation is an incredibly important exercise in bolstering the credibility of the planning process (Alexander & Faludi 1989). As many legislative bodies (the primary funders of planning activities) move to a more corporate governance model in which entities must prove their worth through objective means (Seasons 2003), evaluation becomes increasing critical to securing continued funds for planning. As Bryson (1991) notes, we must legitimize planning, and evaluations showing successes, failures and ways to improve can go along way in this legitimizing process.

Summary

Funding issues aside, the timing for improved ex post evaluation may be right as well. Urban planning has gone through a number of paradigm changes in the past 60 years, from strict rational planning to a more communicative/collaborative focus to what might be categorized as an incremental approach in the present (Beauregard 1990; Geertman 2006). With it, evaluation types have changed, from strictly objective measures to evaluation of planning processes to indicator-based methods. Near and long term issues of sustainability, climate change and the relationship between public health and urban form all point to an increasing concern with the physical built environment and its role in our society (Oliveira & Pinho 2010). For planners, it is these types of plans –those dealing with the physical urban form –that are the most conducive to evaluation.

In sum, ex post plan evaluation, though a critical part of the planning process, is systematically lacking in practice. Evaluation can take a number of forms, roughly divided between conformance and performance-based measures, each with its strengths and weaknesses. Regardless of the type of evaluation, resource shortages, political disincentives and plans themselves all create hurdles in the evaluation process. Careful plan design and new technology, however, can help overcome these limitations. Finally, plan evaluation can be seen as important legitimizing action for the field of planning and should command increased attention in the future.

Seattle's Urban Village Strategy

In the early 1990s a 'second wave' of state level planning initiatives focused on controlling peripheral urban growth swept the country (Weitz 1999). Although the specifics varied by state, this set of regulations and policies can be best labeled as Growth Management. Along with Georgia and Maryland, Washington was one of the first to enact comprehensive, state-wide Growth Management legislation. Passed in the 1990 and amended in 1991, the stated goal of the Washington Growth Management Act (GMA) is:

> *(T)o provide the authority for, and the procedures to be followed in, guiding and regulating the physical development of a county or region through correlating both public and private projects and coordinating their execution with respect to all subject matters utilized in developing and servicing land, all to the end of assuring the highest standards of environment for living, and the operation of commerce, industry, agriculture and recreation, and assuring maximum economies and conserving the highest degree of public*

health, safety, morals and welfare (WA RCW 36.70.010).

This overarching, primary directive is highly normative in nature and, from an evaluation standpoint, imbued with subjective goals and ideals. Out of this legislation, however, came a number of more operable policies. These included, but are not limited to, mandated comprehensive planning, designation of urban growth areas and urban centers, standardized permitting processes and transportation concurrency requirements.

Much of the impetus behind the GMA was the aim of controlling sprawl –a concept for which a true definition remains elusive (Galster et al. 2001). As a result, peripheral suburbs and growing edge cities (Garreau 1991) experienced the most significant changes in development policy. Another important consequence of the GMA was the targeting of new growth for existing areas, a process often referred to as urban intensification (Williams 2001). For the constrained and mostly built-out central city of Seattle, this meant planning for an influx of more jobs and residents within the existing city boundaries.

The process of urban intensification can be accommodated through a multitude of plans and development patterns. On one extreme would be a plan that encourages a slight intensification across the entire city; at the other would be very focused intensification in the central business district (or other designated growth node) combined with no changes in other locations. These two polemics could be described as dispersed and concentrated urban intensification, respectively. Between them, a continuum of dispersion/concentration exists and is likely where any actual intensification plan would fall.

Seattle is often described as a city of neighborhoods (City of Seattle Website 2013). Outside of the central business district, the city contains many small- to medium-sized commercial centers surrounded by moderate density housing. Single family residential areas fill in the spaces between these neighborhood centers. Eager to maintain the neighborhood character of the city, yet also accommodate the additional growth mandated by the GMA, city officials developed an Urban Village strategy in the early-to-mid 1990s.

The Urban Village (UV) strategy was implemented as a central component of the City's Comprehensive Plan, passed in 1994, updated in 2004 and still currently in place. The primary goal of the UV strategy is to focus future growth into spatially delineated "urban villages" –areas of existing density, transit and necessary infrastructure –while maintaining the low density character of the surrounding residential neighborhoods. In terms of the urban intensification dispersion/concentration continuum, this plan represents a moderate level of concentration, though facilitated in a spatially dispersed fashion.

Specifics of the UV Strategy

At the core of the UV strategy are the 41 spatially-delimited "urban villages", the locations of which are shown in Figure 3.1. These villages are divided into four types:

- Urban Center Villages (UCV)
- Hub Urban Villages (HUV)
- Residential Urban Villages (RUV)
- Manufacturing-Industrial Centers (MIC)

The first three types of villages exist in a broad hierarchy, with the Urban Center Villages representing the most densely developed areas and the Residential Urban Villages as the least dense. The two Manufacturing-Industrial centers are very different from the other Villages and consist of heavy industrial and marine-based land uses.

As Figure 3.1 shows, the Villages are spread widely throughout the City of Seattle. The Urban Center Villages (UCVs) are concentrated downtown as well as near the

University (north-northeast of the CBD). The Northgate UCV in the far north of the city represents the outlier to this spatial trend. The Manufacturing-Industrial Centers (MICs) are located in the Duwamish Valley (Port of Seattle) and the Ballard/Interbay area. Both are are large, flat plains offering access to port facilities and/or interstate highways. The Hub and Residential Villages are the most widely dispersed across the city, representing old settlements annexed by Seattle in the early 20th century (Fremont and Ballard) as well as smaller neighborhood centers such as Greenwood and Rainier Beach. By land area, the urban villages as a whole represent about 30% of the City, with the two MICs making up the largest component at 13% (Table 3.1)

Table 3.1: Percent of City Land Area by Village Type

Village Type	Percent of Land Area
Urban Center Village (UCV)	7%
Hub Urban Village (HUV)	3%
Residential Urban Village (RUV)	7%
Manufacturing Industrial Center (MIC)	13%
Non-Urban Village Area	70%

The original UV strategy is defined and discussed in the 1994 City of Seattle Comprehensive Plan (City of Seattle 1994). Updates to the UV strategy are contained in the 2004 Comprehensive Plan (City of Seattle 2004). The original and updated plans list dozens of goals and objectives supporting the UV strategy, most of which are related to the primary goals of focusing growth in existing areas and protecting surrounding low-density development. Along with these goals and objectives are set of village-specific targets for both household and employment growth.[1] Growth targets are presented as 20-year targets and include estimates for the city as a whole, each type of village, each individual village and for non-urban village (NUV) areas. The 2004 update to the comprehensive plan, also updated the 20-year growth targets,

[1]Note that no employment targets are given for Residential Urban Villages (RUV) and no household growth targets for the Manufacturing-Industrial Centers (MICs)

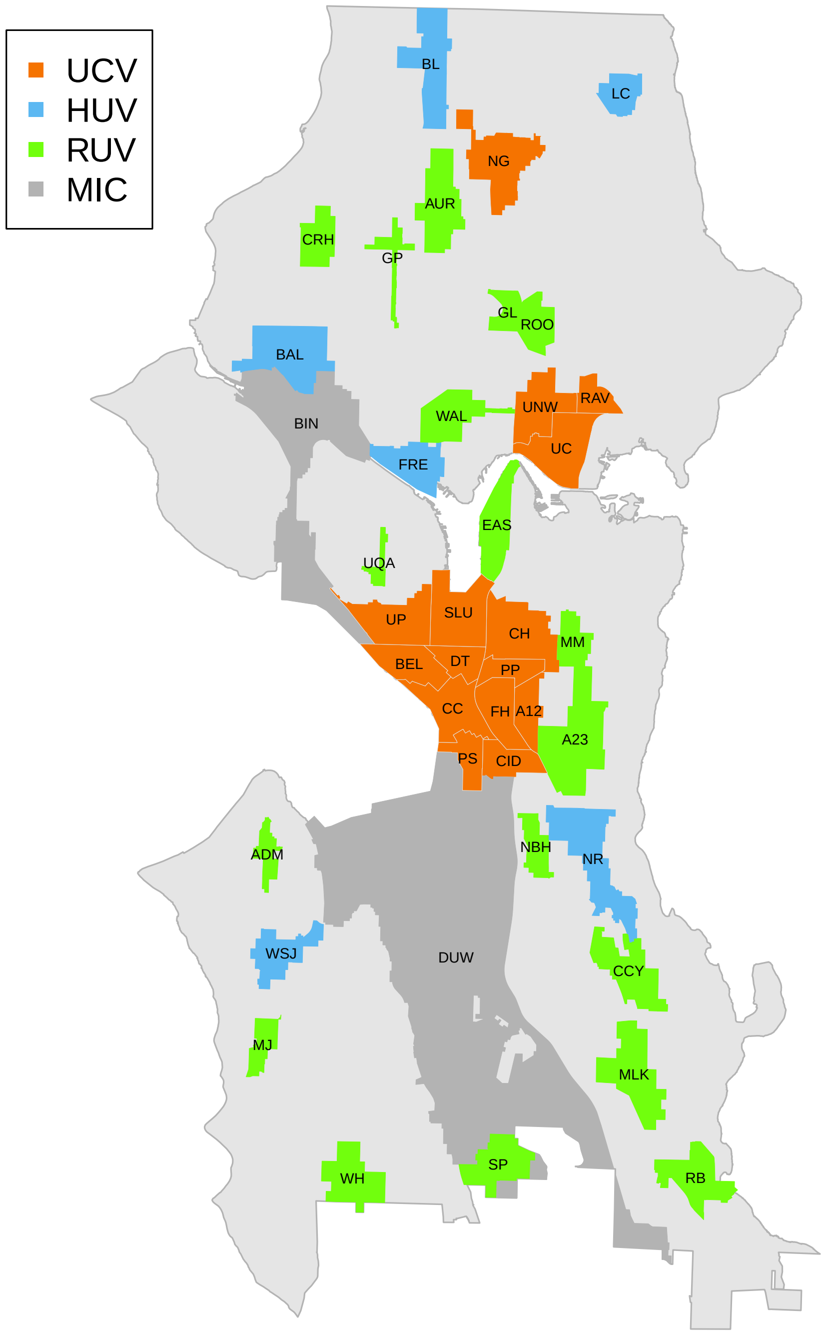


Figure 3.1: Urban Village Location Map

whereby the 1994 plan targets ran from 1994 to 2013, the 2004 targets cover the 2004 to 2023 period. Targets are presented as both absolute values (number of households and jobs) as well as in relative terms (% of overall growth in the city). The relative targets are explicitly presented in aggregate form at the UV classification level (UCV, HUV, RUV and MIC), but can be converted to a village-specific estimate using the existing absolute targets.

The growth targets for the individual urban villages are derived as a component of larger, county-wide growth forecasts that are estimated by the Puget Sound Regional Council (PSRC) and other state-level organizations. Growth allocated for the City of Seattle is then broken down into finer growth targets for the individual urban villages based on existing zoning capacity, the village type and the neighborhood plans (City of Seattle 2004). Specifically, growth targets are designed so that each target represents no more than 80% of total allowed growth in that village as based on current zoning designations. As overall village density approaches the 80% threshold, considerations for re-zoning are addressed through the existing neighborhood planning process. Additionally, existing density levels, transportation facilities and the known growth plans of large institutions are also considered in the development of the growth targets (City of Seattle 2004). The initial 1994 growth targets, the 2004 updates and the relationship between the two are presented in the next section.

The boundaries of the urban villages as shown in Figure 3.1 were initially suggested in the 1994 Comprehensive Plan. The initial village boundaries were based on a combination of the existing density as well as the growth potential given the land use codes in place at the time. Urban Center Village designation was reserved for those areas able to accommodate up to 50 jobs/acre and at least 15 housing units per acre. For the Hub Urban Villages, areas were required to allow growth upwards of 20 jobs and 12 to 15 housing units per acre. Residential Urban Villages had no employment requirement but were intended to reach housing densities of between 8 to 15 units per acre (City of Seattle 1994). Following the enactment of the plan, the final, official urban village boundaries were determined through a neighborhood planning process that occurred from 1994 to 1999. While the names of some of the villages have changed since then, the boundaries have remained almost completely static over time.

Evaluation of the UV Strategy

Plan evaluation, as discussed earlier in this paper, can take a variety of forms depending on the stage of the planning process, the type of plan, the purpose of the plan and the organization conducting the evaluation. The Urban Villages strategy is an existing land use plan focused on encouraging urban intensification in a clustered development pattern. As a result, the goal of this paper is to conduct an ex post evaluation of the primary goal of the urban village plan –focusing new growth. I will analyze the outcomes of the plan under a conformance-based approach, meaning that my aim is to measure whether or not (or to what level) the changes in the built environment meet the intended targets. I will not measure the performance of the plan document itself in guiding decision-making.

Seattle's Urban Village strategy has been in place for nearly 20 years, yet has never been publically evaluated in a comprehensive, conformance-based ex post fashion. The original 1994 plan did not develop any requirements for monitoring or ex post evaluation of the UV strategy. The 2004 plan update, however, provides specific language regarding the ongoing monitoring of the plan. Specifically policy UV44 states:

> *In order to monitor the effects of the Urban Village strategy: collect data, review, and report on growth and change in urban centers, urban villages, and manufacturing/industrial centers at least every 3 years. Include in these reports factors such as: progress on implementing neighborhood plan approval and adoption matrices; changes in the numbers of jobs and housing units; housing costs, including net loss or gain of low-income and very*

low-income housing units; housing types; crime rates; transportation systems and their use; business types; public facilities; services; and open space, to the extent information is practically available. Collect and report on similar data for typical areas outside villages for comparison. Broadly communicate the results of monitoring efforts.(City of Seattle 2004).

Additional policies (UV45 and UV46) develop deviation thresholds that require supplemental neighborhood planning exercises when changes in housing and/or employment changes fall outside of these bounds (City of Seattle 2004). The comprehensive monitoring activities in UV44 and the threshold determination from UV45 and UV46 have not been publically evaluated (to my knowledge).

The city has produced two published and publically available evaluations of the Urban Village strategy. Both released in 2003, one is a case study analysis of five specific villages (City of Seattle 2003a) while the other is an internal issue paper discussing potential options for updating the UV growth targets prior to the 2004 Comprehensive Plan update (City of Seattle 2003b). The case study analysis provides interesting narrative discussion and analysis of the chosen villages, however, an overall analysis of the UV strategy is lacking. This report does offer some growth figures for households and employment, but they are highly aggregated and based on census figures. The issue paper presents a much more detailed assessment of growth in the individual urban village. Using parcel specific data, this study provides village specific changes in housing units (not households) from 1995 to 2003 as well as employment changes from 1995 to 2001 using State Office of Financial Management information.

Through contacts at the city, I have obtained the most recent housing unit growth monitoring report for the urban villages (City of Seattle 2013). This report provides detailed information on total housing units permitted by urban village over time. While useful, these reports do not address housing unit loss through demolition and do not factor in vacancy rates (in comparing housing unit growth to household forecasts). Further, no attempt to evaluate village performance versus overall city growth has been made in this report. My work here takes the issue paper and the housing unit growth monitoring reports as a starting point and expands the analysis in both time and scope.

Research Questions

Specifically, the goal of this paper is to evaluate the conformance of actual housing unit growth in Seattle's urban villages to the UV strategy growth targets over the 2000 to 2012 period. To do so, I ask the following questions:

- Collectively have the urban villages incurred their planned levels of housing growth in absolute and in a relative sense?
- Does conformance with the plan differ by village type (UCV, HUV or RUV)?
- How have growth levels and conformance changed over time (2000 to 2012)?
- How do trends in non-urban village areas relate to growth within the urban village areas?

The evaluation in this study is only concerned with household and housing unit growth. Another contribution of this study is the further presentation and use of the LUCIA system (Krause 2013), a tool-box type planning support system (PSS) that provides land use change data and analysis at the parcel level. Because this study is focused on changes to the physical built environment, creating accurate, parcel level estimates of employment would prove difficult and therefore is outside of the scope of this research. As a result, the two Manufacturing-Industrial Centers (MICs) are excluded from this study. Additionally, the University Campus Urban Center Village (UCV), being completely contained within the University of Washington, does not receive specific household growth targets and is also excluded from this study. In an ideal situation this study would examine growth both before and after the UV strategy was implemented (1994). Detailed data at the parcel level, however, is only available from 2000 to the present and therefore the study period is limited to that time frame.

Data

This study is focused on comparing the City of Seattle's Urban Village strategy household growth targets and actual changes in the number of housing units over the 2000 to 2012 period. Two primary datasets are required, the household forecasts and the actual housing unit counts. Additionally, since housing units do not translate exactly into households, a conversion factor must also be developed and applied. This section begins by discussing the process of converting housing units into households (and vice versa). A discussion and illustration of household growth targets follows. Concluding this section is a description of the actual housing unit growth figures over this time period, as derived using the LUCIA system for measuring land use change.

Housing Units to Households

The U.S. Census[2] defines a household as: "all the people who occupy a housing unit." This definition ties households directly to housing units, meaning that, for quantification purposes, more than one household cannot occupy a single housing unit. Or, in other words, there cannot be more households than housing units. Housing units, therefore, can contain either one household or, if vacant, no households. It is these vacant housing units that must be adjusted for when comparing actual physical housing unit counts to household forecasts.

Due to the mismatch between housing units and households, a generalizable vacancy rate must be determined to inflate household forecasts in order make a direct comparison with observed housing units. Conversely, housing unit counts could also

[2] www.census.gov/cps/about/cpsdef.html

be deflated to match household estimates. I have chosen to inflate household forecasts as opposed to deflating housing units in this study for two reasons. First and foremost, housing units are durable and existing units are not nearly as susceptible to market trends as are household counts (vacancies). Second, household counts are derived from census data in which historical figures are based on infrequent decennial measurements and current and future counts on samples and not full population counts. Housing units, as determined via parcel level data, represent an exact count and therefore can be considered more accurate at small temporal and spatial scales, less susceptible to minor market fluctuations and less prone to sampling design issues.

Vacancy rates can differ by housing unit type, location and age as well as over time. However, this study inflates household estimates instead of deflating housing units and the household estimates produced by the City of Seattle for the urban villages are not broken down by anticipated housing unit choice. Therefore, a single unified vacancy rate is necessary to inflate total household growth targets into necessary housing unit targets. Vacancy rates gathered for the City of Seattle from the U.S. Census 2000 decennial census and 2010-2011 American Community Survey show the variation in rates both over time and between single family residential and multiple family units. Not surprisingly, rates are higher in multi-family units and were higher in 2010/2011 than in 2000 (See Table 3.2). In searching for a single, mid-level vacancy rate estimate, a rate of 6% appears reasonable given the variations over time and dwelling type.

Table 3.2: Seattle Vacancy Rates

Year	Single Family	Multi-Family	Overall
2000	3.2%	6.0%	4.4%
2010-11	5.0%	9.2%	7.1%
Average	4.1%	7.6%	5.8%

Source: U.S. Census

Urban Village Household Growth Targets

Original household growth targets from 1994 and the updated figures from 2004 are both given as cumulative 20-year targets. This study covers a time period of 2000 to 2012, a period spanning portions of both the original and the updated forecast time periods. To convert these sequential 20-year targets I have interpolated the estimates in a straight linear fashion –divided each by 20 and summed over the 2000 to 2012 period –where the original estimates are applied to the years 2000 to 2004 and the updated for 2005 to 2012. After converting the 20-year estimates to 10-year estimates and performing the interpolation to the 2000 to 2012 period, all figures have been inflated by the 6% vacancy rate (multiplied by 1.06) to indicate the number of total housing units that would likely be necessary to accommodate the targeted number of households, given average market conditions that persisted over the past 12 years.

Table 3.3 shows these adjusted 10-year growth targets for each village in the study (38 in total) for both 1995 to 2004 and 2005 to 2014 as well as the interpolated estimates for the 2000 to 2012 period. Included are estimates for non-urban village areas, urban villages aggregated by type (UCV, HUV and RUV), and for the city as a whole.

To show this information graphically, Figure 3.2 compares the adjusted original 1995 to 2004 forecasts to the 2005 to 2014 targets, with individual villages plotted by village code (see Table 3.3). Location along the diagonal dotted line indicates that 1995 to 2004 targets were identical to 2005 to 2014 numbers. Villages lying underneath the dotted line are cases where the updated numbers (2005 to 2014) represent a decrease in the growth targets from the original. For those lying above, the opposite is true. Villages are color-coded by type and the axis are in log-scale to aid in visualization.

A review of the adjusted growth targets in Table 3.3 and Figure 3.2 presents a number of immediate observations. First, the updated growth targets published in

Table 3.3: Housing Unit Growth Forecasts

Code	ID	Name	Fcst. 95-04	Fcst. 05-14	Intr. 00-12
A12	UCV-6	12th Ave	286	371	441
BEL	UCV-1	Belltown	3,445	2,491	3,712
CC	UCV-3	Commercial Core	689	159	473
CH	UCV-7	Capitol Hill	1,049	530	949
CID	UCV-2	Chinatown/ID	689	530	769
DT	UCV-4	Denny Triangle	1,855	1,590	2,202
FH	UCV-8	First Hill	1,272	636	1,147
NG	UCV-10	Northgate	1,590	1,325	1,851
PP	UCV-9	Pike/Pine	329	318	421
PS	UCV-5	Pioneer Square	1,113	530	979
RAV	UCV-12	Ravenna	254	238	317
SLU	UCV-11	South Lake Union	901	4,240	3,842
UNW	UCV-13	University NW	864	1,060	1,278
UP	UCV-15	Uptown	695	530	774
UCV	UCV	UCV Totals	15,031	14,548	19,155
BAL	HUV-1	Ballard	806	530	829
BL	HUV-2	Bitter Lake	668	424	671
FRE	HUV-3	Fremont	435	265	428
LC	HUV-4	Lake City	742	477	754
NR	HUV-5	North Rainier	636	477	704
WSJ	HUV-6	West Seattle Junction	583	371	586
HUV	HUV	HUV Totals	3,870	2,544	3,972
A23	RUV-1	23rd and Jackson	477	344	512
ADM	RUV-2	Admiral	180	106	178
AUR	RUV-3	Aurora	477	265	448
CCY	RUV-4	Columbia City	392	265	403
CRH	RUV-5	Crown Hill	164	132	184
EAS	RUV-6	Eastlake	201	132	204
GL	RUV-7	Green Lake	212	132	209
GP	RUV-8	Greenwood/Phinney	186	212	263
MJ	RUV-11	Morgan Junction	159	106	168
MLK	RUV-10	MLK at Holly	424	313	458
MM	RUV-9	Madison/Miller	212	265	313
NBH	RUV-12	North Beacon Hill	292	260	353
RB	RUV-13	Rainier Beach	392	318	451
ROO	RUV-14	Roosevelt	180	132	194
SP	RUV-15	South Park	186	132	199
UQA	RUV-16	Upper Queen Anne	159	106	168
WAL	RUV-17	Wallingford	106	212	223
WH	RUV-18	Westwood-Highland Park	371	212	353
RUV	RUV	RUV Totals	4,770	3,644	5,281
NUV	NUV	NUV	7,950	4,171	7,311
All	All	All	31,621	24,910	35,738

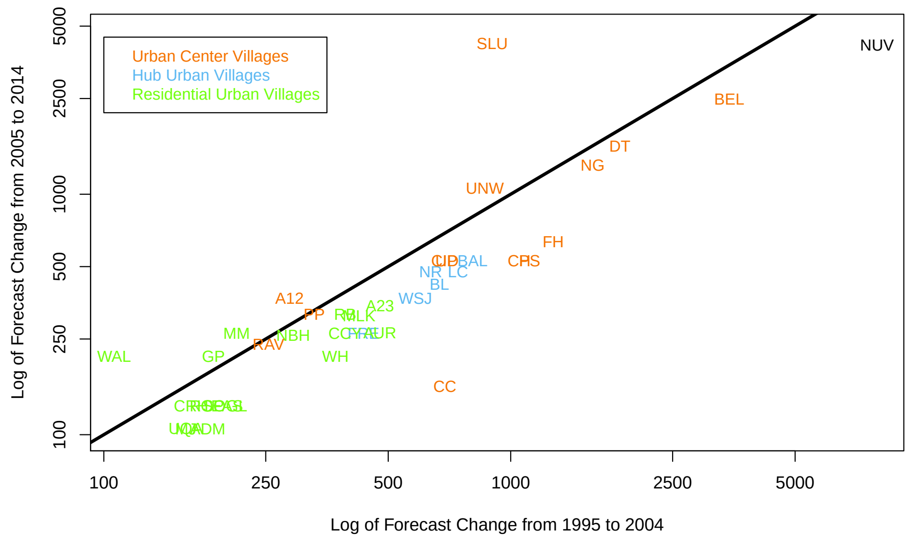


Figure 3.2: Comparison of Forecasts: 95-04 vs. 05-14

2004 represent a slight overall downward adjustment of household growth targets for the city as a whole and for the urban villages collectively. Despite this overall reduction, a number of the villages have seen increases to their village specific targets. Also, the relative percent of growth targeted to the urban villages did not change much with the 2004 update to the forecasts. Finally, the village specific targets are generally highest in the existing high density UCV and lowest in the residential urban villages (RUV).

Calculated Actual Housing Unit Growth

Next, I determine the actual changes to housing units over the 2000 to 2012 period using the LUCIA system. This system uses longitudinal assessor's property characteristics data from the 2000 to 2012 time period to continuously monitor changes in housing units over this period. These data are available for download from the King

County Assessor's website[3] free of charge. The data, stored in a relational database format, are continuously updated and any download represents a "snapshot" of the data as of that day. For data from 2009 to 2012 the data were downloaded on December 31st of each year to represent the final dataset of that calendar year. Data for the years from 2000 to 2008 were gathered from the University of Washington's Map Library and the Runstad Center for Real Estate Studies archival records.[4]

Previous evaluations have used census data (aggregated at the census block level) (City of Seattle 2003a) and building permit data (City of Seattle 2003b; City of Seattle 2013). While readily available, past census data is infrequently updated and current and future data is only sampled and not a full population count. Building permit data is available at the parcel level and on a continuous basis, however, this type of data doesn't often provide information on housing units lost through demolition or conversion and therefore cannot determine the precise net changes in housing units.

Changes to the built environment via new development, redevelopment, conversion and structural expansion often entail changes to parcel boundaries and parcel identification numbers. As a result, directly comparing changes in the number (and type) of housing units over time in a dynamic urban area such as Seattle requires more than simply comparing two longitudinal datasets. To facilitate such comparisons over time and space, I have developed a tool-box type planning support system (PSS) termed the Land Use Change Identification and Analysis (LUCIA) system.

Described in detail in a previous paper (Krause 2013), the LUCIA system follows the following basic steps: 1) compare parcel geometries over time to properly link land use changes in the case of parcel boundary/identification changes; 2) compile parcel level changes to land use; 3) categorize changes by land use, physical dimensions (number of units and building size), time (year of change) and type of change (new construction, conversion, expansion, etc.); and 4) analyze and visualize results. The

[3]http://www.kingcounty.gov/Assessor.aspx

[4]Data from 2002 and 2003 are missing.

LUCIA system is completely flexible from a spatial and temporal perspective meaning that any geographic area can be examined over any time period.

Methodology and Results

In this section I use the LUCIA system to generate urban village-specific counts of net housing unit changes over the 2000 to 2012 period. These changes are then compared to the vacancy-adjusted household growth targets for the villages to determine the conformance of the actual changes in housing units to growth targets as developed in the 1994 and 2004 comprehensive plans. This initial comparison represents an analysis of the absolute level of conformance. A second analysis looks at the growth figures in comparison to overall growth in the city to determine if the relative growth targets (% of total growth) have also been met.[5] Within both the absolute and relative comparisons, growth is examined at the village level as well as aggregated by village type –urban center village (UCV), hub urban village (HUV) and residential urban village (RUV). Finally, both measures, absolute and relative, are examined over time to determine what effect, if any, the housing market crash and ensuing recession of 2008 to 2011 had on the progress of the Urban Village strategy.

Absolute Change in Housing Units

To count the total net change in housing units in each of the 38 urban villages in this study,[6] the boundaries of each village were analyzed by the LUCIA system with the time frame set to 2000 to 2012. Table 3.4 shows the results of this analysis for each villages. Total adjusted growth targets for the 2000 to 2012 period and percent of growth targets achieved by each village are shown for comparison's sake. Figure

[5]A discussion of the merits of the absolute and relative approaches to evaluating housing unit growth in relation to the urban village strategy is presented in the conclusion to this report.

[6]Of the 41 total, the University Campus (UCV), Ballard Interbay Manufacturing (MIC) and Duwamish Industrial (MIC) are excluded

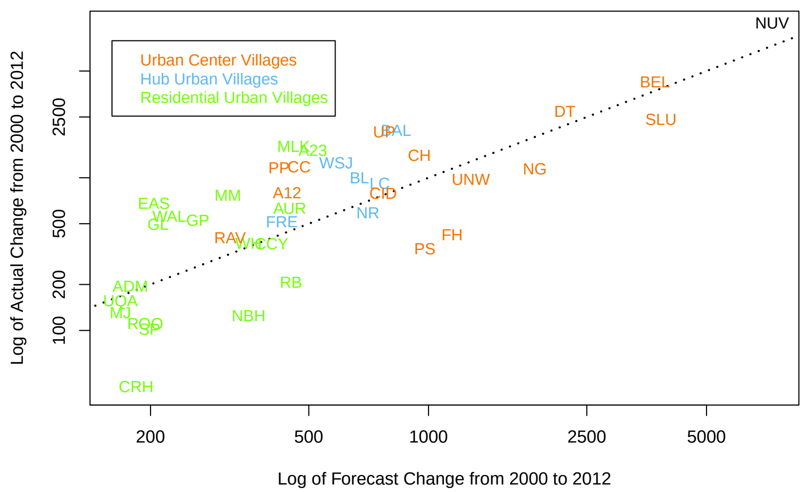


Figure 3.3: Comparison of Actual Growth to Forecasts

3.3 illustrates this comparison graphically. The X-axis represents the total adjusted growth targets for the period and the Y-axis shows the total net change in housing units over this period. Axes are in a log scale for visualization purposes. The diagonal black line represents the point where the actual housing unit growth rate perfectly matches the target rate.

As Table 3.4 and Figure 3.3 suggest, a number of villages have greatly exceeded their target growth, while others have fallen short. By fitting regression lines to the relationship between these two variables (forecasts and actual outcomes) we can determine if any relationship exists between size of forecast and the actual growth in housing units. Figure 3.4 shows the same information as in Figure 3.3, except with points instead of village codes for easier visualization. Next, regression lines are fit to the relationship between forecasts and actual growth for all urban villages (black), urban center villages (orange), hub urban villages (blue) and residential urban villages

Table 3.4: Actual Housing Unit Growth

Code	ID	Name	Fcst 2000-12	Actual 2000-12	Ratio
A12	UCV-6	12th Ave	441	801	182%
BEL	UCV-1	Belltown	3,712	4,267	115%
CC	UCV-3	Commercial Core	473	1,182	250%
CH	UCV-7	Capitol Hill	949	1,407	148%
CID	UCV-2	Chinatown/ID	769	797	104%
DT	UCV-4	Denny Triangle	2,202	2,732	124%
FH	UCV-8	First Hill	1,147	425	37%
NG	UCV-10	Northgate	1,851	1,148	62%
PP	UCV-9	Pike/Pine	421	1,166	277%
PS	UCV-5	Pioneer Square	979	345	35%
RAV	UCV-12	Ravenna	317	406	128%
SLU	UCV-11	South Lake Union	3,842	2,425	63%
UNW	UCV-13	University NW	1,278	978	77%
UP	UCV-15	Uptown	774	2,005	259%
UCV	UCV	UCV Totals	19,155	20,084	105%
BAL	HUV-1	Ballard	829	2,054	248%
BL	HUV-2	Bitter Lake	671	1,002	149%
FRE	HUV-3	Fremont	428	516	121%
LC	HUV-4	Lake City	754	921	122%
NR	HUV-5	North Rainier	704	591	84%
WSJ	HUV-6	West Seattle Junction	586	1,254	214%
HUV	HUV	HUV Totals	3,972	6,338	160%
A23	RUV-1	23rd and Jackson	512	1,516	296%
ADM	RUV-2	Admiral	178	195	110%
AUR	RUV-3	Aurora	448	633	141%
CCY	RUV-4	Columbia City	403	370	92%
CRH	RUV-5	Crown Hill	184	43	23%
EAS	RUV-6	Eastlake	204	682	334%
GL	RUV-7	Green Lake	209	497	238%
GP	RUV-8	Greenwood/Phinney	263	529	201%
MJ	RUV-11	Morgan Junction	168	131	78%
MLK	RUV-10	MLK at Holly	458	1,614	352%
MM	RUV-9	Madison/Miller	313	768	245%
NBH	RUV-12	North Beacon Hill	353	125	35%
RB	RUV-13	Rainier Beach	451	208	46%
ROO	RUV-14	Roosevelt	194	111	57%
SP	RUV-15	South Park	199	102	51%
UQA	RUV-16	Upper Queen Anne	168	157	93%
WAL	RUV-17	Wallingford	223	561	252%
WH	RUV-18	Westwood-Highland Park	353	374	106%
RUV	RUV	RUV Totals	5,281	8,616	163%
NUV	NUV	NUV	7,311	10,335	141%
All	All	City of Seattle	35,738	45,373	127%

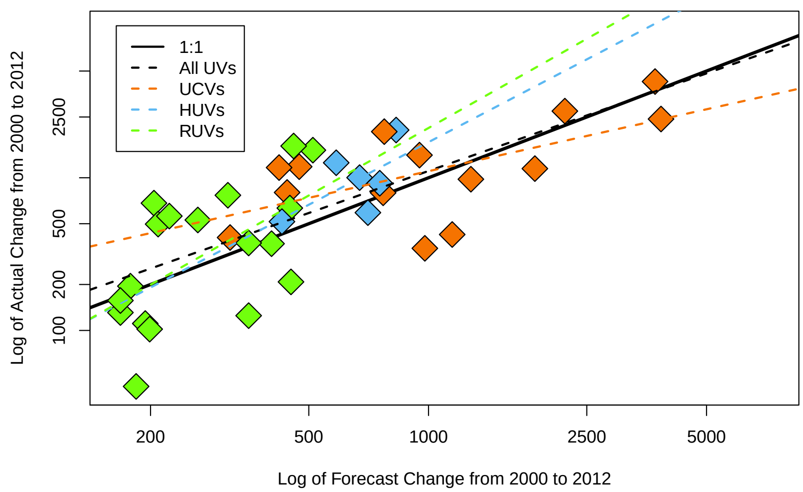


Figure 3.4: Comparison of Actual Growth to Forecasts, with Fit Lines

(green).

Lines with positive slopes (sloping up from left to right) but flatter than that of the 1:1 solid black line show that areas with larger forecasts experienced more growth but that the larger the forecast the less likely the village was to meet its targeted growth. The urban center villages (orange dashed line) falls into this category. On the other hand, lines with a positive slope greater than 1:1 represent a situation where larger forecasts are correlated with greater than forecast growth. For the Hub Urban Villages (HUV) and the Residential Urban Villages (RUV), blue and green dashed lines, respectively, this is the case. The line fit for the aggregate of all villages (dashed black) nearly perfectly fits the 1:1 relationship. Overall this data suggests that urban center villages (UCVs) with the smaller growth targets and hub and residential villages (HUVs and RUVs) with the largest growth targets were those that saw the most growth relative to their forecasts.

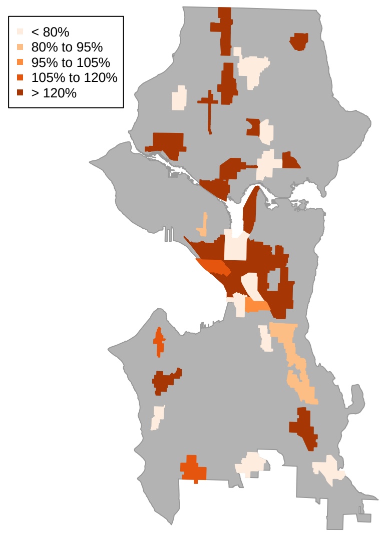


Figure 3.5: Villages by Growth Performance Against Targets

The urban villages are spread across the City of Seattle (see Figure 3.1). As urban growth is highly location specific, it is appropriate to ask whether or not location has played any role in meeting growth targets. Figure 3.5 maps the conformance of the individual villages to their growth targets based on a five point scale: 1) grossly under achieved (<80% of target); 2) under-achieved (80% to 95%), met (95% to 105%); 4) exceeded (105% to 120%); and 5) grossly exceeded (>120%). Examining the conformance of village growth to the targets suggests no obvious spatial trend. As mentioned before, Residential Urban Villages saw the most growth, relative to forecasts, and these villages are primarily located in the peripheral areas of the city. Therefore, one spatial trend that may appear is that outlying villages have performed better than the central core. Using this data, however, it is not possible to draw a causal conclusion as to whether it is the location of the RUVs, their smaller size or simply a systematic under forecasting of growth targets that is causing this finding.

Relative Change in Housing Units

Forecasts of medium- to long-term growth for a large city are rife with uncertainty. Any number of exogenous factors such as changing macro-economic conditions, regional growth trends, natural disasters, changes to state and federal policies and shifting consumer preferences can all render well-supported forecasts irrelevant in a number of years. As a result, evaluating plan conformance based on absolute measures of growth can be misleading if one or more of these factors has greatly swayed overall city, regional, state or federal growth to a significant extent. If possible, impacts due to these exogenous factors should be controlled for in order to better assess plan outcomes.

The primary intent of Seattle's Urban Village strategy is to focus housing and employment growth into existing densely developed areas. In other words, the goal is to increase the ratio of housing (and employment) within urban villages as compared to the remainder of the city. While the Urban Villages strategy gives discrete growth target numbers, these numbers are derived as portions of a larger citywide total of planned growth (City of Seattle 2004). Thus, even in the face of considerable impacts on growth as a result of exogenous factors such as those mentioned above, the Urban Village strategy can be evaluated in a relative sense by comparing growth within and outside of the urban villages.

Overall, city growth in housing units over the 2000 to 2012 time period was 127% of the total forecast. In light of this, it is no surprise that 24 of the 38% individual villages exceeded growth targets during this period (See Table 3.4). This considerably higher level of overall city growth in housing units, when compared to target levels, warrants an examination of the relative growth figures.

Table 3.4 illustrates the wide variety in growth across the 38 different urban villages. To better understand relative growth and aid in visualization, I evaluate the relative growth conformance at the village type level (UCV, HUV and RUV) as opposed to the individual village level. This level of aggregation is supported by the fact that in the initial 1994 comprehensive plan and in the 2004 update the City first allocated growth among village types and then apportioned these figures to the individual villages. Further, since village type designations are based on village characteristics, examining relative growth by village type may reveal information regarding growth trends.

Table 3.5 shows total growth targets, their relative composition, total actual growth, their relative composition and the relative performance of each village type (relative actual divided by relative targeted). From this analysis we see that Urban Center Villages (UCV), the largest and densest urban village type, while exceeding their absolute growth targets, have not taken their relative share of growth for the 2000 to 2012 period (54% vs. 44%). The Hub Urban Villages (HUV) and Residential Urban Villages (RUV), on the other hand have exceeded targets in both an absolute and a relative sense (126% and 129%, respectively). Finally, we see that non-urban village areas also grew at a faster pace both in an actual and a relative sense than targeted (111%). In sum, an examination of relative growth trends suggests more growth in smaller urban villages and in non-village areas than planned for, while the largest villages, the UCVs, met absolute growth targets but only captured 83%.

Relative Growth by Village Type

Table 3.5: Relative Growth by Village Type

Village Type	Fcst. 00-12	% of Target	Actual 00-12	% of Actual	Rel. Growth
UCV	19,155	54%	20,084	44%	83%
HUV	3,972	11%	6,338	14%	126%
RUV	5,281	15%	8,616	19%	129%
Non-UV Areas	7,311	20%	10,335	23%	111%
All City	35,738	100%	45,373	100%	100%

Growth over Time

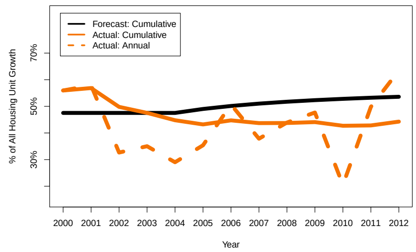
As mentioned, exogenous factors such as macro-economic trends and state and federal policies can add considerable levels of uncertainty to growth forecasts. In terms of exogenous shocks to housing development, the 2000 to 2012 period was anything but benign. The time period began with a mild recession brought on by the dot-com bubble and the NASDAQ crash in which the Seattle region, home to Microsoft and a host of other software/tech companies, suffered more than much of the country. A significant house price bubble followed from 2003 until 2006 ultimately resulting in a crash and subsequent recession that has lasted in some fashion until 2011 or 2012. In light of these large swings in the national economy and in housing markets in particular, it is informative to look at housing unit growth by village type over time to examine the impact, if any, these macro-economic factors have had on relative housing unit growth.

In Figure 3.6, a set of relative housing growth trends is shown for each of the three urban village types (a-c) and for the non-urban village areas of the city (d). The solid black lines show the cumulative relative growth target (as a % of the city's total growth) for each village type, the solid colored lines show the actual cumulative growth (as a % of the total city growth) and the dotted, colored lines show the annual relative growth (as a % of city growth in that year). Despite the increasing relative growth targets for the UCVs (Figure 3.6a), the actual cumulative relative growth has generally decreased over time, although with a small up-tick in the most recent two years. Conversely, HUVs have shown a steady increase in cumulative relative growth over time (Figure 3.6b). Residential Urban Villages (Figure 3.6c) have remained steadily above their forecast relative growth levels for the entirety of the 2000 to 2012 period. Finally, and much like the HUVs, the non-urban village areas (Figure 3.6d) have also experiences a very slow, but steady, increase in the portion of housing unit growth over time, despite decreasing growth targets.

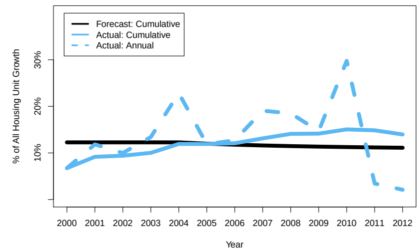
To better determine if any time specific trends are evident in growth differences between the village types, Figure 3.7 shows the normalized annual growth figures over time. To normalize the figures, I have calculated the proportion of total city growth within each village type by the forecast proportion of growth for that year. For example, if UCVs were forecast to receive 50% of all growth in a given year and they actually received 55%, then the normalized value would be 110% (0.55/0.50). In looking at Figure 3.7, the consistent under-performance of the Urban Center Villages (in a relative sense) is evident, as is the year to year variation of the other three village types.[7] Two of the most interesting time periods are highlighted in the figure. In the first highlighted period, 2001 to 2003, the ratio of growth in Urban Center Villages declined rapidly while growth in HUV and non-UV (and to a less extent RUV) increased. This trend of higher growth in HUV, RUV and non-UV areas remained until 2011 at which point UCVs began to take a larger portion of growth at the expense of the other three.

Very broadly speaking, Urban Center Villages are more likely to see growth via apartments and condominium developments, while growth in the other three village types is more commonly experienced through new single family detached and attached units (townhomes). As a result, it is not surprising that this first period (2001 to 2003) coincides with the beginning of the housing bubble and the expansion of easy credit for home purchasers while the later period (2011 to present) matches up with the current apartment construction boom in the City of Seattle. This analysis highlights the extent to which growth targets can be influenced by exogenous factors such as macro-economics, financing trends and changing consumer demand.

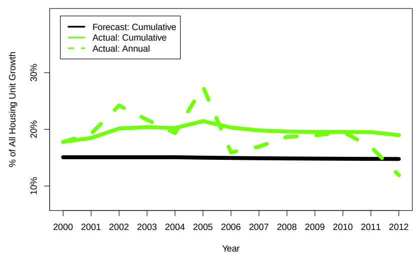
[7]Here I include non-urban villages as a village type for simplicity's sake



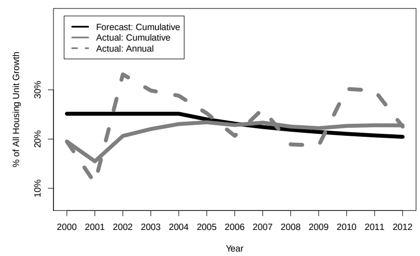
(a) Urban Center Villages



(b) Hub Urban Villages



(c) Residential Urban Villages



(d) Non-Urban Village Areas

Figure 3.6: Relative Housing Unit Growth vs Targets, 2000 to 2012

Growth by Unit Type

As is evident from the large year-to-year variation in growth shown in Figures 3.6 and 3.7, urban growth does not always occur in a smooth, gradual fashion. In other words, housing unit growth can be very "lumpy." The development of real estate, especially higher density urban land uses, follows cyclical trends and is a time-consuming process composed of many independent components –both factors that contribute to these variations in growth over time. This inherent lumpiness is one reason why growth forecasts are often given on a scale of 10 to 20 years, as opposed to shorter annual or monthly horizons.

Some development types, however, are more lumpy than others. In terms of examining urban village growth conformance, the construction of a single apartment or

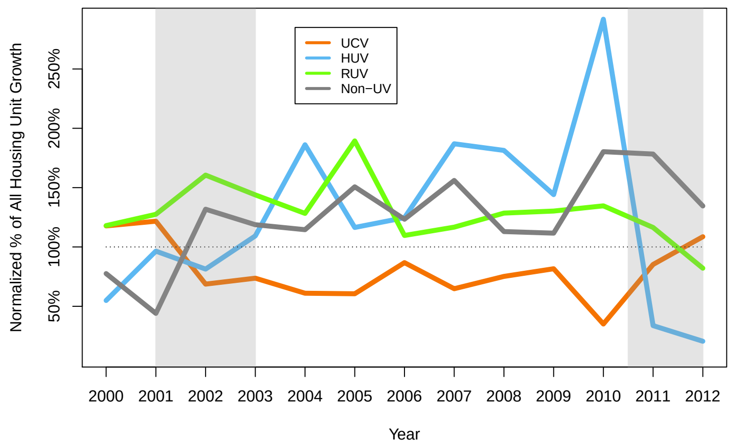


Figure 3.7: Villages by Normalized Growth Performance Against Targets

condominium complex may contribute greatly to the growth total of a given village. Individual single family detached, townhome, and duplex/triplex/quadplex construction, on the other hand, does not have this same effect. As a result, in attempting to explain the rationale for why some villages greatly exceeded targets and others did not, the lumpiness of growth –via a look at growth broken down by unit type –is a likely contributing factor.

Figures 3.8 and 3.9 compare the contribution to total net growth by apartments and condominiums, respectively, within each village (horizontal axis) to the village's overall growth totals versus targets (vertical axis).[8] In each figure, the individual villages are identified by their code.

In comparing apartment contribution to absolute growth versus targets (Figure 3.8) a clear trend emerges. Those villages in which apartment growth represented a

[8]Note that due to the contribution of demolished units to the total net growth, contributions to net growth may be less than 0% or greater than 100%

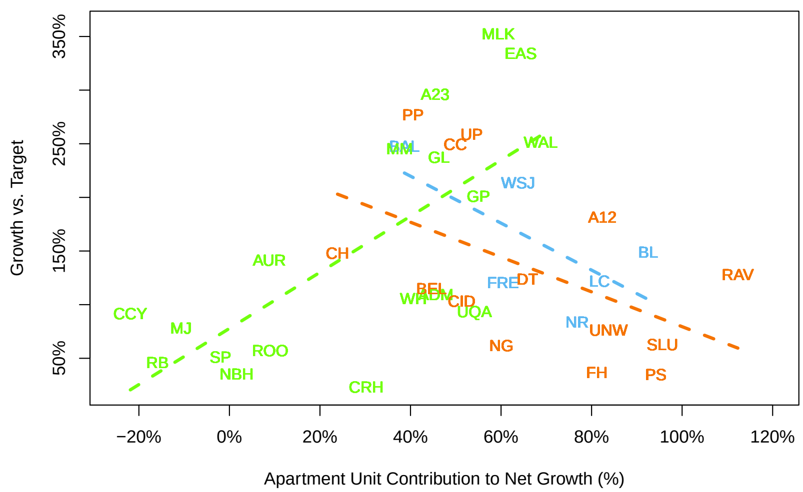


Figure 3.8: Apartment Contribution to Growth

very small or very large component of overall growth were likely to see lower growth-to-target ratios than those villages for which apartments contributed about half of all growth. Breaking this down further, the regression lines in Figure 3.8 show the trends for each of the three village types. Interestingly, this analysis suggests that heavier reliance on apartment growth creates an increase in overall growth versus targets for the low density Residential Urban Villages, but has the exact opposite effect in the higher density Hub and Urban Center Villages.

Examining growth versus target against the contribution of condominium units (Figure 3.9) shows a somewhat similar, though certainly more subdued effect. As the trend lines show, for all village types a greater contribution of condominium units results in greater growth versus targets, though this effect is most pronounced in the HUV and UCV villages.

The analyses of contribution by unit lend a number of insights as to the rela-

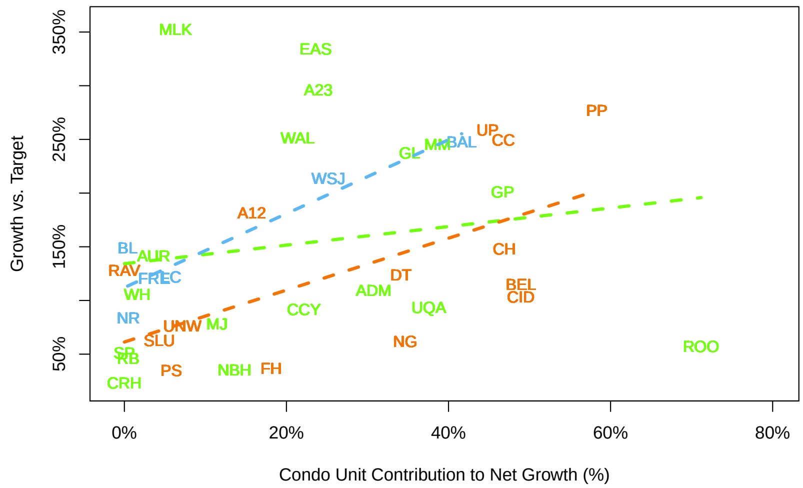


Figure 3.9: Condominium Contribution to Growth

tionship between unit type and growth targets. First, for the low density Residential Urban Villages a few large apartment projects can easily drive overall growth well past intended growth targets. The unpredictability of this type of development means that accurately forecasting growth for small areas is no easy task. As a result, ex post conformance analyses may prove more accurate and insightful at moderately aggregated spatial resolutions.

Second, for the denser HUV and UCV villages, those areas experiencing primarily apartment development saw lower overall growth to target ratios than those villages in which growth was more balanced between apartments and condominiums. This result, along with the positive slopes in Figure 3.9, suggest that condominium growth itself may be a signal that a given area is growing at a faster rate than expected. Condominiums, while often indistinguishable from apartment buildings physically, do attract a different type of resident (generally wealthier) and may be an indicator of a fundamentally different level of demand for location in an area. In short, an increase in condominium permit applications may offer insight into the medium term growth future of a given neighborhood.

Conclusion and Future Research

A common theme across the literature is the lack of ex post plan evaluation and monitoring. Despite monitoring required by the comprehensive plan, the City of Seattle's Urban Village strategy is no exception to this trend. This research uses the Land Use Change Identification and Analysis (LUCIA) system to monitor the conformance of housing unit growth in the City of Seattle to the growth targets set forth in the City's comprehensive plan. Housing unit growth is analyzed by individual village as well as by village type.

In terms of absolute housing unit growth targets, the urban villages as whole exceeded their targeted housing unit growth. At an individual level, nearly two-thirds (63%) of the 38 urban villages monitored in this study met or exceeded interpolated growth targets for the 2000 to 2012 time period. Producing long range growth forecasts, however, is a process laden with uncertainty due to exogenous influences. This analysis finds that overall housing unit growth in the City of Seattle was 27% higher than expected for this period, meaning that absolute growth figures are likely to be higher than targets due to this overall higher level of growth. At its core, the Urban Village strategy is focused on concentrating growth into villages and, therefore, relative measures of growth capture are a better measure of village performance.

From a relative perspective, the urban villages were targeted to take 80% of overall city housing growth over this time period. Actual growth in the villages represented 77% of the total, slightly below the relative target. The smaller Hub Urban Villages (HUVs) and Residential Urban Villages (RUVs) have greatly exceeded their targeted growth, while the largest and densest areas, the Urban Center Villages (UCVs) failed to meet relative growth targets from 2000 to 2012. This information suggests that smaller urban villages (those more likely to have medium density development) have grown faster, in comparison to targets, than the larger and higher density areas of the city.

One caveat to these findings is that the Denny Triangle and South Lake Union neighborhoods are currently experiencing a number of very large apartment developments and if this analysis included 2013, it would likely show a significant increase in absolute and relative growth in housing units for the Urban Center Villages. In fact, the increase in the UCV's housing unit growth appears to have begun as early as 2011 (see Figure 3.7), roughly paralleling the current apartment construction boom in the city. The variation of growth between the different village types speaks to the importance of continuously monitoring land use plans, like the Urban Village strategy. In short, related plans based on a forecast growth level can be rendered insufficient in the face of markedly higher or lower growth than anticipated. Continuous monitoring allows for an increase in proactive solutions to plan deviations brought about by the market. The use of the LUCIA system for this analysis suggests that given the publically available data within a large city such as Seattle, tracking parcel level growth over time is a feasible and desirable process for planners to undertake.

In comparing growth conformance to the type of units being added, two interesting trends emerge. First, HUV and UCV villages that experienced a mix of condominium and apartment development greatly exceeded growth targets, while those relying solely on apartment growth did not. This suggests that condominium development is a key indicator of increased localized demand and that an increase of condominium permitting applications can serve as a warning to local officials that an area is experiencing considerable growth pressure. Second, in the small, low density RUV areas those villages that relied more heavily on apartment growth greatly outpaced forecasts. Villages that saw limited apartment construction generally fell short or just barely met growth targets. In these low density areas the lumpiness of growth in the form of a few large developments can greatly sway conformance measures.

Perhaps the most interesting finding from a policy perspective is that the percentage of housing unit growth occurring outside of the urban villages has slowly, but steadily, increased over time (see Figure 3.6d). While the relative growth in non-UV areas has been small, it, nonetheless, calls into question the efficacy of the Urban Village strategy in concentrating new housing units into the villages and protecting outlying single family areas.

Overall, when examined at the village type level (UCV, HUV, and RUV) housing unit growth in the City of Seattle has been relatively consistent with the growth targets set forth in the comprehensive plan, with small HUV and RUV villages outpacing denser UCVs in a relative sense. Taking a closer look at the village-specific levels shows a good degree of variation between the conformance of various villages to their intended growth targets (Table 3.4). For the smaller villages, this variation is often driven by a few large apartment projects. While this study shows that, in aggregate, the UV strategy appears to be working moderately well, more research is required to determine what factors, if any, are causing some villages to grow much faster than targeted and others much slower. Related, a deeper analysis of the relationship between urban village designation and urban intensification could prove illustrative in evaluating the efficacy of the UV strategy.

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Chapter 4

PART III: PIECE-BY-PIECE: AN ANALYSIS OF LOW-RISE REDEVELOPMENT IN SEATTLE

Abstract

Many forms of planning policies seek to facilitate the intensification of existing neighborhoods. In densely-developed urban areas intensification occurs primarily through redevelopment of existing properties to more intense uses. This paper examines the determinants of low-rise residential redevelopment in the City of Seattle over the 2003 to 2012 time period. Using a duration analysis, I find that factors that increase potential profit or decrease potential costs are positively associated with higher redevelopment risk; results parallel with expectations from redevelopment theory. Testing the impacts of market characteristics –option values and competition/priming effects –show mixed results in terms of theoretical expectations. Finally, the effects of certain factors on redevelopment risk are shown to vary over both space and time. These variations suggest that policies intent on facilitating redevelopment should both consider the localized spatial context and be adaptable to changing market trends.

Introduction

Urban areas are in a constant state of change. This evolution of the built environment is a complex, multi-faceted phenomenon driven by both demand and supply forces. On the demand side, shifting demographics (Nelson 2006; Haase et al. 2008; Pitkin & Myers 2008), economic factors (Glaeser & Shapiro 2003; Glaeser & Gottlieb 2006) and consumer preferences (Nelson et al. 2004) act simultaneously to mold the fabric of the city. In terms of supply, two decades of growth management legislation (Weitz 2012) in the United States and abroad have sought to replace the low-density, peripheral growth common during the 1970s and 1980s with more centralized and higher density development. This effort has met with mixed success (Boarnet et al. 2011).

In order to realize the urban intensification desired by policy and demanded (at varying degrees) by the market, the redevelopment of existing properties is required. Within most developed societies, urban land use change, though heavily regulated by the public sector, is accomplished in large part by the private property market. In other words, the likelihood of redevelopment at any given site at any given time is driven primarily by economic concerns regarding the profitability of investment. For policy-makers seeking to create successful intensification plans, a greater understanding of the drivers of redevelopment is necessary.

In general, the study of land use change has garnered considerable attention in the planning (Wilson & Song 2011), economic (Bell & Irwin 2002; Irwin 2010) and environmental/ecological (Verburg et al. 2004) literature. The vast majority of this work, however, has been focused on the conversion of vacant, rural land into urban uses. Research into the small-scale and often piecemeal succession of land uses within dense urban areas has remained largely understudied. To help fill this gap, this paper examines the influence of four types of factors –policy, physical, neighborhood and market –on low-rise residential redevelopment probability in the City of Seattle over the 2003 to 2012 time period.

This paper proceeds by introducing the relevant theory and empirical work on redevelopment. Next, the study design, data and methodology are discussed. Results from both the base models as well as models looking at variations in the redevelopment process over time and space are then presented. This work concludes with a discussion of the results and recommendations for policy and future research.

Redevelopment

Broadly speaking, redevelopment is one component of the encompassing phenomenon of land use change. Whereas land use change can refer to a transition from forest to agricultural uses or raw prairie to suburban tract homes, redevelopment is specifically confined to processes that result in the replacement of an existing urban use with another, often more intense, use. Discussion of urban land use succession offers the most applicable theoretical context to redevelopment as a generalized process. Land use succession can be conceptualized at the neighborhood scale (Andrews 1971) or at the single property level (Bourne 1971, Clapp 1977). In both cases, the defining feature is the natural depreciation of existing structures over time eventually leading to a change in use and/or structure. At the neighborhood scale presented by Andrews (1971), the temporal and spatial pattern of land use succession depends heavily on the underlying urban development pattern; be it concentric (Burgess 1923), sector-based (Hoyt 1933), multi-nucleic (Harris & Ullman 1945) or some combination of the three.

As Bourne (1971) notes, the actual transition in use occurs at the property scale and is therefore best examined at the property level. Implicit in this recognition is the fact that individual owners and investors are the drivers of change and, as a result, urban land use succession (redevelopment) is a highly erratic, piecemeal and stochastic phenomenon (Clapp 1977). Despite these idiosyncrasies, however, the decision to redevelop a property can be expressed as an economic calculus intent on determining which of the potential actions –to invest or not –produces the highest net present value (NPV).[1] As a result, across a sufficiently large sample generalizable trends and relationships can likely be drawn between a set of property characteristics and redevelopment probability.

Conceptually, redevelopment of an existing property becomes economically viable when the value of the redeveloped property,[2] V_r, is greater than the value of the property in its current use, V_c, plus demolition costs of the existing use, C_d, and construction costs of the new use, C_c (Muth 1969; Wheaton 1982, Dye & McMillen 2007). Mathematically, redevelopment requires the following inequality:

$$V_r > V_c + C_d + C_c \tag{4.1}$$

Equation 4.1 can be re-arranged so that the left hand side of the inequality consists of the total value of the redeveloped property, V_r, minus the demolition, C_d, and construction costs, C_c. By subtracting these costs from the total value of the new development, the current land value, V_l, remains. As a result, another conceptual approach to the redevelopment decision is to compare the land value of the property[3] against the value of the property in its current use. If the land value is greater, then redevelopment is the preferred economic decision. Implicit in this calculation is the fact that vacant land is more valuable than developed land, ceteris paribus, due to the necessity of demolition costs, C_d, prior to redevelopment.

$$V_r - C_d - C_c = V_l > V_c \tag{4.2}$$

In this simple calculus two factors play a role: 1) land value; and 2) the value (in-

[1] In determining the net present value, future incomes and costs are brought to a present value using a discount rate to account for the time value of money. In the equations and discussion that follows I will deal with present values, although the same basic concepts apply to income streams and re-occurring costs.

[2] At its highest and best use

[3] Again, considering development at it highest and best use

come) of the current development. Any factor that increases the value (income) of the current use to a greater extent than it does for the land value of the optimal development will have the effect of delaying redevelopment. Conversely, any factor increasing land value that does not equivalently increase income from the existing use will hasten redevelopment. As Equation 4.2 implies, factors influencing demolition or construction costs can be considered to directly impact the land value.

Redevelopment and Option Value

This simple comparison of net future income (expressed as land value) against current income, referred to as the net present value (NPV) approach, has been the dominant theory of development decisions for nearly forty years (Clapp 1977). More recently, the impact of option value has been noted. Option value is defined as the value attributable to waiting to develop or redevelop (Titman 1985). This additional value is based on the probability of the optimal density increasing in the future and therefore resulting in an increase in the profitability of the new, delayed (re)development (Capozza & Li 1994; Towe et al. 2008). In other words, if the probability of an expected increase in future highest and best use (profitability), I_p, multiplied by the expected magnitude of increase, I_m, is greater than the additional income foregone by waiting, I_f, plus any holding costs, C_h (such as property taxes or financing), then it is economically rational to delay (re)development. With these factors the level of option value,[4] O_v, can be calculated as:

$$O_v = (I_p * I_m) - (I_f + H_c) \tag{4.3}$$

[4]Note that option value is either a positive value or non-existent. If foregone rent and holding costs are greater than the expected gain in value then development should occur immediately and no option value exists.

Option value enters the redevelopment inequality on the right hand side and becomes another hurdle that the land value must overcome to justify the investment:

$$V_l > V_c + O_v \tag{4.4}$$

Option values exist in situations where an investment (development or redevelopment in the case of real estate) is irreversible and the future is unknown (Titman 1985). The basic theory behind this suggests that higher levels of uncertainty can result in higher option value (potential value from waiting to invest) which decrease the likelihood of (re)development. A number of studies on real estate development have validated this theory (Cunningham 2006, 2007; Towe et al. 2008; Bulan et al. 2009; Clapp et al. 2012). In short, the additional value provided by the option to wait until the future to (re)develop can have the effect of slowing the overall development time since waiting for future gains may allow a developer/owner to invest at a higher density/intensity and therefore increase the net present value of future rent streams.

Empirical Analysis of Redevelopment

The theoretical and conceptual framework surrounding redevelopment as an economic decision and as part of the broader urban development and monocentric city models were developed two to three decades ago (Brueckner 1977; Wheaton 1982; Capozza & Helsley 1990; Capozza & Sick 1994). Much of the immediate work that followed sought to solidify the theoretical expectations of urban growth with redevelopment under varying assumptions such as open vs. closed cities (Brueckner 1980) or perfect foresight vs. uncertainty (Braid 2001). Relatively few empirical studies, however, have sought to test these hypotheses.

Rosenthal and Helsley (1994) offer the first empirical test of the net present value (NPV) theory shown in Equation 4.2. Using a structural probit model on a sparse dataset of residential home sales from Vancouver, BC they find that the probability of demolition is increased when land values become greater than the value of the current use of the property. Additional findings suggest that older homes are more likely to be torn down, while properties with higher improvement to land value ratios are less likely to be demolished. Munneke (1996), Weber et al. (2006) and Dye and McMillen (2007) offer similar analyses of teardown activity in the City of Chicago, all using probit-based models. In the former, Munneke confirms the basic NPV theory using commercial and industrial data. Weber et al. (2006) show small, wooden homes with low lot coverage (low home size to lot size ratio) to be most susceptible to demolition, while socio-economic variables offer little impact on the risk of teardown. Similarly, Dye and McMillen (2007) find low lot coverage, high land value to total value ratio (land leverage), and proximity to rail transit, Lake Michigan and historic village centers to be the prime determinants of teardown probability.

Lee et al. (2005) take a slightly different approach in analyzing apartment structures in Seoul, South Korea. They use a basic probit model of redevelopment probability to inform a hedonic price model for the purpose of dividing price impacts into those from depreciation (negative) and from redevelopment potential (positive). This approach shows: 1) that older buildings are more susceptible to redevelopment; and 2) that for the first 30 or so years of an apartment's life values decrease due to physical depreciation, however, after this time the increase in land value due to redevelopment potential causes values to rise prior to redevelopment.

A peripherally-related study by Helms (2003) discusses renovation probabilities while more recent work by Wiesel et al. (2013) offers a purely descriptive analysis of knock down and rebuild (KDR) activity in Sydney, Australia. Finally, at a coarser scale, Rosenthal (2008) examines neighborhood level transitions over five decades and finds that filtering processes and externalities impart much of the cyclical trends in neighborhood fortunes suggested by Andrews (1971). In sum, the empirical literature on redevelopment is sparse, with most studies using a form of probit model to estimate the probability of teardown/demolition. Very little work considers both the demolition of existing properties as well as the construction of a new use in its place.

Early attempts to examine option values in real estate development (real options) have focused on the conversion of vacant land to urban uses, most often single family housing. In a study on vacant land transformation in King County, WA, Cunningham (2006) finds evidence of real option values only in peripheral suburban regions. In a follow-up study, Cunningham's (2007) results suggest that the Urban Growth Area (UGA) boundary in King County decreases uncertainty and, therefore, lowers the option values for suburban development. This decrease in option value ultimately led to more investment in building. Towe et al. (2008) find that the impact of market volatility on the decision to develop is conditional on the potential size of the subdivision, with a positive (negative) impact in situations where a large (small) number of home lots are permissible.

More recent work has looked at the relationship between development/redevelopment and option value in urban areas. Examining condominium development in Vancouver, BC, Bulan et al. (2009) find that competition by other developers can moderate the impacts of risk (and therefore option value) on development, essentially showing that the benefits to waiting may be decreased with competitive pressure. Grovenstein et al.'s (2011) work on redevelopment in Chicago highlights the variation in option values across land uses. By modeling the differences between maximum potential developments and actual prices they find that high density residential and warehouse properties may exhibit option values of up to 10% to 12% of the total property value, whereas similar figures for small retail and industrial sites are in the range of 1% to 2%. Finally, Clapp and Salavai (2010) show that option values can be a significant contributor to value for older single family homes and that failure to account for these influences in hedonic price studies can result in biased estimates of independent variables, especially those associated with redevelopment probability such as structure age, condition and lot size.

In sum, empirical research on the determinants of redevelopment is a small, but growing set of literature. Most findings to date generally validate the existing Net Present Value (NPV) theory in which future profitability is balanced against the value of the current use. The consideration of option value, or the value of waiting to development, has also been added to the discussion. A few recent studies have focused on option values and urban redevelopment (Clapp & Salavai 2010; Grovenstein et al. 2011); however, none explicitly consider redevelopment in the low-rise residential market.

Motivation and Research Design

Redevelopment is the primary process by which dense, urban environments evolve. This paper builds on the existing empirical research by examining the entire redevelopment process, from demolition to the ensuing new construction. In doing so, I attempt to answer the following question: "To what extent do policy, physical, locational and market factors influence the probability of a single family home redeveloping to a more dense residential use?" Additionally, in consideration of the location-specific and cyclical nature of real estate development, I also examine whether the determinants of low-rise residential redevelopment vary over space and time.

Study Design

In this paper, the study area is limited to the City of Seattle, located at along the eastern shore of the Puget Sound and at the heart of the Seattle-Tacoma metropolitan statistical area (MSA). The entire region stretches across four counties, King, Kitsap, Pierce and Snohomish, and is home to approximately 3.5 million residents (Figure 4.1). The City of Seattle claims a population of approximately 630,000 as of the 2010 census. Seattle, the most densely developed area in the region, is also the center of redevelopment activity.

Redevelopment occurs across a number of land uses and at a variety of densities. The factors that drive redevelopment differ by use and density. To avoid confus-

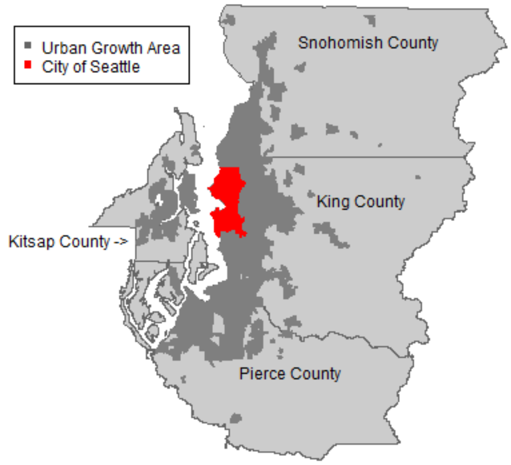

Figure 4.1: Regional Map

ing these various use-specific processes this study focuses on a single type of redevelopment: the change from detached single family[5] to low-rise or medium density residential uses. Low-rise residential developments are defined here as townhomes, rowhouses, small apartments and small condominium structures. Properties transitioning from single family, detached residences to low-rise residential uses represent the most common form of redevelopment within the city. By limiting the set of observations to low-rise residential redevelopment, this study is able to focus on a single set of zoning categories within the City of Seattle; the Lowrise (LR) zones. By analyzing only properties within these zones, the maximum potential building densities for redevelopment are well established and entitlement variations between the three zones can be clearly accounted for in the statistical models.

The LR zones –LR1, LR2 and LR3 –are the basic transition zone for low-rise residential uses and are widespread throughout the City of Seattle. The LR1 zones possess the most restrictive density regulations and the LR3 the least. LR zones

[5]Includes single family structures currently converted to 2, 3 and 4 unit dwellings.

allow overall floor-to-area ratios (FARs) ranging from 0.9 to a maximum of 2.0 (for apartments in an LR3 zone within an urban village). The exact allowed densities vary incrementally within each zone depending on the type of construction, urban village location, proximity to transit and conformance to City's green building code (City of Seattle 2011). In a majority of situations the allowable density limits range from FARs of 1.0 (LR1) to 1.4 (LR3). Allowed uses in the LR zones are limited to single family detached dwellings, rowhouses, townhomes, apartments and condominiums. Most of the properties within these zones not having already redeveloped are composed of older detached single family residential structures built prior to 1950 and, therefore, are particularly susceptible to redevelopment.

This study focuses on the individual land use decisions made by property owners and, as such, requires a data-rich set of observations to analyze the desired relationships. More specifically, this means the use of parcel (or property) level data. Additionally, in order to examine the changing nature of redevelopment over time, longitudinal data are necessary. Through the King County Assessor's Website, the University of Washington's Map Library and the Runstad Center for Real Estate Studies' data archives I have pieced together a panel dataset of both property characteristics and GIS shapefiles for all parcels in the City of Seattle from 2000 to 2012. Using these data it is possible to determine the land use, structural characteristics and parcel shape for each property for each year during this period, missing years withstanding.[6]

Model Variables

By utilizing the Land Use Change Identification and Analysis (LUCIA) system developed in an earlier paper (Krause 2013) I began by creating a dataset that identifies the type of land use change that has occurred on each property over this period, the year

[6]Property information from 2002 and 2003 is missing, as are the GIS coverages from 2002.

of that change, the beginning and ending land use and the relevant structural characteristics. From the LUCIA data, I then selected all properties within an LR zone for the entirety of the period and those having a detached single family residential land use as of the initial time period of the study, 2003. This universe of parcels represents 8,367 individual properties[7]. Using the LUCIA data, parcels that have redeveloped to a higher density residential use (townhomes, rowhouses, condominiums or apartments) are easily identified. Whether or not these properties redeveloped represents the dependent variable in this dataset, *REDEV*. The time of redevelopment or the time at which the observations were censored (end of study period) is recorded in the *REDEVTIME* variable. Over the 10-year period, 1,122, or 13.41% of the universe of parcels redeveloped into a higher density residential use.[8] The location of the study observations are shown in Figure 4.2. Seattle's Urban Villages are highlighted on the map to indicate the location of the downtown core as well as smaller neighborhood centers spread throughout the city.

Independent variables that explain the risk or probability of redevelopment fall into one of four categories; 1) policy; 2) physical; 3) location/neighborhood and 4) market. Variables are introduced briefly by category below, a detailed discussion of the development of those requiring complex calculations is found in Appendix A. Table 4.1 contains summary statistics for each variable.

Public policy, via the granting of legal entitlements, controls the type of use and the density to which real property can be developed. As a result, these institutional controls impart considerable impact on the feasibility (and therefore probability) of redevelopment. The primary governing forms of legal entitlements are zoning regulations. To measure zoning designation three variables indicate location within the LR1 Zone, *LR1*, the LR2 zone, *LR2*, and the LR3 zone, *LR3*. Finally, a small number

[7] A discussion of the filtering process to remove outlying values occurs on page 115.

[8] Of these redevelopments, 98% involved townhome or rowhouse construction. The remaining 2% are composed of apartments and condominiums.

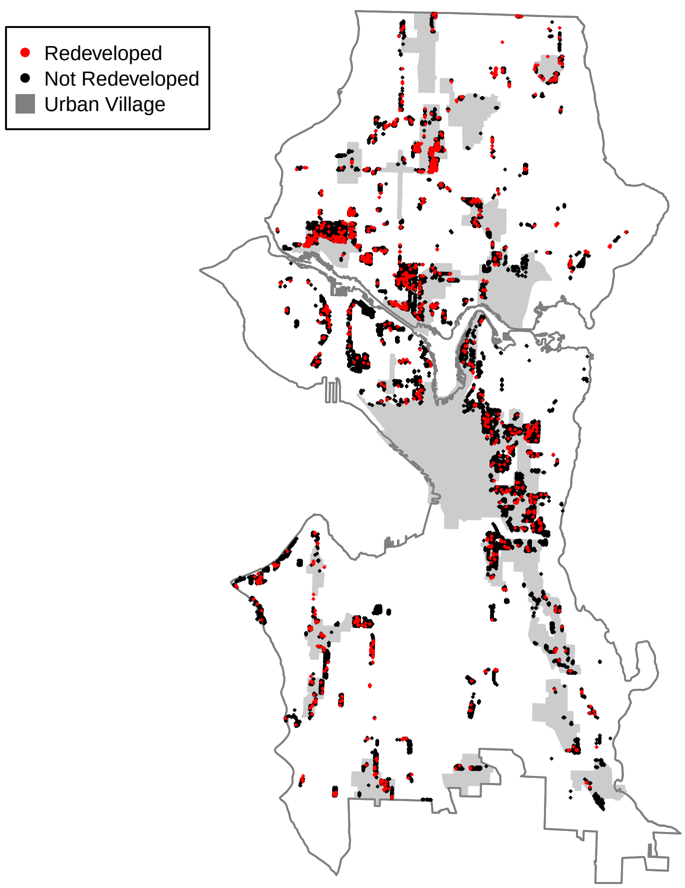

Figure 4.2: Subject Locations

of the properties in the study are located in a Residential-Commercial (RC) overlay zone in which small, ground floor retail land uses are allowed. The *RCOVERLAY* variable identifies those properties in the overlay zone.

As previous research suggests, both the existing structure and the characteristics of the lot can influence the probability of teardown, a precursor to redevelopment (Weber et al. 2006; Dye & McMillen 2007). Data collected on the structure include the size of the main structure[9], *STRSF*, the year the main structure was built, *YEARBUILT*, the condition of the property, *COND*, the quality of construction as judged by the King County Assessor, *BLDGGRADE*, an indicator variable denoting that the home has been divided up into multiple living units[10], *XUNITS*, and a variable indicating that a separate, accessory dwelling unit is present on the property, *ADU*. Characteristics of the lot are described by variables representing the lot size, *LOTSF*, the shape, or squareness of the lot, *SHPFCTR*[11], the King County Assessor's assessment of view quality[12], *VIEW*, and a variable indicating that the Assessor believes the site topography to be negatively influencing value, *TOPO*. One final variable compares the density of the existing property[13] to the potential density given the property's zoning, *FARDIF*.

Next, a set of location or neighborhood variables were developed. These include measures of accessibility, socio-economics and neighborhood design. Accessibility is measured as the distance to the center of downtown Seattle, *DISTCBD*. Census 2010 median income at the block group level, *MEDINC*, is included as a indicator of socio-economic status. Next, the RENTPER variable measures the percentage of housing

[9]The largest dwelling on site.

[10]Limited to those homes classified as duplexes, triplexes and quadplexes.

[11]See Appendix B for a description of this calculation.

[12]In the case of multiple views, the best is taken. The scale ranges from 0 (none) to 4 (best).

[13]Represented as the floor-to-area ratio (FAR): total structural square footage / total lot square footage.

units occupied by renters, again using 2010 Census data.[14] Neighborhood design is composed of features that are relatively stable, such as the street network, as well as those that are not such as overall neighborhood density and the mixture of land uses in the area. As a result, two different types of variables are developed here, those that are static (time-invariant) and those that change (time-dependent) over the ten-year period of the study. The term neighborhood is also ambiguous. I used GIS analysis to create a $\frac{1}{4}$ mile (400m) radius around each observation from which to calculate the following neighborhood design variables.[15] The time-invariant design variables include a measure of intersection density, *INTDENS*, and a measure of the the 'grid-ness' of the street network, *INTGRID* (Bitter & Krause 2013). Time-dependent measures of neighborhood design include land use mix, *LUMIX*, overall neighborhood floor-to-area ratio, *NBHFAR*, and adjacency to a commercial, industrial or multiple-family use, *ADJCIMU*.

Finally, four market-based variables were developed. First, measures of market change and uncertainty are created in an attempt to examine the impact of option values on redevelopment. The first is a metric of overall price appreciation in the neighborhood, *NBHTREND*, and second, the level of uncertainty surrounding this trend, *NBHUNCERT*.[16] These two variables loosely follow the trend and uncertainty variables used by Cunningham (2007) and Towe et al. (2008). Finally, two indicators of local competition (Bulan et al. 2009) or priming (Wilson & Song 2011) were developed. These variables, *NBHREDEV* and *ADJREDEV*, measure the number of medium density redevelopment having occurred over the past three years within the neighborhood ($\frac{1}{4}$ mile radius) and the adjacent parcels, respectively.

As with most observational data, a small number of outlying values generally exist

[14] Ideally the socio-demographic variables would be time-varying as well, however, the annual Census ACS data does not reach back to the beginning of this study. As a result, the 2010 figures were used to roughly approximate the income and tenure-type over this time period.

[15] A complete discussion of this process is available in Appendix A.

[16] See Appendix A for more information on how the variables were calculated.

across the variables in a dataset. This compilation of data is no exception. The following filtering criteria were applied to the original dataset of 8,715 properties in order to eliminate observations with uncommon data or characteristics not representative of a typical single family home at risk for redevelopment. Removed were observations with: 1) lot size less than 2,000 or more than 20,000 square feet; 2) structural size less than 400 or greater than 8,000 square feet; 3) a structure of more than 4 stories; and 4) a 2003 assessed value per square foot of land greater than $100 or per square foot of improvement greater than $300. In sum,348 total observations were removed from the original dataset of 8,715 (3.99%).

Exploratory Data Analysis

Data on an urban process like redevelopment is inherently spatial. As a result, the spatial context of the data is important in developing models and explaining the phenomenon of interest. Figure 4.3 shows the probability of redevelopment in LR zones as a surface fitted over the extend of the City of Seattle.[17] As shown, conversion rates are much higher in north Seattle as well as in the southwest part of the city (in the area known as West Seattle).[18]

Another key component of this dataset and the analysis in general is the impact of time. The urban environment in which the observations are located is highly dynamic. Consumer preferences, market cycles and the onward march of continued urban growth all interact over time to influence the probability of redevelopment on any given site at any given time. Added to this underlying, constant state of change is the fact that the 2003 to 2012 time period saw a considerable housing price bubble

[17]Rates are calculated as the redevelopment rate of the nearest 100 observations to each grid point on the map.

[18]Since observations in this data are not evenly spread over space, it is misleading to represent a smoothed surface of values for areas in which there are few to no observations. As a result, in Figure 4.3 colors indicate the smoothed surface value while the transparency of the color at each point corresponds to the density of data at that point where more transparency equals less data density (also known as visual weighting).

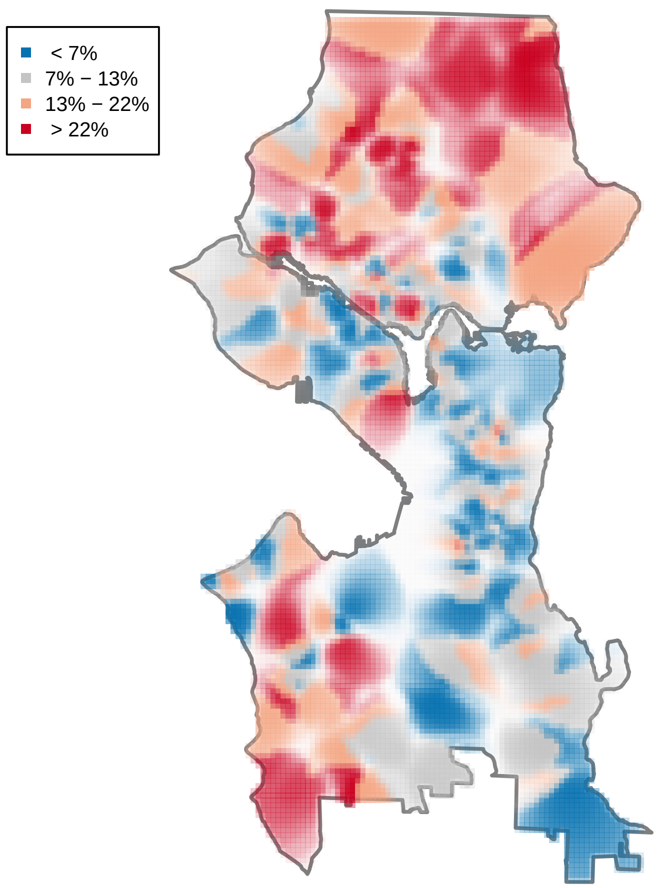

Figure 4.3: Conversion Rate Surface

Table 4.1: Summary Statistics

Name	Type	Time	Unit	Min	25th%	Median	Mean	75th%	Max
REDEV	Dep		Bin	0.00	0.00	0.00	0.13	0.00	1.00
REDEVTIME	Dep		Year	2003	2005	2007	2007	2008	2012
LR1	Policy	Inv	Bin	0.00	0.00	0.00	0.43	1.00	1.00
LR2	Policy	Inv	Bin	0.00	0.00	0.00	0.36	1.00	1.00
LR3	Policy	Inv	Bin	0.00	0.00	0.00	0.22	0.00	1.00
RCOVERLAY	Policy	Inv	Bin	0.00	0.00	0.00	0.03	0.00	1.00
STRSF	Phys.	Inv	Cont	400	1,120	1,560	1,677	2,050	6,170
YEARBUILT	Phys.	Inv	Year	1,900	1,908	1,921	1,929	1,950	1,999
COND	Phys.	Inv	Fctr	1.00	3.00	3.00	3.40	4.00	5.00
BLDGGRADE	Phys.	Inv	Fctr	3.00	6.00	7.00	6.80	7.00	12.00
XUNITS	Phys.	Inv	Bin	0.00	0.00	0.00	0.37	1.00	1.00
ADU	Phys.	Inv	Bin	0.00	0.00	0.00	0.01	0.00	1.00
LOTSF	Phys.	Inv	Cont	2,000	3,720	4,800	4,926	5,740	19,600
SHPFCTR	Phys.	Inv	%	41.54	87.93	92.22	91.16	95.01	106.00
TOPO	Phys.	Inv	Bin	0.00	0.00	0.00	0.05	0.00	1.00
VIEW	Phys.	Inv	Fctr	0.00	0.00	0.00	0.30	0.00	4.00
FARDIF	Phys/Pol	Inv	Cont	0.36	64.60	79.00	78.55	94.71	132.80
MEDINC	Loc/Nbh	Inv	Cont	0.93	5.46	6.83	6.98	7.95	18.26
RENTPER	Loc/Nbh	Inv	%	0.79	42.11	57.66	56.50	71.43	100.00
DISTCBD	Loc/Nbh	Inv	Cont	0.98	2.06	3.63	3.69	5.01	8.84
LUMIX	Loc/Nbh	Var	%	10.60	49.15	57.89	57.02	65.68	95.45
NBHFAR	Loc/Nbh	Var	Cont	0.06	0.33	0.44	0.48	0.58	1.85
ADJCIMU	Loc/Nbh	Var	Bin	0.00	0.00	0.00	0.38	1.00	1.00
INTGRID	Loc/Nbh	Inv	%	53.85	69.44	75.60	75.91	82.05	100.00
INTDENS	Loc/Nbh	Inv	Cont	9.00	35.00	49.00	50.06	64.00	105.00
NBHTREND	Market	Var	Cont	-32.24	-1.08	13.47	10.18	22.98	48.50
NBHUNCERT	Market	Var	Cont	-23.93	-5.23	-0.61	-1.12	3.46	20.17
NBHREDEV	Market	Var	Cont	0.00	6.00	17.00	24.58	34.00	226.00
ADJREDEV	Market	Var	Bin	0.00	0.00	0.00	0.07	0.00	1.00

and subsequent burst. While it is true that many of the worst effects of this intense market cycle were felt in the suburbs (Kuminoff & Pope 2013), low-rise residential development in urban areas is still, to a large extent, composed of owner-occupied units and therefore subject to some of the same financial forces as suburban tract homes.

Given these temporal dynamics, it is likely that overall redevelopment probability varied over the 2003 to 2012 period. Figure 4.4 shows the inverse of the survival curve (1 - survival curve) for the observations in this study. In this case, redevelopment

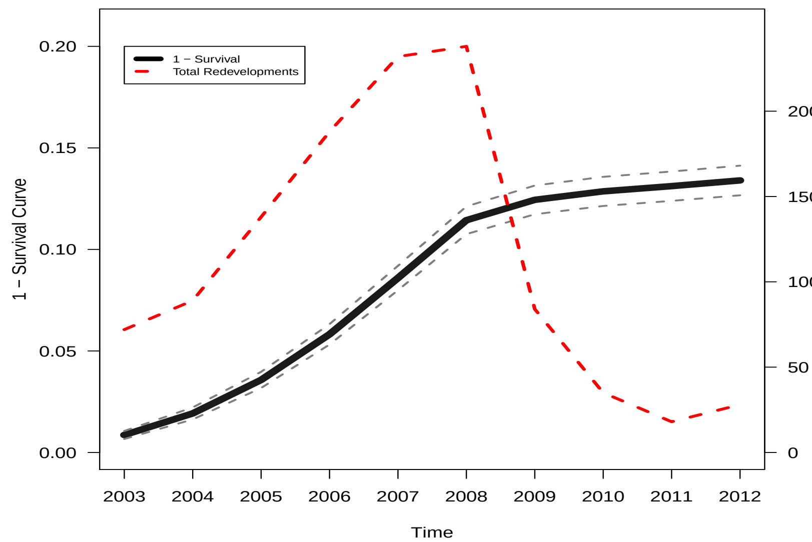

Figure 4.4: Overall Cumulative "Death" for Subject Properties

is analogous to a "death" in a more traditional duration (survival) analysis setting. This curve represents the cumulative rate of "death" over time.[19] The upper and lower 95% confidence intervals are shown to give the level of uncertainty inherent in the estimation. The total number of observations in the dataset is 77,764. There are 8,367 observations in year 1 and each year as properties "die" (redevelop) they drop out of the dataset the following year, resulting in only 7,245 observations remaining for year 10 (2012).

Redevelopments in LR zones were fairly steady from 2003 until about 2005 at which point the rate of redevelopment increased markedly. This elevated rate lasted until 2008 when, simultaneous with the national recession, rates of redevelopment declined precipitously. Given the overall state of the economy from 2009 until 2011,

[19] Since the temporal resolution of the observations are at the annual level, the true survival curve would be a step function. I have smoothed it out here for visualization purposes using a LOESS-based smoothing algorithm.

and the real estate market in particular, this trend is not surprising.

Methodology

The existing literature on redevelopment or teardown probability exclusively use probit model specifications (Rosenthal & Helsley 1994; Weber et al. 2006; Dye & McMillen 2007). However, recent studies looking at suburban land use change have adapted duration models to this task (Towe et al. 2008; Wilson & Song 2011) A recent simulated comparison of two model types shows that in studies spanning a long time period and containing time-varying independent variables, duration models outperform probit specifications (Wang et al. 2013). In light of these recent studies and the data developed for this study, I use a duration model specification known as the Cox Proportional Hazards model to estimate redevelopment probability in the City of Seattle.[20]

As with most statistical models, each specification type comes with an underlying set of assumptions. For the Cox model, it is the proportionality assumption that is most relevant. In this framework, proportionality means that the relationship between each co-variate and the dependent variable is constant over time. Allison (2010), however, questions the necessity of meeting this requirement in all cases and notes that in the presence of a small temporal drift in parameter values, the coefficient estimate from a Cox Proportional Hazards model will simply represent the average parameter estimate over time. Due to the Cox model's ability to handle both temporally-varying data and a non-constant baseline hazard, I have chosen to use the Cox model here, while paying attention to the proportionality assumption as being meaningful but not completely essential.[21]

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[20]For a more in-depth discussion of the relative merits of each model type see Appendix B.

[21]Note that a Cox model with relatively large temporal resolution (such as year) is equivalent to a piecewise exponential survival model that includes one piecewise time component for each of the observed event times in the data (Vermunt 1997). A comparison of results between these two model specifications using this dataset validated this equality, minus minor deviations due to the

A Cox Proportional Hazards model directly estimates the hazard rate (the instantaneous probability of an event) with a log-linear model specified as follows (Vermunt 1997):

$$h(t|x) = h_0(t)\, exp(\sum_{j=1}^{j} \beta_j x_{ij}) \tag{4.5}$$

where $h_0(t)$ is the baseline hazard (can vary over time), β_j is the coefficient vector and x_{ij} is the matrix of independent variables. A key component of the Cox model is that the underlying base hazard, h_0, does not need to be known or specified since this constant cancels out during the partial likelihood calculation used to estimate the model.[22]

The Cox model is estimated in a log-linear fashion. As a result, raw coefficient estimates are multiplicative, meaning that an estimate of 0.2 indicates a 20% change in redevelopment risk due to a one unit increase in the independent variable. In interpreting the raw coefficient estimates, values less (greater) than 0 equate to a reduction (increase) in the probability of the event. The coefficient values can also be exponentiated in order to derive the change in relative odds of the event probability given a one unit change in the co-variate values. Under this interpretation, relative odds of less than 1 indicate a reduction in the probability of the event, while the opposite holds for odds greater than 1.

The models used in this research have been estimated in the R software package (R Core Team 2013) using the coxph() function from the `survival` package (Therneau 2013). The data is singly, right-censored (Type I).

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manner in which event ties are handled between the coxph() and phreg() functions in R (`survival` and `eha` packages, respectively). Models were also tested using a discrete time specification in the `eha` package (Brostrom 2013). Coefficient results from the discrete time model (which uses a complimentary log-log link under a logistic regression framework) were similar to three or four significant digits to those from the Cox models reported here.

[22] Allison (2010) offers a lengthy, but straightforward explanation of the partial likelihood calculation.

Results

To examine the factors correlated with low-rise residential redevelopment in the City of Seattle, I begin by estimating a number of sequentially more complex Cox Proportional Hazards models using the data developed above (referred to as the base models). Summary model results, including coefficient estimates and indicators of statistical significance ($\alpha = .05$) are shown in Table 4.2 on page 124. Full model results for each of the five individual base models are given in Appendix C. The five model specifications estimated are divided into three major model types based on the variables used in the models. Models 1a and 1b utilize time-invariant policy and physical variables only. Model 2 sees the addition of time-dependent location and neighborhood variables. Models 3a and 3b incorporate the market variables.

In addition to the coefficients, the bottom of Table 4.2 contains a number of model diagnostics and measures of fit. The first, concordance, is a measure of the discriminatory power of the model.[23] In this context, discriminatory power relates to the ability of the model to properly rank any two pairs of observations, one experiencing the outcome (redevelopment in this case) and one not. An overall concordance measure is calculated by comparing all sets of outcome to non-outcome data pairs and recording the cases where the risk score (sum of the linear predictor coefficients) is greater for the observations in which the outcome occurred than in the paired observation in which it did not occur (Steyerberg et al. 2010). Summing the total number of these correct discriminations versus the total number of pairs in the data produces a concordance measure which is naturally in the range of 0 to 1. The discriminatory ability of the three sets of models range from a low of 0.757 for model 1a to a high of

[23] From Therneau (2013, p. 79): "Concordance is defined as Pr(agreement) for any two randomly chosen observations, where in this case agreement means that the observation with the shorter survival time of the two also has the larger risk score. The predictor (or risk score) will often be the result of a Cox model or other regression. For continuous covariates concordance is equivalent to Kendall's tau, and for logistic regression is equivalent to the area under the ROC curve. A value of 1 signifies perfect agreement, 0.6 - 0.7 is a common result for survival data, 0.5 is an agreement that is no better than chance, and 0.3 - 0.4 is the performance of some stock market analysts."

0.781 for model 3b, suggesting that this set of models correctly discriminates between a redeveloped and non-redeveloped property (by measure of risk score) 76% to 78% of the time.

Measures of the log-likelihood (logLik) and Akaike Information Criteria (AIC) are also shown.[24] Higher log-likelihood suggests a better fit to the model. Conversely, lower AIC values indicate a reduced loss of information (better fit to the data) for a given model. For comparison purposes, all three measures –concordance, log-likelihood and AIC –can be used to differentiate between some subset of the models. Across all specification types the concordance measure can be used for comparison. As the models become more complex left to right in Table 4.2, the concordance measure increases, suggesting that each change to the model helps discriminate to a great degree than the one before. Technically, the log-likelihoods cannot be compared between models 1a, 1b and 2 because these models are not nested. Because the AIC measure does not require nested models it, like the concordance measure, can be used to assess the relative performance of two distinct model specifications. The AIC metrics decrease consistently from models 1a to 3b, suggesting that each sequential change to the specification improves model fit.

[24] Note that the `AICcmodavg` package that I used to extract AIC values from a Cox Proportional Hazards model actually calculates the AICc value, a slightly more penalized version of AIC. AIC and AICc are asymptotic in large samples and therefore present no difference in interpretation here from traditional measures of AIC.

Table 4.2: Condensed Model Results

Variable	Model 1a	Model 1b	Model 2	Model 3a	Model 3b
LR2	0.908*				
LR3	1.086*				
logSTRSF	-1.101*				
COND	-0.025	-0.027	-0.048	-0.049	-0.068
BLDGGRADE	0.09	-0.005	-0.053	-0.056	-0.054
YEARBUILT	-0.004*	-0.002	-0.006*	-0.006*	-0.007*
XUNITS	0.316*	0.229*	0.213*	0.211*	0.196*
ADU	-1.079*	-0.44	-0.509	-0.512	-0.48
TOPO	-0.732*	-0.707*	-0.505*	-0.511*	-0.469*
VIEW	-0.193*	-0.185*	-0.102	-0.102	-0.071
logLOTSF	1.587*	0.746*	0.794*	0.798*	0.817*
SHPFCTR	0.039*	0.041*	0.038*	0.038*	0.035*
FARDIF		0.033*	0.03*	0.03*	0.03*
MEDINC			0.018	0.018	0.015
RENTPER			-0.011*	-0.012*	-0.01*
DISTCBD			0.193*	0.188*	0.173*
LUMIX			0.001	0.001	-0.003
NBHFAR			1.175*	1.134*	1.114*
ADJCIMU			0.471*	0.47*	0.351*
INTDENS			0.001	0.001	0
NBHTREND				-0.002	-0.002
NBHUNCERT				0.016*	0.017*
NBHREDEV					0.004*
ADJREDEV					0.491*
Concordance	0.757	0.757	0.777	0.777	0.781
logLik	-9648	-9627	-9527	-9524	-9495
AIC	19319	19274	19087	19087	19032
AICChange		-46		-1	-55
n	8,367	8,367	77,764	77,764	77,764

Base Models

I begin by estimating a model (1a), that includes only policy and physical variables.[25] All of the initial variables show significant impacts on the risk of redevelopment, with the exception of structure condition, *COND*, and quality, *BLDGGRADE*.[26] All variables show the expected signs with the exception of the *BLDGGRADE* and *VIEW* variables. Rationale for these unexpected results are given in the discussion that follows.

In their study on high density redevelopment in Chicago, Grovenstein et al. (2011) suggest the use of the difference between existing density and potential density (under existing zoning regulations) as an explanatory variable determining redevelopment risk. In model 1b, I add this variable, *FARDIF*, which is calculated as the difference between the existing floor-to-area ratio and potential under the zoning designation. Deriving the *FARDIF* variable uses a linear combination of the *STRSF*, the *LOTSF* and one of the zoning designation variables (*LR1* (the control in model 1a), *LR2* or *LR3*) and, as a result, two of these three variables have to be removed when *FARDIF* is entered into the model due to near perfect multicollinearity with the *FARDIF* variable. I remove the zoning designation and the structure square foot measure. In using this combined measure, *FARDIF*, the concordance and log-likelihood increase and the AIC decreases, all indicators of improved model fit. Future models use the specification in model 1b as a starting point. The remaining variables, with

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[25] The hedonic price literature has shown that non-linear (Clapp & Salavai 2010) or vintage effects (Coulson & McMillen 2008; Bitter 2013) often exist when modeling the relationship between home age and home prices. Tests of non-linear effects on the *YEARBUILT* variable added no additional explanatory power to the model. Additionally, tests of vintage effects suggest that grouping homes by vintage decreases the explanatory power of the model and does not impact other coefficient estimates. As a result, neither non-linear nor vintage effects were considered in the final model specifications. In short, non-linear and vintage effects found to impact home prices may be less pronounced in determining redevelopment probability.

[26] The impact of the *RCOVERLAY* was tested as well, but found to be insignificant. As there is no theoretical justification for this variable and because it affects a very small number of properties it was removed from the model.

the exception of *logLOTSF* which is intrinsically related to the *FARDIF* variable, maintain similar coefficient estimates between models 1a and 1b.

In model 2, I add the location and time-varying neighborhood variables to the specification. In doing so, the model now uses the panel set of observations with the total number increasing from 8,367 to 77,764. All added location variables are significant at the $\alpha = 0.05$ level with the exception of the *MEDINC*, *LUMIX* and *INTDENS*. As expected overall neighborhood density, *NBHFAR*, and adjacency to a commercial, industrial or multiple family use, *ADJCIMU*, both have a positive relationship with redevelopment. Percent of renter-occupied units, *RENTPER*, on the other hand, shows a negative relationship with redevelopment risk. The neighborhood/location variables are based on a neighborhood definition of $\frac{1}{4}$ mile (400m). Sensitivity tests using alternate neighborhood definitions of $\frac{1}{8}$ mile (200m) and $\frac{1}{2}$ mile (800m) produced very similar parameter estimates for both the neighborhood/location variables and other co-variates.

Next, models 3a and 3b each add one set of the market-based variables. I start with the addition of the variables measuring localized[27] price trends and the uncertainty in those trends. Price trends, *NBHTREND*, show no significant impact, but price deviations, *NBHUNCERT*, that are higher than expected do exhibit a positive relationship with redevelopment. In model 3b I add two measures of competition (Bulan et al. 2009) or priming effects (Wilson & Song 2011): 1) the total number of low-rise residential redevelopments in the neighborhood over the past three years, *NBHREDEV*; and 2) adjacency to a low-rise redevelopment occurring in the previous three years, *ADJREDEV*. Both variables are positively related to redevelopment risk. By adding these four market variables, all other co-variates have maintained their sign though coefficient magnitudes have shifted slightly. This relative consistency over the five base model specifications speaks to the robustness of the model.

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[27]Nearest 500 homes sales within past three years

Discussion of Base Model Results

Results for all five base models are shown in Table 4.2 and are discussed in detail below. To aid in visualizing and comparing these results across variables, Figure 4.5 on page 130 illustrates the relative risk of redevelopment associated with a one standard deviation increase (or 1 unit increase for binary variables) for only the preferred model specification, model 3b.

To begin, the impacts of legal development entitlements are highly influential in the redevelopment process. Location within an LR2 or LR3 zone provides moderate increases in the allowable floor-to-area ratio (FAR) of about 0.2 to 0.3 for LR2 and 0.2 to 0.5 for LR3 compared to the LR1 zone.[28] Yet, location within these two more dense zones double the odds of redevelopment (model 1a). These findings may suggest that there is a threshold point in terms of density at which redevelopment to low-rise, medium density housing is profitable and that a small increase in FAR from 1.0 to 1.3 can cross this threshold and thereby trigger redevelopment. The addition of the *FARDIF* variable, a measure of the difference between existing and potential density, necessitates the removal of the *LR2* and *LR3* variables from the model for statistical reasons. The *FARDIF* variable, a mix of policy and physical characteristics, shows a strong and consistently positive impact on redevelopment risk across all models in which it is used. An increase of this difference of 0.1 FAR relates to an increase in the relative odds of redevelopment of 0.42 to 0.51.

Structural characteristics such as the shape of the lot, *SHPFCTR*, and additional units in the home (a proxy for conversion to duplex/triplex/quadplex), *XUNITS*, show a positive relationship with redevelopment risk, as expected. More square lots allow for greater building footprints in most cases due to setback restrictions in the Lowrise zones. Conversion of an existing home to a multi-family use, *XUNITS*, signals that the property is being used as an investment as opposed to an owner occupied

[28] Excluding small density bonuses that may be applicable.

home, a fact that is likely to increase the probability of the owner's willingness to sell and/or teardown the structure if financial calculations suggest that such an action would be profitable. Structure condition, *COND*, and quality, *BLDGGRADE*, show no significant relationship to redevelopment. Structure year built (newer homes), *YEARBUILT*, additional dwelling structures, *ADU*, and difficult topography, *TOPO*, decrease redevelopment probability, all of which are in line with the NPV theory.

Interestingly, view quality, *VIEW*, shows a significant negative relationship with redevelopment probability. A potential explanation for this is that properties with a view have a moderate level of topographical challenge, not enough to warrant a classification by the county assessor, but enough to limit potential redevelopment via higher construction costs and decreased density. Additionally, properties with good view are more likely to have high land values due to the view amenity, a cost which may not be able to be fully passed on to buyers or renters since only some portion of the low-rise housing that may be built can capitalize on the view. Overall, physical features that increase the potential size of redevelopment (and therefore potential profit) increase the risk of redevelopment and those factors that increase the costs of redevelopment decrease it. The empirical relationships found here validate the existing net present value (NPV) theory of urban (re)development.

Within the location/neighborhood variables, moderate relationships to redevelopment are found. Overall neighborhood density, *NBHFAR*, and adjacency to a commercial/industrial/multi-family use, *ADJCIMU*, both show significantly positive relationships with redevelopment risk. These results are expected, as both overall density and adjacency to non-single family uses are indicators of an area with demand for low-rise residential redevelopment. At the neighborhood scale, however, both land use mix, *LUMIX*, and intersection density, *INTDENS*, show no significant impact on redevelopment risk. At first these results may appear counter-intuitive since the walkability provided by dense street networks and mixed uses are often cited as amenities (Matthews & Turnbull 2007; Pivo & Fisher 2011). Most low-rise residential redevelopment, however, is composed of owner-occupied housing units and may value the quiet streets and easy parking that are more common in single use, residential neighborhoods (Song & Knaap 2003). The neighborhood boundaries used in the GIS calculation here are small, $\frac{1}{4}$ mile, and these findings could also signal that the cost and benefits of close proximity to mixed use areas are offsetting (at least at the $\frac{1}{4}$ mile scale). Finally, the ratio of nearby dwelling occupied by renters, *RENT-PAR*, exerts a negative impact on redevelopment risk, while median income shows no significant effect. Again, due to the prevalence of owner-occupied units in low-rise redevelopment, proximity to areas largely composed of renters may be seen as a nuisance, resulting in decreased demand. The ambiguous effect of median income could be due to issues of causality, i.e., it is difficult to disentangle whether income drives redevelopment or if the redevelopment is significantly changing the demographics of the neighborhood.[29]

[29] As the subsequent analysis shows, the impact of income varies over time.

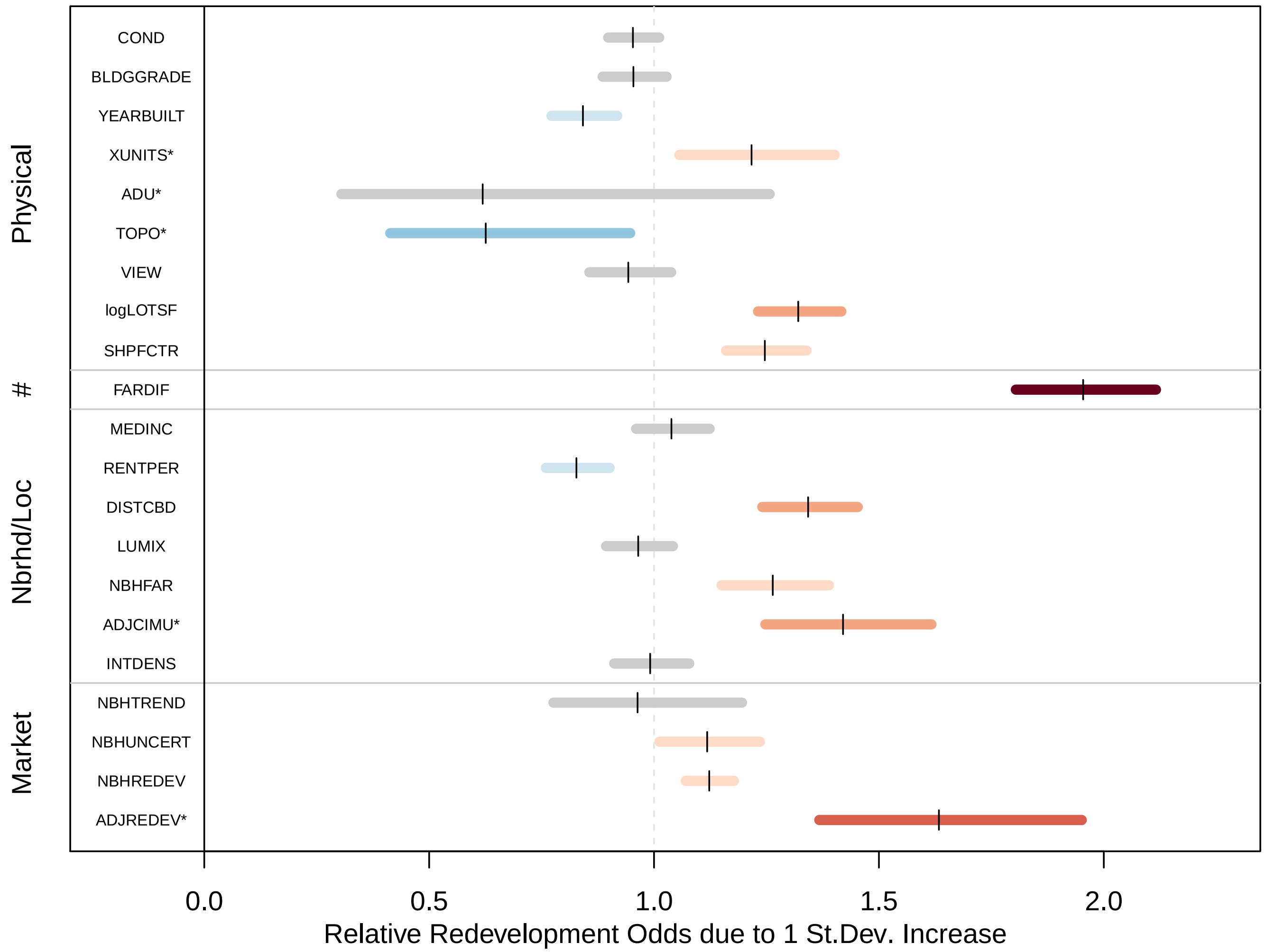


Figure 4.5: Variable Impacts on Redevelopment (Base Model)

The final variables added to the models are those dealing with market effects. First are measures related to market price trends and the uncertainty in these trends, grouped as "option value" effects. *NBHTREND* measures the impact that localized home price trends[30] have on the risk of redevelopment. As Table 4.2 shows, neighborhood home price trends appear to have an ambivalent effect on the probability of redevelopment; a finding that warrants discussion. Option value theory suggests that in the face of rising prices (potential profit) an owner may decide to withhold investment in the hopes that in a future time period the property may be developed to a more intense highest and best use, therefore resulting in a higher net present value to the owner than a redevelopment today. In this situation, there is value in the option to wait and increasing prices will have a negative influence on redevelopment probability. Two problems exists with this line of thinking in the case of low-rise residential redevelopment in the City of Seattle. The first is that most properties that are redeveloped must be purchased by a developer. As a results, increasing prices can raise the cost of purchasing the property which may not mean an increase in overall profitability from the redevelopment, despite the rising market. Existing option value theory (Titman 1985) is generally concerned with an owner who is also the developer, a situation which may not be all that prevalent in the case of redevelopment from a detached single family home to a low-rise residential use. The second issue with option value theory in this context is that zoning and other land use regulations limit the potential highest and best use that may be achieved in the future. As a result, increased prices (market demand) may increase the ultimate price that may be charged for units in the future, but, often cannot increase the total intensity (number of units) that can be built, barring a change in legal entitlements. In such a situation, option value is likely to be greatly diminished by existing land use regulations that considerably limit the highest and best use of the property. Given these two issues,

[30]Nearest 500 homes sales over the prior 3 years

the findings of these models, though contrasted with much of the existing work on option values (Cunningham 2006, 2007; Bulan et al. 2009; Grovenstein et al. 2011)[31], may be entirely reasonable.

A related issue to be considered here is that within a Cox Proportional Hazards model the impact of time is controlled by the partial likelihood calculation. In other words, the coefficient estimates, *NBHTREND*, represent the change in redevelopment risk due to differences in local house price trends over space not over time. As a result, the coefficient estimates here are interpreted as indicating the effect that greater price appreciation in one neighborhood or area has on redevelopment as opposed to the same property in a neighborhood with a lower price appreciation trend at the same point in time. Given this, the insignificant effect of neighborhood price trend simply suggests that spatial differences in price trends have a de minimus impact on redevelopment risk. In sum, the two theoretical issues noted above combined with the methodological constraints noted here mean that the deviation from earlier published findings on option value is plausible.

The second option value variable, *NBHUNCERT*, measures the deviation in the neighborhood home price trend for the year prior to the observation (T-1) as forecast by the trend for the periods two and three years prior.[32] Contrary to previous research (Cunningham 2006, 2007) that measured uncertainty as overall deviation, I have simplified the measure to be a one year difference (an average residual over four quarters). This simplified measure has two benefits; 1) it smooths out seasonal effects in house price trends that may contribute to a quarterly-based measure of deviation; and 2) it allows for the measure of uncertainty to take a positive or negative value. This second point suggests that while, theoretically-speaking, uncertainty of any kind

[31]The fact that most of these previous research deal with suburban vacant land may also be a cause for the discrepancy in results. In other words, due to the greater inflexibility in land use regulations in an urban setting, option values may place less of a role in dense redevelopment decision than in subdivision development at the periphery.

[32]For a complete description of this calculation see Appendix A

can make waiting to invest more profitable, that positive deviations from expected trends may have different effects than negative ones on redevelopment decisions. The results from models 3a and 3b (Table 4.2) suggest that, indeed, local house price trends that deviated from expectations in positive (negative) manner had a strong positive (negative) relationship with an increased odds of redevelopment even when controlling for other co-variates and the overall home price trends for three years prior to the redevelopment. Due to the strength of this relationship, there might be some concern that this metric is simply accounting for the housing market bubble, a phenomenon that has a correlation with higher rates of redevelopment in Seattle.[33] One factor limiting this concern is the fact that the Cox Proportion Hazards model specification allows for the base hazard of the event (redevelopment in this case) to vary over time, therefore mediating any correlation between uncertainty measures and the increased periods of redevelopment.

Unlike the *NBHTREND* variable, spatial variations in price trend uncertainty do have a positive influence on the decision to redevelop. This finding may indicate that rapid, and somewhat unexpected, changes in neighborhood price dynamics are a key factor attracting redevelopment. In such a situation, developers may be searching for the best value –buying land cheap and benefiting from neighborhood improvement –when choosing redevelopment sites.

Finally, the impacts of previous neighborhood, *NBHREDEV*, and adjacent, *ADJREDEV*, redevelopment are tested. In other literature, similar variables are either considered to measure competition in the market (Bulan et al. 2009) or a priming effect indicating that the market is ready for a particular type of development (Wilson & Song 2011). In both cases, the impact of these variables is hypothesized to increase redevelopment. I find similar relationships here as overall neighborhood redevelopment counts and adjacency to previous low-rise redevelopment are both associated

[33]As evidenced by the increased slope during the 2006 to 2008 time period shown in Figure 4.4 on page 119.

with an increase in the risk of redevelopment. Conceptually, these findings make sense as competition can decrease option value and encourage development while priming effects reduce the financial risk that a new development type in a given area may have.[34]

Overall, the strongest relationships, both negative and positive, are those involving the size of the current structure, size of the lot, the zoning designation and the difference in densities between existing and potential developments. These findings, much like previous work (Rosenthal & Helsley 1994; Weber et al. 2006; Dye & McMillen 2007), validates the net present value (NPV) theory of redevelopment.

Temporal Variation

One of the key assumptions of the Cox Proportional Hazards model is that the impact of each co-variate relative to all others is proportional over time (Vermunt 1997). Allison (2010), however, notes that in the absence of satisfying proportionality a coefficient will represent the average value of the impact over time and, therefore, small violations of this assumption may not be debilitating to the use of a Cox model. In addition, findings of temporal non-proportionality may suggest that the redevelopment process itself varies over time, as indicated by changes to coefficient estimates over the length of the study period.

The cox.xph() function within the R `survival` package offers a convenient method for both statistically and visually examining the degree of proportionality (or lack thereof) in the co-variates over time. Proportionality here is tested by comparing the scaled Schoenfeld residuals[35] with a scaled measure of time (based on the density

[34] Evidence of existing, successfully developments in an area may help convince lenders of the feasibility of a project and therefore increase the chance of a developer finding sufficient funding for a redevelopment project.

[35] Schoenfeld residuals are calculated as the difference between the observed covariate X for individual i and the weighted average of the covariate value for all observations in that time period (Schoenfeld 1982). Schoenfeld residuals are only calculated for the observations experiencing an event.

Table 4.3: Temporal Proportionality Test

	rho	chisq	p
COND	-0.010	0.112	0.738
BLDGGRADE	0.008	0.071	0.790
YEARBUILT	-0.013	0.185	0.667
XUNITS	0.002	0.005	0.946
ADU	0.002	0.004	0.950
TOPO	0.036	1.496	0.221
VIEW	0.024	0.697	0.404
lotLOTSF	0.043	1.493	0.222
SHPFCTR	-0.059	2.935	0.087
FARDIF	-0.067	4.392	0.036
MEDINC	-0.094	6.816	0.009
RENTPER	0.071	4.827	0.028
DISTCBD	-0.093	10.023	0.002
LUMIX	-0.087	8.694	0.003
NBHFAR	-0.070	4.243	0.039
ADJCIMU	0.037	1.494	0.222
INTDENS	-0.006	0.040	0.841
NBHTREND	0.065	4.015	0.045
NBHUNCERT	0.002	0.005	0.943
NBHREDEV	-0.043	1.771	0.183
ADJREDEV	-0.017	0.329	0.566
Global		64.060	0.000

of events) in which *rho* is expressed as the correlation coefficient between the scaled residuals and scaled time (Fox 2002). A chi-squared test is then performed to determine if the deviation in time for each coefficient is statistically significant. Table 4.3 shows the results of this test on model 3b, the preferred model from the set of base model specifications.

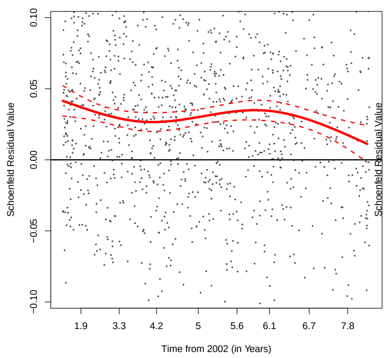
As shown in Table 4.3, this diagnostic measure suggests than seven of the variables possess some level of statistically significant deviation (α = .05) over time (non-proportionality). Figures 4.6 (a)-(g) plot the relationship between the Schoenfeld residuals for each variable and a scaled time measure.[36] In these plots a smoothed line along with 95% confidence intervals have been fitted to the data. The horizontal line across the center of each plot represents a coefficient value of 0.

The observed trends in Figures 4.6(a)-(g) suggest that a linear time trend may sufficiently captures the time-varying effects of these variables. The most straightforward manner in which to introduce linear time trends into the model is by interacting each of these variables with time. Results of adding these interaction terms are shown in Table 4.4. The addition of the interaction terms produce no significant impact in the direction or the general magnitude of the non-interacted variables, speaking to the robustness of the models. The interactions do, however, produce significant changes to the main effects of the seven interacted variables, as expected.[37]

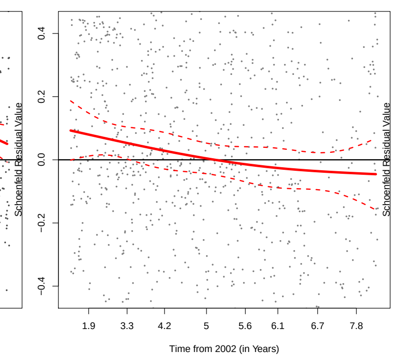
Overall, this analysis suggests that most of the variables in this model of redevelopment risk are generally stable over time; however, a select few show statistically significant temporal variation that can be accounted for with interaction terms. These interactions show that the impact of some factors on the redevelopment process in the City of Seattle have slowly changed over the 2003 to 2012 time period. In looking at the variables exhibiting this temporal variation, five of the seven are neighborhood

[36]Custom plotting of this relationship is not a standard feature of the cox.zph() function and has been accomplished via user-created code that is available from the author upon request.

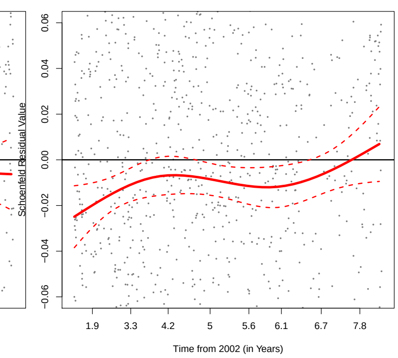
[37]Note that because the Cox Proportional Hazards model is semi-parametric and varies over time a main effects variable for TIME is not required.



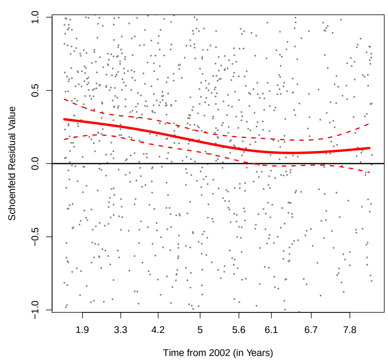
(a) FARDIF



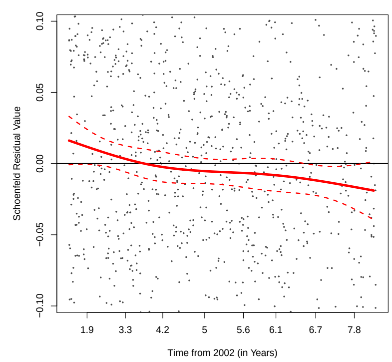
(b) MEDINC



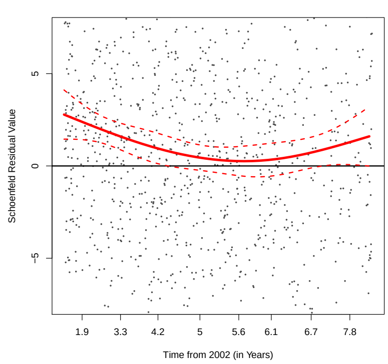
(c) RENTPER



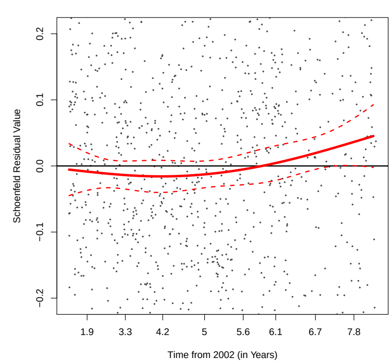
(d) DISTCBD



(e) LUMIX



(f) NBHFAR



(g) NBHTREND

Figure 4.6: Proportionality Tests: Schoenfeld Residuals vs. Time

or location variables. This suggests that the spatial context of redevelopment at the neighborhood level has changed over time in the city. Given the wild market fluctuations over this study period, the finding of temporal variation in the redevelopment process is to be expected.

The most interesting of the temporal trends are those involving the median income and rental percentage variables. Over time the impact of income on redevelopment has evolved from being positive to negative (though insignificant). Rental percentage shows an opposite trend. These changes in the relationship are likely picking up on the increased gentrification activity in the City of Seattle over the past four to five years. This activity has primarily occurred in lower income, higher renter areas such as the First Hill, Beacon Hill and Columbia City neighborhoods. In sum, the observed variations in the redevelopment process over time mean that public policies aimed at encouraging intensification should: 1) continuously monitor the redevelopment market; and 2) be flexibly designed so that during times of changing market fundamentals policy changes and updates may be quickly and easily assigned.

Spatial Variations

Real estate market and property development processes, the primary drivers behind redevelopment, are inherently spatial phenomena. Up to this point, the models presented in this research have accounted for impacts of space through the use of parametric co-variates such as measures of view scores, demographics and a host of neighborhood and market factors. In short, these variables, along with accounting for their main effects, are also serving in a limited capacity as proxies for more general spatial trends that may exist in the redevelopment process.

To examine if the redevelopment process itself varies over space, I have divided the City of Seattle into three submarkets, shown in Figure 4.7. The number of submarkets and their boundaries were chosen so as to be large enough to maintain a sufficient sample size, yet also reflect generally agreed upon market areas of the city. To specify

Table 4.4: Model 4 Results

	Coef	SE	Z	pval
COND	-0.07	0.043	-1.651	0.099
BLDGGRADE	-0.064	0.044	-1.452	0.147
YEARBUILT	-0.007	0.002	-3.885	0
XUNITS	0.188	0.072	2.603	0.009
ADU	-0.497	0.362	-1.374	0.169
TOPO	-0.474	0.211	-2.243	0.025
VIEW	-0.076	0.059	-1.278	0.201
logLOTSF	0.835	0.105	7.932	0
SHPFCTR	0.035	0.006	5.931	0
FARDIF	0.039	0.004	9.184	
MEDINC	0.111	0.04	2.755	0.006
RENTPER	-0.025	0.006	-4.261	0
DISTCBD	0.358	0.052	6.867	0
LUMIX	0.019	0.007	2.754	0.006
NBHFAR	2.418	0.529	4.568	0
ADJCIMU	0.349	0.066	5.27	0
INTDENS	-0.001	0.002	-0.356	0.722
NBHTREND	-0.025	0.015	-1.693	0.09
NBHUNCERT	0.016	0.008	2.118	0.034
NBHREDEV	0.005	0.001	4.803	0
ADJREDEV	0.485	0.091	5.345	0
FARDIF * TIME	-0.002	0.001	-2.301	0.021
MEDINC * TIME	-0.021	0.008	-2.561	0.01
RENTPER * TIME	0.003	0.001	2.799	0.005
DISTCBD * TIME	-0.041	0.01	-4.085	0
LUMIX * TIME	-0.005	0.001	-3.529	0
NBHFAR * TIME	-0.275	0.098	-2.817	0.005
NBHTREND * TIME	0.005	0.003	1.844	0.065
Concordance	0.783			
logLik	-9469			
AIC	18994			
n	77,764			

Figure 4.7: Submarket Regions

the three submarkets, I have aggregated a number of the local real estate broker's multiple listing service (MLS)[38] submarkets.[39]

The Central submarket is the oldest, most dense and most expensive of the three. The North and South markets are somewhat similar in overall urban form; less dense with larger lots than the Central submarket. The North, however, contains, on average, higher income individuals and possesses generally higher housing prices, all else equal. The large Duwamish industrial area bifurcates the South region into SE Seattle and SW Seattle (known locally as West Seattle).

A separate model using the specification from model 3b above was developed for each of the three submarkets. A graphic representation of the results of this analysis are shown in Figure 4.8, with full tabular results found in Appendix D. In

[38]The Northwest Multiple Listing Service, www.nwmls.com

[39]The North includes the North Seattle and Ballard/Greenwood markets, the Central combines the Queen Anne/Magnolia, Capitol Hill/Madison Valley and Downtown Seattle markets and the South is made up of the West Seattle, Beacon Hill and Central Seattle markets.

this figure, the dark gray lines indicate the coefficient estimate and the standard error for the North submarket, the medium gray lines for the Central and the light gray for the South. By comparing the coefficients for each variable we can determine if any substantial differences in the redevelopment process exist over the three submarkets.

Most of the variables show generally overlapping estimates, suggesting that their influence is relatively stable over the spatial extent of the city. Others, however, vary markedly over space. The impact of lot size ($logLOTSF$) on redevelopment probability is much greater in the Central market than in the North or South. Due to the generally smaller lot sizes in the older, Central area, this result is expected and shows the greatly increased likelihood of redevelopment for a large lot in an area with predominantly small parcels. View, median income and land use mix show considerably greater influence on redevelopment risk in the North market than in the others. In the South, the surrounding density and number of previous redevelopments play a bigger role than in the North and Central, while the importance of the difference between the existing and potential density ($FARDIF$) is diminished.

Overall, these spatial trends suggest considerable variation in the redevelopment process over space. Namely, in the densely populated and expensive Central submarket, lot size plays a large role. In the North, redevelopment is more likely to occur in localized areas of higher income near mixed use neighborhood centers. Finally, in the South, redevelopment appears to be more spatially contagious, where intensification is clustered in the highest density areas near recent, similar redevelopment. These variations suggest that in order to increase the prevalence of redevelopment, the differing spatial contexts should be recognized and exploited within land use plans.

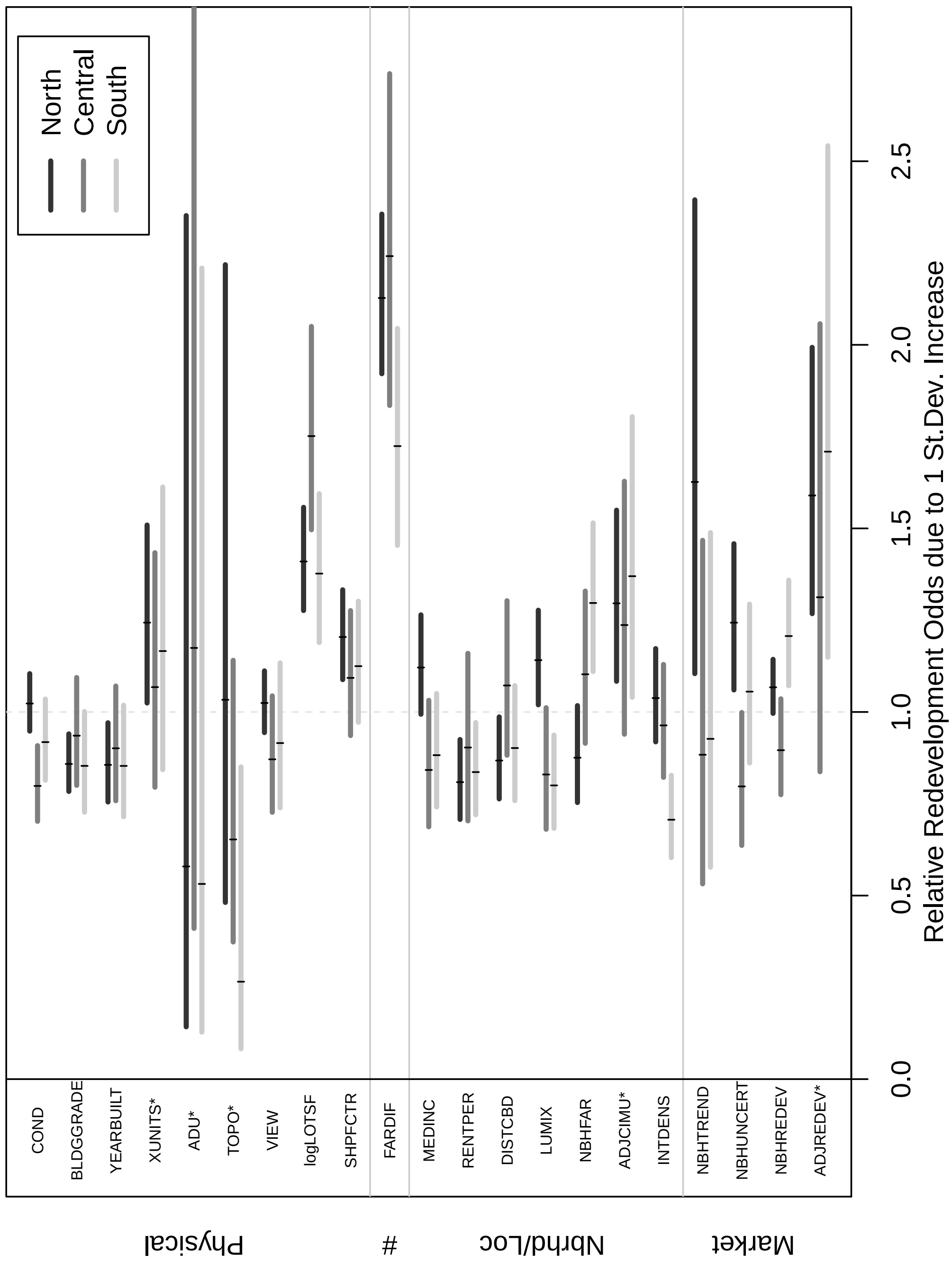


Figure 4.8: Submarket Model Results

Conclusion and Future Research

This research set out to test the determinants of low-rise redevelopment within the City of Seattle. Overall, the findings validate the basic net present value (NPV) theory of redevelopment that states that factors that increase the potential income from a redevelopment or lower the costs of such development will have a positive impact on redevelopment probability. Namely, properties with larger and more square lots, smaller homes and a larger difference between the existing property density and potential density under current zoning regulations are more likely to redevelop, ceteris paribus. The influence of lot size and differences in existing and potential density (*FARDIF*), however, vary between the three major submarkets in the city. This finding of spatial heterogeneity in the relationship suggests that in developing plans aimed at urban intensification policy makers should considered localized market processes. In sum, policies aimed at urban intensification cannot ignore the physical constraints and the existing built environment, specifically in regards to lot and home sizes. The interaction between these physical variables and legal entitlements is a critical factor in determining low-rise redevelopment.

In terms of neighborhood effects, overall neighborhood density and adjacency to non-single family uses show a positive relationship with redevelopment risk. Similarly, nearby low-rise redevelopment also increases redevelopment risk. These relationships highlight the priming effects in real estate development as both developers and their financiers use nearby market activity to gauge the potential success of a proposed project. Finally, an examination of option value factors does not find that option values inhibit low-rise redevelopment, however, option values are notorious hard to measure (Towe et al. 2008) and the Cox model specification limits option value comparison to the spatial dimension only. Also much of the existing empirical work and basic theoretical underpinnings of option values do not measure urban land use changes or factor into account strict density constraints such as those found in Lowrise zones in the City of Seattle. More work on option values and land use change within dense urban areas is required.

One issue often overlooked in the theoretical and empirical literature and not directly addressed in this research is the influence of lot assemblage in driving redevelopment decisions. Lot assemblage involves the combination of more than one adjacent lot in order to construct a development that normally would not be physically possible or legally permissible on the single parcel. Assemblages are difficult to properly model in a statistical sense because they are both highly idiosyncratic and inherently spatially dependent. Of the nearly 1,150 redevelopments observed in this dataset approximately 30% involved a lot assemblage situation. A cursory analysis of the differences between assembled and non-assembled redevelopment appears in Appendix E. Overall, this exploratory analysis shows that for assembled redevelopments the lot size and the lot shape (of the individual parcels) play a reduced role in determining redevelopment risk as compared to non-assembled redevelopments. Conversely, FAR differences, medium income and positive localized price uncertainty show increased influence. This analysis suggests that developers may be willing to undergo the time-consuming process of assemblage in areas with higher zoning entitlements and rapidly increasing market prices. More work on the assemblage phenomenon, including the spatial dependence of redevelopment probability, offers a worthwhile direction for future research.

Previous work using duration model analysis has focused on analyzing the factors contributing to peripheral, low-density suburban development. As a result, this study provides a contribution to the literature in being the first to apply a duration model to urban redevelopment decisions. By doing so, the effects of time-varying coefficients such as neighborhood density and changing market trends may be considered in modeling redevelopment risk.

This research also examines the changing nature of the redevelopment process over both space and time, another contribution to the existing knowledge of the process of urban intensification. The results of this spatio-temporal inquiry illustrate that the factors influencing redevelopment can vary over space and time, suggesting that planners need to take into account the context of the neighborhood and overall market trends when developing plans to encourage redevelopment. In short, urban intensification plans may need to be written in a manner that allows for timely and flexible updates, consistent with knowledge about localized trends gained from market information.

One interesting avenue for future research includes expanding this analysis to other areas in the region (such as Bellevue, Everett or Tacoma) or to other dense central cities through the country. It might also be instructive to see if similar relationships hold in zones in which higher densities are allowed, such as the Midrise and Highrise zones in Seattle. In these higher density zones, differences between mixed use and single use redevelopments could also be examined via multi-nomial analytical methods. The large impact that the small increase in FAR has on redevelopment probability could signal that a threshold effect is present. In this hypothesized situation, low-rise residential redevelopment is generally not financially feasible until a certain potential density level (in FAR) is reached.

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Appendix A: Development of Select Independent Variables

This appendix discusses the independent variables for which the calculation and/or rationale for their use is not fully explained in the body of the text.

XUNITS

Owner occupancy and/or overall investment in the property may also influence the likelihood of redevelopment. Absentee property owners may be less connected to the structure as a home and view the property as a simple economic investment, thus leading to increased willingness to redevelop if economic conditions favor such a decision. True owner occupancy variables are not available at the property level over this time period. The land use category of the property is used as a proxy here. Specifically, those properties listed as a duplex, triplex or quadplex are labeled as a 1 in the *XUNITS* (extra units) variable. Basic, one-unit detached single family residences receive a 0 in this field. While some owners may live in one unit and rent the remaining, the presence of these extra units signals that, at least to some degree, the property is more likely considered an investment by the owner than a traditional home.

ADU

The City of Seattle has expanded its Detached Accessory Dwelling Units (DADU) program to allow for the construction of more accessory dwelling units on certain single family residential properties. A variable, *ADU*, captures whether or not an ADU exists on a given property. The impact of an accessory dwelling unit on redevelopment probability is likely negative as the new construction of an ADU requires owner occupancy as well as signals a significant capital investment (and higher rent) in the property that would have to be demolished (overcome) to make redevelopment a feasible, economic decision.

SHPFCTR

Most setbacks within the Lowrise zones are 5 feet but can be as low as 0 feet for rear setbacks in rowhouses with an alley and up to 15 feet for rear setbacks of apartments with no alley.[40] Due to these setbacks and basic construction costs[41], the shape of the lot will also affect the potential profitability and therefore probability of redevelopment. To account for the "square-ness" of a given parcel, the *SHPFCTR* variable is calculated as:

$$SHPFCTR = \frac{\sqrt[2]{A}}{\frac{1}{4}L} * 100 \tag{4.6}$$

where A is the area of the parcel and L is the length of the perimeter of the parcel. This formula produces a convenient interpretation where a perfectly square parcel would equal 100, while a very long and narrow parcel would approach 0.[42] Note that a perfectly circular parcel would have a *SHPFCTR* of 200. Circular parcels are incredibly rare, however, a mostly square parcel with one or two curved sides could potentially have a *SHPFCTR* value of greater than 100.[43]

Locational Factors

The impact of the immediate local environment on the decision to redevelop can occur at two different scales, the broader neighborhood scale and the immediate, adjacency scale. In general, the real estate literature has found that for residential properties proximity to non-residential uses can contribute value, but that being too close is often a disamenity (Li & Brown 1980; Des Rosiers et al. 1996). I hypothesize that the same effect could occur in regards to redevelopment to low-rise residential uses.

[40]See Seattle RCW 23.45.518 for more details.

[41]Square buildings require less exterior finishing, complex roofing and design than a building with a geometrically complicated shape.

[42]Values are scaled by 100 here to improve the interpretation of the results in the empirical models that follow.

[43]Due to the fact that most buildings are constructed using straight exterior walls, the added value from a convex shaped lot line is likely minimal. Within this dataset, very few parcels have measurements greater than 100 so any potentially overestimate of utility based on this equation is trivial.

To capture both of these effects, a number of geospatial variables were calculated for the neighborhood (a $\frac{1}{4}$ mile or 400m radius) surrounding each observation as well as for the parcels immediately adjacent to it. Some of the variables have been calculated for both, others at only one of the two scales.[44]

The decision to redevelop and the observed redevelopment are not instantaneous. Instead, a given amount of time for property acquisition, permitting, design and construction are required. As a result, the actual decision to redevelop is influenced by the locational factors prior to the actual time at which the property is redeveloped. To account for this time lag, all of the location factors discussed below are calculated for one year prior to the time period of the observation. A one year lag is consistent with the temporal resolution of the data observations (accurate to the year) and has been used by other researchers investigating a related phenomenon (Cunningham 2006).

The first locational variable calculated is a measure of land use mix, *LUMIX*. Land use mix seeks to measure the equal proportionality of a variety of land use classes within a given area, in this case the 400m radius around each property.[45] The most common measure of land use mix (Song & Knaap 2003; Wilson & Song 2011) is based on an entropy measure where the mix coefficient is calculated as:

$$LUMIX = -\sum_{i=1}^{n} \frac{p_i * ln(p_i)}{ln(N)} \tag{4.7}$$

where N is the number of land uses and p_i is the proportion of land use in each category. For this calculation I have used the following five land use categories: 1) Single Family Residential (including 2, 3 and 4 unit structures); 2) Multiple Family

[44]The asymmetry in spatial scales is due to the fact that a largely aggregate measure like land use mix (LUMIX) may not be as applicable when applied to a few adjacent parcels and, similarly, adjacency to a commercial/industrial/multi-family use (ADJCIMU) has no real correlate at the neighborhood scale.

[45]In other words, the neighborhood for each property varies based on its location.

Residential; 3) Commercial/Office; 4) Retail; and 5) Other. Proportionality here is represented by a total count of each use as a percentage of the total count of parcels in the neighborhood.

Next, the total floor-to-area ratio (FAR) of the neighborhood (the $\frac{1}{4}$ mile or 400m radius), *NBHFAR*, is calculated for each of the ten time periods in the study, using the one year time lag. This FAR calculation is based on the total amount of built square footage of all property types, as gathered from the Assessor's records, divided by the total land area of the parcels within the neighborhood. Right-of-ways and bodies of water are not counted in the denominator of this equation.

Finally, an indicator variable measuring adjacency to commercial, industrial or multi-family use, *ADJCIMU*, is derived. All of these locational variables are time-varying and consist of one observation per property per year.

Option Values

The importance of option values, investor expectations and investment under uncertain conditions has become an important component of understanding real estate market dynamics (Titman 1985; Cunningham 2007; Towe et al. 2008; Bulan et al. 2009). In short, the ability to postpone (re)development until a time when the highest and best use or the profitability of the potential development is greater has a non-negative present value, known as option value. Previous research suggests that option value in its simplest form will increase land values and postpone development, two phenomenon that decrease the probability of redevelopment in any given year (Cunningham 2006; Clapp et al. 2012). This effect, however, can be moderated by the effect of localized competition (Bulan et al. 2009).

Two time-varying variables have been constructed to account for potential option value effects during the 2003 to 2012 time period. These two, *NBHTREND* and *NBHUNCERT*, seek to measure the overall home price trends in the neighborhood of each observation and the level of uncertainty surrounding those trends. Both metrics are calculated using a localized price index created with the nearest 500 home sales[46] occurring from three (T-3) to one year (T-1) prior to the year of the observation. The basic formula for this calculation is the following:

$$ln(Price) = \alpha + \beta\, X_k + \gamma\, Q_{1-12} + \epsilon_i \quad (4.8)$$

where ln(Price) is the natural log of the sales price, X is an N x k vector of explanatory variables such as home size, age, etc., Q is N x 12 set of indicator variables indicates sales in quarters Q-12, Q-11, etc. where Q is the first quarter of the year of the observation, α, β and γ are parameters to be estimated in the model and ϵ is the error term. The variable *NBHTREND* is calculated as the difference, expressed as a percent, between the mean of the quarterly indicators in year T-3 (quarters Q-12 to Q-9) and the quarterly indicators in year T-1 (quarters Q-4 to Q-1). By using the mean of these quarters I have eliminated any seasonality effects. In other words, this formula calculates the average percentage change in neighboring housing prices over the three-year period prior to the decision to redevelop (or not to do so).

Measuring buyer and investor uncertainty is much more difficult to do (Cunningham 2007; Towe et al. 2008). Loosely following Cunningham (2006) I estimate uncertainty, *NBHUNCERT*, as the deviations in the T-1 (quarters Q-4 to Q-1) observed neighborhood price trend from the expected value given a linear projection from the years T-3 and T-2 data (the Q-12 to Q-5 quarters). The rationale for this metric is that potential investors are likely looking to past trends for some measure of a future projection. If the current market, the T-1 trend at the time at which the decision is being made, differs significantly from the previous trend, either up or down, the investor/developer is likely to be more unsure about the future than if a constant

[46] Using the 1/4 mile or 400m radius resulted in sample sizes that were too small to get stable results. The use of 500 nearest sales represents a small enough number to measure some true spatial variation in price but also a large enough number that a few outlying sales transactions won't bias the coefficient estimates to a great degree.

rate of appreciation/depreciation is observed. These deviations are expressed as a percent and are derived as the mean residual of Equation 4.8 used to predict a likely price trend for quarters Q-4 through Q-1. Contrary to previous research (Cunningham 2006, 2007) that measures uncertainty as overall deviation, I have simplified the measure to be a one-year difference (an average residual over four quarters). This simplified measure has two benefits: 1) It soothes out seasonal effects in house price trends that may contribute to a quarterly-based measure of deviation; and 2) It allows for the measure of uncertainty to take a positive or negative value. This second point suggests that while, theoretically-speaking, uncertainty of any kind can make waiting to invest more profitable, that positive deviations from expected trends may have different effects than negative ones on (re)development decisions.

Appendix B: Discussion of duration versus probit models

The net present value theory (NPV) considers redevelopment an economic decision and therefore is undertaken or initiated by an individual agent(s). Within this framework, the act of redevelopment and land use change in general is observed as a discrete binary variable, i.e. it either has occurred or it hasn't.[47] The most traditional and most popular approach to modeling discrete processes is through generalized linear models such as logit, probit and multi-nomial specifications. Indeed, the existing literature on redevelopment, renovation and teardown probability relies exclusively on the use of probit-based models (Rosenthal & Helsley 1994; Munneke 1996; Helms 2003; Weber et al. 2006; Dye & McMillen 2007). In the broader land use change literature, however, a number of recent papers –focused on suburban development and land conversion –have utilized duration analysis to model the the land use change process (Hite et al. 2003; Towe et al. 2008; An & Brown 2008; Wilson & Song 2011).

Given that both types of models have been successfully used in land use change studies, the question remains as to which one should be used when. Properties of the data can help answer this question. In situations where a long time period is observed (potentially leading to censoring of data), duration models offer the ability to better account for temporal effects. For example, in a logistic regression study over a long time period, a land use change in an early period of the study is treated the same as a change in the final period and, as a result, relationships that may be due to the passing of time can potentially be assigned to correlations between dependent and independent variables if the observed events have temporal patterns. A related problem with logistic regression in a land use change environment is that many types of independent variables such as population density, nearby land uses as well as other rules, regulations and market dynamics all change over time and

[47]Land use changes may also be categorized into one of a number of outcomes, in which case a multi-nomial approach may be used (Fragkias & Geoghagen 2010; Wang et al. 2012)

a logistic regression model spanning a significant time period is unable to properly control for these time-varying independent variables (Vermunt 1997). Both of these issues can cause incorrect inferences to be drawn from model results.

Additionally, a recent study by Wang et al. (2013) directly addresses the issue of choosing between traditional logit/probit and duration models in a longitudinal land use change study. Their work compares the ability of each type of model to estimate known parameters (from a simulated dataset) for a set of independent variables. These findings indicate that, overall, duration models outperformed the logistic specifications and that within the duration models the piecewise parametric specification performed the best. Additional findings of their research suggest that logistic-based regression models can struggle in situations where the binary (or one of the multinomial) outcomes is a rare occurrence, validating advice offered by King and Zeng (2001) in the past. Wang and co-authors (2013) surmise that the reason that duration models were able to outperform the logistic regression models is their ability to incorporate temporally-varying independent variables into the analysis; variables which are an important component of understanding land use changes.

Given the length of the time period covered by this study (10 years), the number of time-dependent variables and the heterogeneity in the overall redevelopment rate (Figure 4.4), I have chosen to use a duration model analysis here.

Appendix C: Full Base Model Results

Table 4.5: Model 1a Full Results

	coef	exp(coef)	se(coef)	z	Pr(>|z|)
LR2	0.908	2.480	0.078	11.623	0.000
LR3	1.086	2.964	0.086	12.682	0.000
logSTRSF	-1.101	0.332	0.108	-10.195	0.000
COND	-0.025	0.975	0.043	-0.581	0.561
BLDGGRADE	0.090	1.095	0.047	1.943	0.052
YEARBUILT	-0.004	0.996	0.001	-2.670	0.008
XUNITS	0.316	1.371	0.082	3.850	0.000
ADU	-1.079	0.340	0.360	-2.994	0.003
TOPO	-0.732	0.481	0.209	-3.503	0.000
VIEW	-0.193	0.825	0.059	-3.267	0.001
logLOTSF	1.587	4.891	0.086	18.558	0.000
SHPFCTR	0.039	1.040	0.006	6.850	0.000

Table 4.6: Model 1b Full Results

	coef	exp(coef)	se(coef)	z	Pr(>|z|)
COND	-0.027	0.973	0.043	-0.641	0.521
BLDGGRADE	-0.005	0.995	0.040	-0.124	0.901
YEARBUILT	-0.002	0.998	0.001	-1.552	0.121
XUNITS	0.229	1.258	0.070	3.256	0.001
ADU	-0.440	0.644	0.359	-1.224	0.221
TOPO	-0.707	0.493	0.209	-3.381	0.001
VIEW	-0.185	0.831	0.059	-3.161	0.002
logLOTSF	0.746	2.108	0.097	7.683	0.000
SHPFCTR	0.041	1.041	0.006	6.931	0.000
FARDIF	0.033	1.033	0.002	18.351	0.000

Table 4.7: Model 2 Full Results

	coef	exp(coef)	se(coef)	z	Pr(>|z|)
COND	-0.046	0.955	0.042	-1.082	0.279
BLDGGRADE	-0.054	0.948	0.043	-1.231	0.218
YEARBUILT	-0.006	0.994	0.002	-3.443	0.001
XUNITS	0.219	1.245	0.072	3.040	0.002
ADU	-0.502	0.605	0.362	-1.389	0.165
TOPO	-0.497	0.608	0.211	-2.355	0.019
VIEW	-0.097	0.908	0.059	-1.623	0.105
logLOTSF	0.799	2.222	0.105	7.589	0.000
SHPFCTR	0.037	1.038	0.006	6.306	0.000
FARDIF	0.030	1.030	0.002	16.491	0.000
MEDINC	0.019	1.019	0.016	1.216	0.224
RENTPER	-0.012	0.988	0.002	-5.128	0.000
DISTCBD	0.189	1.208	0.021	8.870	0.000
LUMIX	0.001	1.001	0.003	0.470	0.639
NBHFAR	1.143	3.135	0.220	5.200	0.000
ADJCIMU	0.469	1.599	0.062	7.526	0.000
INTDENS	0.004	1.004	0.003	1.281	0.200

Table 4.8: Model 3a Full Results

	coef	exp(coef)	se(coef)	z	Pr(>|z|)
COND	-0.049	0.952	0.042	-1.150	0.250
BLDGGRADE	-0.056	0.945	0.044	-1.293	0.196
YEARBUILT	-0.006	0.994	0.002	-3.468	0.001
XUNITS	0.211	1.235	0.072	2.936	0.003
ADU	-0.512	0.599	0.362	-1.416	0.157
TOPO	-0.511	0.600	0.211	-2.419	0.016
VIEW	-0.102	0.903	0.059	-1.728	0.084
logLOTSF	0.798	2.220	0.105	7.615	0.000
SHPFCTR	0.038	1.038	0.006	6.411	0.000
FARDIF	0.030	1.031	0.002	16.456	0.000
MEDINC	0.018	1.018	0.016	1.168	0.243
RENTPER	-0.012	0.989	0.002	-5.102	0.000
DISTCBD	0.188	1.207	0.023	8.215	0.000
LUMIX	0.001	1.001	0.003	0.356	0.722
NBHFAR	1.134	3.109	0.225	5.046	0.000
ADJCIMU	0.470	1.600	0.062	7.533	0.000
INTDENS	0.001	1.001	0.002	0.288	0.774
NBHTREND	-0.002	0.998	0.007	-0.304	0.761
NBHUNCERT	0.016	1.016	0.008	2.157	0.031

Table 4.9: Model 3b Full Results

	coef	exp(coef)	se(coef)	z	Pr(>|z|)
COND	-0.068	0.935	0.043	-1.586	0.113
BLDGGRADE	-0.054	0.947	0.044	-1.235	0.217
YEARBUILT	-0.007	0.993	0.002	-3.879	0.000
XUNITS	0.196	1.217	0.072	2.719	0.007
ADU	-0.480	0.619	0.361	-1.327	0.185
TOPO	-0.469	0.626	0.211	-2.217	0.027
VIEW	-0.071	0.931	0.059	-1.200	0.230
logLOTSF	0.817	2.264	0.105	7.782	0.000
SHPFCTR	0.035	1.036	0.006	6.019	0.000
FARDIF	0.030	1.031	0.002	16.490	0.000
MEDINC	0.015	1.015	0.016	0.945	0.345
RENTPER	-0.010	0.990	0.002	-4.330	0.000
DISTCBD	0.173	1.189	0.024	7.308	0.000
LUMIX	-0.003	0.997	0.003	-0.913	0.361
NBHFAR	1.114	3.047	0.229	4.861	0.000
ADJCIMU	0.351	1.420	0.066	5.305	0.000
INTDENS	-0.000	1.000	0.002	-0.202	0.840
NBHTREND	-0.002	0.998	0.007	-0.339	0.735
NBHUNCERT	0.017	1.017	0.008	2.194	0.028
NBHREDEV	0.004	1.004	0.001	4.766	0.000
ADJREDEV	0.491	1.633	0.091	5.413	0.000

Appendix D: Full Results of Submarket Models

Table 4.10: North Submarket Model Results

	Coef	SE	Z	pval
COND	0.034	0.059	0.587	0.557
BLDGGRADE	-0.236	0.072	-3.283	0.001
YEARBUILT	-0.006	0.003	-2.425	0.015
XUNITS	0.218	0.099	2.205	0.027
ADU	-0.546	0.715	-0.764	0.445
TOPO	0.033	0.39	0.084	0.933
VIEW	0.067	0.116	0.579	0.563
logLOTSF	1.052	0.156	6.765	0
SHPFCTR	0.034	0.01	3.594	0
FARDIF	0.036	0.002	14.51	0
MEDINC	0.058	0.031	1.86	0.063
RENTPER	-0.011	0.003	-3.1	0.002
DISTCBD	-0.111	0.051	-2.167	0.03
LUMIX	0.01	0.004	2.297	0.022
NBHFAR	-0.808	0.466	-1.736	0.083
ADJCIMU	0.259	0.091	2.84	0.005
INTDENS	0.002	0.004	0.597	0.55
NBHTREND	0.033	0.013	2.464	0.014
NBHUNCERT	0.037	0.014	2.677	0.007
NBHREDEV	0.002	0.001	1.851	0.064
ADJREDEV	0.464	0.115	4.017	0
Concordance	0.8			
logLik	-4655			
AIC	9352			
n	27,922			

Table 4.11: Central Submarket Model Results

	Coef	SE	Z	pval
COND	-0.295	0.086	-3.424	0.001
BLDGGRADE	-0.077	0.092	-0.835	0.403
YEARBUILT	-0.004	0.003	-1.184	0.236
XUNITS	0.065	0.15	0.435	0.663
ADU	0.161	0.536	0.3	0.764
TOPO	-0.426	0.285	-1.498	0.134
VIEW	-0.136	0.091	-1.495	0.135
logLOTSF	1.702	0.244	6.977	0
SHPFCTR	0.014	0.012	1.122	0.262
FARDIF	0.036	0.005	7.901	0
MEDINC	-0.068	0.041	-1.659	0.097
RENTPER	-0.005	0.007	-0.798	0.425
DISTCBD	0.094	0.134	0.701	0.483
LUMIX	-0.014	0.008	-1.846	0.065
NBHFAR	0.419	0.409	1.025	0.305
ADJCIMU	0.213	0.14	1.515	0.13
INTDENS	-0.003	0.006	-0.459	0.646
NBHTREND	-0.007	0.016	-0.478	0.632
NBHUNCERT	-0.031	0.015	-1.973	0.049
NBHREDEV	-0.005	0.003	-1.485	0.138
ADJREDEV	0.272	0.229	1.186	0.236
Concordance	0.805			
logLik	-1761			
AIC	3564			
n	28,672			

Table 4.12: South Submarket Model Results

	Coef	SE	Z	pval
COND	-0.126	0.09	-1.398	0.162
BLDGGRADE	-0.171	0.088	-1.947	0.052
YEARBUILT	-0.006	0.004	-1.759	0.079
XUNITS	0.154	0.165	0.928	0.354
ADU	-0.632	0.727	-0.869	0.385
TOPO	-1.327	0.594	-2.233	0.026
VIEW	-0.1	0.124	-0.81	0.418
logLOTSF	0.92	0.215	4.274	0
SHPFCTR	0.018	0.011	1.579	0.114
FARDIF	0.026	0.004	6.262	0
MEDINC	-0.044	0.031	-1.408	0.159
RENTPER	-0.011	0.005	-2.345	0.019
DISTCBD	-0.074	0.063	-1.174	0.24
LUMIX	-0.018	0.006	-2.768	0.006
NBHFAR	2.69	0.821	3.277	0.001
ADJCIMU	0.315	0.141	2.239	0.025
INTDENS	-0.026	0.006	-4.313	0
NBHTREND	-0.004	0.014	-0.314	0.753
NBHUNCERT	0.008	0.016	0.52	0.603
NBHREDEV	0.008	0.003	3.101	0.002
ADJREDEV	0.536	0.203	2.645	0.008
Concordance	0.756			
logLik	-1832			
AIC	3707			
n	21,170			

Appendix E: Lot Assemblage Analysis

The assemblage of more than one adjacent lot prior to redevelopment is a common method of increasing the density of a potential development. Within the data for this study 31.19% of the observed redevelopments were involved in an assemblage situation. Figure 4.9 shows the difference in coefficient estimates from a model containing only assembled redevelopments versus those not. Full model results are given as well.

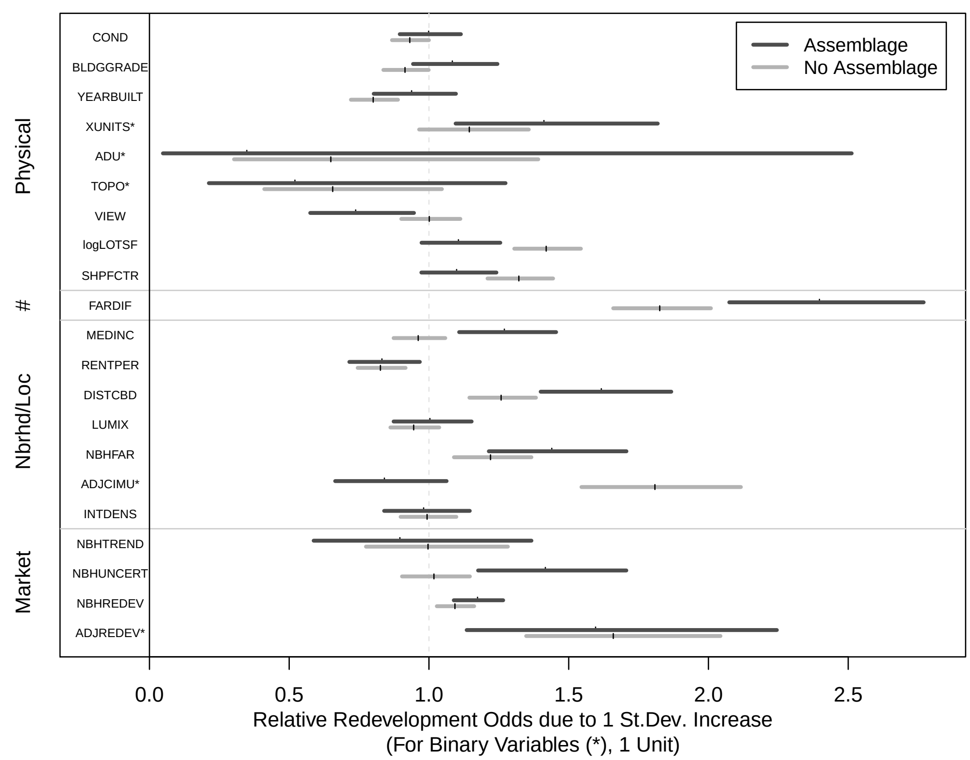

Figure 4.9: Assemblage vs No Assemblage Models

Table 4.13: Assemblage Model Results

	Coef	SE	Z	pval
COND	-0.001	0.078	-0.019	0.985
BLDGGRADE	0.093	0.082	1.133	0.257
YEARBUILT	-0.002	0.003	-0.804	0.422
XUNITS	0.345	0.129	2.665	0.008
ADU	-1.054	1.008	-1.046	0.296
TOPO	-0.653	0.457	-1.43	0.153
VIEW	-0.366	0.153	-2.395	0.017
logLOTSF	0.295	0.191	1.546	0.122
SHPFCTR	0.015	0.01	1.518	0.129
FARDIF	0.039	0.003	11.856	0
MEDINC	0.096	0.028	3.438	0.001
RENTPER	-0.01	0.004	-2.392	0.017
DISTCBD	0.282	0.043	6.537	0
LUMIX	0	0.005	0.049	0.961
NBHFAR	1.731	0.412	4.196	0
ADJCIMU	-0.174	0.12	-1.45	0.147
INTDENS	-0.001	0.004	-0.242	0.809
NBHTREND	-0.007	0.013	-0.51	0.61
NBHUNCERT	0.052	0.014	3.666	0
NBHREDEV	0.006	0.001	4.179	0
ADJREDEV	0.468	0.174	2.688	0.007
Concordance	0.795			
logLik	-2915			
AIC	5871			
n	76,992			

Table 4.14: Non-Assemblage Model Results

	Coef	SE	Z	pval
COND	-0.1	0.051	-1.967	0.049
BLDGGRADE	-0.103	0.052	-1.984	0.047
YEARBUILT	-0.009	0.002	-4.158	0
XUNITS	0.135	0.087	1.55	0.121
ADU	-0.432	0.389	-1.111	0.266
TOPO	-0.422	0.238	-1.77	0.077
VIEW	0.001	0.064	0.02	0.984
logLOTSF	1.027	0.125	8.192	0
SHPFCTR	0.045	0.007	6.171	0
FARDIF	0.027	0.002	12.35	0
MEDINC	-0.016	0.02	-0.8	0.424
RENTPER	-0.01	0.003	-3.615	0
DISTCBD	0.135	0.028	4.768	0
LUMIX	-0.004	0.004	-1.193	0.233
NBHFAR	0.947	0.275	3.444	0.001
ADJCIMU	0.592	0.08	7.395	0
INTDENS	0	0.003	-0.131	0.896
NBHTREND	0	0.008	-0.026	0.979
NBHUNCERT	0.003	0.009	0.291	0.771
NBHREDEV	0.003	0.001	2.856	0.004
ADJREDEV	0.506	0.106	4.775	0
Concordance	0.787			
logLik	-6492			
AIC	13026			
n	76,158			