LAND USE, SPATIAL STRUCTURE, AND REGIONAL ECONOMIC PERFORMANCE: ASSESSING THE ECONOMIC EFFECTS OF LAND USE PLANNING AND REGULATION

BY

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DISSERTATION

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ABSTRACT

Although it has been readily acknowledged that regional economic growth and structural changes can directly affect land use patterns within the regions, little is known about the inverse: how a change or intervention in land use influences regional economic performance. Does land use planning or regulation promote a region's economic well-being? Alternatively, does this action raise barriers to development and thus slow the pace of economic growth or progress? Under what circumstances and how can we promote the potential contribution and/or minimize unexpected economic consequences of government interventions in land use?

This dissertation research consists of the following three related studies that analyze the implications of land use planning and regulation for regional economic performance. The first study empirically examines the potential negative effects of strict land use regulations on local housing supply and household residential mobility. The second study looks at the potential contribution of land use planning to uncertainty reduction and the economically efficient use of land. The third study assesses the macroeconomic effects of reactive land use regulations, implemented by some suburban communities in the Chicago metropolitan area, using a new, improved simulation model. It is expected that the overall research provides better insights into the connections between regional economic shifts and land use changes and will eventually contribute to a more systematic coordination of land use policies and economic development initiatives.

<u>1) Land Use Regulation and Intraregional Population-Employment Interaction</u>

Land use regulation often delays the development process and increases the cost of development, although it may contribute to addressing market failures and realizing a well-organized spatial structure. Raising barriers to development may prevent households from responding to job relocations or job growth at certain locations in a timely manner, by restricting local housing supply. Further, this situation may result in longer commuting distances, times, and costs as well as greater spatial mismatches. To examine the possible adverse effect of the regulation, this study analyzes how intraregional population-employment interaction varies by metropolitan areas having different degrees of land use regulations. First, through a correlation analysis, the results reveal that highly regulated regions are likely to show a lower correlation between intraregional population and employment changes and an increasing mean commuting time between 1990 and

2000. In addition, a spatial econometric analysis using a regional disequilibrium adjustment framework suggests that intraregional population and employment changes may not be well integrated in highly regulated metropolitan areas due to the lower household mobility, even though households and businesses consider accessibility to each other importantly in their location choices.

2) Land Use Planning as Information Production & Exchange

Local governments' land use planning practice has been economically justified as an efficient means of producing and distributing necessary information relevant to land markets and further reducing the intrinsic uncertainties and transaction costs involved in land development processes. Although this way of justification, in addition to traditional welfare-economics-based rationales, has been adopted to give reason for land use planning, not much empirical evidence supporting the claim has been reported. In order to fill this gap, this study attempts to empirically validate the argument by focusing on a particular case, namely the urban fringe land markets where the farmland owners make decisions under uncertainties regarding the timing of potential land development for urban uses. First, through the exploration of land use data in Oregon, distinct farmland use patterns are found, consistent with the expectation that the establishment of urban growth boundaries (UGB) reduces uncertainty and therefore helps farmland owners make informed decision. Furthermore, cross-sectional regression analysis using 82 single-county MSAs' data detects a positive effect of UGB on agricultural investment levels, which may indicate the real contribution of the UGB to uncertainty reduction. The UGB's effect is found to be statistically significant in the MSAs showing relatively larger shares of livestock and fruit production (as opposed to crops) operations that generally require a greater amount of sunk costs and a longer period of operation for profits.

3) The Macroeconomic Effects of Suburban Reactive Land Use Regulations: A Simulation Study using a Spatial REIM (Regional Econometric Input-Output Model)

This study assesses the macroeconomic effects of minimum-lot-size requirements and building permit caps that have been implemented by some of the suburban municipalities in the Chicago metropolitan area. This is accomplished by developing a new simulation model, which overcomes the shortcomings of traditional top-down approach to vertical regional economy – land use integration. The new framework captures local- and lower-level dynamics and their effects on regional economic performance by using a modified regional disequilibrium

adjustment model that incorporates the intraregional dynamics into a regional econometric input-output model in a reciprocal, interactive manner, as opposed to a top-down allocation process. The model simulation results reveal that the reactive land use regulations (minimum lot size zoning and permit caps), which bind local housing supply and population growth within the jurisdictions, 1) dampen the pace of regional economic growth considerably, although the actions are sometimes favorable to the long-term prosperity of the individual implementing municipalities; 2) tend to generate disproportionate impacts on different sectors of the economy – i.e. local sectors, which heavily depend on household expenditures, are affected more strenuously; and 3) induce effects that vary substantially by location and timing of the implementation.

To My Grandfather

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1. INTRODUCTION

1.1. Background

Unlike other commodities or production factors, in most societies, the use of land is more or less out of the owners' hands and under the control of government, although the property rights systems and intervention approaches vary significantly across history and culture. Despite never-ending challenges from a wide ideological spectrum, in the United States land use planning and regulation have remained at the core of decentralized governmental operations since the 1920s when zoning was legitimized as an exercise of police power in Euclid vs. Ambler Realty Co. (1926) and the Standard City Planning Enabling Act of 1928 (Kaiser & Godschalk 1995; Teitz 1996).[1] Nowadays, most local and regional government bodies manage or control land use in and around their jurisdictional areas using a variety of policy instruments in addition to the traditional zoning techniques (see e.g. Rudel 1989; Platt 1996). According to a fairly recent survey of 50 largest U.S. metropolitan areas conducted by Pendall *et al*. (2006), 91.5 percent of municipalities have zoning ordinance; 84.6 percent have comprehensive plans; 37.5 percent have impact fees; 18.6 percent have adequate public facilities ordinance, while 16.4 percent have urban containment policies.

The prevalent government intervention in land use is certainly based on the notion that proper land use controls actually enhance public interest, by 1) eliminating negative externalities among conflicting land uses (see e.g. Bailey 1959; Stull 1975; Lafferty & Frech 1978); 2) protecting natural environments and consequently promoting the location-specific amenities (see e.g. Correll *et al*. 1978; Spalatro & Provencher 2001; Randolph 2004); 3) providing adequate amount of public goods and services more efficiently (see e.g. Moore 1978; Burchell *et al*. 1998 and 2005; Muro & Puentes 2004); and 4) reducing uncertainty and transaction costs involved in the land development processes (see e.g. Schaeffer & Hopkins 1987; Alexander 1992 and 1994; Dawkins 2000).

[1] Governments' planning practice, including land use planning and regulation, has been criticized by many ideological perspectives: "On the left are the neo-Marxists who argue that planning by the capitalist state was intended not to serve the people but to save capitalism from the crisis it had created. … On the right is the argument that planning is, at best, ineffective and, at worst, counterproductive. … In the center are the post-modernists who argue that planning is part and parcel of the modernization project and, hence, should be rejected as yet another form of social control to implement a hegemonic vision of progress" (p.330, Sanyal 2000).

Some previous studies, however, report that: 1) there are undesirable consequences of strict land use regulations, such as the enhancement of monopoly power of the land owners (see e.g. Hamilton 1978; Thorson 1996), the rapid increases in land or house price due to limited supply (see e.g. Rose 1989; Pollakowski & Wachter 1990), and consequent affordable housing problems (see e.g. Downs 1991; Quigley & Raphael 2004); 2) land use regulations, implemented by one locality for its own sake, sometimes generate unfavorable external effects on adjacent communities or the region as a whole (see e.g. Foster 2001; Buzbee 2005; McKinney & Essington 2006); 3) some types of land use controls (e.g. low-density zoning and building caps) and the fragmented political system are likely to aggravate sprawl, causing a long list of undesirable consequences (see e.g. Pendall 1999; Razin & Rosentraub 2000; Carruthers & Ulfarsson 2002).[2]

Furthermore, in recent years, it has been suggested that strict regulations on land use might hinder economic growth by constraining land supply for urban uses excessively, increasing the costs of housing significantly, and limiting not only land but also labor supply for business activities (see e.g. Evans 2002; Glaeser *et al*. 2006; Saks 2008; Vermeulen & Ommeren 2008). In other words, land use regulations may have negative effects on the performance of economies that offset the benefits stemming from the correction of the market failures.

Does land use planning or regulation really promote our economic well-being? Alternatively, does this action raise barriers to development and thus slow the pace of economic growth or progress? Although it has been readily acknowledged that regional economies and land use are highly interrelated with each other (see e.g. Parr 1979 and 1987; Knaap & Nelson 1992; Krabben & Bokema 1994), little is known about the interrelationship, particularly how a change or intervention in land use influences the behavior of economic systems.[3] Typically, economic

[2] Numerous studies suggested that sprawl leads to automobile-based longer commuting, disruption of environmentally sensitive areas, central city decline, segregation, inefficient public service provision, etc. (See e.g. Ewing 1996; Burchell *et al*. 1998 and 2005; Ewing *et al*. 2002; Carruthers & Ulfarsson 2003; Muro & Puentes 2004), while a few research, such as Gordon and Richardson (1997), contended that the spatial pattern of urban development, called ‘sprawl’, is the natural consequence of economic decentralization and majority Americans’ preference on suburban living environment. It also needs to be noted that some, including Glaeser & Kahn (2003), argued that government intervention in land use is not a main cause of sprawl.

[3] According to Parr (1979), “One of the most unsatisfactory features of regional analysis, or for that matter regional science, is the gulf that has emerged between the study of regional economic change on the one hand and the study of regional spatial structure on the other. … Although this division of the field of regional analysis may be legitimate and perhaps even inevitable, it is regrettable fact that the two branches appear to have been developing independently, with

development strategies have focused on labor force training, business recruitment, and tax incentives, rather than seeking a better spatial arrangement of the socio-economic activities within a region. Moreover, in many planning studies and models, the interactions have been considered from a 'top down' perspective without consideration of 'bottom up' connections; that is, regional economic growth and transformation is only assumed to have significant effects on land use and the spatial structure of the region. This lack of appreciation of the 'bottom up' impacts may limit current land use planning practices and further generate some unintended conflicts between land use policies and regional economic development initiatives.

1.2. Research Objectives, Approaches, and Contributions

To better understand the interrelationships between land use and regional economies, this dissertation research analyzes the economic consequences of land use planning and regulation through the three studies and a literature review. More specifically, the first and second studies empirically examine the selected causal links between land use and regional economies which have not been fully investigated: first, the potential negative effect of strict land use regulations on local housing supply and household residential mobility and, second, the potential contribution of land use planning to uncertainty reduction and the economically efficient use of land. The third study assesses the macroeconomic effects of minimum-lot-size requirements and permit caps, implemented by some of the suburban municipalities in the Chicago metropolitan area, using a new integrated simulation framework that overcomes the shortcomings of 'top down' models. Overall, the research aims to provide better insights into the 'bottom up' causal connections and derive meaningful lessons for planners and policy makers. The dissertation research seeks to inform local planning practices and land use decision making, not only by discovering how land use planning and regulation affect regional economic variables but also by developing a new analytic tool which can be used for the analysis of the macroeconomic effects of land use policies. Furthermore, it contributes to a more systematic coordination of economic development and land use planning, which is essential for achieving a more complete realization of urban development that is ecologically and socio-economically sustainable and prosperous.

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remarkably little interaction or cross-fertilisation." (p.825) In fact, despite Parr's indication, this unsatisfactory feature has not been completely addressed until now.

1.3. Dissertation Outline

The remainder of this dissertation is structured as follows. Chapter 2 provides a review of the literature, from which the causal links between government interventions in land use and regional economic performance can be inferred. Chapters 3 through 5 present the three empirical studies. Chapter 6 concludes the dissertation by summarizing the findings, outlining limitations of the present studies, discussing the policy lessons, and identifying directions for future research.

2. LITERATURE REVIEW: THE ECONOMIC CONSEQUENCES OF LAND USE PLANNING AND REGULATION

2.1. Overview

Although just a few studies explicitly relate a change or intervention in land use to the performance of a regional economy, much research has examined the economic effects of land use regulation or land use planning and suggested that land use may have significant implications for regional economic performance.[4] This chapter attempts to examine how government interventions in land use can influence the behavior of regional economic systems and to derive some policy lessons by reviewing relevant literature.

One could argue that the goal of land use planning is not to generate economic benefits. It can also be claimed that economic development is more efficiently accomplished through appropriate taxation, labor force training, industrial policies, and so on, rather than through an intervention in land use. Although such claims are valid to some extent, a better understanding of 'bottom up' causality is not trivial because land use planning is one of the most powerful instruments in the hands of planners; regional economic prosperity is a common goal of planners; and most importantly, economic prosperity and land use are tightly interrelated.

First, however, some preliminary points should be noted.

1) Land use regulation and land use planning are distinct and different from one another. Hopkins (2001, p.9-10) clarifies this point by stating that "Regulations [are] … enforceable assignment and reassignment of rights. Regulations affect the scope of permissible actions. Plans … provide information about interdependent decisions in relation to expected outcomes but these plans do not determine directly the scope of permissible actions." In this literature review, the effects of governmental actions on land use are examined, including both land use regulation and planning practices. To some

[4] It needs to be noted that some fairly recent studies, such as Nelson & Peterman (2000), Glaeser *et al*. (2006), and Saks (2008), reviewed in section 2.2 and 2.5, pay explicit attention to the effects of land use policies on regional economic growth. Also, there are some other studies, considering the regional property market as an important factor in the region's competitiveness and suggesting that land use and development process may have significant implications for regional economic prosperity (see e.g. D'Arcy & Keogh 1999; Gibb et al. 2002; Bramley & Lambert 2002).

extent, land use regulation or policies can be regarded as a product of land use planning practices, although the implementation and enforcement steps are not generally controlled by planners.

2) The dependent variable of interest in this literature review is the performance of regional economies. In fact, this is a somewhat elusive concept, as it is associated with both qualitative improvement in wealth creation process (i.e., economic development) and quantitative growth in production or employment size (i.e., economic growth). However, it is useful to employ this inclusive concept, as it is relevant to a common goal: the economic prosperity of regions.
3) Since different strands of research attempt to probe different causal links between land use and regional economies, a broad range of literature needs to be reviewed, and a broad-brush approach needs to be adopted to thoroughly understand how government actions in land use influences the performance of regional economies. Thus, this review tries to provide a synthesis of various studies from which 'bottom up' causal links can be inferred. Covering a variety of studies inevitably results in a somewhat incomplete explanation of each research and the exclusion of some studies that deserve recognition. The focus of the paper will be on research findings and implications rather than on detailed research design, data treatment, and methodological improvements as showcased in individual studies.
4) A synthesis across various literatures is presented along with four categories that represent the major causal links, namely, the connections through 1) development pattern changes and spatial structure reformation; 2) land development process efficiency improvements; 3) supply constraints and price increases in property markets; and 4) labor market shifts. Subsequent sections will review the studies in each category with an emphasis on what the findings of the studies imply with respect to the hypothesized causal link between land use and regional economies.
5) Here, consideration is mainly given to urban and metropolitan areas, rather than rural settings. Although an intervention in land use probably generates substantial effects in the context of an agriculture-based rural economy, these areas are less likely to adopt many types of land use regulations and planning practices as compared with urban regions. In the latter case, internal changes are often dramatic, which in turn creates greater demand for the systematic management of land use.

6) This literature review does not cover some research that examines the positive effect of property rights reform on economic development by analyzing transitional economies or developing countries (Feder and Feeny 1991; Besley 1995; Do and Iyer 2003) because the objective of this review is not to determine the contribution of stable private property rights to economic development but rather to understand the economic effects of prevalent land use policies in the U.S., where the property rights system is firmly established.

2.2. Development Pattern Changes and Spatial Structure Transformation

Land use regulations are primarily implemented to better manage the spatial arrangement of various human activities by controlling the associated uses of land for these activities. For instance, traditional zoning is mainly designed to implement a spatial form that minimizes negative externalities among different types of urban activities by separating conflicting uses. Another typical example includes urban growth boundaries (UGB), which have been widely adopted in the U.S. to promote more compact and contiguous development by allowing land use for urban purposes only within the boundaries.

Consistent with their primary purpose, these regulations are expected to substantially change development patterns and further improve the spatial structures of areas. Numerous theoretical and empirical studies have paid attention to the effectiveness of a variety of land use regulations in achieving these expected outcomes, i.e., whether or not a particular type of regulation is actually effective in modifying land development patterns, creating a more desirable spatial structure, and generating the benefits that are linked with well-managed spatial arrangements. If land use regulation really contributes to creating a desirable form of socio-economic activity, the performance of regional economies will be improved thanks to "efficient urbanization," as argued by Cervero (2001) and others.

2.2.1. Improving Welfare by Correcting Market Failures

One typical example in the literature involves justifying land use regulations based on welfare economics and supporting such justification with empirical evidence. Bailey (1959) and Davis

(1963) contend that the welfare level of landowners can be increased through appropriate land use controls, particularly zoning, that eliminate negative externalities among different uses. According to them, this welfare increase is a major benefit of land use controls. Gardner (1977) and Moore (1978) argue that land use regulations can also contribute to preserving public goods that are unlikely to be maintained without government intervention, since the social values of these public goods are not seriously considered by private agents who focus on pursuing their own interests. Lee's (1981) article "Land use planning as a response to market failure" highlights the same point: residents and the region as a whole should benefit from proper land use planning practices that address intrinsic market failures in land use and, consequently, lead to a more economically efficient land use.

Claims that land use regulations can increase the welfare of landowners and even of all residents by correcting market failures have been mainly buttressed by two sets of empirical analyses. The first is a set of research showing the virtual existence of negative external effects in the context of non-managed land use. For instance, Stull (1975) analyzes the property values of single-family housing units across communities in the Boston metropolitan area and finds that their value is more likely to be higher when the property is in communities where the proportion of land devoted to non-single-family uses is low. As argued by the author, this finding may imply that negative externalities actually do exist between single-family houses and other land uses, and a separation of different land uses by zoning ordinances is therefore warranted. Lafferty and Frech (1978, 382) extend Stull's (1975) research with more detailed land use data from Boston and conclude that "increases in non-single-family land uses within a town raises property values if suitably concentrated, but increasing the dispersion of a fixed amount of these land uses reduces property values." Although their finding certainly differs from that of Stull's (1975), the argument that a greater degree of dispersion of different types of land use results in lower property values also supports the presence of negative external effects at the neighborhood level or at more spatially-disaggregated levels. Burnell (1985) tries to differentiate air polluting activities from other types of commercial and industrial land use to present a more refined understanding of the main source of negative external effects. He concludes that air-polluting activities generate statistically significant negative influences on housing values, while other types of commercial and industrial land use exhibit positive impacts. Hughes and Sirmans (1992) direct their attention to traffic intensity rather than to a particular type of land use. They examine single-family house transaction data from Baton Rouge, Louisiana, between 1985 and 1989 and analyze how the amount of traffic on streets can influence the value of individual housing units using a traditional hedonic formulation. They find a statistically significant negative price effect of high traffic. Although traffic - as opposed to land use - is their focus, the traffic externality may justify the need for a zoning protocol that separates commercial and industrial activities, which in turn leads to a greater amount of traffic from residential uses.

The second group includes empirical studies that demonstrate the positive effects of environmental amenities, preserved by land use regulations, on housing values.[5] Correll *et al*. (1978) analyze the effect of the green belt of Boulder, Colorado, on the prices of residential properties in the region. Conducting a regression analysis, they find that walking distance to the green belt has a negative effect on property values; i.e., if a property is closer to the green belt, it is more likely to sell for a higher price. They interpret this result as a quasi-public good effect of greenbelts. In other words, the preserved open space and the associated higher amenity level provided by the green belt generate positive effects in terms of resident welfare; this increase in welfare and a better living environment might be capitalized and thus transformed into an increase in property price. Spalatro and Provencher (2001) investigate the case of minimum frontage zoning in northern Wisconsin and also conclude that this regulation generates economic gains by preserving lakefront amenities rather than constraining development and leading to economic losses. The significant, positive impacts of amenities preserved by environmental zoning are also identified by Netusil (2005), who considers the different effects of various types of amenities.

It should be noted that although a number of studies have provided empirical evidence in support of the potential welfare gains that may accompany land use regulations as explained above, many other researchers have been unable to find any statistically significant evidence of these effects. Crecine *et al*. (1967) analyze urban property transactions in Pittsburgh, Pennsylvania, and find no evidence of the externality or interdependence of the property market. Rueter (1973, 336) also investigates Pittsburgh and concludes that "there is little likelihood that all of the external effects anticipated by the zoning ordinance actually arise in urban property markets." In addition, in their analysis of land prices in Rochester, New York, Maser *et al*. (1977) detect insignificant external effects in all but certain exceptional cases. Mark and Goldberg (1986, 257) also argue

[5] Although the literature on the amenity effect is voluminous, there are relatively few studies that focus explicitly on the role of land use regulations in preserving such amenities and that measure the benefits of preserved amenities.

that "the negative externalities that are generally assumed to exist may in fact not exist … the use of zoning to control the effects of such presumed externalities may not be justified", based on statistical analyses of single-family housing sales price data over a 24-year time period. Although these results might be attributable to problems associated with data, model formulation, or estimation, the conclusion regarding insignificance may imply that the extent of conflicts is narrower than that suggested by received theory. Also, the status quo (i.e., no zoning at all) may not be a chaotic state with negative externalities that carry significant dead-weight loss. Accordingly, the true contribution of zoning would not be very substantial.[6]

I note certain additional points. First, most studies typically focus on the prices of single-family housing units, assuming that this variable suitably represents the welfare levels of residents. Although it is true that amenities are capitalized and can thus be represented by housing prices, these prices are also determined by supply, as discussed later. It seems clear that this supply-side effect is not appropriately controlled in many of these studies. In fact, a location with a larger proportion of preserved natural amenities under environmental zoning conditions will inevitably have a reduced capacity for housing supply within a given area. Thus, it remains to be verified that higher prices are attributable to the elimination of negative external effects and/or the preservation of amenities, rather than a relative scarcity in supply.

Second, as a generally static framework, the welfare economics approach may not be perfect in dealing with the dynamics of urban environments, although the framework and approach are indeed useful. Within cities and metropolitan areas, a particular location that is initially suitable for single-family houses can become a desirable site for multi-family housing, businesses, or public facilities in the future. On the basis of these welfare economics and market failure approaches, one might question whether zoning or other types of land use planning can really handle such dynamic problems adequately, and then contribute to the development of a desirable spatial pattern that promotes inter-temporal economic well-being.

[6] It is well known that residential and commercial-industrial land use tends to be segregated in Houston, Texas, even without zoning; see Siegan (1972) and Berry (2001). In other words, private deed covenants or other types of private bargaining in the market system may also mitigate negative effects.

2.2.2. Desirable Spatial Structures and Consequent Economic Benefits: Compact Development versus Sprawl

While the research mentioned above focuses on the benefits of well-managed land use patterns at the level of neighborhoods or other relatively low levels of geography, another set of research has emphasized the impact of land use planning and regulations on the spatial structure of an entire region. These studies attempt to evaluate the desirability of a region's spatial structure based on certain criteria and test whether a certain land use policy is effective in improving it.

This literature includes research on urban sprawl versus compact development. Because sprawling patterns of physical growth can force public service provision to become inefficient (Ewing 1996; Moe & Wilkie 1997; Burchell *et al*. 1998 and 2005; Ewing *et al*. 2002; Carruthers & Ulfarsson 2003; Muro & Puentes 2004), we can secure fiscal benefits and other favorable economic impacts at the regional level by curbing sprawl. Also, it has been suggested that compact development, which promotes agglomeration benefits and increased productivity, may have additional positive effects on regional economies (Ciccone & Hall 1993; Nelson & Peterman 2000; Cervero 2001). Thus, the issue is whether a particular type of land use intervention actually controls sprawl and promotes compact development or whether it in fact causes a more dispersed spatial structure within the region. Also, attention needs to be paid to the side effects of regulations that may offset the benefits of compact development.

Although results are mixed, growth management policies have generally been considered effective in curbing sprawl, particularly when they are implemented with the systematic cooperation of multiple local governments.[7] For instance, Nelson and Moore (1993) assess the effectiveness of the urban growth boundary (UGB) of Portland, Oregon, by analyzing residential building permits, residential land divisions, and the density of residential development from 1985 to 1989. They find that almost all new development was directed toward the UGB, although they did identify problems with the administration of growth management policies. Moore and Nelson (1994) evaluate the Medford metropolitan statistical area (MSA), another case of growth management in Oregon, using a similar method. They examine the location and density of new

[7] In contrast to many other studies, Jun's (2004) analysis of Portland's urban growth boundary suggests that its effectiveness is doubtful. He compares Portland with 31 other metropolitan areas and finds that Portland did not experience less suburbanization or greater infill development between 1980 and 2000. In addition, according to his regression analysis, the presence of the urban growth boundary does not lead to a statistically significant effect on the location of new housing construction.

development, including commercial and industrial development, from 1985 to 1989. They conclude that the policy is somewhat effective in encouraging new development within the UGB and in facilitating high-density development, although it does not sufficiently contribute to protecting resource lands. The effectiveness of Portland's UGB approach is also confirmed by Kline and Alig (1999). They analyze the conversion of land use from forest or farmland to urban purposes using the U.S. Department of Agriculture's (USDA) land use dataset and find that new development has been concentrated within the designated areas thanks to the UGB.

In addition to the above case studies that look exclusively at a particular growth management region, some studies compare growth management regions or states with control groups (i.e., comparable areas that lack such initiatives) and identify similar outcomes, implying that growth management does accomplish its mission of sprawl control. Nelson (1999) examines the effectiveness of state-level growth management in not only preventing urban sprawl but also preserving farmland, reducing automobile use, improving transit accessibility, supporting energy conservation, and minimizing tax burdens. Specifically, he compares Florida and Oregon as representative of growth-management states with Georgia as representative of states without significant government intervention in this regard. To pinpoint the effect of growth management on sprawl control, he looks at density changes from 1980 to 1990 and finds that Florida and Oregon experienced a much smaller density decline than Georgia. Analyzing the spatial pattern of new residential development, Dawkins and Nelson (2003) also examine the effectiveness of state-level growth management in preventing sprawl and promoting the revitalization of central city areas. They conduct a multivariate regression analysis using a panel dataset covering 293 metropolitan areas across 19 time periods and find a statistically significant, positive effect of state-level growth management on attracting new housing construction into central cities. Similar to Dawkins and Nelson's (2003) research, Nelson *et al*. (2004) examine the effectiveness of various urban containment policies implemented before 1985 in attracting new development activities into central cities. Through a simple comparison and regression analysis, it is found that the central cities in regions with containment programs attracted more development per capita, although they did not exhibit a greater share of development within their metropolitan areas than the control cases. In particular, according to their analysis, the effects of containment policies are strong for the construction of multi-family housing units as well as for the remodeling or addition of commercial buildings.

In contrast to growth management policies, some types of land use regulations that are implemented by individual communities seem to aggravate the problem of sprawl. Shen (1996) investigates reactive growth controls enacted by local governments in the San Francisco Bay Area and finds a significant displacement effect, indicating the spatial dispersion of development rather than a compact urban development profile. Pendall (1999) examines the effects of various locally-adopted land use regulations on controlling sprawl. According to his analysis, low-density-only zoning and building-permit caps are associated with more sprawl, while land use controls that impose social costs of development on developers, such as adequate public facilities ordinances, are effective in reducing sprawl. Also, a growing number of recent studies have investigated the relationship between political fragmentation and sprawl and report that the level of fragmentation is strongly associated with urban sprawl (Razin & Rosentraub 2000; Glaeser *et al*. 2001; Fulton *et al*. 2001; Carruthers & Ulfarsson 2002; Carruthers 2003; Ulfarsson & Carruthers 2006). One possible explanation for this correlation is that land use regulations implemented by fragmented municipalities for their own sake, as opposed to those based on systematic cooperation among local governments, cause a sprawling pattern of development by excluding high-density development.

2.2.3. Desirable Spatial Structures and Consequent Economic Benefits: Land Use, Transportation, and the Regional Economy

While the studies on compact development versus sprawl focus on density improvement and subsequent environmental, fiscal, and socio-economic benefits, another set of research evaluates the spatial structure of a region based on transportation-oriented criteria and examines whether and how land use policies impact the spatial arrangement of socio-economic activities related to transportation. Although this research typically investigates the relationship between land use and transportation rather than focusing on regional economies, the effects of land use policies on regional economies can be inferred because 1) transportation plays an important role in supporting various economic activities; 2) congestion as well as non-congested auto-based travel generate significant social costs; and 3) providing a broader range of travel choice options should be an important factor in residents' welfare.[8] Given that transportation has a significant effect on

[8] The relationship between transportation sectors and regional economies has been better documented and established than the relationship between land use and regional economies. See the articles in *The Annals of Regional Science Vol 42, No 3*, which is a special issue comprised of cutting-edge research on transportation investment and economic development.

the performance of regional economies, the major issues related to the effects of land use on regional economies via transportation include whether or not some types of land use regulation cause transportation problems (e.g., job-housing imbalances or excess commuting) and whether such problems can be addressed by implementing appropriate land use policies.

A few studies have wrestled whether a particular type of land use regulation is responsible for jobs-housing imbalances or excess commuting. Levine's (1998) article and subsequent book (Levine 2006) are notable achievements that explore this issue. Based on the outcome of his analysis of residential locations in Minneapolis, Minnesota, and other cases, he argues that housing units for low or moderate-income groups may be "zoned out" due to restrictive land use policies in many suburban communities that exclusively favor low-density development. As a result, job-housing balance has not been a prominent feature of most U.S. metropolitan areas. Ihlanfeldt and Sjoquist (2000) also present survey-based evidence from Atlanta, Georgia, suggesting that job-housing imbalances have persisted due to the limited supply of affordable housing in suburban communities. Ihlanfeldt (2004) later indicates that exclusionary land use regulations are a potential cause of this persistence of spatial imbalance, which in turn leads to undesirable transportation outcomes. According to him, "since land use regulations contribute to … [the scarcity of affordable housing units in suburban areas] … the implication [of Ihlanfeldt and Sjoquist's (2000) finding] is that they also contribute to the spatial mismatch problem" (p.272).

Overall, the spatial job-housing imbalance may be encouraged by restrictive land use regulations and thus may lead to elevated transportation costs in the affected region. At the same time, this mismatch indicates a potential problem for the local labor market. In this sense, residential land use regulations indirectly affect business location decisions and further distort the spatial structure of the region. Section 2.5 deals with this adverse effect of land use regulations on the performance of regional economies with regard to housing and the labor market.

With respect to the second issue, namely whether some other land use policies are effective in addressing job-housing imbalances, auto-based congestion, and the limited availability of transportation options, mixed-land-use attracts attention as a policy instrument. Research has explored the correlation between land use and urban design attributes, on the one hand, and travel outcomes, on the other; evidence shows that not only a higher density but also a greater degree of mixed land use are negatively associated with the number of auto-based travel miles (Cervero and Kockleman 1997; Crane 2000; Ewing and Cervero 2001). This correlation can be explained by the fact that mixed land use reduces trip distances by bringing origins and destinations closer to one another as well as by reducing the number of auto trips by encouraging people to use alternatives such as walking or bicycling. Cervero and Duncan (2006) compare the magnitude of the potential impact of a job-housing balance with that of retail-housing mixing using travel data from the San Francisco Bay Area. They conclude that improvement in the job-housing balance may be a more effective way of reducing vehicle traffic.

However, as Crane (2000), Knaap and Song (2004), and some others, point out, this research typically relates transportation outcomes to certain land use attributes rather than to the implementation of land use policies.[9] In addition, there may be endogeneity problems. For example, the actual reason for the higher correlation between mixed-use and lower levels of auto travel may not be that mixed-use policies induce people to walk or use bicycles but rather that a group of people choose mixed-use areas since they have a lower preference or financial capacity for driving. For this reason, it is still unclear whether promoting mixed-use policies can improve transportation conditions. Furthermore, empirical evidence still needs to be assembled regarding the extent of transportation and economic benefits that can be generated by mixed-use zoning or similar measures.

2.3. Land Market Efficiency Improvements

Government interventions in land use may also have a favorable effect on regional economic systems by improving land market efficiency. Unlike other market transactions, land development is a process with a high degree of uncertainty and information asymmetry. Consequently, it incurs significant and various transaction costs, all over the entire course of development ranging from land purchases to construction and property transfers (Alexander 2001 and Buitelaar 2004).

[9] It needs to be noted that some studies, such as Rodriguez *et al*. (2006) and Deal *et al*. (2009), attempt to investigate the effects of land use policies, as opposed to land use attributes, on transportation, although the relationship between land use characteristics and travel behavior is the main subject of research in the literature related to this issue.

Throughout the practice of land use planning, information relevant to land use and development is generated. This includes the analysis of current land use patterns, all estimates of future demand for new development, and the determination of potentially suitable locations for new development. In addition, such information is widely distributed and helps the decision-making process for various actors involved in land development and land use (Friend & Jessop 1969 and Schaeffer & Hopkins 1987). Furthermore, there is a stronger degree of certainty when local governments announce future plans regarding land use patterns within and around their jurisdictional areas. In general, as compared with other institutional arrangements, government involvement in land use planning and regulation may be a relatively desirable institutional form for managing the land market and land development process.

The importance of this contribution to land use planning has been emphasized by studies that draw on transaction cost economic theory. For instance, Alexander (1992, 1994, and 2001) argues that transactions in a free land market are generally unplanned and spontaneously decided, and therefore tend to involve substantial unnecessary transaction costs, which could be reduced by land use planning. In his view, the presence of uncertainty and transaction costs, like the existence of externalities, is one of the main rationales for government intervention in land use. Dawkins (2000) also pays attention to this aspect of land use planning and contends that a land use plan or regulation that serves as an agreement among actors who are involved with land development can effectively lower uncertainty as well as transaction costs.

However, empirical studies that validate these theoretical suppositions are scarce; little is known about the magnitude of the effect of land use planning on uncertainty and transaction costs. Empirical tests to date have been limited as to whether plans or information contained in the plans have significant effects. Talen (1996a) discusses several approaches as well as critical issues in evaluating plan implementation; she later conducts an illustrative analysis of Pueblo, Colorado, using various methods (Talen 1996b). In this case study, she examines the degree to which the location pattern of parks in 1990 is consistent with patterns suggested by the earlier plan. Overall, her finding is inconclusive with respect to whether the plan was successfully implemented. However, she reports that the access pattern in the earlier plan has explanatory power for the implemented access distribution under certain methods, although other techniques fail to substantiate this finding. Knaap *et al*. (2001) investigate whether a light rail plan influences posterior land development in Washington County, Oregon. By analyzing land sales data, they find that both the timing and the pattern of land development were affected by the announcement of the plan preceding any investment or legislation. This finding implies that planning practice as well as information contained in plans really matter for shaping land development patterns.

2.4. Supply Constraints and Price Increases in Property Markets

While land use regulations can enhance the welfare of residents and further promote regional economic prosperity by creating a better spatial pattern of human activities or by improving land market efficiency, they often constrain the supply of developable land and delay the development process, thereby affecting property sectors that are an important and fundamental basis of regional economies.[10] In particular, land use regulations tend to raise the costs of providing housing and other built structures, and they may elevate prices in the housing and business space markets.

2.4.1. Housing Price Inflation

The effects of land use regulations on land or housing prices are one of the most popular research topics in this field. Pogodzinski and Sass (1991), Malpezzi (1996), Quigley and Rosenthal (2005) and some other studies have comprehensively reviewed the research on price effects.

Theoretically, it seems obvious that land use regulations can induce a certain level of housing price increases for both supply- and demand-side reasons. Also, the significant price effects of many types of land use regulations, ranging from zoning to growth management policies, have been identified in numerous empirical studies, although some exceptions do exist.[11] Currently,

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[10] The importance of property sector for economic growth has long been recognized. Morevoer, recently, in the literature on urban economic competitiveness, a group of studies highlighted the role of the property sector in shaping or determining the performance of regional economies by influencing business environments and controlling the internal changes to external shocks (Begg 1999; D'Arcy and Keogh 1999; Gibb *et al*. 2002; Bramley and Lambert 2002).

[11] However, some empirical studies have reported negligible or small price effects. For example, no consistent and statistically significant effect of zoning on housing prices was identified by Mark and Goldberg (1986); their study analyzed single-family housing price data over a period of time that exceeded 20 years. Philips and Goodstein (2000) analyzed the effect of Portland's UGB on housing prices in the region by comparing Portland's housing prices to those in other metropolitan areas using a regression technique. They reported that "the urban growth boundary has created upward pressure on [land and thus] housing prices, but the effect is relatively small in magnitude" (p.334). They argued that the higher level of density induced by the urban growth boundary mitigated the negative impact of the shortage of developable land. Downs (2002) also compared changes in Portland's housing prices from 1980 to 2000

academic attention is increasingly being paid to why prices increase, beyond asking whether a certain type of land use regulation increases housing prices. That is, does the observed price increase mainly come from 1) amenity improvements and subsequent increases in demand or 2) supply constraints and greater costs of development? This issue is critical because a different conclusion regarding the effect of land use regulations on the performance of regional economies may be expected, depending on why housing prices increase. If price increases are mainly attributable to elevated demand induced by a higher quality of life in the area, then one might posit that the regulation attracts new residents and thus contributes to regional economic growth.[12] In contrast, if housing price increases are stimulated by limited supply, this would seem to suggest that regulation dampens growth momentum by preventing a region from satisfying its need for growth. Also, in this case, inflated housing expenses and development costs may generate significant economic impacts on not only construction but also other interdependent sectors in regional economies; this can also affect the consumption and investment patterns of residents. Moreover, as discussed in the following section, these changes further affect regional labor markets, which are directly linked to the performance of regional economies. Although a large number of studies claim that land use regulations raise the demand for an area by improving amenities and thus raising housing prices,[13] more recent studies increasingly suggest that price inflation is mainly caused by the limited supply and higher development costs under strict land use regulations. A notable study, analyzing the reasons behind price increases is one by Pollakowski and Wacher (1990). They estimate the effects of zoning restrictions on housing prices by investigating Montgomery County, Maryland and find significant direct effects as well as significant spillover effects. This spillover effect is important, because it implies that the higher price is attributable to supply constraints rather than demand-side dynamics. More specifically, the spillover effect "could only occur through supply restrictions in a closed rather than open-city model, unless the adjacent zone restrictions also affected the desirability of living within the nearby areas" (p. 323), which was not the case in their analysis.

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with those of other metropolitan areas to determine the price effect of the UGB. He found a significant price effect only for a limited time period and argues that the increase in housing prices is not an inevitable consequence of this land use regulation.

[12] Of course, even in this case, price increases may have macroeconomic implications. Consideration should be given to the magnitude of any increase, in the context of housing supply elasticity as well as the size of demand expansion, in order to precisely analyze the economic impacts of price changes.

[13] These include most of the studies mentioned in Section 2-1. However, as indicated above, some of these studies just regard higher prices as an indication of reduced disamenities or a higher level of preserved amenities, rather than identifying the exact cause of price increases through a consideration of supply-side and other effects.

The conclusion that the price effects of land use regulations are primarily attributable to supply constraints is also supported by studies that investigate how the housing supply is affected by land use regulations. For example, Thorson (1997) analyzes the case of agricultural down-zoning in McHenry County, Illinois, and finds that housing supply as measured by the number of building permits significantly declined with a lag after zoning implementation. Levine (1999) examines the effect of growth controls in California and reports a similar outcome; the policy of interest (i.e., growth controls) actually reduces housing supply, thereby elevating housing prices. Mayer and Somerville (2000) and Green *et al*. (2005) relate the amount of housing supply or supply elasticity in metropolitan areas to the degree of overall restrictiveness of residential land use regulation in various regions, based on a variety of survey-based data. Both studies report a smaller housing supply and lower elasticity in a highly regulated region, which may imply that land use regulations in general do indeed serve as supply constraints.

2.4.2. Higher Costs for Business Spaces

Since land use regulations can increase the price of developable land in a community or a region, it is anticipated that businesses will pay commensurately higher costs for the sites or floor spaces used in their production activities. This probable consequence of land use regulations should be considered when the macroeconomic impact of land use regulations is of interest, since land availability and costs are some of the most important factors in industrial location decisions, as shown in Calzonetti and Walker's (1991) survey analysis and other studies. In particular, industries that require large sites for production purposes can be seriously affected by the scarcity and/or high price of industrial land. Also, such effects, in the form of limited reinvestment or production expansion, can spread across an entire regional economy through inter-industry linkages.

In fact, these adverse economic effects of land use regulations are less likely to be documented in the U.S. literature, where studies on housing price effects have been much more prominent, compared to many other countries.[14] This is probably because the adverse effects are generally weak due to the favorable attitudes of local governments toward commercial and industrial development (Cheshire and Hilber 2008). Actually, in the U.S., the tax system as well as various

[14] The effect of land use regulations on the price of business space has been more thoroughly researched in the U.K. and other countries where land availability is relatively low and stricter controls of land use exist (Evans 2004; Henneberry *et al.* 2005; Cheshire and Sheppard. 2005; Cheshire and Hilber 2008).

fiscal incentives often forces local and state governments to compete with each other to attract businesses into their jurisdictions.

Even in the U.S. context, however, land use regulations can cause a serious shortage of business space or even prevent particular production activities from settling into a region. The 1000 Friends of Oregon (1982) analyze whether a sufficient area of land was made available for industrial development in Portland, where developable land is limited by the enforcement of the urban growth boundary as well as by local government zoning. They report that industrial land supply is much smaller than the estimated demand. They also find that some sites zoned for industrial use are in flood plains or inaccessible given the existing infrastructure, so that nominal supply, already failing to meet the demand, overestimates the amount of available land. Also, according to Hanushek and Quigley (1990), in the 1970s and 1980s, many local governments, particularly in California, implemented restrictive non-residential zoning ordinances designed to control industrial growth, since those activities were presumably not fiscally desirable.

2.5. Labor Market Shifts

The effect of housing market changes prompted by land use regulations in the context of the regional labor pool is not trivial, given that spending for housing comprises a major proportion of total household expenditures; for example, this figure generally totals about 20 percent in the U.S. More specifically, higher housing prices and a limited supply of new housing may significantly increase the cost of living; may make the region less attractive as a place to live; may push the labor supply curve upward; and eventually may hinder the economic growth of the region. Recently, a set of studies has highlighted this causal link between land use regulation and the performance of regional economies via housing and labor markets.

For instance, Glaeser (2006) claims that land use controls seriously constrain housing supply and adversely affect the economic growth of a region, positing that “No Homes, No People, No Jobs”, since “the economy cannot grow unless population grows and the population cannot grow without new housing” (p.2). In another paper, Glaeser *et al*. (2006) attempt to empirically support this argument. By conducting a MSA-level econometric analysis, they detect a positive effect of strict land use regulations on housing prices and a deterrent effect on population growth;

that is, in a metropolitan area with strict land use regulations, the population is less likely to grow in response to labor demand increases, while housing prices are more likely to increase even though no effect on income is apparent. The magnitude of this effect is substantial: "the effect of labor demand on population growth is 50% lower in areas with highly regulated housing markets" (p.85).[15] Saks (2008) also investigates this issue empirically by using a three-variable vector auto regression model. Here consideration is given to not only short-term but also long-term impacts of land use regulations that restrict the housing supply. Based on this empirical analysis, she reports that under a given constant labor demand increase, land use regulations tend to lower the elasticity of housing supply, increase housing prices more rapidly, raise the wage level, and hinder employment growth. In addition, the adverse effect of land use regulations on employment growth extends over time. Vermeulen and Ommeren (2008) also examine this issue using a model of a simultaneous three-equation system that includes the labor force, employment, and housing. They conclude that employment growth is determined by the labor supply, which is predominantly affected by the housing supply. Based on these findings, they argue that strict land use regulations that deter housing and limit the labor supply are responsible for sluggish regional economic growth.

So far, these studies typically have focused on the aggregate population or workforce, rather than on discerning different socio-economic groups. Studies such as Downs (1991), Levine (1999), Anthony (2003), and Quigley & Raphael (2004), for example, identify the serious scarcity of affordable units as a consequence of restrictive land use controls. This may imply that socio-economic groups are affected by and react to the tightened housing market differently due to their different financial capabilities and asset holdings. This disproportionate effect is useful to better understand the labor market implication of land use regulations. Furthermore, a different portfolio of industries within a region will generate different qualitative and quantitative labor demands, and a careful consideration of this disproportionate effect will enable us to better assess the distinct impact of land use regulations on a particular industry, as well as the overall influence on the industrial structure of a region.

[15] It needs to be noted that interregional variation in many respects other than the degree of land use regulation is not considered to be a potential factor in the lower responsiveness of population to labor demand increases. Likewise, in Saks (2008), no alternative hypothesis is tested to corroborate these claims.

2.6. Summary of the Literature Review

With this literature review, a set of complex causal links between land use and regional economies have been identified (figure 2.1). These links suggest that land use regulation and planning have countervailing effects on the performance of regional economies. On the one hand, land use regulations may promote regional economic prosperity 1) by eliminating negative externalities, preserving public goods, and implementing amenity improvements; 2) by encouraging compact development, which is associated with a higher efficiency in public service provision as well as other agglomeration benefits; 3) by improving transportation outcomes or broadening the potential options for travel choices that have significant implications for regional economies; and 4) by reducing the uncertainty and transaction costs involved in land development. On the other hand, land use regulations may affect regional economies negatively 1) by causing a more dispersed or mismatched pattern of development rather than controlling urban sprawl, if local governments distort market processes through exclusionary land use regulations; 2) by reducing site availability for urban uses, imposing additional costs on developers, and dramatically increasing the prices of developable land, housing, and business spaces; and 3) by preventing regions from satisfying the increasing needs for housing and labor in a timely manner as regional economies grow.

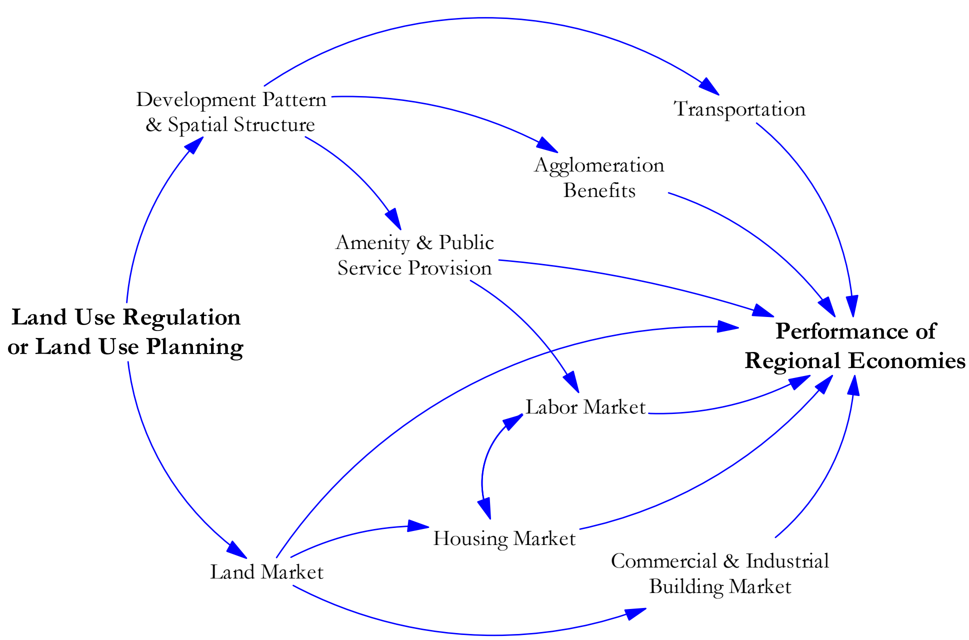

Figure 2.1. The Complex Causal Links between Land Use and Regional Economic Performance

Given that countervailing effects exist, in all probability, most regional economies will be pushed and pulled by both the negative and positive effects of land use planning and regulation. The resultant forces may generate influences on regional growth and development that are dynamic in nature and that exhibit very complex paths over time. Furthermore, the policy outcome – i.e., whether a land use regulation or planning actually promotes or hinders regional economic prosperity – might depend on the context, including the institutional setting, as well as the timing, degree of restrictiveness, and the detailed approaches of the intervention.

3. LAND USE REGULATION AND INTRAREGIONAL POPULATION – EMPLOYMENT INTERACTION

3.1. Introduction

Through the literature review, it has been found that land use regulations can bring a considerable amount of economic benefits by addressing market failures and realizing a well-organized spatial structure. However, on the other hand, the regulations often delay the development process (Mayer & Somerville 2000) and sometimes shift the cost of development from the localities to developers (Quigley & Rosenthal 2005). Raising barrier to development may prevent a region from satisfying the growing demand for labor and housing in a timely manner, even if there are significant opportunities for rapid economic growth. As noted in section 2.5, recently Glaeser *et al*. (2006) and Saks (2008) highlight this issue and claim that strict land use regulations limit housing and thus labor supply, thereby hindering regional economic growth.

Is the same claim valid at the intraregional level? Within a highly regulated region, households could not respond to job growth at certain locations or job relocations, due to the inflexible local housing supply. This situation may result in longer commuting distances, times, and costs as well as spatial mismatches. For instance, if the supply of affordable housing units is significantly limited in suburban communities, many employees working for increasing suburban retailers or other firms may need to travel long distances everyday to work (probably from a central city, where housing units for low- or moderate-income households are available, to the suburban communities) due to the difficulties in moving into the regulated communities. Furthermore, business relocation may also be influenced by the affected property market conditions or limited labor supply. Consequently, the spatial structure of the region may be distorted and evolve into a state that is far from an efficient form.

There are a few studies that have reported some evidence consistent with this possible adverse effect. The studies include Levine (1998 and 2006) and Ihlanfeldt (2004) that point out that restrictive land use controls that exclusively favor low-density development, as opposed to housing units for low or moderate-income groups, may be responsible for intraregional spatial mismatch. The studies by Shen (1996) and Pendall (2000), indicating the displacement or exclusion as a consequence of some types of regulations, are also relevant. Moreover, some literature on residential relocation suggests that local housing market conditions have significant implications for residential mobility of households (see e.g. Cameron & Muellbauer 1998 and Van der Vlist *et al*. 2002).

This chapter empirically examines the possible adverse effect of land use regulations in the U.S. context. The analysis focuses on how intraregional population-employment interaction varies by metropolitan areas having different degrees of land use regulations using two methods: 1) correlation analysis and 2) spatial econometric analysis. The first analysis computes the correlation between disaggregated-level population and employment changes for each of selected 40 large U.S. metropolitan areas and checks whether there is any notable relationship between the correlation and the degree of regulatory barriers to residential development (measured by a residential land use regulation index). Here, consideration is also given to mean commuting time changes, a variable of policy interest that is closely related to this issue. Then, in the second spatial econometric analysis, by employing a regional disequilibrium adjustment framework, an attempt is made to estimate some advanced measurements of intraregional population-employment interaction (i.e. population adjustment rate; employment adjustment rate; magnitude of job effect on household location choice; and magnitude of population effect on business location choice) and closely investigate how such measures differ across regions with different regulation levels. In the process, this study attempts to shed a light on the issue of interest, namely the potential effect of strict land use regulations on intraregional population-employment interaction.

3.2. Correlation Analysis

How are land use regulations and intraregional population-employment interactions related to each other? What if land use regulations freeze local housing markets, thereby preventing people from following jobs in a timely manner? In this section, these issues are explored through the examination of the relationships among three variables of interest: 1) the region-wide degree of regulatory barriers to residential land development, 2) the correlation between disaggregated-level population and employment changes (hereafter, PCh-ECh Correlation), and 3) mean commuting time change. If the hypothesis that within a highly regulated region, households are less likely to relocate responding to the changes in job conditions due to the inflexible local housing supply, there will be an expectation that commuting distances and times tend to increase. If these assumptions are correct, then the analysis should reveal 1) a negative relationship between the regulatory level and PCh-ECh Correlation and 2) a positive relationship between the regulatory level and mean commuting time changes, although the relationship itself does not necessarily verify that the hypothesis is correct.

3.2.1. Variables & Data

3.2.1.1. Land Use Regulation Index

Pendall *et al* (2006) and many others have noted that a variety of land use policy instruments, ranging from traditional zoning ordinances to urban growth boundaries and impact fees, have been adopted by local or state governments in the U.S. Also, the set of policy actions (e.g. zoning) is often qualitatively and administratively different in different regions. For this reason, case studies, analyzing the effect of a government intervention in a particular location for a particular time period, are a typical format of research, dealing with primarily with land use policies.

Despite the difficulties in comparison and quantification, however, there have been considerable efforts to synthesize a wide range of land use regulations across states in an attempt to measure the degree of regulatory actions in a quantitative manner. An underlying rationale of the synthesis is that such regulations may commonly generate a certain effect, particularly on housing market, because they mostly raise barriers to land development by delaying the development process or increasing the cost of development. In addition, the quantification allows comparisons or other types of analyses, seeking a more generalizable conclusion on the causes and effects of land use regulations in general like this study.

The Wharton Residential Land Use Regulatory Index (WRLURI; Linneman & Summers 1991; Gyourko *et al*. 2008) is a notable accomplishment. By conducting surveys and analyzing other information (e.g. how long it takes to get subdivision approvals; whether a region or locality implements some land use policy measures or not) an index has been produced that represents the level of regulatory barriers, covering metropolitan and some other areas in the U.S.

In this study, an index developed by Saks (2008) has been used; this index is primarily based on an earlier version (late 1980s) of WRLURI. But it also reflects the outcomes of a few additional surveys, such as one by the Fiscal Austerity and Urban Innovation project (Clark 1988) and by American Institute of Planners (1976). In other words, the index is designed to represent the overall degree of various regulatory barriers to residential development, imposed by state as well as local governments. This index was chosen not only because it considers a broader range of information but also because 1) it is available for a large number of U.S. metropolitan areas and 2) it represents the relative level of residential land use regulation in late 1980s, that corresponds to the time span of this analysis, namely 1990 to 2000.

3.2.1.2. PCh-ECh Correlation (Correlation between disaggregated-level population and employment changes)

The primary focus of interest is in intraregional population-employment interaction and its variance across regions having different levels of land use regulations. Here, a simple way of operationalizing and quantifying this population-employment interaction within each region is used. In other words, the correlation between population and employment changes for smaller geographical units is computed and employed.

The Census Transportation Planning Package (CTPP) provides individual census tracts' 2000 population and employment as well as 1990 population and employment by traffic analysis zone for most U.S. metropolitan areas. An area-based spatial interpolation technique is used to construct a dataset having both 1990 and 2000 population and employment for identical geography (i.e. census tracts) by translating 1990 information by traffic analysis zone to the values for each tract.

Then, one more step is made to derive a better measurement of intraregional population-employment interaction. Consider two contrasting cases: (A) responding to a job increase in a census tract, a group of households locate in a census tract next to the tract having new jobs vs. (B) despite a job increase in a census tract, households do not or cannot respond to that signal by moving. If the correlation between population and employment changes is computed at the census-tract-level, that is generally smaller than the typical scope of labor sheds in metropolitan areas, it is not possible to distinguish Case (A) from (B). Therefore, alternatively, the correlation between ΔP and $(I+W)\cdot\Delta E$ is computed. Here ΔP and ΔE are population and employment change of individual census tracts respectively. W is a spatial weight matrix constructed based on tract-level journey to work data (i.e. row-normalized flow matrix in which all diagonal elements are zero), so that $(I+W)\cdot\Delta E$ indicates the employment change in the labor market centered on each census tract.

Figures 3.1 through 3.3 show the correlations of three largest metropolitan areas in the U.S.: 1) New York, 2) Los Angeles, and 3) Chicago. According to the regulation index, New York is a typical highly regulated region, while residential development in Chicago is relatively unregulated. Los Angeles is between the two in terms of the index.

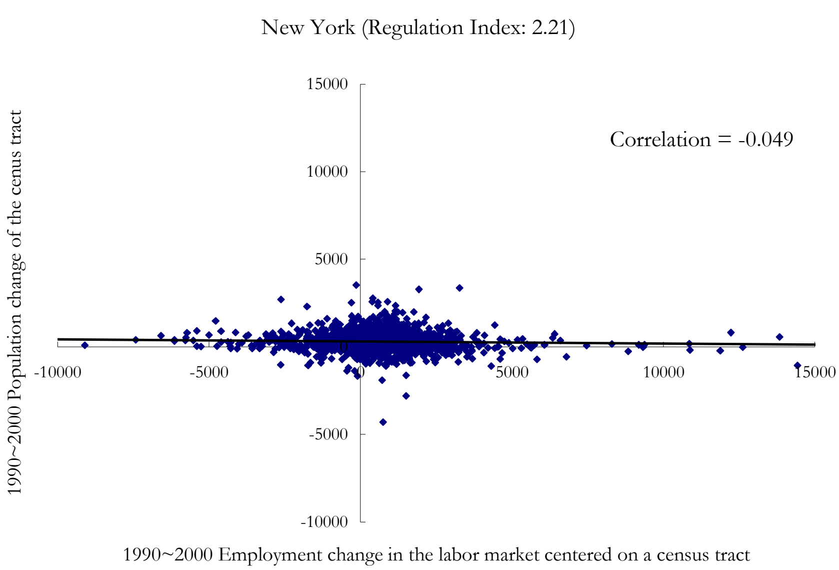

Figure 3.1. PCh-ECh Correlation: New York

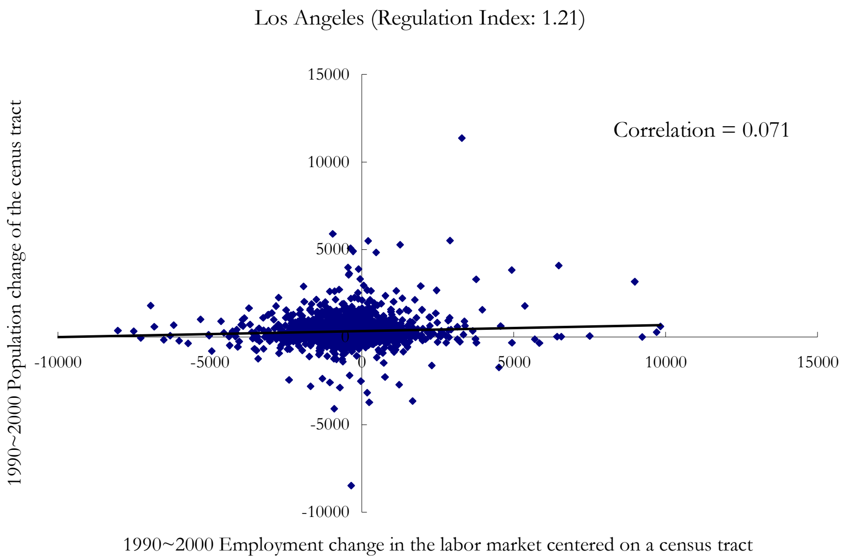

Figure 3.2. PCh-ECh Correlation: Los Angeles

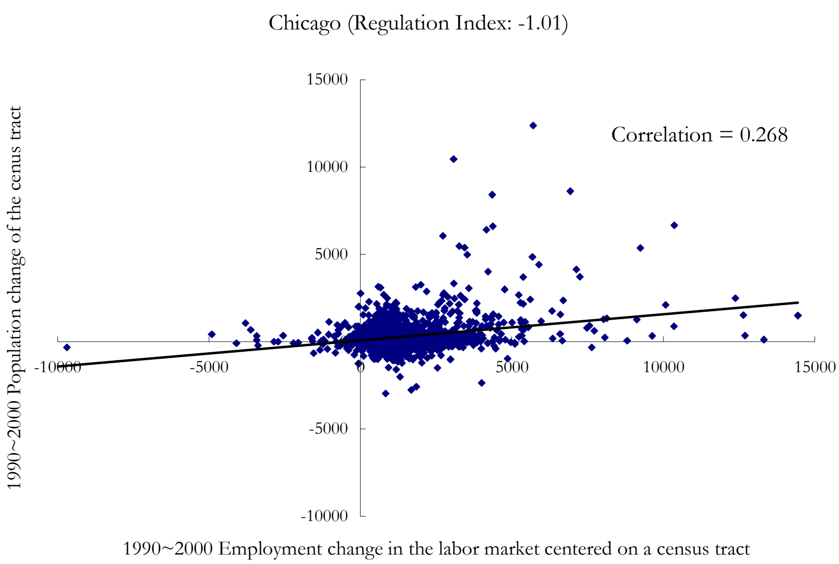

Figure 3.3. PCh-ECh Correlation: Chicago

For completeness, the correlation between $(I+W)\cdot\Delta P$ and ΔE instead of that between ΔP and $(I+W)\cdot\Delta E$ was also calculated to see how much these two differ from each other. There is no significant difference (the correlation between the two correlation variables is 0.910). It has been also confirmed that the outcomes of this analysis are almost same in the two cases.

3.2.1.3. Mean Commuting Time Changes

Mean commuting time information is almost readily available for most metropolitan areas. CTPP provides not only region-wide but also more disaggregated-level mean commuting time data. I compute the changes in place-of-work-based mean commuting time between 1990 and 2000 for each region. The place-of-work-based value, as opposed to place-of-residence one, is chosen to better capture the potential increase in commuting time attributable to the difficulties in moving towards the job locations due to the limited housing options in and around the place-of-work.

3.2.2. Study Areas

Consideration is given to 40 metropolitan areas in U.S., meeting two conditions: 1) the 1990 (initial year) population is greater than a million, so the number of census tracts (i.e. sample size) is sufficient for the analysis and 2) the residential land use regulation index is available (table 3.1). The 1990 Census definitions of metropolitan areas, corresponding to the index, are used here.

Table 3.1. List of the Selected Study Areas

Region	1990POP	Regulation Index
New York, NY PMSA	8,546,846	2.21
San Francisco, CA PMSA	1,603,678	2.10
Sacramento, CA MSA	1,481,102	1.89
Riverside--San Bernardino, CA PMSA	2,588,793	1.73
San Jose, CA PMSA	1,497,577	1.65
San Diego, CA MSA	2,498,016	1.60
Seattle, WA PMSA	1,972,961	1.48
Los Angeles--Long Beach, CA PMSA	8,863,164	1.21
Newark, NJ PMSA	1,824,321	1.02
Salt Lake City--Ogden, UT MSA	1,072,227	0.96
Portland, OR PMSA	1,239,842	0.94
Washington, DC--MD--VA MSA	3,923,574	0.86
Boston, MA PMSA	2,870,669	0.86
Baltimore, MD MSA	2,382,172	0.80
Orlando, FL MSA	1,072,748	0.50
Philadelphia, PA--NJ PMSA	4,856,881	0.47
Miami--Hialeah, FL PMSA	1,937,094	0.47

Table 3.1 (cont.)

Region	1990POP	Regulation Index
Pittsburgh, PA PMSA	2,056,705	0.26
Fort Lauderdale--Hollywood--Pompano Beach, FL PMSA	1,255,488	0.23
Milwaukee, WI PMSA	1,432,149	0.19
Tampa--St. Petersburg--Clearwater, FL MSA	2,067,959	0.16
Cincinnati, OH—KY--IN PMSA	1,452,645	0.16
Oakland, CA PMSA	2,082,914	0.10
Charlotte--Gastonia--Rock Hill, NC--SC MSA	1,162,093	-0.04
Columbus, OH MSA	1,377,419	-0.07
Minneapolis--St. Paul, MN--WI MSA	2,464,124	-0.16
New Orleans, LA MSA	1,238,816	-0.2
Cleveland, OH PMSA	1,831,122	-0.25
Houston, TX PMSA	3,301,937	-0.52
Indianapolis, IN MSA	1,249,822	-0.55
St. Louis, MO--IL MSA	2,444,099	-0.66
San Antonio, TX MSA	1,302,099	-0.66
Denver, CO PMSA	1,622,980	-0.68
Rochester, NY MSA	1,002,410	-0.68
Detroit, MI PMSA	4,382,299	-0.69
Atlanta, GA MSA	2,833,511	-0.77
Phoenix, AZ MSA	2,122,101	-0.91
Kansas City, MO--KS MSA	1,566,280	-0.95
Chicago, IL PMSA	6,069,974	-1.01
Dallas, TX PMSA	2,553,362	-1.18

Note: A higher value of regulation index (Saks 2008) indicates a more severe residential land use regulation.

3.2.3. Analysis Outcomes

Figure 3.4 shows the relationship between the regulation index (on the x-axis) and the PCh-ECh correlation (on the y-axis). Although the relationship is not very strong, they are negatively associated with each other (correlation = –0.314). This is consistent with the hypothesis.

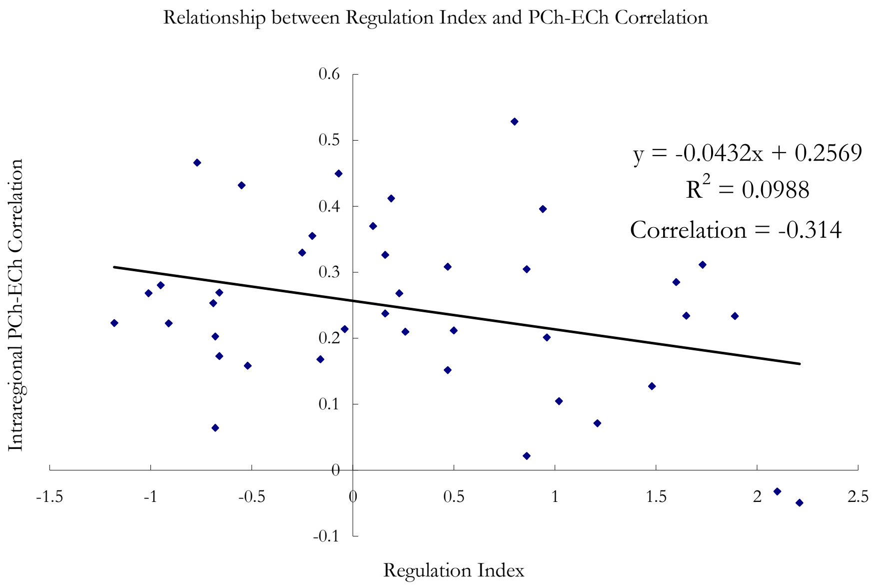

Figure 3.4. Relationship between Regulation Index and Intraregional PCh-ECh Correlation

I also relate both the regulation index and PCh-ECh correlation to the mean commuting time changes. The outcomes are presented in figure 3.5 and 3.6, respectively. As expected, the commuting time changes show a positive relationship with the regulation index and a negative relationship with the intraregional PCh-ECh correlation. This suggests that commuting time tends to increase more in highly regulated regions where generally population and employment are not strongly tied to each other. It should be noted that commuting time changes are more strongly associated with the regulation index rather than the PCh-ECh correlation. This may imply that the real spatial mismatch between a particular class of jobs and the corresponding (or affordable) housing supply would be more serious than what I captured by using the correlation between aggregated population and aggregated employment.

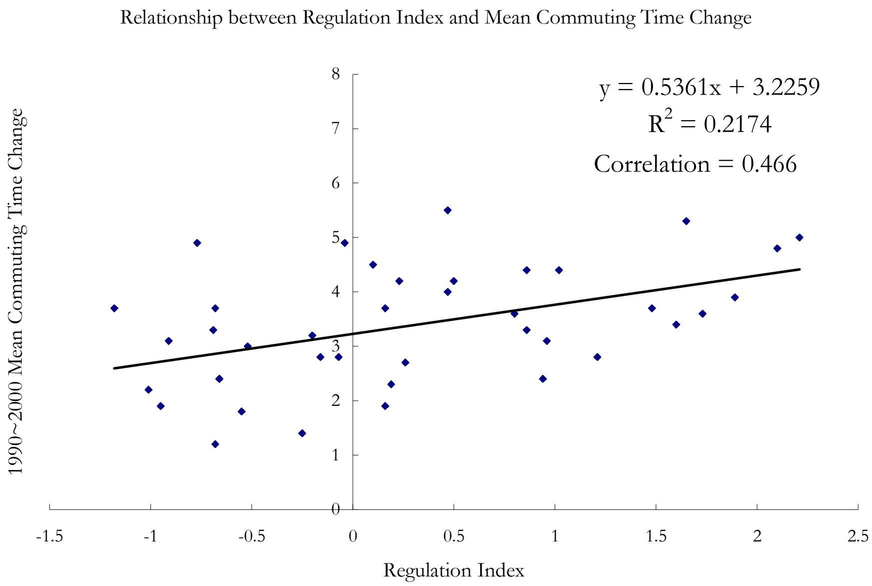

Figure 3.5. Relationship between Regulation Index and Mean Commuting Time Change

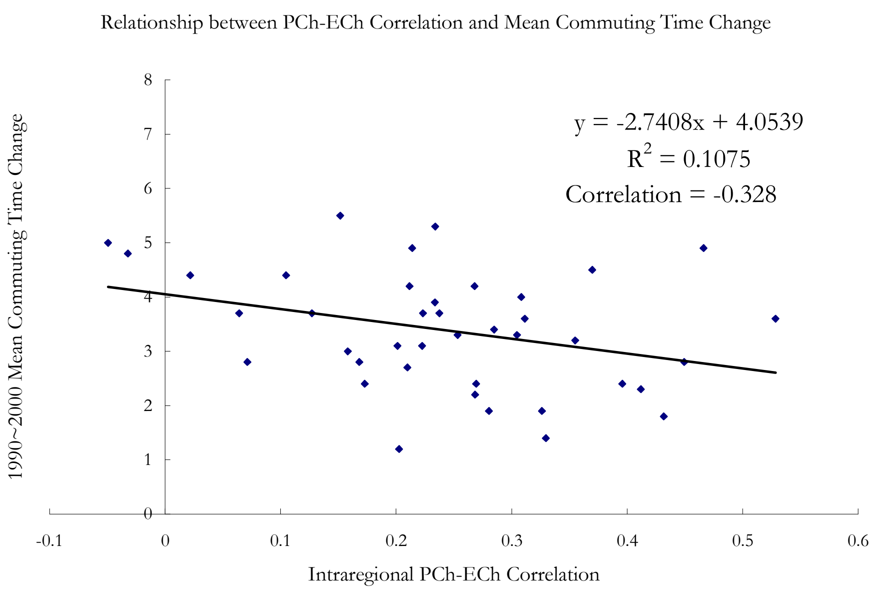

Figure 3.6. Relationship between PCh-ECh Correlation and Mean Commuting Time Change

In addition, the analysis probed whether the relationships vary by metropolitan size, measured by 1990 (initial year) population, to explore whether the hypothesis may be more valid in certain size categories. The selected study regions were grouped into two categories – 1) those greater than two million and. 2) those between one and two million – and performed a similar analysis. As summarized in table 3.2, the relationships are much stronger in relatively smaller metropolitan areas, while the relations, except the one between PCh-ECh correlation and commuting time change, are somewhat maintained in larger regions as well.

Table 3.2. Relationships among the Variables of Interest in Different Sizes of Metropolitan Areas

Category	Relationship Type	Slope	R-Squared	Correlation
Greater than two million (n=19)	Regulation Index (X) and PCh-ECh Correlation (Y)	-0.036	0.071	-0.267
	Regulation Index (X) and Commuting Time Change (Y)	0.269	0.117	0.342
	PCh-ECh Correlation (X) and Commuting Time Change (Y)	0.100	0.000	0.017
Between one and two million (n=21)	Regulation Index (X) and PCh-ECh Correlation (Y)	-0.051	0.136	-0.368
	Regulation Index (X) and Commuting Time Change (Y)	0.859	0.351	0.593
	PCh-ECh Correlation (X) and Commuting Time Change (Y)	-5.789	0.311	-0.558

Finally, tests were performed to explore whether a particular type of intervention is more or less relevant to the lower PCh-ECh correlation and increasing mean commuting time. For this purpose, four components of the regulation index, which are available, were used – 1) months to approve subdivision, 2) number of growth management techniques, 3) implementation of development fees, and 4) state-level regulatory index – individually, as opposed to the aggregated index and see how the relationships vary by types of intervention.[16] Different approaches to land use control may generate different impacts, although they may commonly raise barriers to land development within the regions, as mentioned above. Therefore, by checking the intervention-type-specific relation to the PCh-ECh correlation and commuting time change, we can obtain a refined understanding of the potential effect from which more informative policy lessons are eventually drawn. For example, if it is determined that the delay of development (measured in terms of the months to approve subdivision) only matters, we could say that the potential negative impact of land use regulations on intraregional population-employment interaction can be effectively addressed by reducing the delay through appropriate institutional or procedure reform.

[16] The original data sources of these components of the index are an earlier version of WRLURI (Linneman & Summers 1991) and a survey by American Institute of Planners (1976). This information is available through Mayer & Somerville (2000) and Malpezzi (1996).

In contrast, if the implementation of impact fees is found to have a more significant relationship, we could recognize that extra development costs imposed on the developers may be related to this issue and pay further attention to the improvement of the policy instrument.

It is found that the relationships hold in every case (table 3.3). In particular, the relationships appear most apparent, when a statistic, representing the time delay in development process (i.e. Months to approve subdivision) is adopted. This may suggest various land use regulations generally have some potential effects on intraregional population-employment interaction and, consequently, affect commuting time within the region, although the delay of development matter most significantly.

Table 3.3. Relationships by Intervention Type

Intervention type	Correlation with	
	PCh-ECh Correlation	Mean Commuting Time Change
Months to approve subdivision [1]	-0.484	0.359
Number of growth management techniques [1]	-0.146	0.391
Implementation of development fees [1]	-0.145	0.229
State-level regulatory index [2]	-0.251	0.178

Sources: 1) Linneman & Summers (1991) and Mayer & Somerville (2000)
2) American Institute of Planners (1976)

3.3. Spatial Econometric Analysis

Through the correlation analysis, it was found that a highly regulated region is more likely to show a lower level of intraregional PCh-ECh correlation and an increasing mean commuting time between 1990 and 2000. However, the findings of the correlation analysis do not necessarily mean that the hypothesis is valid. It is probable that household location decisions in highly regulated regions depend less on job locations than those in less-regulated areas. The observed lower PCh-ECh correlation may also be attributable to the business-side reasons. In other words, the PCh-ECh correlation has limited usefulness in informing how intraregional population-employment interaction varies by metropolitan areas having different degrees of land use regulations.

In this section, the investigation focuses on the intraregional population-employment interaction more closely and checks four possible explanations for the relatively looser connection between population and employment changes in highly regulated areas.

1) Lower household mobility … This means that households cannot rapidly respond to the evolving job conditions or other factors within a highly regulated area. This explanation is consistent with the hypothesis.
2) Smaller magnitude of job effect on household location choice … This means that households in a more regulated region may consider other factors, such as natural amenities, public services, etc, more importantly, when they decide their places of residence.
3) Lower business mobility … Businesses may also follow people. But the mobility may vary by regions. This explanation means that businesses are hard to locate or relocate where they want to be, if the metropolitan area is highly regulated. This may be the case, because residential land use regulations can affect the entire property market, including business space supply. Another possibility is that commercial-industrial development may also be much more regulated in the metropolitan areas having higher values of the residential land use regulation index.
4) Smaller magnitude of population effect on business location choice … This means that business do consider population distribution as less important in highly regulated regions for some reasons, such as different industrial structures, different production recipes, and so on, in their location decision making.

Although these four explanations are neither mutually exclusive nor exhaustive, explanation (2), (3), and (4) can be regarded as alternative hypotheses. And, by examining what explanation is the case, we can better understand why highly regulated regions tend to show the relatively weaker connection between intraregional population and employment changes and, further, obtain an enhanced insight into the potential negative effect of strict land use regulations, although this investigation is not a test of causality.[17] This is accomplished by conducting a spatial econometric analysis, using a regional disequilibrium adjustment framework, in which population and employment interaction is explicitly described in a form of simultaneous equation system.

[17] This investigation approach has bee employed by Sohn (2004) and many other studies, which attempt to draw better insights, understandings, and policy recommendations from the found patterns or correlations.

3.3.1. Regional Disequilibrium Adjustment Framework

The regional disequilibrium adjustment model (RDAM) was initially developed by Steinnes & Fisher (1974) and Carlino & Mills (1987), and then further extended by Boarnet (1994a) to a spatial econometric version. Because the RDAM framework properly separates population-employment interaction out of the other factors, it has been used by various studies, 1) determining whether jobs follow people or people follow jobs or the both (see e.g. Steinnes 1977; Boarnet 1994b), 2) examining the determinants of growth or location decisions (see e.g. Steinnes & Fisher 1974; Fisher & Fisher 1975; Carlino & Mills 1987; Boarnet 1994a), 3) investigating spread vs. backwash effects (Henry *et al*. 1997 and 2001; Feser & Isserman 2005), and 4) analyzing the impacts of other events or policies (see e.g. Bollinger & Ihlanfeldt. 1997; Carruthers & Mulligan 2007).

The RDAM framework assumes that the spatial distributions of population and employment are at disequilibrium but tending to adjust to an equilibrium point that is moving over time. The framework regards the adjustment process towards the equilibrium state as the main element of population and employment changes. It also considers other determinants of household and business location decisions – i.e. H and B in following RDAM equations –, in accordance with more traditional urban location theories.

More specifically, an estimable RDAM can be formulated, as follows. First, the equilibrium levels of population and employment of area *i* at time *t*, that are not observable, can be written:

$$P^*_{i,t} = f(H_{i,t}, \overline{E}^*_{i,t}) \quad (3\text{-}1)$$

$$E^*_{i,t} = g(B_{i,t}, \overline{P}^*_{i,t}) \quad (3\text{-}2)$$

where $H_{i,t}$ and $B_{i,t}$ indicate a vector of household and business location factors of zone *i* at time *t* respectively; and $\overline{P}^*_{i,t}$ and $\overline{E}^*_{i,t}$ represent equilibrium population and employment in the labor market centered on zone *i* at *t*.

As noted above, assuming that actual population and employment are adjusting to their equilibrium points, population and employment changes that can be observed are expressed:

$$\Delta P_{i,t} = P_{i,t} - P_{i,t-1} = \lambda_p \cdot (P^*_{i,t} - P_{i,t-1}) \quad (3\text{-}3)$$

$$\Delta E_{i,t} = E_{i,t} - E_{i,t-1} = \lambda_E \cdot (E^*_{i,t} - E_{i,t-1}) \quad (3\text{-}4)$$

where λ_p and λ_E are [0,1] adjustment rates of population and employment changes responding to the gap between *t-1* state and equilibrium level at *t*.

Applying the same logic, the changes in population and employment in the labor market centered on zone *i* at time *t* are:

$$\Delta \overline{P}_{i,t} = \overline{P}_{i,t} - \overline{P}_{i,t-1} = \lambda_p \cdot (\overline{P}^*_{i,t} - \overline{P}_{i,t-1}) \quad (3\text{-}5)$$

$$\Delta \overline{E}_{i,t} = \overline{E}_{i,t} - \overline{E}_{i,t-1} = \lambda_E \cdot (\overline{E}^*_{i,t} - \overline{E}_{i,t-1}) \quad (3\text{-}6)$$

By rearranging the equations, we can get

$$\overline{P}^*_{i,t} = \overline{P}_{i,t-1} + \frac{1}{\lambda_p} \cdot (\overline{P}_{i,t} - \overline{P}_{i,t-1}) \quad (3\text{-}7)$$

$$\overline{E}^*_{i,t} = \overline{E}_{i,t-1} + \frac{1}{\lambda_E} \cdot (\overline{E}_{i,t} - \overline{E}_{i,t-1}) \quad (3\text{-}8)$$

One more required step for making a RDAM is to specify the population and employment in the labor market centered on each zone. As explained when the method of intraregional PCh-ECh correlation calculation is presented in the previous section, the census-tract is typically smaller than the scope of labor sheds in metropolitan areas, so that the population and employment growth in a particular tract may be directly influenced the employment and population changes in adjacent areas as well as the changes in the very tract. The RDAM is designed to consider such effects over the tract boundary by using the population and employment in the labor market centered on zone *i*, rather than those in the zone only. More specifically, the population and employment in the labor market centered on zone *i* at t is computed by employing a spatial weight matrix (*W*), as follows.

$$\overline{P}_{i,t} = (I + W) \cdot P_{i,t} \quad (3\text{-}9)$$

$$\overline{E}_{i,t} = (I + W) \cdot E_{i,t} \quad (3\text{-}10)$$

If (3-9) and (3-10) are plugged into (3-7) and (3-8), then

$$\overline{P}^*_{i,t} = (I + W) \cdot P_{i,t-1} + \frac{1}{\lambda_p} \cdot (I + W) \cdot \Delta P_{i,t} \quad (3\text{-}11)$$

$$\overline{E}^*_{i,t} = (I+W)\cdot E_{i,t-1} + \frac{1}{\lambda_E}\cdot(I+W)\cdot\Delta E_{i,t} \quad (3\text{-}12)$$

To finalize the formulation, let's assume a linear relationship in equation (1) and (2) and substitute into equation (3) and (4). This generates

$$\Delta P_{i,t} = H_{i,t}\cdot\beta_P + \theta_p\cdot\overline{E}^*_{i,t} - \lambda_p\cdot P_{i,t-1} + u_{i,t} \quad (3\text{-}13)$$

$$\Delta E_{i,t} = B_{i,t}\cdot\beta_E + \theta_E\cdot\overline{P}^*_{i,t} - \lambda_E\cdot E_{i,t-1} + v_{i,t} \quad (3\text{-}14)$$

where β_P and β_E are column vectors of parameters for individual household and business location factors; θ_p and θ_E are scalar parameters; and $u_{i,t}$ and $v_{i,t}$ are i.i.d. errors.

By plugging (3-11) and (3-12) into (3-13) and (3-14), finally, an estimable RDAM can be derived, as follows.

$$\begin{aligned}\Delta P_{i,t} &= H_{i,t}\cdot\lambda_p\cdot\beta_P + \lambda_p\cdot\theta_P\cdot(I+W)\cdot E_{i,t-1}\\ &\quad + \frac{\lambda_p\cdot\theta_P}{\lambda_E}\cdot(I+W)\cdot\Delta E_{i,t} - \lambda_p\cdot P_{i,t-1} + u_{i,t}\end{aligned} \quad (3\text{-}15)$$

$$\begin{aligned}\Delta E_{i,t} &= B_{i,t}\cdot\lambda_E\cdot\beta_E + \lambda_E\cdot\theta_E\cdot(I+W)\cdot P_{i,t-1}\\ &\quad + \frac{\lambda_E\cdot\theta_E}{\lambda_P}\cdot(I+W)\cdot\Delta P_{i,t} - \lambda_E\cdot E_{i,t-1} + v_{i,t}\end{aligned} \quad (3\text{-}16)$$

In the next section, attention will be directed to the main parameters of interest.

3.3.2. Parameters of Interest

There are four main parameters of interest, which are associated with the four explanations for the found weaker connection between intraregional population and employment changes in highly regulated regions, respectively: 1) lower household mobility, 2) smaller magnitude of job effects on household location choice, 3) lower business mobility and 4) smaller magnitude of population effect on business location choice. The first one is λ_p, which is the rate of population adjustment responding to the gap between its state and the equilibrium level; and thus represents the level of household mobility. If the estimated values of λ_p for highly regulated areas are significantly lower than those of relatively unregulated regions, it could be argued that households in a highly regulated region could not respond to new job conditions or other location factors in a timely manner, so that intraregional population and employment changes are not well connected.

The second parameter of interest is θ_p, the magnitude of the effect of employment on population, relevant to the second explanation. This indicates how strong job conditions influence household location decision-making in a region. If the estimated values of θ_p for highly regulated areas are smaller than those of less regulated areas, the relatively looser connection between population and employment changes in the regulated regions can be attributed to the differences in household location choice preference.

In the same vein, λ_E and θ_E are associated with the third and fourth explanation, respectively. In other words, it is possible to check whether the third and fourth explanations are the case or not, by analyzing how λ_E (representing business mobility) and θ_E (meaning the magnitude of population effect on business location choice) vary by regions having different regulatory levels.

It needs to be noted that each parameter of interest cannot be determined based on a single estimated coefficient in the RDAM, namely a set of equation (3-15) and (3-16). For instance, λ_p is included in both population and employment change equations, so that can be obtained in two different ways: 1) from the estimated coefficient of $P_{i,t-1}$ in population change equation and 2) from the estimated coefficients of $(I+W)\cdot P_{i,t-1}$ and $(I+W)\cdot \Delta P_{i,t}$ in employment change equation. The case of λ_E is similar. In addition, θ_P and θ_E can be derived by using two estimated coefficients, $(I+W)\cdot E_{i,t-1}$ & $P_{i,t-1}$ and $(I+W)\cdot P_{i,t-1}$ & $E_{i,t-1}$ respectively. For this reason, the values of the parameters are accepted only when all these coefficients in each equation have statistically significant estimates.

3.3.3. Data & Estimation

Like the exploratory analysis presented above, I consider the 40 metropolitan areas; the time span of analysis is 1990 to 2000; a spatial weight matrix (*W*), constructed based on tract-level journey to work data, is used. For the independent variables, the 1990 Census, CTPP, and National

Highway Planning Network data that are commonly available for all study areas are used (see table 3.4).

The RDAM is a spatial cross-regressive simultaneous equation system (according to the Rey & Boarnet's (2004) taxonomy). Due to the feedback and spatial simultaneity problems, traditional least square techniques, including traditional two-stage least square, cannot yield consistent and unbiased estimates. Hence, the model is estimated using a spatial generalized moments (GM) approach, initially developed by Kelejian & Robinson (1993) and later extended by Kelejian & Prucha (1998 and 1999). According to Rey & Boarnet's (2004) Monte Carlo simulation experiments, the GM estimation method performs better than alternatives, especially as the number of samples increases. In this case, instrumental variables for the endogenous variables are $X(X'X)^{-1}XWy$ rather than $W\left[X(X'X)^{-1}Xy\right]$.

Table 3.4. Independent Variables and Data Sources in the RDAM Estimation

Variable	Description	Data Sources
NWR	The Ratio of Non-White Population in 1990	Census 1990
HISPR	The Ratio of Hispanic Population in 1990	Census 1990
VACR	Vacancy Rate in 1990	Census 1990
EDU [1]	The Level of the Educational Attainment in 1990	Census 1990
MHOHINC	Median Household Income in 1990	Census 1990
MHV	Median Value of Specified Housing Units in 1990	Census 1990
POVR	Poverty Rate in 1990	Census 1990
MIXE [2]	Industry-mix effect 1990~2000	CTPP 1990
SHARE90_S(j) [3]	Share of sector *j* in 1990	CTPP 1990
HW_All	A dummy variable, indicating whether there is any types of highway in the tract	National Highway Planning Network data
HW_C1	A dummy variable, indicating whether there is interstate-highway (Functional Class: 01) in the tract	National Highway Planning Network data
HW_C2	A dummy variable, indicating whether there is other expressway (Functional Class: 02) in the tract	National Highway Planning Network data

1) *EDU* is defined as a percentage of 25+ population, whose educational attainment is Bachelor's degree or above
2) This represents the relative advantage of each tract for job growth because of its industrial structure in initial year.

More specifically, it is defined as $MIXE = \sum_j TrtEmp(j,1990) \cdot \left[\frac{REmp(j,2000)}{REmp(j,1990)} - 1 \right]$

where *TrtEmp(j,t)* and *REmp(j,t)* are tract-level and regional employment in sector *j* at time *t*, respectively

3) This is defined as $SHARE90\_S(j) = \frac{TrtEmp(j,1990)}{\sum_j TrtEmp(j,1990)}$

3.3.4. Analysis Outcomes

Using the spatial GM approach, the model for each region is estimated. To obtain the final estimation outcomes, the model specification is repeatedly modified, by excluding the independent variables that are statistically insignificant (10%-level). Table 3.5 presents the final estimation outcomes for Cincinnati, as an example.[18]

Table 3.5. An Example of the Estimation Outcomes: Cincinnati (Regulation Index = 0.16 | n = 346)

Variable	Description	Coefficient	Standard Error	t-statistic	P-value
Population Change Equation					
C	*Intercept*	-673.166	246.842	-2.72712	[.006]
IWECH	$(I+W)\cdot\Delta E_{i,t}$; *This coefficient is* $\lambda_p \cdot \theta_P / \lambda_E$	0.611898	0.135464	4.51706	[.000]
P0	$P_{i,t-1}$; *This coefficient is* $-\lambda_p$	-0.082974	0.037665	-2.20298	[.028]
IWE0	$(I+W)\cdot E_{i,t-1}$; *This coefficient is* $\lambda_p \cdot \theta_p$	0.046433	0.019877	2.33598	[.019]
MHOHINC	*Median household income*	0.021798	5.00E-03	4.35868	[.000]
MHV	*Median value of specified housing units*	-7.59E-03	2.34E-03	-3.24509	[.001]
R-squared = 0.151 | Adjusted R-squared = 0.139					
Employment Change Equation					
C	*Intercept*	-706.856	286.714	-2.46537	[.014]
IWPCH	$(I+W)\cdot\Delta P_{i,t}$; *This coefficient is* $\lambda_E \cdot \theta_E / \lambda_P$	0.523736	0.116596	4.4919	[.000]
E0	$E_{i,t-1}$; *This coefficient is* $-\lambda_E$	-0.142054	0.026769	-5.30675	[.000]
IWP0	$(I+W)\cdot P_{i,t-1}$; *This coefficient is* $\lambda_E \cdot \theta_E$	0.099835	0.034612	2.88443	[.004]
MIXE	*Industry mix effect*	0.527012	0.140346	3.7551	[.000]
SHARE90_S2	*Share of Construction Sector*	-2395.78	1131.42	-2.11749	[.034]
SHARE90_S7	*Share of Finance, Insurance, and Real Estate Sector*	3111.51	1445.52	2.15252	[.031]
HW_C1	*Interstate highway dummy*	351.369	135.519	2.59276	[.010]
R-squared = 0.192 | Adjusted R-squared = 0.175					

Some of the estimated coefficients, presented in table 3.5, need to be explained. First, the negative coefficient of *MHV* may suggest that a greater amount of housing costs tend to push people out of the area. The positive value of *SHARE90_S7*'s coefficient can be interpreted as the

[18] It needs to be noted that the low values of r-squared, to some extents, are attributable to the model design in which population or employment changes (as opposed to population and employment levels) are dependent variables. In fact, most studies, specifying the RDAM in this way, report r-squared lower than 0.40. Another reason may be a limited number of independent variables considered due to the data availability problem.

attracting force of the financial sector. Finally, the negative coefficient of *SHARE90_S2* can be attributed to the temporary construction jobs in the field. In other words, the areas showing a high share of construction sector in 1990 tend to show a job loss after the completion of development projects which would not last a decade (i.e. from 1990 to 2000).

Like many other studies employing the RDAM, for some metropolitan areas, statistically insignificant estimates for key variables are often found: IWECH, P0, and IWE0 in population change equation and IWPCH, E0, and IWP0 in employment change equation. This may happen, because all location factors cannot be considered due to the data availability problem. According to Boarnet *et al*. (2005), the performance of this model can be improved by considering micro land use information as explanatory variables. Also, Mulligan and others' (1999) experiment suggests that better estimation outcomes would be obtained, if 5 years or shorter time spans are used in the analysis. However, a shorter time span or sufficient explanatory variables could not be used in this study, because tract-level population and employment data only available for decennial years; and the information for many other factors at this level is unavailable.

As mentioned above, in these cases of invalid estimation outcomes, it is impossible to determine valid values of the four parameters of interest. Therefore, the outcomes of these regions are not considered. The estimation outcomes of the key coefficients in valid cases are summarized in table 3.6.

Table 3.6. Estimation Outcome Summary: 16 Metropolitan Areas Showing Valid Results

Region	Regulation Index	Population Change Equation			Employment Change Equation		
		IWECH ($\lambda_p \cdot \theta_P / \lambda_E$)	P0 ($-\lambda_p$)	IWE0 ($\lambda_p \cdot \theta_p$)	IWPCH ($\lambda_E \cdot \theta_E / \lambda_P$)	P0 ($-\lambda_E$)	IWE0 ($\lambda_E \cdot \theta_E$)
Sacramento, CA MSA	1.89		Not Valid		0.95037****	-0.12610*	0.14430**
Los Angeles--Long Beach, CA PMSA	1.21		Not Valid		0.25126***	-0.04758****	0.04345***
Miami--Hialeah, FL PMSA	0.47		Not Valid		0.50012**	-0.12156****	0.11611**
Philadelphia, PA--NJ PMSA	0.47	0.32855****	-0.03184**	0.02665***	0.71001****	-0.14916****	0.04574**
Pittsburgh, PA PMSA	0.26	0.12070****	-0.03464**	0.06373****	0.47314**	-0.29661****	0.14598****
Fort Lauderdale--Hollywood--Pompano Beach, FL PMSA	0.23	0.66911***	-0.11623**	0.07097*	0.43375***	-0.09684***	0.09795*
Milwaukee, WI PMSA	0.19	0.39182****	-0.05889*	0.07807****	0.52439****	-0.16191****	0.12449***
Cincinnati, OH—KY--IN PMSA	0.16	0.61190****	-0.08297**	0.04643**	0.52374***	-0.14205****	0.09984***
Tampa--St. Petersburg--Clearwater, FL MSA	0.16		Not Valid		0.67406****	-0.20866**	0.15683***
Charlotte--Gastonia--Rock Hill, NC--SC MSA	-0.04		Not Valid		0.43678**	-0.20428****	0.13095*
Columbus, OH MSA	-0.07	0.39945***	-0.09865**	0.02295*		Not Valid	
San Antonio, TX MSA	-0.66		Not Valid		0.76274****	-0.55355****	0.15554**
St. Louis, MO--IL MSA	-0.66	0.36427****	-0.08224***	0.04277**	0.49847***	-0.21192****	0.06510**
Rochester, NY MSA	-0.68		Not Valid		0.71154*	-0.12624****	0.13357*
Detroit, MI PMSA	-0.69	0.23336****	-0.07150****	0.02727***		Not Valid	
Kansas City, MO--KS MSA	-0.95	0.56793****	-0.13350****	0.05585**	0.28365**	-0.33916****	0.10012***

Note: **** 0.1% level | *** 1% level | ** 5% level of significance | * 10% level of significance.

Using the valid estimation outcomes, the parameter values are determined for individual metropolitan areas. Then, they are related to the regulation index to see how they differ across regions with different regulation levels. Figures 3.7 through 3.10 demonstrate the relationships between the region-wide land use regulation index and the four parameters.

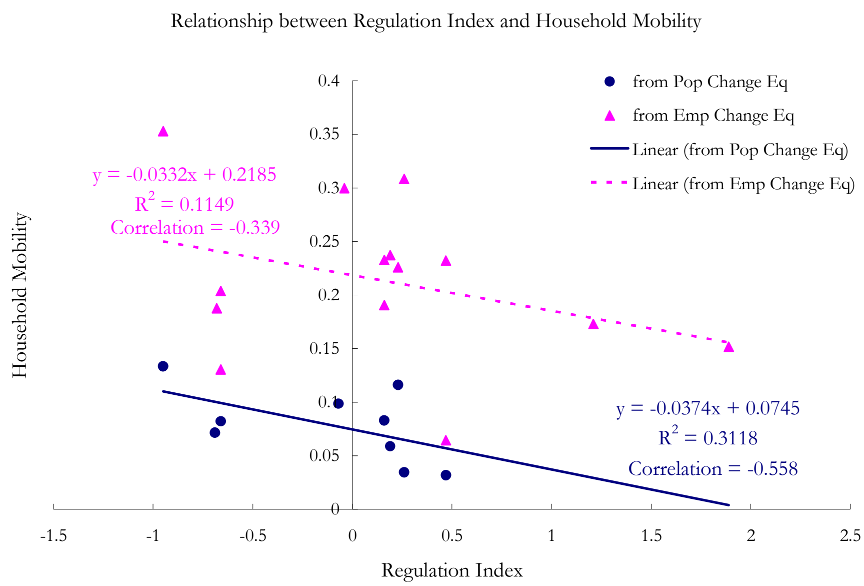

Figure 3.7. Relationship between Regulation Index and Household Mobility (λ_p)

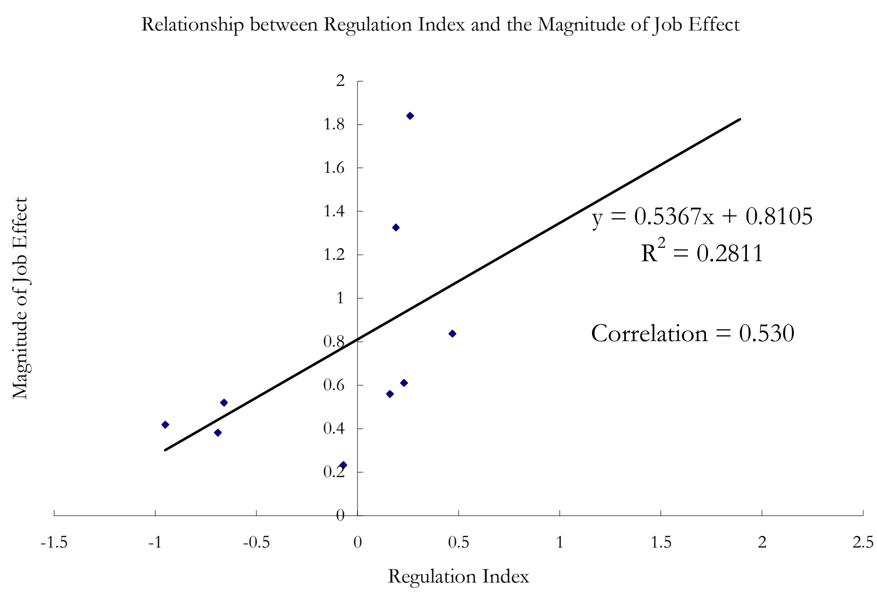

Figure 3.8. Relationship between Regulation Index and the Magnitude of Job Effect (θ_p)

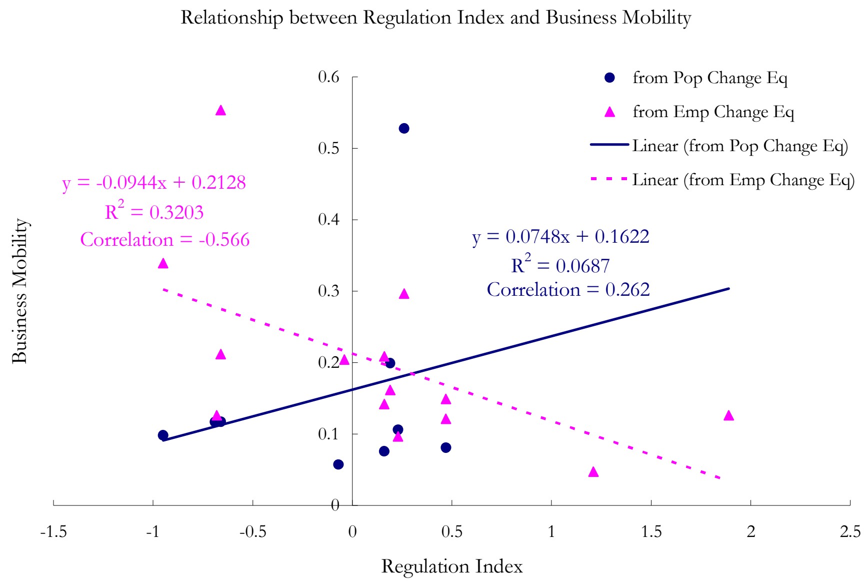

Figure 3.9. Relationship between Regulation Index and Business Mobility (λ_E)

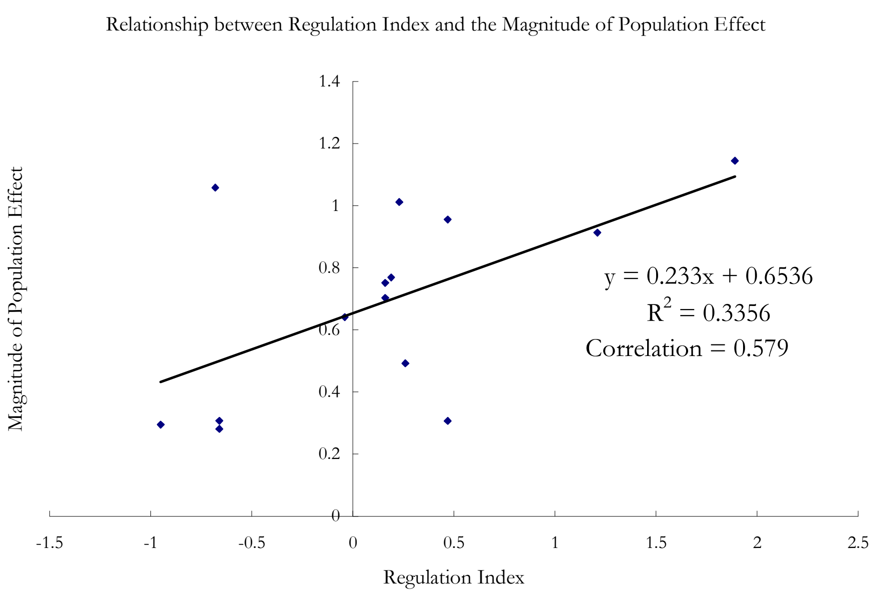

Figure 3.10. Relationship between Regulation Index and the Magnitude of Population Effect (θ_E)

Although the valid outcomes are obtained only for a limited number of study regions, this set of the results, as it stands, suggests that a more regulated metropolitan area tends to have:

1) a lower level of household mobility (figure 3.7);
2) a greater magnitude of job effect on household location choice (figure 3.8);

3) mixed outcomes regarding business mobility (figure 3.9)[19];
4) a greater magnitude of population effect on business location choice (figure 3.10)

Overall, at least, the results may suggest that the alternative hypotheses, particularly a smaller magnitude of job effect on household location choice and a smaller magnitude of population effect on business location choice, may not be the case. Rather, intraregional population and employment may not be well interconnected in regulated metropolitan areas due to the lower household mobility, even though household and businesses may want to locate closer to each other, consistent with the hypothesis of this research.

3.4. Summary & Discussion

In this study, I attempt to examine whether or not land use regulations prevent people from responding to new job conditions or other location factors in a timely manner, by analyzing how intraregional population-employment interaction varies by regions having different degrees of land use regulations. Through the correlation analysis, the results revealed that highly regulated metropolitan areas are more likely to show lower levels of correlation between intraregional population and employment changes and increasing mean commuting time between 1990 and 2000. Also, the estimation outcomes of the spatial econometric analysis, using a regional disequilibrium adjustment model, suggest that household mobility is lower in more regulated areas than relatively less regulated regions, consistent with the hypothesis.

However, the findings rest on limited analysis outcomes and thus are not conclusive. In the correlation analysis, various other factors that may influence the PCh-ECh correlation or commuting time changes are not controlled. Also, in the spatial econometric analysis, valid estimation outcomes were available for only some metropolitan areas. In particular, many highly

[19] First, the estimated coefficients of employment change equations indicate a poorer mobility of business in a highly regulated metropolitan area. This can be explained by 1) that commercial-industrial development is also much more regulated in the regions having high values of the index, although the index primarily represents residential land use regulations or 2) that residential land use regulations affects property market, as a whole, so that business mobility is influenced. However, the opposite relationship (i.e. a higher level of business mobility in the region with higher regulation index) is derived from the estimates in the population change equations.

regulated regions cannot be considered in the interpretation of the outcomes, due to the problem of insignificant estimates.

This study is also limited in the sense that aggregated population and employment, as opposed to households by group and businesses by sector, are modeled. As well presented in housing and migration literature, household location choice heavily depends on many demographic (e.g. household size, age, children, etc) and economic (income level, one-earner vs. two-earner households, etc) factors. A great deal of heterogeneity also exists in business location decision-making, because of the differences in production recipes, suppliers, and customers. This issue of aggregation is clearly important as some income groups have no limitations while, for lower income groups, land use regulation may generate significant impediments to re-location.

Also, the 10 year time span of this analysis may not be ideal for obtaining precise values of residential or business location mobility, although this is somewhat inevitable due to the limited availability of disaggregated-level data. Furthermore, the direction of causality has not been tested especially whether land use regulations are really responsible for the observed inclinations of highly regulated regions, such as the relatively weak intraregional population-employment connections and increasing mean commuting time.

Nevertheless, by showing some empirical analysis outcomes corresponding to the hypothesis, the present research may be able to provide land use planners or policy makers with a meaningful caution about their regulatory actions. It is probable that strict regulatory barriers make local housing markets less flexible and dampen household mobility and that may result in the reduced utility of residents and further reduced profits of businesses. Moreover, the affected intraregional population-employment interaction may generate longer commuting times, distances and costs and distort the spatial structure of the region. However, the results should not be interpreted to imply that planners' intervention in the land development process is harmful. Rather, it is a claim for more informed decision-making as well as a balanced view of the benefits and costs of land use regulations.

4. LAND USE PLANNING AS INFORMATION PRODUCTION & EXCHANGE

4.1. Introduction

Government interventions in land use planning have been traditionally justified from an economic perspective as well as by political theories and environmental rationales. In particular, welfare economic theory, combined with the demonstration of some market failures that can be traced to externalities and public goods problems, has been mainly used for the justification. As explained in the literature review, for example, Bailey (1959) noted that the welfare level of land owners can be raised by appropriate land use controls that eliminate existing negative externalities. He argued that this welfare increase is a major benefit of land use planning. Davis (1963) considered the ideal zoning restriction as a state "under which external diseconomies are simply eliminated" (p.383), so that land use becomes more economically efficient. In addition to these early studies, many others have justified government action in the form of land use planning and regulation, in a similar way – i.e. using welfare economics per se. The studies would include Gardner (1977) and Moore (1978)'s work that focus on the issue of public goods as well as Lee's (1981) article, *Land Use Planning as a Response to Market Failure*, where the regulations of the land market process are advocated. Furthermore, such claims have been supported by many empirical studies that demonstrate the virtual existence of negative externalities in the context of uncontrolled land use (see e.g. Stull 1975; Lafferty & Frech 1978: Burnell 1985) or the benefits of environmental amenities, preserved by the regulations (see e.g. Correll *et al.* 1978; Spalatro & Provencher 2001).

However, there are some critical shortcomings of the justification on the basis of welfare economic theory and the existence of typical market failures. First, because it is a static framework, the welfare economics approach has limited usefulness in dealing with land use and development issues, which are dynamic and irreversible in nature (see e.g. Ohls & Pines 1975; Arnott & Lewis 1979; Capozza & Helsley 1990). In addition, based on the government vs. market dichotomy, this approach only considers the possible benefits of land use regulation, which is just an end-product from a series of land use planning practices, in addressing market failures and, consequently, achieving a higher level of the efficiency in land allocation among various uses.[20] It neglects the other benefits of the entire land use planning process, particularly the aspect of information production and exchange. Land use planning practice produces information relevant to land use as well as facilitates the exchange of information, and consequently may reduce uncertainties and help the decision-making of various actors involved in the process of land development (Friend & Jessop 1969; Schaeffer & Hopkins 1987; Knaap *et al*. 1998). In other words, land use planning practice could bring some economic benefits, even if the final decision – that may or may not be a regulatory action – does not achieve a higher level of the efficiency in allocation.

The importance of this contribution of land use planning (i.e. information production and exchange) has been emphasized by studies that draw on transaction-cost economic (TCE) theory. For instance, as mentioned in the literature review, Alexander (1992, 1994, and 2001) claimed that land markets generally bear substantial uncertainties and unnecessary transaction costs, thus requiring government intervention which reduces those costs by providing valuable information more efficiently. Dawkins (2000) also highlighted this point by arguing that land use planning practices or regulatory interventions by government can effectively lower uncertainties as well as transaction costs involved in land development processes.

Notwithstanding these important theoretical discussions, empirical studies that validate the theoretical suppositions are scarce, so that little is known about the real-world effect of land use planning on uncertainties and transaction costs.[21] The present study attempts to fill this gap. Here, an examination is made to see whether or not land use planning actually contributes to reducing the level of uncertainty in land markets as suggested by the TCE-based claims. Rather than considering various kinds of uncertainties in multi-stage land development and land use processes, the focus will be on a particular case, namely the urban fringe land markets where farmland owners are faced with uncertainty regarding the timing of potential land development for urban uses. Based on an understanding of the strategic behavior of farmland owners under

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[20] In fact, land use planning is different from the regulatory behavior of government. As noted in chapter 2, Hopkins (2001) makes this point clear by explaining that "Regulations [are] … enforceable assignment and reassignment of rights. Regulations affect the scope of permissible actions. Plans … provide information about interdependent decisions in relation to expected outcomes but these plans do not determine directly the scope of permissible actions" (p.9-10).

[21] There are a few empirical studies which examine whether plans or information contained in the plans, as opposed to the regulatory actions, have effects on decision-making of economic agents (See e.g. Talen 1996a and 1996b; Knaap *et al.* 2001). But they do not test the validity of the TCE-based justification of land use planning.

uncertainty, the validity of the TCE-based justification is tested by conducting an exploratory spatial data analysis first followed by an MSA-level statistical analysis.

The remainder of this chapter is structured as follows. Section 4.2 briefly discusses the choice problems and decision making of farmland owners for using urban fringe areas until the uncertain time point of development and the consequences if land use planning, particularly the urban growth boundary (UGB), reduces the uncertainty as suggested by the TCE-based argument. In section 4.3, the farmland use pattern in Oregon is explored as an example to see how farmland owners may exploit or respond to the information in the UGB. Section 4.4 presents a regression analysis designed to measure the effect of the land use planning practice (i.e. UGB establishment) on uncertainty reduction, by using the data of 82 single-county MSAs across states. A concluding section, where the findings are summarized and discussed, completes the paper.

4.2. Behaviors of Farmland Owners & the Establishment of UGBs

Farmland conversion to developed land is a general trend across the states. According to the 1997 National Resources Inventory prepared by USDA Natural Resources Conservation Service (NRCS), approximately 15 million acres of cropland, pastureland, and rangeland had been developed for urban uses between 1982 and 1997 (table 4.1). In particular, the farmland at the urban fringe has been the main target of the new development.

Under this situation with a high pressure or probability of conversion, the farmland owners at the urban fringe are facing two types of important decision-making every year. The first decision to be made is a discrete choice on whether to subdivide their lots and convert them for urban uses right now or keep using the land for agricultural production at least for the current year.[22] The farmland owners, who seek to maximize their profits, may develop their land, if and only if they conclude that the conversion at this time brings a greater value in terms of the future stream of returns than all other alternatives (i.e. no conversion or conversion at all other time points),

[22] This (first) decision-making process has been discussed more intensively by many studies on land use changes, such as Bockstael (1996), Irwin & Geoghegan (2001), and Segerson *et al*. (2006).

considering the profitability of continuing agricultural production activities and the expected returns of the development in future.[23]

Table 4.1. Land Use Change between 1982 and 1997 in the United States (Unit: 1000 acres)

Land cover/use in 1982	Land cover/use in 1997								1982 total
	Cropland	CRP land	Pasture-land	Range-land	Forest land	Other rural land	Developed land	Water areas & federal land	
Cropland	350,265	30,412	19,269	3,659	5,607	3,159	7,098	1,485	420,954
Pasture-land	15,347	1,330	92,088	2,568	14,091	1,619	4,230	733	132,006
Rangeland	6,968	729	3,037	394,617	3,022	1,703	3,281	3,383	416,739
Forest land	2,037	129	4,168	2,099	380,343	1,755	10,279	2,528	403,338
Other rural land	1,387	93	1,014	719	2,768	42,713	727	228	49,648
Developed Land	197	1	79	111	227	12	72,619	1	73,246
Water areas & federal land	798	3	337	2,204	898	181	18	443,761	448,198
1997 total	376,998	32,696	119,992	405,977	406,955	51,142	98,252	452,118	1,944, 130

Source: Table 5, 1997 National Resources Inventory, USDA NRCS

The second decision-making option comes when the farmland owners do not convert their land at this time. If this is the case, a set of decisions need to be made on how to use the land without development, until the time comes for them to opt for development. In other words, they decide the items of production, the number of workers to be hired, and the level of capital investment in order to maximize the profits while using their land for the agricultural production.[24]

These decisions, particularly production item choice and capital investment, are highly affected by the farmland owners' prediction of the timing of land development in the future. Because cultivating certain items requires a longer period of operation or a larger amount of sunk costs to

[23] The assumption of farmland owners' profit maximization does not mean the homogeneity of the owners. There is a significant amount of variance by individuals in this decision making, as reported by Barnard & Butcher (1989) and many others.

[24] It is possible not to use the land for any purposes. However, since there is a considerable amount of financial advantages while using land for agricultural activity in the U.S., the owners may tend to use or pretend to use the land for agricultural production.

make an acceptable amount of profit, they are reluctant to choose those items if there is an enhanced probability of development of his/her parcels within the next few years. Also, since capital investment is generally irreversible, they are less likely to put capital in agricultural production if they think the invested capital may not be fully utilized in terms of the return on investment. In this case, they may give up the improvement of irrigation or other supporting system or use existing machinery and equipment rather than buying new ones, even if new investment is required for the optimal agricultural production from a long-term perspective.

These influences of development timing have been investigated by some studies on agricultural production, although consideration has not been given to the role of land use planning. For example, Lopez *et al.* (1988) conducted a longitudinal analysis to examine how agricultural production in New Jersey is affected by the degree of suburbanization, measured by population in nonurban counties, and found that fruit and livestock production is discouraged by suburbanization. Their analysis outcomes also suggest that agricultural production tends to become more labor intensive (i.e. declining capital and land inputs), as the region is more suburbanized.

The Farm & Ranch Irrigation Survey, conducted by the USDA National Agricultural Statistics Service (NASS), also provides some evidence of this behavioral pattern. As a part of the survey, the farmers were asked about the "barriers to making improvements to reduce energy use or conserve water". According to the survey, 5~8 percent of respondents in the entire U.S. answered "will not be farming this operation long enough to justify improvements" in response to the question, "why not invest in improvements?" (table 4.2).

Table 4.2. Farm & Ranch Irrigation Survey Outcomes: Barriers to the System Improvements

	2008 Survey		2003 Survey	
	Farms	%	Farms	%
1."Investigating improvements not a priority"	46,825	21.7%	9,055	8.0%
2. "Risk of reduced yield or poor crop quality"	18,578	8.6%	9,818	8.7%
3. "Physical field/crop condition limit system improvements"	20,888	9.7%	8,951	7.9%
4. "Improvements will not reduce costs enough to cover installation costs"	33,725	15.7%	21,304	18.8%
5. "Cannot finance improvements"	37,512	17.4%	20,122	17.7%
6. "Landlord will not share in cost"	6,815	3.2%	8,194	7.2%
7. "Uncertainty about future availability of water"	19,536	9.1%	13,790	12.2%
8. "Will not be farming this operation long enough to justify improvements"	17,280	8.0%	6,204	5.5%
9. "Other"	14,272	6.6%	15,995	14.1%
Total	215,431	100.0%	113,433	100.0%

Source: Table 41, 2008 Farm & Ranch Irrigation Survey Report
Note: Respondents are allowed to choose more than one barrier to improvement. Here, "Total" is the number of all responses, as opposed to the number of respondents.

In the real world, the farmland owners' prediction of development timing and the following decisions are made with uncertainty. Under a higher level of the uncertainty, the owners cannot predict the exact timing of land development and attach low values of confidence in their predictions. This may raise the risk of over-investment and alter the item choices and capital investment decision-making for the agricultural production: i.e. the farmland owners are less likely to grow the items with a greater amount of sunk costs and are less likely to increase or continue irreversible investment.

According to the argument of TCE-based justification of planning, these kinds of uncertainties can be reduced with relevant information, produced and exchanged through effective land use planning practices. Particularly, the uncertainty in the urban fringe land markets could be lowered by the establishment of an UGB, a widely used land use planning practice related to such fringe areas.[25] Although the practice qualitatively and administratively differs across regions (see e.g. Gale 1992; Innes 1992), through the UGB establishment processes, local and regional government bodies typically 1) conduct population projections, 2) determine the future demand

[25] In the United States, an UGB was first adopted by Lexington, Kentucky in 1958 (Nelson & Duncan 1995). As of 1998, more than a hundred regions establish UGBs (Staley et al. 1999). Furthermore, Oregon, Washington, and Tennessee enacted state-level legislation that mandates local and regional government to do this work and to incorporate the UGBs into their comprehensive plans.

of new development, 3) investigate suitable or desirable locations for new development, and then 4) draw the boundary, as a proposal (Anderson 1999). In addition, like many other planning processes, the proposed boundary is publicized and reviewed by various actors at public hearings or some other forms of public engagement where the ideas and information related to future development are exchanged. In the end, an UGB, as a final product that reveals the expected expansion of developed areas for upcoming 20 years or some other periods of time, is established.

From the perspective of farming, the UGB is not a regulation binding item choice, investment, or detailed operation. Rather, the boundary is valuable information that helps individual farmland owners obtain a better sense about the probable timing for development of their land, as characterized by Knaap (1985). In addition to the UGB itself, population projection, new development demand estimation, site investigation, and opinions of other actors at the place of collaborative planning may also inform the farmland owners, who make their own decisions looking forward.

4.3. Spatial Data Analysis

Do uncertainties exist in urban fringe land markets? Does the UGB establishment really inform farmland owners in the sense of reducing uncertainty and thus transactions costs? In this section, a data analysis will be conducted using the case of Oregon, in order to explore 1) whether or not there are any notable relationships between farmland use patterns and the established UGBs and 2) whether the demonstrable relationships suggest a real contribution of the UGB establishment practice to the uncertainty reduction.

Given that disaggregated-level investment data or other measurements representing the uncertainty level are not available, the only option is to use the farmland use pattern (i.e. what items are grown at particular location points), along with the knowledge about the characteristics of various items, such as the minimum period of operation for the profit and the required level of sunk costs for production. Although farmland use is determined by many other factors, such as physical characteristics, the farmer's capability and preferences, and so on, certain types of agricultural production, with greater time and sunk cost requirements, may be less likely to appear where land development is expected to happen soon.

4.3.1. Method & Data

The main task of this spatial analysis is to explore how the farmland use patterns vary across space. To do this, above all, the urban fringe areas of interest are divided according to the distance to the cities. This is accomplished by using the boundaries of the Census's Urbanized Area and Urban Cluster, which well represent the borders of the densely developed territories, rather than using the administrative city limits. In other words, the fringe areas are first classified into six categories: 1) between the border and 0.5 mile buffer, 2) 0.5~1.0 mile area, 3) 1.0~1.5 mile area, 4) 1.5~2.0 mile area, 5) 2.0~2.5 mile area, and 6) 2.5~3.0 mile area. Although this way of space division is useful for capturing the relationship between the farmland use pattern and the proximity to the cities that had been well discussed in the land use analysis of von Thunen (1826), the buffer width (i.e. 0.5 mile) may be too large to consider the uncertainty and thus the full impact of the UGB. Therefore, the first category (i.e. between the border and 0.5 mile buffer) is sub-divided to 0.1 mile buffer zones: i.e. 1-a) between the borders and 0.1 mile buffers, 1-b) 0.1~0.2 mile area, 1-c) 0.2~0.3 mile area, 1-d) 0.3~0.4mile area, and 1-e) 0.4~0.5 mile area (figure 4.1). Then, the zones are further classified by overlaying the UGBs. As a result, the areas Within vs. Out of the UGBs are differentiated, even though the areas have the same distance to the cities. Finally, by using the Tabulate Area function in ArcGIS as well as high-resolution land use data, the farmland use patterns in each type of zones are measured in terms of the land use mix.

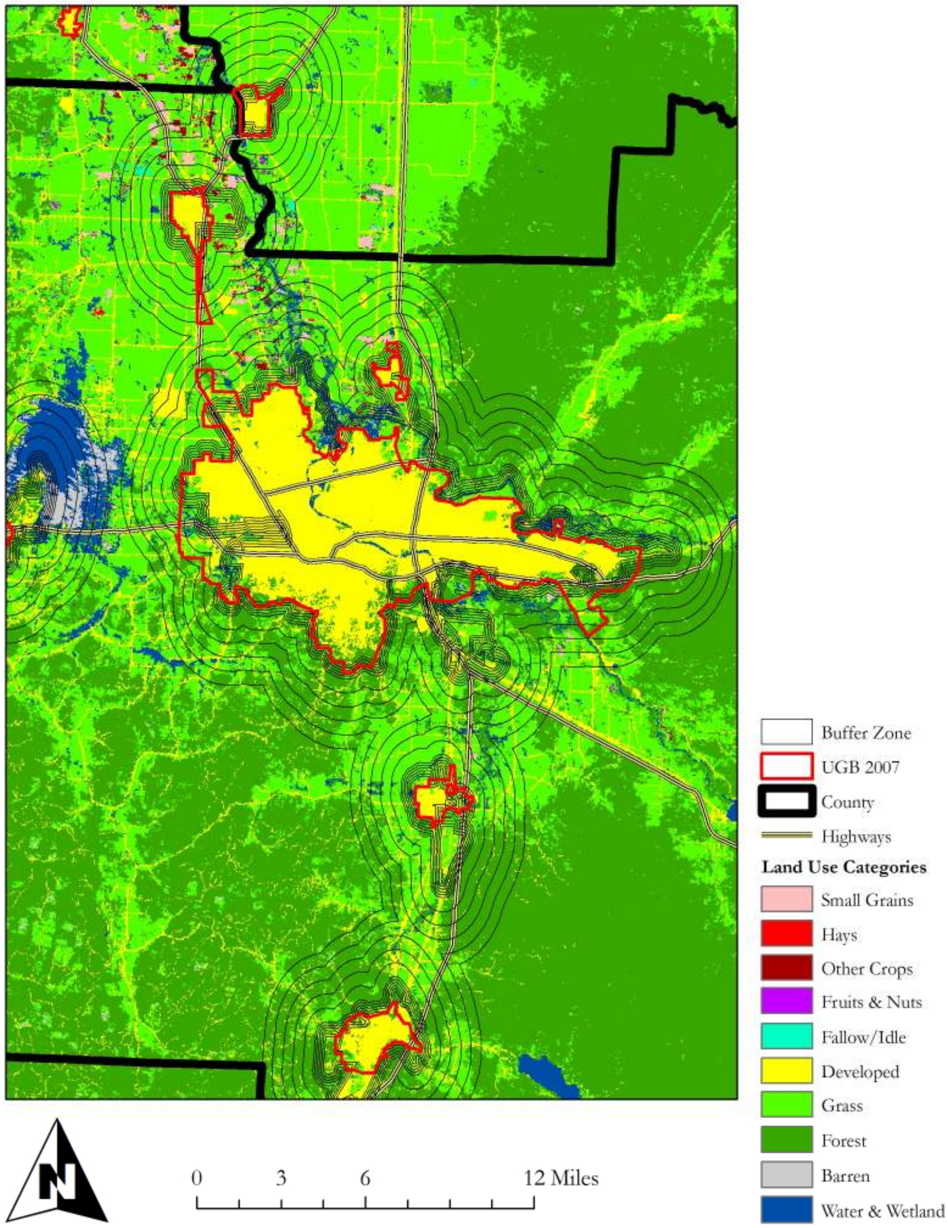


Figure 4.1. Space Division and Land Uses: The Case of Eugene-Springfield MSA (Lane County, OR)

This method of analysis is applied to the state of Oregon where the UGBs have long been implemented. The availability of GIS data for the analysis is another reason of the choice. The Oregon Geospatial Enterprise Office provides the UGB shapefiles for recent years; 2007 version is used for this analysis. For the land use information, the 2007 Cropland Data Layer (CDL) for Oregon made by USDA NASS is employed. Because the original CDL adopts a very detailed land use type classification, the uses are aggregated into 10 categories for the analysis, as presented in figure 4.1. For the boundaries of Census's Urbanized Area and Urban Cluster, the Census TIGER (Topologically Integrated Geographic Encoding and Referencing) data are employed.

4.3.2. Analysis Outcomes

Table 4.3 shows how the land use mixes differ across 0.5-mile buffer zones from the urbanized area borders in Oregon. Also, the varying farmland patterns are graphically demonstrated in figure 2, where each item's share of the sum of all croplands is plotted over the distance to the cities.

The general trends of farmland use across space are well revealed here. Small grains, such as corn, rice, and wheat, are more likely to be grown, as the distance to the cities goes up. In contrast, consistent with our intuition based the lessons from von Thunen, tree fruits and nuts as well as potatoes, onions, peas, etc, bearing larger per distance transportation costs, tend to be grown more in the areas with higher accessibility to the cities. The pattern of Fallow/Idle Cropland (i.e. declining share over distance) is interesting. One possible explanation could be traced to the farmland owner's strategic behavior, that is they are less likely to improve the soil quality by letting their land lie fallow near city edges, because they feel that the land will be developed soon, so that agricultural production will not continue long enough.[26]

[26] Alternatively, this may happen, because this type of land use (i.e. Fallow / Idle Cropland) is highly associated with small grains, showing the same declining pattern over distance, rather than other items.

Table 4.3. Land Use Patterns by 0.5-Mile Buffer Zones in Oregon

	Borders ~0.5mile	0.5~1.0 mile	1.0~1.5 mile	1.5~2.0 mile	2.0~2.5 mile	2.5~3.0 mile
<u>Percentage to total</u>						
Small grains, including corn, rice, barley, wheat, etc	1.7%	2.4%	2.6%	2.7%	2.7%	2.8%
Hays, including rye, oats, canola, etc	1.2%	1.5%	1.7%	1.7%	1.8%	1.6%
Other crops, including potatoes, onions, peas, etc	1.6%	2.0%	1.7%	1.7%	1.9%	1.6%
Tree fruits and tree nuts	0.6%	0.6%	0.7%	0.6%	0.5%	0.5%
Fallow/Idle cropland	0.4%	0.5%	0.6%	0.8%	0.7%	0.8%
Developed	21.0%	12.2%	10.2%	9.1%	8.4%	7.4%
Grassland, including seed/sod grass, herbs, clover/wildflowers, etc	28.2%	30.2%	29.8%	28.7%	28.1%	27.2%
Forest, woodland, and shrubland	32.4%	40.4%	43.3%	46.7%	49.2%	51.8%
Barren	0.9%	0.9%	0.9%	0.8%	0.7%	0.8%
Water and wetlands	12.0%	9.2%	8.4%	7.2%	6.1%	5.6%
<u>Percentage to the sum of croplands</u>						
Small grains, including corn, rice, barley, wheat, etc	30.8%	34.0%	35.3%	36.0%	35.7%	38.2%
Hays, including rye, oats, canola, etc	21.7%	21.5%	23.7%	22.8%	23.4%	21.5%
Other crops, including potatoes, onions, peas, etc	30.0%	27.9%	23.6%	23.0%	24.6%	22.3%
Tree fruits and tree nuts	10.9%	8.9%	9.2%	8.2%	6.3%	6.2%
Fallow/Idle cropland	6.6%	7.7%	8.1%	10.0%	10.0%	11.7%

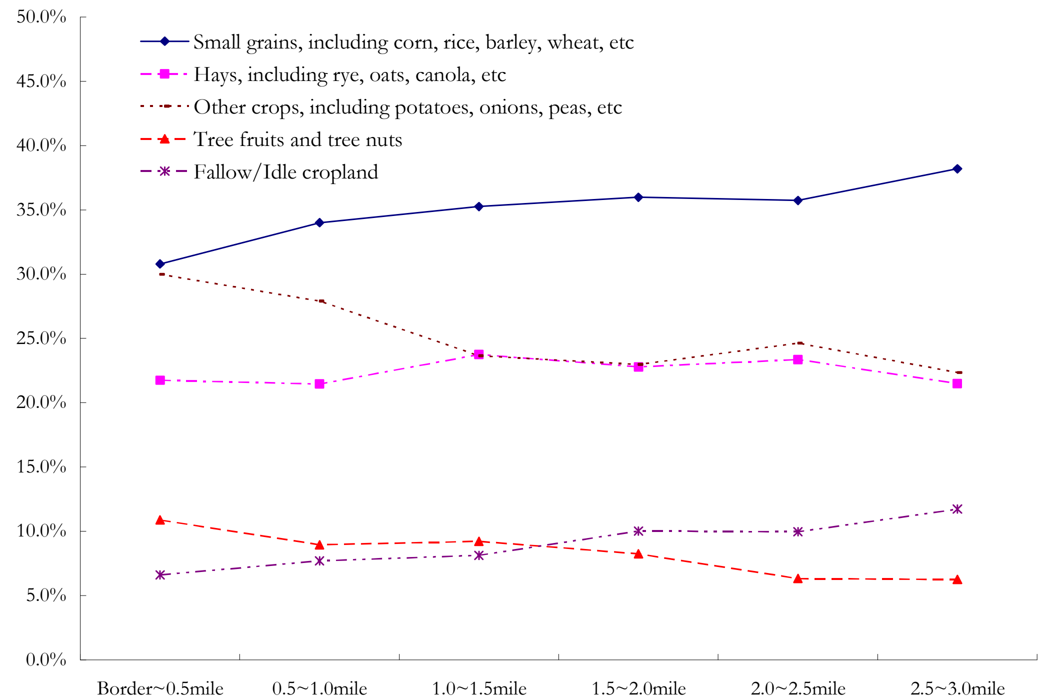


Figure 4.2. Farmland Use Patterns in Oregon's Urban Fringe Areas

The farmland land use patterns within the 0.5 mile buffer, where a higher level of uncertainty may exist, are investigated in detail by using the 0.1 mile buffer zones and UGBs. Table 4.4 presents the patterns over distance with respect to UGBs in terms of percentage to the sum of croplands.

Above all, attention needs to be paid to the pattern of tree fruits and tree nuts. As found in the previous analysis, generally this item is more likely to occupy the areas close to the cities. However, since it bears a larger amount of sunk costs, thereby profitable when the operation continues for a certain period of time, the item may be less likely to appear where development is expected to occur in few years or development timing is very uncertain. If the UGBs really inform the farmland owners and help their decision-making as argued by the TCE-based justification of land use planning practices, we will find the distinct difference in this land use type between Within-UGBs zones and Out-of-UGBs zones, although the difference does not necessarily mean the TCE-based argument is valid.

Table 4.4. Land Use Patterns within 0.5-Mile Buffer in Oregon

	Borders ~0.1mile	0.1~0.2 mile	0.2~0.3 mile	0.3~0.4 mile	0.4~0.5 mile
Percentage to the sum of croplands (Within UGBs)					
Small grains, including corn, rice, barley, wheat, etc	23.8%	27.8%	36.4%	37.9%	43.7%
Hays, including rye, oats, canola, etc	20.6%	17.7%	16.1%	14.4%	11.7%
Other crops, including potatoes, onions, peas, etc	37.5%	35.0%	32.1%	31.9%	29.5%
Tree fruits and tree nuts	9.1%	9.9%	7.6%	7.3%	6.1%
Fallow/Idle cropland	9.1%	9.5%	7.9%	8.5%	9.0%
Percentage to the sum of croplands (Out of UGBs)					
Small grains, including corn, rice, barley, wheat, etc	28.3%	28.8%	30.1%	30.7%	32.9%
Hays, including rye, oats, canola, etc	19.8%	22.3%	23.7%	23.3%	22.4%
Other crops, including potatoes, onions, peas, etc	30.9%	30.3%	30.0%	29.6%	27.3%
Tree fruits and tree nuts	14.3%	12.3%	10.6%	10.5%	10.5%
Fallow/Idle cropland	6.8%	6.2%	5.7%	5.9%	6.8%

It needs to be noted that the item choice in reality is path-dependent, thus more complicated than the description here. Suppose a farmland owner who has grown tree fruits in his land a long time before the emergence of development pressure. Because the trees and other structures for the operation are sunk costs, he may continue to cultivate the fruits rather than changing the item with a certain (probably low) level of investment in maintenance, even if his land will be developed soon. This results in the production of the tree fruits in the farms with high development probability or uncertainty, in contrast to the noted expectation. However, new fruit production may be less likely to locate in these farms. It may tend to go to the sites where the need for accessibility and the required operation period for profits are satisfied. If an UGB functions as anticipated, it provides valuable information for this site selection. As a result, the fruit items will be more likely to appear out of UGB, *ceteris paribus*.

The outcomes of the detailed investigation suggest this is the case. It is apparent that tree fruits and tree nuts is much important in the farmlands outside of the UGBs (table 4.4 and figure 4.3).

One could interpret this finding as one that can be traced to the uncertainty reduction effect of UGB establishment: i.e., setting UGBs makes it more probable that large acres of farmland outside of the UGBs are not going to be developed soon even though they are close to city edges, so that the farmland owners do not need to give up the option of tree fruits and tree nuts. This results in a more efficient use of land.

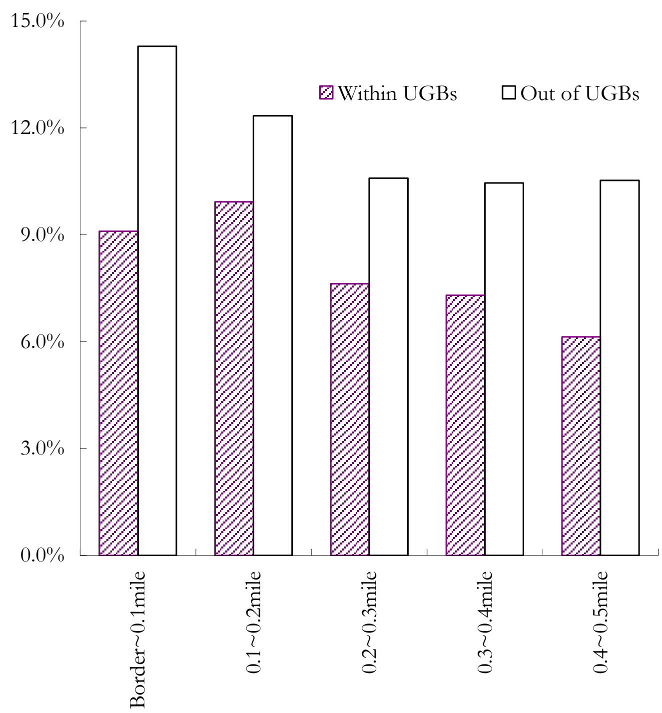


Figure 4.3. The Land Use Share of Tree Fruits and Tree Nuts in Oregon

The case of Fallow/Idle cropland also needs to be noted. According to the analysis outcomes, this type of land use tends to appear within UGBs more (figure 4.4). More specifically, the share of Fallow/Idle cropland within UGBs exceeds its value at 1.5 miles from the cities. At first glance, this seems counter-intuitive. Why do the farmland owners tend to let their farmlands lie fallow, even though the areas are included in UGBs that indicates development in near future? This cannot be explained if the soil quality improvements were the only motivation of this type of land use. To elucidate this, consideration may need to be given to the possibility of farmland owners not growing anything in their farmlands while waiting development, so that the land use is recognized as Fallow/Idle cropland. If this is the case, it can be argued that a larger part of the urban fringe lands (i.e. the areas outside of the UGBs) is more intensively used as a direct consequence of the establishment of the UGB that informs the farmland owners that their parcels are not going to be developed soon.

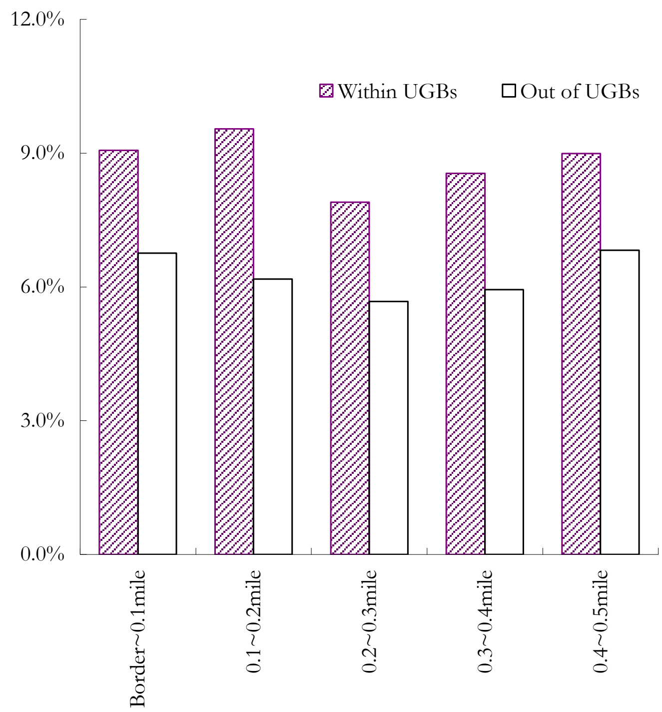


Figure 4.4. The Land Use Share of Fallow / Idle Cropland in Oregon

4.4. Regression Analysis

The previous section explored the UGB's effect in the urban fringe land markets by using high-resolution land use data. In this section, an examination will be made of the possible contribution of UGB establishment to uncertainty reduction and to derive a more generalized conclusion on the validity of TCE-based justification of land use planning practice by conducting a statistical analysis with single-county MSAs as units of analysis. The idea, explained in section 4.2, is that the farmland owners may tend to increase the value of investments if the level of the uncertainty associated with the timing of development of their farmlands is reduced, as they would then be faced with a lower risk metric with respect to wasting irreversible investments. In other words, the value of investments may to some extent represent the uncertainty level. If the UGB establishment really reduces the uncertainty consistent with TCE-based arguments, then there should be a positive effect of UGBs on agricultural investment when other factors are properly controlled.

4.4.1. Model

For the simplicity, suppose that the agricultural production exhibits constant returns to scale with a Cobb-Douglas form.

$$X = \phi \cdot S^{\alpha} \cdot K^{\beta} \cdot L^{\gamma} \quad (4\text{-}1) \qquad \alpha + \beta + \gamma = 1$$

where X is the output of agricultural production, S is land input, K is capital investment, and L is labor force for the production. Coefficient ϕ is the technology parameter, which represents the efficiency level in production. α, β, and γ are cost share parameters for land, capital, and labor force, respectively.

In this setting, the optimal levels of land and capital input, that minimizes the production cost for a certain amount of production, are

$$S^{*} = \frac{\alpha \cdot p \cdot X}{p_S} \quad (4\text{-}2) \qquad\qquad K^{*} = \frac{\beta \cdot p \cdot X}{p_K} \quad (4\text{-}3)$$

where p, p_S, and p_K are the price of final farm product, land, and capital, respectively.

From the equation (4-2) and (4-3), the optimal level of per acre capital investment can be derived, as below.

$$\left(\frac{K}{S}\right)^{*} = \frac{K^{*}}{S^{*}} = \frac{\beta \cdot p \cdot X / p_K}{\alpha \cdot p \cdot X / p_S} = \frac{\beta \cdot p_S}{\alpha \cdot p_K} \quad (4\text{-}4)$$

Then, by taking log on both sides of the equation (4-4), a linear form, which is a basis of the model making, can be obtained.

$$\log\left(K/S\right)^{*} = \log(p_S) - \log(p_K) - \log(\alpha) + \log(\beta) \quad (4\text{-}5)$$

The equation (4-5) implies that per acre capital investment is a function of land price (p_S), capital price (p_K), and the two cost share parameters (α and β), in the assumed situation of agricultural production. Among the four determinants in this equation, land price is the most important factor to explain the level of per acre capital investment in an empirical analysis using cross sectional data like this study, since it varies significantly across regions. The two cost share parameters, representing the character of agricultural production, are also influential ones. Because these parameters are item- and region-specific, this study tries to capture the influence of these factors on per acre capital investment by including additional explanatory variables, such as individual items' shares in terms of sales and the regional control dummies. Unlike land price and the two cost share parameters, capital price is assumed to be a constant, since its variance across regions in the U.S. is not available.

In addition to the above variables, several more factors should be included to precisely explain the real per acre capital investment and correctly examine the effect of UGB establishment practice on investment level. Since the farmland owners are able to adjust the level of capital investment responding to the relative prices of other inputs (i.e. they can substitute capital with other inputs and vice versa) for the cost minimization as well, here, the price of labor (i.e. wage level of hired farm labor), which varies by region most significantly, is included in the list of the independent variables. Also, because the economies of scale may exist in the real agricultural production and supporting industries, total acre of farmland in each single-county MSA is included as an explanatory variable in the model.[27]

Moreover, as noted, the actual level of per acre capital investment may be determined by the probable development timing of individual farmland properties and uncertainty level. As a MSA is growing more rapidly, a larger share of farmland is expected to be developed soon with a higher uncertainty level. Therefore, in this model, the population growth rate is used to reflect the influences of the development timing and uncertainty. Finally and the most importantly, a dummy variable, representing whether a region has established an UGB or not, is included in the

[27] This is relevant to the "critical mass", suggested and investigated by many studies on agricultural sector and farmland loss, such as Dhillon & Derr (1974) and Lynch & Carpenter (2003). Because the level of critical mass threshold is uncertain and may not constant across state, total acre of farmland in each county, as opposed to a dummy variable based on a threshold, is used in the estimation.

model to examine the effectiveness of such land use planning work in reducing the uncertainty. As noted in following sections, interactive dummy variables, derived by multiplying the UGB dummy and other item-related dummies, are also used, because the UGB's effect on investment may significantly depend on what items (i.e. one requiring large sunk costs vs. the others) are mainly cultivated.

4.4.2. Samples & Data

To conduct an empirical analysis using the model presented above, this study selects the single-county metropolitan statistical areas (MSAs) in the U.S. with year 2000 population ranging between 100,000 and 500,000, except for Anchorage MSA, Alaska (see table 4.5 and figure 4.5).[28] Here, the MSAs that consist of multiple counties or county equivalent areas, are excluded to measure the presence of the UGB establishment practice more accurately.[29] Also, by limiting the range of population, this sample selection tries to use a set of homogeneous MSAs in size and, eventually, to minimize the possible unexpected variances and disturbance.

Table 4.5. List of the Samples

No	MSA	State	County	Pop in 2000
1	Lakeland--Winter Haven	FL	Polk County	483,924
2	Melbourne--Titusville--Palm Bay	FL	Brevard County	476,230
3	Lancaster	PA	Lancaster County	470,658
4	Modesto	CA	Stanislaus County	446,997
5	Fort Myers--Cape Coral	FL	Lee County	440,888
6	Madison	WI	Dane County	426,526
7	Spokane	WA	Spokane County	417,939
8	Salinas	CA	Monterey County	401,762
9	Santa Barbara--Santa Maria--Lompoc	CA	Santa Barbara County	399,347
10	York	PA	York County	381,751
11	Reading	PA	Berks County	373,638
12	Provo--Orem	UT	Utah County	368,536

[28] The geographical delineation of the MSAs follows 1999 definition of U.S. Office of Management and Budget, which is used for Census 2000, found at http://www.census.gov/population/estimates/metro-city/99mfips.txt.
[29] Since an UGB is usually established by municipalities or counties, the identification of the UGB practice for such MSAs consisting of a number of counties and municipalities is more likely to generate a larger error than the single-county MSAs.

Table 4.5 (cont.)

No	MSA	State	County	Pop in 2000
13	Visalia--Tulare--Porterville	CA	Tulare County	368,021
14	Reno	NV	Washoe County	339,486
15	Brownsville--Harlingen--San Benito	TX	Cameron County	335,227
16	Eugene--Springfield	OR	Lane County	322,959
17	Fayetteville	NC	Cumberland County	302,963
18	Erie	PA	Erie County	280,843
19	South Bend	IN	St. Joseph County	265,559
20	Ocala	FL	Marion County	258,916
21	Fort Collins--Loveland	CO	Larimer County	251,494
22	Naples	FL	Collier County	251,377
23	Lincoln	NE	Lancaster County	250,291
24	San Luis Obispo--Atascadero--Paso Robles	CA	San Luis Obispo County	246,681
25	Lubbock	TX	Lubbock County	242,628
26	Green Bay	WI	Brown County	226,778
27	Yakima	WA	Yakima County	222,581
28	Gainesville	FL	Alachua County	217,955
29	Waco	TX	McLennan County	213,517
30	Merced	CA	Merced County	210,554
31	Chico--Paradise	CA	Butte County	203,171
32	Myrtle Beach	SC	Horry County	196,629
33	Laredo	TX	Webb County	193,117
34	Cedar Rapids	IA	Linn County	191,701
35	Lake Charles	LA	Calcasieu Parish	183,577
36	Elkhart--Goshen	IN	Elkhart County	182,791
37	Medford--Ashland	OR	Jackson County	181,269
38	Champaign--Urbana	IL	Champaign County	179,669
39	Tyler	TX	Smith County	174,706
40	Las Cruces	NM	Dona Ana County	174,682
41	Fort Walton Beach	FL	Okaloosa County	170,498
42	Topeka	KS	Shawnee County	169,871
43	Bellingham	WA	Whatcom County	166,814
44	Tuscaloosa	AL	Tuscaloosa County	164,875
45	Redding	CA	Shasta County	163,256
46	Benton Harbor	MI	Berrien County	162,453
47	Yuma	AZ	Yuma County	160,026
48	Jackson	MI	Jackson County	158,422
49	Bryan--College Station	TX	Brazos County	152,415

Table 4.5 (cont.)

No	MSA	State	County	Pop in 2000
50	Janesville--Beloit	WI	Rock County	152,307
51	Bloomington--Normal	IL	McLean County	150,433
52	Jacksonville	NC	Onslow County	150,355
53	Panama City	FL	Bay County	148,217
54	Monroe	LA	Ouachita	147,250
55	Punta Gorda	FL	Charlotte County	141,627
56	Pueblo	CO	Pueblo County	141,472
57	Jamestown	NY	Chautauqua County	139,750
58	Columbia	MO	Boone County	135,454
59	Greenville	NC	Pitt County	133,798
60	Billings	MT	Yellowstone County	129,352
61	Altoona	PA	Blair County	129,144
62	Waterloo--Cedar Falls	IA	Black Hawk County	128,012
63	Dover	DE	Kent County	126,697
64	Abilene	TX	Taylor County	126,555
65	Alexandria	LA	Rapides Parish	126,337
66	Wausau	WI	Marathon County	125,834
67	Florence	SC	Florence County	125,761
68	Rochester	MN	Olmsted County	124,277
69	Bloomington	IN	Monroe County	120,563
70	Sharon	PA	Mercer County	120,293
71	Muncie	IN	Delaware County	118,769
72	Grand Junction	CO	Mesa County	116,255
73	Auburn--Opelika	AL	Lee County	115,092
74	Lawton	OK	Comanche County	114,996
75	Decatur	IL	Macon County	114,706
76	Goldsboro	NC	Wayne County	113,329
77	Sheboygan	WI	Sheboygan County	112,646
78	Iowa City	IA	Johnson County	111,006
79	Sherman--Denison	TX	Grayson County	110,595
80	Sumter	SC	Sumter County	104,646
81	San Angelo	TX	Tom Green County	104,010
82	Gadsden	AL	Etowah County	103,459

Note: “Pop in 2000” is each MSA’s population by Summary File 1, Census 2000, U.S. Census Bureau.

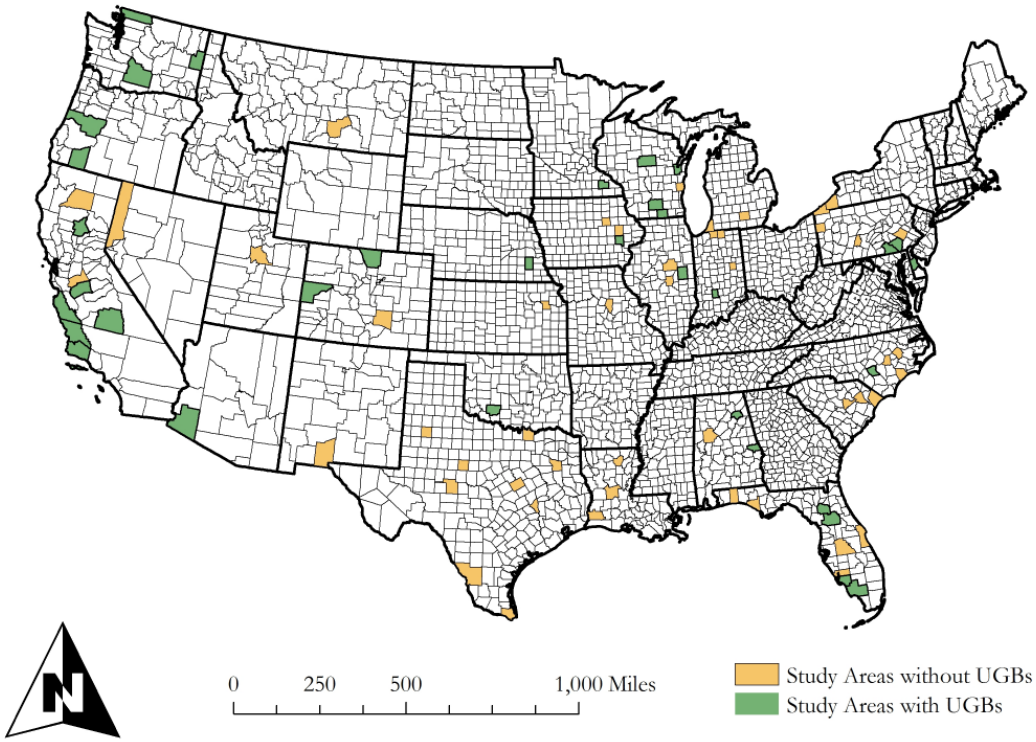


Figure 4.5. Study Areas: 82 Single-County MSAs in the U.S.

The necessary agricultural and economic data are derived from the National Agricultural Statistics Service (NASS), U.S. Department of Agriculture (USDA), namely 2002 Census of Agriculture data, and Regional Economic Information System (REIS), U.S. Bureau of Economic Analysis (BEA). In addition, the presence of an UGB in each MSA is identified by not only reviewing other surveys, particularly Burby *et al*. (2001), but also modifying the surveys' results through an investigation on the official web-sites of the municipalities and counties for each individual MSA. Table 4.6 lists the measurements for both dependent and independent variables and the data sources for the measurements. In table 4.7, the statistics of the collected input data for the 82 MSAs are summarized.

Table 4.6. Measurements & Data Sources

Variable	Measurement	Data Sources
Dependent Variable		
Log of per acre capital investment	*LPACI = log [(Value of machinery and equipment in 2002) / (Land in Farm in 2002)]*	NASS, USDA
Independent Variables		
Log of land price	*LLP = log [(Estimated market value of land and buildings in 2002) / (Land in Farm in 2002)]*	NASS, USDA
Log of labor force price	*LLFP = log [(Hired Farm Labor Expenses in 2002) / (Number of Non-proprietors Employment in 2002)]*	REIS, BEA
Total acre of farmland	*TAF = Land in Farms in 2002*	NASC, USDA
Share of fruits, tree nuts, and berries in terms of sales [1]	*SFTB = (Sales of Fruits, Tree Nuts, and Berries in 2002) / (Total Sales in 2002)*	NASS, USDA
Share of the crops (except fruits, tree nuts, and berries) in terms of sales	*SNFC = (Sales of Crops except Fruits, Tree Nuts, and Berries in 2002) /(Total Sales in 2002)*	NASS, USDA
Dummy for the regions showing high shares of non-fruit crop production [2]	*If the MSA's SNFC > 0.4, HSNFC1 =1* *Otherwise, HSNFC = 0*	NASS, USDA
Dummy for the regions showing low shares of non-fruit crop production [2]	*If the MSA's SNFC =< 0.4, LSNFC1 =1* *Otherwise, LSNFC = 0*	NASS, USDA
Regional control dummies for Midwest, South, & West	*If the MSA is in the Census Region, MIDWEST, SOUTH, or WEST = 1; Otherwise, MIDWEST, SOUTH, or WEST = 0*	U.S. Census Bureau
Population growth rate	*PGR = [(Pop in 2001) – (Pop in 1991)] / (Pop in 1991)*	REIS, BEA
Presence of the UGB establishment practice	*If the MSA has the UGB establishment practice, UGB=1* *Otherwise, UGB=0*	Anderson (1999) GOP&R (1999) Burby *et al*. (2001)

[1] The data of Sales of Fruits, Tree Nuts, and Berries in 2002 for some MSAs are suppressed. In these cases, the suppressed values are estimated using 1997 data for the MSAs or state-level data.
[2] *HSNFC* and *LSNFC* are multiplied by *UGB* and used as interactive terms, in order to capture the potential difference in UGB's effect under different contexts. It is expected that the UGB effect may be greater in the regions having relatively lower *SNFC* (i.e. where NSNFC = 1) thereby having relatively larger shares of live stocks or fruit production which require greater amount of irreversible investments.

Table 4.7. Statistics of the Input-data

Variable	Description	Mean	Variance	Min	Max
LPACI	Log of per acre capital investment	-1.424	0.531	-4.704	0.001
LLP	Log of land price	0.827	0.309	-0.798	2.060
LLFP	Log of labor force price	3.428	0.151	2.410	4.615
TAF	Total acre of farmland	411,883	1.510E+11	10,863	2,042,680
SFTP	Share of fruits, tree nuts, and berries in terms of sales	0.104	0.029	0.0003	0.764
SNFC	Share of crops, except fruits, tree nuts, and berries	0.403	0.058	0.947	0.038
HSNFC	Dummy for the regions with higher *SNFC*	Number of samples with 1 = 39			
LSNFC	Dummy for the regions with lower *SNFC*	Number of samples with 1 = 43			
MIDWEST	Regional control dummy for Midwest	Number of samples with 1 = 21			
SOUTH	Regional control dummy for South	Number of samples with 1 = 33			
WEST	Regional control dummy for West	Number of samples with 1 = 21			
PGR	Population growth rate	0.143	0.015	-0.040	0.613
UGB	Presence of the UGB establishment practice	Number of samples with 1 = 34			

From the estimation, it is anticipated to have the positive estimated coefficients for log of land price (*LLP*), as presented in the model: equation (4-5), because the farmland owners may use expensive land more intensively by making a greater amount of investment per area. A positive coefficient is also expected for log of labor force price (*LLFP*), since the farmland owners' dependence on capital will increase as the price of labor force, which can substitute for capital or be substituted by capital to some extent, goes up. In contrast, the coefficients for the Share of fruits, tree nuts, and berries (*SFTP*) and Total acre of farmland (*TAF*) may show negative signs, due to the high labor-intensity (i.e. relatively low dependence on capital) of the production of *FTP* items and the benefit of the scale effect in saving expenditures, respectively. The expected sign for population growth rate (*PGR*) is negative, which implies that a larger share of total farmland is under the situation of being developed soon with a higher level of uncertainty, so that investment level may be generally low in a more rapidly growing MSA. Finally, for the *UGB* dummy variable, a positive coefficient will be found, if the establishment of UGB really reduces uncertainty, consistent with the TCE-based justification of land use planning.

4.4.3. Analysis Outcomes

Using the data of the 82 MSAs, the models with different settings are estimated by employing the ordinary least square regression method. Table 4.8 presents the estimation outcomes of two model types showing the highest R-squared. In the first one, *UGB*, the dummy variable of interest, is included as it stands, whereas the second model uses the interactive dummy variables, derived by multiplying it by HSNFC and LSNFC, to capture the UGB effects in the relatively higher- and lower-crop-share MSAs separately.

Table 4.8. Estimation Outcomes of the Regression Analysis

Variable	Description	Model 1	Model 2
C	Intercept	-2.221 ****	-2.265 ****
LLP	Log of land price	0.771 ****	0.762 ****
LLFP	Log of labor force price	0.218 *	0.226 *
TAF	Total acre of farmland	-0.510E-06 ****	-0.510E-06 ****
SFTP	Share of fruits, tree nuts, and berries to total sales	-0.552 **	-0.520 *
MIDWEST	Regional control dummy for Midwest	-0.170	-0.131
SOUTH	Regional control dummy for South	-0.229	-0.212
WEST	Regional control dummy for West	-0.159	-0.165
PGR	Population growth rate	-1.434 ****	-1.411 ****
UGB	Presence of the UGB establishment practice	0.150	-
UGB HSNFC*	UGB in the regions with higher crop shares	-	0.045
UGB LSNFC*	UGB in the regions with lower crop shares	-	0.233 **
R-squared | Adjusted R-squared		0.764 | 0.734	0.770 | 0.738

Note: **** 0.1% level | *** 1% level | ** 5% level of significance | * 10% level of significance.

The overall models' explanatory powers seem moderately high, considering the adjusted R-squared, 0.734 and 0.738. Most control variables, except the three regional control dummies (*MIDWEST, SOUTH,* and *WEST*), show high-level statistical significances as well as the expected signs in both models. More specifically, the positive estimated coefficients are found for log of land price (*LLP*), which indicates the farmland owners' extensive use of expensive land. The positive sign of the estimated coefficients for log of labor force price (*LLFP*) is also the expected finding, because of the substitution effect between labor and capital as explained above. The negative coefficients of Share of fruits, tree nuts, and berries (*SFTP*) and Total acre of farmland (*TAF*) also correspond to the intuition noted above: i.e. the *FTP* items' labor-intensive character and the economies of scale in agricultural production and supporting activities.

Population growth rate (*PGR*), that is included in the model to capture the influences of development timing and uncertainty level, also exhibits the expected sign with 0.1% level of significance in both models. The negative sign of *PGR*'s estimated outcome may suggest that rapid (mostly urban) population growth increases the area of farmlands under the situation of being developed soon with a higher level of uncertainty and, consequently, has a negative effect on the average per acre investment level in the region.

Of considerable interest are the estimated coefficients of Presence of the UGB establishment practice (*UGB*) in the first model and the UGB-based interactive dummy variables in the second one. In both models, the signs of these experimental variables' coefficient are positive which indicate that the MSAs having an established UGB are more likely to have a higher level of per acre capital investment. As discussed above, this outcome of the regression analysis may suggest that the UGB establishment practice actually reduces the uncertainty regarding development timing of the farmlands at urban fringe and thus increases the per acre capital investment in the area.

It should be stressed that only *UGB* LSNFC* in the second model shows a statistically significant (5%-level) estimation outcome. On the one hand, this implies that the UGB establishment has a strong effect on per acre capital investment in the MSAs having larger shares of live stock and fruit production that require greater amount of sunk costs as well as a longer period of operation for profits to be realized, in contrast to crop production. More specifically, the magnitude of the coefficient, 0.233, indicates that the UGB establishment raises the per acre capital investment by about $55.1 [$2.1~$233.1], which is approximately $22.7 million in a medium size single-county MSA (figure 4.6).[30] On the other hand, the result suggests that the UGB's effect is weak or neglectable in the MSAs where crop production is dominant. However, this may not mean that the UGB establishment contributes to uncertainty reduction only in the limited number of regions. Rather, it may imply that the per capita investment is not much dependent on the level of

[30] The unit of *PACI* in this study is $1000/acre. Therefore, the 0.0551 increase in *PACI* is interpreted as $55.1 additional investment per acre.

uncertainty in the crop-oriented areas, because generally a larger amount of sunk costs or a longer period of operation is not necessary for profitable crop production. For example, certain types of crop production can continue right before the physical development begins.

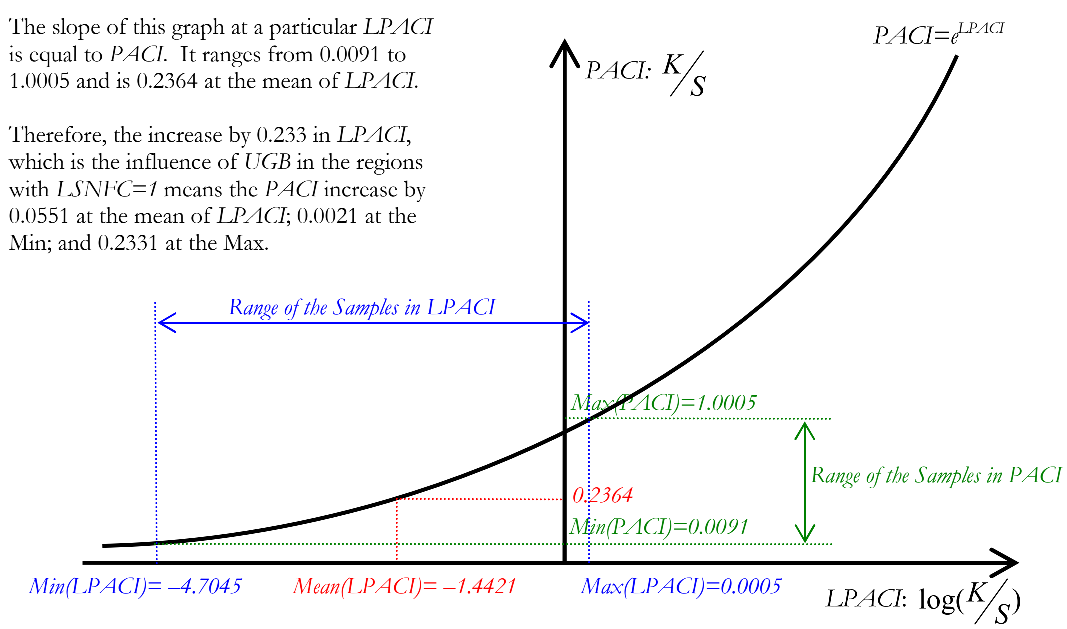


Figure 4.6. Interpretation of the Magnitude of UGB's Estimated Coefficient

4.5. Conclusion

The present study attempts to test the empirical validity of the TCE-based justification of land use planning. More specifically, this study examines whether or not the establishment of an UGB supports the farmland owners' informed decision-making and eventually contributes to a more efficient use of land by reducing the level of uncertainty regarding the timing of potential farmland development in the urban fringe land markets. Testing this proposition was accomplished by conducting an explanatory analysis of high-resolution farmland use data in Oregon as well as a statistical analysis using 82 single-county MSAs' data with a log-linear regression model.

Through the exploration of farmland use data in Oregon, the results revealed that:

1) Tree fruits and tree nuts, which generally require a larger amount of sunk costs and a longer period of operation for the profits, is more likely to be grown outside of UGBs rather than within UGBs, even if the distance to the cities is controlled. This may suggest that the farmland owners exploit the information contained in UGB plans in their decision-making, become more certain about the timing of potential land development, and enjoy a wider range of item choice options if their land is not included in the growth boundaries (i.e. information is available that the area will not be developed soon.)
2) Fallow/Idle cropland, which may indicate inactive use of farmland while waiting development rather than soil quality improvements for a long-term agricultural purpose in this case, is less likely to appear outside of UGBs, compared to the areas within UGBs. This may also be evidence of the UGB's effect on uncertainty reduction, thereby offering support for the TCE-based arguments. In other words, the UGB establishment informs many farmland owners (having the areas out of the UGBs) that their parcels are not going to be developed soon and, consequently, induces a more intensive and efficient use of land.

According to the MSA-level statistical analysis, regressing available independent variables on log of per acre capital investment (*LPACI*),

1) For Population growth rate (*PGR*), negative estimated coefficients are obtained with a very high level (0.1%) of statistical significance. This may imply that the farmland owners' decision making is indeed a strategic choice looking forward and that the uncertainty, which could be represented by the variable, exists, as argued by TCE-based justification of land use planning practice.
2) For the variable indicating the Presence of an UGB (*UGB*), positive coefficients were found that suggest that the UGB establishment reduces the uncertainty and further facilitates capital investment for agricultural production. However, the estimated coefficient is statistically significant (5%-level), only in the MSAs having relatively larger shares of livestock and fruit production, as opposed to crops; these activities generally require a greater amount of sunk costs as well as a longer operation period to be profitable. The insignificance of the estimates for other MSAs may need to be

explained by the weak connection between the uncertainty and capital investment, rather than no or weaker UGB's effect on uncertainty reduction.

Overall, this study empirically validates the TCE-based justification of land use planning. It is suggested that uncertainties exist in land markets and prevent economically efficient use of land. Furthermore, land use planning practice may help land-owners make better land use-related decisions by proving the relevant information and reducing the level of uncertainties. In this sense, governments' involvement in land use and development may be warranted, because of the higher efficiency of information production and exchange, beyond the appropriateness of regulatory actions.

Finally, it should be emphasized that this contribution of land use planning may not be trivial. The UGB's effect on agricultural investment estimated in this study (i.e. 22.7 million dollars in the case of a medium size single-county MSA) may turn out to be a very small portion of the full potential contribution. Land use planning practice may inform not only the farmland owners in urban fringe areas but also land developers in this particular situation. More generally, a larger amount of benefits may arise in urban areas where various kinds of uncertainties along with dramatic internal changes exist, which in turn causes a greater amount of transaction costs and a greater demand for the systematic management of land use.

5. THE MACROECONOMIC EFFECTS OF REACTIVE SUBURBAN LAND USE REGULATIONS: A SIMULATION STUDY USING A SPATIAL REIM

5.1. Introduction

As summarized in the literature review, the performance of a regional economy is likely to be influenced by interventions in land development, which significantly affect its property and labor markets as well as overall spatial structure. It seems that this issue, namely the macroeconomic effects of land use regulations, has attracted a great deal of attention by planning academics and the planning profession as a whole. Recently, even a greater deal of attention is paid to the issue, as policy makers explore the full vision of sustainable development by reconciling the potential conflicts among economic, environmental, and social goals (Campbell 1996).

How does a particular type of land use regulation affect a regional economy? How can we better assess the effects? In thinking about the issue, at least two very important dimensions of the subject need to be considered. The first one is the complexity and dynamics of regional economies. Generally, a regional economic system is structured by many sectors and components that are highly interrelated in multiple markets and also linked through non-market connections. Therefore, the impact of any event or intervention, including land use regulation, is inevitably system-wide, even if it is directly related to a part of the system (e.g. housing sector). Furthermore, the system's behavior is dynamic, so that a shock presenting one time period often generates long run consequences. For this reason, it would be desirable to use a simulation model that better characterizes the structure of a regional economic system and further describes the dynamic behavior of the system, in order to properly assess the effects of land use regulation on a regional economy.[31]

[31] A simulation model is an excellent instrument that enables scientists to experiment with a system of interest (see. e.g. Frigg & Hartmann 2006). It is more valuable, especially when the system is very complex and cannot be experimented with in the real world. Despite some disadvantages, such as inherent biasedness of modeler, "Modeling and Simulation" has been appreciated in the field of planning, because 1) it enables us to conduct valuable experiments about urban system under various conditions and to answer many "what if?" questions that we frequently asked in the process of planning practice and 2) it allows us to conduct an analysis with a long time frame, which is essential for planning practice dealing with not only short-term but also long-term future.

Secondly, consideration needs to be given to the way in which land use regulations are implemented. In the U.S. context, land use regulations and public goods provisions are typically under the control of local authorities rather than region-wide planning agencies, although metropolitan-level or state-level involvement is not absent. Also, a large degree of heterogeneity is likely to exist within a region.[32] Thus, it is necessary to appropriately deal with the spatial organization of local decision-making and to consider the interaction between local and region-wide variables over hierarchy. If a simulation model is adopted because of its methodological advantages for the analysis, it needs to be designed to handle these spatial and multi-level aspects of the problem.

In the urban economics literature, there are a series of theoretical studies that analyze the economic consequences of zoning or growth controls by employing a spatial general equilibrium framework, in which land use and regional economy are interrelated (see e.g. Brueckner 1990; Engle 1992; Sakashita 1995; Sasaki 1998; Lai & Yang 2002; Sheppard 2004). These studies have contributed a great deal to improving our understanding of the economic effects of land use regulation. However, the complexity and dynamics of the problem are too often simplified in most of these theoretical studies, so their framework, as it stands, has limited usefulness in simulating the reality. In particular, it is difficult to examine the outcomes of policy options or to explore for the role of planning practice in complex metropolitan areas.[33] For example, many of the models posit a monocentric spatial structure and single government having the authority of land use control. Also, the models often lack consideration of detailed industrial structure, demographics, irregular physical characteristics, and so forth.

Although various operational urban and regional system models have been developed and are now available for policy and impact analyses, most of them have limited usefulness in analyzing the effect of local land use policies on regional economic performance, due to the top-down approach to regional – local integration. In a recent study (Kim & Hewings 2010), an investigation of the integrated analytic frameworks of 26 large U.S. metropolitan areas' planning

[32] Following Tiebout's (1956) pioneering examination, a voluminous literature has discussed the variance in local actions (see e.g. Ross & Yinger 1999 for a detailed summary). Also the presence of intraregional heterogeneity has been shown by some empirical studies, such as Heikkila (1996) and McDonald & McMillen (2004).

[33] A notable exception is the RELU-Trans model, developed by Anas and his colleagues through their long efforts to integrate regional economy, land use, and transportation within a general equilibrium framework (See e.g. Anas & Kim 1996, Anas & Xu 1999, and Anas & Liu 2007). Their model is considered as one of the most theoretically robust operational urban system models, because of its solid microeconomic foundation.

agencies was made and the results revealed that most of them, except Atlanta, Portland, and San Diego, adopted a strict top down approach to the vertical integration (table 5.1). In these models, regional variables are typically determined without consideration of local conditions; and then, the local growth dynamics were strictly bounded by fixed regional totals in most cases.[34]

Table 5.1. The Analytic Frameworks of 26 Large U.S. Metropolitan Planning Agencies (As of July 2009)

Representa-tive City	Organization	Regional Growth Modeling Method	Sub-regional Development Modeling Method	Approach to Vertical Integration
Atlanta	Atlanta Regional Commission	REIM (REMI)	Simulation Model (PECAS)	Feedback
Boston	Boston Metropolitan Area Planning Council	Cohort-Component	Share-based Allocation	Top-down
Buffalo	Greater Buffalo-Niagara Regional Transportation Council	Other Type	Share-based Allocation	Top-down
Chicago	Chicago Metropolitan Agency for Planning	REIM	Share-based Allocation	Top-down
Cincinnati	Ohio-Kentucky-Indiana Regional Council of Governments	External	Share-based Allocation	Top-down
Cleveland	Northeast Ohio Areawide Coordinating Agency	External	Share-based Allocation	Top-down
Columbus	Mid-Ohio Regional Planning Commission	External	Share-based Allocation	Top-down
Dallas	North Central Texas Council of Governments	External	Simulation Model (DRAM/EMPAL)	Top-down
Detroit	Southeast Michigan Council of Governments	REIM (REMI)	Simulation Model (UrbanSIM)	Top-down
Houston	Houston Galveston Area Council	Other Type	Simulation Model (UrbanSIM)	Top-down
Kansas City	Mid-America Regional Council	REIM (REMI)	Simulation Model (DRAM/EMPAL)	Top-down
Los Angeles	Southern California Association of Governments	Cohort-Component	Other Type	Top-Down
Milwaukee	Southeastern Wisconsin Regional Planning Commission	Cohort-Component	Other Type	Top-down

[34] This does not imply that regional as well as local projections used for planning practices are not under local reviews. Rather, this indicates that in the analytic frameworks, the sum of all local-level values is strictly controlled by the regional totals, while regional variables are independent of the local indicators. Although the outcomes of the models, particularly socio-economic forecasts, are the subject of local reviews to some extent before approval, such review processes are generally an adjustment of model outcomes rather than a modification of model structure or formulation. In many metropolitan planning agencies, local level variables are determined by using a share-based allocation approach where attention is paid to the share only, accepting the given totals to be multiplied. The top-down approach is also adopted by the agencies, employing various urban system simulation models for their sub-regional level analysis. This may be attributed to the designs of the simulation models, where regional totals, as exogenous inputs, are required. Under this setting, sub-regional analyses are nothing other than the allocation procedure of regionally-determined growth, so that here the region-wide growth is not influenced by local actions, including land use regulations.

Table 5.1 (cont.)

Representa-tive City	Organization	Regional Growth Modeling Method	Sub-regional Development Modeling Method	Approach to Vertical Integration
Minneapolis	Metropolitan Council	Cohort-Component	Share-based Allocation	Top-down
New York	New York Metropolitan Transportation Council	Cohort-Component	Simulation Model (NYMTC-LUM)	Top-down
Phoenix	Maricopa association of governments	External	Simulation Model (DRAM/EMPAL)	Top-down
Philadelphia	Delaware Valley Regional Planning Commission	Cohort-Component	Simulation Model (Other)	Top-down
Pittsburgh	Southwestern Pennsylvania Regional Planning Commission	REIM (REMI)	Other Type	Top-down
Portland	Metropolitan Service District	REIM	Simulation Model (Other)	Feedback
Sacramento	Sacramento Area Council of Governments	Cohort-Component	Other Type	Top-down
San Antonio	San Antonio-Bexar County Metropolitan Planning Organization	External	Simulation Model (DRAM/EMPAL)	Top-down
San Diego	San Diego Association of Governments	REIM	Simulation Model (Other)	Feedback
San Francisco	Association of Bay Area Governments	Cohort-Component	Simulation Model (POLIS)	Top-down
Seattle	Puget Sound Regional Council	REIM	Simulation Model (UrbanSIM)	Top-down
St. Louis	East-West Gateway Council of Governments	Cohort-Component	Simulation Model (LEAM)	Top-down
Tampa	Hillsborough County Metropolitan Planning Organization (MPO)	External	Share-based Allocation	Top-down

Source: Kim & Hewings (2010)

Therefore, in this study, an alternative integrated analytic framework (i.e. a spatial regional econometric input-output model) has been developed, which may be more appropriate for the analysis of the macroeconomic effects of local actions. This model extends a coupling-type regional econometric input-output model (REIM), by incorporating local- and lower-level dynamics in a reciprocal interactive manner, as opposed to a top-down allocation process. The model is then applied to the Chicago metropolitan area; a set of simulation analyses are conducted to assess the macroeconomic effects of the reactive land use regulations (i.e. minimum-lot-size zoning and building permit caps), implemented by some of the suburban municipalities.

The remainder of this paper is structured as follows. Section 5.2 first provides a concise explanation of a REIM, which is the starting point of the spatial REIM development. Then, the discussion turns to the way in which the spatial REIM has been constructed on the REIM with an emphasis on the ways in which local variables are incorporated and vertical interaction is handled. In section 5.3, the model is applied to the Chicago metropolitan area and the baseline projections for individual municipalities as well as the Chicago region as a whole are generated. The simulation analyses are presented in section 5.4, followed by a summary and discussion.

5.2. Modeling: A Spatial REIM

5.2.1. Conventional REIM

This study develops an alternative framework that overcomes the shortcomings of existing models and can be used for the analysis of the macroeconomic effects of local actions, particularly land use regulations. Before presenting the new framework, in this section, a concise explanation will be provided of the conventional regional econometric input-output models (REIMs), particularly the Chicago REIM (Israilevich *et al*. 1997), on which the new framework is built.

By integrating regional input-output (hereafter IO) and econometric, the REIMs exploit the advantages of both methods. In fact, this 'IO+econometric' integration offers the possibility of making the regional IO matrix dynamic and price-responsive and to forecast the growth, decline, and transformation of the regional economy with the consideration of a disaggregated industrial structure (see e.g. West & Jackson 1998; Rey 2000).

More specifically, the Chicago REIM (CREIM), here a basis for the new integrated framework development, is a coupling-type REIM (according to Rey's (1998) taxonomy) for the Chicago region. Its structure, most simply, can be demonstrated in figure 5.1.

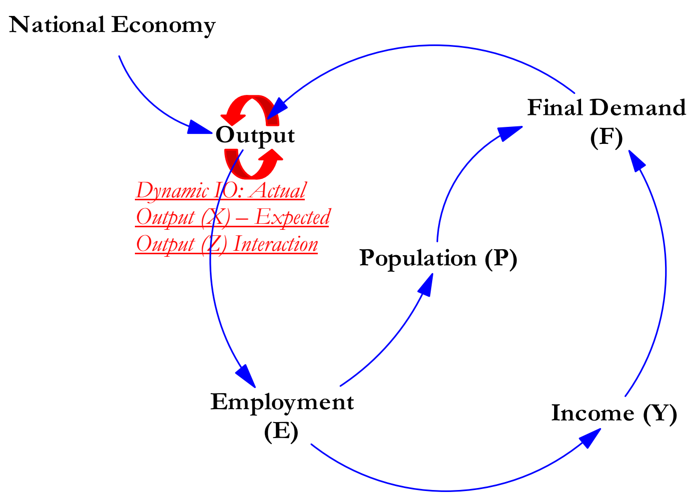


Figure 5.1. Conventional CREIM Structure

The CREIM's logic starts from the exogenous national economy (and implicitly, the international economy), driving or constraining Chicago's economic growth, as a major source of demand for regional production. As the national economy grows, Chicago's production is stimulated; this initial stimulus generates not only the immediate production increase but also ripple effects through regional inter-industry linkages. This mechanism is simulated by CREIM's dynamic input-output module, which is one of the most important features of CREIM.

The module is designed to consider the dynamic nature of inter-industry and final demand linkages and to update the IO coefficients over time. Adopting the idea presented in Conway (1990), here, the temporal IO coefficient changes are described by using two types of output that interact with each other, rather than a rule or function of direct transformation. More specifically, consideration is given to two different types of output – 1) "actual output" (X): the real values of production and 2) "expected output" (Z): the expected level of outputs, derived from the base year's input-output matrix. By definition, these two variables are related to each other, as follows.

$$Z = A \cdot X + F \quad (5\text{-}1)$$

where A is a base year's input-output matrix and F represent final demands.

In base year, *Z* is exactly same as *X* (i.e. $Z = A \cdot X + F = X$), because *A* is the IO for that year. Also, if the IO coefficients (*A*) were not changing over time, the equation *Z*=*X* can be maintained in all other years. In reality, due to the technological shifts and other factors affecting the production recipe changes, IO coefficients are not constant but evolving over time. Consequently, *Z* and *X* are rarely identical, although they are associated with each other.

Figures 5.2 and 5.3 show *Z* and *X* in two sectors as examples – 1) Sector 18: Fabricated metal products manufacturing and 2) Sector 35: Real Estate.[35]

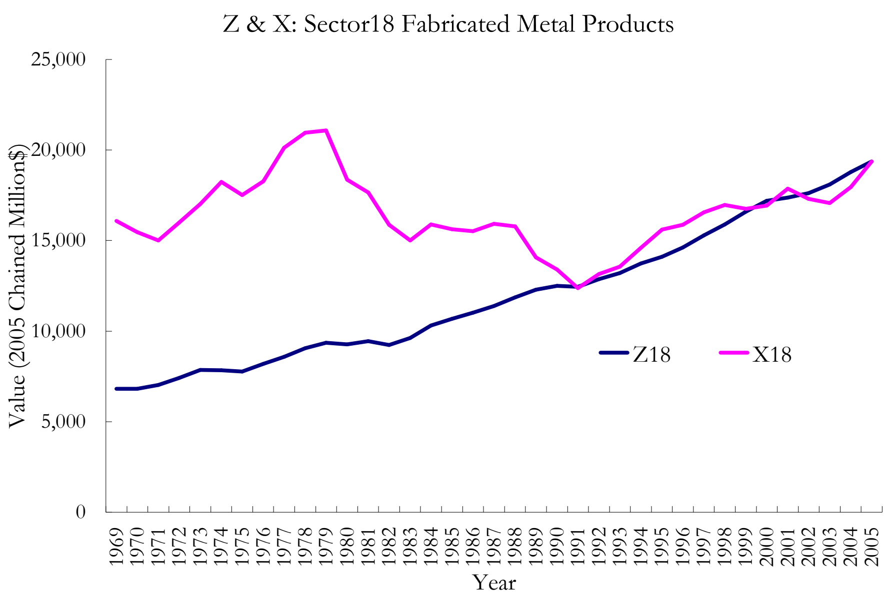


Figure 5.2. Expected Output (*Z*) and Actual Output (*X*) in Fabricated Metal Products Manufacturing (1969~2005)

[35] The data series *Z* can be generated by using historical data of actual output (*X*) by sector and final demands (*F*) as well as a base year IO matrix (*A*).

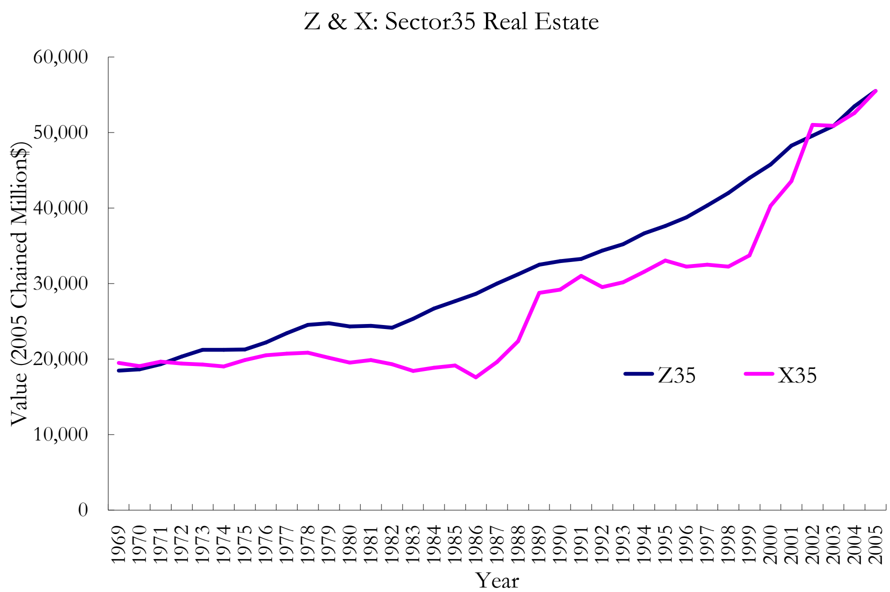


Figure 5.3. Expected Output (*Z*) and Actual Output (*X*) in Real Estate (1969~2005)

Here, the base year is Year 2005, where *Z* and *X* are identical. In all other years, *Z* is not equal to *X;* and sometimes they reveal large differences. More specifically, in the case of Sector 18: Fabricated metal products manufacturing, *X* is much greater than *Z* in 1970s and 1980s, while the gaps are relatively smaller since 1990 (figure 5.2). This implies that the level of output will be underestimated, if the base year IO table is used for 1970s and 1980s. In other words, the current linkages of this industry to other sectors in the Chicago economy are weaker than those in past (i.e. 1970s and 1980s). This is consistent with the understanding of changes in the Chicago economy, particularly the increased locational fragmentation of manufacturing activities (implying declining forward and backward linkages) in that period of time (see Hewings *et al*. 1998, Okuyama *et al*. 2002 and 2006). The real estate sector, which is primarily local, shows a different trajectory of *Z* and *X* over time, with little evidence of fragmentation, unlike manufacturing (figure 5.3).

Finally, *Z* and *X* need to be related econometrically. In the process, a dynamic IO, which is embedded in the model, will be generated; further, it will be possible to obtain actual output (*X*) in the future corresponding to the final demands (*F*) and the updated IO. In CREIM, this is accomplished in the following form.

$$\ln(\frac{x_{i,t}}{z_{i,t}}) = \alpha_0 + \alpha_Z \cdot \left(\frac{x_{i,t-1}}{z_{i,t-1}}\right) + \alpha_g \cdot g_{i,t} + \varepsilon_{i,t} \quad (5\text{-}2)$$

where *i* and *t* are industry and time subscripts, respectively; and *g* represent a set of exogenous variables. It needs to be noted that the lag structure (e.g., first order or second order) varies by sector depending on the fitness. As demonstrated in Israilevich *et al*. (1996), this specification captures the lag effect of any shock in IO coefficients.

Once the output (*X*) is derived based on the dynamically updated IO module in the model, employment (*E*) by industry needs to be projected. This can be accomplished by forecasting regional labor productivity using national productivity projections, which are exogenous, as shown below.

$$\ln(\frac{x_{i,t}}{e_{i,t}}) = f(\cdot) + \phi_{i,t} \;\rightarrow\; e_{i,t} = \frac{x_{i,t}}{\exp[f(\cdot) + \phi_{i,t}]} \quad (5\text{-}3)$$

where $f(\cdot)$ is industry-specific regional productivity function; and $\phi_{i,t}$ is an error term.

Then, based on the employment projection, CREIM generates income (y) by sector in a similar manner.

$$\ln(\frac{y_{i,t}}{e_{i,t}}) = h(\cdot) + \omega_{i,t} \;\rightarrow\; y_{i,t} = e_{i,t} \cdot \exp[h(\cdot) + \omega_{i,t}] \quad (5\text{-}4)$$

where $h(\cdot)$ is industry-specific regional wage function; and $\omega_{i,t}$ is an error term. In this case, the national wage level is used as the main exogenous independent variable.

As income is derived from employment, CREIM sets working age population as a function of regional employment as well as other factors. In addition, regarding population, birth and death rates in future are forecast primarily based on historical trends, and also applied to generate the projections for population by cohort. Net migration is also estimated, completing the demographic accounting.

Then, using both income and population, the endogenous final demand levels – i.e. various types of consumption, investment, and state and local government spending – are determined. Finally, the model is brought to closure by linking the endogenously determined final demands back to the input-output module, particularly F in equation (5-1): $Z = A \cdot X + F$.

The regional economic and population forecasts can be generated, once the entire model is constructed, through the estimation of all equations in the input-output module as well as employment, income, population and final demand bloc. Forecasting identifies the solutions for the entire set of equations and identities for every forecast year. In this sense, it can be stated that the forecasts represent a sort of general equilibrium state where all markets are balanced. That is the reason why this type of REIM is sometimes referred to as a Marshallian type of general equilibrium model in which commodity adjustments (through changes in the IO coefficients) facilitate market equilibrium at each point in time.

It needs to be emphasized that, although not perfect, the model systematically connects various macroeconomic variables; and it is designed to describe the dynamic behaviors of the system. Particularly, detailed inter-industrial linkages are well characterized in a dynamic manner. Also, the model integrates regional population and employment in a reciprocal manner. One the one hand, as mentioned above, regional employment is used to explain changes in working age population. On the other hand, population is linked to the regional economic production (X) via final demands (i.e. household consumption and expenditure of state and local governments); and further employment (E), which is derived from the production, creating an endogenous multiplier process.

5.2.2. Spatial REIM: A Multi-level Integrated Analytic Framework

The REIMs are relatively more sophisticated regional macro-economic tools which support regional economic forecasting and economic impact analysis based on dynamically updated IO. This family of the models has been widely employed by applied research since 1980s and has now become a key analytic tool, competing with Walrasian computable general equilibrium models (see e.g. West 1995; Rey 2000). According to Kim & Hewings (2010), this technology is increasingly adopted by metropolitan planning agencies as well to generate region-wide forecasts and to conduct the analysis of regional economic scenarios.

However, the conventional REIMs (including CREIM), as they stand, only focus on the macroeconomic and region-wide demographic behaviors.[36] The models neither support disaggregated-level analysis or forecasting nor consider the sub-regional-level conditions or the spatial structure of the region.[37] In order to overcome this limitation and further to make a multi-level framework which is suitable for the analysis of land use regulations, the REIM (particularly CREIM) will now be developed into a spatial REIM where 1) attention is also paid to the dynamics within a region and 2) regional- and sub-regional variables are vertically integrated in a reciprocal interactive form.

The proposed new framework has a hierarchical structure (as opposed to the REIM having region-wide variables only) that consists of 1) three endogenous layers: region – municipalities – cell and 2) national economy as an exogenous input remains on the top. Rather than simply allocating the region-wide totals generated by the conventional REIMs, here the main idea of the framework development is to establish a reciprocal vertical integration (figure 5.4) – i.e. in every round of model run (i.e. in each year (*t*) of the projection) the model is working across the hierarchy as follows:

1) Using national economic forecasts for year *t*, the potential (expected) regional economic growth rate by sector is first derived from the regional layer.
2) The cell-level information (i.e. lowest level conditions) at *t-1* for each municipality is quantified to be taken into account in local level forecasting and analysis at *t*.
3) Local level population and employment changes are tentatively determined with the consideration of a) the region-wide potential growth at *t*, b) the cell-level conditions at *t-1*, c) local socio-economic characteristics at *t-1*, and d) local level 'population – employment' interactions across space.
4) The tentative values of local population and employment changes are sent back to the regional-level to project macro-economic variables, which are systemically integrated with each other according to the REIM formulation.

[36] There have been the extensions of the conventional REIMs, such as the application to multi-regional contexts or the temporal disaggregation (see e.g. Rey & Dev. 1997; Donaghy *et al*. 2007). However, the incorporation of intraregional dynamics (i.e. development of the spatial REIM) has not been accomplished.

[37] Therefore, when this modeling technology is adopted by metropolitan planning agencies, it is used only for generating regional level forecasts or region-wide impact analysis; and sub-regional level values are separately determined by using share-based allocation techniques or urban simulation models that just allocate the given totals (from REIMs) across space within the region (Kim & Hewings 2010). Again, the combined use of a REIM and a disaggregation tool has been typically made in a top-down manner.

*) Then, the potential (expected) growth rate by sector is newly derived based on the new levels of final demands. (1) – (3) – (4) processes are iterated until convergence, with given (2).

5) Once the values of all regional and local variables for year *t* are finally determined through the iteration, cell level conditions are updated from *t-1* to *t* by employing a simple logic or a more sophisticated simulation method. The updated cell-level information is used in the next round (i.e. year *t+1*).

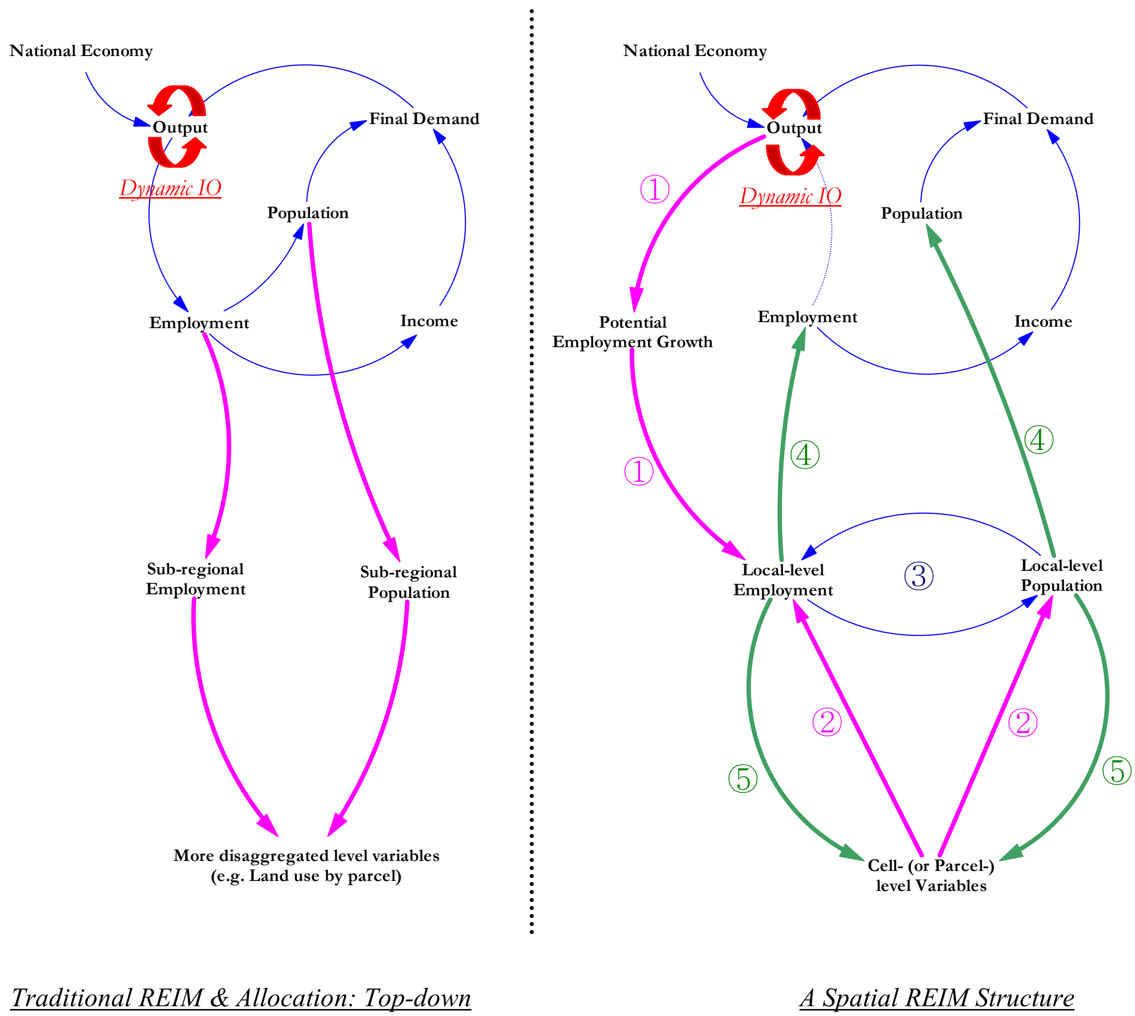


Figure 5.4. The Spatial REIM Structure, as Opposed to a Traditional REIM & Allocation

The third step is the most important part of this model formulation and operation. Although various methods can be adopted for this stage, use here is made of a spatial econometric version of regional disequilibrium adjustment model (RDAM), that has a following spatial cross-regressive simultaneous equation system (according to Rey & Boarnet's (2004) taxonomy), as explained in detail in section 3.3.1.

$$\Delta P_t^k = H_t^k \cdot \lambda_p \cdot \beta_P + \lambda_p \cdot \theta_P \cdot (I+W) \cdot E_t^k + \frac{\lambda_p \cdot \theta_P}{\lambda_E} \cdot (I+W) \cdot \Delta E_t^k - \lambda_p \cdot P_t^k + u_{i,t} \quad (5\text{-}5)$$

$$\Delta E_t^k = B_t^k \cdot \lambda_E \cdot \beta_E + \lambda_E \cdot \theta_E \cdot (I+W) \cdot P_t^k + \frac{\lambda_E \cdot \theta_E}{\lambda_P} \cdot (I+W) \cdot \Delta P_t^k - \lambda_E \cdot E_t^k + v_{i,t} \quad (5\text{-}6)$$

where *k* and *t* denote cross sectional unit (e.g. municipalities) and time, respectively.

The RDAM's dynamic nature and explicit treatment of disaggregated-level population and employment changes together with the consideration of their spatial interdependence promote its use combined with a REIM. In addition, the benefits of using a RDAM could be larger than expected, since many local or lower level factors, such as social indicators, land use, and location-specific amenities, can be conveniently included as exploratory variables to determine local population and employment changes.

However, because it primarily focuses on population and employment changes originating from the spatial adjustment process and intraregional location factor differentials, a RDAM itself is not suitable for long-term forecasting, even though the dependent variables are population and employment changes. To be an effective supporting tool for long-term analysis, the system would need to consider the fundamental growth drivers. This is the reason why the potential (expected) growth is derived in step (1) and used in local forecasting and analysis.[38]

[38] It needs to be emphasized that the forecasting accuracy can be improved by the inclusion of upper-level estimates in the model for disaggregated-level variables. Zellner & Tobias (2000) compared seven models which can be classified into three main categories – 1) aggregated-level forecast, 2) disaggregated-level forecast, and 3) using the aggregated-level forecasts in disaggregated-level forecasting as an explanatory variable – and found that the third approach shows the best performance.

More specifically, instead of the actual employment change between *t-1* and *t* (i.e. ΔE_t^k), the dependent variable of the employment change equation is set as below.

$$\Delta E_t^k - (ZE_t^k - E_{t-1}^k) = (E_t^k - E_{t-1}^k) - (ZE_t^k - E_{t-1}^k) = E_t^k - ZE_t^k$$

where ZE_t^k is the potential level of employment, calculated based on the region-wide potential employment growth rate by sector between *t-1* and *t*.

This new dependent variable indicates the number of job increase beyond the potential (expected) level of growth. If a particular municipality shows actual employment growth larger than expected for a certain time period, the value of the variable will be positive. In contrast, if it fails to attain the expected level of growth, the value will become negative.

ZE_t^k is computed as follows (Step 1 in the model working). First of all, the potential regional-level employment growth rate by sector is derived using the concept of expected output (*Z*), existing in CREIM.

$$\frac{ze_{i,t}}{e_{i,t-1}} = \frac{z_{i,t} \cdot \exp\left[\alpha_0 + \alpha_Z \cdot \left(\frac{x_{i,t-1}}{z_{i,t-1}}\right) + \alpha_g \cdot g_{i,t} - f(\cdot)\right]}{e_{i,t-1}} \quad (5\text{-}7)$$

where $ze_{i,t}$ is the expected level of regional employment in sector *i* at time *t*; and the multiplied part in the form of exp( ) is industry-specific function which converts *Z* to employment via *X*, as presented in equation (2) and (3). The numerator of this equation indicates the number of employees that the producers in sector *i* may hire to meet demand growth. Whereas the numerator is adopted as the predicted value of employment in sector *i* at time *t* in the conventional CREIM without consideration of local conditions or supply constraints, the new framework uses it as an indicator that represents the potential employment growth of each municipality, as further explained below.

Then, this expected rate of employment growth by sector is applied to individual municipality's employment at time *t-1*($e_{i,t-1}^k$) to generate the expected employment level at time *t* in municipality *k* (i.e. ZE_t^k), as follows:

$$ze_{i,t}^{k} = e_{i,t-1}^{k} \cdot \frac{ze_{i,t}}{e_{i,t-1}} \quad (5\text{-}8)$$

$$ZE_{t}^{k} = \sum_{i} ze_{i,t}^{k} \quad (5\text{-}9)$$

This expected employment level of each municipality can be understood as the sum of growth and industry-mix effect in the context of shift share analysis, although the "expected" change by sector in a higher-level, as opposed to the "actual" change, is used. In this sense, the new dependent variable, which is the residual (i.e. $E_t^k - ZE_t^k$), represents the competitiveness of each municipality in terms of job attraction. In other words, given that the new dependent variable is adopted, the employment change equation tries to capture the variance of the competitiveness across municipalities by using the changing proximity to population and other business location factors. This is a feature in various urban system simulation models, ranging from Lowry-type spatial interaction frameworks to micro-simulation and spatial IO approaches (see e.g. Wegner 1994; Hunt *et al*. 2005; Kim & Hewings 2010)

In a similar way, the population change equation is modified. Here, the new dependent variable, used instead of ΔP_t^k, is

$$\Delta P_t^k - (ZP_t^k - P_{t-1}^k) = (P_t^k - P_{t-1}^k) - (ZP_t^k - P_{t-1}^k) = P_t^k - ZP_t^k$$

where ZP_t^k is the potential (expected) level of population, which is simply computed by multiplying the natural population growth rate (i.e. the gap between the birth rate and death rate) and P_{t-1}^k.

In the present application of the spatial REIM, for simplicity and due to the data availability problem, the birth rate and death rate are exogenously determined using regional level information; and no consideration is given to the different rates for different cohort groups. However, the demographics can be further extended by introducing the logic of the cohort component survival model as well as exploiting the possibility of using more (spatially) detailed migration data.

As the regional expected growth rate is used in local forecasting and analysis, some variables, that represent the cell-level conditions such as detailed land use or other physical conditions, are measured and plugged into the local level layer to reflect the bottom-up effects (Step 2 in the model working). This is accomplished by including such conditions at *t-1* as components of *B* or *H* in the population and employment change equations for time *t*. It is not a new method to derive a particular variable from the lower-level and to include it in higher level estimation. For instance, White & Engelen (2000) derive 1) cellular density by activity, 2) mean cellular potential by activity, and 3) mean suitability for agricultural land from cell-based land use change simulation module and use them as explanatory variables to determine the regional-level growth. Furthermore, it has been found that the performance of RDAM can be improved by including micro land use information (Boarnet *et al.* 2005).

Returning back to Step 3, local population and employment changes are calculated based on the modified RDAM. Again, in this process, the factors of local population and employment changes include 1) region-wide growth driving forces derived from the upper layer in terms of $ze_{i,t}^{k}$, 2) lower level information, such as detailed land use attributes, 3) socio-economic characteristics of each municipality (e.g. municipalities' ethnic composition, education level, house price, etc), and 4) the intraregional 'population – employment' interaction over space captured by using the spatial weight matrix.

It should be noted that aggregate employment, as opposed to employment by sector, is modeled in the current application to the Chicago metropolitan area, presented in the next section. Because the sectoral employment is required for the next rounds of model run and regional forecasts, the sectoral disaggregation of the projected employment for each municipality is conducted as follows.[39]

$$e_{i,t}^{k} = \hat{E}_{t}^{k} \cdot ze_{i,t}^{k} \Big/ \sum_{i} ze_{i,t}^{k} \qquad (5\text{-}10)$$

[39] The assumption here is that local level changes in industrial structure stems only from the regionally determined growth differentials by sector. Under this setting, if a particular municipality shows employment change same as the expected one (i.e. if $\hat{y}_{t}^{k} = 0$), for every sector $e_{i,t}^{k}$ will be equal to $ze_{i,t}^{k}$. Because this assumption is somewhat unrealistic, it may need to be released later by modeling employment in different sectors differently rather than using a two equation system for population and aggregate employment. It has been found that there is a challenge that the simulation outcomes become instable, as the number of structured equations increases.

Here, $\hat{E}_t^k$ is the projected employment for municipality *k*, that is equal to $\hat{y}_t^k + ZE_t^k$, where $\hat{y}_t^k$ is the predicted value of the modified RDAM employment equation.

As mentioned above, the calculated values of local population and employment for *t* are sent back up to regional-level layer to project macro-economic variables (Step 4 in the model working). In detail, first region-wide population and sectoral employment are calculated by summing up the employment and population of all municipalities.[40] Then, all other macroeconomic variables are determined according to the REIM formulation.[41] Further, the expected output (*Z*) will be newly calculated using the new final demands as well as the actual output (*X*), based on the equation (5-1): $Z = A \cdot X + F$.

The newly calculated *Z* generates a new series of the potential level of employment for individual municipalities (ZE_t^k). In other words, step 1 of the modeling working is repeated. (Step 1) – (Step 3) – (Step 4) processes need to be iterated until convergence to finally determine local population and employment as well as regional variables for *t*.

Once this is done, cell level conditions need to be updated from *t-1* to *t* based on the new local population and employment (Step 5). For instance, to be consistent with the determined population and employment increases between *t-1* and *t*, an appropriate number of undeveloped cells within a municipality need to be converted to residential and commercial-industrial land uses respectively. This task can be accomplished by simple updating or through the use of a more sophisticated simulation method. The updated cell-level information is again plugged into the local level layer as explanatory variables in the population and employment change equations for time *t+1*. This is for step 2 of the model flow-chart in the next round.

Suppose that a key sector of the study region is projected to grow very rapidly, according to the national economic forecasts. Under these national economic forecasts, the REIM tends to generate a rapid increase in regional employment in many others as well as the sector. If we

[40] In real applications, regional and local level may have different levels of sectoral details, because of data availability (i.e. generally, much disaggregated information is only available for regions.) If this is the case, appropriate aggregation and disaggregation process is required when the values are transferred over hierarchy.
[41] While the actual output (*X*) is generated by the equation (2) using *Z* in the conventional REIM, it is now derived by the equation (3) using the locally determined employment level.

adopt the conventional CREIM, a large employment growth will be placed in the region regardless of local conditions. In contrast, the spatial REIM framework transmits this signal to the local level, particularly to the municipalities having greater numbers of employment in the key sector and checks whether or not the rapid demand increase of this sector's employment can be satisfied by the existing local and lower level conditions, so that a large amount of multiplier effects can be realized. If many establishments in this sector are currently located in a very congested zone where growth cannot be accommodated efficiently, the level of actual employment growth in the sector may be projected to be lower than the expected level at the local layer; and the regional employment growth trajectory is also altered according to the modified employment increase.[42] This may be more consistent with the reality that the chance of attaining the potential growth in the region is influenced by the internal conditions.

This is what the spatial REIM attempts to describe by establishing a feedback link that was described earlier. More generally, it tries to reflect the probable supply constraints and the effect of regional spatial structure on the performance of a regional economy, rather than assuming that all demand increases will be satisfied and that the additional activities to meet the demand increase will be located somewhere within the region.

5.3. An Application of the Spatial REIM: The Case of Chicago

5.3.1. Study Area

The established framework is applied to the Chicago metropolitan area by extending the 2008 version of CREIM (Base year: Year 2005). In this version of CREIM, the economy of the seven-county Chicago Metropolitan Agency for Planning (CMAP) region – Cook, DuPage, Kane, Kendall, Lake, McHenry, and Will in Illinois – is described with a new industrial classification system that consists of 45 NAICS-based industries and government sectors, listed in table 5.2. The 2008 CREIM, estimated with historical data between 1969 and 2005, is capable of producing

[42] One critical issue in modifying the regional growth trajectory may be whether the unmet potential growth will be deflected to another part of the metropolitan area or outside the region. The spatial REIM does not directly describe this behavior of the system. Rather, in the model, the modified trajectory is determined by solving the entire set of macroeconomic and the RDAM equations under given conditions through the iteration.

the macroeconomic forecasts from 2006 up to 2040 by using national economic forecasts for the corresponding forecast years.

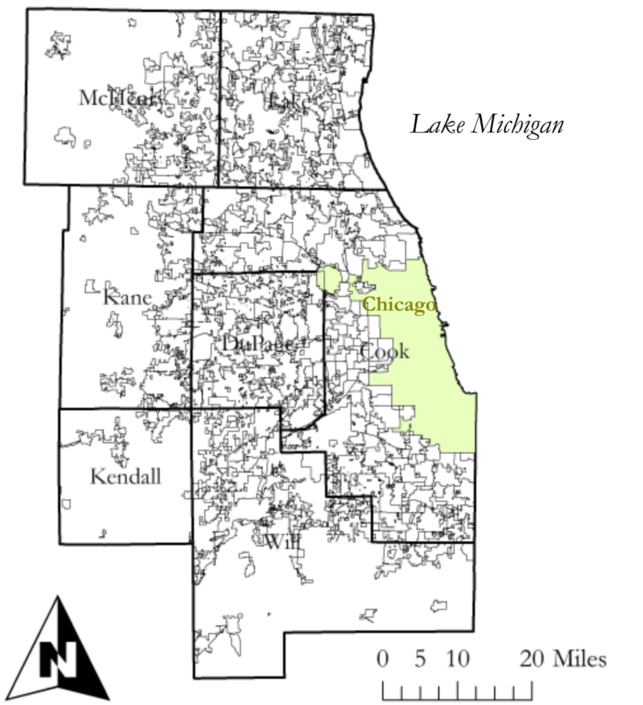


Figure 5.5. Study Area: Seven County CMAP Region

Table 5.2. Industry Classification System of CREIM

Code	Description	2002NAICS
01	Livestock and Other Agricultural Products	111, 112
02	Agriculture, Forestry and Fisheries	113, 114, 115
03	Mining	21
04	Utilities	22
05	Construction	23
06	Food and Kindred Products	311
07	Tobacco Product Manufacturing	312
08	Apparel and Textile Products	313, 314, 315
09	Leather and Leather Products	316
10	Lumber and Wood Products	321
11	Paper and Allied Products	322
12	Printing and Publishing	323, 511, 516

Table 5.2 (cont.)

Code	Description	2002NAICS
13	Petroleum and Coal Products	324
14	Chemicals and Allied Products	325
15	Rubber and Misc. Plastics Products	326
16	Stone, Clay, and Glass Products	327
17	Primary Metals Industries	331
18	Fabricated Metal Products	332
19	Industrial Machinery and Equipment	333
20	Computer and other Electric product, component manufacturing	334, 335
21	Transportation Equipment Manufacturing	336
22	Furniture and Related Product Manufacturing	337
23	Miscellaneous Manufacturing	339
24	Wholesale Trade	42
25	Retail Trade	44, 45
26	Air Transportation	481
27	Railroad Transportation and Transportation Services	482, 492, 487, 488
28	Water Transportation	483
29	Truck Transportation, Warehousing, Waste & Remediation services	484, 493, 562
30	Transit and Ground Passenger Transportation	485
31	Pipeline Transportation	486
32	Information, except Motion Picture and Sound Recording Industries	515, 517
33	Motion Picture and Sound Recording Industries	512
34	Finance and Insurance	52, 55, 533
35	Real Estate	531
36	Professional and Management services and other support services	54, 518, 561
37	Educational Services	61
38	Health Care	621, 622, 623
39	Social Assistance	624
40	Arts, Entertainment, and Recreation	711, 713
41	Accommodation Services	721
42	Food Services	722
43	Repair and Maintenance	811
44	Personal and Laundry Services	812
45	Memberships Organizations and Private Households	712, 813, 814
FGE	Federal Government Enterprises	N/A
OFGC	Other Federal Government, Civilian	N/A
FGM	Federal Government, Military	N/A
SLGE	State and Local Government Enterprises	N/A
OSLG	Other State and Local Government	N/A

There are 296 municipalities within this area, as shown in figure 5.5. While most of them are completely included in the study area, a few municipalities are located across the region's boundaries. The partly included municipalities are considered, with their shares of population and employment within the portions included in the study area. The unincorporated areas of each county are considered as a municipality to maintain the identity between the regional values and the sum of all local units. As a result, there are 303 units of local analysis.

5.3.2. Model Calibration

The main tasks of this spatial REIM application are 1) to calibrate the model by estimating the modified RDAM, 2) to solve the entire set of equations with a feedback loop for every forecast year and 3) to generate a set of baseline simulation outcomes. First, for the calibration task, data for five time spans were used, from [2000,2001] to [2004,2005] due to the data availability problem. Particularly, there is no single source of information, providing annual employment by municipality, which is the main variable of this analysis. Therefore, an employment dataset was constructed using three data sources: 1) 2000 Census Transportation Planning Package (CTPP) data, 2) Zipcode Business Pattern (ZBP) data by U.S. Census, and 3) Regional Economic Information System (REIS) data by U.S. Bureau of Economic Analysis. More specifically, employment by sector in 2000 for individual municipalities was identified using CTPP data that provides employment information for each census tract in decennial years.[43] Then, using the ZBP dataset, that contains annual establishment and employment information at zip-code area level, the rate of employment changes from 2000 to other years for each zip-code areas are derived. A series of spatial smoothing is applied to generate a more realistic surface of employment change rates across the space. Then, by multiplying the values of smoothed employment change rates with 2000 employment derived from CTPP, employment by municipality is derived for every year from 2001 to 2005. Finally, the outcome of the former procedure is adjusted to match to the values provided by REIS (annual employment by sector at county level), when they are aggregated up to county-level, because REIS has been used as a main source of information for CREIM development. Since there are some discrepancies in definitions of employment in

[43] Local employment information available is disaggregated by 14 sectors based on NAICS, whereas CREIM has a 45-sector classification scheme. For this reason, aggregation and disaggregation work is conducted when the values are transferred over hierarchy. It needs to be noted that the potential (expected) employment growth (i.e. $ze_{i,t}^{k}$) for each municipality is computed based on the 14-sector classification.

different datasets, the gaps to be adjusted are inevitable. A similar approach (i.e. using multiple data sources and trying to mitigate the discrepancies and errors) is used to cope with the data availability problems of other variables. The variables used in this analysis and data sources are presented in table 5.3.

Table 5.3. Variables and Data Sources in the RDAM Estimation

Variable	Description	Data Sources
Main Variables		
P	Population	Annual Population Estimates by US Census
E	Employment	CTPP, ZBP and REIS
Derived from Regional level		
ZE	Expected level of employment[3]	CREIM
Municipality-level Socio Economic Characteristics		
NWR	The Ratio of Non-White Population	Census 2000 and American Community Survey
HISPR	The Ratio of Hispanic Population	Census 2000 and American Community Survey
VACR	Vacancy Rate	Census 2000 and American Community Survey
EDU[1]	The Level of the Educational Attainment	Census 2000 and American Community Survey
MHOHINC	Median Household Income	Census 2000 and American Community Survey
MHV	Median Value of Specified Housing Units	Census 2000 and American Community Survey
POVR	Poverty Rate	Census 2000 and American Community Survey
Micro-level Information		
HINTERLA[2]	The Area of Lands for Potential Incorporation	TIGER[4]
LU_UDL	The Area of Developable Land within the Jurisdictional Boundaries	National Land Cover Database by USGS and CMAP's Land-Use Inventory
OS	The Area of Developed Open Space	National Land Cover Database by USGS and CMAP's Land-Use Inventory
RC	The Lengths of the Major Arterial Roads	TIGER and Annual road mileage data by Illinois Department of Transportation
GOV	Presence of Major Government Offices	CMAP's Land-Use Inventory
UNIV	Presence of Universities or Colleges	CMAP's Land-Use Inventory
BIZPARK	Presence of Business Parks	CMAP's Land-Use Inventory
DISTCBD	Distance to CBD	GIS data by City of Chicago
DISTOHARE	Distance to O'Hare International Airport	GIS data by City of Chicago

1) *EDU* is defined as a percentage of 25+ population, whose educational attainment is Bachelor's degree or above
2) This is a measurement to consider the area of available hinterlands surrounding each municipality. This represents the area of unincorporated land closet to each municipality.
3) See the equation (5-7)~(5-9) for details.
4) TIGER indicates the **T**opologically **I**ntegrated **G**eographic **E**ncoding and **R**eferencing system provided by U.S. Census.

To complete this RDAM estimation, a spatial weight matrix (*W*) is necessary. The matrix was constructed using 2000 municipality-level journey to work data contained in CTPP. This way of constructing the weight matrix is theoretically desirable, because here the matrix is introduced to consider the labor market areas beyond municipality boundaries. Also, according to the experiment by Boarnet *et al.* (2005), a journey-to-work-data-based weight matrix is more likely to generate reasonable estimation outcomes.

It should be noted that I make a following treatment on many explanatory variables and use the converted index value (i.e. $index(x)^k$), as opposed to the real magnitude (x^k), in the estimation for a long-run simulation purpose.

$$Index(x)_t^k = \frac{(x_t^k - \bar{x}_t)}{\sigma(x)_t} \quad \text{(5-11)}$$

This treatment may be necessary for the situations such as the following case. Suppose that a positive and statistically significant effect of *HISPR* (the ratio of Hispanic population) on local population change is found with given data. This may be probable, because the newly immigrated Hispanic population may tend to settle down in the communities where many people in the same ethnic group are living. As the Hispanic population is moving into the region in increasing numbers over time, the level of *HISPR* in most municipalities will increase. If the population change equation is set as a function of the real magnitude of *HISPR* with a positive coefficient, the overall population will be growing rapidly simply because of the generally increasing *HISPR* in the region. Although this may be the case in the sense that the Chicago has come to attract more Hispanic immigrants in competition with other regions, this is not very probable. Rather, it would be more reasonable to think that the location choice of a certain number of Hispanic residents or new immigrants is influenced by relative level of *HISPR* and to use local *HISPR* variance within the region to capture this effect. The index, which indicates the relative position of each municipality on a variable's distribution, is used for this reason. By adopting this strategy, the overall increase or decrease in the real magnitude of the variables will affect the region-wide totals in a more realistic fashion.

Because the modified RDAM is also a spatial cross-regressive simultaneous equation system having the feedback and spatial simultaneity problems, traditional least square techniques, including traditional two stage least square, cannot provide consistent and unbiased estimates.

Therefore, like the spatial econometric analysis in chapter 3, the model is estimated using a spatial generalized moments approach, initially developed by Kelejian & Robinson (1993) and later extended by Kelejian & Prucha (1998 and 1999). More specifically, the simultaneous equation system model is estimated in a constant coefficients model form. Also, to obtain the final estimates for the simulation, the model specification is modified repeatedly, by excluding the independent variables that are statistically insignificant at the 5%-level. Table 5.4 presents the final estimation outcomes.

Table 5.4. Final Estimation Outcomes of the Modified RDAM

Variable	Description	Coefficient	Standard Error	t-statistic	P-value
[Population Change Equation] Dependent Variable: *P – ZP*					
C	Intercept	201.061	37.9227	5.30186	[.000]
IWECH	(I+W) * (Employment Change)	0.018523	8.14E-03	2.27683	[.023]
P0	Population in t-1	-0.012422	1.26E-04	-98.7758	[.000]
IWE0	(I+W) * (Employment in t-1)	2.74E-04	9.28E-05	2.95723	[.003]
Index(*HISPR*)	*HISPR* Index	109.496	17.0398	6.42593	[.000]
Index(*MHOHINC*)	*MHOHINC* Index	101.471	44.0884	2.30155	[.021]
Index(*EDU*)	*EDU* Index	194.153	31.296	6.20377	[.000]
Index(*MHV*)	*MHV* Index	-276.375	38.7214	-7.13754	[.000]
Index(*UNIV*)	*UNIV* dummy Index	54.7356	15.5275	3.52507	[.000]
Index(*LU_UDL*)	*LU_UDL* Index	214.496	18.3866	11.6659	[.000]
Index(*HINTERLA*)	*HINTERLA* Index	256.229	18.8212	13.6138	[.000]
DUMMYREC[1]	Dummy of recession years	85.9552	41.4773	2.07234	[.038]
R-squared = 0.884617 | Adjusted R-squared = 0.883772					
[Employment Change Equation] Dependent Variable: *E – ZE*					
C	Intercept	176.177	44.3415	3.97317	[.000]
IWPCH	(I+W) * (Population Change)	0.08044	0.024666	3.26123	[.001]
E0	Employment in t-1	-0.01769	2.43E-04	-72.8692	[.000]
IWP0	(I+W) * (Population in t-1)	5.02E-04	1.58E-04	3.17294	[.002]
Index(*HISPR*)	*HISPR* Index	116.64	24.0711	4.84565	[.000]
Index(*EDU*)	*EDU* Index	207.491	40.3936	5.13674	[.000]
Index(*MHV*)	*MHV* Index	-142.785	38.3557	-3.72267	[.000]
Index(GOV)	*GOV* dummy Index	74.2272	22.8953	3.24202	[.001]
R-squared = 0.871904 | Adjusted R-squared = 0.870909					

1) In the recession years, while employment decreases significantly, generally net-migration is not much affected in spite of the unfavorable economic situation, because of the similar unfavorable situations in other areas. So, employment is hardly matched to population in a RDAM set-up. By including the dummy variables for such recession years, we can better deal with this unusual mismatch. The dummy variables are expected to exhibit positive coefficients in the population change equation.

The overall model's explanatory power is good (adjusted r-squared are 0.87~0.88). Also, the rate of adjustment, which are the negative values of the estimated coefficients for *P0* in population change equation (i.e. 0.012422) and that for *E0* in employment change equation (i.e. 0.01769), are between 0 and 1 as expected. This means that the model will generate dynamically stable processes. Moreover, statistically significant reciprocal 'population –employment' interactions are found (see the estimates for *IWECH* and *IWPCH* in the two equations).

In addition, the estimation captures the effects of municipality level socio-economic characteristics and micro-level attributes on household and business location decisions. For example, the results revealed that population is more likely to grow in the towns showing higher ratios of Hispanic population, median income, and education level. The presence of any university is found to be favorable to population increase, while the relative level of housing price has a negative effect on population growth. Moreover, large areas of developable or incorporable land are positive factors of population growth.

In similar fashion to population changes, the estimation outcomes suggest that employment tends to grow faster than expected if the municipality has a higher Hispanic population ratio or educational attainment level. In the case of employment, the presence of major government offices also exhibits a statistically positive effect. However, the presence of business parks and per capita major arterial road shows statistically insignificant effects.

5.3.3 Model Solving

Using the modified RDAM estimated above, the spatial REIM is constructed according to the structure presented in the previous section. The overall framework has the equations for the macro-economic variables in the CREIM and the two equation system for local population and employment as well as the cell-level module.

The entire set of equations is solved through the five step process for each forecast year, as explained above. More specifically, once the values of all explanatory variables, including the potential level of employment for individual municipalities (ZE_t^k) are prepared in steps 1 and 2, the two equation system, with 606 unknowns (i.e. population and employment for 303 municipalities), interlinked based on the W matrix, is solved by using a simple algorithm, as demonstrated in figure 5.6. Although it varies by forecast year, generally the convergence (within 0.001% tolerance) is attained with between 5 and 7 iterations.

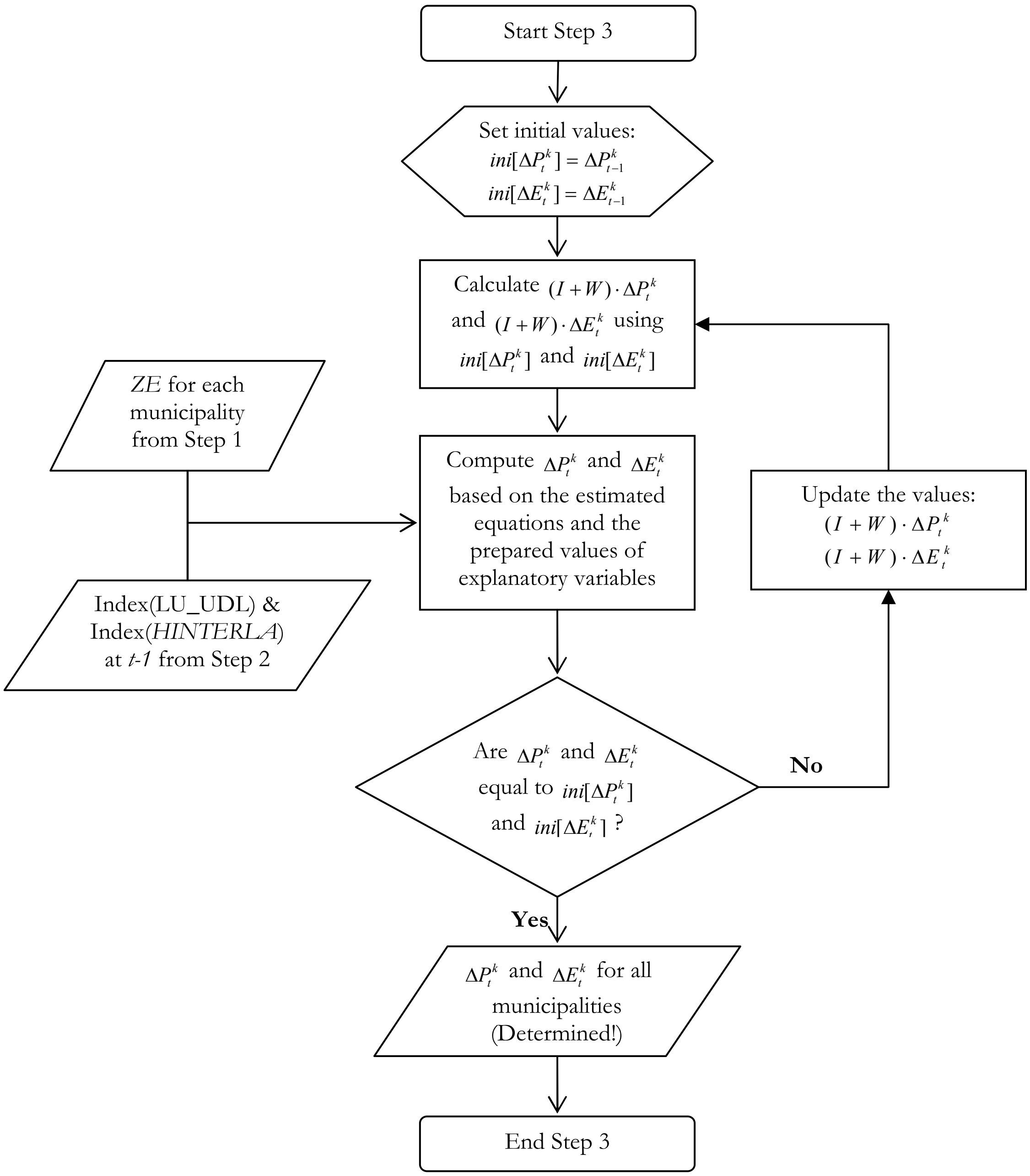


Figure 5.6. Algorithm to Solve the Modified RDAM

The iteration along with the larger loop (i.e. Step 1 – Step 3 –Step 4), mentioned in the previous section, is conducted in a similar manner. In other words, the *ZE* calculation (Step 1), RDAM solving (Step 3), and macroeconomic variable calculations (Step 4) are repeated until *Z* used for *ZE* calculation at starting point is the same as the new *Z,* calculated with the RDAM solutions and macroeconomic equations at the end. In the case of this larger loop, the convergence within 0.001% tolerance is also typically attained through with 10 to 15 iterations.

Once the solutions for the all CREIM and RDAM variables are determined, the cell-level attributes (i.e. *LU_UDL* and *HINTERLA*) need to be updated as the final stage of each round of model run. In this application, for simplicity, updating is accomplished based on following assumed rules.[44]

1) Density of new development will be same as the base year level in the future, as long as undeveloped and incorporable land is available.
2) Each municipality tries to maintain the area of undeveloped land within its jurisdiction at the base year level, by incorporating hinterland areas as the undeveloped land stock is decreasing.
3) Pre-developed land will not be converted to undeveloped land even though population and employment is declining due to assumed irreversibility of changes.

According to these rules, *LU_UDL* and *HINTERLA* for each municipality are updated based on the determined population and employment changes in the municipality. Also, in every year of the simulation the Index(*LU_UDL*) and Index(*HINTERLA*) are calculated again for use in solving the modified RDAM.

5.3.4. Baseline Simulation

Using this method, the spatial REIM, applied to the Chicago area, is solved for the forecast period, from 2006 to 2040, and, as a result, baseline simulation outcomes are obtained.[45] The

[44] Under this setting, if population is growing in a particular municipality, first hinterland area (*HINTERLA*) is declining by the required land which is new population divided by the base year density. If there is no sufficient hinterland, the stock of undeveloped land starts to decrease.

[45] In the baseline run, Index(*HISPR*), Index(*MHOHINC*), Index(*EDU*), Index(*MHV*), Index(*UNIV*), and Index(GOV) are fixed at the base year level for every municipality.

information generated includes not only the forecasts for detailed macroeconomic forecasts but also population and employment projections by municipality.

Figures 5.6 and 5.7 demonstrate how the spatial REIM projects the long-term regional growth differently compared to the conventional CREIM by showing the trajectories of regional population and total employment. It is found that the overall growth, projected by the spatial REIM, is similar to the CREIM's forecast in terms of the pace until 2020, although it fluctuates less. However, the spatial REIM projects the regional growth rate to be slower than the conventional CREIM for the time periods beyond 2020; this is especially true for population. This slower growth after 2020 may be attributable to the potentially emerging shifts in the spatial structure or other intraregional level conditions, newly considered in the spatial REIM.

Alternatively, it may be caused by some limitations of this application, such as the linear fashion of the RDAM or a short period of data used for the calibration.

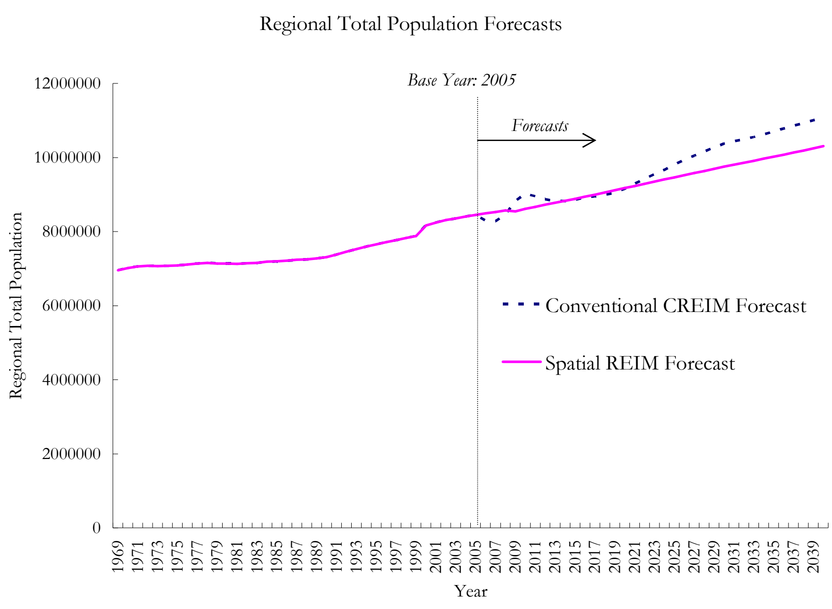


Figure 5.7. Conventional CREIM vs. Spatial REIM: Regional Population Forecasts

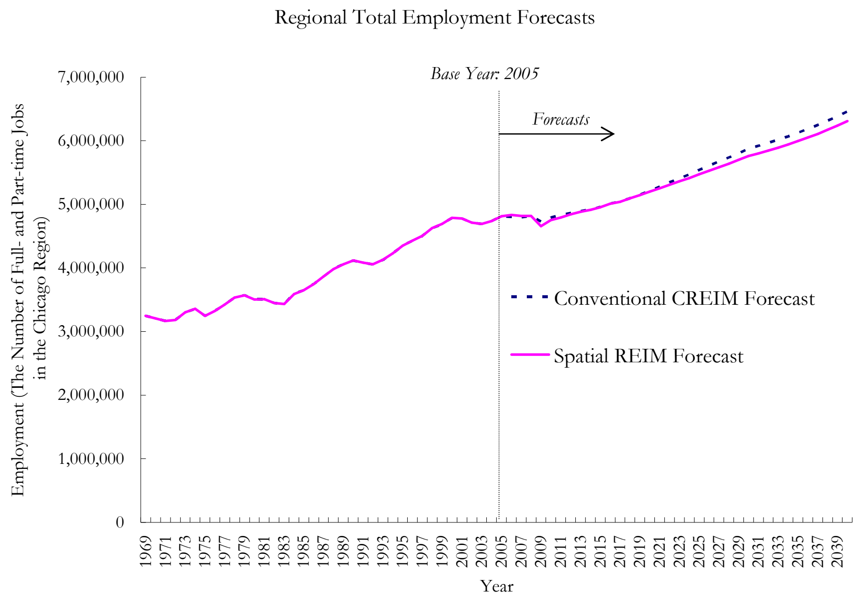


Figure 5.8. Conventional CREIM vs. Spatial REIM: Regional Total Employment Forecasts

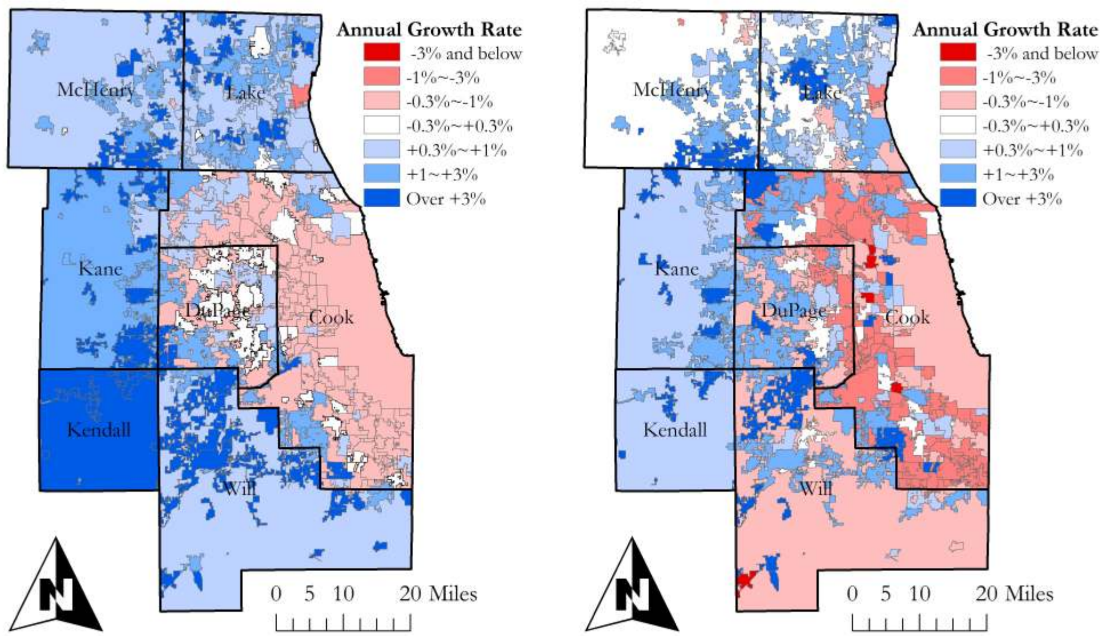
The larger difference between the new projection and existing CREIM forecasts after 2020 is also revealed in table 5.5, where the forecasts for main macroeconomic indicators in terms of annual growth rates for different forecast time periods are presented. This table also shows that the gap is wider especially in the population growth trend, that is largely determined with the consideration of local conditions in the spatial REIM, rather than directly related to the employment at regional level. Also, the gap is relatively large in construction, trade (including retail trade), and some service sectors, which largely depend on local spending, compared to other industries. This may suggest that the spatial REIM seems to be responding to some constraints in household sector (especially slower growth rates) and that the effect of such constraints is spread out over the economy, particularly the local sectors.

Table 5.5. Conventional CREIM vs. Spatial REIM: Regional Total Employment Forecasts

	Past 35 Years (1970~ 2005)	Overall Forecast Period (2005~2040)		2005~2020		2020~2040	
		CREIM	Spatial REIM	CREIM	Spatial REIM	CREIM	Spatial REIM
GRP	1.78%	2.13%	2.09%	2.08%	2.07%	2.16%	2.10%
Population	0.53%	0.78%	0.57%	0.54%	0.55%	0.96%	0.58%
Total Output	2.57%	2.07%	2.02%	1.49%	1.47%	2.51%	2.42%
Employment	1.17%	0.84%	0.78%	0.53%	0.52%	1.08%	0.97%
Construction (Sector 5)	*1.85%*	*0.62%*	*0.53%*	*0.06%*	*0.05%*	*1.05%*	*0.88%*
Manufacturing (Sector 6~23)	*-2.10%*	*-0.74%*	*-0.78%*	*-0.48%*	*-0.49%*	*-0.94%*	*-1.00%*
Trade (Sector 24~25)	*0.76%*	*0.61%*	*0.52%*	*0.41%*	*0.40%*	*0.75%*	*0.61%*
FIRE (Sector 34~35)[1]	*2.23%*	*0.99%*	*0.94%*	*0.87%*	*0.83%*	*1.09%*	*1.03%*
Service (Sector 36~45)	*3.36%*	*1.14%*	*1.07%*	*0.64%*	*0.62%*	*1.52%*	*1.41%*
All Other Sectors	*0.55%*	*1.07%*	*1.02%*	*0.98%*	*0.97%*	*1.14%*	*1.06%*
Personal Income	2.17%	1.86%	1.83%	1.43%	1.42%	2.19%	2.13%

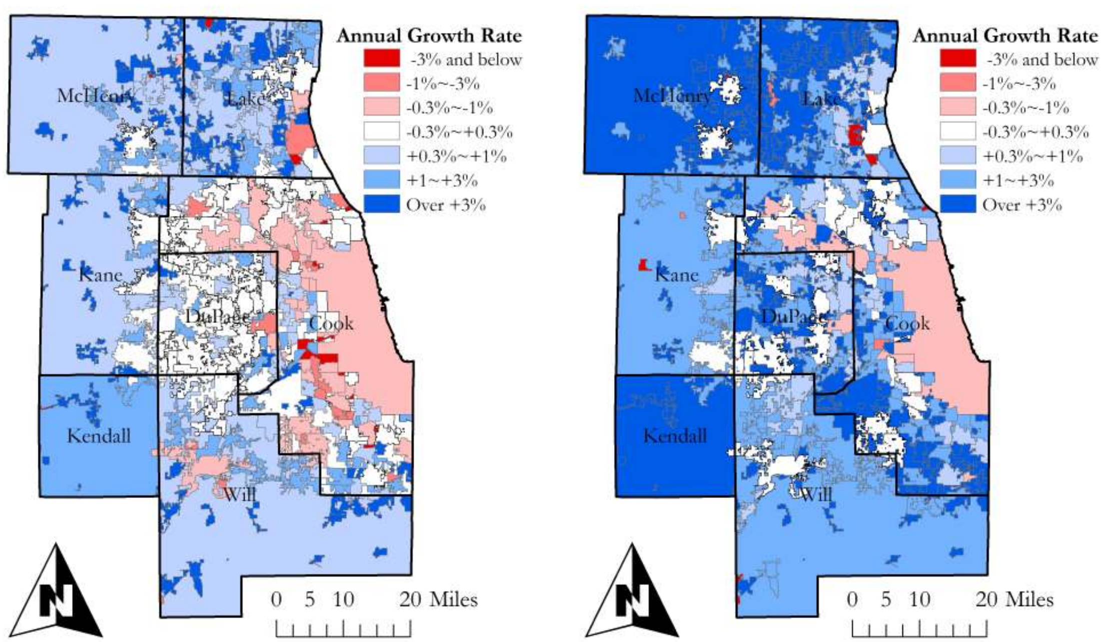
1) FIRE stands for Finance, Insurance, and Real Estate.

In addition to these region-wide projections, local population and employment forecasts can be generated by the new framework, that now incorporates municipality and cell-level layers into the CREIM. Figures 5.9 and 5.10 present historical (2000~2005) and projected (2005~2040) population and employment changes of individual municipalities, respectively, in terms of annual growth rates. According to these projections, basically the historical patterns of population and employment growth will be maintained in future, in the sense that 1) suburban areas attract more people and jobs compared to the city of Chicago or other municipalities in Cook County and 2) the population and employment growth are highly correlated at the municipality-level. However, it can be seen that the employment growth rate will exceed the pace of population growth in most suburban communities in the future, whereas population had been grown much more rapidly there in past. This can be attributed to the consideration of population – employment interactions and dynamic adjustment processes in the new framework. In other words, jobs are more likely to locate in the suburban areas where people are abundant, while population growth momentum will not increase continuously until the wide gap between job opportunities and labor supply there become narrower.



Historical Population Growth (2000~2005) *Historical Employment Growth (2000~2005)*

Figure 5.9. Historical Population and Employment Growth by Municipality (2000~2005)



Projected Population Growth (2005~2040) *Projected Employment Growth (2005~2040)*

Figure 5.10. Projected Population and Employment Growth by Municipality (2005~2040)

5.4. Impact Analysis of Reactive Land Use Regulations

5.4.1. Reactive Land Use Regulations by Suburban Communities

Using the spatial REIM, in this section, a set of impact analyses are conducted to assess the macroeconomic impacts of some types of reactive land use regulations that limit housing supply and population growth in the municipalities. Although Chicago has been considered as a less regulated region compared with many other metropolitan areas, a considerable number of suburban municipalities have implemented minimum-lot-size zoning ordinances or building permit caps. According to a recent survey conducted by the Wharton's residential land use regulation project in 2005 (Gyourko *et al.* 2008), among 98 municipalities surveyed (of total 296 entities in this area), 11 cities or towns have at least a two-acre-minimum-lot-size requirement somewhere within their jurisdictions; and another 5 communities have at least a one-acre-minimum-lot-size requirement (see figure 5.11). Also, 10 municipalities have one or more explicit "statutory limits on the number of building permits for single family and multifamily product, on the number of single-family or multifamily units authorized for construction in any given year, on the number of multifamily dwellings permitted in the community, or on the number of units allowed in any given multifamily building" (p.701). Interestingly, there is no municipality having both restrictions – i.e. 1) two- or one-acre-minimum-lot-size requirement and 2) permit caps – together. This may suggest that the two types of regulations are functioning in a similar way, that may be limiting population increases as well as housing construction in the municipality.

As noted, such reactive land use regulations directly affect housing supply and thus population growth within the jurisdictions; and building permit data shows this deterrent effect. Municipality-level building permit data were compiled for the Chicago region, provided by U.S. Census, between 2006 and 2008 to check the effect of the regulations, because the regulation information is for year 2005. Then, the number of permitted units divided by 2005 population (on the y-axis) was related to the projected annual population growth rate for the three years (on the x-axis) for two different groups: 1) municipalities with the minimum-lot-size requirements or permit caps vs. 2) municipalities without such reactive regulations (figure 5.12).[46] Two things are notable. First, *x* and *y* show somewhat strong positive relationship, which may imply that the population growth projected by the spatial REIM correctly forecasts the population changes of individual municipalities because there appears to be a strong correlation with the observed building permit data. Secondly, consistent with the expectation, the group of municipalities having the more reactive regulations shows a flatter slope, which indicates that the number of building permits tends to be smaller in these communities, when population growth potential is controlled. In other words, the regulations may have a significant negative effect on local housing supply.

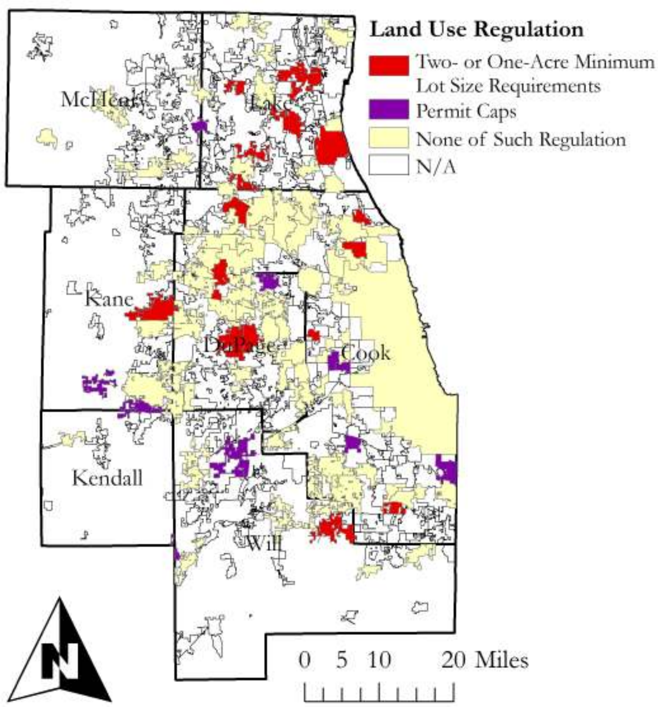


Figure 5.11. Reactive Land Use Regulations in Chicago

[46] Rather than using the number of permitted units as they stand, here I divide the number by the base year population and use the value to control the effects stemming from the size variance. It also needs to be noted that the figure excludes the municipalities where building permit or land use regulation information is not available or 2005 population is smaller than 5,000.

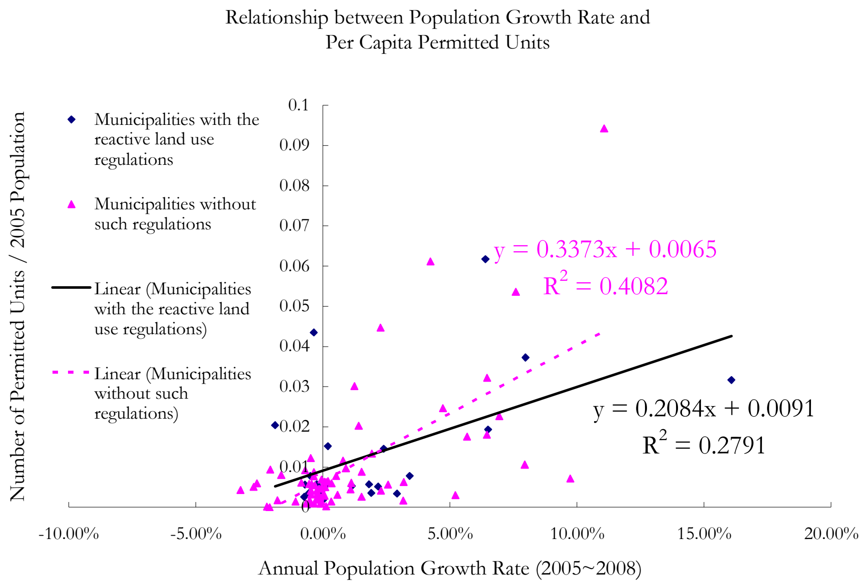


Figure 5.12. Building Permits & Reactive Land Use Regulations

However, the regulations may not always come into effect. There is no reason the regulations reduce local housing stock or population if there is no demand for new construction. Also, as far as the new construction plans satisfy the lot-size or permit cap requirements, the regulations will not limit housing supply and following population increase to that extent. This means that the presence of the regulations needs to be interpreted in the model as an upper limit of housing stock or population growth rate rather than a negative shock with a certain magnitude on the variables. Once the regulations are reflected in this way, mirroring reality, in simulation the potential negative shock will take effect conditionally with different amounts in different municipalities.[47] This issue also highlights that the effects of local land use regulations can be better analyzed by "modeling and simulation," particularly a simulation model like the spatial REIM, in which population by municipality is projected, so that it is possible to identify whether or not the actions come into effect in a particular locality at a particular time point.

[47] The shock will be zero, if a municipality does not satisfy both conditions: 1) the regulations are implemented and 2) population is likely to grow more rapidly than the given upper limit.

5.4.2. Prior Experiments: The Effects of a Negative Population Shock at a Particular Location

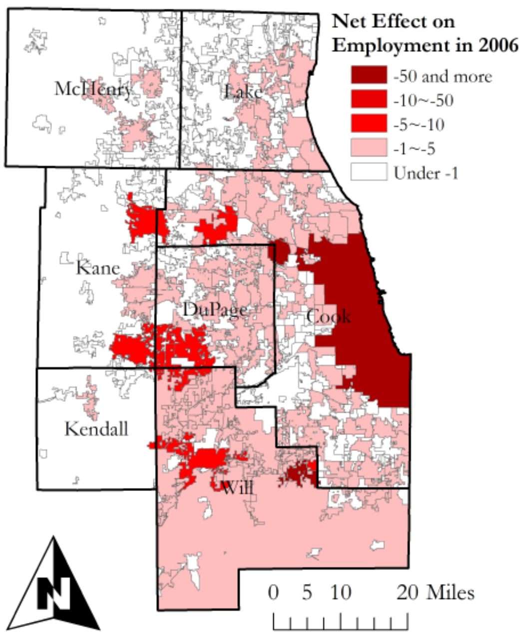
As noted, the impact analyses of minimum-lot-size requirements and building caps can be properly conducted by imposing the upper limit on population increase. Before conducting the impact analyses, a simple negative population shock to two selected municipalities, one at a time, will be considered to explore how the impact is spread out over the region's economy and space in each case. These experiments will enhance the interpretation of the complicated simulation outcomes in the main impact analyses, which are a mixture of many different shocks in different places having the regulations.

More specifically, a negative population shock with the magnitude -1,000 is first given to the Frankfort village in year 2006; and then the same amount of shock is imposed on the Sugar Grove village in the same year. According to the Wharton survey, both towns implemented the reactive regulations as of 2005. At the same time, their population is estimated to grow very rapidly in the baseline spatial REIM projections.

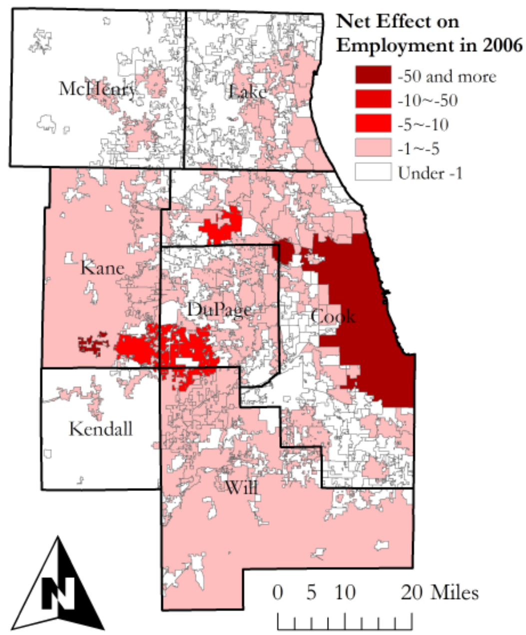
Figure 13 demonstrates how the population shock affects employment across space in the two cases. Above all, it is evident that a greater employment loss occurs not only in the very municipality but also in the places which import the workers from the municipality with a shock, such as the cities of Chicago, Aurora, and Naperville, because the municipality-level employment change is linked to the population changes in the labor market areas captured by the spatial weight matrix based on the journey-to-work data in the modified RDAM. Furthermore, although small, many other municipalities will experience employment decreases, even though they have no interaction with the affected municipalities in terms of the journey-to-work flow. This is attributable not only to the indirect linkages through the power series of spatial weight matrix at municipality level but also to the systematic interconnections from a municipality to others via the regional layer.[48] In other words, population and employment shock in any part of the region

[48] A shock given to a particular municipality first alters the projections of all municipalities with consideration of their spatial interdependence and then changes the values of macroeconomic variables accordingly. In addition, through the iteration of (Step 1) – (Step 3) – (Step 4), population and employment in individual municipalities are further adjusted to determine the probable state of the spatial economic system under the shock which satisfies the modified RDAM as well as all macroeconomic equations at the same time.

will alter macroeconomic variables (i.e. decreasing consumption, production, and inter-industry purchases) and then generate unfavorable effects on all parts of the regional economic system.



The Case of Frankfort Village



The Case of Sugar Grove Village

Figure 5.13. The Effects of the Population Shock on Employment by Municipality in 2006

Table 5.6 presents the effects of the population shock on regional employment by sector in each case. First of all, the magnitudes of the impacts in Construction and Trade sectors are larger than the shares in the base year's regional employment, listed in table 5.7. In contrast, Manufacturing, which accounts for 9.5% of regional total employment in the base year, received just about 7.6% of the total impact in both cases. This is consistent with the intuition that generally a population shock more profoundly affects the local sectors, that heavily rely on local spending.

In addition, it is clearly shown that the magnitude and composition of overall impacts on regional employment vary by the location of the shock. Even though the same amount of shock is given to the population, the effect is greater in the case of Frankfort village than the Sugar Grove village, probably for two main reasons: 1) Frankfort is more highly interconnected to other places in the region as a labor supplier and 2) the population shock given to the Frankfort affects the sectors in a manner that generates a larger ripple effects on regional employment. The differences in the composition can be partly explained by the differences in the industry mixes between the two municipalities and their associated communities (i.e. the places which have tight connections with the municipality). In other words, the Frankfort's larger share of Trade sector (18.2%), compared to that of the Sugar Grove (7.7%) may partly cause the larger impact on Trade sector in the case of Frankfort village.[49]

Table 5.6. The Effects of the Population Shock on Regional Employment by Sector

	The Case of Frankfort Village		The Case of Sugar Grove Village	
	#	%	#	%
Construction (Sector 5)	-63.9	11.5%	-54.1	11.3%
Manufacturing (Sector 6~23)	-42.4	7.6%	-36.3	7.6%
Trade (Sector 24~25)	-129.3	23.2%	-98.3	20.5%
FIRE (Sector 34~35)	-46.5	8.4%	-37.5	7.8%
Service (Sector 36~45)	-208.1	37.4%	-176.8	36.9%
All Other Sectors	-66.0	11.9%	-76.7	16.0%
Total	-556.2	100.0%	-479.7	100.0%

Table 5.7. Industry Mixes of the Region and the Two Municipalities

	Region as a Whole	Frankfort Village	Sugar Grove Village
Construction (Sector 5)	5.6%	10.6%	12.5%
Manufacturing (Sector 6~23)	9.5%	12.4%	12.7%
Trade (Sector 24~25)	20.2%	18.2%	7.7%
FIRE (Sector 34~35)	11.3%	8.5%	7.8%
Service (Sector 36~45)	41.2%	40.9%	43.2%
All Other Sectors	12.2%	9.3%	16.0%
Total	100.0%	100.0%	100.0%

Figure 5.14 demonstrates the long-run effect of the shock given in year 2006 on regional employment. The graph shows that the negative effect on regional employment will be quickly mitigated in several following years, when a shock is given to a particular year (i.e. Year 2006 in this case) only. This may be because the regional economic growth is largely determined by the

[49] But, for a more complete explanation, consideration needs to be given to the industry mixes of the associated communities and inter-industry linkages of the Chicago economy. In fact, a larger impact on Construction sector is found in the case of Frankfort village, even though the share of the sector is smaller there than the Sugar Grove.

exogenous national growth trends, and these are assumed to be unchanged. However, it is found that approximately 20% of the immediate effect will be remaining in the long term. First, this suggests that the full recovery will be difficult to achieve, when growth momentum is once disturbed by any shock. In addition, this implies that the negative effects will accumulate, if the shock will be imposed for a longer period of time, as opposed to a single year.

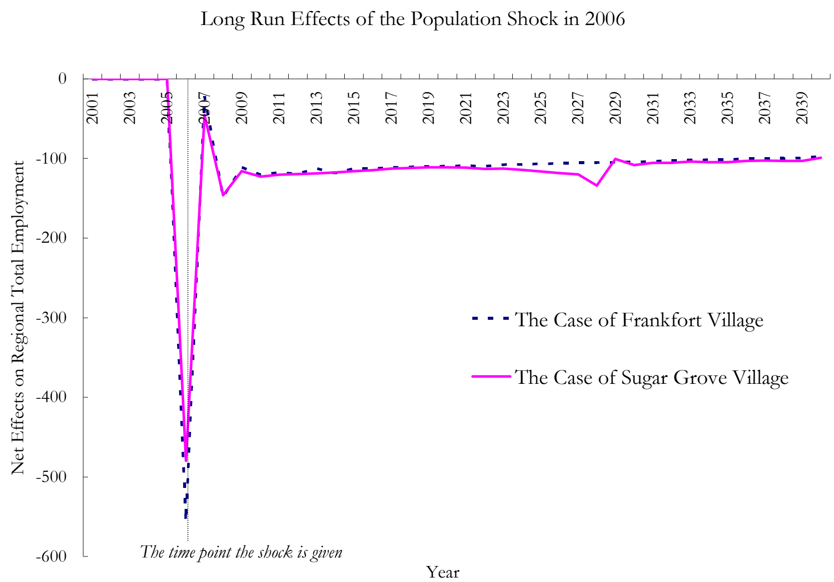
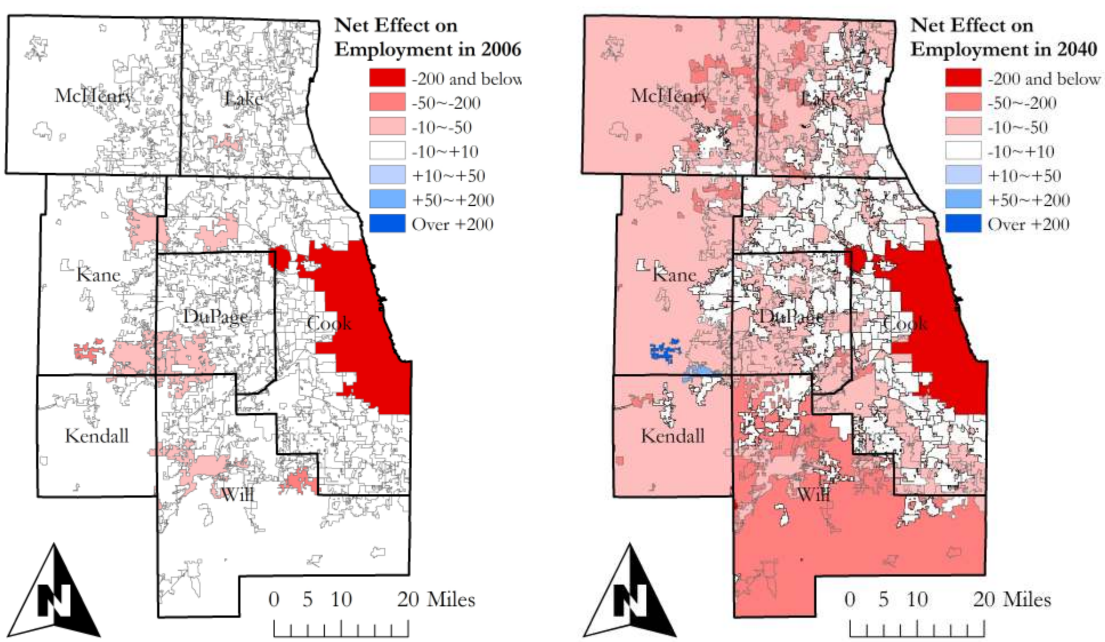


Figure 5.14. Long-run Effects of the Population Shock in 2006

5.4.3. Macroeconomic Impact Analyses of the Reactive Land Use Regulations

Finally, using the spatial REIM, the macroeconomic effects of the reactive land use regulations are assessed. As explained above, the minimum-lot-size requirements and permit caps are regarded as an upper limit of population growth, rather than a negative shock on population. In detail, to measure the effects, the upper bounds on year-by-year population growth rates are imposed in the 26 municipalities having such regulations according to the Wharton survey for all forecast years (i.e. between 2006 and 2040). Because detailed information about the degree of land use regulations in individual municipalities is not available, the model is run multiple times for different scenarios that represent different levels of the upper limits ranging from 5% to 10%. It is assumed that the level of the upper limit is same in all 26 municipalities in each scenario.

Figure 5.15 presents the effects of the regulations on employment by municipality, when the upper limit is set as 5% (i.e. population growth can be attained up to 5%/year in the municipalities with the regulations.). As shown, in 2006 (the first year with the restriction), the considerable negative impacts begin to appear in some municipalities, including Frankfort, Sugar Grove, Chicago, Aurora, Naperville, etc. As discussed in the previous section, these places are the villages where the projected rapid population growth is limited by the regulations or the cities that import the workers from the affected villages. Then, in 2040 (the last year in the simulation), it was found that the employment loss is dramatically expanded across space; most of the municipalities exhibit employment decline by more than 10 jobs due to the regulations implemented by a limited number of towns. This expanding negative effect is also clearly demonstrated in figure 5.16, that shows the long-run effects of the regulations on region-wide employment level. More specifically, net employment loss in the entire region will reach about 5,500 (approximately 0.1% of total employment) in 2040, if year-by-year population growth rates are bounded at 5% continuously in the 26 municipalities, due to the regulations. The figure also indicates that the magnitude of the effect depends on the degree of restrictiveness of the regulations.



The Net Employment Effect in 2006 *The Net Employment Effect in 2040*

Figure 5.15. The Long-Run Effects of the Regulations on Regional Employment

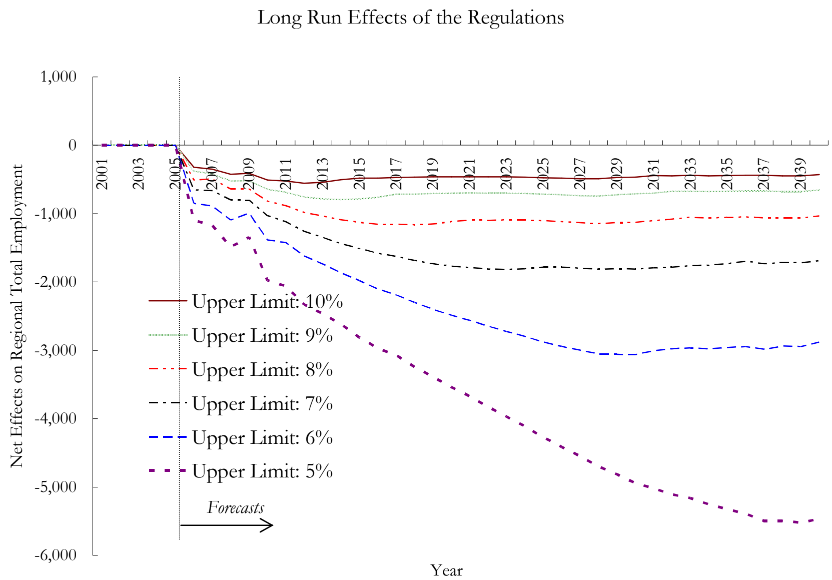


Figure 5.16. The Long-Run Effects of the Regulations on Regional Employment

Another finding to be noted is that some municipalities appear to achieve employment gains, compared to the baseline in 2040. Interestingly, the municipality, which achieves the largest job gain, is the Sugar Grove Village, one of the towns where population growth is limited by its land use regulation. As demonstrated in figure 5.17, although the village experiences a large negative effect in a short- and mid-term with a peak loss by about 1,500 in 2025, thereafter, the net effect starts to decline; and, at the end, its 2040 employment level with the land use regulation is greater than that in the baseline projection. This can be partly explained when attention is paid to the population growth trajectories of the village (figure 5.18). In the baseline scenario, its population rises very rapidly until 2025, but then is stagnant, perhaps due to the depletion of developable land which is found as an important determinant of local population increase in the modified RDAM estimation. Given this baseline trajectory, if the pace of population growth is controlled by the land use regulation, the village will be able to maintain the comparative advantage of larger developable land, which may be its major growth momentum, for a longer period of time and achieve extra population and employment growth in the long run. In this sense, the land use control can be a strategic action to enhance the long-run local growth. However, from the perspective of the region as a whole, such strategic behaviors of individual local governments may not be favorable, as confirmed by the found significant regional employment loss.

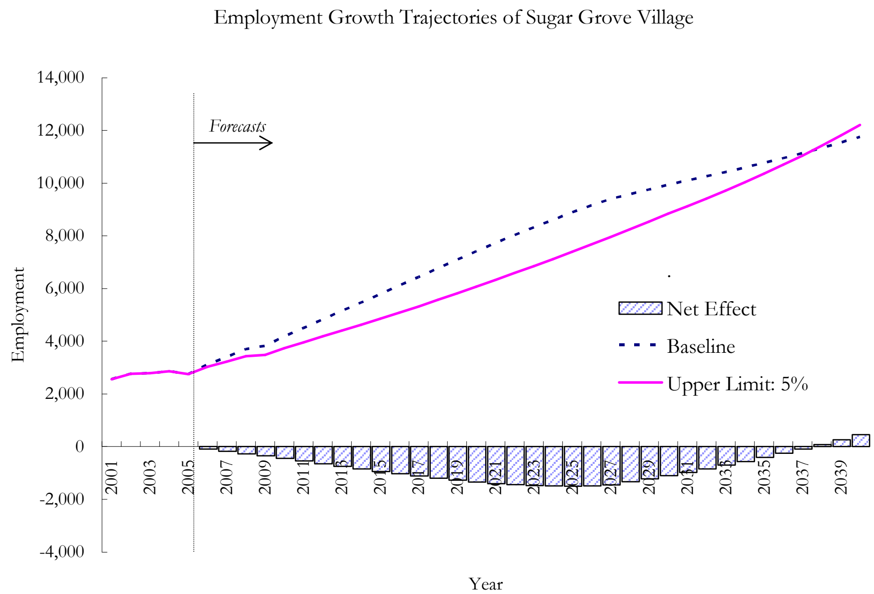


Figure 5.17. Employment Growth Trajectories of Sugar Grove Village

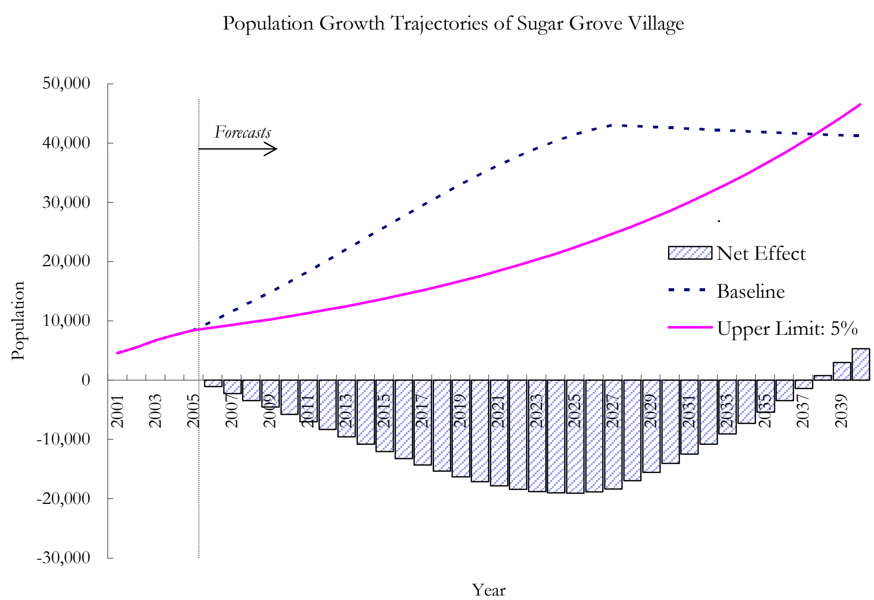


Figure 5.18. Population Growth Trajectories of Sugar Grove Village

Table 5.8 summarizes the effects of minimum-lot-size requirements and permit caps on main macroeconomic variables in the case of 5% upper limit. Consistent with the expectation, population, which is directly limited by the regulations, show the greatest percentage loss compared to the baseline. Although the magnitudes are smaller, the negative effects are found in all other variables, such as GRP, production, employment, and income. Particularly, as in the case of the prior experiments, local sectors' losses are larger than Manufacturing, which is relatively less dependent on household spending and local governments' expenditures. As demonstrated above, the regional economy will be affected more significantly if the regulations are implemented in a more restrictive manner. The larger impact is also probable, when a greater number of municipalities in the region use such reactive land use regulations for their own interests, as opposed to considering the overall region's prosperity.

Table 5.8. Macroeconomic Effects of the Regulations: Baseline vs. Upper Limit: 5%

	Year 2005	Year 2040			
		Baseline	Upper Limit: 5%	Net Effect	%
GRP	404,448	832,890	832,451	-438	-0.05%
Population	8,449,379	10,305,923	10,260,947	-44,976	-0.44%
Total Output	921,052	1,851,569	1,850,418	-1,151	-0.06%
Employment	4,813,568	6,309,561	6,304,096	-5,466	-0.09%
Construction (Sector 5)	269,899	324,307	323,968	-338	-0.10%
Manufacturing (Sector 6~23)	455,135	346,076	345,951	-125	-0.04%
Trade (Sector 24~25)	974,122	1,169,071	1,167,585	-1,486	-0.13%
FIRE (Sector 34~35)	541,939	752,546	752,246	-300	-0.04%
Service (Sector 36~45)	1,983,305	2,877,071	2,874,330	-2,741	-0.10%
All Other Sectors	589,168	840,491	840,016	-475	-0.06%
Personal Income	362,000	682,226	681,945	-282	-0.04%

Note: All monetary values are in 2005 chained million dollars.

5.5. Summary & Discussion

This study develops a new integrated multi-level simulation model, a spatial REIM, in which local- and lower-level dynamics are incorporated into a coupling-type REIM in a reciprocal interactive manner, as opposed to a top-down allocation process. The integration of the multi-level variables in a single framework expands the capabilities of the conventional REIM, which is a macroeconomic tool as it stands by facilitating the development of local-level forecasting and analysis.

In addition, with the established feedback connections from local layer to region-wide variables, the spatial REIM can support the analysis of the macroeconomic effects of local actions, particularly land use policies, for which most existing models based on a strict top-down approach, has limited usefulness.

The spatial REIM was applied to the Chicago metropolitan area in which about three hundred municipalities with their own local government authorities of, but highly interconnected with each other as a part of the large single economic system. Furthermore, the applied model is used to assess the macroeconomic effects of reactive land use regulations (i.e. minimum-lot-size requirements and building caps), which have been implemented in some suburban communities in the region. From the impact analyses, it was found that the regulations that bind local housing supply and population growth within the jurisdictions:

1) generate negative impacts, spread out over space and the economy through the labor supply chains and inter-industry linkages.
2) dampen the pace of regional economic growth considerably, although the actions are sometimes favorable to the long-run prosperity of the implementing, individual municipalities.
3) tend to induce disproportionate impacts on different sectors of the economy – i.e. local sectors, which heavily depend on household expenditures, are affected more seriously.
4) induce effects that vary substantially by the location of the implementation.

Although the new model and the impact analyses provide additional analytical capabilities for planning practices and a better understanding of the economic implications of land use regulations respectively, this study is not without limitations. First of all, when local growth dynamics are modeled in the Chicago application, attention is only paid to aggregated population and employment, as opposed to population by group and employment by sector. Without appropriate consideration of the heterogeneity among various groups of households and businesses, the model cannot effectively describe the complexity inherent in mobility and location decision-making processes that vary significantly by industry, firm size, population cohort, and income group. However, expanding the complexity of the system may generate instability in the model, as the number of structured equations in the modified RDAM is increased to capture increased heterogeneity.

In addition, the linear fashion of the RDAM formulation, adopted to model the local growth dynamics, is not ideal for describing the intrinsic non-linearity of a dynamic metropolitan system. Again, the challenge is the model stability, which is more difficult to be attained with non-linear forms of dynamic equations.

Moreover, the present version of the spatial REIM employs a modified RDAM, where the spatial interdependence is represented by a fixed spatial weight matrix, even though it is questionable that the matrix is a proper representation of true interdependence among municipalities over a long period of forecast years. The simple cell-level updating module, as opposed to a more advanced simulation method, is another limitation of the present application. Generally poor availability of local level economic data is also a challenge to be overcome to better calibrate the model.

Future research will seek to figure out the effective ways to address these limitations and challenges in modeling and applications. It is expected that the model will be improved and become a more competitive analytical tool to fully describe the complexity and dynamics of spatial economic systems. Then, it will be able to better support various impact and policy analyses and facilitate informed decision makings.

6. SUMMARY & DISCUSSION

6.1. Summary of the Overall Dissertation Research

While changes in the regional economy are sometimes taken into account in connection with land use changes and the evolution of spatial structure, the reverse connection is rarely, if at all, studied. To address this shortcoming, throughout the three pieces of research as well as a literature review in this dissertation, I examine how a regional economy is influenced by interventions in land development which significantly affect its property markets and overall spatial structure.

The first study empirically analyzes the potential negative effect of strict land use regulations on household residential mobility. Here, a correlation analysis first reveals that the metropolitan areas, where strict land use regulations were implemented in late 1980s, are more likely to exhibit a lower correlation between intraregional population and employment changes and an increasing mean commuting time between 1990 and 2000. In addition, the spatial econometric analysis using a regional disequilibrium adjustment framework shows a lower population adjustment rate in the regulated regions, which implies lower household mobility in the areas. The findings suggest that strict regulatory barriers to land development may freeze the local housing supply and dampen household residential mobility within the region. The affected mobility itself may indicate the reduced utility of residents. Further, it induces greater spatial mismatches and longer commuting, which may significantly reduce the efficiency in the operation of the regional economic system.

In contrast, the second study empirically investigates the potential contribution of land use planning to uncertainty reduction and a more economically efficient use of land by focusing on the case of urban fringe land markets where agricultural production is operated under the uncertainties regarding the timing of potential land development for urban uses. According to the analysis of land use data in Oregon, the UGBs seem to inform farmland owners' decision making. Furthermore, a cross-sectional regression analysis using data for 82 single-county MSAs detects a positive effect of UGB on agricultural investment levels, suggesting the real contribution of the

UGB to uncertainty reduction. The UGB's effect is found to be statistically significant where larger shares of livestock and fruit are produced so that farmers are more likely to require information regarding the timing of development to reduce the risk of overinvestment.

The third study assesses the macroeconomic effects of minimum-lot-size requirements and building permit caps that have been implemented by some of the suburban communities in the Chicago metropolitan area. This is accomplished by employing a new integrated simulation model in which region-wide, local, and cell-level variables are interacted with each other in a reciprocal manner, as opposed to traditional 'top down' approach. The restrictive regulations are found to impede regional economic growth by constraining local housing supply and population growth within the places, although the regulations sometimes enhance the long-run prosperity of the implementing, individual municipalities.

6.2. Policy Implications of the Findings

The implications of the findings for land use planning and policy reform appear great. By showing some empirical analysis outcomes that suggest the negative effect of strict land use regulations on local housing supply and household residential mobility, the study on land use regulations and intraregional job-people interactions cautions land use planners or policy makers. Also the study raises an important issue: how can we minimize the delay of the development process and impact on housing supply, while maintaining the contribution of interventions to addressing market failures and realizing a well-organized spatial structure? Is it desirable to add another layer of regulation (e.g. mixed use zoning or affordable housing requirements) to deal with the problem? Alternatively, do we need to remove some of the regulatory barriers? What type of institutional reform will be effective in shortening the delay of the development process? Do we need to advocate market-based approaches over traditional location-specific regulations? Future research that tackles such questions may be helpful for shedding light on this important issue.

The second study emphasizes the benefits of land use planning practice with respect of information production and distribution, which have been largely ignored. Given that land markets and development processes generally bear significant transaction costs due to intrinsic uncertainties, we need to pay more attention to how we can reduce the uncertainty and realize a more efficient development process and land use effectively through land use planning practice. In this regard, planners need to make an effort to identify and target the situations in which uncertainties and transaction costs prevent an efficient use of land resources. For instance, they need to think about why many brownfield sites are less likely to be redeveloped. Do we have to facilitate redevelopment only by using financial incentives? Or, can we deal with the problem effectively by addressing the lack and asymmetry of information regarding the sites? Moreover, we need to seek a better institutional arrangement in which information is more efficiently produced and distributed.

The third research also provides some lessons for planners and policy makers. Given that land use controls in a particular municipality are found to have significant effects on other places and the overall regional economy, land use planning practice and regulation enforcement at local level needs to be better coordinated and conducted with proper consideration of region-wide concerns. This is required not only for unregulated places but also for the municipality itself, because every locality as a part of the regional economic system, highly interrelated with each other, so that a negative effect spilling over to others is likely to return. The third study highlights the analytic needs for dealing with the interrelationships among municipalities and 'land use – regional economy' interactions. Without an analytic tool, in which the behavior of a spatial economic system is well described, it is difficult to assess the potential effects of various policy options and, consequently, hard to attain informed policy decision making that is essential not only for effective land use management but also for regional economic development.

One final point to be stressed is that the economic consequences of land use planning and regulations are found to highly depend on context. As presented in the study on the contribution of land use planning to uncertainty reduction, the UGB's positive effect on agricultural investment is more likely to be realized in the regions where the items that require a large amount of sunk costs and a long period of operation are mainly cultivated. The real economic benefits of the UGB in farmland use may be very small in crop-dominant contexts, although its contribution with many other aspects would exist. In addition, as discussed and demonstrated in chapter 5, the effect of minimum-lot-size requirements and permit caps significantly vary by the location and time of the intervention.

This suggests that linking land use planning and regulation to economic development requires context-based management of land use that promotes potential positive effects and/or dampens negative effects of interventions rather than simply reducing government interventions in land development or trying to articulate a one-size-fits-all policy approach. To achieve a more systematic coordination of economic development and land use planning, attention needs to be paid to how and why policy outcomes vary by context. In what circumstances are containment programs more likely to bring a greater efficiency gains in public service provision or agglomeration benefits, rather than generating housing affordability problems? When does mixed-use zoning really contribute to reducing auto-based travel, rather than merely acting as an additional regulatory barrier? To what degree and how can state or regional government bodies lead and guide local land use planning practices in order to facilitate the systematic cooperation of localities, rather than harming local autonomy? Future research to answer such questions is needed in order to fully understand the relationship between land use policies and regional economic development.

6.3. Limitations and Future Research

The present dissertation research finds a set of significant causal links from land use to the performance of regional economy. In addition, as explained above, the findings provide meaningful policy lessons and highlight the issues that need to be considered in order for us to improve current land use planning practice. However, the studies are not without limitations.

As noted in chapter 3, the first study suffers from the invalid estimation outcomes for many metropolitan areas, so that the results are not fully conclusive. In addition, the causality (i.e. whether the strict land use regulations are really responsible for the lower household mobility in the areas or not) is still remaining untested, although the evidence suggests that this may be the case. The design of the spatial econometric analysis, where only aggregate population and employment are considered, also needs to be extended to better assess heterogeneous household and business mobility and their location choices. Moreover, the measurement of the land use regulations, namely a single index, is another limitation of the study to be improved in the future research.

Similar limitations exist in the second study. Although the UGB may qualitatively differ by regions, the UGB establishment practice is considered by using a single dummy variable. The use of investment in “machinery and equipment” as dependent variable is also an unsatisfactory feature of the regression analysis, stemming from the data availability, because this type of investment is relatively less irreversible compared to long-term soil improvement or building construction for agricultural purposes.

Although the third study develops a new analytic framework, which can be employed for the economic impact analysis of local land use policies, the Chicago application as well as the model itself needs to be extended in many respects, as discussed in the discussion part of chapter 5. Particularly, the spatial REIM can better support planning practices, once it can properly deal with various groups of households and businesses, the non-linearity of growth dynamics, the evolving spatial interdependence among the municipalities of interest, etc.

Future research will strive toward overcoming these limitations of each study. Further, attention also will be paid to the policy questions derived from the findings of these studies. By doing this, it will be possible to obtain a better understanding of the ‘bottom-up’ causal connections of how a change or intervention in land use influences regional economic performance. Then, land use planning practice and economic development initiatives can be coordinated more systematically, leading a more complete realization of urban development that is economically prosperous and, at the same time, ecologically sustainable.

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