THE EFFECTS OF LOCAL ECONOMIC AND ENVIRONMENTAL POLICIES ON COUNTY POPULATION AND EMPLOYMENT GROWTH

DISSERTATION

Presented by Partial Fulfillment of the Requirements for

the Degree Doctor of Philosophy in the Graduate

School of The Ohio State University

By

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The Ohio State University
2006

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ABSTRACT

This study explores the effects of local economic development policies and environmental policies on county population and employment growth in the US. Local environmental policies are policies adopted by counties to control unplanned growth. Using a monocentric city model, growth control is shown to have a negative effect on population growth. The model suggests that optimal growth control policies depend on the policies of neighboring counties, on the strength of agglomeration economies, and on the degree of congestion resulting from population concentration.

Aspatial and spatial analysis are conducted to explore the relationship between population and employment growth. Environmental policies and economic development policies are found to be endogenous, and instrumental variables are used to address this problem. An extended weight matrix is constructed to overcome the problem of spatial discontinuity of the sample data due to nonresponse.

Estimates from the spatial models using the contiguity weight matrix and the inverse distance weight matrix are consistent with expectations. The main findings are: (1) local environmental policies have negative effects on population growth of both metro and nonmetro counties and positive effects on employment growth of metro counties but negative effects on employment growth of nonmetro counties; (2) local economic development policies stimulate employment growth but have no effects on population growth; (3) initial population level has a positive effect on population growth, while initial employment level has nonpositive effects on employment growth; (4) manufacturing industry concentration is negatively associated with employment growth while retailing industry concentration is positively associated with employment growth; (5) population density is negatively associated with population growth but has no effect on employment growth; (6) and people follow jobs and jobs follow people.

Dedicated to my wife and parents

ACKNOWLEDGMENTS

I want to express my warmest thanks to my committee for their support, contributions and encouragement while I was conducting this research. David Kraybill enriched my knowledge of regional economics and public finance through innumerable valuable critiques and constructive suggestions. He also taught me the importance of editing and contributed time generously in offering suggestions for the revision of my manuscript. Elena Irwin extended and deepened my understanding of spatial econometrics with her breadth of knowledge and experience in spatial research. Linda Lobao provided insightful suggestions on how to inspect and clean raw data statistically. I am grateful to Brent Sohngen for his suggestions concerning the use of air pollution data. I am also indebted to Alan Murray, who suggested considering congestion effects in the regression.

I cannot express enough gratitude to Larry Libby, who supported me financially for the first several years of my Ph.D. studies. I acknowledge gratitude to the Environmental Protection Institute (EPI) for providing a year of funding for this research.

Appreciation is expressed to Ji Tao, Xu Lin and Siyang Xiong for sharing new findings in spatial econometrics and keen perspectives on microeconomic theories.

Finally, I wish to express my deepest thanks to my wife, Hua Sheng. Her support and encouragement was the source of my strength in the final stages of the dissertation.

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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation or Acronym	Definition
CBD	Central Business District
D-W	Dubin-Watson
EPA	Environment Protection Agency
ERS-USDA	Economic Research Service, US Department of Agriculture
FGS2SLS	Feasible Generalized Spatial Two-stage Least Squares
GAO	General Accounting Office
GIS	Geographical Information Systems
GLS	Generalized Least Squares
GMM	Generalized Method of Moments
GS2SLS	Generalized Spatial Two-stage Least Squares
ILS	Indirect Least Squares
LIML	Limited Information Maximum Likelihood
MAD	Median Absolute Deviation
MLE	Maximum Likelihood Estimator
MSAs	Metropolitan Statistical Areas
NAC	National Association of Counties
OLS	Ordinary Least Squares
PDR	Purchase of Development Rights
SAR	Spatial Autoregressive
TDR	Transfer of Development Rights
SD	Standard Deviation
2SLS	Two-stage Least Squares
3SLS	Three-stage Least Squares

CHAPTER 1

INTRODUCTION

Local governments play an important role in the national economy, particularly when they are authorized by federal governments to adopt and implement economic and environmental policies in their own jurisdictions. Fiscal federalism, introduced in the United States through various acts of Congress and administrative actions of federal agencies over several decades, gives local governments the responsibility for providing a wide range of public services and for raising revenue locally. This expansion of local fiscal responsibility, in turn, creates incentives for local governments to employ policy measures to stimulate the local economy. In addition to receiving grants allocated by federal or state governments, local governments attempt to enrich their budgets by levying taxes on property, income, and sales and charging user fees for services. Not only fiscal authorization but also development and management of national resources are delegated to local governments. For example, under the amendments of the Clean Water Act passed in 1972, they are entitled to control the usage and conservation of land and water resources directly. It seems likely that local policies have a significant influence on the influx and exodus of capital and other resources across jurisdictions. In the aggregate, local policies may influence national growth.

When economic growth is associated with urban sprawl, local governments are often forced to focus on environmental protection measures rather than simply economic stimuli. Urban sprawl is a major impetus of farmland loss, a deteriorating regional environment, and congested communities. Because markets fail to constrain unplanned spatial expansion, local governments often attempt to control growth. Brueckner (2001) argues market prices fail to include the implicit social cost of public goods such as open space, congestion and new infrastructure, which leads to urban sprawl. A recent General Accounting Office (GAO) survey reports that 53 percent of counties and 35 percent of cities have officials or residents who are highly concerned about sprawl and are interested in adopting stringent land use and amenity conservation plans[1]. Most counties have a comprehensive development plan and watershed protection policies. Counties in some states such as New Jersey, Maryland and Rhode Island have allocated funds for programs such as purchase of development rights (PDR) and transfer of development rights (TDR) to reduce the rate of farmland loss in the future. Zoning is popular at the county, township and community level for regulating the usage of land.

The national economy experienced a relatively long period of economic growth from 1990 to 2000. The most rapid growth during this period was concentrated in the western and southern regions, which competed against other parts of the country and absorbed capital and labor for development. Population in metropolitan areas grew faster than that in non-metropolitan areas. Despite the overall growth, regional economies performed in an uneven pattern. Continuous growth in some regions, such as New Jersey, aggravated

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[1] Detailed information is available at http://www.gao.gov/new.items/rc00178.pdf, GAO/RCED-00-178, "Local growth issues – federal opportunities and challenges".

local social and environmental problems. At the same time, other counties experienced no growth or negative growth in their economies.

This dissertation examines the determinants of uneven regional growth, focusing especially on the growth impacts of local economic and environmental policies in the 1990s. The focus here is on population and employment growth rather than population and employment density growth. Density variables account for spatial factors such as urban sprawl, congestion and agglomeration economies. Many studies of suburbanization and regional growth utilize density change to represent growth (Carlino and Mills 1987). Some empirical studies conclude that population density is more useful than population level in characterizing urban versus rural dimensions of growth (Berry et al. 2000). However, in my view, marginal effects of most variables on growth have more interpretive power in level change than in density change. Density is related to land use patterns, and it is heterogeneous and difficult to measure within counties. Therefore, it is appropriate to focus on population and employment growth.

Local economic and environmental policies may have a direct impact on employment and population growth. Local economic policies such as property taxes and income taxes and other economic programs affect firms' profits and households' disposable income directly and indirectly. Environmental policies, whether national, state, or local, may improve local amenities and benefit residents. Besides local policies, demographic, economic conditions and social amenities are likely to affect the pattern of local economic growth.

The origin and scope of local policies can be best understood in the context of fiscal and environmental federalism. To this end, section 1.1 describes the theoretical foundations of fiscal and environmental federalism. Section 1.2 discusses the relationship between environmental policies and economic growth. Section 1.3 explains the importance of focusing on county studies. Section 1.4 lays out the hypotheses this study will test. Section 1.5 is a statement of the research problem on which this dissertation focuses. Section 1.6 states the research objectives of this dissertation. Section 1.7 discusses the empirical models used to analyze the growth effects of local policies. Section 1.8 describes the organization of the dissertation.

1.1 Fiscal and Environmental Federalism

The "new federalism" was introduced by the Nixon administration, institutionalizing and extending various administrative reforms. Selected welfare, health care, housing, and environmental programs were delegated to state and local governments. For example, under the Clean Air Act of 1972, air quality standards are set at the federal level by the Environment Protection Agency (EPA) but implementation is delegated largely to state and local government authorities. Land use and regulation of other resources are primarily the responsible of local jurisdictions. Other industrialized countries such as the United Kingdom, Italy and Germany have also decentralized regulation to some extent, though the particular nature of federalism varies a great deal across countries.

Why do governments decentralize? Economic arguments in favor of fiscal and environmental federalism emphasize welfare gain and efficiency improvement induced by this policy. Instead of uniform provision of public goods in all local jurisdictions, fiscal devolution can produce different packages of public goods suited to the needs of heterogeneous residents and firms. It reduces the deadweight loss of taxation (Oates

1972, 1997). Local governments may be more competent than the federal government to manage local growth because asymmetric information and heterogeneous preferences of residents and firms make it difficult or impossible for the central government to react quickly or to match the actual supply of public goods with the unrevealed but implicit demand for these goods.

Participation incentive is an important consideration in putting fiscal and environmental controls at local disposal. A local government is motivated to use competitive taxation to attract businesses to relocate because the increased tax base enriches local budgets and increases the political power of local officials. Environmental policies, mainly land use and water preservation policies, are passed either because of a desire to control growth in the future or because of conflicts arising from past or current patterns of development deemed to be undesirable. The interaction between local government and local residents and the interaction among local governments may result in a more efficient outcome than could be achieved by centralized policies.

Spillovers across units of local government may reduce the efficiency of decentralization. Local jurisdictions and countries may race to the bottom to attract business in adopting environmental regulations (Cumberland 1981, Kim and Wilson 1997). Esty (1996) argues decentralization may not achieve efficiency in controlling spillovers when transaction costs and technical requirement are really high for internalizing externalities across jurisdictions. Inman and Rubinfeld (1997) contend that recognizing the potential coordinating role of the central government is an important aspect of federalism that should be considered when dealing with issues of interjurisdictional spillovers of public goods.

1.2 Local Environmental Policies and Economic Growth

There are two opposite views about the effects of environmental policies on economic growth. Some researchers presume stringent environmental regulations have a negative impact on economic growth because these regulations may increase the production costs of polluting firms and make them uncompetitive in domestic and international markets. For example, Garofalo and Malhotra (1995) find stringent regulations have a negative effect on firms' investment capability. Other authors, such as Oates (1999), contend local amenities are important public goods, and therefore stringent environmental policies will not necessarily diminish the attractiveness of the locality to firms and residents. Especially for high-technology firms, these policies may not deter their formation or growth.

Empirical studies indicate that stringent environmental policies impede economic growth by thwarting the expansion of polluting industries. Areas with stringent environmental policies are observed to have less polluting industries and a low birthrate of polluting industries. Stringent environmental regulations also have been found to affect the relocation decision of domestic and foreign investments and branch location decisions of large firms.

1.3 Need for a Focus on Counties

A local government focus is important, first, because of the variation in local government environmental policies. Counties also differ greatly in their resources, population characteristics, and histories. The large number of counties in the U.S. represents, effectively, a laboratory to determine the effects of various policies. Second, in a system of decentralized governance, local governments may react not only to local conditions and to the preferences of local voters but they may react also to the policy choices of neighboring local governments. If local governments interact strategically in their choice of environmental and economic policies, a focus only on higher levels of geography, such as the state or the nation, would yield biased results in measuring the effects of local policies. Third, counties cover the entire surface area of most states, allowing the researcher to explore spatial interactions among metropolitan and nonmetropolitan areas.

Most previous research on the growth impacts of environmental policies has focused on federal or state environmental policies. This study, therefore, addresses a gap in the literature by focusing on local environmental policies, especially land-use policies, which typically attempt to regulate resource use in particular geographical areas.

County data are readily available and easy to use. The U.S. Census has published a wide range of county demographic and economic data over the past four decades. County boundaries are quite stable compared with those of metropolitan areas and did not change much in the 1990s, the period studied in this dissertation.

1.4 Problem Statement

In a decentralized system of governance, local governments are potentially important makers, implementers, and enforcers of environmental policies. Localities differ greatly in natural resources, industries, demographics, political preferences and location, leading to large differences in policies. To understand the effects of local government policies, analysis must be conducted at a geographical scale that matches the jurisdictions of these governments.

Previous empirical studies of employment and population growth have focused on various economic and social factors, including natural amenities, but the growth effects of local economic and environmental protection policies have not been examined in a systematic manner. Since land use policies and planning processes are pervasively employed by local governments, it is relevant to study their effects on local population and employment growth.

Small geographical areas are interdependent in several ways. Land use patterns in one locality may influence land use in a neighboring locality. Water and air pollution may flow across locality boundaries. Furthermore, environmental and economic policies chosen by one locality may influence the choice of policies by neighboring localities for reasons of either defense or offense. Relatively few previous county growth studies have taken spatial interaction arising from local environmental policies into account. This is a shortcoming because failing to account for spatial spillover effects may influence empirical analyses of these policies a great deal.

The direction of causation between population growth and employment growth is not clear on theoretical grounds. In the empirical literature, there is no consensus on this question, due to the use of different datasets, methods and periods. It seems likely that population and employment are jointly determined, and models used to study growth should allow for the possibility of simultaneity.

1.5 Hypotheses

Six hypotheses are tested in this study to address the questions posed in the problem statement:

(1) County environmental (growth control) policies impede population growth but do not affect employment growth.

(2) County economic policies have a positive effect on employment growth but no significant effects on population growth.

(3) Initial population, population potential, employment and employment potential have a positive effect on growth.

(4) Manufacturing industry concentration and retailing industry concentration have significant positive effects on employment growth.

(5) Counties with high population density are expected to have less population growth than that those with low population density.

(6) People follow jobs and jobs follow people. That is, employment growth has a positive effect on population growth and population growth has a positive effect on employment growth.

1.6 Research Objectives

The objectives of this study include the following: (1) to identify the key economic, demographic, and amenity variables that contributed to county economic growth in the United States in the 1990s; (2) to construct indices of county environmental and economic policies from survey data that capture observed differences in county policies and estimate their effects on population and employment growth; (3) to test for endogeneity of policy variables, and if endogeneity exists, correct for it using appropriate instrumental variables; and (4) to compare results from an aspatial model with those from a spatial model.

1.7 Brief Description of Models

Two distinct types of econometric models are used in this study. One is an aspatial simultaneous equations model and the other is a spatial simultaneous equations model. The spatial model is used to correct for spatial correlation and to take into account the spillovers of employment and population among neighboring counties.

Aspatial models have often been used in surburbanization and county growth studies. Spatial interaction is not accounted for in this type of model. Though the model is simplistic, it is a useful step prior to estimating the spatial model.

The spatial model extends the simple aspatial model by including spatial spillover effects. By controlling for spatial interactions, this model gives a more realistic view of the determinants of county growth than the aspatial model.

1.8 Organization of this Dissertation

Chapter two reviews the literature on regional growth and local environmental policies. This body of literature is chosen to focus on the problem statement, hypotheses, and objectives described in chapter one. Chapter three discusses theoretical and methodological foundations for the relationship of local environmental policies and regional growth. Chapter four presents the empirical model used in this study and the method of estimation. Chapter five presents the econometric results and compares them with the results of previous studies. Chapter six concludes empirical analysis by summarizing the findings of this study and discussing policy implications of the findings.

CHAPTER 2

LITERATURE REVIEW

Rapid urban sprawl and environmental federalism have stimulated interest in studying the role of local governments in environmental protection. Many older studies focused on the role of local governments in economic growth, but as the debate on quality of life and sustainable growth has become increasingly intense, recent regional economic studies have been concerned with environmental policies. Some researchers pay attention to the potential conflict between environmental protection and economic growth and focus on horizontal competition of local governments. Other researchers examine whether current environmental protection policies are efficient and whether they are a feasible way to control growth.

The purpose of this chapter is to review empirical studies of regional growth and to highlight how local economic policies affect growth. Second, the chapter clarifies the relationship between environmental protection and economic growth and examines the effects of local environmental policies on growth. Third, the chapter discusses how local governments interact with each other strategically in making policies. Literature chosen for review in this chapter is conducive to understanding the empirical model used in the later chapters.

To this end, section 2.1 introduces simultaneous models of employment and population growth. Section 2.2 is devoted to describing how local economic policies affect employment and population growth. Section 2.3 discusses the effects of local environmental policies on employment and population growth. This section also explores how local governments interact with each other in making environmental policies and the relationship between environmental policies and economic stimuli.

2.1 Simultaneous Models of Employment and Population Growth

Simultaneous models of employment and population growth are derived from urban and regional growth theories. The earliest urban growth models assumed regional growth was determined by the exogenous growth rate of labor. Migration behavior was not considered[2]. Muth (1968) realized the shortcoming of these models and extended them by specifying an endogenous relationship between net migration, total employment, wage rate and natural population growth. All these studies keep the one-way causality assumption that employment location affects residence location but not vice versa. Most strikingly, the role of space and government in growth is overlooked (Goldstein and Moses 1973). Steinnes and Fisher (1974) introduced a simple model recognizing the simultaneity of employment and population growth in spatial and time dimensions[3]. The model is based on the assumption that employment and population in a region are in

[2] Growth pole theory (Nichols 1969) and the economic base model (Richardson 1973, Tiebout 1956b) are rooted in the input-output model (Armstrong and Taylor 2000) in which growth occurs due to exogenous demand shock. Factor supply is assumed to be perfectly elastic, which amplifies the multiplier effect of the demand shock.

[3] Steinnes and Fisher express their model as follows: (1) $E = f(P, \overline{P}, X_1, \overline{X}_2) + \mu_1$, (2) $P = f(E, \overline{E}, \overline{X}_1, X_2) + \mu_2$, where E is employment, P is population, and X represents exogenous variables that affect employment and population growth. An upper bar on a variable indicates the potential level of the variable. The model is extended by disaggregating employment and population sectors in empirical studies (see Steinnes and Fisher 1974, Cooke 1978, Thurston and Yezer 1994).

equilibrium. The shortcoming is that the equilibrium point was unknown and empirical studies often assumed the latest observation was in equilibrium. Mills and Price (1984) revised the model to specify a rate of adjustment from the current state to the equilibrium of employment and population growth[4]. This model was further revised by Carlino and Mills (1987) to refine the relationship between employment growth and population growth[5]. Although Steinnes and Fisher, as well as Carlino and Mills, considered the spatial commuting patterns of residents, they did not account for the spillover effects of neighboring regions directly in the model. Boarnet (1994) augmented the Steinnes-Fisher model to include spatial spillover effects[6]. Influences of spatial spillover effect and temporal growth effect are identified and tested for empirically in this model. Henry et al. (1999a) developed a spatial autoregressive (SAR) version of the Carlino-Mills model to study rural-urban linkages in the economic development process[7]. Henry et al. (1999b) subsequently extended Boarnet's model, including both urban growth and rural growth rates, to examine the spread and backwash effect of urban economic growth[8]. The literature on migration includes models with other endogenous factors, such as income,

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[4] Mills assumes $Y_t - Y_{t-1} = \lambda(\bar{Y} - Y_{t-1})$, where Y stands for E and P and λ is the adjustment rate. The model is simplified as (1) $E_t = f(P, E_{t-1}, X_1) + \mu$, (2) $P_t = f(E, P_{t-1}, X_2) + \mu_2$.

[5] Carlino-Mills model is: (1) $\Delta E = f(\Delta P, E_{t-1}, X_1) + \mu$, (2) $\Delta P = f(\Delta E, P_{t-1}, X_2) + \mu_2$, where Δ stands for the first difference.

[6] Boarnet expresses growth as: $\bar{Y}_t - \bar{Y}_{t-1} = \lambda(\bar{Y}^* - \bar{Y}_{t-1})$, where $\bar{Y}_t = (I + W)Y$ is short run employment and population growth potential. Y stands for E and P, and λ is adjustment rate. The final model is (1) $\Delta P = f((I+W)\Delta E, (I+W)E_{t-1}, P_{t-1}, X_1) + \mu_1$; (2) $\Delta E = f((I+W)\Delta P, (I+W)P_{t-1}, E_{t-1}, X_2) + \mu_2$.

[7] The model is expressed as follows: (1) $P_t = f(WP_t, E_t, P_{t-1}, E_{t-1}, X_1) + \mu_1$; (2) $E_t = f(WE_t, P_t, P_{t-1}, E_{t-1}, X_2) + \mu_2$.

[8] Their model can be simplified as: (1) $\Delta P = f(X_1, (I+W)\Delta E, P_{t-1}, g_1, g_2)$, where g1 (g2) is the urban center (urban fringe) employment growth rate; (2) $\Delta E = f(X_2, (I+W)\Delta P, E_{t-1}, h_1, h_2)$, h1 (h2) is the urban center (urban fringe) population growth rate. This model gives detailed information on the spatial linkages between the urban center, the urban fringe and the rural hinterland.

gross migration, and unemployment (Greenwood and Hunt 1984). All these models are applied to explore the pattern of regional economic growth.

Whether people follow jobs or jobs follow people is one of main tests conducted using simultaneous growth models. This test has been carried out often in suburbanization studies. Many studies support the hypothesis that jobs follow people[9]. These studies conclude population decentralization causes suburbanization of manufacturing. Some studies conclude that jobs follow people and people follow jobs. For example, Thurston and Yezer (1994) find employment suburbanization of industries such as transportation, communication and public utilities and service sectors induces population to move to the suburbs. Population growth in the suburbs also causes employment growth in the service and retail sectors. Henry et al. (2001) compare all the above models and reach different conclusions on causality. They find the Boarnet and Henry et al. models support the hypothesis that "people follow jobs" but the Boarnet SAR model supports the "jobs follow people" hypothesis.

This inconsistency may be due to data differences and structural change of industries in the suburbs. More fundamentally, however, industrial structure has changed dramatically in recent years as the retail industry and service industry have replaced the manufacturing industry as the main source of growth. As the newly dominant industries expand in the suburbs, people may follow jobs to lower the transportation cost of commuting and shopping. This is consistent with the observations of duo-centric or multi-centric urban growth models (Henderson and Mitra 1996).

[9] Studies by Steinnes and Fisher (1974), Cooke (1978) and Mills and Price (1984) support this conclusion.

2.2 Local Economic Policies and Growth

Many factors have been found to affect local economic growth. For example, climate is a critical factor in determining quality of life and it affects interregional migration (Haurin 1980, Carlino and Mills 1987). In addition, unique resources such as a port can stimulate the formation of firms and concentration of firms and residents can further accelerate growth through agglomeration economies (Krugman 1991b). The crime rate and other social disamenities are also found to affect population distribution among different areas (Bradford and Kelejian 1973). All these factors contribute to employment and population growth at the aggregate level. This section deals with factors related to local economic policies, because these factors have important policy implications.

Local governments play an important role in economic growth. Local governments stimulate growth through economic policies which include not only fiscal policies, but also facilities and programs such as industry parks, enterprise zones, worker training and small business development programs, etc. (Bartik 1995).

Many studies of local fiscal policies on employment and population growth are based on the Tiebout model. Tiebout argues that different packages of local public goods and per capita tax determine the migration of residents and the equilibrium distribution of footloose residents reflects their preferences for local policies (Tiebout 1956a). While the original Tiebout model characterizes the behavior of governments and consumers, it can be readily modified to explore the relationship between governments and firms (Mieszkowski and Zodrow 1989).

The income tax and property tax are two main fiscal instruments used by local governments to finance public infrastructure (Kay 1990). Theoretical models imply local taxes may have different effects on economic growth depending on whether the taxes are distortionary or not. Samuelson (1954) presents a formula for governments to raise public goods optimally with lump-sum taxes. But since no appropriate institutional arrangement is available general to ensure that the optimal tax is chosen and markets for public goods fail due to nonexcludability, Samuelson's allocation is not generally possible (Davis and Whinston 1967). Diamond and Mirrlees (1971) derive the second best outcome of commodity taxation given that it is distortionary, and Mirrlees (1971) explores how to impose optimal nonlinear income taxation. Because of asymmetric information between governments and consumers, these optimal taxation rules, generally, are not applicable and result in distortion.

The efficient outcome in the Tiebout model can be achieved sometimes even if the tax instruments are not lump-sum taxes. Local property or income taxes can be benefit taxes, which are capitalized into property values and consumers self-selectively choose location according to their preferences (Oates 1969). Hamilton (1975) shows that binding zoning which segregates different income groups can allow the property tax to work like a head tax in the Tiebout model. Mieszkowski and Zodrow (1989) contend the property tax can be distortionary if zoning is not perfectly binding and will cause capital to move out of a region.

Empirical studies indicate local taxes have non-positive effects on population and employment growth. Carlino and Mills (1987) find local government tax per capita has no impact on county population growth. Mills and Price (1984) find high taxes in central cities are not factors causing people and employment to move to suburbs. Enchautegui (1997) studies the effect of immigration on county economic growth, and his results indicate high tax effort per capita in a county has a negative effect on both native and foreign population growth. Deitz (1998) finds higher commercial tax rates decrease employment growth of the service industry and the sales business, but higher tax rates have no significant effects on employment growth of executive, professional or technician occupations.

Public investment on transportation and education has a critical impact on local economic growth. Growth pole theory contends better transportation improves the interaction between the growth pole and the hinterland, which implies public infrastructure investment may spur the economy in satellite cities (Hirschman 1958). Public capital stock research often treats public capital as an input to private production, and it may have a positive effect on economic growth depending on whether or not the public capital stock is optimal (Meade 1952, Aschauer 1989). The monocentric city model (Alonso 1964, Mills 1967, Muth 1969) indicates transportation cost has a critical impact on the location decisions of firms and residents.

Empirical studies provide evidence that local public infrastructure investment is critical in economic growth or development. Most studies confirm local transportation systems have a positive effect on firm formation and employment growth (Bruinsma et al. 1997, Rives and Heaney 1995, Munnell 1990). Libraries and education are also shown to be conducive to local population and employment growth (Beeson et al. 2001).

There is evidence that some local economic policies can stimulate employment growth. Bartik (1991) reviews studies by Papke (1994), Luger and Goldstein (1991), Erickson and Friedman (1990), and other authors on economic development programs such as establishing enterprise zones and research parks. He concludes that most programs have a small positive effect on employment growth. Ó hUallacháin and Satterthwaite (1992) study employment growth in Metropolitan Statistical Areas (MSAs) in the U.S. for the period 1977-1984 and find that enterprise zones and university research parks stimulate employment growth, but state subsidies do not. Rauch (1993) finds evidence that private industrial zones attract new investment because they lower location costs and tax abatements and other incentives reduce uncertainty for new businesses. In contrast, Boarnet and Bogart (1996) and Dowall (1996) find that enterprise zones have no effects on employment growth.

2.3 Local Environmental Policies and Growth

2.3.1 Rapid Growth Creates Interest in Environmental Protection

Environment amenities have become increasingly important for local economic growth. “The presence of natural amenities—pristine mountains, clean air, wild life, and scenic vistas—stimulates employment, income growth and economic diversification by attracting tourists, small business owners and retirees” (Lorah and Southwick 2003). Amenities are “location-specific, nonexportable goods or services” which benefit local businesses indirectly (Gottlieb 1994). Rosen (1979) treats location as a bundle of wages, rent and amenity, so households’ and firms’ location choice problem depends on local amenities. Given differences in local amenities, he concludes wage and rent vary across regions to compensate for the utility loss due to poor amenities. Haurin (1980) assumes good climate increases firms’ production and households’ utility, and his model indicates that good climate is conducive to population growth. Empirical studies of counties containing wilderness areas find population growth drives employment growth.

Migration may be driven by demand for local amenities (Rudzitis and Johansen 1989, Vias 1999). Deller et al. (2001) test the effects of amenity variables that include climate, developed recreation, land, water and winter on rural population, employment and income growth. Results indicate rural economic growth in the 1990s is strongly related to good amenities. Climate may affect migration of population among regions, though Gottlieb's study (1994) concludes that evidence for amenities affecting firm locations is weak.

Governments pass environmental regulations and intervene in the private actions of firms and individuals to promote the public interest or the interest of particular groups when imperfect competition, imperfect information and externality cause market failure (Laffont and Tirole 1993). In addition to Pigouvian taxes, which can be used to internalize negative externalities and overcome market failures, local environmental policies are often adopted to improve quality of life and mitigate urban sprawl in local jurisdictions. Kline and Wichelns (1994) compare referenda conducted in Pennsylvania and Rhode Island from 1982 through 1990. Their results support the hypothesis that the motive to pass purchase of development rights (PDR) arises not only from the willingness of the public to preserve agricultural resources but also from the willingness to protect environmental resources. In another paper, Kline and Wichelns (1996) argue that the public may benefit from broadening the scope of farmland preservation programs to encompass environmental goals.

2.3.2 Local Competition and Environmental Policy Interaction

Presuming intense competition for private investment among local governments, researchers use various models to test if environmental federalism will lead to lax environmental regulations. Theoretical analyses conclude that a "race to the bottom" and a "race to the top" are equally possible. Oates and Schwab (1988) show a "race to the bottom" could happen when capital which is mobile across regions but fixed in the entire system is burdened by tax. Bárcena-Ruiz and Garźon (2003) show it is possible for governments in developed countries to adopt lax environmental policies when wage income rises due to unionization. Kim and Wilson (1997) show that a "race to the bottom" can make all countries better off because there is a positive externality of the outflow of capital to other countries with lax environmental regulations. Markusen et al. (1995) and Hoel (1997) show regions may adopt stringent environmental policies when the disutility from pollution is prohibitively high. Glazer (1999) shows local governments may have an incentive to adopt more stringent environmental policies than centralized governments to optimize social welfare if capital is mobile and the returns to capital go to local residents. Considering that environmental damage could be irreversible, ecological economists suggest that stricter environmental regulations benefit the whole society (Collados and Duane 1999, Farmer et al. 2001).

Recent studies of environmental strategy interaction among local governments indicate that a "race to the bottom" may not generally occur. An empirical model to test this assumption can be simplified as a reaction function: $z_i = f(z_{-i}, X_i)$[10], where z_i represents reaction of local government i, X_i represents other variables affecting choice of behavior, and z_{-i} represents choices made by neighboring jurisdictions

[10] This model is used widely to study yardstick competition and policy interaction among different jurisdictions. For example, Besley and Case (1995) use it to study how the local tax rate is affected by neighboring tax policies, Figlio et al. (1999) study welfare games between states, and Kelejian and Robinson (1993) use it to explain county police expenditure patterns.

(Brueckner 2003). The marginal effects of neighboring strategies can be estimated using a spatial model: $z = \rho Wz + X\beta + \varepsilon$, where z represents policies adopted by local governments, W is spatial weight matrix, X is independent variables, ρ and β are parameters to be estimated, and ε is the error term. Brueckner (1998) uses this model to study strategic interactions of local governments in setting growth control policies. He finds growth controls in neighboring cities tend to stimulate a city to choose the same strategy. Fredriksson and Millimet (2002a) use three different models to test if there is a "California effect"[11] when states in the US adopt environmental policies. The results show pollution abatement expenditures of the most of the studied states depend on pollution abatement expenditures in nearby states. However, states near California are not influenced by the policies adopted in California. Fredriksson and Millimet (2002b) also use a similar model to study the interaction of environmental abatement costs among states. They find there is a positive relationship between the studied state and neighboring states in the stringency of environmental policies.

2.3.3 Effects of Local Environmental Policies on Growth

How do stringent environmental policies affect local economic growth?[12] Some studies of state and local regulations on clean air, shown in table 2.1, find that stringent environmental policies do not drive firms away (Bartik 1988, McConnell and Schwab 1990, Levinson 1996). Other studies focusing on county level policies find stringent

[11] "The gradual tightening of local regular standards in all policy areas…… is the true working definition of the 'California effect'" (Fredriksson and Millimet 2002a).

[12] While some studies focus on the impact of stringent environmental policy on foreign investment and the competitiveness of national industries and national economic growth, this review concerns only the impacts on firm location decisions in the US. A good review of studies related to the above topics can be found in Jaffe et al (1995).

local environmental policies have a negative effect on the location of polluting firms (Henderson 1996, Becker and Henderson 1996, Becker and Henderson 2000).

Some studies explore the effects of environmental policies on employment growth rather than on firm location. Crandall (1993) studies the effects of environmental compliance costs of manufacturing on employment growth. The estimated results indicate environmental costs have no significant effects on gross employment growth. Studies by List and Kunce (2000) show pollution abatement operating expenditures and state and local environmental regulatory expenditures per manufactory have larger negative effects on employment growth of polluting industries than on non-polluting industries.

Table 2-1 should be here

The inconsistency of the effects of local environmental policies on economic growth may be due to the following factors:

(1) *Geographic scope and industry scale differences*. Many studies use state-level data, ignoring differences in environmental protection efforts of county jurisdictions, and may cause the estimated results to be insignificant.

(2) *Differences in measurement of environmental policies and endogeneity of environmental policies*. Two different kinds of measures of local environmental protection stringency are tested in the literature. One consists of environmental policy indices; the other consists of state pollution abatement expenditures or firm pollution abatement costs. Jeppesen and Folmer (2001) argue environmental laws are not directly

related to firms' profits. They suggest studies should avoid using dummy indices for these policies. They believe that potential endogeneity of environmental policies should be emphasized. A few studies, such as Henderson (1996), Becker and Henderson (2000), and List and Kunce (2000) attempt to deal with the endogeneity of environmental policies.

(3) *Misclassification of local policies*. Land use and water conservation policies are important components of local environmental policies that influence the location of both households and firms. Most studies fail to recognize the benefit side of these environmental policies.

(4) *Omission of economic policies*. Many surveys find environmental policies are not the first consideration for firms' location decisions. Instead economic factors and policies are more directly correlated with firms' decisions. Though studies have included local tax variables, wage rates and public expenditures, other economic policies used to attract businesses may correlate with the environmental variables and influence the environmental effects.

(5) *Methodological problems*. Jeppesen and Folmer (2001) contend models using panel data and disaggregated data are more precise than models based on cross-sectional data and aggregated data. Methods using panel data allow the modeler to explore the sequential relationship of environmental policies and firm locations.

Land use policies are often adopted to internalize the externality of uncontrolled growth, and empirical studies of land use policies pay attention to their effects on land prices. The Empirical studies find that land use control decreases land supply and increases land price (Fischel 1990). Change of land price affects the utilities of different income groups, and affects the distribution of population and employment in an area endogenously. Land use policies such as minimum lot zoning regulation could be exclusionary, since they increase housing value and may exceed the budgets of low-income households (Ó Sullivan 1993). Fernandez and Rogerson (1997) find exogenous zoning regulations increase the income gap between rich and poor communities. Plans to limit urban expansion will change land values because transportation cost is affected directly by development controls (Sheppard and Stover 1995). Pasha (1996) shows land prices in the central city go down with the introduction of suburb zoning, and the poor benefit from zoning regulations. Cheshire and Sheppard (2002) estimate the costs and benefits of land use planning. They find provision of open space that is generally accessible to the public tends to reduce inequality, while if open space is inaccessible to the public, land use policy tends to increase inequality.

Recent studies on growth controls focus on optimal growth control and its effect on welfare and population distributions. Engle et al. (1992) show growth controls will increase land and housing prices and reduce population growth. When congestion exists, growth control policies will eliminate dead weight loss. Growth control policies may create environment amenities (Brueckner 1990, Engel et al. 1992). On the other hand, they will create welfare difference between local residents and renters (Brueckner 1995, Helsley and Strange 1995) and between resident land owners and absentee land owners (Brueckner and Lai 1996). The optimal land supply in the growth control model is found to be affected by agglomeration effects, per capita provision cost (Sasaki 1998), and the number of renters in the city (Lai and Yang 2002). Quigley et al. (2002) analyze how land use policies in California affect the distribution of ethnic groups in different cities.

They find land use policies favoring high-income groups encourage non-Hispanic white population growth and discourage Hispanic and Asian population growth in cities.

In general, studies indicate the aggregate effects of land use policies can be negative or positive, depending on the distribution of benefits and costs of these policies on different income groups.

2.4 Summary

This chapter reviews literature that addresses the relationship between local environmental policies and economic growth. The main findings are as follows:

1. Stringent environmental policies do not necessarily reduce economic growth.
2. Local economic and environmental policies do not necessarily conflict in stimulating economic growth. These two types of policies may need to be integrated to achieve optimal growth.
3. Studies of the linkages of local land use and water conservation policies and economic growth indicate welfare effects of these policies vary across different income groups. Land use policies aimed at matching the interests of specific population groups often result in excluding other population groups.

Study	Time period and geographic scope	Industry scope	Environmental policy measures	Results
Bartik (1988)	1970s State level studies	Branch plants of Fortune 500 companies	State expenditure on water and air pollution control; industry environmental compliance costs	No significant effects
McConnell and Schwab (1990)	1973-1982 County level	Motor vehicle industry	Attainment and non-attainment dummies and pollution abatement costs and expenditure	Most regulation variables have no effects
Levinson (1996)	1982-1987 State level studies	All new plants and branch plants of large firms	The Conservation Foundation index[13], the FREE index[14], the Green index[15], aggregate abatement cost and industry abatement cost	Branch plants of large firms are sensitive to regulations
Henderson (1996)	1977-1987 County level	Five major VOC emission industries	Attainment and non-attainment county dummies	Regulation affects the locations of polluting firms
Becker and Henderson (2000)	1963-1992 County level	Four major VOC emission industries with different plant sizes	Attainment and non-attainment dummies	Regulation affects large size firms and new born firms
Stafford (2000)	1976-1993 State level	Hazardous waste management industry	Per capita spending on all environmental programs; the Green index.	Spending has a positive effect, while policy index has a negative effect.

Table 2.1: Empirical Studies of Firm Location and Environmental Policies

[13] This index is constructed using 19 components characterizing states' environmental and land-use efforts .
[14] Published by the Fund for Renewable Energy and the Environment to measure the strength of state laws regarding air quality, hazardous waste, and ground water pollution for the early 1980s.
[15] Hall et al. (1992) construct this index by simply adding up the number of statutes each state has adopted related to environmental laws. Levinson chose statutes that focus on air and water pollution controls.

CHAPTER 3

THEORETICAL BACKGROUND

A simple regional growth model is introduced in this chapter to investigate the effects of growth control policies on the spatial distribution of population. The analysis sheds light on how strategic interaction among regions affects growth control and how agglomeration economies affect the optimal growth control strategy.

Section one presents a model without growth control. Section two introduces growth control into the model and addresses growth control with and without interaction. Section three analyzes growth control policy in the presence of agglomeration economies. Section four examines how public goods affect growth control.

3.1 Model Description

County economic growth varies considerably depending on whether the county is with or without a central city. Spatial concentration and dispersion of population and employment among counties are driven by economic and social interaction among cities and their peripheries. Cities and metropolitan areas are 'growth poles' in which economic activities are concentrated. Growth controls are adopted to internalize diseconomies of scale, which are an inevitable phenomenon of the municipal city.

The analytical framework in this chapter is a monocentric city model that incorporates distance, transportation and land rent gradients. Distance is a key factor affecting the spatial distribution and interaction of economic activities. The analysis is based on models introduced by Helsley and Strange (1995) and Brueckner (1995, 1998) to study the effects of growth control. In contrast to those models, a congestion toll on traffic is the growth control tool used by local governments in the model presented in this chapter.

The model consists of two regions, region 1 and region 2. Each region is a mono-centric city, which has the shape of a straight line. There is one central business district (CBD) in the region and all residents are mobile renters who commute to the CBD to work and earn income (y). Land is owned by absentee landowners. The representative resident maximizes utility $U(c,l)$ by consuming a commodity (*c)* and land (*l)*. The utility function is assumed to be additively separable. For simplicity, land consumption is fixed exogenously at a single unit for every resident, and the price of the commodity is the numeraire. The problem of the consumer can then be written as

(1) $\underset{\{c_i,l\}}{Max} \quad U(c_i,l)$

subject to $c_i + R_i l + tx_i = y_i$

where index *i* stands for the representative resident of region *i*,

R_i is land rent,

y_i is household income,

t is unit transportation cost,

x_i is the distance of the residence to the Central Business District (CBD).

Since land consumption is fixed, residents' utility level is determined by the level of consumption (c). Given that residents in a region are assumed to be homogenous and the utility level is the same for residents in both regions in equilibrium, the utility level can be specified without subscript as u.

From the constraint in the optimization problem of the consumer, using the assumptions of additivity of the utility function and fixed land consumption where the unit of land is chosen so that $l = 1$, equation (2) is derived:

(2) $R_i = y_i - u - tx_i$

Equation (2) is the bid rent function for a representative resident. It indicates land rent is a decreasing function of the distance to the CBD. There is a tradeoff between land rent and transportation cost. Residents who live near the CBD have to pay higher rent to enjoy the convenience of proximity to work.

The equilibrium condition also requires the following equation to be satisfied:

(3) $\sum_{i=1}^{2} \overline{x_i} = N$

where $\overline{x_i}$ is the distance of the city boundary to the CBD,

N is total population in region 1 and region 2.

Equation (3) indicates that total residents are determined by city size in region 1 and region 2 because land consumption per resident is fixed.

Equation (4) states that the land rent of both regions at the city boundary is equal to the farmland price, which is assumed to be 0.

(4) $R_0 = y_i - t\overline{x}_i - u = 0$

where R_0 is land rent at the city boundary.

Combining (3) and (4), we can derive the utility function in region 1 and region 2 as:

(5a) $u_1 = y_1 - t\bar{x}_1$

(5b) $u_2 = y_2 - t(N - \bar{x}_1)$

From equations (5a) and (5b), we can determine uniquely the optimal city size or number of residents in both regions. Since the utility function in both regions is a monotonic decreasing function of city size, the optimal city size will lie at the intersection of the utility lines of both regions in figure 3.1, where utility in the two regions is equal; that is, $u = u_1 = u_2$.

(6) $\bar{x}_1 = (y_1 - y_2 + tN)/2t$

Equation 6 is the optimal city size derived from equations (5a) and (5b). It indicates the equilibrium city size is determined by the regional income difference, total population, and transportation cost. The equilibrium utility level is an outcome of regional interaction. Population will migrate from the region with lower utility to the region with higher utility until an equilibrium is reached where residents' utility is the same in the two regions.

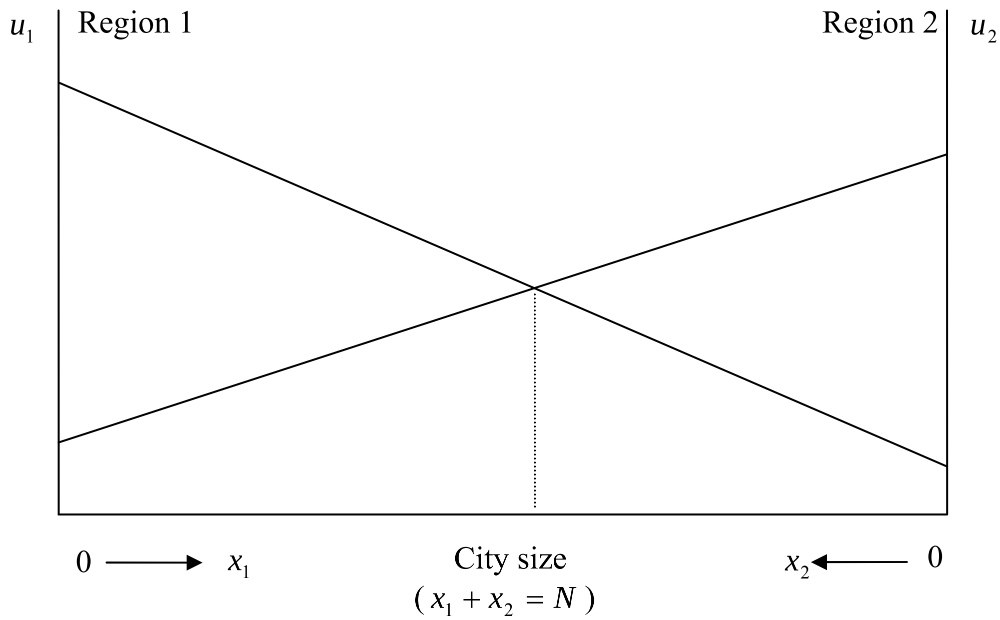

Figure 3.1: Utility in Two-Region Monocentric Model

3.2 Optimal Growth Control

How does growth control come into being? Growth control is often seen as a voting outcome for higher land prices to satisfy landowners (Brueckner and Lai 1996, Brueckner 1998) or city developers (Helsley and Strange 1995). In the model developed in this section, absentee landowners are assumed to control the voting system in the regions, so local policy is designed to maximize total land rent. But unlike previous studies, a congestion toll rather than a city boundary is used as the growth control tool. Theoretically, the effects of these two policies are the same, though a congestion toll has rarely been imposed in the real world.

Fast growth causes congestion problems. Let us assume the individual unit distance cost of travel is a function of the number of residents, $C(N_i)$, which is assumed to be an increasing function of the number of regional residents, that is $C^{'}(N_i) > 0$, and $C''(N_i) \leq 0$. Local governments have the right to impose a congestion toll, τ_i (Arnott 1997). The optimal toll imposed by the government must satisfy the condition that total social cost is equal to total revenue. Total travel cost is $N_i C(N_i)$, and the marginal social cost of travel is:

(7) $\partial(N_i C(N_i))/\partial N_i = C(N_i) + N_i C'(N_i)$

The normal travel cost is $C(N_i)$, which was t , defined for equation (1). The congestion externality is $N_i C'(N_i)$. So the optimal congestion toll is:

(8) $\tau_i^* = N_i C'(N_i)$

Equation (8) gives the optimal Pigouvian congestion toll, τ_i^*, which equals the marginal congestion cost caused by an additional resident. Since $C^{'}(N_i) > 0$, the optimal congestion toll, τ_i^*, increases with the city size; that is, $\partial \tau_i^* / \partial \bar{x}_i > 0$. Also, since $C(N_i)$ is a convex function of N_i, $t \geq \tau_1^*$.

Suppose the optimal congestion toll is adopted in both regions. The new equilibrium will be determined by the following equations:

(9) $u = u_1 = y_1 - (t + \tau_1^*)\bar{x}_1 = y_1 - t\bar{x}_1 - C'(\bar{x}_1)\bar{x}_1^{\,2}$

(10) $u = u_2 = y_2 - (t + \tau_2^*)\bar{x}_2 = y_2 - t\bar{x}_2 - C'(\bar{x}_2)\bar{x}_2^{\,2}$

The optimal city size with the congestion toll is different from the case without the congestion toll, as shown in figure 3.2. The solid straight lines represent utility in region 1 and region 2 without the congestion toll while the underlying curved lines represent utility with an optimal congestion toll. Since the congestion toll increases with city size, the utility function becomes very steep when the population level is large in a region. The equilibrium utility level is decreased compared to the situation of no congestion tolls. The optimal city size depends on the elasticity of the land bid to the congestion toll in both regions (see curved lines a, b and c). Compared to the situation without the congestion toll, the region with the more elastic land bid function will result in a smaller city.

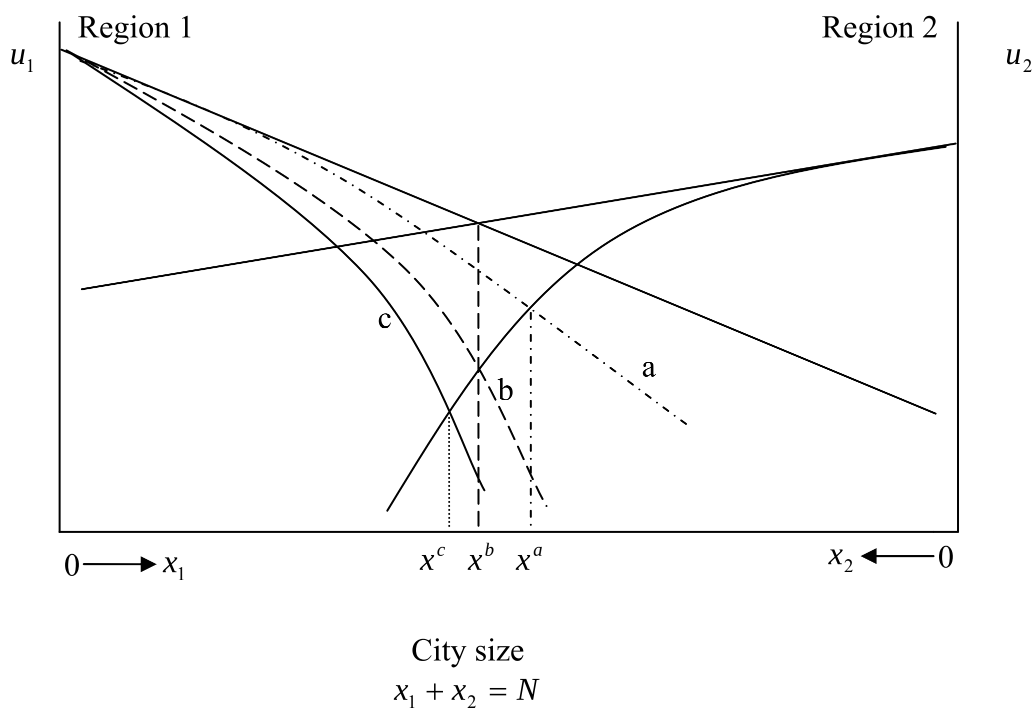

Figure 3.2: Utility with and without a Congestion Toll

Suppose region 1 believes region 2 will retain its current congestion toll. Then region 1 imposes a congestion toll to maximize land rent. Let us introduce a land-use control intensity parameter θ, the value of which lies between 0 and 2. The parameter θ is arbitrarily bounded at 2, which is the maximum multiplier we assume local residents will accept. When θ is 0, growth control is the least stringent. When θ increases, growth control policy is more stringent. The utility lines of residents now rotate downward, so that utility is lower and the land rent function is steeper. From an initial utility represented by line a, utility now declines to line b or c in figure 3.2.

The new utility functions of region 1 and region 2 are:

(11) $u = y_1 - (t + \theta\tau_1^*)\bar{x}_1 \qquad 0 \le \theta \le 2$

(12) $u = y_2 - (t + \tau_2^*)\bar{x}_2$

In equilibrium, residents' utilities in both regions must equal each other. From equation (2), (11) and (12), land rent in region 1 is:

(13) $R_1 = y_1 - (t + \theta\tau_1^*)x_1 - [y_2 - (t + \tau_2^*)\bar{x}_2]$

Note that the city size x_1 in equation (13) has no upper bar. It varies between 0 and the equilibrium city size $\bar{x}_1$. The expression in square brackets on the right of equation (13) is the equilibrium utility level.

The government in region 1 chooses θ to maximize total land rent:

(14) $Max_\theta \int_0^{\bar{x}_1} (y_1 - (t + \theta\tau_1^*)x_1 - [y_2 - (t + \tau_2^*)\bar{x}_2])dx_1$

subject to $\bar{x}_1 + \bar{x}_2 = N$

Using Leibniz's rule to take the first derivative of equation (14) with respect to θ, the optimal θ must satisfy:

$$
(15)\quad \begin{aligned}
&\{y_1 - (t + \theta\tau_1^*)\bar{x}_1 - [y_2 - (t + \tau_2^*)\bar{x}_2]\}\frac{\partial \bar{x}_1}{\partial \theta} - \bar{x}_1[0.5\tau_1^*\bar{x}_1 + 0.5\theta\bar{x}_1\frac{\partial \tau_1^*}{\partial \bar{x}_1}\frac{\partial \bar{x}_1}{\partial \theta} \\
&- (t + \tau_2^*)\frac{\partial \bar{x}_2}{\partial \theta} - \bar{x}_2\frac{\partial \tau_2^*}{\partial \bar{x}_2}\frac{\partial \bar{x}_2}{\partial \theta}] = 0
\end{aligned}
$$

The first part of equation (15) is zero in equilibrium from equation (11) and (12). It follow from equation (3) that $\frac{\partial \bar{x}_2}{\partial \theta} = -\frac{\partial \bar{x}_1}{\partial \theta}$. So equation (15) can be rewritten as

$$
(16)\quad \frac{\partial \bar{x}_1}{\partial \theta} = -\frac{0.5\tau_1^*\bar{x}_1}{t + \tau_2^* + 0.5\theta\bar{x}_1\partial\tau_1^*/\partial\bar{x}_1 + \bar{x}_2\,\partial\tau_2^*/\partial\bar{x}_2} < 0
$$

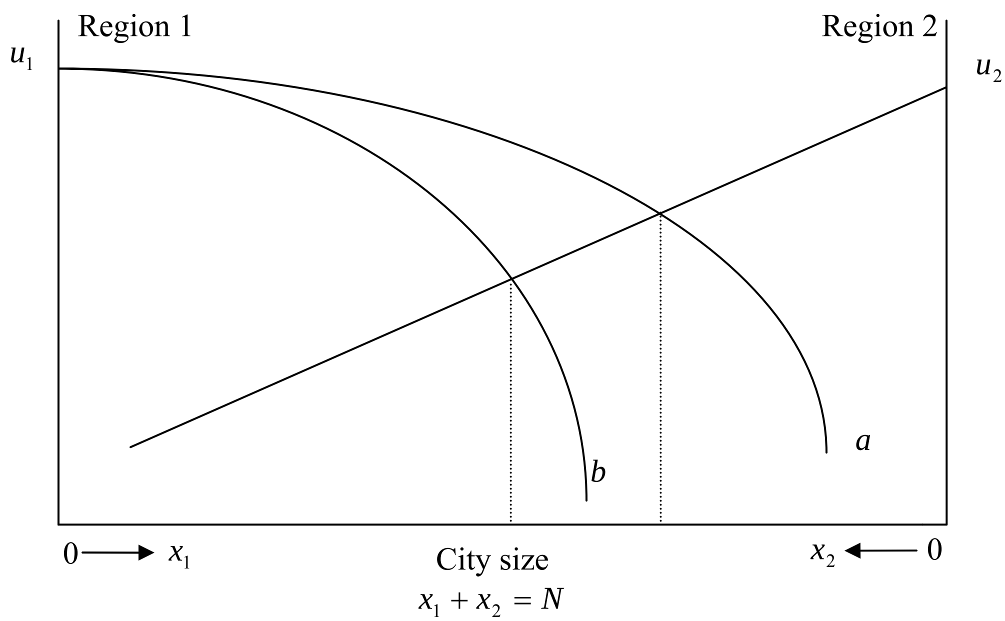

Figure 3.3: Utility with Different Control Intensity Parameters

Equation (16) implies that the optimal θ causes the city size of region 1 to decrease. If there is no congestion toll in region 2, $\partial \tau_2^* / \partial \bar{x}_2 = 0$, then equation (16) will still be less than 0. Government in region 1 will choose a congestion toll to attain a smaller city size, no matter whether a congestion toll is applied or not in region 2. When the slope of the utility line is fixed for region 2, the city size of region 1 will decrease if the utility line of region 1 rotates downward. This occurs if region 1 adopts a stringent growth control policy. In figure 3.3, the curved line a is the utility function in the previous equilibrium, and the curved line b is the utility function in the new equilibrium.

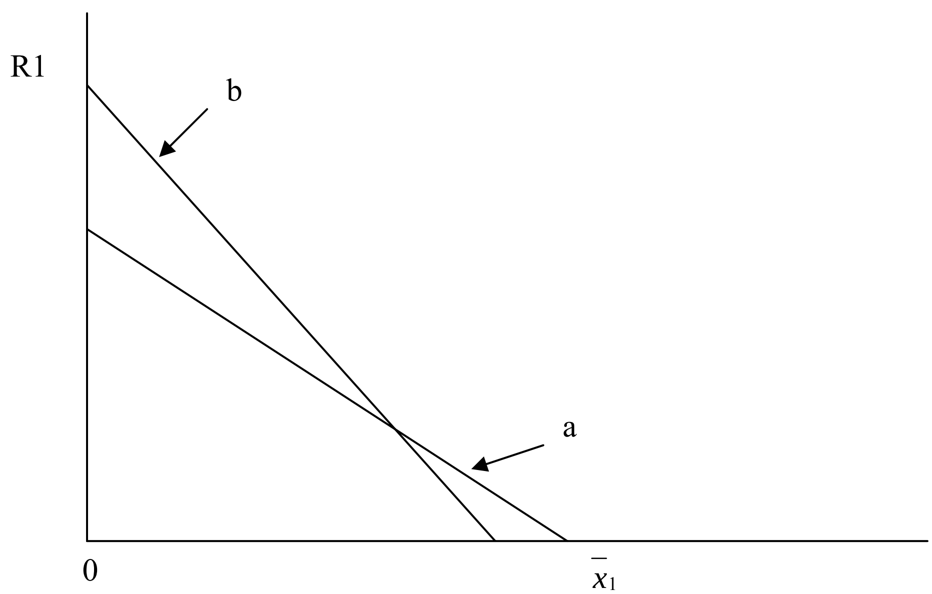

Figure 3.4: Bid Rent in Region 1 with Different Control Intensity Parameters

Government in region 1 chooses a congestion toll to maximize total rent. The rent in region 1 is $R_1 = y_1 - (t + \theta\tau_1^*)x_1 - u$. The slope of the rent depends on transportation cost and the congestion toll, and the rent at CBD depends on u. In the figure 3.4, line a represents the original situation with $\theta = 1$, while line b represents the situation with new control intensity parameter, $\theta > 1$. When the control intensity parameter increases, the slope of the rent line becomes steeper, resulting in a smaller city. But $u = y_2 - (t + \tau_2^*)\overline{x}_2$ in equilibrium is decreasing with θ since city size in region 2 is increasing, and rent at CBD (intercept with the vertical axis) increases (see the rent bid function above where $x_1 = 0$ at CBD). The area underlying line b is greater than the area underlying line a, which implies that land rent increases with a stringent congestion toll. This conforms to the result of equation (16). Thus, the optimal control intensity parameter is greater than 1 (and bounded by 2 by assumption). If it is 2, it will be a corner solution since we define it as the upper bound.

The optimal growth control strategy indicates landowners' benefits from growth control are conditional on the utility loss of local residents. Equation (16) implies the stringency of the growth control will depend on the belief of local governments about the equilibrium city size without growth control. The larger the city size is expected to be without control, the more stringent the growth control policy that will be adopted. Equation (16) shows that city size will decrease with a higher numerator.

The distributional and welfare effect of the congestion toll is consistent with the outcome derived in previous studies using the city boundary as the policy tool. In both cases, stringent growth control will decrease the city size and lower the utility level of all residents. The difference in the present model is that the land price at the city fringe is not discontinuous as it was in the model in which the city controlled the boundary. In the congestion toll model, the bid rent and farm land price are the same on the city fringe, since the congestion toll absorbs the transportation savings induced by a smaller city.

The above static analysis is derived without considering the reaction of region 2 to growth control strategies adopted by region 1. How will the optimal policy change if region 2 strategically plays a game in growth control? Before continuing the analysis, let's assume $\tau_1^* > \tau_2^*$, which implies that region 1 is a larger city and has a worse congestion problem with more population than region 2.

Local government chooses θ_1 to maximize total land rent in region 1, given that region 2 chooses θ_2. This is a Nash equilibrium solution:

$$(17)\quad Max_{\theta_1} \int_0^{\bar{x}_1} \{y_1 - (t + \theta_1\tau_1^*)x_1 - [y_2 - (t + \theta_2\tau_2^*)\bar{x}_2]\}dx_1$$

subject to $\bar{x}_1 + \bar{x}_2 = N$

$0 \le \theta_1 \le 2$

$0 \le \theta_2 \le 2$.

Using Leibniz's rule, the optimal θ_1 must satisfy:

$$(18)\quad \begin{aligned} &\{y_1 - (t + \theta_1\tau_1^*)\bar{x}_1 - [y_2 - (t + \theta_2\tau_2^*)\bar{x}_2]\}\frac{\partial \bar{x}_1}{\partial \theta_1} - \bar{x}_1[0.5\tau_1^*\bar{x}_1 + \\ &0.5\theta_1\bar{x}_1\frac{\partial \tau_1^*}{\partial \bar{x}_1}\frac{\partial \bar{x}_1}{\partial \theta_1} - \frac{\partial \theta_2}{\partial \theta_1}\tau_2^*\bar{x}_2 - (t + \theta_2\tau_2^*)\frac{\partial \bar{x}_2}{\partial \theta_1} - \theta_2\bar{x}_2\frac{\partial \tau_2^*}{\partial \bar{x}_2}\frac{\partial \bar{x}_2}{\partial \theta_1}] = 0 \end{aligned}$$

Since the first part of equation (18) will be 0 in equilibrium, solving equation (18), we have:

$$(19)\ \frac{\partial \bar{x}_1}{\partial \theta_1} = \frac{-0.5\bar{x}_1\tau_1^* + \frac{\partial \theta_2}{\partial \theta_1}\tau_2^*\bar{x}_2}{t + \theta_2\tau_2^* + 0.5\theta_1\bar{x}_1 \partial\tau_1^* / \partial\bar{x}_1 + \theta_2\bar{x}_2 \partial\tau_2^* / \partial\bar{x}_2} < 0$$

In contrast with equation (16), the second part of the numerator in equation (19) accounts for the strategic interaction of growth control. The equation indicates that the optimal growth control level in region 1 is dependent on the reaction function of region 2 to the growth control strategy adopted by region 1. If $\frac{\partial \theta_2}{\partial \theta_1} \le 0$, region 2 adopts a cooperative growth control strategy. In this case, the absolute value of equation (19) will be larger with a high absolute value of $\partial\theta_2/\partial\theta_1$, since θ_2 decreases with the increase in $\partial\theta_2/\partial\theta_1$. Growth control will be more stringent in region 1 with cooperative interaction. Equation (16) is an extreme case of equation (19), where $\partial\theta_2/\partial\theta_1 = 0$ and $\theta_2 = 1$. On the other hand, if $\frac{\partial \theta_2}{\partial \theta_1} > 0$, region 2 takes a retaliatory attitude to the growth control strategy adopted by region 1. In this case, the absolute value of equation (19) is smaller than the value when $\frac{\partial \theta_2}{\partial \theta_1} \le 0$. Growth control is less stringent compared to the case of cooperative interaction. The underlying logic of the outcome is that as region 2 takes a retaliatory position, equilibrium utility will drop so that there is less room for region 1 to reduce city size and benefit from it. Thus, growth control strategy in region 1 will be less stringent.

3.3 Agglomeration Economies and Optimal Growth Control

Agglomeration economies affect growth control when a region benefits from the concentration of economic activities. To introduce agglomeration effects into the model, let us simply assume local residents' income in region 1 increases with larger city size.

(20) $\partial y_1(N_1)/\partial N_1 = \partial y_1(\bar{x}_1)/\partial \bar{x}_1 > 0$

Substituting new residents' income into (17), we have:

(21) $Max_\theta \int_0^{\bar{x}_1} \{y_1(\bar{x}_1) - (t+\theta_1\tau_1^*)x_1 - [y_2 - (t+\theta_2\tau_2^*)\bar{x}_2]\}dx_1$

subject to $\bar{x}_1 + \bar{x}_2 = N$.

Using Leibniz's rule, the optimal θ must satisfy:

(22)
$$\{y_1(\bar{x}_1) - (t+\theta_1\tau_1^*)\bar{x}_1 - [y_2 - (t+\theta_2\tau_2^*)\bar{x}_2]\}\frac{\partial \bar{x}_1}{\partial \theta} - \bar{x}_1[\frac{\partial y_1}{\partial \bar{x}_1}\frac{\partial \bar{x}_1}{\partial \theta} + 0.5\tau_1^*\bar{x}_1 +$$
$$0.5\theta_1\bar{x}_1\frac{\partial \tau_1^*}{\partial \bar{x}_1}\frac{\partial \bar{x}_1}{\partial \theta_1} - \frac{\partial \theta_2}{\partial \theta_1}\tau_2^*\bar{x}_2 - (t+\theta_2\tau_2^*)\frac{\partial \bar{x}_2}{\partial \theta_1} - \theta_2\bar{x}_2\frac{\partial \tau_2^*}{\partial \bar{x}_2}\frac{\partial \bar{x}_2}{\partial \theta_1}] = 0$$

Since the first part of equation (22) will be 0 in equilibrium, we have:

(23)
$$\frac{\partial \bar{x}_1}{\partial \theta_1} = \frac{-0.5\bar{x}_1\tau_1^* + \frac{\partial \theta_2}{\partial \theta_1}\tau_2^*\bar{x}_2}{\partial y_1/\partial \bar{x}_1 + t + \theta_2\tau_2^* + 0.5\theta_1\bar{x}_1\,\partial \tau_1^*/\partial \bar{x}_1 + \theta_2\bar{x}_2\,\partial \tau_2^*/\partial \bar{x}_2} < 0$$

Given $y'_1(\bar{x}_1) > 0$, the denominator of equation (23) will be larger than the denominator of equation (19), so the absolute value of (23) will be smaller than that of equation (19). This implies the optimal growth control strategy will be less stringent and the city will be allowed to increase in size. Less stringent growth control policy is optimal because agglomeration economies will make landowners benefit from a larger city, which increases residents' income and bids up the land rent in region 1.

The optimal growth control will be indeterminate if agglomeration economies exist in both regions. In this case, regions will strategically interact in adopting growth control, since both regions prefer a larger city. A 'race to the bottom' may happen depending on the intensity of agglomeration economies.

3.4 Public Goods and the Optimal Growth Control

Public goods are critical to the location decision of local residents. In this section, we will analyze how public goods affect growth control strategies. Revenue from the congestion toll will be spent on public goods, which will affect the utility of local residents. The new problem of the consumer can then be written as

(24) $\underset{\{c_i, l, Z_i\}}{Max} \quad U(c_i, l, Z_i)$

subject to $c_i + R_i l + (t + \tau_i^*)x_i = y_i$

$$\int_0^{\bar{x}_i} \tau_i^*(N_i) x_i dx_i = N_i Z_i,$$

where Z_i is public goods per capita in region i, which equals the congestion toll.

From $\int_0^{\bar{x}_i} \tau_i^*(\bar{x}_i) x_i dx_i = \bar{x}_i Z_i$, we have $Z_i = 0.5\tau_i^* \bar{x}_i$.

Since land consumption is fixed, the consumption of normal goods and public goods must bring the same utility in equilibrium, no matter which region in which residents decide to stay. This results in:

(25) $c_1 + hZ_1 = c_2 + hZ_2$

where h is the marginal rate of substitution between consumption goods and public goods (Lai & Yang 2002).

Combining the constraints of equation (24) and equation (25), the rent bid function in region 1 will be:

$$(26)\quad \begin{aligned} R_1 &= y_1 - (t+\tau_1^*)x_1 - (c_2 + hZ_2 - hZ_1) \\ &= y_1 - (t+\tau_1^*)x_1 + 0.5h\tau_1^*\bar{x}_1 - [(y_2 - (t+(1-0.5h)\tau_2^*)\bar{x}_2] \end{aligned}$$

To simplify the problem, let's look at how region 1 chooses the congestion toll assuming that the congestion toll in region 2 is fixed. The maximization problem with public goods in regions will be:

$$(27)\quad Max_{\theta_1} \int_0^{\bar{x}_1} \{y_1 - (t+\theta_1\tau_1^*)x_1 + 0.5h\theta_1\tau_1^*\bar{x}_1 - [y_2 - (t+(1-0.5h)\tau_2^*)\bar{x}_2]\}dx_1$$

subject to $\bar{x}_1 + \bar{x}_2 = N$

$0 \le \theta_1 \le 2$.

Using Leibniz's rule, the optimal θ_1 must satisfy:

(28)

$$\{y_1 - (t+(1-0.5h)\theta_1\tau_1^*)\bar{x}_1 - [y_2 - (t+(1-0.5h)\tau_2^*)\bar{x}_2]\}\frac{\partial \bar{x}_1}{\partial \theta_1} - \bar{x}_1[0.5(1-h)\tau_1^*\bar{x}_1 +$$

$$0.5(1-h)\theta_1\bar{x}_1\frac{\partial \tau_1^*}{\partial \bar{x}_1}\frac{\partial \bar{x}_1}{\partial \theta_1} - 0.5h\theta_1\tau_1^*\frac{\partial \bar{x}_1}{\partial \theta_1} - (t+(1-0.5h)\tau_2^*)\frac{\partial \bar{x}_2}{\partial \theta_1} - (1-0.5h)\bar{x}_2\frac{\partial \tau_2^*}{\partial \bar{x}_2}\frac{\partial \bar{x}_2}{\partial \theta_1}] = 0$$

Since the first part of equation (28) will be 0 in equilibrium, solving equation (28), we have:

(29)

$$\frac{\partial \bar{x}_1}{\partial \theta_1} = \frac{-0.5(1-h)\bar{x}_1\tau_1^*}{t + (1-0.5h)\tau_2^* + 0.5(1-h)\theta_1\bar{x}_1 \partial\tau_1^* / \partial\bar{x}_1 + (1-0.5h)\bar{x}_2 \partial\tau_2^* / \partial\bar{x}_2 - 0.5h\theta_1\tau_1^*}$$

$$= \frac{-0.5\bar{x}_1\tau_1^*}{t + (1-0.5h)\tau_2^* / (1-h) + 0.5\theta_1\bar{x}_1 \partial\tau_1^* / \partial\bar{x}_1 + (1-0.5h)\bar{x}_2 / (1-h) \, \partial\tau_2^* / \partial\bar{x}_2 + (t-0.5\theta_1\tau_1^*) / (1-h)}$$

Equation (29) is still less than 0 since $t \geq \tau_1^*$ and $\theta_1 \leq 2$ from equation (8). Therefore, the analysis in section 3.3 and 3.4 is still valid. If $h < 1$, then the absolute value of equation (29) is less than equation that of (16). Growth control is less stringent, since the city is less attractive given that the average marginal contribution of public goods is less than the cost of the public goods. If $h > 1$, then growth control will be more stringent with smaller absolute value. Since the average marginal contribution of public goods is more than the cost of public goods, stringent control policies are needed to control the number of residents attracted to the city. If $h = 1$, the congestion toll has no effect on growth control, because it will not affect residents' utility.

3.5 Summary

This chapter uses a simple model to analyze how growth control strategies affect population growth and how regions adopt growth control policies strategically. To make the model tractable, landowners are assumed out of the system. The optimal congestion toll adopted would change if landowners were introduced into the system. Brueckner and Lai (1996) show the optimal growth control will be less stringent when landowners reside in the city. Compared with the situation of absentee landowners, landowners must pay land rent themselves, so increased rent price due to growth control decreases their utilities.

From this model, we can generate several testable hypotheses:

(1) *Stringent land use policies have a negative effect on population growth.* Stringent land use policy may be implemented by local governments to maximize total land rent. Land use control results in less congestion but with higher land prices and lower utility of residents. This holds true on condition that residents derive no utility from environmental amenities.

(2) *Strategic interaction among regions affects the optimal growth control policy.* A locality's optimal growth control policy depends on the growth control strategies adopted in other regions. The model in this chapter shows growth control will be less stringent when neighboring regions take a retaliatory attitude in adopting growth control policies.

(3) *Land use policies are likely to be less stringent when agglomeration economies exist.* If agglomeration economies are present, they create a positive income effect for local residents and landowners.

(4) *Public goods affect the optimal growth control policies.* Residents will migrate from one region to the other region if the bundle of public goods and the congestion toll in that region increases residents' utility. Therefore, when the marginal benefit of public goods is greater than the marginal cost, a stringent growth control needs to be adopted to achieve a smaller city.

The optimal growth control policy is a trade-off of renters' and landowners' utility and an outcome of strategic interaction among different regions. The conclusion from this simple model in which residents derive no utility from environmental amenities is that growth control policies have a negative effect on population growth. Agglomeration economies play an important role on growth control strategy and population growth. A fast growing region benefits from a less stringent land use policy if the agglomeration effect outweighs the congestion effect. Growth control will be more stringent when the marginal contribution of public goods is greater than the marginal cost.

CHAPTER 4

EMPIRICAL MODEL

In chapter three, the effects of local environmental policies on population growth are analyzed using a simple monocentric city model. The purpose of this chapter is to introduce empirical models for hypotheses testing and discuss econometric issues on how to estimate a simultaneous equations model with and without spatial components.

Section one discusses the assumptions of the aspatial and spatial model. Section two illustrates criteria for choosing explanatory variables and describes the data used in the analysis. Section three lays out estimation methods and ways to test for endogeneity.

4.1 Model Selection

This dissertation will use two models to conduct empirical tests of the growth effects of local economic and environmental policies. The aspatial model is similar to one used by Carlino and Mills (1987). The spatial model is similar to one used by Boarnet (1994). Results from these two models reveal how spatial interaction affects the estimates.

The Carlino-Mills model recognizes that population growth interacts with employment growth in the same jurisdiction. Without immigration control or constraints on capital mobility and other trade barriers among regions, equilibrium of population and employment growth is reached when factors of production in all regions get the same economic return. The Carlino-Mills model captures growth dynamics of population and employment, and it has been used widely to estimate how different regional factors affect the long-run growth pattern. The model hypothesizes no spillover effects in population and employment growth among various regions.

Boarnet allows for the possibility that population and employment may interact beyond the borders of jurisdictions. His model assumes that spatial equilibrium is reached within a small region in the short run. Long run equilibrium is a steady state in both time and space. Since spillover effects occur between employment and population growth, this kind of spatial econometric model is called a spatial cross-regressive model to differentiate it from the spatial autoregressive (SAR) model.

4.2 Variable Choice

4.2.1 Variables Used in Previous Studies

Regions grow as capital and labor concentrate and accumulate in space. Conditions such as initial endowment, increasing returns to scale, low transportation cost (Krugman 1991a), and product diversity and specialization (Glaeser et al. 1992) have been argued to affect factor accumulation. Nonmarket factors such as public goods, environmental amenities and institutional arrangement are also critical to regional growth. Theoretical models alone can not provide definitive conclusions with regard to growth effects of all these factors, so empirical studies attempt to verify how specific factors determine regional growth patterns.

Variables related to fiscal conditions, income and regional amenities used in previous studies are presented in table 4.1 to explore the possible choices for this study (See table

4.1). Per capita government expenditure, income tax and property tax are widely used fiscal variables, and are often found to have a direct impact on employment and population growth (Mills and Price 1984, Carlino and Mills 1987, Boarnet 1994). Per capita government expenditure is used to capture the effects of local public goods such as highways, public safety and education on capital movements and population migrations. Per capita public expenditure is used more often than gross expenditure, since it puts expenditures on a comparable basis across regions. Property tax and income tax are common in regional studies, since they are main government revenue sources. According to Tiebout's model, differences in public expenditure and taxes will result in different settlement patterns among regions. Empirical studies find fiscal variables are not always significant, which may be due to incorrect measurement of local taxes and the difficulty in controlling for the high correlation between taxes and expenditure.

Income is measured in previous studies using per capita income, family income or wages (Steinnes and Fisher 1974, Mills and Price 1984). High income is advantageous to regions since it can stimulate consumption and investment. Low wage rates on the other hand attract business. To control for regional differences in living expenses, real income and wage rate are sometimes used instead of nominal income and wage. Income segregation limits the economic growth potential of areas of disadvantage, which aggravates the unevenness of growth patterns in a region. Therefore, variables such as poverty rate, unemployment rate and percent old housing are often used in regional growth studies (Palumbo et al. 1990, Deller et al. 2001).

Boarnet (1994) and Sohn and Hewings (2000) use industry concentration to capture agglomeration effects. Environmental amenities and social amenities, which are considered elements of "quality of life", are often used, too. Environmental amenities are measured using climatic variables, such as number of sunny days, cold days and precipitation. Social amenity variables include percent black, percent Hispanic, and age and job distributions (Deller et al. 2001, Carlino and Mills 1987). Population ratio is used to test if racial segregation or "flight from blight" is the main cause of population decentralization (Mills and Price 1984).

Table 4.1 should be here

Table 4.1 shows that most previous studies are metropolitan-focused, while a few studies are county-focused. Variables included in county studies often differ from those in metropolitan studies because of different policy concerns. Metropolitan studies typically focus on the impacts of the central city on surrounding suburbs. Therefore, variables are mostly related to the geographical distance between the central city and the surrounding areas. Studies on population decentralization or suburbanization use the characteristic ratio of the central city to the surrounding areas in order to capture the effects of amenity disparity on residence. The strength of these studies is in estimating differences in characteristics despite the geographical proximity between the city and suburb. The disadvantage is that it is difficult to interpret the effects of local policies due to homogeneity and discontinuity of these policies within metropolitan areas in a small sample. In contrast, county-focused studies pay more attention to strategic interactions among different jurisdictions, so state and local policies are one of the main focuses of these studies. The weakness of county-focused studies is that internal distributions of different racial and income groups are often overlooked.

4.2.2 Variables Used in This Study

The choice of variables for this study is based on theoretical considerations identified in chapter three and on previous regional growth studies (see table 4.2). Demographic data used in this dissertation are from the US Census 1990 and 2000, and the 1994 County and City Data Book. Natural amenity scale and urban-rural classification data are from the Economic Research Service, US Department of Agriculture (ERS-USDA)[16]. Nonattainment county data are from EPA[17]. Counties with a nonattainment history during 1992 to 2003 are considered nonattainment counties. Environmental and economic policy indices are constructed from a survey directed by Lobao and Kraybill (2005). The construction of policy indices is described in the next section.

The aspatial model used in this dissertation can be written as follows:

(30)
$$POP_{0090} = f(EMP_{0090}, POP_{90}, EMP_{90}, T) + \varepsilon_1$$

$$EMP_{0090} = f(POP_{0090}, POP_{90}, EMP_{90}, S) + \varepsilon_2$$

$$\varepsilon_1 \sim N(0, \sigma_1^2 I);\ \varepsilon_2 \sim N(0, \sigma_2^2 I);\ E(\varepsilon_1 \varepsilon_2 ') = \sigma_{12} I$$

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[16] The natural amenity scale is a simple additive scale of six measures including warm winter, winter sun, temperate summer, summer humidity, topographic variation and water area. The natural amenity scale is found to be highly correlated with county population change from 1970 to 1996 and contains much more information than individual measures. Detailed information and data are available from http://www.ers.usda.gov/data/NaturalAmenities/.

[17] The Clean Air Act defines a nonattainment area as "any area that does not meet (or that contributes to ambient air quality in a nearby area that does not meet) the national primary or secondary ambient air quality standard for the pollutant." Detailed information is available from the EPA Green Book.

where POP_{0090} and EMP_{0090} are population and employment growth between 1990 and 2000, and EMP_{90} and POP_{90} are employment and population in 1990. T and S are vectors of explanatory variables.

The spatial model can be written as follows:

(31) $$POP_{0090} = \gamma_0 + \gamma_1 T + \gamma_2 (I+W)EMP_{90} + \gamma_3 (I+W)EMP_{0090} + \gamma_4 POP_{90} + \varepsilon_1$$

$$EMP_{0090} = \delta_0 + \delta_1 S + \delta_2 (I+W)POP_{90} + \delta_3 (I+W)POP_{0090} + \delta_4 EMP_{90} + \varepsilon_2$$

$$\varepsilon_1 \sim N(0, \sigma_1^2 I);\ \varepsilon_2 \sim N(0, \sigma_2^2 I);\ E(\varepsilon_1 \varepsilon_2') = \sigma_{12} I$$

The terms $(I+W)EMP_{0090}$ and $(I+W)POP_{0090}$ are spatially weighted employment and population growth between 1990 and 2000, and $(I+W)EMP_{90}$ and $(I+W)POP_{90}$ are spatially weighted employment and population in 1990. Spatially weighted growth is a measure of regional growth potential. Equation (31) indicates that population growth depends not only on previous population, but also on local employment growth potential. The parameter of the growth potential variable measures spillover effects among neighboring counties.

Vector S in the employment equation includes *Government Expenditure* (local government expenditure per capita), *Property Tax* (local property taxes per employee), *Average Industry Earnings* (constructed by dividing total industry earnings by total employment), *Education* (education quality), *Manufacturing Concentration* (concentration of manufacturing), $POPDEN_{90}$ (population density in 1990), and *Natural Amenity* (natural amenity scale)[18]. *Government Expenditure* and *Property Tax* reflects

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[18] Government expenditure, property tax and income tax are for all local governments not just county governments.

fiscal policies that may affect capital movement. *Average Industry Earnings* and *Education* are expected to affect employment demand. *Manufacturing Concentration* and *Retailing Concentration* are used to capture agglomeration effects. *Manufacturing Concentration* is the potential employment level in 1990 in the manufacturing sector, which is constructed using three different weight matrices[19]:

(32) $$Manufacturing\ Concentration = (I + W)MANEMP_{90}$$

where $MANEMP_{90}$ is county manufacturing employment in 1990. *Retailing Concentration* is potential employment level in 1990 in the retailing sector, and is constructed similarly using county retailing employment in 1990.

$POPDEN_{90}$ is a proxy for congestion. *Natural Amenity* quantifies the physical characteristics of a county by combining six measures of climate, typography, and water that reflect environmental quality. The natural amenity indicator controls for amenities available to local employees. *Nonattainment*, a dummy variable that indicates whether counties meet federal air quality standards, is used to control for air pollution. Local policy indices, *Economic Policy* (economic development policy index) and *Environmental Policy* (environmental policy index) represent local policy influences. These indices are described in detail in the next section.

The explanatory variable vector T in the population equation follows similar logic, including: (1) fiscal variables, *Government Expenditure*, *Per Capita Tax* (local taxes per capita); (2) environmental amenity variables, *Natural Amenity* and *Nonattainment*; (3)

[19] Definition of weight matrices is given in section 4.3.6.

social amenity variables, *Education*, *Poverty Rate, Crime Rate* and $POPDEN_{90}$; and (4) local policy indices, *Economic Policy* and *Environmental Policy*.

In both equations, metropolitan dummies, *Metro* (metropolitan counties) and *Adjacency* (indicating counties that are adjacent to the central cities or metropolitan areas) are included to control for the difference of growth patterns among metropolitan and nonmetropolitan counties. Counties adjacent neither to metropolitan nor to central city are the default category, which includes rural areas. Regional dummies such as *Northeast* (Northeast region), *Midwest* (Midwest region), and *West* (West region) specify regional growth differences. The default region is the South region.

4.2.3 Survey Data and Local Policy Indices

Local economic and environmental policy indices are constructed from a county government survey conducted by researchers at the Ohio State University with the cooperation of the National Association of Counties (NAC) in 2001 (Lobao and Kraybill 2005). Nearly 2700 counties in 46 states were surveyed. Of these, 1678 counties responded to the survey, and the response rate was 62 percent. The questionnaire consists of over 200 questions, covering issues such as services provided, economic development policies, environmental protection policies, public services and fiscal conditions.

Information gathered from the questionnaire covers various local policies and programs. Two policy indices are constructed from the survey (table 4.3). The economic development policy index is constructed by summing the number of policies designed to attract businesses and stimulate economic growth. The environmental policy index is constructed by summing the number of growth control policies adopted by the county. Variables including comprehensive planning, impact fee, lot size restriction, urban growth boundaries and zoning are used to construct the environmental policy index, which summarizes variables used to control growth.

4.3 Model Estimation Methods

4.3.1 Identification of the Aspatial Model

A simultaneous equations model can be written in two forms: one is the structural form; the other is the reduced form. The estimation methods used in this chapter draw heavily on Greene (1996), Anselin (1988), Rey and Boarnet (1998), and Kelejian and Prucha (1999). The structural form is as follows:

$$Y'\Gamma + X'B = E' \tag{33}$$

where $Y_{2\times n} = \begin{bmatrix} POP_{00} \\ EMP_{00} \end{bmatrix}$, $\Gamma_{2\times 2} = \begin{bmatrix} 1 & -\gamma_2 \\ -\gamma_1 & 1 \end{bmatrix}$, $X_{k\times n} = \begin{bmatrix} 1 \\ x_1 \\ \vdots \\ x_k \end{bmatrix}$

$B_{k\times 2} = \begin{bmatrix} -\alpha_0 & -\beta_0 \\ -\alpha_1 & -\beta_1 \\ \vdots & \vdots \\ -\alpha_k & -\beta_k \end{bmatrix}$, and $E_{2\times n} = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix}$

n is the number of observations,

k is the number of explanatory variables.

This system is a complete system of equations, since the number of equations equals the number of endogenous variables. The symbol X denotes exogenous variables in both equations, and B denotes the parameters of variable X. Variables appearing only in one equation have a zero parameter in the other equation. The solution of the system, where Y is solved in terms of X, gives the reduced form:

(34) $$Y' = -X'B\Gamma^{-1} + E'\Gamma^{-1} = X'\Pi + V'$$

The reduced form implies the simultaneous equations model can be solved equation-by-equation mathematically given there are no restrictions on parameter space and that orthogonality holds for the error terms. But to guarantee that this system has a unique solution, additional conditions must be satisfied. These conditions are known as identification conditions.

From the reduced-form coefficient matrix, $\Pi = -B\Gamma^{-1}$, which implies $\Pi\Gamma = -B$, or

(35) $$\begin{bmatrix} \pi & \Pi \\ \pi^* & \Pi^* \end{bmatrix} \begin{bmatrix} 1 \\ -\gamma_1 \end{bmatrix} = \begin{bmatrix} \alpha \\ 0 \end{bmatrix}$$

The symbols π , Π represent the parameters for exogenous variables in the reduced form, and they are partitioned to correspond to endogenous variables. The symbols π^*, Π^* denote parameters for the excluded variables in the reduced form. This requires that $\pi - \Pi\gamma_1 = \alpha$ (the number of equations equals the number of exogenous variables), and $\pi^* - \Pi^*\gamma_1 = 0$ (the number of equations equals the number of excluded variables). For identification, a simultaneous equations model must satisfy both the order and rank condition. The order condition requires the number of exogenous variables excluded from an equation to be at least as large as the number of endogenous variables included in the equation, which means equation $\pi^* - \Pi^*\gamma_1 = 0$ has a solution. This is a necessary condition, which ensures the system has at least one solution. The rank condition requires rank$\left[\pi^* \quad \Pi^*\right]$= rank$\left[\Pi^*\right]$, which ensures that $\pi^* - \Pi^*\gamma_1 = 0$ has one unique solution. This can be shown to be equivalent to the order condition (Greene 1996). In this system, there is more than one excluded variables in each of the two equations, so the order and rank conditions both hold. In fact, this system is over-identified because there are more excluded variables than endogenous variables in both equations.

4.3.2 Estimation of the Aspatial Model

Because a simultaneous equations model can be shown in the reduced form where all endogenous variables are expressed as a function of exogenous variables, standard ordinary least squares (OLS) method can be used to estimate the reduced-form system in the exactly identified case, given no cross-sectional correlation. This method is known as indirect least squares (ILS) estimation, since all these estimates are functions of the parameters of the structural model. Further computation is needed to retrieve the estimates of the structural model. But because of over-identification of our system, ILS is unable to produce one unique solution.

OLS gives an inconsistent estimate of the structural model if independent variables are correlated with the error terms, which violates the assumptions of OLS estimation. A technique used frequently to deal with endogenous variables is the two-stage least squares (2SLS) estimation. In OLS estimation, if the assumptions of the model hold, the fitted value is orthogonal to the error term in the limit. That is,

(36) $$p\lim \frac{1}{N}[\hat{y}'_j \varepsilon_j] = p\lim(\frac{Y_j^{'} X}{N})(\frac{X'X}{N})^{-1}(\frac{X'\varepsilon_j}{N}) = 0$$

when $p\lim \frac{1}{N}[X'_j \varepsilon_j] = 0$

The 2SLS method involves a choice of instrumental variables, which must be exogenous, to implement OLS estimation. Because excluded exogenous variables in the other equations satisfy the orthogonality condition, they can be used to derive 2SLS estimates in a simultaneous equations model, so no additional instrumental variables are needed.

The 2SLS estimator is:

(37) $$\hat{\delta}_{j,2SLS} = \begin{bmatrix} \hat{Y}_j^{'} Y_j & \hat{Y}_j^{'} X_j \\ X_j^{'} Y_j & X_j^{'} X_j \end{bmatrix}^{-1} \begin{bmatrix} \hat{Y}_j^{'} y_j \\ X_j^{'} y_j \end{bmatrix}$$

where $\hat{Y}_j = X(X'X)^{-1}X'Y_j$, Y_j is the endogenous variable in equation j, X_j is all exogenous variables in equation j, and y_j is the normalized dependent variable. The 2SLS method has the same efficiency as other estimation methods such as the generalized method of moments (GMM) method and limited information maximum likelihood (LIML) method.

If the cross-sectional covariance of the system is not zero, the 2SLS estimator is less efficient than a generalized least squares (GLS) estimator. In this case, the three-stage least squares (3SLS) or full-information maximum likelihood (FIML) estimator is preferred. The difference between 3SLS and 2SLS is that 3SLS allows for the possibility of heteroscedasticity and normalizes the covariance matrix while computing the estimators.

4.3.3 Identification and Estimation of the Spatial Model without Error Autocorrelation

Simultaneous equations models with spatial effects are relatively new in the econometrics literature and relatively rare in empirical analysis. Most estimation methods for spatial models are based on a single equation. Previous studies using simultaneous systems of equations in spatial econometrics are based on the strict assumption that the disturbance term of each equation has a zero mean and the errors are not spatially autocorrelated. Under this assumption, a general form of a simultaneous equations model with spatial interactions can be expressed as follows (Rey and Boarnet 1999):

(38) $$Y'\Gamma = WY'P + X'B + E',$$

where $$Y_{2\times n} = \begin{bmatrix} y_1 \\ y_2 \end{bmatrix}, \Gamma_{2\times 2} = \begin{bmatrix} 1 & -\gamma_2 \\ -\gamma_1 & 1 \end{bmatrix}, W = \begin{bmatrix} w_{11} & \cdots & w_{1n} \\ \vdots & \vdots & \vdots \\ w_{n1} & \cdots & w_{nn} \end{bmatrix},$$

$$P = \begin{bmatrix} \rho_{11} & \rho_{21} \\ \rho_{12} & \rho_{22} \end{bmatrix}, X_{k\times n} = \begin{bmatrix} 1 \\ x_1 \\ \vdots \\ x_k \end{bmatrix}, B_{k\times 2} = \begin{bmatrix} \alpha & \beta \end{bmatrix} = \begin{bmatrix} -\alpha_0 & -\beta_0 \\ -\alpha_1 & -\beta_1 \\ \vdots & \vdots \\ -\alpha_k & -\beta_k \end{bmatrix}, E_{2\times n} = \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix}$$

where W is a spatial weight matrix,

P is a parameter matrix to capture spatial interactions.

In general, spatial interactions can be of a spatial auto-regressive or spatial cross-regressive type. The structural form can be transformed into the reduced form:

(39) $$y_1 = F^{-1}A^{-1}(\rho_{12}W + \gamma_1)C^{-1}(X\beta + \varepsilon_2) + F^{-1}A^{-1}(X\alpha + \varepsilon_1)$$

where $A = (I - \rho_{11}W)$, $C = (I - \rho_{22}W)$

$$F = 1 - A^{-1}(\rho_{12}W + \gamma_1)C^{-1}(\rho_{21}W + \gamma_2)$$

If no autoregressive endogenous variables exist in the model, then the reduced form is simplified:

(40) $$y_1 = F_1^{-1}(\rho_1 W + \gamma_1)(X\beta + \varepsilon_2) + F_1^{-1}(X\alpha + \varepsilon_1)$$

where $F_1 = 1 - (\rho_1 W + \gamma_1)(\rho_2 W + \gamma_2)$

If the spillover effect is an autoregressive effect, then the reduced form is:

(41) $$y_1 = F_1^{-1}A^{-1}\gamma_1(X\beta + \varepsilon_2) + F_1^{-1}A^{-1}(X\alpha + \varepsilon_1)$$

where $F = 1 - A^{-1}\gamma_1 C^{-1}\gamma_2$

The above reduced form is similar to that of the aspatial case, so the system is identified given that there are more excluded variables than endogenous variables in the equation.

Given no autocorrelation, the 2SLS estimators of P and B are consistent (Anselin 1988, Kelejian and Robinson 1998, Anselin and Kelejian 1997). From the reduced form, the endogenous variables can be expressed as a function of X and WX . So, X and WX are commonly used in the first-step regression as instrumental variables.

Let $H = (X, WX)$, then $(I \hat{+} W)Y_j = H(H'H)^{-1}H'(I + W)Y_j$. The 2SLS estimator is:

$$\hat{\delta}_{j,2SLS} = \begin{bmatrix} (I \hat{+} W)Y_j^{'}Y_j & (I \hat{+} W)Y_j^{'}X_j \\ X_j^{'}Y_j & X_j^{'}X_j \end{bmatrix}^{-1} \begin{bmatrix} (I \hat{+} W)Y_j^{'}y_j \\ X_j^{'}y_j \end{bmatrix} \tag{42}$$

There are two ways to instrument $(I + W)Y_j$. One is to instrument Y_j in the first-stage and then multiply it by $(I + W)$. The other is to instrument the whole equation $(I + W)Y_j$ in the first-stage directly. Rey and Boarnet (1998) use Monte Carlo simulations to compare these two methods. Their results show that in the first-stage estimation using $(I + W)Y_j$ as the dependent variable rather than Y_j and then multiplying by $(I + W)$ gives a better estimation with a small mean square error.

4.3.4 Estimation of the Spatial Model with Error Autocorrelation

Kelejian and Prucha (1997) have revealed pitfalls in the estimation of a spatial model with an autocorrelation error structure by 2SLS procedures. Though tempting for convenience, 2SLS estimator is inconsistent in this case.

The maximum likelihood method is often used in single equation spatial models with error correlation (Anselin 1988). This method can also be used to estimate the simultaneous equations model. The spatial cross-regressive system can be expressed as follows using the vector operator:

(43) $$(\Gamma \otimes I)VEC(Y) = (P \otimes W)VEC(Y) + (B \otimes I)VEC(X) + VEC(E)$$

$$VEC(E) = (\lambda \otimes W)VEC(E) + U$$

where $U \sim N(0,\Omega)$, $\Omega = \begin{bmatrix}\sigma_1^2 & \sigma_2^2\end{bmatrix} \otimes I$

which can be simplified as:

(44) $$(G - H)y = Dx + \varepsilon$$

$$\varepsilon = K^{-1}u \cdot$$

where $G = (\Gamma \otimes I)$, $H = (P \otimes W)$, $D = (B \otimes I)$

$x = VEC(X)$, $y = VEC(Y)$, $\varepsilon = VEC(E)$ and $K = (I - \lambda \otimes W)$

Since the error covariance matrix $E[u'u] = \Omega$ is a diagonal matrix, there exists a vector of random disturbance ν and $\nu = \Omega^{1/2}u$. Substituting ν and K into the system, the system can be written as $\Omega^{-1/2}K[Ay - Dx] = \nu$, where $A = G - H$. Based on the assumption of a normal distribution, maximum likelihood estimator (MLE) is a consistent estimator that maximizes the log likelihood function:

(45) $$L = -(N/2)\ln(2\pi) - (1/2)\ln(\Omega) + \ln|K| + \ln|A| - (1/2)\nu'\nu$$

Computational work required to implement the maximum likelihood method in a spatial model is prohibitive. Because of nonlinearity of the first order condition of the maximization problem, Anselin suggests a grid method to search for the spillover parameter values over the range of –1 to +1, which will maximize the concentrated likelihood function.

A simple way to deal with autoregressive disturbances is a generalized spatial 2SLS (GS2SLS) method introduced by Kelejian and Prucha (1998). In the system, the equation can be simplified as:

(46) $y_1 = Z\delta + \varepsilon$

$\varepsilon = \lambda W\varepsilon + u$

$u \sim N(0, \sigma_u^2)$

where $Z = (X_1, (I+W)Y_2)$ and $\delta = (\alpha', \rho)$

Kelejian and Prucha propose using a three-step procedure to estimate this model consistently:

First step: estimate δ using 2SLS, $\hat{\delta} = (\hat{Z}'\hat{Z})^{-1}\hat{Z}'y_1$, where

$\hat{Z} = (X_1, (I \hat{+} W)Y_2) = (X_1, P_H(I+W)Y_2)$, $P_H = X(X'X)^{-1}X'$, and X is a vector of instrumental variables.

Second step: from the first estimation step, obtain residuals. Let $\tilde{\varepsilon} = y_1 - Z\hat{\delta}$,

$\tilde{\tilde{\varepsilon}} = W\tilde{\varepsilon}$, and $\tilde{\tilde{\tilde{\varepsilon}}} = W^2\tilde{\varepsilon}$, and $G_n = \frac{1}{n}\begin{bmatrix} 2\sum \tilde{\varepsilon}\tilde{\tilde{\varepsilon}} & -\sum \tilde{\tilde{\varepsilon}}^2 & 1 \\ 2\sum \tilde{\tilde{\varepsilon}}\tilde{\tilde{\tilde{\varepsilon}}} & -\sum \tilde{\tilde{\tilde{\varepsilon}}}^2 & Tr(W'W) \\ \sum\left[\tilde{\varepsilon}\tilde{\tilde{\tilde{\varepsilon}}} + \tilde{\tilde{\varepsilon}}^2\right] & -\sum \tilde{\tilde{\varepsilon}}\tilde{\tilde{\tilde{\varepsilon}}} & 0 \end{bmatrix}$,

$g_n = \frac{1}{n}\begin{bmatrix} \sum \tilde{\varepsilon}^2 \\ \sum \tilde{\tilde{\varepsilon}}^2 \\ \sum \tilde{\varepsilon}\tilde{\tilde{\varepsilon}} \end{bmatrix}$. Estimates of $\hat{\lambda}$ and $\hat{\sigma}_u^2$ are derived by minimizing the following expression:

(47) $$\left[g_n - G_n\begin{bmatrix}\lambda \\ \lambda^2 \\ \sigma_u^2\end{bmatrix}\right]'\left[g_n - G_n\begin{bmatrix}\lambda \\ \lambda^2 \\ \sigma_u^2\end{bmatrix}\right]$$

Third step: given the estimated value of $\hat{\lambda}$, re-estimate δ using 2SLS:

(48) $$\hat{\delta}_{GS2SLS} = \left[\hat{Z}(\hat{\lambda})'\hat{Z}(\hat{\lambda})\right]^{-1}\hat{Z}(\hat{\lambda})' y_1(\hat{\lambda})$$

where $\hat{Z}(\hat{\lambda}) = (X_1 - \hat{\lambda}WX_1, (I \hat{+} W)Y_2(\hat{\lambda}))$

$$(I \hat{+} W)Y_2(\hat{\lambda}) = P_H[(I+W)Y_2 - \hat{\lambda}W(I+W)Y_2]$$

$$y_1(\hat{\lambda}) = y_1 - \hat{\lambda}Wy_1$$

In a recent paper, Kelejian and Prucha (2004) demonstrated the GS2SLS method is valid for estimating a simultaneous equations model. Since the spatial model involves a system of equations, it may be necessary to correct for heteroschedasticity due to the correlation between the equations. A feasible general spatial two-stage least squares (FGS2SLS) method is one that weights the regression variables by the estimated variance from the above estimation, and for which the 2SLS estimates for the covariance matrix of the system are robust.

Another possible way to solve a spatial model with autoregressive disturbances is to use the generalized method of moments (GMM) method, but the critical issue is how to find the best instrumental variables for the system. Lee (2001a, 2001b) has shown a way to find the best instrumental variables using the GMM method in a single equation model to improve 2SLS estimation and achieve the same efficiency of estimation using the maximum likelihood estimation method. It is possible to extend this method to a system of equations, but it is difficult to implement in empirical work with a high dimension spatial weight matrix.

The 2SLS estimation method is used to estimate the spatial model in this study. Since the sample data is spatially discontinuous, some of the tests and regression techniques described above can not be implemented. Reasons for this are explained in chapter 5.

4.3.5 A Test for Spatial Autocorrelation

In section 4.3.3 and 4.3.4, various estimation methods were proposed for different spatial structures. The critical question is how to identify spatial autocorrelation in a model. Which kind of test statistics should be used in empirical work?

Moran's I statistic is applied widely as a diagnostic test for the existence of spatial autocorrelation. This method is similar to the Durbin-Watson (D-W) test for diagnosing the possibility of autocorrelation in an aspatial model. Estimation is based on the assumption of no autocorrelation (null hypothesis), and if there are no additional endogenous variables in the model, standard OLS estimation can be used to compute the residuals (Anselin 1988). Anselin and Kelejian (1997) have shown residuals of 2SLS estimation or IV estimation can be used to construct Moran's I statistic in the presence of endogenous regressors:

(49) $$I = N(\hat{\varepsilon}'W\hat{\varepsilon}) / S_0(\hat{\varepsilon}'\hat{\varepsilon})$$

where $\hat{\varepsilon} = y_1 - Z\hat{\delta}_{2SLS}$ and $S_0 = \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}$

It has been shown that Moran's I statistic is distributed approximately normal, $N^{1/2}I \sim N(0,\phi^2)$. If $\left| N^{1/2}I / \hat{\phi} \right| > Z_{a/2}$, then the hypothesis of no spatial autocorrelation is rejected and the generalized spatial 2SLS method will be appropriate to use in this situation. Hepple (1997) introduces another way to construct Moran's I statistic in the simultaneous equations models, but this statistic is limited in use due to the assumption of no spatial endogenous variables.

4.3.6 Weight Matrices

Spatial interaction among different jurisdictions is one of the main concerns of this dissertation. Spatial interaction can be estimated using Krieging interpolation for geostatistical data (Cressie 1993). The idea is to approximate the spatial covariance matrix using geographical attributes. This method is useful for forecasting but is not appropriate for statistical inference. A spatial weight matrix is often assigned for lattice data, which specifies the pattern of spatial interaction and reduces the number of parameters.

Spatial weight matrices need to satisfy the following assumptions (Anselin and Kelejian 1997):

(1) The elements of W are not a function of the sample size, and W is uniformly bounded in both row and column sums. This implies the elements of the weight matrix must not change with the addition of neighbors.

(2) The number of rows in W that consist entirely of zero elements is a finite constant no matter how large is the sample size. This assumption avoids abrupt change in the structure of spatial dependence.

(3) If region i is the neighbor of region j, then region j must be the neighbor of region i. Also W_{ii} must be zero, which means region i cannot be its own neighbor (Cressie 1993).

In empirical work, the first assumption is often neglected by assigning a weight of zero to border regions. This creates a sample bias problem since the missing data may matter in the system of spatial interactions. In this dissertation, W is extended to include the border county.

The spatial weight matrix is often constructed using geographical location information based on the gravity theorem. Sometimes regional economic interaction information such as international trade data or inter-regional migration data is used. The law of gravity states that increasing distance will reduce spatial interaction, so there should be a boundary for spatial interaction.

In this dissertation, three different weight matrices are constructed according to the geographical location of counties:

Contiguity matrix: $w_{ij} = \begin{cases} 1, & if \ counties \ share \ a \ common \ border \\ 0, & otherwise \end{cases}$.

Inverse distance matrix: $w_{ij} = \begin{cases} 1/d_{ij}, & if \ d_{ij} < 100 \ mile \\ 0, & otherwise \end{cases}$

Inverse square distance matrix: $w_{ij} = \begin{cases} 1/d_{ij}^{\ 2}, & if \ d_{ij} < 100 \ mile \\ 0, & otherwise \end{cases}$

The symbol d_{ij} is the distance from centroid of county i to centroid of county j.

All weight matrices are normalized in rows, which is important because this guarantees the influence of neighbors will not be inflated when the region has a large number of neighbors. If a county has more neighbors than another county, then the influence of each neighbor on this county is less than the influence of each neighbor of that county.

4.3.7 Endogeneity Test

In econometric analysis, the estimation is biased if exogenous variables are correlated with the error term. Local policy variables are likely to be endogenous in this system since local environmental and economic policies are highly related to local economic growth. On the one hand, local environmental and economic policies affect local economic growth; on the other hand, economic growth affects local environmental and economic policies. Counties with high income and a high rate of economic growth have a strong incentive to adopt stringent environmental policies. In contrast, counties with a low rate of economic growth and low income are more likely to adopt economically stimulating policies. Land use policies are endogenous because these policies create externalities for different land users. Developers and governments must consider these effects when maximizing their welfare functions (Stull 1974).

Hausman's test (1978) is implemented to diagnose whether local policy indices are endogenous or not. If policy variables are exogenous, 2SLS estimates with the original policy data are consistent, but they are biased if these policies are endogenous. In contrast, 2SLS estimates with instrumented policy indices give a consistent estimate in both cases, but they are not efficient if there is no endogeneity problem. If the policy indices are exogenous, there is little difference in estimates using the two methods. We can use a chi-squared test based on the Wald criterion to test if policy indices are endogenous: $W = \chi^2[2] = \lfloor b - \hat{\beta} \rfloor \hat{\Sigma}^{-1} \lfloor b - \hat{\beta} \rfloor$. Under the null hypothesis of no endogeneity, W asymptotically has a chi-square distribution with two degrees of freedom.

If local policy variables are found to be endogenous, an estimation method must be used to correct the endogeneity problem. Two methods are often used in the literature to deal with this problem. One is the instrumental variable method, and the other is the panel data method. If instrumental variables are appropriate, then the second stage estimates using fitted values of endogenous variables can give consistent estimates. But it is difficult to find suitable instruments, and there are no convincing ways to evaluate the goodness of the instruments. The alternative method is to use panel data and to estimate parameters using first-order differenced variables. This method has some advantages, because both the correlation of X_i and ε_i, and spatial error dependence are reduced after first differencing. This approach eliminates fixed effects and random effects if we specify the error term in a more complicated form, such as $\varepsilon_{it} = d_i + \mu_{it}$. But coefficients of the variables that are invariant in time are not estimable. The 2SLS method can give consistent estimates for the spatial differencing case, but the GMM method is more efficient if error dependence still exists. This method has been implemented in studies by Figlio et al. (1999) and Revelli (2001). In this dissertation, because the survey data covers only one year and some variables for Census 1980 are not available, the instrumental variable method is adopted rather than the first differencing method.

4.4 Summary

In this chapter, criteria for selecting empirical models and estimation methods for both aspatial and spatial models are discussed. Because of spatial interaction among different jurisdictions, spatial models are emphasized. For spatial models, this chapter focuses on how to estimate the models consistently with and without error autocorrelation. Endogeneity tests of local policies and estimation methods for the endogeneity models are discussed.

Studies	Study area	Objective	Employment equation	Population equation
Steinnes and Fisher (1974)	Chicago metropolitan area	Model geographic allocation of employment and residence	Industrial land Corporate tax Trucking zone dummies Hospital beds Exogenous activity employment	Median income Property tax rate College faculty Ghetto dummies Residential land Subway dummy Area on lake
Mills and Price (1984)	SMSA	Study factors affecting suburbanization	Wage rate ratio of C/S Ratio of percent nonwhite of C/S Crime rate ratio of C/S Ratio of education of C/S Tax rate ratio of C/S Per capita income ratio of C/S	Income per capita Ratio of percent nonwhite Of C/S Crime rate ratio of C/S Ratio of education of C/S Tax rate ratio of C/S
Carlino and Mills (1987)	All US counties	Study determinants of county employment and population growth	Percent black Interstate highway density Median family income Percent union Total value of state industrial revenue bonds Regional dummies	Percent black Interstate highway density Local taxes per capita Family income Regional dummies
Palumbo (1990)	66 central cities and their suburbs	Identify factors affecting economic and population decentralization	Old house percentage Percent poverty Percent black Crime rate City, suburban education expenditure Tax rate of C/S Central city pupil residence rate Employment ratio of C/S	Old house percentage Percent poverty Percent black Crime rate City education expenditure Tax rate of C/S Central city pupil residence rate Population ratio of C/S

Continued

Table 4.1: Explanatory Variables Used in Previous Regional Growth Studies[20]

[20] C/S represents the central city versus suburban areas

Table 4.1 continued

Studies	Study area	Objective	Employment equation	Population equation
Boarnet (1994)	365 municipals in northern New Jersey	Study intra-metropolitan population and employment growth using a spatial model	Distance from the centroid of New Jersey municipal to the centroid of Manhattan Island Highway dummy Railway station dummy Manufacturing agglomeration variable Retail agglomeration variable Property tax rate Public expenditure per employee Violent crime rate Property crime rate Percentage of old housing Land area	Distance from the centroid of New Jersey municipal to the centroid of Manhattan Island Highway dummy Percent black Poverty rate Per capita tax Per capita public goods expenditure Violent crime rate Property crime rate Percentage of old housing Land area
Schmitt and Henry (2000)	Six French communes	Study city size and growth influences on rural population and employment changes	Urban center employment growth rate Fringe employment growth rate Unemployment rate Skilled manual workers Executive and intermediate occupations Percentage of non-salaried jobs Tourism accommodation Distance to nearest urban agglomeration inhabitants Distance to the nearest freeway entrance Household taxable income	Urban population growth rate Fringe population growth rate Distance to urban center Frequency of 28 types of residentiary services Percentage old housing Distance to the nearest freeway entrance Distance to the nearest secondary school Distance to the nearest hospital Household taxable income

Continued

Table 4.1 continued

Studies	Study area	Objective	Employment equation	Population equation
Deitz (1998)	Boston metropolitan area	Study interdepen-dence of residential and employment location	Access to own workers Access to all others Access to other jobs Commercial tax rate Highways Distance to center	Access to own work Access to other jobs Highways Distance to center Tax rate Crime rate Public service Education quality
Henry et. al (1999a)	Functional Economic Areas construct-ed from three southern states	Study rural-urban development linkage	Distance to the nearest hospital Highway density Water and sewer line density Percentage of occupied housing with public sewer utilities Students per teacher in local high school Poverty rate Old housing percentage	Distance to the nearest hospital Water and sewer line density Percentage of occupied housing with public sewer utilities Students per teacher in local high school Quality of local labor Poverty rate
Deller et. al (2001)	2243 rural US counties	Study the effects of local amenity and quality of life on rural economic growth	Percent nonwhite Percent population under 17 Percent population above 65 Entropy income distribution index Poverty rate Unemployment rate Percent high-school graduate Crime rate Number of physicians Property tax Government expenditure Climate Recreational infrastructure Land Water Winter	Percent nonwhite Percent population under 17 Percent population above 65 Entropy income distribution index Poverty rate Unemployment rate Percent high-school graduate Crime rate Number of physicians Property tax Government expenditure Climate Recreational infrastructure Land Water Winter

Variable name	Description	Data source
<u>Aspatial model</u>		
EMP_{0090}	Employment growth from 1990 to 2000	Census of Population, 2000 and 1990
POP_{0090}	Population growth from 1990 to 2000	Census of Population, 2000 and 1990
EMP_{90}	County employment, 1990	Census of Pop.,1990
POP_{90}	County population, 1990	Census of Pop.,1990
$POPDEN_{90}$	County population density, 1990	Census of Pop.,1990
Government Expenditure	Government expenditure per capita, 1986-87	Constructed from County and City Data Book, 1994
Average Industry Earnings	Average industry earnings, 1990	Constructed from County and City Data Books, 1994
Property Tax	Local property tax rate, 1986-87	County and City Data Book, 1994
Crime Rate	Serious crime per 100,000 populations, 1991	County and City Data Book, 1994
Poverty Rate	Percentage of families with income below poverty level, 1989	County and City Data Book 1994
Family Income	Median family income, 1989	Census of Pop.,1990
Education	Percentage persons 25 years or old with bachelor degree or higher, 1990	County and City Data Book, 1994
Per Capita Tax	Local per capita taxes, 1986-1987	County and City Data Book, 1994
Natural Amenity	Natural amenity scale, 1999	ERS-USDA
Manufacturing Concentration	Manufacturing employment concentration, 1990	Constructed from County and City Data Book, 1994
Retailing Concentration	Retail employment concentration, 1990	Constructed from County and City Data Book, 1994

Continued

Table 4.2: Description of Variables and Sources of Data

Table 4.2 continued

Variable name	Description	Data source
Metro	Dummy for metropolitan counties	ERS-USDA
Adjacency	Dummy for counties adjacent to Central City or metropolitan counties	ERS-USDA
Nonattainment	Dummy for counties that do not meet federal air quality standard	EPA
Northeast	Northeast region dummy	ERS-USDA
Midwest	Midwest region dummy	ERS-USDA
West	West region dummy	ERS-USDA
Economic Policy	County economic development policy index	Survey data
Environmental Policy	County environmental policy index	Survey data
Spatial model		
$(I+W)EMP_{0090}$	Employment growth potential from 1990 to 2000	Census of Population, 2000 and 1990
$(I+W)POP_{0090}$	Population growth potential from 1990 to 2000	Census of Population, 2000 and 1990
$(I+W)EMP_{90}$	Employment potential, 1990	Census of Population, 1990
Instrumental variables		
Democratic Vote	Percent who voted for a Democratic presidential candidate, 1992	County and City Data Book 1994
Per Capita Income	Per capita income, 1989	County and City Data Book 1994
Administration	Dummy variable, if county government is operated with an elected county administrator then Administration=1, else Administration=0	Survey data
Land Loss Rate	Farm land loss rate from 1987 to 1992	Constructed from County and City Data Book 1994

Economic development policies
Developed county strategic plan for economic development
Developed county marketing plan for economic development
Called on national company headquarters
Developed a new industrial park
Expanded an existing industrial park
Built spec buildings to attract business
Maintained small business development center
Maintained a business incubator
Had an economic development professional on staff
Environmental policies
Comprehensive planning
Impact fee
Lot size restrictions
Urban growth boundaries
Zoning

Table 4.3: Economic Development and Environmental Policies Indices

CHAPTER 5

EMPIRICAL RESULTS

In this chapter, empirical models introduced in chapter four are estimated and the hypotheses listed in chapter one are tested. The main focus is on how county environmental regulations affect population and employment growth. For policy implications, the effects of environmental policies on employment growth are emphasized.

This chapter consists of four sections. Section one lays out some facts on employment and population growth in the 1990s, which are conducive to interpreting the model estimates. Section two states expected model results, which are based on the studies reviewed in chapter two. Section three focuses on the aspatial model estimates. Section four is devoted to the spatial model and estimates obtained using three different kinds of spatial weight matrices are presented and compared.

5.1 Population and Employment Growth in the 1990s

5.1.1 Population and Employment Growth Patterns in the 1990s

Population increase in the 1990s was the greatest of all the decades in US history. The gross increment was 32.5 million without including Hawaii and Alaska, and the growth rate was 13.2 percent (see table 5.1)[21]. Population grew in both metropolitan and non-metropolitan areas but it grew faster in metropolitan areas than in non-metropolitan areas. By the end of the 20th century, about 80 percent of population was concentrated in metropolitan areas. Metropolitan population increased by 13.9 percent from 1990 to 2000. Although population grew in all major regions, population in the South and West grew faster than in the other two regions. The growth rate of counties in these two regions was about twice that of counties in the Northeast and Midwest. This indicates that migration from the frostbelt to the sunbelt, which started at the beginning of the 20th century, was still the main force determining the population distribution in the decade of the 1990s. Within the United States, middle-sized counties, which have populations between 0.1 and 1 million, grew faster than other counties. Middle-sized counties had a growth rate of 14.2 percent.

Employment growth has similar patterns as population growth (table 5.2). Aggregate employment growth rate was one percent lower than population growth rate. Metropolitan employment in 2000 accounted for 81.2 percent of total employment in the United States. Although metropolitan areas have more employment than non-metropolitan areas, employment in nonmetropolitan areas grew faster than that in metropolitan areas. Employment growth favored small-sized counties in the 1990s. Counties with population between 10,000 and 100,000 had an employment growth rate of 16 percent. The Northeast had the lowest employment growth rate, which is about one sixth of that in the South. Employment growth rate in the South is the highest with a growth rate of 16.6 percent.

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[21] Detailed growth patterns of population in the 1990s within the United States are studied by Perry (2002).

Although population and employment in all states and regions grew, growth occurred unevenly among counties. Figure 5.1, 5.2, 5.3 and 5.4 are maps showing growth and growth rate of population and employment in the 1990s at the county level. Since population growth and employment growth are highly skewed as compared to the normal distribution, median absolute deviation (MAD) from the median is used to classify the change. For population and employment growth rates, the standard deviation (SD) from the mean is used to classify county groups since these rates are less skewed. Population and employment decrease are identified by cold color, and population growth and employment growth are identified by warm color. These maps show growth tends to cluster within a state, and there is a great deal of variation across counties. The mean population growth from 1990-2000 was 10,417, while the standard deviation was 38,821. Baltimore County, Maryland, had the greatest population decrease (84,860), while Maricopa County, Arizona had the greatest population increase (950,048).

The mean employment growth from 1990-2000 was 4,538, while the standard deviation was 15,819. Los Angeles County, California had the greatest employment decrease (250,377). In contrast, Maricopa County, Arizona had the greatest employment increase (421,367). Uneven growth of county population and employment indicates conditions affecting regional growth vary greatly across counties.

5.1.2 Description of the Sample Data

A total of 1678 counties are included in the regression analysis. The sample includes 432 metropolitan counties and 1246 nonmetropolitan counties. The sample data have a metro-nonmetro ratio close to that of all U.S. counties (see figure 5.5). The sample data contains 91 Northeastern, 615 Midwestern, 718 Southern and 254 Western counties, which accounts for 5%, 37%, 43% and 15%, respectively, of the sample. This is close to the proportions of regions in the U.S. Census data.

Counties in the sample are spatially discontinuous (figure 5.6). Discontinuity results from survey nonresponse. An extended weight matrix is used in the paper to overcome the issue of discontinuity while estimating the spillover effect. An extended weight matrix is based on three criteria:

(1) Population and employment data of all U.S. counties are available;

(2) The model to be estimated is not a SAR model;

(3) The sample data is similar to population data.

Criterion (1) ensures an extended spatial weight matrix can be constructed. In contrast with ordinary spatial weight matrix, the extended spatial weight matrix is not a square matrix. The extended spatial weight matrix is a special case of the square weight matrix. A square weight matrix could be constructed using all US counties if population and employment data of all U.S. counties were available. The spatial weight matrix used here is rectangular since rows of missing counties are eliminated from the matrix. The resulting rectangular matrix ensures that variables such as employment and population growth potential in the spatial model contain information on all neighboring counties.

Criterion (2) ensures that an extended spatial weight matrix can be used. A spatial simultaneous equations model can be an SAR model or a cross-regressive model. An SAR model requires that the spatial weight matrix must be square and counties must be continuous. However, cross-regressive models such as Boarnet's model do not need all spatial points to estimate spatial effects. The shortcoming of an extended spatial weight matrix is that spatial error autocorrelation can not be tested, since observations are discontinuous.

Criterion (3) implies the sample can be used to interpret the population without bias. An inspection of sample components by metropolitan and nonmetropolitan regions (figure 5.5) and spatial distribution of counties (figure 5.6) reveals the sample data is representative, and can be used to interpret factors affecting growth of counties. Lobao and Kraybill (2005) conducted bias tests of the survey data and found no nonresponse bias associated with county characteristics such as unemployment rate, median family income, population size, metro status, and region of the county. Furthermore, they found no bias due to informant characteristics such as the official's age, education, gender and length of time in county employment.

Because extended weight matrices are used for $W * POP$ and $W * EMP$, 3021 counties are used to construct the contiguity matrix and 2944 counties are used to construct the inverse distance matrix and inverse distance square matrix. This covers nearly all counties in the US. Descriptive statistics on the main variables used in the regression are shown in table 5.3.

5.2 Expected Effects of the Independent Variables on Growth

In chapter four, variables used in the empirical model are introduced. In this section, expected signs of these variables are discussed. Expectations are based on economic theory and previous research findings discussed in chapter two and chapter four. For convenience, description of variables used in the regression is restated in table 5.4.

5.2.1 Variables in the Population Equation

Government expenditure per capita is expected to have a nonnegative (i.e., either positive or null) impact on population growth. Income tax per capita is expected to have a negative effect on population growth. Median family income and education quality is expected to be positively associated with in-migration. A high value on the natural amenity scale is expected to stimulate population growth. The poverty rate is expected to have a nonpositive effect on population growth and the crime rate is expected to have a negative effect. Population density in 1990 is expected to have a negative effect on population growth due to congestion. The economic development policy index, which is higher the more growth-promoting the policies the county has adopted, is expected to have a nonnegative effect on population growth. The environmental policy index, which is higher the more land use control policies the county has adopted, is expected to have a negative effect. Nonattainment counties are expected to have less population growth due to the negative externality of pollution. Metropolitan areas are expected to have a population increase while counties adjacent to the central city or metropolitan areas are expected to have a nonnegative population growth. Population in the Northeast grew slowly, while population in the Midwest and West grew fast, according to census data.

5.2.2 Variables in the Employment Equation

Government expenditure per capita is expected to have a nonnegative effect on employment growth. Property taxes are expected to have a negative effect on employment growth. Average manufacturing earnings, a proxy of the wage rate, is expected to be negatively associated with employment growth. Education quality is expected to be positively associated with employment growth. Manufacturing industry concentration and retailing industry concentration are expected to have a positive effect on employment growth due to industrial structure change. Population density in 1990 is expected to have a null effect on employment growth. The natural amenity scale is expected to have a null effect on employment growth. The nonattainment dummy is expected to be positively associated with employment growth. A high value of the economic development policy index is expected to have a positive effect on employment growth, while the environmental policy index is expected to have a null effect on employment growth. Metropolitan location is expected to have a positive effect on employment growth. Adjacency to a central city or metropolitan areas is expected to have a positive or null effect on employment growth. Northeast and Midwest locations are expected to have nonpositive effects on employment growth, while being located in the West is expected to have a nonnegative effect on employment growth.

5.3 Instrumental Variables and a Test for Endogeneity

Instrumental variables are used to test for endogeneity of the policy indices. Instrumental variables must be highly correlated with the endogenous variables but not correlated with the error term. Since there are no obvious instrumental variables from economic theory, instrumental variables are selected according to previous empirical studies.

Political influences are argued to affect economic growth. Santa-Clara and Valkano (2003) find stock market returns are higher under Democratic than Republican presidencies after controlling for the effects of business cycle and risk premium. In a cross-country study, Jensen (2003) also shows democratic governance is positively associated with the inflow of foreign direct investment. Thus there is evidence that the political system may affect the outcome of local economic and environmental policies. Appointed officials may have less incentive to stimulate development than elected officials. In contrast, high income regions, urban areas and regions confronted with severe land loss often have a high demand for environmental quality. Therefore, *Democratic Vote* (percent who voted for a Democratic presidential candidate and *Administration* (dummy variable indicating that the county government has an elected administrator rather than an appointed administrator) are used to instrument the economic development policy index, while *Democratic Vote*, *Per Capita Income* (per capita income) and *Land Loss Rate* (farmland loss rate from 1987 to 1992) are used to instrument the environmental policy index.

A simple OLS regression is applied to test for endogeneity. The results of the local policy index regressions are shown in table 5.5. *Democratic Vote* is significant at the 5 percent level and is positively associated with the economic and environmental policy indices. This implies that the higher the percentage of voters in a county who voted for a Democratic presidential candidate, the more likely that county is to adopt economic stimuli and environmental protection measures. The coefficient on *Administration* is negative and statistically significant at the 5 percent level, indicating that counties with an elected administrator are less likely to put effort into economic development than counties with an appointed administrator. This is not what was expected, but it may be reasonable. Local property owners and businessmen who serve the local market and therefore are highly dependent on local income may be more able to influence an appointed official to adopt economic development policies than they could if the official were elected. *Per Capita Income* is not significant in the environmental policy index regression. This may occur since it is highly correlated with variables like family income and poverty rate. Both poverty rate and family income are significant and have correct signs, which indicate rich counties are more likely to adopt growth control policies. *Land Loss Rate* is positive and statistically significant. The results indicate counties confronted with severe farmland loss are more likely to adopt stringent environmental policies.

Endogeneity tests are applied before the 2SLS estimates are derived from the system. The Hausman test is used to compare the parameters based on the assumption of exogenous versus endogenous policy indices. The results of this test are shown in table 5.6. A p-value less than 0.05 indicates the policy index variables are endogenous. The Hausman test shows policy indices are endogenous in all cases for both the aspatial and the spatial model.

5.4 Results of the Aspatial Model

Both environmental and economic policy indices are endogenous in the employment growth equation but are exogenous in the population growth equation in the aspatial model. Therefore, fitted policy values are used in the second stage regression in the employment equation but not in the population growth equation. Results of the aspatial regression using the 2SLS method are shown in table 5.7. Table 5.7 reveals that population growth has a positive effect on employment growth, and employment growth has a positive effect on population growth. This result implies that people follow jobs, and jobs follow people. Population level in 1990 has a negative effect on population growth and a positive effect on employment growth. Employment level in 1990 is positively associated with population growth but negatively associated with employment growth. That is, initial population level has a negative effect on population growth, and initial employment level has a negative effect on employment growth. Population density in 1990 ($POPDEN_{90}$) has a negative effect on population growth but a positive effect on employment growth. Hence, population concentration may cause congestion and slow down population growth while stimulating employment growth.

Fiscal variables such as government expenditure per capita and average industry earnings are significant at the 10 percent level and have a positive effect on employment growth. Local property tax is significant and has a negative effect on employment growth. Educational attainment has a positive effect on employment growth while a negative effect on population growth. Fiscal variables and social amenity variables (crime rate and poverty rate) in the population equation are insignificant.

Manufacturing industry concentration has a positive effect on employment growth, and retailing industry concentration has a null effect on employment growth. The natural amenity scale is negatively correlated with employment growth but has a positive effect on population growth.

The economic development policy index is negatively associated with population growth and has a null effect on employment growth. The environmental policy index is not significant in either the employment or population equations. The aspatial model shows no evidence that growth control policies affect population growth, which is contrary to expectation.

Metro and adjacency dummies are insignificant in both employment and population growth equations. In the employment equation, the Midwest and Northeast region dummy variables are positive and significant while the variable for the West is not significant. In the population equation, the Midwest dummy is negative and significant at the 10 percent level while the other two regional dummies are insignificant.

In summary, most of the aspatial model estimates are consistent with theory-based expectations about regional growth, although the environmental policy effect is contrary to expectation. In the next section, spatial models with different weight matrices reveal how spatial spillover affects local economic growth.

5.5 Results of the Spatial Model

5.5.1 Results with Contiguity Weight Matrix

The Hausman test shows economic development policy index and environmental policy index are endogenous in both the population and employment growth equations. So the second stage regression is estimated using the fitted values of these indices.

The estimated results using the contiguity weigh matrix are shown in table 5.8. The results indicate that population growth rises with high employment growth potential ($(I+W)EMP_{0090}$), and high population growth potential ($(I+W)POP_{0090}$) leads to more employment growth of the studied county. This implies a positive spillover effect between population growth and employment growth exists across regions. Lagged employment potential ($(I+W)EMP_{90}$) is not significant in the population growth equation, while lagged population potential ($(I+W)POP_{90}$) is significant and has a negative effect on employment growth. Counties with higher population in 1990 (POP_{90}) have higher population growth, while counties with higher employment in 1990 (EMP_{90}) have less employment growth though not so significant. This conforms to the idea that initial population concentration was an important factor in sustaining population growth in the last decade. Higher population density ($POPDEN_{90}$) reduces population growth but has a null effect on employment growth.

Fiscal variables including government expenditure per capita and property tax are not significant in the employment growth equation. Most social and economic amenity variables in the population equation are significant and consistent with expectations. A high crime rate and per capita income tax is associated with less population growth, while counties with high income have more population growth. Poverty rate is not significant.

For the employment equation, average industry earnings level has no significant effect on employment growth, while high educational attainment leads to more growth. Manufacturing industry concentration decreases employment growth and is significant, while retailing industry concentration stimulates employment growth. The significance of the retailing industry concentration variable indicates agglomeration effects of retailing industry concentration play an important role in local economic growth.

The natural amenity scale is insignificant in both the population growth equation and the employment growth equation. Nonattainment status (i.e. counties with high air pollution) is positively associated with employment growth but is negatively associated with population growth.

The local economic development policy index is significant and negative in the population equation, but is not significant in the employment equation. The environmental policy index is negative and significant in the population growth equation, but is not significant in the employment equation. This implies local economic development policies have no significant effects on employment growth. Local environmental policies aimed at controlling growth reduce population growth and have no effect on employment growth.

Most regional dummies are significant and consistent with expectations. Metropolitan location is associated with positive employment growth and negative population growth. Counties adjacent to central cities or metropolitan areas are associated with negative population growth. Population growth is significantly lower in the Midwest, while population growth and employment growth in the other regions are insignificant.

5.5.2 Results with Inverse Distance and Inverse Distance Square Weight Matrix

Results using the inverse distance weight matrix and inverse distance square weight matrix are shown in table 5.9 and table 5.10. Both policy indices are endogenous in the population and employment equations, so a second stage estimation is implemented using fitted values.

The results with the inverse distance weight matrix are highly consistent with the results with the contiguity weight matrix, but there are several differences. Population growth rises with employment growth potential ($(I+W)EMP_{0090}$) and employment growth rises with population growth potential ($(I+W)POP_{0090}$) but the significance level of the latter variable is lower than it was when the continuity weight matrix was used. Lagged employment potential ($(I+W)EMP_{90}$) is now significant and positive in the population equation whereas it was not significant when the contiguity weight matrix was used. Lagged population remains negative and significant in the employment equation. Government expenditure is significant and has a negative effect on employment growth whereas previously, it was not significant. The poverty rate, which was not significant in the previous model, is now significant and has a negative effect on population growth. As before, manufacturing concentration is negatively associated with employment growth. The economic development policy index is insignificant in the population growth equation, wheras previously it was significant and negative; it is positive and significant in the employment growth equation, whereas previously it was not significant. The environmental policy index remains negative and significant in the population equation and not significant in the employment equation. Metro location has a positive and significant effect on employment growth as before but no significant effect on population (previously it was negative and significant). Northeast location is negatively associated with population growth (previously not significant) but has not effect on employment location as before. Location in the West is positively and significantly associated with both population and employment growth whereas previously it affected neither population nor employment.

Results from the model with the inverse distance square weight matrix are similar to those from the model with the inverse distance weight matrix. One difference is that 1990 (EMP_{90}) is now significant and negatively associated with employment growth. As before, the economic development policy index is positively and significantly associated with employment growth while the environmental policy index is negative and significant in the population equation. Adjacency location is no longer significant in the population equation.

Comparing the results of the aspatial model with the results of the spatial model, the spatial model produces results that are closer to expectations. Compared with the results from the contiguity weight matrix, the results from the inverse distance weight matrix are closer to expectations (and there is little difference between the results using the two distance weight matrices).

In a final regression, tests are conducted to determine whether the effects of economic and environmental policies differ across metro, nonmetro adjacent, and nonmetro nonadjacent locations. To do this, interaction terms, in which the policy variables are multiplied by the location variables, are introduced into the spatial model with the inverse distance weight matrix. The results are shown in table 5.11, and F tests of metro and nonmetro difference in policy effects are shown in table 5.12. The results for the nonpolicy variables in the population and employment equations change little compared with the earlier results in table 5.9. The economic development policy index is negatively and significantly associated with population growth in metro locations but is not significant in nonmetro adjacent and nonmetro nonadjacent locations. Economic development policies are not significantly associated with employment growth in either metro or nonmetro (adjacent and nonadjacent) counties. The environmental policy index is significant and negatively associated with population growth in all metro and nonmetro counties, though the marginal effects differ across the locational categories. The negative impacts in nonmetro counties are greater than those in metro counties. The environmental policy index is significant and positively associated with employment growth in metro locations but significant and negatively associated with employment growth in nonmetro locations.

The F tests in table 5.12 reveals impacts of economic and environmental policies on population growth differ across metro and nonmetro counties. Pairs of coefficients are compared in the table and the coefficients are deemed different if $P \leq 0.01$. Economic policy has the same impact on employment growth but a different impact on population growth across metro and nonmetro counties. Environmental policy has a different impact on both employment and population growth across metro and nonmetro counties. No differences in policy impacts are found between nonmetro adjacent and nonmetro nonadjacent locations. The magnitudes of the coefficients in table 5.11 indicate that growth is dampened less by growth control policies in metro counties than in nonmetro counties.

5.6 Summary

In this chapter, an aspatial model and a spatial model are estimated and results from the estimation are used to test hypotheses about the effects of environmental and economic development policies. The endogeneity test indicates that both the environmental policy index and the economic policy index are endogenous. The endogeneity problem is corrected using the instrumental variable method. Estimates from the spatial models with different weight matrices are largely consistent with expectations. The environmental policy index is found to be negatively associated with population growth but not significantly associated with employment growth. The economic development policy index has a positive effect on employment growth but a null effect on population growth. When policy-location interaction terms are used, impacts of local policies on economic growth are found to differ across metro and nonmetro counties.

Category	Number of counties	Population		Growth rate	
		2000	1990	Numeric	Percent
Total US population	3,111	279.6	247.1	32.5	13.2
Metro	834	224.1	196.8	27.4	13.9
Non-metro	2,277	55.5	50.3	5.2	10.3
Northeast	217	53.6	50.8	2.8	5.5
New England	67	13.9	13.2	0.7	5.4
Middle Atlantic	150	39.7	37.6	2.1	5.5
Midwest	1,055	64.4	59.7	4.7	7.9
East North Central	435	45.1	42.0	3.1	7.5
West North Central	620	19.3	17.7	1.6	8.9
South	1,425	100.3	85.5	14.8	17.3
South Atlantic	591	51.8	43.6	8.2	18.9
East South Central	364	17.0	15.2	1.9	12.2
West South Central	470	31.5	26.7	4.7	17.8
West	414	61.4	51.1	10.2	20.0
Mountain	281	18.2	13.7	4.5	33.1
Pacific	133	43.2	37.5	5.7	15.3
County size in 2000:					
> 1 million	34	70.3	62.2	8.0	12.9
0.1-1 million	486	140.3	122.8	17.5	14.2
0.01-0.1 million	1,912	65.3	58.3	6.9	11.9
<10000	679	3.8	3.7	0.1	3.3

- States of Alaska and Hawaii are not included.
- Source: U.S. Census Data 2000 and 1990.

Table 5.1: Population Growth from 1990 to 2000
(Population and Numeric Change in Millions)

Category	Number of counties	Employment		Growth rate	
		2000	1990	Numeric	Percent
Total US population	3,111	128.9	114.9	14.0	12.2
Metro	834	104.7	93.7	11.0	11.7
Non-metro	2,277	24.3	21.2	3.0	14.3
Northeast	217	24.9	24.3	0.6	2.4
New England	67	6.9	6.6	0.3	4.2
Middle Atlantic	150	18.0	17.7	0.3	1.8
Midwest	1,055	31.2	28.0	3.2	11.4
East North Central	435	21.6	19.5	2.0	10.5
West North Central	620	9.6	8.5	1.2	13.7
South	1,425	45.2	38.8	6.4	16.6
South Atlantic	591	23.9	20.6	3.3	16.1
East South Central	364	13.8	11.6	2.2	18.6
West South Central	470	7.5	6.6	1.0	14.6
West	414	27.6	23.8	3.8	15.8
Mountain	281	8.5	6.2	2.2	36.0
Pacific	133	19.1	17.6	1.5	8.7
County size in 2000:					
> 1 million	34	31.5	29.6	1.9	6.4
0.1-1 million	486	66.7	58.7	8.0	13.6
0.01-0.1 million	1,912	29.1	25.1	4.0	16.0
<10000	679	1.7	1.5	0.1	8.2

- States of Alaska and Hawaii are not included.
- Source: U.S. Census Data 2000 and 1990.

Table 5.2: Employment Growth from 1990 to 2000
(Employment and Numeric Change in Millions)

Variable	Mean	Std Dev	Minimum	Maximum
POP_{00}	88,839.00	31,2740.00	67.00	9,519,338.00
EMP_{00}	40,996.00	141,631.00	42.00	3,953,415.00
POP_{90}	77,068.00	287,240.00	107.00	8,863,164.00
EMP_{90}	35,931.00	137,940.00	59.00	4,203,792.00
$POPDEN_{90}$	137.10	545.54	0.16	11,846.20
Per Capita Tax	520.97	392.41	44.00	5,939.00
Property Tax	82.02	15.68	21.90	99.80
Government Expenditure	1,389.81	615.41	128.26	8,635.51
Education	13.50	6.33	3.70	53.40
Poverty Rate	12.61	6.39	0.00	56.50
Family Income	28,434.00	6,722.00	10,903.00	62,749.00
Crime Rate	3,049.79	2,245.24	0.00	13,444.00
Average Industry Earnings	21,922.07	10,354.39	5,933.87	242,398.63
Natural Amenity Scale	0.12	2.28	-6.40	11.17
Manufacturing Concentration	13,051.17	36,282.56	31.80	972,841.06
Retailing Concentration	12,507.77	31,601.27	176.13	764,297.23
Economic Policy	2.89	2.40	0.00	9.00
Environmental Policy	1.29	1.36	0.00	5.00
Metro	0.26	0.44	0.00	1.00
Adjacency	0.32	0.47	0.00	1.00
Nonattainment	0.14	0.35	0.00	1.00
Northeast	0.05	0.23	0.00	1.00
Midwest	0.43	0.49	0.00	1.00
West	0.15	0.36	0.00	1.00
Democratic Vote	38.47	10.32	9.50	82.80
Administration	0.27	0.45	0.00	1.00
Per Capita Income	15,317.00	3,372.00	5,559.00	33,330.00
Land Loss Rate	5.74	14.51	-51.87	353.51

*Total observations = 1678, Metro = 432, Non-metro = 1246

Table 5.3: Descriptive Statistics of Variables Used in the Analysis

Variable name	Description
<u>Aspatial Model</u>	
EMP_{0090}	Employment growth from 1990 to 2000
POP_{0090}	Population growth from 1990 to 2000
EMP_{90}	County employment, 1990
POP_{90}	County population, 1990
$POPDEN_{90}$	County population density, 1990
Government Expenditure	Government expenditure per capita, 1986-87
Average Industry Earnings	Average industry earnings, 1990
Property Tax	Local property tax rate, 1986-87
Crime Rate	Serious crime per 100,000 populations, 1991
Poverty Rate	Percentage of families with income below poverty level, 1989
Family Income	Median family income, 1989
Education	Percentage persons 25 years or old with bachelor degree or higher, 1990
Per Capita Tax	Local per capita taxes, 1986-1987
Natural Amenity	Natural amenity scale, 1999
Manufacturing Concentration	Manufacturing employment concentration, 1990
Retailing Concentration	Retail employment concentration, 1990
Metro	Central city dummy variables
Adjacency	Dummy for counties adjacent to Central City or metropolitan areas
Nonattainment	Dummy for counties that do not meet federal air quality standard

Continued

Table 5.4: Description of the Variables

Table 5.4 continued

Variable name	Description
Northeast	Northeast region dummy
Midwest	Midwest region dummy
West	West region dummy
Economic Policy	County economic development policy index
Environmental Policy	County environmental policy index
<u>Spatial Model</u>	
$(I+W)EMP_{0090}$	Employment growth potential 1990-2000
$(I+W)POP_{0090}$	Population growth potential 1990-2000
$(I+W)EMP_{90}$	Employment potential, 1990
$(I+W)POP_{90}$	Population potential, 1990
<u>Instrumental Variables</u>	
Democratic Vote	Percent who voted for a Democratic presidential candidate, 1992
Per Capita Income	Per capita income, 1989
Administration	Dummy variable, if county government is operated with the elected board or commissioner then Administration=1, else Administration=0
Land Loss Rate	Farm land loss rate from 1987 to 1992

Variable	Economic development policy index	t-value	Environmental policy index	t-value
Intercept	0.33	0.45	-0.42	-1.05
POP_{90}	9.98e-06**	3.25	3.59e-06**	2.23
EMP_{90}	-1.32e-05	-1.61	-4.77e-06	-1.11
$POPDEN_{90}$	2.38e-04*	1.94	-1.04e-04	-1.61
Government Expenditure	0.32**	2.31	-0.03	-0.46
Average Industry Earnings	8.30e-07	0.15	-6.64e-06**	-2.10
Property Tax	-1.71e-03	-0.41	1.95e-03	0.90
Per Capita Tax	-1.03e-03**	-4.48	-2.55e-04**	-2.06
Crime Rate	6.17e-05*	1.99	2.19e-05	1.34
Poverty Rate	-6.48e-4	-0.04	-0.04**	-5.23
Family Income	1.11e-04**	5.63	5.64e-05**	5.24
Education	-0.06**	-4.68	-0.01	-1.19
Manufacturing Concentration	-2.71e-05**	-2.84	-1.82e-05**	-3.65
Retailing Concentration	-8.33e-06	-0.23	4.16e-06	0.22
Natural Amenity Scale	-0.06*	-1.69	5.91e-02**	3.13
Nonattainment	0.18	0.91	-0.14	-1.30
Metro	0.19	0.99	0.42**	4.08
Adjacency	-0.09	-0.69	0.11	1.55
Midwest	-1.02**	-6.08	0.15*	1.75
Northeast	-0.07	-0.27	-0.65**	-4.61
West	-0.37*	-1.74	0.91**	8.10
Democratic Vote	0.02**	3.00	0.01**	3.74
Administration	-0.50**	-3.88		
Per Capita Income			3.91e-06	0.27
Land Loss Rate			4.40e-03**	2.15
R-Square	0.18		0.30	

(** significant at the 5 percent level, * significant at the 10 percent level)

Table 5.5: Results of Regression of Policy Indices on Instrumental Variables

Models	Population equation		Employment equation	
	Hausman's statistic	P value	Hausman's statistic	P value
Aspatial model	1.69	0.4296	13.39	0.0012
Spatial model with contiguous weight matrix	35.41	<0.0001	9.72	0.0078
Spatial model with inverse distance weight matrix	59.10	<0.0001	9.48	0.0087
Spatial model with inverse distance square weight matrix	56.61	<0.0001	8.05	0.0179

Table 5.6: Endogeneity Test

	Employment growth	t-value	Population growth	t-value
Intercept	-976.22	-0.29	9653.92	1.39
EMP_{0090}			1.41**	23.51
POP_{0090}	1.17**	4.33		
POP_{90}	0.31**	2.27	-0.15**	-4.20
EMP_{90}	-0.98**	-4.74	0.54**	7.50
$POPDEN_{90}$	14.00**	3.47	-9.04**	-6.65
Government Expenditure	2039.58**	2.20	-1105.67	-0.71
Average Industry Earnings	0.07*	1.82		
Property Tax	-82.24**	-2.51		
Per Capita Tax			0.38	0.15
Crime Rate			-0.21	-0.62
Poverty Rate			-114.32	-0.70
Family Income			-0.01	-0.07
Education	354.26**	3.93	-269.22*	-1.83
Manufacturing Concentration	1.11**	2.98		
Retailing Concentration	-0.91	-0.69		
Natural Amenity Scale	-884.82**	-2.90	829.30**	2.08
Nonattainment	-815.28	-0.37	-3655.39	-1.59
Economic Policy	-70.81	-0.08	-629.26**	-2.27
Environmental Policy	-2279.99	-1.60	-568.92	-1.07
Metro	-976.28	-0.59	-1057.55	-0.48
Adjacency	177.34	0.21	-436.09	-0.29
Midwest	3597.28**	2.16	-3242.32*	-1.88
Northeast	6992.80**	2.13	-3633.31	-1.20
West	356.19	0.20	490.10	0.21
R-square	0.55		0.72	

(** significant at the 5 percent level, * significant at the 10 percent level)

Table 5.7: Aspatial Model Estimates (2SLS)

	Employment growth	t-value	Population growth	t-value
Intercept	-1798.20	-0.49	-131.59	-0.02
$(I+W)EMP_{0090}$			1.69**	21.61
$(I+W)POP_{0090}$	0.20**	4.49		
$(I+W)EMP_{90}$			-0.01	-1.36
$(I+W)POP_{90}$	-0.19**	-14.85		
POP_{90}			0.11**	17.87
EMP_{90}	-0.01*	-1.78		
$POPDEN_{90}$	0.46	0.42	-7.91**	-4.69
Government Expenditure	-536.97	-0.85	1641.86	0.89
Average Industry Earnings	0.01	0.20		
Property Tax	-34.16	-1.31		
Per Capita Tax			-11.34**	-3.36
Crime Rate			-0.78**	-2.01
Poverty Rate			-323.80	-1.29
Family Income			1.66**	5.40
Education	249.34**	3.04	-471.10**	-2.33
Manufacturing Concentration	-0.14*	-1.92		
Retailing Concentration	2.35**	9.24		
Natural Amenity Scale	-359.74	-1.46	-44.13	-0.08
Nonattainment	5868.86**	4.50	-13300.77**	-4.62
Economic Policy	1276.14	1.40	-5192.81**	-2.10
Environmental Policy	-1045.44	-0.79	-16072.20**	-3.25
Metro	2841.53**	2.14	-6791.19**	-2.50
Adjacency	125.97	0.15	-5563.55**	-3.31
Midwest	1609.64	1.04	-7558.99**	-2.28
Northeast	-211.52	-0.10	-2572.05	-0.62
West	2622.71	1.42	7690.04	1.49
R-square	0.48		0.70	

(** significant at the 5 percent level, * significant at the 10 percent level)

Table 5.8: Spatial Model Estimates with Contiguous Weight Matrix (2SLS)

	Employment growth	t-value	Population growth	t-value
Intercept	-4426.30	-1.25	-3721.34	-0.51
$(I+W)EMP_{0090}$			1.55**	22.49
$(I+W)POP_{0090}$	0.09*	1.85		
$(I+W)EMP_{90}$			0.05**	6.14
$(I+W)POP_{90}$	-0.23**	-13.04		
POP_{90}			0.08**	15.01
EMP_{90}	-0.01	-0.91		
$POPDEN_{90}$	-0.79	-0.72	-10.29**	-6.45
Government Expenditure	-1255.48**	-1.98	-663.44	-0.37
Average Industry Earnings	-0.02	-0.65		
Property Tax	1.27	0.05		
Per Capita Tax			-8.62**	-2.61
Crime Rate			-0.86**	-2.24
Poverty Rate			-725.50**	-3.15
Family Income			1.76**	6.11
Education	262.12**	3.28	-200.40	-1.03
Manufacturing Concentration	-0.27**	-3.34		
Retailing Concentration	3.17**	9.34		
Natural Amenity Scale	-93.77	-0.39	359.81	0.71
Nonattainment	7024.52**	5.12	-11016.75**	-4.04
Economic Policy	1814.12**	2.07	-1108.63	-0.50
Environmental Policy	-1916.21	-1.51	-25913.00**	-6.05
Metro	4827.69**	3.70	772.70	0.30
Adjacency	979.43	1.15	-3248.92**	-1.98
Midwest	1670.03	1.10	-2825.99	-0.93
Northeast	-3141.64	-1.61	-16175.58**	-4.15
West	4513.52**	2.53	16470.00**	3.61
R-square	0.50		0.70	

(** significant at the 5 percent level, * significant at the 10 percent level)

Table 5.9: Spatial Model Estimates with Inverse Distance Weight Matrix (2SLS)

	Employment growth	t-value	Population growth	t-value
Intercept	-3892.50	-1.06	-381.06	-0.05
$(I+W)EMP_{0090}$			1.48**	22.26
$(I+W)POP_{0090}$	0.12**	2.50		
$(I+W)EMP_{90}$			0.07**	9.60
$(I+W)POP_{90}$	-0.21**	-12.05		
POP_{90}			0.07**	13.06
EMP_{90}	-0.02**	-3.42		
$POPDEN_{90}$	0.28	0.25	-11.31**	-6.91
Government Expenditure	-1177.04*	-1.83	-896.44	-0.49
Average Industry Earnings	-0.02	-0.44		
Property Tax	-4.63	-0.18		
Per Capita Tax			-7.93**	-2.37
Crime Rate			-0.81**	-2.12
Poverty Rate			-824.95**	-3.49
Family Income			1.57**	5.44
Education	291.89**	3.53	-79.95	-0.40
Manufacturing Concentration	-0.22**	-2.79		
Retailing Concentration	2.81**	8.85		
Natural Amenity Scale	-141.08	-0.57	390.57	0.76
Nonattainment	6753.34**	4.89	-10753.26**	-3.93
Economic Policy	1608.05*	1.79	-294.21	-0.13
Environmental Policy	-2162.81	-1.63	-26955.44**	-6.10
Metro	4741.24**	3.83	1682.47	0.68
Adjacency	1030.40	1.20	-2363.36	-1.40
Midwest	1767.05	1.14	-2219.91	-0.71
Northeast	-3092.49	-1.61	-17534.17**	-4.42
West	4427.62**	2.43	17939.02**	3.81
R-square	0.48		0.70	

(** significant at the 5 percent level, * significant at the 10 percent level)

Table 5.10: Spatial Model Estimates with Inverse Distance Square Weight Matrix (2SLS)

	Employment growth	t-value	Population growth	t-value
Intercept	77.95	0.02	8312.36	1.08
$(I+W)EMP_{0090}$			1.45**	20.68
$(I+W)POP_{0090}$	0.04	0.78		
$(I+W)EMP_{90}$			0.04**	4.42
$(I+W)POP_{90}$	-0.24**	-13.32		
POP_{90}			0.09**	16.27
EMP_{90}	0.00	0.49		
$POPDEN_{90}$	0.38	0.35	-6.76**	-4.04
Government Expenditure	-1089.54*	-1.74	-609.97	-0.34
Average Industry Earnings	0.00	0.10		
Property Tax	-12.76	-0.50		
Per Capita Tax			-8.31**	-2.49
Crime Rate			-0.47	-1.22
Poverty Rate			-1050.80**	-4.54
Family Income			1.54**	5.39
Education	131.59*	1.65	-330.23*	-1.73
Manufacturing Concentration	-0.28**	-3.21		
Retailing Concentration	3.26**	9.80		
Natural Amenity Scale	-163.72	-0.69	362.88	0.73
Nonattainment	6635.12**	4.79	-11117.00**	-4.15
Economic Policy*Metro	-484.96	-0.35	-6230.02**	-2.37
Economic Policy*Adjacency	1739.08	1.57	1123.74	0.45
Economic Policy*Nonadjacency	1405.93	1.49	-132.94	-0.05
Environmental Policy*Metro	8584.71**	5.02	-10435.00**	-2.28
Environmental Policy*Adjacency	-3457.96**	-2.37	-33259.00**	-7.41
Environmental Policy*Nonadjacency	-3123.84**	-2.26	-29865.00**	-6.77
Metro	-7907.72*	-1.78	-9800.07	-1.24
Adjacency	997.17	0.34	-1784.73	-0.31
Midwest	627.00	0.42	-2992.28	-1.00
Northeast	-838.85	-0.44	-13208.00**	-3.43
West	4944.82**	2.79	19100.00**	4.23
R-square	0.51		0.72	

(** significant at the 5 percent level, * significant at the 10 percent level)

Table 5.11: Spatial Model Estimates with Policy-Location Interaction Terms (2SLS)

Hypothesis test	Population equation		Employment equation	
	F-statistic	P value	F-statistic	P value
Economic Policy*Metro= Economic Policy*Adjacency	9.24	0.0024	2.70	0.1006
Economic Policy*Metro= Economic Policy*Nonadjacency	7.31	0.0069	2.28	0.1310
Economic Policy*Adjacency= Economic Policy*Nonadjacency	0.39	0.5339	0.10	0.7533
Environmental Policy*Metro= Environmental Policy*Adjacency	66.37	<0.0001	67.52	<0.0001
Environmental Policy*Metro= Environmental Policy*Nonadjacency	47.49	<0.0001	65.82	<0.0001
Environmental Policy*Adjacency= Environmental Policy*Nonadjacency	1.93	0.1654	0.07	0.7951

Table 5.12: F-Tests of Differences of Local Policies Impacts across Metro and Nonmetro Counties

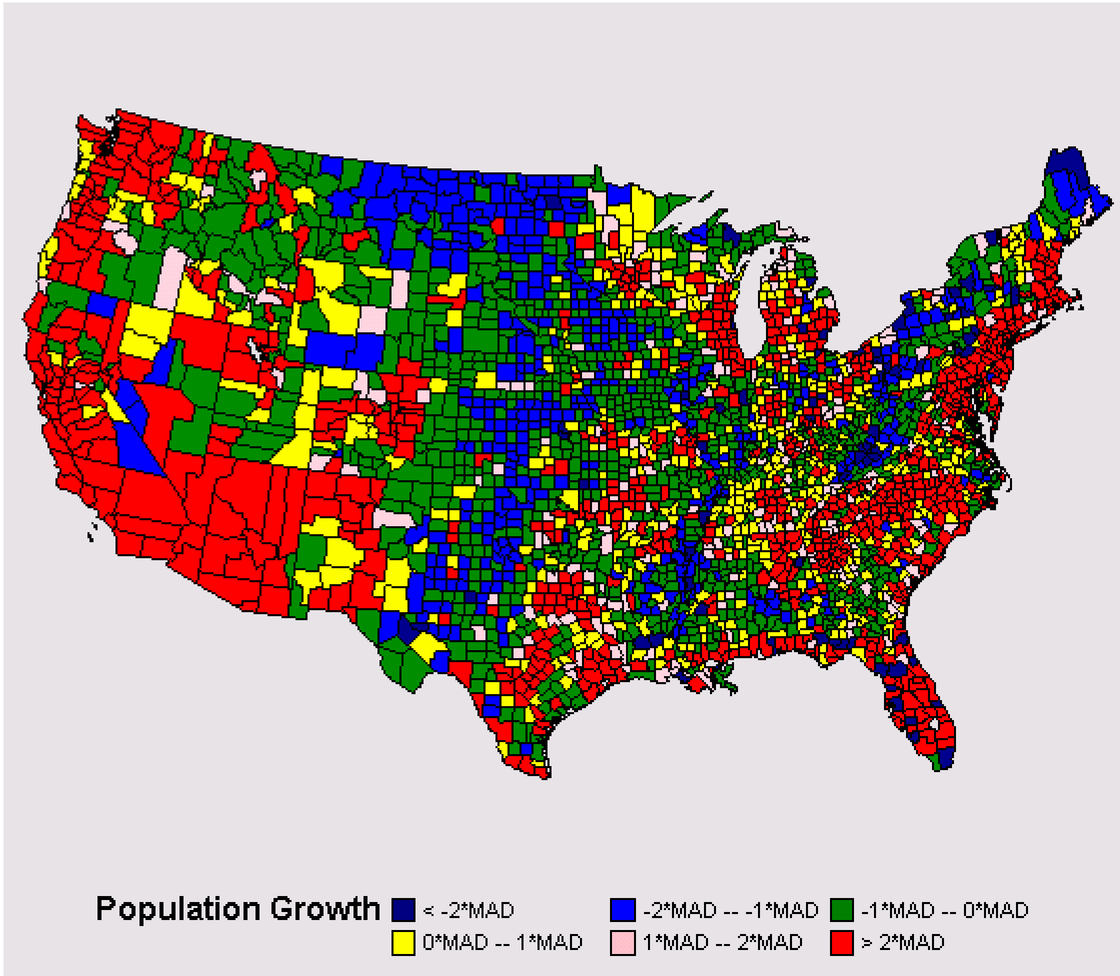


Figure 5.1: Map of Population Growth in the 1990s

Median population growth is 1756 and the median absolute deviation (MAD) is 1941. Puerto Rico, Alaska and Hawaii are not included.

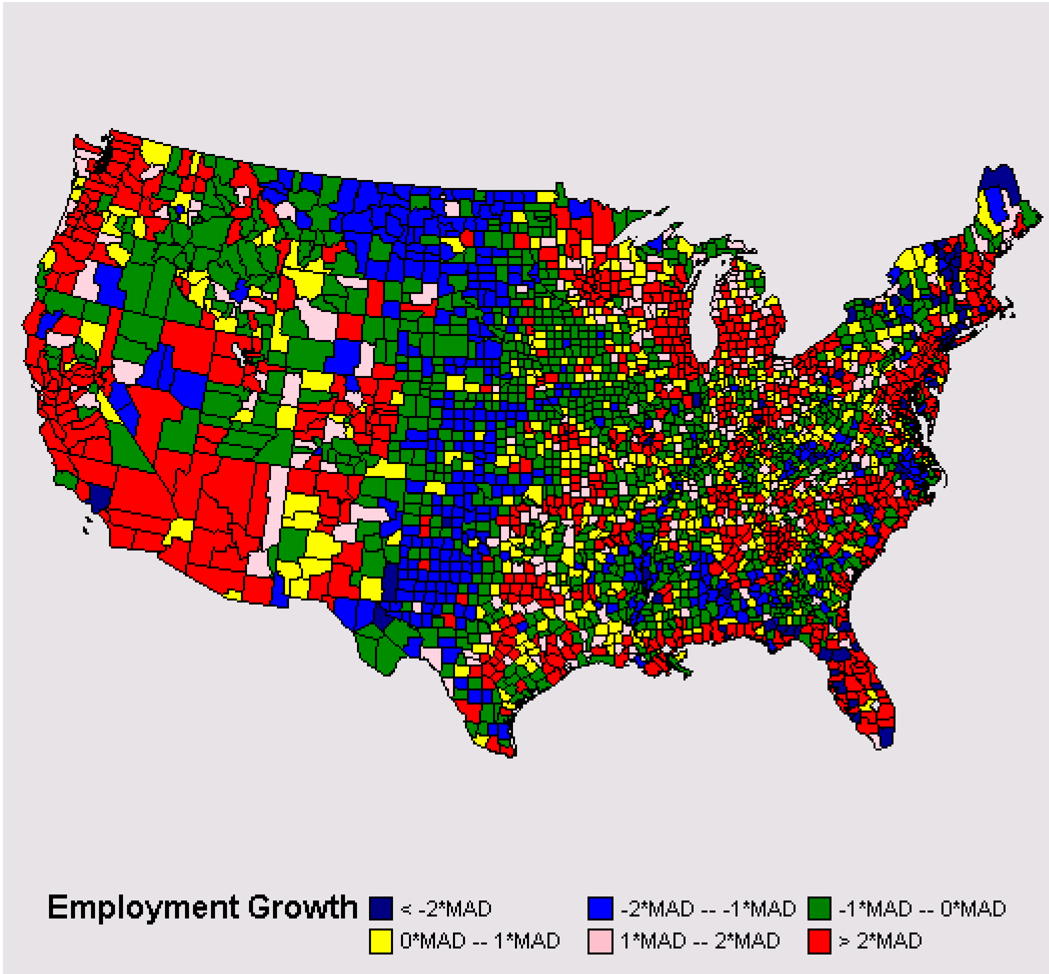


Figure 5.2: Map of Employment Growth in the 1990s

Median employment growth is 1107 and the median absolute deviation (MAD) is 1077.
Puerto Rico, Alaska and Hawaii are not included.

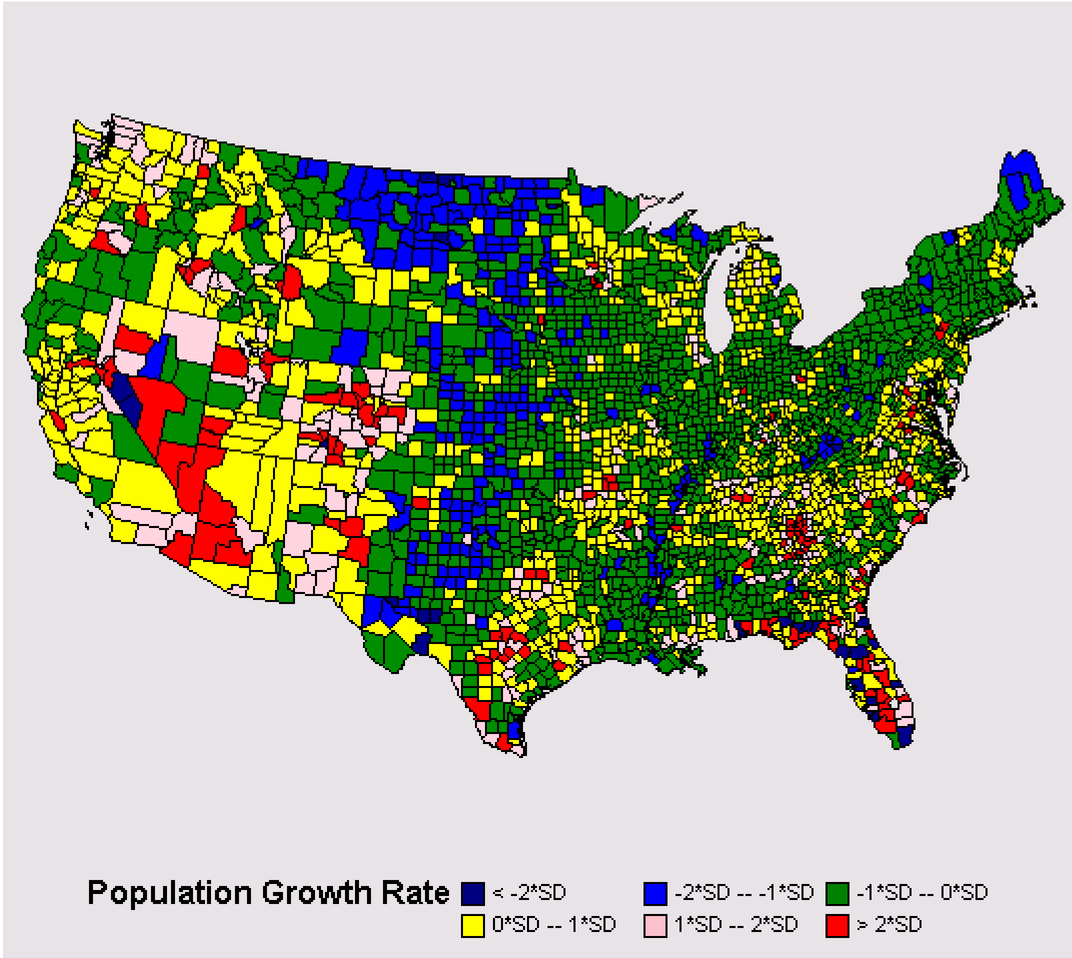


Figure 5.3: Map of Population Growth Rate in the 1990s

Average population growth rate is 11.09% and the standard deviation is 16.04%. Puerto Rico, Alaska, and Hawaii are not included.

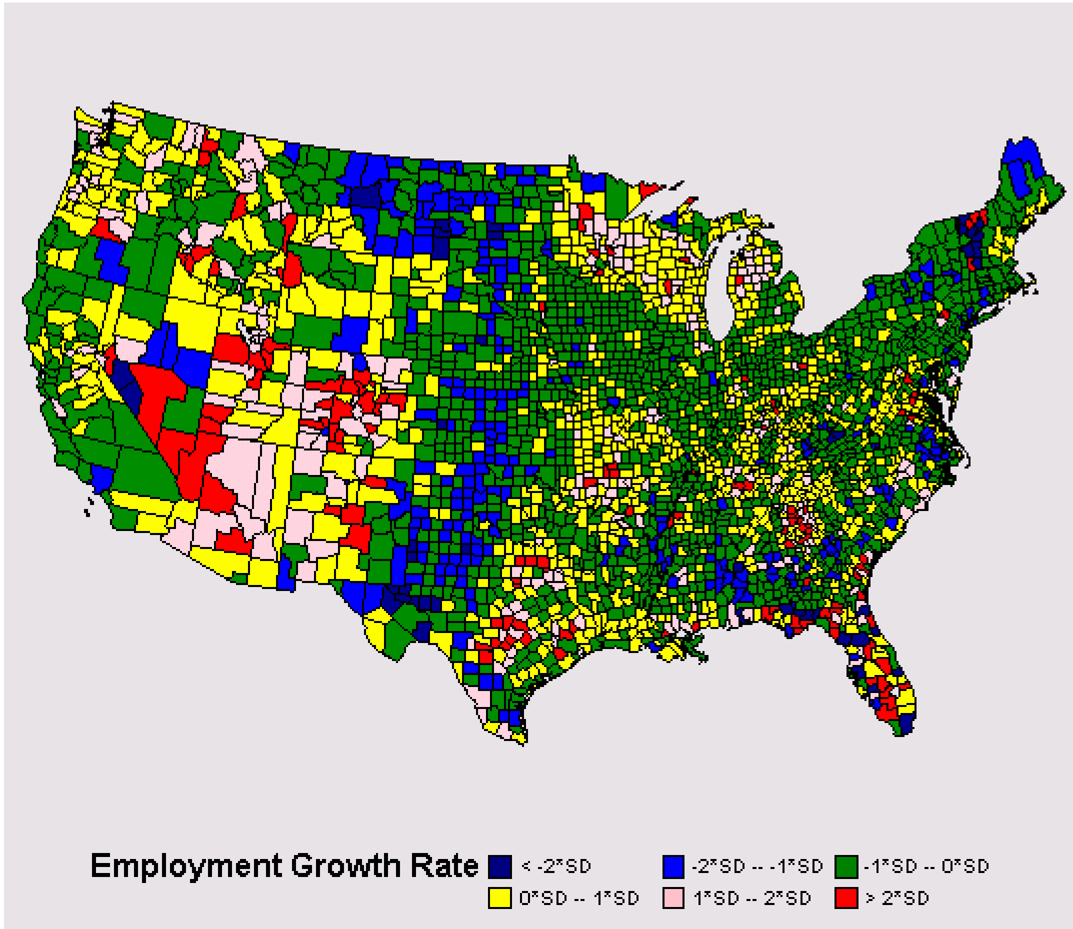
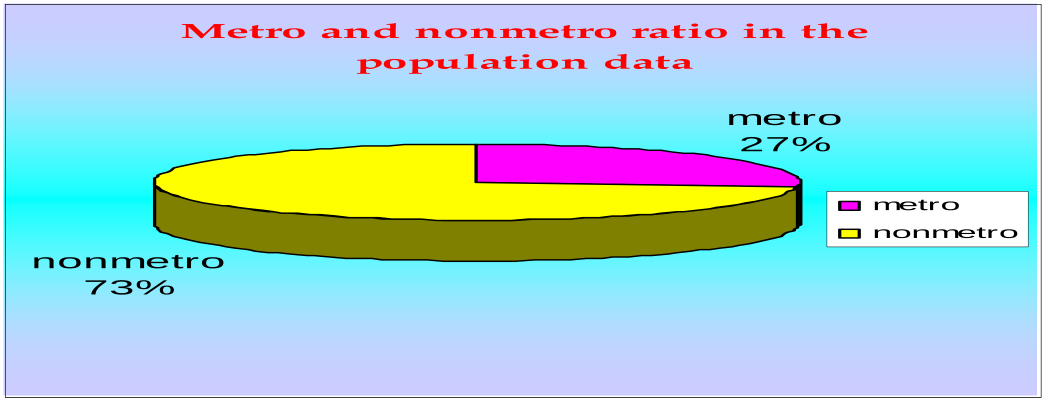
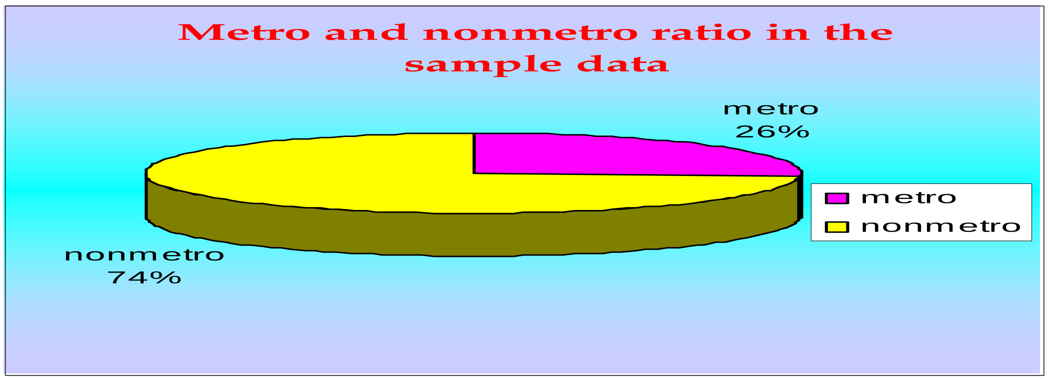
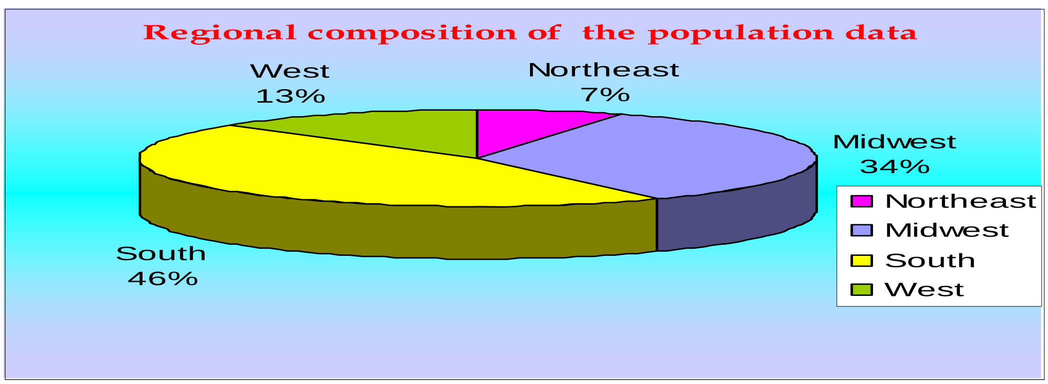


Figure 5.4: Map of Employment Growth Rate in the 1990s

Average employment growth rate is 14.72% and the standard deviation is 16.94%. Puerto Rico, Alaska, and Hawaii are not included.







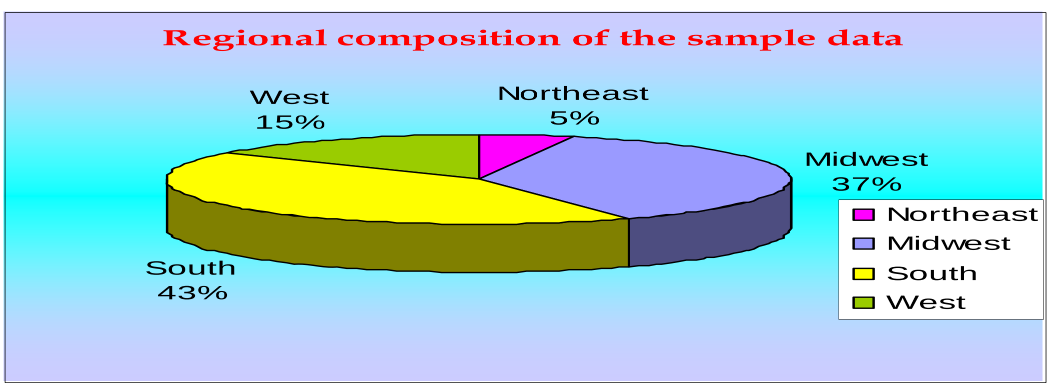


Figure 5.5: Components of the Sample and Population Data

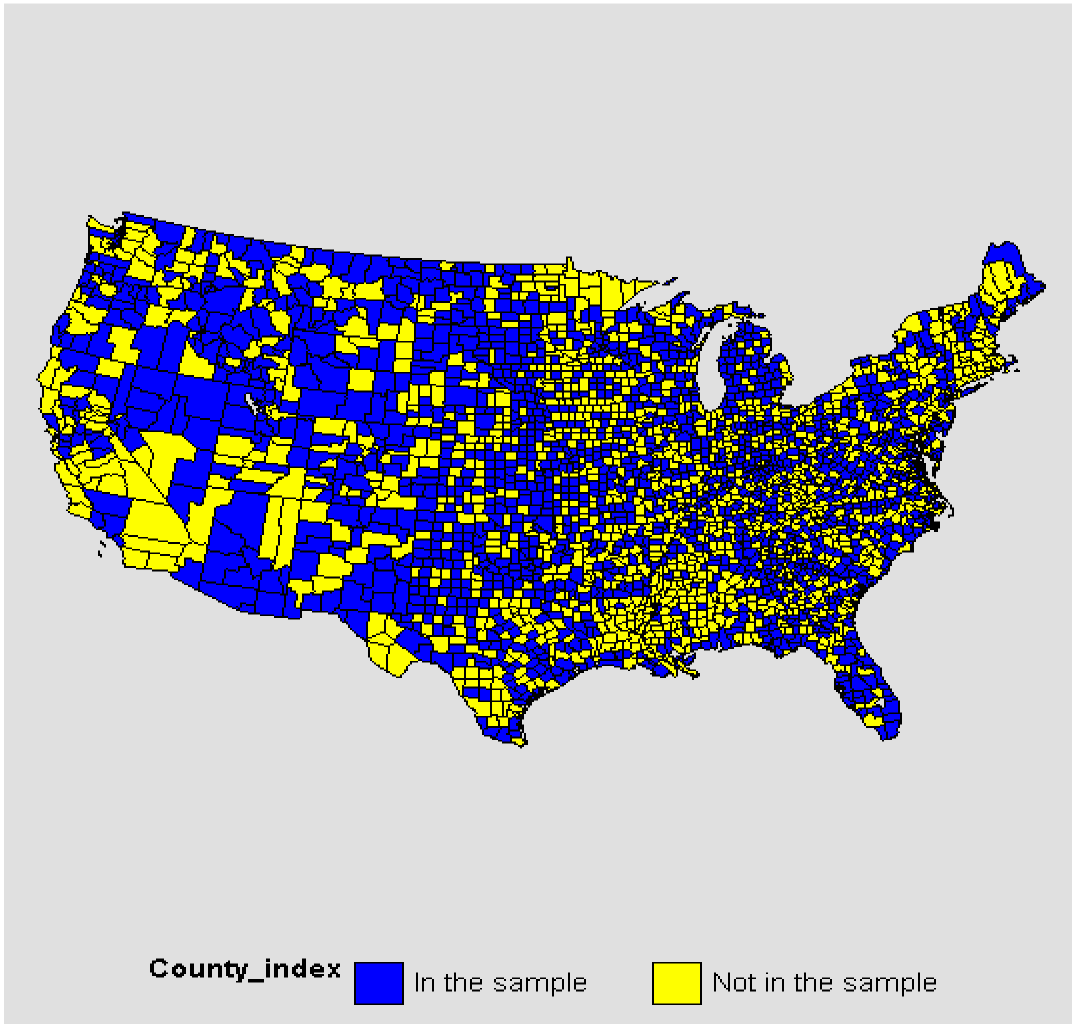


Figure 5.6: Map of Counties in the Sample

A total 1678 out of 3111 counties are included in the sample.

CHAPTER 6

CONCLUSION

This chapter examines the research hypotheses set out in chapter one and assesses their validity in light of the regression results in chapter five. Section one presents conclusions from the spatial model estimation. Section two discusses policy implications of this research. Section three identifies contributions this research makes to regional growth studies. Section four describes limitations of the research. Section five provides suggestions for further research.

6.1 Conclusions from the Model Estimations

Six hypotheses have been laid out on the relationship between regional policies and population and employment growth. These hypotheses pertain to the period from 1990 to 2000. They are repeated here for convenience:

(1) County environmental (growth control) policies impede population growth but do not affect employment growth.

(2) County economic policies have a positive effect on employment growth but no significant effects on population growth.

(3) Initial population, population potential, employment and employment potential have a positive effect on growth.

(4) Manufacturing industry concentration and retailing industry concentration have significant positive effects on employment growth.

(5) Counties with high population density are expected to have less population growth than that those with low population density.

(6) People follow jobs and jobs follow people. That is, employment growth has a positive effect on population growth, and population growth has a positive effect on employment growth.

6.1.1 Hypothesis One

Results of the spatial model show local environmental policies have negative effects on population growth in both metro and nonmetro counties and may have negative effects on employment growth in nonmetro counties. The results for the effects of local environmental policies on population growth are consistent with the hypothesis. However, the results for the effects of local environmental policies on employment growth are inconsistent with the hypothesis.

Local environmental policies are adopted to internalize negative externalities caused by unplanned growth. These policies have negative effects on population growth, at least in the short run. This is consistent with the theoretical analysis in chapter three. It is possible in the long run, these environmental policies may have positive effects on population growth if they create amenities but long run effects are not examined in this study.

Local environmental policies are found to have a positive effect on metro employment growth but a negative effect on nonmetro employment growth. These results are reasonable since amenity policies are expensive. Economic theories indicate growth control policies often increase land price, which may affect the location decision of firms. In nonmetro areas, it is possible that firm location decisions are driven solely by cost of production, rather than by amenities that appeal to managers or workers. Growth control policies may drive up production costs, causing nonmetro areas to lose their cost of production-based comparative advantage. In contrast, in metro areas, cost of production may also rise but the amenities arising from growth control may have a greater "magnet effect" in metro areas, and this may offset the rise in the cost of production due to growth control in metro areas.

6.1.2 Hypothesis Two

Results from chapter five indicate the effect of local economic development policies on employment growth is positive, even though not always significant. This is consistent with previous studies, which conclude that growth effects of local economic policies are positive though often relatively small (Bartik 1991).

There is no evidence of a relationship between economic policies and population growth from the estimated results, perhaps because there are many motivations for residential location. Job opportunity is an important factor, but other nonmarket factors, such as the local natural environment, cultural and shopping opportunities, social interactions, and transportation are also critical. The finding in this study that crime rate, poverty rate and family income are statistically significant provides support for the notion that nonmarket variables are important determinants of population growth.

6.1.3 Hypothesis Three

The regression results in chapter five show that population and employment potential in 1990 have a positive effect on population growth, but employment and population potential in 1990 have a non-positive effect on employment growth. This is inconsistent with the hypothesis that initial conditions are positively related to both population and employment growth, but it is consistent with previous studies. Many studies conclude high initial levels of employment have a negative effect on employment growth, which may be due to higher operation costs, lower economic rent or intense competition in developed areas (Wheat 1986, Glaeser et al. 1992).

6.1.4 Hypothesis Four

Results from chapter five indicate that manufacturing industry concentration is non-positively associated with employment growth while retailing industry concentration is positively associated with employment growth. Retailing industry concentration apparently has an agglomeration effect on employment growth. The negative influence of manufacturing industry concentration on employment growth indicates manufacturing was not an "engine of growth" in the period 1990-2000.

6.1.5 Hypothesis Five

Results from the spatial model imply high population density has a negative effect on population growth and no effect on employment growth. This result is consistent with previous studies. Population decentralization and industrial decentralization in US make population more dispersed than before. As transportation costs have dropped and average incomes have risen, it appears that many people prefer to avoid places with high population density.

6.1.6 Hypothesis Six

All the models estimated in this study support the hypothesis that people follow jobs. Similarly, jobs may follow people, though the evidence varies depending on the weight matrix that is used. Results from the contiguity weight matrix and inverse distance square weight matrix reveal positive spillover between population growth and employment growth across counties, but results from the inverse distance weight matrix indicate that the positive effect of population growth potential on employment growth is weak.

6.2 Policy Implications

According to the econometric results of chapter five, local environmental policies have different effects on population and employment growth in metro and nonmetro counties. This result has several implications.

First, growth control strategies adopted by county governments are effective in achieving their objective. Fragmented local governance and intense local competition made economists and politicians doubt whether local governments could reduce urban sprawl (Anas 1999). Should state and central governments pass uniform growth control policies? This study shows such policies may not be necessary. Growth control strategies adopted by county governments are found to have a negative effect on population growth. This is consistent with the aim of reducing urban sprawl.

Second, growth control policies may affect local growth of nonmetro counties. A survey by General Accounting Office (GAO) shows fast growth counties have strong incentives to adopt these policies, while underdeveloped counties have less incentive to adopt them. This research shows growth control policies benefit metro counties, since they control population growth but stimulate employment growth. Nonmetro counties may lose jobs while adopting amenity creating policies. So policy makers adopting growth control policies should consider the local economic situation, since implementing these policies on add additional costs for local firms and local governments. ‘Poor’ governments may not be able to afford amenity strategies and, at the same time, to provide adequate public services.

Third, low growth counties need more support to stimulate economic growth. This study shows economic development policies have a small positive effect on local growth and nonmetro counties are shown to have greater positive population growth from local economic stimuli than metro counties. But nonmetro counties are less likely to adopt economic development programs and provide public services than metro counties (Lobao and Kraybill 2005). Some nonmetro counties may need state or federal assistance in order to implement economic development policies to create jobs for local residents and to create a tax base capable of supporting basic public services.

6.3 Contribution to Regional Growth Studies

First, spatial interaction is found to affect county growth pattern. Econometric estimates carried out using aspatial and spatial models of population growth and employment growth as simultaneous processes show that the spatial model provides results that are more robust than those from the aspatial model. This study demonstrates that capturing inter-county spillovers is important for accurately analyzing county economic growth.

Second, growth control policies affect local growth. Regional growth studies and environmental policy studies often consider only one kind of environmental policy, namely clean air regulations. Land use control is seldom considered in empirical regional growth studies in cross-section regressions. Theoretical models conclude both positive effects and negative effects exist for these policies, but no previous county-level empirical studies of the United States have been done to verify the effects of growth controls.

Third, the problem of endogeneity of local policies is addressed properly and corrected with the instrumental variable method. The policy endogeneity problem is often ignored in regional growth studies. Most studies assume all variables are exogenous. This causes inconsistent estimates and unconvincing interpretations.

6.4 Limitation of This Study and Suggestions for Future Studies

First, the local policy indices are constructed somewhat arbitrarily and further work is needed to explore how different ways of constructing the indices would affect the estimation results. In the dissertation, I assign a uniform weight to all policy dummies. Different weights may result in different estimates, and comparison of results of different policy indices would be helpful to verify the robustness of the estimation in the dissertation.

Second, the behavior of firms is not addressed specifically in this study though firms obviously play an important role in providing employment. Employment growth is shown not to be associated with local fiscal and amenity variables in chapter five. Though the variables representing manufacturing and retailing concentration are significant, the mechanism by which local industries affect employment growth spatially needs more theoretical and empirical work. Empirical investigation of this issue may require either a better data source than US Census with detailed industry growth information, or a better way to construct fiscal and amenity variables.

Third, the scope of spatial spillover effects is not fully explored in this study. The choice of the spatial boundary of growth expansion, in this study, is solely based on jurisdiction boundaries, and spatial distance was used to define spatial interactions. Whether or not 100 miles is a good way to define the spillover domain among counties ought to be verified empirically.

Finally, several critical econometric issues should be explored further in future studies. Criteria for the best choice of spatial model ought to be defined and refined. Currently, there is no good way to determine whether a spatial SAR model or a cross regressive model is the best choice when analyzing a particular dataset. Spatial error autocorrelation has not been tested in this study because the sample data is spatially discontinuous. Future studies on regional growth should test for spatial error autocorrelation. Finally, the panel data method was not applied here because of the lack of a complete dataset for more than two time periods. In future regional growth studies, the panel data method should be considered since it is an excellent way to correct for the problem of endogeneity.

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