THREE ESSAYS IN REGIONAL ECONOMIC MODELING

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by

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THREE ESSAYS IN REGIONAL ECONOMIC MODELING

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ABSTRACT

My dissertation is about using regional economic modeling for economic impact analysis, forecasting, and for better understanding the local economy. In the first essay, I developed a nonspatial version of a community policy analysis model for Missouri counties. The model recognized the intersectoral linkages in the Missouri economy. The model consists of four modules: labor market, demography, housing market, and local public finance. Employment and total personal income drive the model. The model predicts reasonably well that increases in local employment lead to increases in local population, housing demand, local revenues, and demand for public services.

However, by not considering the effects of space, the impact analysis and forecasting capabilities of my first model may not be as accurate as needed. Therefore, in my second essay, I introduce a spatial dimension into my model by specifying and estimating generalized spatial three-stage least squares procedures. The results show significant cross-county interactions within Missouri in terms of the supply of public goods, labor mobility, retail trade, and the choice of residential location.

In my third essay, using South Korean regional data, I compared the forecasting accuracy of non-spatial, spatial lag, spatial error, and spatial lag and error models using in-sample data. I also compared the impact estimates of nonspatial and spatial models. The spatial components appear to improve the accuracy of the intra-county impacts. It appears that the estimated parameters tend to be sensitive to the specification of weight matrices, if the sizes of spatial units are heterogeneous and vise versa.

CHAPTER I

GENERAL INTRODUCTION

Economic forecasting and impact studies are often part of the everyday practices of policy makers at state and local levels. When a new plant locates in a certain county, policy makers are interested in the answers to several questions. What happens to unemployment? What happens to out-commuting and in-commuting? What happens in the housing market? How will local expenditures on police, education, and fire protection be impacted by the changes? And what could happen to property taxes, sales taxes, and other sources of local revenue? Most past researches have focused on a single market or at best two (the local finance and labor market) to estimate these impacts.

Decentralized governance leads to increased responsibilities on the part of local government for economic development, land use, natural resource management, education, healthcare, and public safety to name a few. As a result, local communities' demand for decision support tools has been increased to make more informed decisions. They not only need more complex and complete analytical tools at their disposal but also need tools that can address the issue at different dimensions including spatial, temporal, distributional, and sectoral.

In many instances, incorporating labor market variables and demographic variables together with local finance and housing market variables and accounting for spatial interactions among these variables gives a more accurate picture of a local economy than the analysis of a single market in isolation (Gyourko and Tracy, 1989 1991; Roback, 1982). Policy makers and economic planers have long been involved in forecasting and impact analysis efforts and analyzing their meaningfulness. Thus, a better understanding of the local economy has become important from county, state, and regional policy perspectives with respect to designing policies that stimulate the local economy on many fronts.

Community policy analysis models such as the Show Me Model (Johnson and Scott, 2006) have been helpful in addressing economic impact related questions. The Virginia Impact Projection (VIP) Model, the first model of its kind developed by Johnson (1991), illustrates how such a model could be used to aid local decision makers. The Iowa Economic/Fiscal Impact Modeling System (Swenson and Otto, 1998), the Idaho model (Cooke and Fox, 1996), an Integrated Economic Impact and Simulation Model for Wisconsin Counties (Shields, 1998), and the Small Area Fiscal Estimation Simulator for Texas (SAFESIM; Evans and Stallmann, 2006) are the examples of other impact models.

This dissertation is a continuation of the Show Me Community Policy Analysis Model project undertaken by Johnson and Scott (2006). Although their model has performed well, it requires updating and important extensions to be of maximum relevance for analytic and policy uses. Therefore, in the first essay, I enhanced this model by adding more categories of local government expenditures and revenues and by adding a housing market component.

In addition, the current and future fortunes of many local communities are often impacted by changes outside the local area. Therefore, accounting for spatial interactions among neighboring communities is an important addition in the regional modeling literature. The second essay of my dissertation devotes to the spatial analysis of Missouri counties. As a system of simultaneous equations, both of these models recognize the county-level connection among the labor market, demographics, local finance, and housing market variables.

In the third essay, I estimated a spatial econometric model for the Korean economy. In this essay, I compared different estimation procedures and conducted sensitivity analysis for different spatial linkages. I validated the model based on forecasting accuracy of in-sample data using mean absolute percentage error.

This dissertation is organized into six chapters. This chapter provides overall introduction of the studies. The second chapter provides theories and conceptual framework. The next three chapters present the different themes of regional economic modeling for economic impact analysis and forecasting. While each chapter is meant to stand alone, there is a progression of estimation methods and analytical techniques. A final chapter provides overall summary and conclusions.

CHAPTER II

BACKGROUND AND THEORETICAL STRUCTURE

2.1 Regional Modeling: What and Why

Regional models are built for variety of reasons. As Bolton (1985) outlines, there may be four purposes: pure economic science, economic forecasting, government revenue forecasting, and policy analysis including impact analysis. The scope of pure science is rather limited in regional modeling. As Bolton quotes Sharpio and Fulton (1985), regional modelers are like skillful bricklayers rather than the manufacturers of new bricks. They do not "invent the wheel", rather they use the existing techniques to create the new structures.

According to Treyz (1993), a regional model can be classified as nonstructural or structural. Nonstructural models do not account for the economic causal relationships; however they may work better for short-term forecasting. Many time-series models fall under this category. Sometimes regional changes are predicted based on national changes. In a nonstructural model, past values of the variables of interest are used to predict the future values. Unlike nonstructural models, structural models are usually more complex because they investigate cause and effect relationships in an economy. Economic theories are very important to determine the equation's structure. The beauty of structural models is that they can simulate the impact of policy changes. Furthermore, comprehensive structural models contain a number of 'policy handles' such as public infrastructure investment, property tax rate, minimum wage and the like. As Johnson and Scott (2006) point out, responsibility for public decision is migrating toward the community level. As a result, local regions have to make decisions related to economic development, public services, land use and the like. To make an informed decision on these issues, they need new tools because many tools traditionally used by planners, economists and others can not provide satisfactory answers to new issues.

Input-output models have been the staple of the regional scientist for a long time. However, these models were expensive and only affordable by large and rich communities. To cater to the customized need of communities, a number of innovations have occurred in regional policy analysis models. After the introduction of the impact model for planning system (IMPLAN) by U.S. Forest Service, many researchers still are looking for ways to make meaningful impact projections. Given the diversity of communities and their needs, it was not practical to base the IMPLAN system on primary data or to develop unique models for each community or region (Johnson et al., 2006). Although there were other modeling systems such as RIMS (Regional Input-Output Modeling System), the RSRI (Regional Science Research Institute) model, and the REMI (Regional Economic Modeling Inc.) model, IMPLAN have been the most popular at land grant universities because of a small investment by USDA Extension Service. Parallel to these efforts, researchers kept on focusing on building local models to customize the services to address the need of the local communities. Earlier versions of these models typically focused on particular communities or regions, and were developed for particular purposes, such as the impacts of coal mining, hydroelectricity, residential development, or other issues (Johnson et al., 2006). According to Johnson et al., in 1984, a number of researchers identified the need to advance the local-scale modeling systems. These are (a) standards for economic and fiscal impact analysis, (b) desirable features of economic and fiscal impact models, (c) materials designed to better inform clients about desirable features in impact analysis, and (d) procedures for researchers to exchange best practices. In this effort, different regional rural centers and the Rural Policy Research Institute (RUPRI) have supported many rural researches. In 1995, RUPRI started to promote and support multistate, interdisciplinary research and outreach network called the community policy analysis network (CPAN). As a result of these efforts, a family of models known as community policy analysis systems (COMPAS) emerged. This dissertation is a continuation of this effort where much emphasis is given to spatial analysis.

2.2 Community Policy Analysis System

Although there are impact analysis models at the regional level, their levels of analysis may vary. Some notable ones are as follows: the multi-region model developed by Kort and Cartwright (1981), the Mississippi model developed by Adams et al (1975), the Ohio model by Baird (1983), the Philadelphia model by Glickman (1971), the San Diego model by Rey (1994). These are a few examples of regional impact models. Most of these models are similar to that of a national model where regions were treated as an open economy. The models were generally applied for forecasting and policy impact analyses. However, these models were not that beneficial to rural and smaller communities. To address the need of rural communities, RUPRI has been taking the lead to develop a more holistic and systematic approach to modeling economic and fiscal impacts in rural areas.

As a pioneering work in developing a policy analysis model, Swallo and Johnson (1987) estimated a more comprehensive fiscal impact model for Virginia counties. This model provides a framework for analysts to forecast the economic, demographic and fiscal consequences of particular economic shocks. They estimated the tax revenue base rather than taxes so that a county can chooses its tax rate to achieve a balanced budget. Their equation estimates the property tax base as a function of the business[1] and population levels. Their local sales equation is a function of employment. In their model, they included expenditure equations including fire protection, parks and recreation, police protection, correction and detention, health, welfare, court, community development, administration, and public works.

Many models of similar nature were developed during last two decades: the Virginia Impact Model by Johnson (1991), the Show Me model by Johnson and Scott (2006), the Idaho model by Cooke and Fox (1996), The Iowa Economic/Fiscal Impact Modeling System by Swenson and Otto (1999), an Integrated Economic Impact and Simulation Model for Wisconsin Counties by Shields (1998), and the Small Area Fiscal Estimation Simulator for Texas by Evans and Stallmann (2006). Although there are only minor differences in all of these models, each is tailored to meet the primary policy analysis needs of the communities in which models are used. The main features of some of these models are presented below.

As a continuation of developing the impact model, Johnson and Scott (2006) estimated a Show Me Community Analysis Model for Missouri Counties. Using a three-stage least squares procedure, they estimated a model consisting of labor market, demography and fiscal impact modules. The uniqueness of their approach is that they use expansion variables (i.e. area × employment, area × external employment, area × external labor force) to account for the structural changes in spatial dimension of labor market. Their labor market module consists of four equations (e.g. labor force, in-commuters,

[1] Swallo and Johnson (1987) use total employment as proxy for level of business in actual estimation.

out-commuters, second jobs) and one identity (unemployment). Their fiscal impact module consists of two revenue base equations (e.g. property value and retail sales), three revenue equations (e.g. charges, other revenue, intergovernmental revenue) and six expenditure equations including police, jail, court, road, administration, and other expenditures.

Following Swallo and Johnson (1987) and Johnson and Scott (1997), Swenson and Otto (1999) estimated an economic/fiscal impact modeling system for Iowa counties. They based their model on similar assumptions that economic growth is caused by exogenous increases in employment. Their model consists of labor market, demography, housing market, and fiscal impact equations. The labor market consists of supply equations (e.g. labor force, in-commuters, out-commuters) and unemployment as an identity. Although they included external labor force and external employment as an explanatory variable, their model only partly captures the spatial effect in labor market variables. The demographic component contains a population equation and school enrollment equations which are functions of labor force, labor force participation rate, and dependency rate. In their model, there are three housing market equations: occupied housing units, housing cost, and new housing. Due to lack of wage data, their housing cost equation may be biased. The new housing equation is estimated as a function of occupied housing, vacant housing, change in real income, change in employment and the like. Similar to the Virginia model, the fiscal impact component of the Iowa model consists of revenues and expenditures equations. They estimated six categories of revenue equations: property taxes, other taxes, federal aid, state aid, local aid and miscellaneous.

Shields (1998) estimated a more comprehensive model for Wisconsin Counties. His model consists of six different components of local economy. These are production, labor, demographics, housing, local government and retail. Because this model is intricately linked with an input-output model, it assumes that changes in the local economy are driven by changes in export production. Changes in industry output lead to changes in labor demand. Consequently, as in other policy analysis models, changes in labor demand create changes in whole economy including population and demand for public services. He estimated six labor market equations: employment, wage, unemployment, in-commuters, out-commuters, and labor force. He assumes that change in labor demand leads to change in wages. This assumption is typically different than in other models. He estimated total personal income as a function of earnings. However, in the Show Me model, Johnson and Scott (2006) treat per capita income as an exogenous variable because they assume that for a smaller region, changes in labor demand do not affect the wage.

Shields' model contains two housing market equations: the number of housing starts and value of new housing starts. The number of housing starts equation is estimated as function of income, growth of number of households, mortgage rate, inflation, property tax, existing housing stock, and local government spending. These equations are different from the Swenson and Otto (1999) where they model the stock of housing rather than change in housing stock.

The local government module of Shields' model consists of six expenditure equations (i.e. health and welfare, government administration, road maintenance, police and fire, waste and sewer, amenities) and two revenue equations (i.e. intergovernmental revenue and property tax revenue). He assumes that there is an interaction between intergovernmental revenue and local property tax revenue. Therefore, he modeled intergovernmental revenue as a function of local property tax revenue.

An adaptation of Shield's Wisconsin model, Farrigan et al (2001) estimated a fiscal impact model for New Hampshire communities. The uniqueness of their model is that its unit of analysis is municipalities rather than counties. They used a seemingly unrelated regression procedure for model estimation. Similar to the Wisconsin model, their model consists of labor market, demographics and municipal government revenue and expenditures.

Likewise, Evans and Stallmann (2006) developed the Small Area Fiscal Estimation Simulator for Texas counties. Using a two-stage least squares procedure, they estimated a 14-equationed model consisting of demographics, labor market and fiscal impact modules. The uniqueness of their fiscal impact module is that they use non-traditional equations in their model such as hotel receipts, receipts of eating and drinking establishments. They also disaggregated the property value into residential property and commercial property values. Unlike Johnson and Scott (2006) where they treat per capita income as given, Evans and Stallmann endogenize total income as a function of earnings, population, net commuting and rural dummy. However, they do not account for the spatial interactions in any of the equations in their model.

2.3 Model Structure

The models presented in three essays are based on a common theoretical structure. The general framework of these models consists of different pieces of the local economic "puzzle". Each of these pieces is designed to capture an important aspect of the local economy. Each piece is backed by appropriate theories. Each model that I developed in this dissertation is composed of the same four common pieces (components or modules): a labor market econometric component, a demographic econometric component, a housing market econometric component and a local public finance econometric component (Figure 2.1). Each module is developed to capture the explicit measures of economic activity in Missouri counties and Korean regions. The model design allows for interaction among the four modules so that changes in one module will coincide with changes in the others. Employment and total personal income are exogenously determined variables which drive the model. This chapter focuses on the description of the underlying theory of labor markets, local public sector, and housing market.

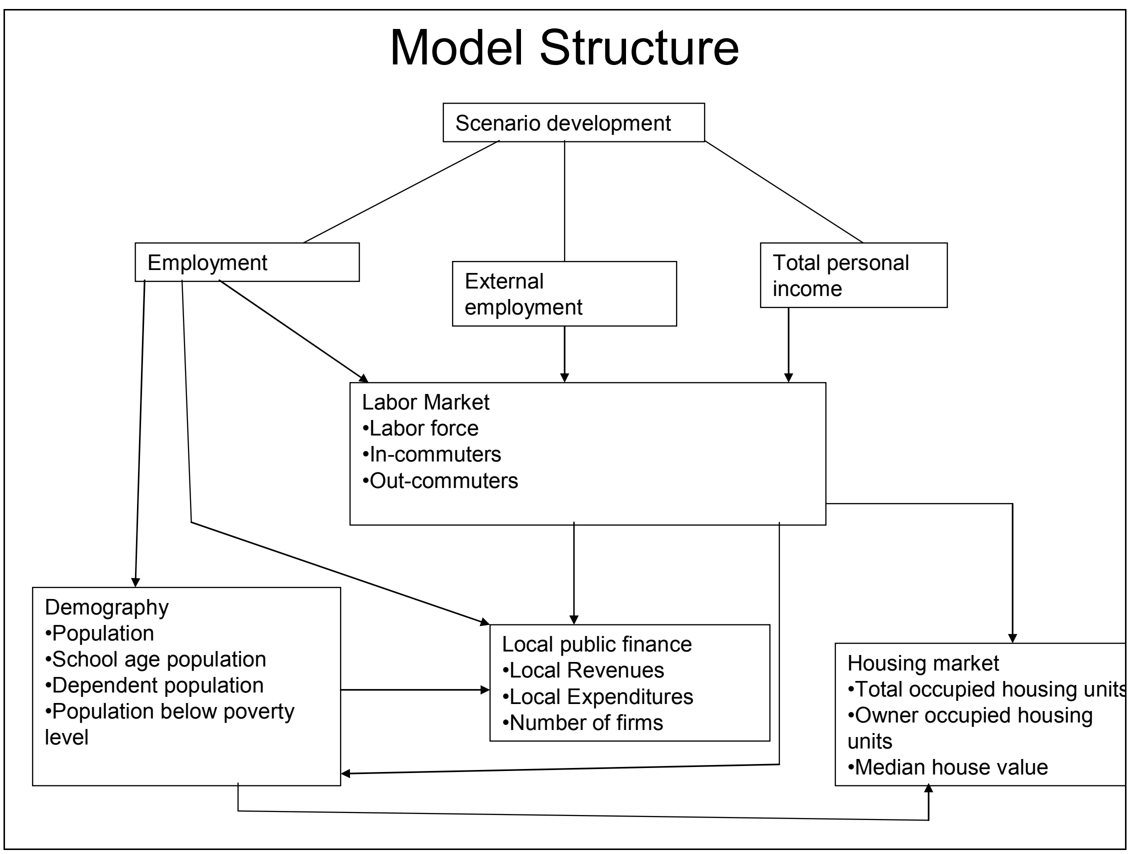

Figure 2.1 Model Components

2.3.1 Local Public Sector

2.3.1.1 Public Sector Equilibrium

The public sector equilibrium theory provides a modeling framework that attempts to describe the demand and supply of public goods. This section develops a theoretical comparison among different models of public sector equilibrium and compares the applicability of these models to real-world situations. The most common public goods equilibriums are Samuelson equilibrium, Bowen equilibrium, Tiebout equilibrium, and Lindahl equilibrium, (Holcombe, 1983). However, the first three equilibriums which are the most common in literatures are discussed in detail.

2.3.1.1.1 Samuelson Equilibrium

Paul Samuelson (1954, 1955) defined public good as one in which consumption by one person does not reduce the availability to others (i.e. non-rival). If G be the total amount of good and G_i be the individual i's consumption, then $G = G_i$ for all i. If M_i is individual i's marginal valuation for the good, and MC be the marginal cost of production of the good, then Samuelson shows the optimal level of output in a region of n persons as $\sum_{i=1}^{n} M_i = MC$. When this situation exists, it is called Samuelson equilibrium. This condition simply tells that the total amount of public good produced is all supplied to each consumer. This condition is shown graphically in Figure 2.2.

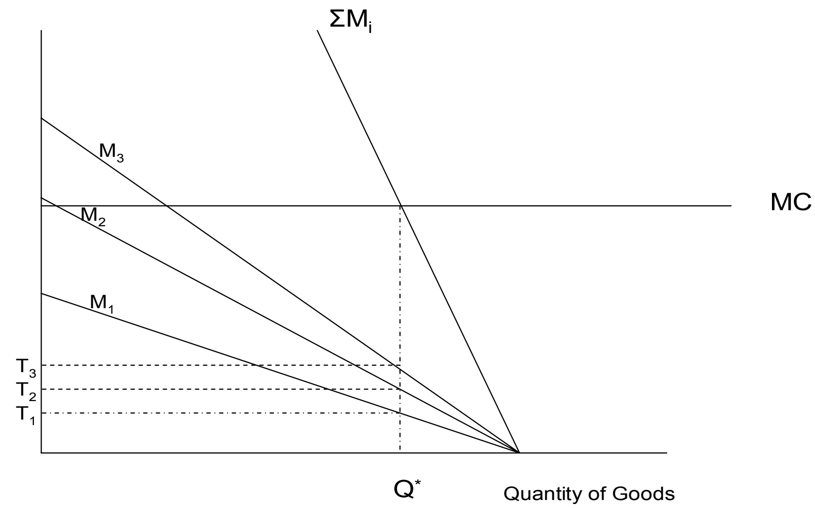

Figure 2.2 Samuelson Equilibrium

Consider the community of three individuals shown in Figure 2.2 where M_1, M_2 and M_3 are the marginal benefit for individual 1, 2, and 3 and Q^* is the equilibrium quantity of goods produced. At Q^* vertical summation of the marginal benefit of three individuals is equal to the marginal cost. Each individual pays the T_1, T_2 and T_3 taxes. Although each person pays a different price (i.e. tax), each consumes the same quantity Q^*.

Although solution appears to be straight-forward, there are two issues at hand. The first issue is that there is no incentive for individuals to reveal their preferences, because of the non-excludable nature of public good. Therefore it is very challenging to estimate the Samuelson equilibrium level of output. The second issue is about optimal size of consuming group. Without introducing congestion, the optimal group size for a public good is the largest possible group.

2.3.1.1.2 Bowen Equilibrium

Bowen equilibrium is also known as median voter equilibrium. The idea was first propounded by Hotelling (1929) and then further developed by Bowen (1943). In Hotelling's equilibrium, two ice cream vendors set up their shop at the middle of the beach. This is a tendency for a majority rule system of government where quantity of output is selected based on median voter preference. Figure 2.3 presents the Bowen equilibrium where a community of five individuals has demand schedules D_1 through D_5 and the cost of production is equally divided among them. It is logical to think that extreme quantity as preferred by first and last individuals are not preferred by the majority. Q^* is the equilibrium quantity because it is a median demand for public goods among five individuals.

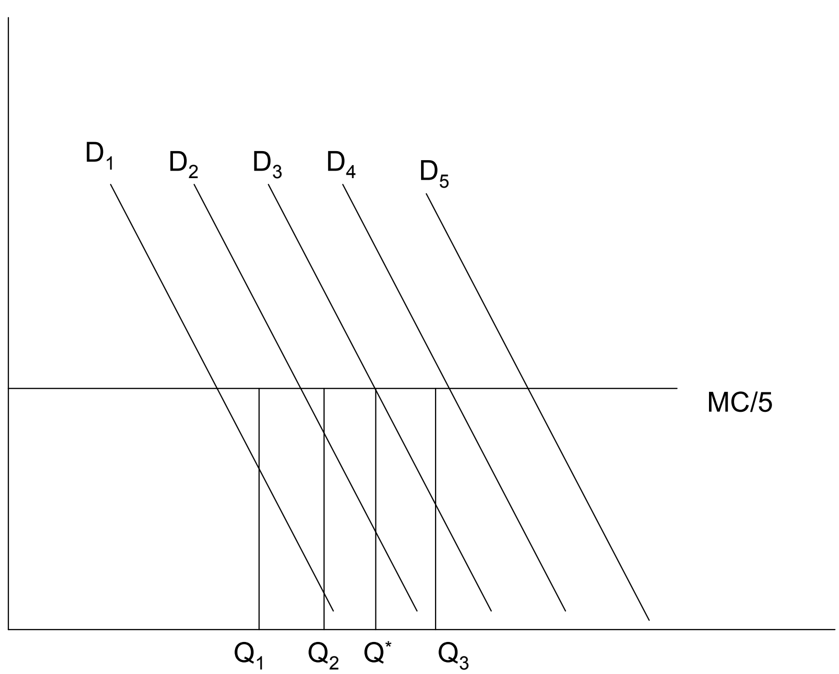

Figure 2.3 Bowen Equilibrium

The main assumptions of Bowen equilibrium are (a) all people participate in the voting process (b) cost of public goods is known (c) all voters pay the same amount to cover the cost of public good, and (d) people's preferences are normally distributed. In the analytical ground, Bowen equilibrium is easier to calculate than the Samuelson equilibrium because in Bowen equilibrium only the preferences of one individual are to be estimated.

2.3.1.1.3 Tiebout Equilbrium

According to Tiebout, there are competitive forces which tend to make local governments allocate resources that are in Pareto optimal (Tiebout, 1956). People choose to live in a community where they can find their preferred mix of taxes and public goods. Tiebout argues that people will express preference by "voting with their feet." Tiebout's model has the benefit of solving two major problems with government provision of public goods: preference revelation and preference aggregation. His model also sheds light on the balancing effect of taxes and public services on property value. In fact, high tax communities may be more desirable places in which to live if the public goods provisions are also of high quality. Consider the community of three people with public goods demand D_1, D_2, and D_3 (Figure 2.4). If there were communities that charge the same tax rate but offer different levels of public services, then the individuals with demand like D_1, D_2, and D_3 would live in the community producing Q_1, Q_2, and Q_3, respectively. This solution appears to be more efficient than the Samuelson solution because it offers a better way of revealing preferences. Individuals with similar demands are grouped together which is also called Tibout sorting.

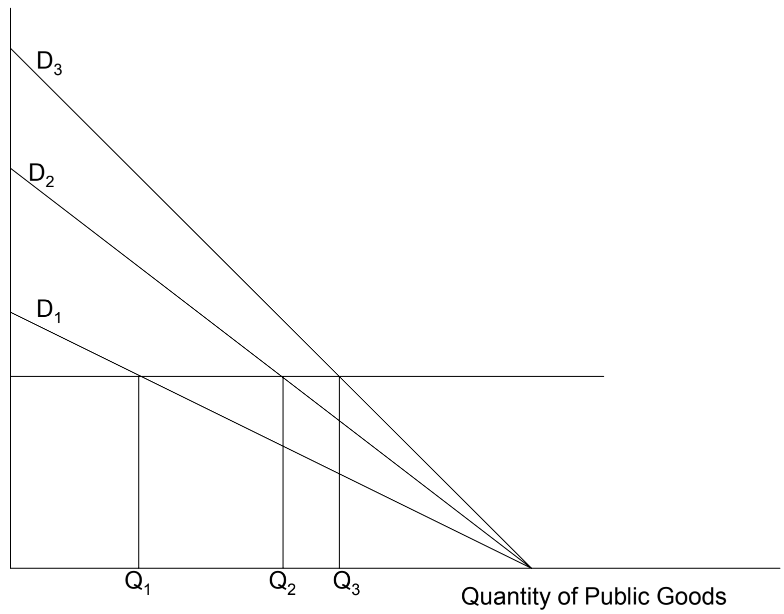

Figure 2.4 Tiebout Equilibrium

Tiebout assumes that (a) there is no cost of migration and (b) consumer has perfect information about the public goods offered by different communities.

Among these three equilibriums, the Samuelson equilibrium describes optimality conditions whereas the Bowen and Tiebout equilibriums describe institutional process leading to equilibrium (Holcombe, 1983). All of the equilibriums provide theoretical underpinnings to the community policy analysis models.

2.3.1.2 Public Sector Modeling Issues

This section deals with the local public sector modeling as a part of regional modeling. Some of the theoretical issues that economic modelers are faced with will be laid out as part of conceptual and empirical construction of the public sector in a regional economic model. As a starting point, the nature of public goods and private goods are contrasted. A typical private good has three main characteristics: excludability, rivalry, and rejectability. Unlike private goods, public goods are non-excludable and non-rival in consumption. The definition of non-excludable is that the goods cannot be confined to those who have paid for them. In this sense, non-payers can take a free ride and enjoy the benefits of consumption. Non-rival nature of public goods implies that consumption by one person does not reduce the availability of a good to others. Because of these natures of public goods, a market mechanism does not exist to ensure Pareto optimal allocation of goods and services (Samuelson, 1954). Unlike individual demand schedules of private goods and services, the demand schedules of public goods are aggregated vertically. This implies that any number of individuals can consume a fixed level of good or service.

In the case of private goods, marginal benefit is equated with price so that there exists a market for them. Whereas in non-excludable public goods, if prices are attached to a benefit received, then there is lack of incentive for a consumer to reveal his/her true preferences. Therefore, market fails to exist and then modeling of demand for public goods becomes challenging. Demand modeling gets further complicated when congestion becomes a real issue where public goods cannot be jointly consumed perpetually. The issue of over capacity or under capacity of public goods complicates modeling further. Some of the public goods are lumpy**.** For example, it would not be practical to increase the width of road for every addition of traffic volume.

Despite these challenge, public finance economists have spent considerable time and energy to model the demand and supply of public goods. Policy makers are increasingly concerned about the impact on public revenue and expenditure as a result of changes in the local economy. Most of the early studies on local revenues and expenditures were focused on the factors that determine them. These empirical works link a set of local regional socio-demographic characteristics with local governmental expenditure and revenue levels. Their results appeared to be consistent that higher level of public services are associated with higher per capita income, larger fiscal base, greater unemployment, relatively urban environment, and higher intergovernmental aid. The resulting regression coefficients are used as expenditure multipliers which show expenditure increment associated with the increase in one unit of each independent variable. The appropriateness of the coefficients is judged on the basis of congruence with economic theory; however these studies were not well founded with economic theories.

As second generation models which combine public goods theories, public choice theories, and microeconomic theories, median voter models are estimated by assuming equilibrium in the public goods market (Deller, 2006; Barr and Davis, 1963; Borcherding and Deacon, 1972; Bergstrom and Goodman, 1973; Deacon 1977, 1978; Bergstrom et al. 1982). The traditional downward-slopping demand curve is met with a horizontal supply curve. This implies that quantity of supply may change without changing the price. The individual utility maximization framework as such is not applicable in estimating demand for public goods. Here individual demands are assumed to be aggregated through political voting. In this framework, demand for public goods is assumed to depend on both median voter income and tax prices.

2.3.1.3 Supply and Demand of Local Public Goods

2.3.1.3.1 Supply of public goods

As discussed in the previous section, modeling local public sector can be a challenging task. There is a conceptual similarity between demand for private and public goods. In both cases income, price, taste and preferences play an important role. However, the market demand curve for public goods are obtained by summing individual demand curves vertically, whereas the private market demand is obtained from horizontal summation of individual demand curves. Therefore, the concept of aggregate demand is not the same.

There have been numerous studies on modeling the demand and supply of public goods (Barr and Davis, 1966; Ohls and Wales, 1972, Bergstrom and Goodman, 1973). These studies deal not only with the theoretical exposition of demand and supply of public goods, but also deal with policy issues. It appears that Borcherding and Deacon (1972) are the first to attempt to model the public goods market by integrating supply and demand for the local public goods using median voter framework. Deller (2006) also use the similar framework to model the supply of public goods. They use firm's profit maximization framework to determine the supply. They included only capital and labor as input for municipal goods production. Assuming cost of capital constant among different municipalities, they came to the conclusion that municipal good supply solely depends on wage rate. Following Borcherding and Deacon, supply function of public good can be derived as follows using the Cobb-Douglas production function:

$$X = \alpha L^{\beta} K^{1-\beta} \tag{1}$$

where X is physical output of public goods, L is labor input, K is capital input, and β is elasticity of labor, and $1-\beta$ is elasticity of capital.

In the Cobb-Douglas production function, total cost is a function of labor cost and capital cost. Using the assumption of efficient production function, following is obtained.

$$w = \frac{\beta C_x X}{L} \tag{2}$$

where w is wage rate and C_x is marginal cost of output.

$$r = \frac{(1-\beta)C_x X}{K} \tag{3}$$

where is r is rental rate.

$$L = \frac{\beta C_x X}{w} \tag{4}$$

and $K = \frac{(1-\beta)C_x X}{r}$ (5)

Substituting L and K into production function (1), following is obtained.

$$X = \alpha\left[\frac{\beta C_x X}{w}\right]^{\beta}\left[\frac{(1-\beta)C_x X}{r}\right]^{(1-\beta)} = \alpha C_x X\left(\frac{\beta}{w}\right)^{\beta}\left(\frac{1-\beta}{r}\right)^{(1-\beta)} \tag{6}$$

They solved for marginal cost C_x from above equation as:

$$C_x = \left(\frac{1}{\alpha}\right)\left(\frac{w}{\beta}\right)^{\beta}\left(\frac{r}{1-\beta}\right)^{(1-\beta)} \tag{7}$$

By assuming rental rate on capital constant over all municipal units, they obtained marginal cost or supply of public good as:

$$C_x = a' w^{\beta} \text{ where } a' = \left(\frac{1}{\alpha\beta}\right)\left(\frac{r}{1-\beta}\right)^{1-\beta} \tag{8}$$

Thus marginal cost or supply function of municipal goods is derived as a function of wage rate.

A cost minimization framework may not be suitable criteria for modeling public goods supply because the local budgeting decisions are political in nature (Niskenen, 1971; Romer and Rosenthal, 1979). This school of thought is based on the assumption that bureaucrats have no incentive to minimize the cost, rather they always maximize their budget. Deller (2006) points out that "the economic approach to modeling the local public sector is narrow in its perspective and that the political science and public administration literature provide significant insight into the decision-making process at the local level."

2.3.1.3.2 Demand of Public Goods

Beaton (1983) indicates that two problems must be addressed with regard to the market solution to the supply and demand for public goods. The first problem is "the description and quantification of public goods". The second problem is "the decision-making process that aggregates individual choices for packages of public goods into a single bundle over the effective period of the collective decision." To address the first problem, it is assumed that higher level of public goods and services are more expensive. This implies that expenditures are a proxy of quantity of output. To address the second problem, it is assumed that median voter's preferences are considered because median voter theory can be applied to utility maximization framework for private goods to model the demand for public goods.

Following the works of Borcherding and Deacon (1972), Beaton outlines the demand model for public goods. Assuming nondiscrimination in the provision of public goods where each individual receives an average share of the public goods, the number of public goods consumed by an individual is defined as:

$$q = \frac{X}{N^{\alpha}} \tag{9}$$

where X is the number of units of public goods produced, N is the population, and α is the degree of privateness of public goods which is $0 < \alpha \leq 1$. If α reaches 0 then, $q = X$. Then X becomes pure public good. The next step is to determine the price of public goods. In the public sector, revenues are commonly derived through taxes. A median voter pays an equal share of taxes $s = \frac{C_x X}{Nq}$

(10)

to finance each unit of output X. By substituting q in (10), marginal tax price per unit of q is obtained as $C_x N^{\alpha-1}$ (11)

where C_x is marginal cost.

A median voter maximizes utility

$$U = f(X, Q) \tag{12}$$

subject to budget constraints

$$y = pQ + \tau C_x X \tag{13}$$

where X is a public good and Q is a private good, p is price of private good, and τ is individual citizen's tax share. Substituting X in (13) results in

$$y = pQ + \tau C_x N^{\alpha} q \tag{14}$$

Now the price of a public good becomes

$$s = \tau C_x N^{\alpha} \tag{15}$$

Assuming a Cobb-Douglas constant elasticity specification of the utility function, the demand equation for a public good is derived as

$$q = a(\tau C_x N^{\alpha})^{\eta} y^{\delta} \tag{16}$$

where $C_x = a^{'} w^{\beta}$. However, to avoid the population endogeniety problem, a total expenditure model is proposed as:

$$X = qN^{\alpha} \tag{17}$$

$$X = a(\tau a^{'} w^{\beta} N^{\alpha})^{\eta} N^{\alpha} \tag{18}$$

$$E = C_x X = a\tau^{\eta} C_x^{\eta+1} N^{\alpha(\eta+1)} y^{\delta} \tag{19}$$

Total county expenditure can be expressed as function of four factors: tax share, unit cost of production (i.e. wage), population size and personal income. However, in actual model estimation, income instead of wage was used to make model parsimonious.

2.3.1.4 Spatial Analysis of Public Sector

In the spatial econometric literature, strategic interaction among local governments has been a central issue in public finance. Although there are different interactions that may exist, the notable interactions are classified into three broad categories (Brueckner, 2003; Revelli, 2005). Although their focus in the model is to estimate the spatial interactions in each revenue and expenditure categories. According to Revelli (2005), the literatures on spatial public finance is divided into three main categories. The first category is public expenditure spillover. The main characteristics of the spillover model is that an action chosen by the government of a spatial unit affects directly the preferences of governments of other spatial units. Examples of local public expenditures that can have spill-over effects in the neighborhood are varied from public transport to education, and environmental services. One of the notable studies in this category is by Case, Hines and Rosen (1993). Using a panel data set of the US states' budget, they estimated an expenditure determination equation. They found significant spillover effect across states where state public expenditure on roads, education, and welfare may affect the residents in neighboring states. Using municipal data, Murdoch, Rahmatian, Thayer (1993) estimated a recreation expenditures model where they found that these expenditures by local governments in California affect the well-being of non-residents as well. Solé-Ollé (2006) estimates expenditure spillover model for 2500 Spanish local governments. He estimated reaction functions for benefit spillovers and crowding spillovers. In his model, benefit spillovers are accounted for by spatial lag of the dependent variable (i.e. expenditure), whereas the crowding spillovers are accounted for by spatial lag of population.

The second category of spatial interaction is the fiscal competition that arises due to policy driven capital migration (Brueckner). The fiscal policy by local government (i.e. taxes) affects the budget constraints of other governments. Policy of one jurisdiction affects the policies of another jurisdiction resulting into fiscal competition for mobile resources. Estimation of fiscal reaction function is a typical empirical implementation of these models. Many studies support the idea that the optimal tax rate in a county or city depends on the tax rate in nearby counties or cities (Brueckner and Saavedra, 2001; Brueckner 1998, Levinson 2003).

The third category of spatial interaction is yardstick competition which arises due to informational externality among neighboring jurisdictions (Basley and Case, 1995). Due to the information spillover, the voters in a local jurisdiction would learn more about the quality and efficiency of local government services by using other governments' performance as a yardstick (Basley and Smart 2002).

As Revelli points out, it is challenging to ascertain what attributes the spatial auto-correlation: Is it due to strategic interaction? or Is it due to simply exogenous correlation? Another issue to identify is the theoretical model generating the observed spatial pattern. The irony is that similar predictions can be obtained by reduced form reaction functions of the each expenditure spillovers, tax competition and yardstick competition models.

2.3.2 Labor Market

2.3.2.1 Demand and supply of labor

Regional labor market analysis involves a synthesis of economic and demographic modeling. This chapter provides a discussion of the theoretical foundation and modeling approaches involved in studying labor demand and labor supply. There are number of theories that explain the demand and supply of labor; however, figuring out the appropriate form of the theory that captures the reality of a regional economy is a challenging empirical question. Broadly speaking, the neoclassical view of labor market is assumed where the equilibrium is resulted from the interaction between profit-maximizing firms and utility maximizing workers. The approach is viewed from the level of the individual employer that the labor supply is infinitely elastic, the labor demand completely inelastic and the wage is exogenous (Figure 2.5) . Consider the region shown in Figure 2.5. It views supply as infinitely elastic at S_L and demand as perfectly inelastic with wage rate w, because, in a small region, increase in labor demand from D_L to D_{L1} may not change the prevailing wage rate. Therefore, wage in this case is exogenously determined. It is assumed that most income is accounted for by earned income.

Therefore, in the model, total personal income is treated as given (exogenous). The COMPAS model (Johnson, 2006) implicitly employs this approach to model the labor market.

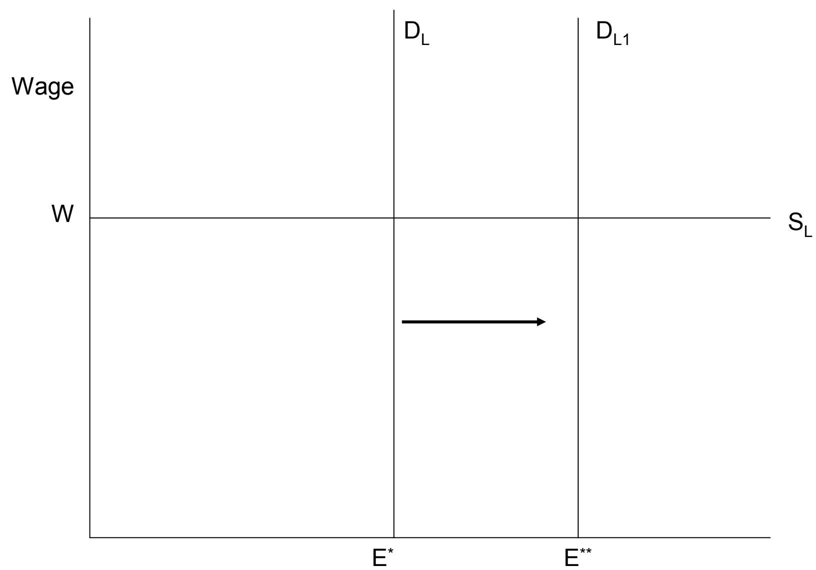

Figure 2.5 Infinitely Elastic Labor Supply and Inelastic Labor Demand

Another modeling approach could be that an employer is facing a completely inelastic labor supply and downward sloping demand. It is assumed that the first approach is more relevant in our model because a county or city is an open economy where it faces an infinitely elastic labor supply because of its residents, in-commuters and in-migrants. The third approach is usual one where a county or city may face positively sloped labor supply and negatively sloped labor demand (Hamermesh, 1993).

Following Johnson (2006), the formal analysis is begun by assuming equilibrium in labor market where

$$X_D = X_S$$

where X_D is labor demand in terms of local employment and X_S is labor supply in terms of employed labor force from all locations. Here demand curve would be a function of wage, $X_D = f(w)$. When it is inverted to eliminate wage from the equation, it becomes $w = g(X_D)$. Labor supply consists of the following components, each of which is a function of employment and a vector of supply shifters. Let

$$X_S = LF - UEMP - COMOUT + COMIN$$
$$LF = f_L(wage, Z_{LF}) = f_L(g(X_D), Z_{LF})$$
$$COMOUT = f_{OUT}(wage, Z_{OUT}) = f_{OUT}(g(X_D), Z_{OUT})$$
$$COMIN = f_{IN}(wage, Z_{IN}) = f_{IN}(g(X_D), Z_{IN})$$

where *LF* is resident labor force, *UEMP* is number of unemployed, *COMOUT* is out-commuters, *COMIN* is in-commuters, and *Zs* are supply shifters. Unemployment is treated as an identity in the labor supply equation.

Unemployed = Labor force + In-commuters – Employment – Out-commuters

The three components of labor supply—labor force, out-commuters, and in-commuters—are functions of employment. Similar definition of "second job" is used as suggested by Johnson and Scott (2006), which is as follows.

Second job= Employment + Out-commuters + Unemployed – Labor force – In-commuters.

2.3.2.2 Spatial Labor Market

One of the most important principles in the field of regional science is that space is a key component of people's lives: their social and business relationships, and institutional organizations. The importance of space or location in labor market analysis is easy to demonstrate. Consider the case of two simple adjacent regions (for example, a county and its surrounding neighbors) as illustrated in Figure 2.6. The diagram is composed so that the county's labor market demand and supply relationships are shown on the right-hand side and the neighbor's relationships are shown as a mirror reflection on the left-hand side. Wages are measured on the vertical axis and employment on the horizontal axis.

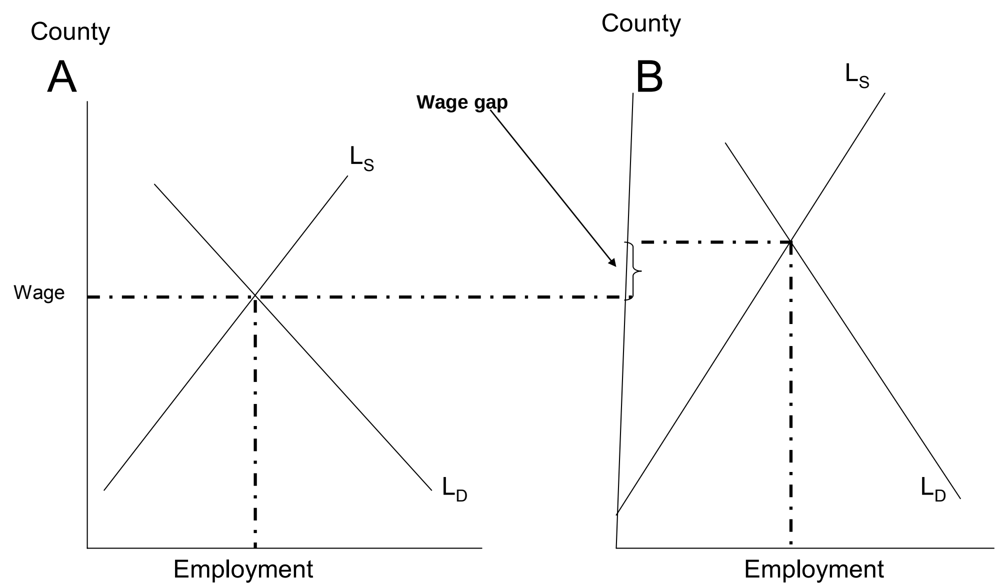

Figure 2.6 Spatial Equilibrium of Labor Market

Each region is in equilibrium separately. Presently, Figure 2.6 indicates that there is a "wage gap" between the county's labor market and the neighbor's. Although there will be some pressure to reduce this wage gap because workers can quit their jobs in the "low wage" region and work in the "high wage" region. However, a wage gap may still exist even after everyone changes their jobs. The reason for a permanent wage gap (at least in the short to medium term) is that changing jobs has a cost. At a minimum there are the commuting costs. Also, workers have residential preferences that make them will to incur greater commuting costs to live where they prefer.

Given the existing conditions within these two labor markets, suppose that a new plant locates in the county (the low cost region). This will shift the county's labor demand curve to the right and creates new job opportunities. The increase in job opportunities can be filled by various types of workers. For example, some of the new employment positions may be filled by unemployed workers. Some of the positions may be filled by migrants, some by people presently not in the labor force, and so on. However, it is possible that the new job opportunities may be filled by neighboring resident workers quitting their jobs in the neighboring region to take some of the new positions in county (i.e., deciding to commute into the county). This would mean that the neighboring counties' labor supply curve would shift up and to the right in Figure 2.6. The result is that although the plant located in the county, the labor market effects are likely to occur in the surrounding counties. The point here is that local labor markets are likely to display substantial spatial variations that can not be adequately accounted for or capture by analyzing the markets as separate and mutually exclusive entities.

The number of labor market studies is truly vast. Several recent comprehensive literature reviews have been compiled providing excellent summaries of past studies, "state-of-the-art" analytical methodologies, and empirical results (Isserman et al, 1986; Elhorst, 2003). Only those studies and empirical results that are relevant to the analysis discussed in this paper will be noted. Early treatments of local labor markets focused on the determination of wages rather than labor force, unemployment, in-commuting, and out-commuting (Roback,1982; Topel 1986). In fact, most labor market studies (until very recently) have ignored the spatial relationships within and between local labor markets.

Regional economic studies in the past have emphasized the importance for researchers to explicitly account for spatial processes underlying the relationships between people, businesses, and institutions, see Anselin (1988) and Griffith et al. (1998). There have been several recent studies investigating spatial labor markets, however, most are partial. For example, Lauridsen and Nahrstedt (1998) investigated the importance of various determinants for inter-municipal commuting variations between 275 Danish municipalities using a generalized version of Anselin's spatial tests for regimes. They found evidence of both spatial instability and spatial dependence in commuting patterns (net and out commuting). Rouwendal (1998) used a labor search model framework to model the spatial interactions between residential and employment locations. He found that excess commuting occurs when workers maximized their utility and employers maximum their profits. Mohlo (1995) constructed a model of unemployment that is consistent with the existence of spatial equilibrium processes. His results suggested that there are significant spatial interactions in unemployment, especially in relation to adjustments in demand shocks.

Although the preceding approaches provide some valuable insights in the spatial structure of local labor markets, they only reveal part of the story. Little attention is given to the interdependence between labor force, in-commuting, out-commuting, and unemployment. Veen and Evers (1983) were among the earliest researchers to develop a simultaneous equation framework to study regional labor market supply while incorporating labor force participation, commuting, and migration. However, they did not consider potential regional spillover effects within labor market processes. Using a "spatial expansion method", Cox and Johnson (1999) and Johnson (2006) provide useful insights for understanding spatial labor markets. The spatial expansion method uses interaction terms between area size (for example, square miles) and other explanatory variables to account for systematic variation of parameters due to the size of the observational unit. Their results suggest that certain spatial effects can be captured by use of these expansion terms.

2.3.3 Housing Market

2.3.3.1 The Demand for Housing

Most economists use the neoclassical consumer theory to estimate the demand for housing. According to this theory, the determinants of housing demand are income, price and taste. Numerous articles have been written using this theory. The most notable ones are by Muth (1960), Quigley (1979), Mayo (1981), Olsen (1987), Smith et al (1988) and Whitehead (1999). However, the concept of housing demand is not free from ambiguity. Rothenberg et al (1991) categorizes housing demand into four categories: (a) the demand for housing services, (b) the demand for individual housing attributes, (c) the demand for owner occupancy versus renting, and (d) the spatial allocation of households. Each category may demand different modeling and estimation methods. Zabel (2004) presents a detail estimation procedure for each category of housing demand.

The first category, the demand for housing services, is useful for estimating price and income elasticities of housing demand. Here, housing demand is modeled as a function of price of housing, non-housing expenditures and taste factors. The second category, the demand for individual housing attributes, is useful to determine the demand for specific characteristics such as number of bedrooms, neighborhood attributes and the like. The most cited literature of this category is by Rosen (1974). The third category, the tenure choice, is estimated as a binary choice model (i.e. owner or renter occupied housing units). The final category, the spatial allocation of household, is useful for explaining the choice of neighborhood.

I use the first category of housing demand in this analysis. It is assumed that housing units are a homogenous commodity facing perfect competition. The general form of housing demand equation is set up as given below.

$$OWN\_OCU = f(POP\_NUM,\ EMP,\ HOWN\_VAL,\ TPI)$$

where *OWN_OCU is* owner-occupied housing units, *POP_NUM* is population, *EMP* is employment, *HOWN_VAL* is price of housing (median house price), and *TPI* is total personal income. In this model, owner-occupied and renter-occupied housing units are modeled as a function of median house value, population, total personal income, and employment.

As discussed before, the spatial housing market also echoes the spatial labor market in most aspects. Changes in demand or supply of housing services in neighboring regions will have an impact on a residence region. Like wage gap, house rent gap or mortgage gap between two regions may exist in housing market equilibrium.

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CHAPTER III

SHOW ME MODEL RE-ESTIMATION FOR MISSOURI COUNTIES

ABSTRACT

Regional economies are systems, driven by intersectoral linkages. A change in one sector of the economy leads to a series of changes in other sectors. Community policy analysis models such as the Show Me Model have helped analysts address impact-related questions. Although this study is a continuation of the Show Me Community Policy Analysis System undertaken by Johnson and Scott, the new features to the model is added by (a) expanding labor market variables, (b) including additional public revenues and expenditures variables, and (c) adding a housing market module. Using cross-sectional data for Missouri counties, a three-stage least squares model of local revenues and expenditures, labor, and housing markets is estimated. The model consists of 5 local revenue equations, 10 local expenditure equations, 4 housing market equations, and 9 labor market and demographic equations. The employment and total personal income are the main drivers of the model. Our model predicts reasonably that increases in local employment lead to increases in local population, housing demand, local revenues, and demand for public services.

3.1. Introduction

Regional economies are systems, driven by intersectoral linkages. A change in one sector of the economy leads to a series of changes in other sectors. The public sector is an integral part of this system. For example, when a business opens or an existing business expands (or closes), the subsequent gain (or loss) of employment and income affects the demand for public goods, the housing market, and local revenues. The growing role of local and regional policy makes it imperative that regional policy makers more accurately and precisely understand the consequences of local policies and economic events. This demands an understanding of the economic linkages among various sectors of a regional economy. A simultaneous equation model provides a reasonably accurate estimate of the regional economic structure.

Community policy analysis models such as the Show Me Model (Johnson and Scott, 2006) have been helpful in addressing economic impact questions. The Virginia Impact Projection (VIP) Model, the first model of its kind developed by Johnson (1991), illustrated how such a model could be used to aid local decision makers. The Iowa Economic/Fiscal Impact Modeling System developed by Swenson and Otto (2000) , the Idaho model developed by Cooke and Fox (1996), an Integrated Economic Impact and Simulation Model for Wisconsin Counties (Shields, 1998), and the Small Area Fiscal Estimation Simulator for Texas (SAFESIM) developed by Evans and Stallmann (2006) are examples of other impact models. This paper is a continuation of the Show Me Community Policy Analysis System (COMPAS) project undertaken by Johnson and Scott (2006). Although this model has performed well, it requires updating and important extensions to be of maximum relevance for analytic and policy uses. Therefore, this model is enhanced by adding more categories of local government expenditure and revenue and by adding a housing market component. Using Missouri counties data, we estimate a three-stage least squares (3SLS) Tobit model. As a system of simultaneous equations, this model recognizes the county-level connections among the labor market, local finance, the housing market, and demographic variables.

Our model consists of labor market and demography, local revenue, local expenditures, and housing market modules. The first component of the model is labor market and demography. It consists of four demographic equations—population, school-age population, dependent population, and population—and nine labor market equations—labor force, women labor force, in-commuters, out-commuters, second jobs, population, school-age population, dependent population, and population below the poverty level. The second component is local revenues equations, including two tax-base equations (property value and retail sales), intergovernmental revenues, other revenue, and a utility revenue equation. Likewise, the expenditure module consists of 10 equations: education, health, transportation, police, fire, parks and recreation, welfare, sanitation, general administration, and utilities. The next component of our model, the housing market, includes four equations: owner- and renter-occupied housing units, vacant housing units, and median house value. The total occupied housing units is treated as an identity.

This paper is organized as follows. Research objectives are presented in the next section, followed by a description of the model. Section 4 describes the data, and Section 5 describes the empirical results. The final two sections present the estimated impacts and summarize, respectively.

3.2. Research Objectives

The main objectives of this study are (a) to develop and re-estimate the Show Me model, consisting of a labor market, fiscal impact, demography, and housing market module for Missouri counties, (b) to expand the model by including more categories of local revenue and expenditures variables and adding housing market module, and (c) to perform policy analysis. Once completed, the model is expected to provide guidelines to local economic policy makers at government, and private-sector in the assessment of policy analysis and possible impact scenarios.

3.3. The Structure of the Model

This model is fashioned from the COMPAS framework developed by Johnson and Scott (2006). The conceptual design of the Show Me model is straightforwardly structured according to the operation of local government and the functioning of local economy. Similar to the previously estimated Show Me model, the new Show Me model structure is comprised of a labor market and demographic module, a fiscal impact module, and a housing market module. Each module is developed to capture the explicit measures of economic activity in the local community, and the simultaneous system of model design allows for the interaction within and among these modules. The assumptions of this model are based on conceptual logic and empirical studies of small area modeling. The main assumptions are as follows:

1. Policy provision, public services, and tax rates are uniform within a county in Missouri. Communities within the Missouri state share a common constitutional limitations and responsibilities.

2. The fundamental engine of economic growth, decline, and change at the local level is employment. This assumption implies that impact occurs in a community through labor market changes. Changes in employment, unemployment, commuting, labor force, and population lead to changes in housing needs, property tax bases, public service demands, and intergovernmental transfers.

3.3.1 Labor Market and Demography Module

The labor market is one of the important factors that impact the local economy on many fronts. Changes in labor market factors such as employment, unemployment, commuting, labor force, and population not only impact local expenditures and revenue variables that are directly related to public services demand and supply but also shape the housing market of the area. Although there is an unsettled issue of whether jobs follow people or people follow jobs (Hoogstra et al. 2005), it is assumed that there is greater flexibility of Missouri labor market where the response to changes in labor demand take place via migration and in-commuting. Furthermore, unlike knowledge society where jobs can follow people, Missouri labor market is better characterized by traditional industrial society where people tend to follow jobs.

As part of the important foundation work in regional labor market modeling, Johnson (2006) incorporated spatial dimension. Johnson theorized that when the size of jurisdiction increases, the size of the labor force and employment also increase. On the other hand, the proportion of in-commuters and out-commuters increases as the size of the jurisdiction gets smaller. Assuming commuting pattern as a gravity model, Johnson argued that labor force, out-commuting, and in-commuting are functions of employment, housing conditions, cost of living, public services, industry mix, area, distance to job, and distance to residence. Following Casetti's (1972) expansion method, which captures the structural changes originated due to geographic size, Johnson included the area and its interaction terms as explanatory variables. He warned that if the area effect is ignored, the parameter estimates will be biased. Using Missouri data, Johnson and Scott (2006) estimated the expansion model. They found the area and its interaction terms significant in explaining labor force and commuting.

Following the estimation and development principle of the Virginia Impact Projection (VIP) model (Johnson, 1987), and an earlier version of the Show Me Model for Missouri communities (Johnson, 1991), Johnson and Scott (2006) estimated a modeling consisting of two parts: labor market module and fiscal impact module. In their model, labor force is considered to be the function of employment, unemployment, out-commuters, area, and area × employment. In-commuters and out-commuters are function of employment, external employment, external labor force, and unemployment. Johnson and Scott added an extra equation called second jobs, which is estimated as a function of the labor force. Second jobs is calculated as residual and represents the actual number of people who hold two or more jobs. Second jobs may also contain measurement errors.

Second job holding is also called dual-job holding or moonlighting in labor market literature. There are number of reasons for holding second job: hours constraints in primary job (Shisko and Rostker, 1976), liquidity constraints (Abdukadir, 1990), maintain family income (Krishnan 1990), underemployment (Paxon and Sicherman, 1996). Using Canadian Labor Force Survey data, Sussman (1998) found that women tend to hold multiple jobs more often than men. Sussman also found that holding of second job is more prevalent among those with at least some postsecondary education than among those with a high school diploma. The same study found that highest rate of second jobs occurred among those involved in farming. In the model, total personal income, female labor force, employment and dependent population are included as explanatory variables to explain the second jobs equation.

Following Johnson (2006), the formal analysis is begun by assuming equilibrium in labor market where

$$X_D = X_S$$

where X_D is labor demand in terms of local employment and X_S is labor supply in terms of employed labor force from all locations. Here, demand curve is allowed to be the function of wage, $X_D = f(w)$. When it is inverted to eliminate wage from the equation, it becomes $w = g(X_D)$. Labor supply consists of following components, each of which is a function of employment and a vector of supply shifters. Let

$$X_S = LF - UEMP - COMOUT + COMIN$$
$$LF = f_L(wage, Z_{LF}) = f_L(g(X_D), Z_{LF})$$
$$COMOUT = f_{OUT}(wage, Z_{OUT}) = f_{OUT}(g(X_D), Z_{OUT})$$
$$COMIN = f_{IN}(wage, Z_{IN}) = f_{IN}(g(X_D), Z_{IN})$$

where *LF* is resident labor force, *UEMP* is number of unemployed, *COMOUT* is out-commuters, *COMIN* is in-commuters, and *Zs* are supply shifters. Unemployment is treated as an identity in the labor supply equation.

Unemployed = Labor force + In-commuters – Employment – Out-commuters

The three components of labor supply—labor force, out-commuters, and in-commuters—are functions of employment. The definition of "second jobs" is used as suggested by Johnson and Scott (2006), which is as follows.

Second job= Employment + Out-commuters + Unemployed – Labor force – In-commuters.

It is hypothesized that population is dependent on labor force, school-age population is dependent on population and labor force, and dependent population is simply the function of population. Population below the poverty level is dependent on income, size of dependent population, and percentage of rural population. As part of a system, the following labor market and demographic equations are estimated. The expected sign of each variable is presented in parentheses just below each explanatory variable.

$$LF = \beta_0 + \underset{(+)}{\beta_1 EMP} + \underset{(+)}{\beta_2 AREA} + \underset{(\pm)}{\beta_3 A\_EMP} + \underset{(+)}{\beta_4 CEMP} + \varepsilon$$

$$LF\_F = \eta_0 + \underset{(+)}{\eta_1 LF} + \underset{(+)}{\eta_2 EMP} + \underset{(+)}{\eta_3 CEMP} + \underset{(\pm)}{\eta_4 TPI} + \underset{(\pm)}{\eta_5 RUR} + \varepsilon$$

$$COM\_IN = \phi_0 + \underset{(+)}{\phi_1 EMP} + \underset{(+)}{\phi_2 AREA} + \underset{(\pm)}{\phi_3 A\_EMP} + \underset{(-)}{\phi_4 CEMP} + \varepsilon$$

$$COM\_OUT = \lambda_0 + \underset{(+)}{\lambda_1 LF} + \underset{(-)}{\lambda_2 AREA} + \underset{(-)}{\lambda_3 EMP} + \underset{(\pm)}{\lambda_4 A\_EMP} + \underset{(+)}{\lambda_5 CEMP} + \varepsilon$$

$$JOB2 = \delta_0 + \underset{(\pm)}{\delta_1 TPI} + \underset{(+)}{\delta_2 LF\_F} + \underset{(+)}{\delta_3 EMP} + \underset{(-)}{\delta_4 POP\_DEPEN} + \varepsilon$$

$$POPNUM = \kappa_0 + \underset{(+)}{\kappa_1 LF} + \varepsilon$$

$$POP\_SCH = \varpi_0 + \underset{(+)}{\varpi_1 POP\_NUM} + \underset{(+)}{\varpi_2 LF} + \varepsilon$$

$$POP\_DEPEN = \tau_0 + \underset{(+)}{\tau_1 POP\_NUM} + \varepsilon$$

$$POOR = \upsilon_0 + \underset{(-)}{\upsilon_1 TPI} + \underset{(+)}{\upsilon_2 POP\_DEPEN} + \underset{(\pm)}{\upsilon_3 RUR} + \varepsilon$$

3.3.2. Revenue Module

In this section, I review some of the empirical literature on local government revenue modeling and then specify our model. Generally speaking, literature explaining local government revenue is rare. Bahl (1978) noted four problem areas in revenue forecasting: cleaning tax revenue series of discretionary changes in the tax rate and tax-base, determining proper explanatory variables, developing an appropriate model, and forecasting intergovernmental revenue. Because of the discretionary nature of tax rates, annual revenue must be adjusted so that it will net out the discretionary changes in the series. In the case of variable selection problem, Bahl mentioned that there is a dilemma regarding whether to choose an income or an employment base variable as the explanatory variable. He recommended employment base rather than income as an explanatory variable because the former captures the economic activities of the region more accurately. The summary of factors determining local revenue or revenue base is presented in Table 3.1.

It is assumed that government expenditures are determined prior to setting tax rates that are designed to make up the difference between those expenditures and other revenue sources. Therefore, model tax base is modeled instead of tax revenues because it makes the model more flexible when used by local policy makers. There are five revenue equations in the model. Each tax base (property value, retail sales), intergovernmental revenue, other revenue, and utility revenue may require a different set of explanatory variables.

In the model, revenue sources are considered a function of economic activities in a county. Income, employment, in-commuting, out-commuting, homeownership, housing condition, and so on may reflect the economic activities in the region. It is expected that these variables are to be positively associated with local revenue or revenue base. On the other hand, vacant housing units, intergovernmental revenue, and rural dummy are hypothesized to be negatively related to local revenues. The specification of revenue equations are presented below. The first two equations estimate property tax base and sales tax base, respectively. Property value or retail sales are the function of income, employment, and population, whereas intergovernmental revenue is a function of income and demographic variables. The expected signs of each explanatory variable are presented in the parentheses just below the explanatory variables.

$$PVAL = \delta_{10} + \underset{(+)}{\delta_{11}TPI} + \underset{(+)}{\delta_{12}EMP} + \underset{(-)}{\delta_{13}HOUSE\_VAC} + \underset{(+)}{\delta_{14}AREA} + \varepsilon$$

$$RSAL = \delta_{20} + \underset{(+)}{\delta_{21}TPI} + \underset{(+)}{\delta_{22}POP\_NUM} + \underset{(+)}{\delta_{23}EMP} + \underset{(\pm)}{\delta_{24}RUR} + \varepsilon$$

$$INTERGOV = \delta_{30} + \underset{(-)}{\delta_{31}EMP} + \underset{(-)}{\delta_{32}TPI} + \underset{(+)}{\delta_{33}POP\_DEPEN} + \underset{(+)}{\delta_{34}POOR} + \underset{(+)}{\delta_{35}AREA} + \varepsilon$$

$$REV\_OTH = \delta_{41} + \underset{(+)}{\delta_{4}OWN\_OCU} + \underset{(+)}{\delta_{4}TPI} + \underset{(\pm)}{\delta_{4}COM\_OUT} + \varepsilon$$

$$REV\_UTL = \delta_{50} + \underset{(+)}{\delta_{51}AREA} + \underset{(+)}{\delta_{52}EXP\_ADM} + \underset{(+)}{\delta_{53}COM\_IN} + \underset{(-)}{\delta_{54}COM\_OUT} + \underset{(\pm)}{\delta_{55}RUR} + \varepsilon$$

$$CHARGES = \delta_{60} + \underset{(-)}{\delta_{61}COM\_OUT} + \underset{(+)}{\delta_{62}POP\_NUM} + \varepsilon$$

3.3.3. Expenditure Module

Traditionally, local fiscal choice about public services is a matter of consumers' utility maximization subject to budget constraints. In this framework, the interest of the median voter is considered by politicians. The most common approach of modeling demand for local public expenditure is, therefore, the median voter model pioneered by Bowen (1943) and then improved by Black (1958), Bergstrom and Goodman (1973), and

Borcherding and Deacon (1972). The median voter theory employs the same solution framework as used by a perfectly competitive market for private goods. The main assumptions of the median voter model are (a) voters always have single peak preferences, (b) voters show their true preferences, and (c) the issues voted on are one-dimensional. Although these assumptions seem very strong, they are prerequisites for the model to work.

Literature on local government expenditures is plentiful; a review of some empirical studies is as follows. Following the work of Scott and Edward (1957), Welcher (1970) estimated expenditure models of each of four service categories—police protection, fire protection, sewers and sanitation, and highways—and found that fiscal capacity variables such as median family income, unemployment, retail sales per capita, number of manufacturing established per capita, and intergovernmental revenue tend to be significant across the expenditure categories. Welcher used 1960 per capita expenditure data for 206 cities in Standard Metropolitan Statistical Areas (SMSA). He classified explanatory variables into six categories: (a) measures of size represented by population of central city and rate of population growth, (b) fiscal capacity variables, (c) metropolitan political fragmentation represented by ratio of central city population to population of the urbanized area (d) ratio of total manufacturing employment within the city to that of the SMSA, (e) taste variables that affect the service conditions that affect input requirements, (f) including percentage of population of foreign stock, fraction of non-white population, fraction of population under 21, fraction of population over 25 with less than five years of schooling, and fraction of population over 25 who are college graduates), and (f) service condition, represented by population density, percentage of housing units with more than one person per room, percentage of dilapidated housing units, percentage of housing units built before 1930, retail sales per store, number of employees per manufacturing establishment, and mean January temperatures of the city. For estimating the impact of key explanatory variables, he found that models with large numbers of variables tended to work better. A summary of the studies conducted to model the local government expenditures are presented in Table 3.2.

In this study, public service expenditures categories include expenditure on education, health, transportation, police, fire, parks and recreation, welfare, sanitation, administration, and utilities. These expenditures categories are functions of economies of scale, county-level political fragmentation, service condition, and intergovernmental revenues. Population and school-age population capture the economies of scale in providing educational services. It is expected that per student cost of education falls as student population increases and that a difference in fiscal capacity of rural and urban areas will exist. The level of expenditure on public services also depends on intergovernmental aids; a positive relationship is expected between intergovernmental aid and local expenditures. The specification of regression equation for estimating expenditures categories are as follows. The expected sings of the parameter estimates are presented in the parentheses just below each explanatory variable name.

$$EXP\_EDU = \gamma_{10} + \underset{(+)}{\gamma_{11} POP\_SCH} + \underset{(+)}{\gamma_{12} EMP} + \underset{(+)}{\gamma_{13} TPI} + \underset{(+)}{\gamma_{14} PVAL} + \varepsilon$$

$$EXP\_HLT = \gamma_{20} + \underset{(+)}{\gamma_{21} TPI} + \underset{(+)}{\gamma_{23} POP\_NUM} + \underset{(+)}{\gamma_{24} COM\_IN} + \underset{(-)}{\gamma_{25} EMP} + \underset{(+)}{\gamma_{26} INTERGOV} + \varepsilon$$

$$EXP\_TRN = \gamma_{30} + \underset{(+)}{\gamma_{31} TPI} + \underset{(-)}{\gamma_{32} COM\_OUT} + \underset{(-)}{\gamma_{33} EMP} + \underset{(+)}{\gamma_{34} AREA} + \underset{(\pm)}{\gamma_{35} RUR} + \varepsilon$$

$$EXP\_POL = \gamma_{40} + \gamma_{41}TPI + \gamma_{41}COM\_IN + \gamma_{41}AREA + \gamma_{41}CRIMET + \varepsilon$$
(+) (+) (±) (+)

$$EXP\_FIR = \gamma_{50} + \gamma_{51}HOWN\_VAL + \gamma_{52}TPI + \gamma_{53}AREA + \gamma_{54}RUR + \varepsilon$$
(+) (+) (+) (±)

$$EXP\_PRK = \gamma_{60} + \gamma_{61}TPI + \gamma_{62}POP\_DEPEN + \gamma_{63}AREA + \gamma_{64}RUR + \varepsilon$$
(+) (±) (+) (±)

$$EXP\_WEL = \gamma_{70} + \gamma_{71}TPI + \gamma_{72}INTERGOV + \gamma_{73}POOR + \varepsilon$$
(−) (+) (+)

$$EXP\_SAN = \gamma_{80} + \gamma_{81}TPI + \gamma_{82}HOUSE\_OCU + \gamma_{83}RUR + \varepsilon$$
(+) (+) (±)

$$EXP\_ADM = \gamma_{90} + \gamma_{91}POP\_NUM + \gamma_{92}COM\_IN + \gamma_{93}TPI + \gamma_{94}AREA + \varepsilon$$
(+) (+) (+) (+)

$$EXP\_UTL = \gamma_{100} + \gamma_{101}AREA + \gamma_{102}EXP\_ADM + \gamma_{103}COM\_IN + \gamma_{104}COM\_OUT + \gamma_{105}RUR + \varepsilon$$
(+) (+) (+) (−) (±)

3.3.4 Housing Market Module

Because most housing market analysts agree that neoclassical consumer theory is the only the theory capable of explaining the housing market, the neoclassical model is used as explained by Megbolugbe, Marks, and Schwartz (1991) to analyze housing market determinants. In their study, household decision making is assumed to be parallel to individual consumer decision making. Consumers maximize their utility subject to budget (income and price) constraints. It is also assumed that housing units are a homogenous commodity facing perfect competition. The general form of housing demand equation is set up as given below.

$$OWN\_OCU = f(POP\_NUM,\ EMP,\ HOWN\_VAL,\ TPI)$$

Where *OWN_OCU is* owner-occupied housing units, *POP_NUM* is population, *EMP* is employment, *HOWN_VAL* is price of housing (median house price), and *TPI* is total personal income. Housing can be a consumption good and/or an investment good;

however, in this case housing is treated as the former. In this model, owner-occupied and renter-occupied housing units are modeled as a function of median house value, population, total personal income, and employment. The expected sings of the parameter estimates are presented in the parentheses just below each explanatory variable name.

$$RENT\_OCU = \psi_{10} + \underset{(+)}{\psi_{12}POP\_NUM} + \underset{(+)}{\psi_{13}HOWN\_VAL} + \underset{(-)}{\psi_{14}TPI} + \varepsilon$$

$$OWN\_OCU = \psi_{20} + \underset{(+)}{\psi_{21}EMP} + \underset{(-)}{\psi_{22}HOWN\_VAL} + \underset{(+)}{\psi_{23}TPI} + \varepsilon$$

$$HOUSE\_VAC = \psi_{30} + \underset{(-)}{\psi_{31}HOWN\_VAL} + \underset{(\pm)}{\psi_{32}RUR} + \underset{(-)}{\psi_{33}TPI} + \underset{(+)}{\psi_{34}UNEMP} + \varepsilon$$

$$HOWN\_VAL = \psi_{40} + \underset{(+)}{\psi_{41}PCI\_VAL} + \underset{(\pm)}{\psi_{42}RUR} + \underset{(-)}{\psi_{43}POOR} + \underset{(+)}{\psi_{44}HOUSE\_OCU} + \varepsilon$$

3.4. Data description and data sources

All the data used in this study were obtained from secondary sources such as the Census Bureau; the Bureau of Economic Analysis Regional Economic Accounts, the Bureau of Labor Statistics, and the U.S. Department of Agriculture Economic Research Service. The variables used in the model and their description and sources are presented in Appendix 1. Data for expenditure variables were obtained from the U.S. Census of Government, and employment data originated from the Bureau of Economic Analysis. The employment data used in the analysis is by place of work. The second job variable is calculated as a residual of the employment, unemployment, commuting, and labor force data. Some of the expenditures and utility revenues are zeros because some counties do not have such services or revenue sources. To correct this truncation bias, Tobit procedure is proposed. Table 3.3 presents the descriptive statistics of the variables employed in the empirical analyses.

3.5. Estimation methods and results

As mentioned previously, a 3SLS Tobit method is used, that allows us to estimate parameters in a simultaneous system of equations with censored dependent variables. A 3SLS Tobit procedure accounts for three factors. First, it takes care of the simultaneity bias which arises in simultaneous system of equation model when a dependent variable is correlated with another equation's error term. Second, it allows correlated errors between equations which improved the efficiency of the parameter estimates. Third it will use an appropriate distributional assumption for the censored data. Some of the expenditures and utility revenues are zeros because some counties do not have such services or revenue sources. This suggests that the distribution of the dependent variables and thus the error terms may not be normal. Therefore, the typical solution for non-normal distribution is the Tobit procedure. To ensure the identifiability of the model, order condition is tested and satisfied. The revenue module, expenditure module, housing market module, and labor market module is estimated as one system of equations. Property value, retail sales, and other revenue and expenditure variable were kept at $10,000 to ease the estimation process; otherwise, we obtain a large value of variance, which, when inverse of variance covariance matrix is taken, it causes all values to become zeros. This situation hinders the model's ability to estimate cross-equation interaction.

Though the model is estimated as one system of equations, the estimated results are presented in separate sections for each module for ease of discussion. Following sections discuss the 3SLS Tobit regression results for each module.

3.5.1 Labor Market and Demography Module

The results of the 3SLS Tobit regression analysis of the individual labor market and demography module are shown in Table 3.4. There are nine equations in this module. Population is estimated as a function of labor force. School-age population and dependent population are, correspondingly, modeled as functions of population and labor force and population, respectively. Both equations have very high R^2 values (i.e., 0.99) in two-stage least squares (2SLS) estimation. The population below the poverty level equation is estimated as a function of total personal income, dependent population, and percentage rural population. As expected, an increase in total personal income tends to decrease poverty, and an increase in dependent population tends to increase the population below the poverty level. Rural counties appear to have more poor people than that of urban counties.

The labor force equation is estimated as a function of employment, area, area × employment, and external employment. The variable area × employment is also called as expansion variable which captures the structural changes that are caused by the different sizes of counties. Most variables are significant and of the expected sign. Employment and external employment are highly significant and positive. This implies that both within-county employment and neighboring-counties employment encourage more people to participate in the labor force. Unexpectedly, the area variable appears to be negative and significant. However, the marginal impact of employment on labor force is higher for larger counties.

It is assumed that labor force and female labor force are impacted by different factors. Therefore female labor force equation is estimated as a function of labor force, employment, external employment, total personal income, and percentage rural population. As expected, labor force, external employment, and employment are found to be significant and positive. Total personal income is positive and significant. This implies that more women participate in labor force from rich counties than that of poor. Percentage rural population appears to be negative and significant. This implies that increase in percentage rural population leads to decrease in women labor force participation.

Commuting equations such as in-commuting and out-commuting are estimated as functions of employment opportunity available to both residence counties and surrounding counties, area of residence counties, and expansion variable area × employment. Most variables are significant and of the expected sign. As expected, an increase in employment leads to an increased level of in-commuters and a decreased level of out-commuters. From both equations, a negative sign of the expansion variable shows that for larger counties the area variable decreases the marginal effect of employment on commuting. Labor force is significant and positive in explaining out-commuting. This implies that an increased labor force leads to an increased level of out-commuting.

Second job is a residual variable used to measure both measurement error and actual number people who hold two or more jobs. This variable is modeled as a function of total personal income, female labor force, employment, and dependent population. It appears that income is significantly and positively associated with second jobs. This result indicates that lower income people who hold second jobs live in rich areas. As expected, dependent population is negatively associated with second jobs. People who live in families with children or the elderly may not have enough time to hold second jobs.

3.5.2 Revenue Module

The regression results of different revenue categories are presented in Table 3.5. Although this table includes parameter estimates from ordinary least squares (OLS) and Tobit, 2SLS Tobit, and 3SLS Tobit procedures, the interpretation of results are based on results obtained from 3SLS Tobit procedures (presented in the sixth column). The two revenue-base equations are estimated along with three revenue equations. We model tax base rather than tax revenue because it allows local government to choose different tax rates to balance the budget. The assessed property value is modeled as the property tax base and retails sales as the sales tax base. Property value is estimated as a function of total personal income, employment, vacant housing units, and area. As expected, an increase in total personal income tends to increase property value. Vacant housing units is estimated to have a negative effect on property value. The sign of area variable is positive and not significant.

The total retail sales equation is estimated as a function of total personal income, population, employment, and percentage rural population. As expected, an increase in total personal income, employment and population leads to increased retail sales. The retails sales in rural appears to be lower than the urban area, however it is not significant. Total charges was estimated as function of out-commuters and population. As expected, population found to be positive and significant. This implies that as population increases, revenue from the total charges also increases. Surprisingly, the out-commuters is found to be positive and significant. It may be that people out-commute for work but consume most government services from their residence counties.

The intergovernmental revenue equation is estimated as a function of employment, total personal income, dependent population, population below the poverty level, and area. Surprisingly, employment and total personal income are significant and positive. This implies that the counties that have more people at work may need as much intergovernmental support. This counteracts the perception that wealthier areas receive more intergovernmental support. An increase in poverty in terms of the number of people below the poverty line tends to increase the intergovernmental revenue which is expected.

Other revenue and other taxes equation is estimated as a function of owner-occupied housing units, total personal income, and out-commuters. A significant portion of this revenue comes from property title change service. As expected, owner-occupied housing units is positive and significant. As the number of homeowners increases, the demand for tile change services increases; consequently other revenue increases. The out-commuter variable appears to be negative but not significant. Unexpectedly, total personal income is significant and negative.

The utility revenue equation is estimated as a function of total personal income, population, vacant housing units, and percentage rural population. As expected, population appears to be positive and significant. However, total personal income is negatively associated with utility revenue, which is unexpected. The vacant housing units significantly causes to decrease the utility revenue.

3.5.3 Expenditure Module

This section presents the estimated results for expenditure module. The expenditures module consists of 10 equations: education, health and hospital, transportation, police/protective/inspection/judicial, fire, parks and recreation, public welfare, sanitation, general administration, and utilities (Table 3.6). The 2SLS Tobit results show that most equations have an adjusted R^2 above 0.80 and log likelihood below -653[2]. Thus the expenditure equations have a reasonably high explanatory power. Most expenditure equations are a function of total personal income, employment, population, commuting, and area, and most of the explanatory variables are significant and of the expected sign. Surprisingly, total personal income is found to be significant and negative in several expenditure equations except police/protective/inspection/judicial and fire expenditures. This may be due to the impact of intergovernmental revenue which may have diminished the impact of total personal income.

As expected, population in the health –and hospital and administrative expenditures equation, school-age population in the education equation, dependent population in the parks –and recreation equation, and population below the poverty level in the public welfare expenditures are significant and positive. Most expenditure functions are impacted by the size of the service-recipient population.

Percentage rural population is positively associated with transportation expenditures, parks and recreation expenditures, sanitation expenditures, and utility expenditures whereas it is negatively associated with fire-protection expenditures. The area variable is found to be positive and but not significant in transportation expenditures

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[2] Tobit procedure was used to estimate utility revenues, health expenditures, parks and recreation expenditures, public welfare expenditures, and utility expenditure.

and police/protective/inspection/judicial expenditures, whereas it is negatively associated with fire-protection and utility expenditures. As expected, crime rate is significant and positive in police/protective/inspection/judicial expenditures.

3.5.4 Housing Market Module

Table 3.7 presents the estimated parameters of the housing market module. In this module, four equations are estimated: renter- and owner-occupied housing units, total vacant housing units, and median house value. The renter-occupied housing units equation is estimated as a function of population, median house value, and total personal income. All variables are significant and have expected signs. As expected, population is positively associated with renter-occupied housing units, whereas median house value and total personal income are negatively associated. This implies that if people have more income, demand for renter housing is less. Similarly, median house value is negatively associated with renter occupied housing units. As the price of houses increase, the demand for renter housing declines.

The owner-occupied housing units equation is estimated as a function of employment, median house value, and total personal income. As expected, employment and total personal income are found to be significant and positive. This implies that housing is a normal good. When income increases, demand for owner-occupied housing also increases. Unexpectedly, median house value is positive and significant.

The explanatory variables used to explain total vacant housing units are median house value, percentage rural population, total personal income, and number of unemployed people. All the explanatory variables have expected signs. The median house value, percentage rural population, and unemployment are positively associated with vacant housing units, whereas total personal income is negatively associated. The final equation in the housing market module, median house value is estimated as a function of per capita personal income, percentage rural population, population below the poverty level, occupied housing units, and amenity. All variables except occupied housing units have expected signs. Per capita personal income is significant and positive. This implies that as the income level rises, the prices of houses also increase. As expected, median house value is estimated to be lower in rural areas than in urban areas.

3.6. Impact analysis

In the model, it is assumed that employment is the driving force for all sectors of the economy. Changes in employment lead to increases in population and wage levels that ultimately alter demands for public services and the supplies of revenues available to fund these services. To demonstrate how the model works, a simple increase in employment is considered.

We chose Greene County, Missouri, as our test community. Greene County is a fairly large county in Southwest Missouri whose population is approximately 240,600. Using the reduced form coefficients of our model, we estimate the impacts of an employment change on each component of the Greene County economy (Table 3.8). According to our impact analysis, an increase of 1,000 jobs in Greene County will lead to a nearly $7,256,000 increase in total local revenue. Much of these increments are attributed to increases in tax revenues caused by increases in population. Regarding the impact on tax bases, property values are expected to increase by $13,276,000 and retail sales are expected to increase by $6,000,000.

The 1,000 job increment also causes an increase in the demand for public services. All expenditures are expected to increase. Our model predicts that overall expenditures will increase by about $15,767,000. This increment in expenditure is mostly attributed to increases in income and population. As far as the housing market is concerned, our model predicts that an additional 292 housing units will be added to the county, and vacant housing units will be decreased by 626. The median house value will be remained almost the constant.

Our model predicts that the 1,000 new jobs are divided among increases in in-commuters, out-commuters, unemployed people, second jobs, and immigrants. Implicitly, the highest proportion of jobs goes to in-commuters, followed by in-migrants and unemployed people.

3.7. Summary

Community policy analysis models are important to understand, explain, and predict local economy. These models work as a decision support tool for local policy makers. Building a new Show Me model is an attempt to understand the Missouri economy with a perspective that accounts for the interdependencies among local revenues, local expenditures, housing markets, and labor markets within a region. Although these interdependencies depend on various explanatory variables such income, population density, and commuting, employment plays a key role in our model because it is an important engine of growth for local economies. Our model predicts that an increase in local employment leads to increases in local population, housing demand, local revenues, and demands for public services (expenditures).

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Table 3.1 Summary of Determinants of Local Revenue or Revenue Base.

Author	Estimation Procedure	Dependent variable	Control variables	Results
Shields (1998)	OLS	Per capita intergovernmental revenue	Equalized assessed value per capita, property tax rate, government expenditure per capita, regional dummy	Government expenditure and property value significantly explain intergovernmental revenue
Auten and Robb (1976)	3SLS	16 tax categories	lag values and disposable income	Lag values and disposable income are significant.
Hernandez-Murillo (2003)	Instrumental variable technique in spatial lag or error model	Tax rates	Population, percent of urban population, per capita income, average monthly temperature, percent of working-age population	Tax rate in surrounding states impact a state's tax rates.
Liu (1970)	Stepwise regression	Total sales, per capita sales	Population, per capita income, population density, current total expenditures, police and fire expenditures, non-property tax, establishment, dependency ratio, education level in ratio, regional dummies.	Most of these variables are significant. Population is of greatest importance to impact retail sales.
Oates (1969)	2SLS	Median house value, tax rate	Property tax rates, education expenditure per student, distance from	Tax rate is significant and negative whereas education expenditure per

			main city, median number of rooms per house, percentage of new house, median family income, and percentage of poor family	student is positive and significant in explaining property value. Results are consistent with Tibout's hypothesis.
Brigham (1964)	OLS	Land value	Distance to business district, accessibility potential as a ratio between employment in surrounding area by distance, amenity, neighborhood, building value, and topography	As expected, land values are found to be significantly impacted by these variables.

Table 3.2 Summary of Factors Determining Local Government Expenditures.

Author	Estimation Procedure	Dependent variable	Control variables	Results
Wong (1996)	OLS	Local government expenditure per capita on education, library, welfare, hospital, health, highway, police, fire etc.	Location quotient for tourism, population density, per capita income, minority population, elderly population, female headed household, education, crime rate, poverty rate and unemployment	Location quotient for tourism is significant determinants of local government expenditures.
Shields (1998)	SUR	Local government expenditures per capita on health, government administration, safety, roads, waste, and amenities	Per capita income, equalized assessed value per capita, property tax rate, households, unemployment rate, and regional dummy	Income, property taxes, and property values are significant determinants of local government expenditures.
Bergstrom and Goodman(1973)	OLS	General, police, and parks and recreation expenditures	Number of households, tax share (% of median income), median income, population change, percent owner occupied, percent nonwhite, and density	Income and population are significant in explaining expenditures
Fisher (1961)	OLS	Per capita expenditure of state and local government	Population, population density, per capita income	Population, density (-), and income are significant.
McMahon (1970)	Time series and cross section analysis by OLS	Expenditure on primary and secondary education	disposable income, age, attendance, population, pupil teacher ratios, number of pupil per school district, population density, state and federal aids, nonwhite population percent, and	Growth of expenditure over time is due to enrollments and state grants rather than income.

			proportion of immigrants	
Bahl and Saunders (1966)	OLS, Non linear regression	Per capita state and local government expenditures	Per capita income, population density, percent urban population, per capita federal grant	Over time explanatory power of model declining with Fabricant's three variables. Federal grant is important.
Bahl, Gustely and Wasylenko (1978)	2SLS	Average wage of police(1), per 1000 population police employee (2), crime (3)	1)manufacturing wage, median education of city population, public sector unionization, per 1000 population police employment 2) average wage of police, cost of living, income, grants in aid, crime rate, percent nonwhite 3) per 1000 police employees, unemployment, income, average income level in the city, percent nonwhite	Simultaneous system of equations help better explain the police expenditure. Income and unemployment are significant in all cases.
Sacks and Harris (1964)	OLS	Total direct general expenditure, highways, welfare, health and hospitals, local schools, other categories.	Population density, percent urban population, per capita income, per capita state aid, per capita federal aid	Federal and state aids are important to explain local government expenditures.
Sunley (1971)	OLS	Per capita expenditures on police, fire, parks and recreation for central city and outside central	median family income, employment-resident ratio, distance from central city, population, population density,	The same explanatory variables are important in explaining city and outside city

		city	percent of population moved into house after 1958, proportion of owner occupied housing units, dummy for city or village, percent increase in population, and percent of population foreign born	expenditures. Income and population are significant.
Welcher (1970)	OLS	Per capita expenditure on police protection, fire protection, sewers and sanitation, and highways	median family income, unemployment, retail sales per capita, number of manufacturing established per capita and intergovernmental revenue	Variables other than income, population density and percent urban population are also important in explaining local government expenditures
Ferris (1988)	OLS	local expenditures(1), employment in public sectors(2), average salary(3)	1) Median household income, median tax share, number of households, percent services contracted out, average salary 2) same as (1).	Public expenditures and employment decrease when the extent of contracting increases.

Table 3.3 Descriptive Statistics of the Variables Used in the Model.

Variable	Label	Mean[a]	Std Dev	Minimum	Maximum
PVAL	Property value($0,000)	54122.8	156167.14	2240.7	1706209.1
RSAL	Retail sales ($0,000)	52614.29	151052.96	1024.7	1501274.1
CHARGES	Total charges($0,000)	1955.53	5053.29	45.5	39542.2
INTERGOV	State and federal intergovernmental revenue($0,000)	4779.85	11027.7	285.6	78744.2
REV_OTH	Other revenue and other taxes($0,000)	1325.63	4763.93	17.9	44273
REV_UTL	Utility revenue($0,000)	1153.55	3244.92	0	29735.5
EXP_EDU	Education expenditures ($0,000)	6917.42	17680.26	308	159538.3
EXP_HLT	Health and hospital expenditures($0,000)	791.874706	2747.58	0	33181.9
EXP_TRN	Transportation expenditures($0,000)	1088.1	3664.66	33.2	32370.5
EXP_POL	Police, protective inspection, judicial and correction expenditures($0,000)	1053.34	3512.24	10.3	26090.7
EXP_FIR	Fire protection expenditure($0,000)	380.471177	1493.56	0	14455.9
EXP_PRK	Parks and recreation expenditure($0,000)	298.972353	1229.45	0	11461.6
EXP_WEL	Public welfare expenditure($0,000)	396.117059	1320.39	0	11646.1
EXP_SAN	Sewage and solid waste management expenditure($0,000)	478.185294	1655.17	1.1	17777.1
EXP_ADM	General administration expenditures($0,000)	1083.91	2939.81	41.3	19953.8
EXP_UTL	Utilities expenditures($0,000)	1325.44	3948.22	0	33228.3
RENT_OCU	Renter occupied housing units	5428.34	13593.95	236	104642
OWN_OCU	Owner occupied housing units	12990.68	29978.65	773	299670
HOUSE_OCU	Total occupied housing units	18419.02	42847.04	1009	404312
HOUSE_VAC	Total vacant housing units	2003.19	3525.74	236	29278
HOWN_VAL	Median house value ($), census data	68958.19	22393.52	28416	156812
POP_NUM	Population	47102.81	107834.66	2382	1016315
POP_SCH	School age population (age 5-17)	8911.15	20540.81	449	192093
POP_DEPEN	Dependent population(<17 and >65)	18462.85	41653.7	1113	399476
POOR	Number of people below the poverty level	5504.85	11056.42	340.626	85654.49
LF	Labor force (BLS)	24620.36	59159.08	1179	563110
LF_F	Female labor force	11155.63	27176.83	510	258337
COM_IN	In-commuters	7149.59	25302.05	134	217140
COM_OUT	Out-commuters	7038.97	16652.64	415	136748
JOB2	Second jobs	4983.88	15232.68	0	159724
UNEMP	Unemployed	876.652941	1890.8	41	15961
TPI	Total personal income ($0,000)	101736.07	295527.2	3695.4	3028415.4
EMP	Employment by workplace (BEA)	28836.96	80506.75	1255	787265
AREA	Land area square miles	576.192059	168.275838	61.92	1178.54
RUR	Rural population percentage	66.3847059	28.2053984	0	100
CRIMT	Number of serious crimes known to police	2091.64	6589.63	0	54778
PCI_VAL	Per capita personal income	17552.15	2957.52	11656	33387
AMENITY	Amenity index	-0.4545294	1.2908417	-2.85	2.74
A_EMP	Area times employment	15828152.6	42069063	334482.6	399781040
CEMP	External employment	161771.02	242620.3	11096	1338960

[a]N=115

Table 3.4 Estimated Parameters of Labor Market Module

Model	Variables	OLS/Tobit		2SLS Tobit		3SLS Tobit	
		estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Population	Intercept	1666.755	0.0083	1554.741	0.1838	1579.03	0.173
	LF	1.81747	<.0001	1.8218	<.0001	1.8208638	0.000
	Adj R-Sq	0.9973		0.9907			
School age population	Intercept	35.81	0.7509	-10.85	0.9422	-16.097	0.913
	pop_num	0.1606	<.0001	0.18833	<.0001	0.1907205	0.000
	LF	0.05187	0.0875	0.00148	0.9407	-0.002811	0.886
	Adj R-Sq	0.9977		0.9958			
Dependent population	Intercept	151.05222	0.3564	162.29496	0.6273	96.159471	0.772
	pop_num	0.3869	<.0001	0.38667	<.0001	0.388025	0.000
	Adj R-Sq	0.9988		0.9949			
Population below poverty level	Intercept	-2974.9809	0.0064	-3730.770	0.0032	-3075.823	0.013
	tpi	-0.10849	<.0001	-0.09817	<.0001	-0.094703	0.000
	pop_depen	0.99148	<.0001	0.92455	<.0001	0.9024694	0.000
	RUR	18.43225	0.1582	32.33208	0.0333	23.51981	0.115
	Adj R-Sq	0.9364		0.9192			
Labor force	Intercept	4470.31439	0.1267	4470.31439	0.1267	4078.1107	0.154
	emp	0.40212	<.0001	0.40212	<.0001	0.4004538	0.000
	area	-9.66072	0.0431	-9.66072	0.0431	-9.091419	0.051
	a_emp	0.00053157	<.0001	0.00053157	<.0001	0.0005325	0.000
	CEMP	0.03826	<.0001	0.03826	<.0001	0.0387972	0.000
	Adj R-Sq	0.9882		0.9882			
Female labor force	Intercept	-73.53173	0.5594	2841.52766	0.0004	1672.1727	0.031
	LF	0.40333	<.0001	0.20332	<.0001	0.2103178	0.000
	emp	0.05425	<.0001	0.06004	0.0065	0.0579903	0.008
	CEMP	0.00066817	0.002	0.0033	0.0343	0.0032977	0.032
	tpi	-0.00395	<.0001	0.03276	<.0001	0.0324323	0.000
	RUR	-1.26541	0.3984	-33.53478	0.0005	-17.55328	0.058
	Adj R-Sq	0.9999		0.9944			
In-commuters	Intercept	-2973.08	0.0343	-2973.08	0.0343	-3457.77	0.012
	emp	0.60689	<.0001	0.60689	<.0001	0.6046587	0.000
	area	3.36809	0.1379	3.36809	0.1379	4.3780472	0.050
	a_emp	-0.000615	<.0001	-0.000615	<.0001	-0.00061	0.000
	CEMP	0.0032	0.0696	0.0032	0.0696	0.0024694	0.153
	Adj R-Sq	0.9862		0.9862			

Table 3.4 (Continued)

Model	Variables	Tobit/OLS		Tobit 2SLS		Tobit 3SLS	
		estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Out-commuters	Intercept	-2310.03	0.0214	-2700.99	0.2808	-3622.563	0.140
	LF	0.83705	<.0001	0.89904	<.0001	0.9117284	0.000
	AREA	2.5859	0.1065	2.87248	0.4707	4.3360104	0.267
	EMP	-0.22713	<.0001	-0.25909	<.0001	-0.267018	0.000
	A_EMP	-0.000398	<.0001	-0.00042	<.0001	-0.000425	0.000
	Adj R-Sq	0.9822		0.8893			
Second jobs	Intercept	1260.455	<.0001	1284.990	<.0001	1408.4314	0.000
	TPI	0.074898	<.0001	0.068354	<.0001	0.0635876	0.000
	LF_F	-0.523844	<.0001	-0.207319	0.4167	-0.078943	0.758
	EMP	0.183248	<.0001	0.176859	<.0001	0.1974453	0.000
	POP_DEPEN	-0.192979	0.0195	-0.341616	0.0274	-0.432951	0.006
	Log Likelihood	-1037		-1041			

Table 3.5. Estimated Parameters of Revenue Model

Model	Variables	OLS/Tobit		2SLS Tobit		3SLS Tobit	
		estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Property value	Intercept	352.268	0.93	3959.61	0.2781	-185.70	0.959
	TPI	0.62025	<.0001	0.55952	<.0001	0.5724168	0.000
	EMP	-0.2799	0.0005	0.03887	0.595	-0.018849	0.794
	HOUSE_VAC	0.55849	0.2418	-2.52931	<.0001	-2.150458	0.000
	AREA	-1.4819	0.8135	-1.97631	0.7299	4.2577854	0.452
	Adj R-Sq	0.9965		0.9971			
Retial sales	Intercept	19075.00	0.0039	11012	0.0907	7701.18	0.227
	TPI	0.38614	<.0001	0.32051	<.0001	0.3016349	0.000
	POP_NUM	-0.03636	0.788	0.25149	0.0556	0.2479114	0.055
	EMP	0.46996	0.0007	0.337	0.0027	0.4130521	0.000
	RUR	-234.068	0.0029	-160.82	0.0377	-114.47	0.130
	Adj R-Sq	0.9884		0.9888			
Charges	Intercept	459.490	0.2703	461.764	0.2702	390.544	0.345
	COM_OUT	0.10614	0.0605	0.17614	0.0052	0.1920963	0.002
	POP_NUM	0.01789	0.0361	0.00714	0.4415	0.0061672	0.501
	Adj R-Sq	0.4814		0.4768			
Intergovernmental revenue	Intercept	426.40	0.428	2133.41	0.0013	599.35	0.359
	EMP	-0.04319	0.0293	0.07425	<.0001	0.0664956	0.000
	TPI	-0.01563	0.0728	0.00643	0.5316	0.0049792	0.631
	POP_DEPEN	0.29019	<.0001	-0.14315	0.1106	-0.106506	0.238
	POOR	0.58078	<.0001	0.80714	<.0001	0.7648666	0.000
	AREA	-2.85998	0.0011	-3.96698	0.0001	-1.514809	0.138
	Adj R-Sq	0.9857		0.9798			
Other revenue	Intercept	-1345.79	0.0001	-2799.09	<.0001	-2590.91	0.000
	OWN_OCU	0.50458	<.0001	1.00694	<.0001	0.9152288	0.000
	TPI	-0.03399	0.0002	-0.08821	<.0001	-0.078326	0.000
	COM_OUT	-0.06493	0.0852	-0.01173	0.7398	-0.01357	0.696
	Adj R-Sq	0.779		0.7688			
Utility revenue	Intercept	-915.5	0.2706	-2050.7	0.0155	-1744.7	0.043
	TPI	-0.04195	<.0001	-0.05801	<.0001	-0.049949	0.000
	POP_NUM	0.135152	<.0001	0.182481	<.0001	0.1609842	0.000
	HOUSE_VAC	-0.29633	0.0046	-0.39730	0.0036	-0.368	0.008
	RUR	6.383781	0.531	17.16543	0.0934	14.914793	0.151
	Log Likelihood	-1046		-1039			

Table 3.6 Estimated Parameters of Expenditure Module

Model	Variables	Tobit/OLS		2SLS Tobit		3SLS Tobit	
		estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Education expenditure	Intercept	-610.92	0.001	-825.94	0.0002	-873.09	0.000
	POP_SCH	0.74212	<.0001	0.87588	<.0001	0.9147812	0.000
	EMP	0.10744	<.0001	0.16842	<.0001	0.1633735	0.000
	TPI	0.00608	0.6346	-0.27384	0.0033	-0.287556	0.002
	PVAL	-0.04983	0.0067	0.41323	0.0074	0.4356247	0.004
	Adj R-Sq	0.9944		0.9914			
Health expenditures	Intercept	-102.33	0.7903	-596.89	0.1024	-252.57	0.478
	TPI	-0.029236	<.0001	-0.073444	<.0001	-0.050799	0.001
	POP_NUM	0.155612	0.0005	0.232647	<.0001	0.1750043	0.000
	COM_IN	0.196997	0.0018	0.256129	<.0001	0.2049274	0.000
	EMP	-0.076084	<.0001	-0.002525	<.0001	-0.032022	0.276
	INTERGOV	-0.618011	0.0032	-0.908109	<.0001	-0.577706	0.003
	Log Likelihood	-1034		-1026			
Transportation expenditures	Intercept	-1412	<.0001	-1838	<.0001	-1467	0.000
	TPI	-0.04535	<.0001	-0.04363	<.0001	-0.041498	0.000
	COM_OUT	0.20129	<.0001	0.2014	<.0001	0.1946158	0.000
	EMP	0.16584	<.0001	0.16091	<.0001	0.1534184	0.000
	AREA	-0.00553	0.9893	-0.19128	0.6903	0.054926	0.909
	RUR	12.32988	<.0001	19.7723	<.0001	12.946872	0.000
	Adj R-Sq	0.9752		0.9665			
Police, correction expenditures	Intercept	-376.34	0.0118	-390.84	0.0108	-316.66	0.039
	TPI	0.00254	<.0001	0.00253	<.0001	0.002725	0.000
	COM_IN	0.02267	<.0001	0.01763	0.0002	0.0214086	0.000
	AREA	0.44142	0.0647	0.45435	0.0638	0.3384165	0.168
	CRIMT	0.34855	<.0001	0.36985	<.0001	0.3452421	0.000
	Adj R-Sq	0.9909		0.9906			
Fire expenditures	Intercept	564.67	0.0193	956.99	0.0009	317.93	0.271
	HOWN_VAL	-0.00647	<.0001	-0.009877	<.0001	-0.005236	0.035
	TPI	0.005343	<.0001	0.005393	<.0001	0.0054369	0.000
	AREA	-0.298319	0.1964	-0.459537	0.0432	-0.170711	0.452
	RUR	-1.359042	0.3979	-2.278661	0.1602	-0.068588	0.966
	Log Likelihood	-815		-813			
Park and recreation expenditures	Intercept	-910.19	0.0008	-989.73	0.0002	-534.69	0.020
	TPI	-0.004189	<.0001	-0.004113	<.0001	-0.003446	0.000
	POP_DEPEN	0.059033	<.0001	0.059067	<.0001	0.0533643	0.000
	AREA	0.631638	0.0705	0.570955	0.0906	-0.038223	0.890
	RUR	0.268612	0.9131	1.954812	0.4231	3.502896	0.078
	Log Likelihood	-656		-653			

Table 3.6 (Continued)

Model	Variables	Tobit/OLS		2SLS Tobit		3SLS Tobit	
		estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Public welfare expenditure	Intercept	-208.51	<.0001	-282.12	<.0001	-201.56	0.000
	TPI	-0.003444	<.0001	-0.002613	<.0001	-0.002393	0.000
	INTERGOV	0.163664	<.0001	0.067367	0.0809	0.0693647	0.052
	POOR	0.033084	0.0149	0.105212	0.0003	0.095442	0.001
	Log Likelihood	-712		-741			
Sanitation expenditures	Intercept	-675.44	0.0138	-1760.69	0.0088	-1530.80	0.021
	TPI	-0.02301	<.0001	-0.0788	<.0001	-0.065067	0.000
	HOUSE_OCU	0.1782	<.0001	0.79443	<.0001	0.6644225	0.000
	RUR	2.68817	0.4224	-2.08323	0.7269	-0.976414	0.869
	Adj R-Sq	0.818		0.4714			
Administrative expenditures	Intercept	-243.48	0.2607	-374.19	0.1297	-545.23	0.026
	POP_NUM	0.04677	<.0001	0.05402	<.0001	0.0532219	0.000
	COM_IN	0.03357	<.0001	0.04838	<.0001	0.0449549	0.000
	TPI	-0.01181	<.0001	-0.01573	<.0001	-0.015139	0.000
	AREA	-0.11394	0.7466	0.005	0.9899	0.2979093	0.446
	Adj R-Sq	0.9632		0.9535			
Utility expenditures	Intercept	3152.50	<.0001	2898.51	0.0013	1046.89	0.268
	AREA	-1.893674	0.0368	-3.437693	0.0035	-1.206977	0.325
	EXP_ADM	2.033882	<.0001	3.425481	<.0001	3.0191126	0.000
	COM_IN	0.006925	0.7657	-0.111906	<.0001	-0.098674	0.000
	COM_OUT	-0.196364	<.0001	-0.218619	<.0001	-0.176859	0.000
	RUR	-19.5311	0.0064	-6.229938	0.4394	1.3997577	0.868
	Log Likelihood	-1039		-1023			

Table 3.7 Estimated Parameters of Housing Market Module

Model	Variables	Tobit/OLS		2SLS Tobit		3SLS Tobit	
		estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Renter occupied housing units	Intercept	2236.98	0.0182	4786.05	0.0037	1877.32	0.248
	POP_NUM	0.31431	<.0001	0.32806	<.0001	0.330428	0.000
	HOWN_VAL	-0.06463	<.0001	-0.10442	<.0001	-0.063312	0.009
	TPI	-0.07003	<.0001	-0.07418	<.0001	-0.074966	0.000
	Adj R-Sq	0.9667		0.9298			
Owner occupied housing units	Intercept	-832.43	0.3653	-546.51	0.6248	341.23	0.757
	EMP	0.04959	0.0008	0.04647	0.0021	0.0508762	0.001
	HOWN_VAL	0.0509	0.0002	0.04674	0.0043	0.0334171	0.037
	TPI	0.08759	<.0001	0.08855	<.0001	0.0876856	0.000
	Adj R-Sq	0.9935		0.9931			
Vaccant housing units	Intercept	-3878.51	<.0001	-4450.58	0.0001	-3627.01	0.001
	HOWN_VAL	0.03248	0.0002	0.03856	0.0005	0.0377899	0.001
	RUR	27.36266	0.0002	29.49336	0.0001	19.960204	0.008
	TPI	-0.01718	<.0001	-0.01757	<.0001	-0.015448	0.000
	UNEMP	4.35015	<.0001	4.40169	<.0001	3.9959724	0.000
	Adj R-Sq	0.8366		0.8341			
Median house value	Intercept	-21749.00	0.0567	-22822.00	0.039	-16079.49	0.147
	PCI_VAL	6.0111	<.0001	6.02617	<.0001	5.33962	0.000
	RUR	-138.331	0.0072	-127.254	0.0131	-71.173	0.165
	POOR	0.12963	0.5226	0.10937	0.5238	0.0694507	0.688
	HOUSE_OCU	-0.10702	0.0648	-0.13918	0.0373	-0.059484	0.374
	AMENITY	4774.43	<.0001	4775.14	<.0001	3274.46	0.000
	Adj R-Sq	0.7336		0.7329			

Table 3.8. Impacts Analysis of 1000 Additional jobs for Greene County

Variables	Impacts
Revenue Module	
Total property value ($,000)	13276
Total retail sales ($,000)	5938
Total charges($,000)	233
Intergovernmental revenue($,000)	2317
Other revenue and other taxes($,000)	452
Utility revenue($,000)	3478
Expenditure Module	
Education total($,000)	8679
Health and hospital total expenditure($,000)	857
Transportation total expenditures($,000)	1725
Police, protective inspection, judicial and correction($,000)	129
Fire protection total expenditure($,000)	0
Parks and recreation, total expenditure($,000)	151
Public welfare1 total expenditure($,000)	404
Sewage and solid waste management total expenditure($,000)	1939
General administration total($,000)	660
Utilities total expenditure($,000)	1222
Housing market module	
Total occupied housing units	292
Renter occupied housing units	241
Owner occupied housing units	51
Median house value ($), census data	0.38
Total vacant housing units	-626
Demography and labor market module	
Population	729
School age population (age 5-17)	138
Dependent population(age <17 and >65)	283
Number of people below poverty	255
Labor force	400
Female labor force	142
In-commuters	605
Out-commuters	98
Second jobs	64
Unemployed (BLS)	-157

Appendix I. Variable Definitions and Data Sources

Variables	Variable description	Data source
AMENITY	Amenity index that combines six measure natural amenities such as summer and winter temperature, sunlight, humidity, proportion of land area covered with water bodies, and topography.	USDA, Economic Research Service
AREA	Area in square miles	US Census Bureau, 2000
CEMP	External employment divided by external population	BEA, Regional Economic Accounts
CHARGES	Fees and charges for services	US Census Bureau, Government Census, 1992, 2002
COM_IN	Number of in-commuters divided by population. In-commuters are people who work in a county and live outside of that county.	U.S. Census Bureau, Population Division, Journey-To-Work and Migration Statistics Branch.
COM_OUT	Number of Out-commuters divided by population. Out-commuters are people who live in a county and work outside of that county	U.S. Census Bureau, Population Division, Journey-To-Work and Migration Statistics Branch.
CRIMT	Crime per 100,000 people	USDS, Bureau of Justice Statistics
EMP	Employment. It is comprised of estimates of full-time and part-time jobs by place of work with equal weights.	BEA, Regional Economic Accounts
EXP_ADM	Financial administration and general government expenditure per capita. This variable consists of expenditure related to 1) general government and financial administration, 2) central staff, and 3) interest payment on debt.	US Census Bureau, Government Census, 1992, 2002
EXP_EDU	Expenditure on education. This includes expenses for elementary, secondary, higher education, and other government educational activities together with expenses of running libraries.	US Census Bureau, Government Census, 1992, 2002
EXP_FIR	Fire protection expenditures per capita. It includes the expenses of fire fighting organization, facilities, and auxiliary services	US Census Bureau, Government Census, 1992, 2002
EXP_HLT	Health and hospital total expenditures per capita. Health expenditures include out-patient health services other than hospital care. Hospital expenditures include financing, construction, maintenance and operation of hospital facilities	US Census Bureau, Government Census, 1992, 2002
EXP_POL	Police and judicial expenditures per capita. These include the expenses related to preservation of law and order, traffic safety and correction.	US Census Bureau, Government Census, 1992, 2002
EXP_PRK	Parks and recreation expenditure per capita	US Census Bureau, Government Census, 1992, 2002
EXP_SAN	Sewerage and solid wastes expenditures per capita	US Census Bureau, Government Census, 1992, 2002
EXP_TRN	Transportation expenditures per capita which includes expenditure on construction and maintenance of highways and airports.	US Census Bureau, Government Census, 1992, 2002

EXP_UTL	Utility total expenditures per capita. These include expenses related to water supply, electric power supply, gas supply and the use of mass transit system.	US Census Bureau, Government Census, 1992, 2002
EXP_WEL	Welfare and housing, and public welfare expenditures per capita. These expenditures are related to housing and community development, and public welfare.	US Census Bureau, Government Census, 1992, 2002
HOUSE_OCU	Total housing units per capita	US Census Bureau, 2000
HOUSE_VAC	Vacant housing uits	US Census Bureau, 2000
HOWN_VAL	Median house value in dollar	US Census Bureau, 2000
INTERGOV	Federal and state intergovernmental revenue	US Census Bureau, Government Census, 1992, 2002
JOB2	Second job per capita. Second job= Employment + Out-commuters + Unemployed –Labor force –In-commuters.	Calculated by using BEA, Regional Economic Accounts and Bureau of Labor Statistics data
LF	Labor force per capita. Total labor force divided by population	Bureau of Labor Statistics
LF_F	Women labor force	US Census Bureau, 2000
OWN_OCU	Occupied housing units	US Census Bureau, 2000
PCI_VAL	Property values per capita	Missouri Department of Revenue
POOR	Fraction of population below poverty line	US Census Bureau, 2000
POP_DEPEN	Dependent population(<17 and >65)	US Census Bureau, 2000
POP_NUM	Population	US Census Bureau, 2000
POP_SCH	School age population. Population aged 5 to 17 years.	US Census Bureau, 2000
PVAL	Property values	Missouri Department of Revenue
RENT_OCU	Renter occupied housing units	US Census Bureau, 2000
REV_OTH	Other revenue per capita. It includes amount received from sale of property, rents and royalties, and dividends on investment	US Census Bureau, Government Census, 1992, 2002
REV_UTL	Revenues from utility services per capita. Revenues obtained from water supply, electric power supply, gas supply and the use of mass transit system	US Census Bureau, Government Census, 1992, 2002
RSAL	Retial sales	Missouri Department of Revenue
RUR	Rural dummy. Rural if population is less than 50,000.	USDA, Economic Research Service
UNEMP	Unemployed	Bureau of Labor Statistics
A_EMP	Area times employment	

CHAPTER IV

LOCAL ECONOMIC INTERRELATIONSHIPS IN MISSOURI: A SPATIAL SIMULTANEOUS-EQUATION APPROACH

ABSTRACT

This paper is an extension of the Show Me Community Policy Analysis model for Missouri counties. Using cross-section data for Missouri's counties and adjacent counties in the surrounding states, a spatial lag three-stage least squares model is estimated. We add two new features to the model by including spatial components and expanding the local finance, housing market, and demographic variables. As in many previously estimated community policy analysis models, employment and income drive the model. Our results show significant cross-county interactions within Missouri in terms of the supply of public goods, labor mobility, retail trade, and the choice of residential location. The uniqueness of this study is that the reduced form solution is obtained using a spatial weight matrix. Using the reduced form solution of the model, the economic impacts of the spatial and nonspatial model are compared. The results show that the impact estimates of the nonspatial model are either underestimated or overestimated when we do not take account of the spatial interactions. The impact is disaggregated into two components—one originated with endogenous variable interactions and the other with spatial interactions. The results show that a significant portion of the impact is due to the interactions of endogenous variables. Results appear to be robust across the different spatial arrangements as defined by weight matrices.

4.1. Introduction

Economic forecasting and impact studies are often part of the everyday practices of policy makers at state and local levels. When a new plant locates in a certain county, policy makers are interested in the answers to several questions. What happens to unemployment? What happens to out-commuting and in-commuting? What happens in the housing market? How will local expenditures on police, education, and fire protection be impacted by the changes? And what could happen to property taxes, sales taxes, and other sources of local revenue? Most past research has focused on a single market or at best two (the local finance and labor market) to estimate these impacts. In addition, the current and future fortunes of many local communities are often impacted by changes outside the local area. Therefore, accounting for spatial interactions among neighboring communities is an important addition in this study. As in many past models, the main driving forces of our model are employment and income.

In many instances, incorporating labor market variables and demographic variables together with local finance and housing market variables and accounting for spatial interactions among these variables gives a more accurate picture of a local economy than the analysis of a single, isolated market (Gyourko and Tracy, 1989 1991; Roback, 1982). State policy makers and local leaders have long been involved with forecasting and impact analysis efforts and analyzing their meaningfulness. Consequently, a better understanding of the local economy has become important from county, state, and regional policy perspectives with respect to designing policies that stimulate the local economy on many fronts.

Community policy analysis models such as the Show Me Model (Johnson and Scott, 2006) have been helpful in addressing economic impact related questions. The Virginia Impact Projection (VIP) Model, the first model of its kind developed by Johnson (1991), illustrates how such a model could be used to aid local decision makers. The Iowa Economic/Fiscal Impact Modeling System (Swenson and Otto, 1998), the Idaho model (Cooke and Fox, 1996), an Integrated Economic Impact and Simulation Model for Wisconsin Counties (Shields, 1998), and the Small Area Fiscal Estimation Simulator for Texas (SAFESIM; Evans and Stallmann, 2006) are the examples of other impact models. This paper is a continuation of the Show Me Community Policy Analysis Model project undertaken by Johnson and Scott (2006). Although this model has performed well, it requires updating and important extensions to be of maximum relevance for analytic and policy uses. Therefore, this model is enhanced by adding more categories of local government expenditures and revenues and by adding a housing market component. Using Missouri county data (together with bordering counties in bordering states) from the Census of Government for 2002, a spatial lag three-stage least squares (3SLS) model is estimated. As a system of simultaneous equations, this model recognizes the county-level connection among the labor market, local finance, and housing market variables.

The first component of our model, the local finance component, is subdivided into local revenue and local expenditure. Local revenue consists of two tax-base equations: total property value and total retail sales, intergovernmental revenues, and a utility revenue equation. Likewise, the expenditure portion of the model consists of ten equations: education, health, transportation, police, fire, parks and recreation, welfare, sanitation, general administration, and utilities. The third component of our model is the housing market, which includes total occupied housing units, owner-occupied housing units, renter occupied housing units, and median house value equations. The fourth component of our model is related to demography and includes total population, school-age population, dependent population, and population below the poverty level. The final component of model is the labor market, which consists of seven equations: total labor force, female labor force, in-commuters, out-commuters, the unemployed, and second jobs.

In the following sections, the nature of the spatial economy is discussed and the equilibrium of public finance, the labor market, and the housing market is explained. Next, we define the model and specify the simultaneous system of spatially interrelated equations. This is followed by a review of data and results and a discussion. Then summary of the study and recommendations are presented.

4.2. Research Objectives

The overall objective of this study is to estimate a spatial econometric model for Missouri counties. The specific objective is to add spatial components in the model to account for the spatial interactions.

4.3. Spatial economy

As the first law of geography says, "Everything is related to everything else, but near things are more related than distant things" (Tobler, 1970), neighboring regions have a tremendous economic impact on each other. Employment opportunities created in one region, for example, provide new job options for local unemployed people. Additionally, these employment opportunities may result in increased in-commuters from neighboring regions, reduce the number of local residents who commute to jobs outside the region (out-commuters), or invite migration or new residents to move into the region. Consequently, the local housing market is affected, and the demand and supply for public goods changes as revenue sources (such as property tax, sales tax, and intergovernmental revenues) change. As a generalized example, illustrated in Figure 3.1A, 3.1B, 3.1C, the interactions between two regions (or counties) are showen. The demand and supply relationships in the county and its neighbors are presented in the right and left side of the figure, respectively. Wage, tax, and rent are measured on the vertical axis, and employment, public goods, and housing units are measured on the horizontal axis.

As illustrated in Figure 3.1A, 3.1B, 3.1C, the difference in wages, taxes, and rent in the long run are due to cost of commuting or moving, the level of amenities, and the supply of public goods. In the long run, each region is in equilibrium. If the demand shock is introduced, the county's labor demand curve then shifts to the right and creates new job opportunities. The new job opportunities could be utilized by unemployed residents within the county or by in-commuters or in-migrants from neighboring counties. These changes ultimately impact the labor demand of each of the respective neighboring counties. The story does not end here. Changes in population and commuting patterns impact the demand for housing and then the demand for public goods. This also impacts the local revenue such as property tax, sales tax, and intergovernmental revenue. Therefore, the integrated model contains modules for local government revenue and expenditures, the housing market, demography, and the labor market. Before turning to a discussion of this model, the review of relevant literature is presented focusing exclusively on spatial simultaneous equations.

It has long been a tradition that a spatial model contains either a spatial lag of the dependent variable as a regressor or a disturbance term that is spatially autoregressive. Kelejian and Prucha (1998) formulated mathematical solutions that include both regressors within a simultaneous equation model framework. The same authors, in 2004, developed an estimation framework for a simultaneous system of equations using a two- and three-stage least squares model. These two papers made a breakthrough in spatial econometric estimation.

Following Kelejian and Prucha (2004) and using 417 Appalachian counties' panel data for 1990 and 2000, Gebremariam et al. (2006) estimated a generalized spatial two-stage least squares (2SLS) and a generalized spatial3SLS model to determine the interdependence between small business growth and poverty. Their results show that feedback simultaneity exists between small business and the median household income. Their model successfully accounts for the presence of spatial autoregressive lag simultaneity and spatial cross-regressive lag simultaneity regarding small business and median household income growth rates. This appears to be the first paper that applies Kallejian and Prucha's (2004) estimation method. In the following section, the theoretical background for the following modules is highlighted.

4.3.1 Local public expenditures and revenue

Provision of public goods is very different from private goods due to several factors. First, residents cannot be excluded from many goods and facilities. This creates "free riders" in the economy. Second, investments for public goods are large relative to the population served, and, as a result, competition among private firms is nonexistent.

Finally, public goods facilities are subject to diminishing costs. Therefore, maintenance of a natural monopoly by the government is reasonable.

Following Johnson et al. (1988) and Beaton (1983), a theoretical framework of public goods supply and demand is presented. In this framework, county residents demand both private and public goods. Public goods are financed collectively with taxes; hence, taxes are considered to be the price. Unlike aggregate demand for private goods, which is summed horizontally, demand for public goods is summed vertically because individuals will pay different prices (i.e., tax) to consume the same quantity of public goods. Let *G* be the level of public goods demanded by *n* individual. Total cost and average cost of aggregate demand is the function level of public goods *G*.

$$TC = f(G)$$

$$AC = g(G)$$

Because G is indivisible and jointly determined, each constituent consumes the entire production level, which is

$$G = G_i = G_j$$

Assuming a local government balances its budget to equate revenues with expenditures, the sum of the taxes will equal the total cost of producing *G*, that is,

$$\sum_n T_i = AC \times G$$

T_i is the tax paid by the *i*th individual. From above, $T_i = AC \times G \times t_i$ where t_i is the *i*th individual's share of taxes ($\sum_n t_i = 1$)

Applying the constrained optimization rule to an individual's utility function

$$U_i = u_i(X_i, G_i) \quad (1)$$

subject to the budget constraint

$$Y_i = PX_i + T_i \tag{2}$$

yields the first-order conditions:

$$u_x - \lambda P = 0$$

$$u_G - \lambda t(AC + G * \partial AC / \partial G) = 0$$

$$Y - PX - ACGt = 0 \tag{3}$$

where X_i is the private good consumed by the *i*th individual, Y_i is the income of the *i*th individual, and *P* is the price of private good *X*.

The above conditions lead to an optimizing condition:

$$MRS_{GX} = t(AC + G * \partial AC / \partial G) / P \tag{4}$$

and demand function, $G = f(AC, t, P, Y)$ (5)

Population as a function of the demand for public goods enters into the equation through an average cost term. However, we included only population, income, input conditions variables as explanatory variables to make the model parsimonious.

The main sources of local government revenue are property value, retail sales, and other government charges. Therefore, local policy makers are concerned with local tax bases. One of the binding factors for Missouri is that state law requires city and county governments to balance their budgets. Therefore, theoretically it is not suitable to model the local revenue, especially property tax and sales tax, which are often structured in accounting terms. Therefore, we model the tax base, not the tax revenue. Together with tax base, intergovernmental revenues and other revenues are retained in the equation.

4.3.2 The Local labor market and the housing market

Following Johnson (2006), the formal analysis is begun by assuming equilibrium in the labor market where $X_D = X_S$, where X_D is the labor demand in terms of local employment and X_S is the labor supply in terms of employed labor force from all locations. Labor demand for a profit maximizing form is a function of wage (*w*), population (*P*), and number of firms (*N*).

$$X_D = f(w, P, N)$$

Assuming equilibrium employment, an inverse labor demand function is derived from the above equation as: $w = g(EMP^*, P, N)$

Similarly, labor supply is equal to labor force (*LF*) minus the unemployed (*UEMP*) and out-commuters (*COM_OUT*) plus the in-commuters (*COM_IN*).

$$X_S = LF - UEMP - COMOUT + COMIN$$
$$LF = f_L(wage, Z_{LF}) = f_L(g(X_D), Z_{LF})$$
$$COMOUT = f_{OUT}(wage, Z_{OUT}) = f_{OUT}(g(X_D), Z_{OUT})$$
$$COMIN = f_{IN}(wage, Z_{IN}) = f_{IN}(g(X_D), Z_{IN})$$

where *Zs* are the supply shifters. From the above equations, the following identity can be derived.

Unemployed = Labor force + In-commuters – Employment – Out-commuters

The three components of labor supply (labor force, out-commuters, and in-commuters) are a function of employment in this set-up. The definition of second jobs is used as suggested by Johnson (2006) as follows:

Second jobs = Employment + Out-commuters + Unemployed – Labor force – In-commuters.

The housing market can also be modeled as consumers' utility maximization framework. Because population adds dynamics in our model, housing demand is also explained by population. To make the model simple, total occupied housing units is defined as the equilibrium demand for housing as a function of population and employment only, and owner-occupied housing units as the function of employment and total personal income.

4.4. The Model

To begin with, a single-equation spatial econometric model is introduced that is commonly used in economics and other fields. Then the features of a simultaneous system of equations are added. The general specification of the single equation is $Y = \lambda WY + X\beta + \varepsilon$ where $\varepsilon = \rho W\varepsilon + u$ (Anselin, 1988). *Y* is a column vector of observations on a dependent variable; *X* is a vector of explanatory variables that are assumed to be uncorrelated with error terms; *W* is a contiguity weight matrix; *λ* and *ρ* are spatial lag and spatial error parameters to be estimated; *β* is the column vector parameters of explanatory variables; and *u* is an independent and identically distributed error term. *ε* is a spatial error term that can be solved as $\varepsilon = (I - \rho W)^{-1}u$. Spatial dependence has two sources: Error terms and dependent variables may both be correlated across space. When formal test is conducted for the presence of spatial dependence, the indications of spatial dependence are obtained. Table 4.1 shows that Moran's I estimate of each dependent variable and residual from ordinary least squares (OLS), which indicates the presence of spatial autocorrelation in our data. For the sake of analytical simplicity and model parsimony, we chose a spatial lag model for this study. It is assumed that this is consistent with the regional dependence of the spatial process whereby nearby areas are used to explain the public finance, labor market, housing market, and demography variables.

To account for the spatial simultaneity, we follow Anselin (1988) and Kelejian and Prucha (2004). We specify our model as a spatial lag 3SLS. A 3SLS procedure accounts for two factors. First, it takes care of the simultaneity bias which arises in simultaneous system of equation model when a dependent variable is correlated with another equation's error term. Second, it allows correlated errors between equations which improved the efficiency of the parameter estimates. The model is specified as follows:

$$Y_n = Y_n B + X_n C + \bar{Y}_n A + U_n \qquad (1)$$

$$Y_n = (y_{1,n},\ldots\ldots, y_{m,n}),\ X_n = (x_{1,n},\ldots\ldots x_{k,n}),\ U_n = (u_{1,n},\ldots\ldots, u_{m,n}),\ \bar{Y} = (\bar{y}_{1,n},\ldots\ldots, \bar{y}_{m,n})$$

$$\bar{y}_{j,n} = W_n y_{j,n} \quad j = 1,\ldots\ldots, m \qquad \bar{y}_{ij,n} = \sum_{r=1}^{n} w_{ir,n} y_{rj,n.}$$

where $y_{j,n}$ is the $n\times 1$ vector of cross-sectional observations on the dependent variable; $x_{l,n}$ is the $n\times 1$ vector of cross-sectional observations on the *l*th exogenous variable; $\bar{y}_{j,n}$ is the spatial lag of $y_{j,n,}$; $u_{1,n}$ is the $n\times 1$ disturbance vector of in the *j*th equation; W_n is an $n\times n$ queen row normalized weight matrix; and *B*, *C, A* are parameter matrices of mxm, kxm, and mxm corresponding variables, respectively; and $u_{j,n}$ denotes the column vector of independent and identically distributed error terms.

The first step in the estimation process consists of the estimation of the model parameter vector β_j in a single-equation spatial econometric model by 2SLS using all exogenous variables, their spatial lag values, and the twice spatially lagged exogenous variables (i.e. $X_n, WX_n, W^2 X_n$) as instruments. These instruments are employment, per capita income, external employment, area, their spatial lags, and twice their spatial lags. Up to this point, our model accounts for the potential spatial correlation, but it does not take into account the potential cross-equation correlation in the error term. To account for this, it is helpful to stack the equations as

$$y_n = Z_n \delta + \varepsilon_n \tag{2}$$

where $y_n = (y_{1,n},....,y_{m,n})'$,

$Z_n = diag_{j=1}^{m}(Z_{j,n})$; and $\delta = (\delta_1^{'},.....,\delta_m^{'})'$

It is assumed that $E\varepsilon_n = 0$ and $E\varepsilon_n\varepsilon_n^{'} = \Sigma \otimes I_n$. If Σ is known, a natural system of instrumental variables estimator of δ would be

$$\breve{\delta}_n = [\hat{Z}_n(\Sigma^{-1} \otimes I_n)(\hat{Z}_n]^{-1}\hat{Z}_n(\Sigma^{-1} \otimes I_n)y_n \tag{3}$$

Where $\hat{Z}_n = diag_{j=1}^{m}(\hat{Z}_{j,n})$ and $\hat{Z}_{j,n} = P_H Z_{j,n}^{*}$

To estimate equation (3), the estimators for Σ is needed. The consistent estimator of Σ is $\hat{\Sigma}_n$ where $\hat{\Sigma}_n$ is estimated as a $m \times m$ matrix whose (j,l) th element is $\hat{\sigma}_{jl,n} = n^{-1}\tilde{\varepsilon}_{j,n}\tilde{\varepsilon}_{l,n}$

and $\tilde{\varepsilon}_{j,n} = y_{j,n} - Z_{j,n}\hat{\delta}_{j,n}$. (4)

Replacing the value consistent estimator in equation (3), a spatial lag 3SLS estimator is obtained which is as follows:

$$\breve{\delta}_{3SLS} = [\hat{Z}_n(\hat{\Sigma}^{-1} \otimes I_n)(\hat{Z}_n)]^{-1}\hat{Z}_n(\hat{\Sigma}^{-1} \otimes I_n)y_n \tag{5}$$

with, as a variance matrix: $\text{var}(\breve{\delta}_{3SLS}) = [\hat{Z}_n(\hat{\Sigma}^{-1} \otimes I_n)(\hat{Z}_n)]^{-1}$

The details of the dependent, explanatory endogenous, and exogenous variables used in the structural equation are given in Table 4.2. The expected signs are presented in parentheses for each explanatory variable. As discussed earlier, the model contains 32 structural equations; each equation contains the following general form with a spatial dependent lag and an independent and identically distributed error term:

$$Y_k = a_{k,0} + \lambda_k \overline{Y}_k^N + \sum_{j=1}^{J} \beta_{k,j} Z_{k,j} + \varepsilon_k \qquad (6)$$

where k =1 to 32; N is the number of contiguous neighboring counties; and j is the number of explanatory variables included in an equation.

4.5. Data

County-level data is used in this study. All types of government data are combined within a county. These are county, municipal, township, special district, and school district. The basic data are for 115 counties from Missouri and 55 from bordering counties in surrounding states for 2000 and 2002. Most of the data were obtained from the U.S. Census Bureau and the U.S. Department of Commerce, Bureau of Economic Analysis. Revenue and expenditure of data were obtained from the Census of Government, and housing and population data were obtained from a decennial census of population conducted by the U.S. Census Bureau. The details of variables and their sources are presented in Appendix I, and the descriptive statistics for the variables in the model are presented in Table 4.3A and Table 4.3B. The expenditure and revenue values are calculated as 2002 real dollar.

4.6. Empirical estimation and results

As defined in the previous section, a spatial lag 3SLS procedure is used to estimate the model that consists of 32 equations. The instruments are used in model as suggested by Kelejian and Prucha (2004). These instruments are exogenous variables (employment, per-capita personal income, external employment, and area), their spatial lag values, and twice their spatially lagged values. A spatial lag model is estimated using OLS, 2SLS, and 3SLS procedures. Some of the expenditures and utility revenues are zeros because some counties do not have such services or revenue sources. This suggests that the distribution of the dependent variables and thus the error terms may not be normal. The typical solution for non-normal distribution is the Tobit procedure. However, to estimate a reduced form for a spatial Tobit model we would have to adopt an unbalanced simultaneous equation[3] approach which is arduously difficult to implement. Therefore, I chose to use zeros as such in the model. This may results in somewhat biased parameter estimates toward zero. Tables 4.4, 4.5, 4.6, 4.7, and 4.8 present the parameter estimates and their significance by OLS, 2SLS, and 3SLS procedures. Overall the signs of the parameter estimates appeared to be robust; however, the magnitudes of these estimates varied across the different estimation procedures used. Excluding intercept terms, altogether 22 out of 119 estimates either flipped their signs or changed their significance level.

The coefficient of determination values (R^2) in the 2SLS procedure are higher than 0.70 for 27 out of 32 equations. This indicates that the model has a reasonably high level of explanatory power. The equations with poor coefficients of determination are health expenditures, utility revenue and expenditures, and total charges. This may be due to the erratic nature of county data used in model estimation.

Out of the 32 spatially lagged endogenous variables, 23 appear to be significant (Table 4.9). This suggests that there are strong interactions among the neighboring counties. The negative spatial autocorrelation are found to be significant in property

[3] Schmidt (1977) examines several methodologies for estimating a seemingly unrelated regression model with unbalanced data.

value, retail establishments, finance, insurance and real estate establishments, and expenditures on transportation, fire protection, parks and recreation, and public welfare. The negative spatial autocorrelation is also found to be significant in the labor market variables including labor force, women labor force, out-commuters, and second jobs. The positive spatial autocorrelation is significant in the variables of total charges, intergovernmental revenue, utility revenue, expenditures on education, health and hospital, sewer and solid waste, general administration, and utilities. Other equations that have strong spatial dependence are total occupied housing units, owner-occupied housing units, median house value, population, school-age population, and in-commuters.

Equation-by-equation analysis will not be undertaken because interest here is not in each equation, rather in overall performance of the model. Although the model utilized six exogenous variables, total personal income and employment are the major driving forces in our model. The main revenue sources at the local level are property tax, sales tax, other taxes, intergovernmental revenue, charges, and utility revenues. Model is allowed to be flexible so that the policy maker at the local level can choose tax rates to maintain a balanced budget. Therefore, tax base is modeled (i.e., property value and retail sales) rather than tax revenue. The revenue module of the model performs reasonably well. Parameter estimates support many of the hypotheses. As expected, income and employment variables are found to be significant in explaining revenue sources or revenue bases (Table 4.4). In the case of intergovernmental revenue, both total personal income and property value are found to be negative and significant. It is reasonable that the lower the total personal income of area, the greater the chance of receiving aid. The significance spatial lag of property value, total charges, and intergovernmental revenue indicates that spatial interactions exist among Missouri counties. However, this interaction could originate from any source such as tax competition or informational externalities among neighboring counties (i.e., yardstick competition; Basley and Case, 1995).

In general, expenditure equations are a function of total personal income, employment, population, area, in- and out-commuting, and property values (Table 4.5). In modeling expenditures, it is hypothesized that more affluent counties demand a higher level and quality of pubic goods. Surprisingly, total personal income is found to be negative and significant in many expenditure equations. However, other ability-to-pay variables such as property value and employment are found to be significant in explaining different expenditure equations. As expected, population is consistently and positively significant in most cases. Also as expected, in-commuters in health services, police and protective services, and out-commuters in transportation services impact positively and significantly. The area variable in most equations is significant and positive.

There are three housing market equations in the system (Table 4.6): total occupied housing units, owner-occupied housing units, and median house value. Total occupied housing units is estimated as a function of the spatial lag of itself, population, and employment. An increase in employment and population leads to increased total occupied housing units. Owner-occupied housing units is estimated as a function of total personal income and employment. As expected, these two explanatory variables are found to be significant and positive. This implies that more affluent communities generally own houses rather than rent; which is logical. The last equation in the housing market module is median house value, which is estimated as a function of the spatial lag of itself, total business establishments, population below poverty, and per capita income. As expected, all the coefficients have the right signs. Because all spatial lags of the housing market equation are significant and positive, we can safely conclude that there is a positive spatial spillover effect in housing. A community with good housing leads to good housing in its neighborhood and vice versa.

Although the demographic and labor market variables are intricately linked, for convenience they are broken apart into two separate modules. The four equations in the demographic module are population, school-age population, dependent population, and below poverty population (Table 4.7). Population is estimated as a function of its spatial lag and labor force. Both the explanatory variables are found to be positive and significant. Positive spatial lag implies that counties with larger population areas are likely to be adjoined by similar counties.

School-age population is estimated as a function of the spatial lag of itself and population. Both explanatory variables are significant and positive. Dependent population is estimated as a function of the spatial lag of itself and population. Only population is found to be positive and significant. Population below poverty is modeled as a function of total personal income and dependent population. Both explanatory variables have expected signs. This implies that poverty is a function of both income and employment. The negative sign of the spatial lag coefficient implies that poverty exists in the midst of affluence.

The labor market module is the final module of our model. It contains five equations: labor force, female labor force, in-commuters, out-commuters, and second jobs (Table 4.8). Labor force is estimated as a function of the spatial lag of itself, employment, area, area × employment, and external employment. The variable area × employment is also called as expansion variable which captures the structural changes that are caused by the different sizes of counties. As expected, employment and external employment are positive and significant. This implies that more employment opportunities in resident and neighboring counties leads to more people in the labor force. A negative spatial lag value indicates that the counties with more people in the labor force will be surrounded by counties with fewer. The coefficient of the area variable is negative and area × employment is positive. Although it is expected that as counties' area increase, labor force decreases, for larger counties the area variable increases the marginal effect of employment on labor force.

Female labor force is estimated as a function of the spatial lag of itself, population, and labor force. As expected, both the population and labor force variables are significant and positive. However, the spatial lag of female labor force is negative and significant. This implies that counties that have a larger female labor force are surrounded by counties with a smaller female labor force. Both in- and out-commuters are modeled as a function of their spatial lags, employment, area, area × employment, and external employment. All coefficients have the expected signs. The second jobs equation is estimated as a function of its spatial lag, total personal income, female labor force, and employment. Empirical results show that spatial lag is negative and significant. The total personal income and employment variables are positive and significant. This implies that more affluent areas with more employment opportunities create opportunities for second jobs.

Both the contiguity-based spatial weight matrix and gravity-based spatial matrix were used; however, the estimated results are based on a contiguity-based matrix. Overall, our results appear to be robust across different spatial linkages (Table 4.10). Altogether 23 out of 32 spatial lag equations are found to be significant when we used a uniform spatial weight matrix. A total of 22 spatial lag variables appear to be significant when gravity type I[4] weight matrix was used, whereas 20 spatial lag variables are significant when gravity type II weight matrix was used. It appears that the gravity type II weight matrix is stricter than the other matrices. Spatial lags of sewer and solid waste management expenditures and utility expenditures are found to be significant with both uniform and gravity type I matrices, whereas these are not significant with the gravity type II matrix. Unlike these two variables, the spatial lag of female labor force is significant with both the gravity matrices; however, it is not significant with the uniform matrix. This suggests that analytical results may be sensitive to the specification of spatial weight matrix.

4.7. Reduced Form Solution

The estimation of reduced form coefficients is an important step for impact analysis and forecasting. When all exogenous variables are allowed to filter through the entire system, reduced form equations that are different from the structural model estimates are obtained. However, solving spatial structural equations requires some extra steps. Let

$$Y_n = Y_n B + X_n C + \bar{Y}_n A + U_n \tag{1}$$

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[4] Gravity type I = weight divided by distance; gravity type II = weight divided by distance squared

$Y_n = (y_{1,n},....., y_{m,n})$, $X_n = (x_{1,n},....x_{k,n})$, $U_n = (u_{1,n},....,u_{m,n})$, $\bar{Y} = (\bar{y}_{1,n},...., \bar{y}_{m,n})$

$\bar{y}_{j,n} = W_n y_{j,n} \quad j = 1,....,m \qquad \bar{y}_{ij,n} = \sum_{r=1}^{n} w_{ir,n} y_{rj,n.}$

where *n* is regions, *m* is the endogenous variable, and *k* is the exogenous variable. The dimension of the coefficient is as follows: $B_{(m\times m)}$, $C_{(k\times m)}$, $A_{(m\times m)}$

$$y_n = vec(Y_n) = \begin{pmatrix} y_{1,n} \\ \vdots \\ \vdots \\ y_{m,n} \end{pmatrix} \qquad x_n = vec(X_n) = \begin{pmatrix} x_{1,n} \\ \vdots \\ \vdots \\ x_{k,n} \end{pmatrix}$$

If A_1 and A_2 are conformable matrices, then $vec(A_1 A_2) = (A_2' \otimes I)vec(A_1)$ (Berck et al., 1993).

Following this rule, the reduced form solution of equation (1) would be as follows.

$$y_n = \left[(B'\otimes I_n) + (A'\otimes W_n)\right]y_n + (C'\otimes I_n)x_n \qquad (7)$$

$$y_n = \left\{(I_m \otimes I_n) - [(B'\otimes I_n) + (A'\otimes W_n)]\right\}^{-1}(C'\otimes I_n)x_n \qquad (8)$$

The dimension of the coefficient matrices are as follows:

$$B'_{(m\times m)} = \begin{bmatrix} 0 & \beta_{12} & \cdots\cdots & \beta_{1m} \\ \beta_{21} & 0 & & \vdots \\ \vdots & & \ddots & \vdots \\ \vdots & & \ddots & \vdots \\ \beta_{m1} & \cdots & \beta_{m,m-1} & 0 \end{bmatrix} \qquad A'_{m\times m} = \begin{bmatrix} \lambda_1 & 0 & \cdots & 0 \\ 0 & \lambda_2 & & 0 \\ \vdots & & \ddots & \vdots \\ 0 & \cdots & \cdots\ 0 & \lambda_m \end{bmatrix}$$

when only the dependent variable have spatial lag then, $B'A' = A'B' = 0$

$$\left[(B'\otimes I_n) + (A'\otimes W_n)\right]^2 = (B'^2 \otimes I_n) + (B'A'\otimes W_n) + (A'B'\otimes W_n) + (A'^2 \otimes W_n^2)$$

$= (B'^2 \otimes I_n) + (A'^2 \otimes W_n^2)$ all cross-product terms are zero so that, in general,

$$[(B'\otimes I_n) + (A'\otimes W_n)]^i = (B'^i \otimes I_n) + (A'^i \otimes W_n^i)$$

Equation (8) has the form of $(I - D)^{-1} = I + D + D^2 + D^3 + ...$

Finally, we[5] can disaggregate the solution into initial effect, endogenous equations interactions effect, and spatial interactions effect.

$$\{(I_m \otimes I_n) - [(B' \otimes I_n) + (A' \otimes W_n)]\}^{-1} = (I_m \otimes I_n) + \sum_{i=1}^{\infty} (B'^i \otimes I_n) + \sum_{i=1}^{\infty} (A'^i \otimes W_n^i)$$

(9)

where $(I_m \otimes I_n)$ measures the initial effect, $\sum_{i=1}^{\infty} (B'^i \otimes I_n)$ measures the endogenous variable interactions, and $\sum_{i=1}^{\infty} (A'^i \otimes W_n^i)$ measures the spatial interactions. The matrix in equation (8) was tried to invert , but the normal capacity of the SAS IML procedure did not allow to so. Therefore, the equation (8) has been broken apart and solved for each component for up to six iterations. The values of the Kronecker product of parameter estimates and identity matrix became insignificant after the third iteration. The reduced form solution is a huge matrix (i.e., 5440×5440) to present in a table. However, the impacts of each component are discussed in following section.

4.8. Impacts Estimation

This study is unique in the sense that it solves for the reduced form solution. As showed in the previous section, the reduced form solution can disaggregate into two components: spatial interactions and endogenous variables interactions. Although there are six exogenous variables in the model, employment is one of the main driving forces for all sectors of the economy. Changes in employment lead to increases in population and wage levels, which ultimately alter the demands for public services and the revenue available to fund these services. To demonstrate how the model works, and to determine

[5] Dr. Dennis Robinson with the help of Kelegian and Prucha (2004) developed this solution.

the reasonable estimate of the impact, a 1,000-job increase was hypothesized in Greene County, Missouri. Using the reduced form solution of our model, the impacts of an employment change were estimated on the Greene County economy. Change in employment also changes the external employment for other counties and affects the expansion variable area × employment. After accounting for these changes, the impact of 1,000 new jobs was estimated using the reduced form solution of the spatial lag simultaneous equation model as described in the previous chapter. It is found that a significant portion of the impact resulted from endogenous variable interactions. Both positive and negative impacts that are created are accounted for separately to reveal the values to be cancelled. An additional 1,000 job opportunities created in Greene County impacted 88 counties out of 170 counties; the significant impact is estimated for 7 surrounding counties. For purposes of comparison and to demonstrate the efficacy of our spatial model, a nonspatial simultaneous equation version of the model was also estimated. This study compares the impacts of 1,000 new jobs in Green County using both the spatial and the nonspatial versions of the simultaneous equation model**.**

Table 4.11A and 4.11B present the impact estimates for Greene County and its neighbors. The additional job creation caused an increase in local revenue of $5.1 million and an increase in expenditure of $9.7 million, assuming a constant property tax rate (i.e., 4.6% of property value) and sales tax rate (i.e., 2.82% of retail sale). The creation of new jobs caused an increase of :

- $11 million in retail sales;
- $3.6 million in property value;
- $89,000 in total charges;

- $166,000 in property tax;
- $315,000 in sales tax;
- $3.1 million in local public expenditure on education;
- 562 total occupied housing units;
- 1,438 in population;
- 204 in-commuters and 188 out-commuters

The only decrease was in second jobs, which fell by 41. Our results show that the impact estimates are sensitive to the choice of estimation procedures (Table 4.11B). The variables that are highly sensitive between the spatial and nonspatial model are property value, median house value, total charges, and revenues other than property tax and sales tax. The variables retail sales, business establishments, intergovernmental revenues, education expenditures, and owner-occupied housing units are insensitive to the use of the spatial lag of dependent variables; labor market and demographic variables are moderately sensitive. The impact estimates of the nonspatial model are 20% or higher than the impacts estimated by the spatial model for six dependent variables (total charges, welfare expenditure, sewage and solid waste expenditure, labor force, and second jobs). Impact estimates of the spatial model are slightly higher than those of the nonspatial model for 19 dependent variables. Impact estimate differences of 23 variables are more than 13%. This implies that a spatial spillover effect exists among Missouri counties. It also implies that the nonspatial model either overestimates or underestimates the impacts because it ignores the spatial dependence of variables.

4.9. Summary and Conclusion

A simultaneous spatial econometric model consisting of 32 structural equations was estimated. Although the model was estimated as a system of equations, the model consisted of five modules—local revenues, local public expenditures, housing market, demography, and local labor market. Most of the spatial lags are significantly associated with the county value indicating strong spatial spillover in local revenues, local expenditures, housing market, demography, and labor market variables. These spillovers may exist due to strategic interactions among neighboring counties, or they may be due to a common shock. This study is unique in the sense that it provides the reduced form solution originated from endogenous variables' interactions and spatial interactions. To test the model performance, the impact of 1,000 new jobs created in Green County, Missouri was estimated. The model predicts that $5.1 million in local revenue would be collected; however, an additional $9.7 million is needed to finance the additional supply of education and other local public goods. The impacts estimated from the spatial and nonspatial model do not correspond closely; the spatial model better captures the local interrelationships and estimates economic impacts more accurately. The results indicate that the parameter estimates are robust across the spatial linkages.

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Table 4.1. Test for Spatial Dependence Using Moran's I Test

Variables	Moran's I of dependent variables	Moran's I - OLS residual
Revenue Module		
Property value	0.3255671	0.349828
Retail sales	0.3539254	-0.06481
Total business establishments	0.3976276	-0.05324
Retail establishment	0.4270096	-0.03449
Finance, insurance and real estate establishment	0.3305883	0.17098
Service establishment	0.3858481	-0.10872
Total charges	0.4156909	-0.1157
State and federal intergovernmental revenue	0.5645268	-0.19457
Other revenue and other taxes	0.2917682	0.014201
Utility revenue	0.2259471	0.090751
Expenditure Module		
Education expenditure	0.468323	0.245267
Health and hospital total expenditure	0.1731646	0.059696
Transportation total expenditures	0.3578303	-0.00194
Police, protective inspection, judicial and correction	0.4086772	-0.18249
Fire protection total expenditure	0.3059821	-0.10071
Parks and recreation, total expenditure	0.2241186	0.12208
Public welfare1 total expenditure	0.3835364	-0.08255
Sewer and solid waste management total expenditure	0.2533515	-0.25607
General administration total	0.4979954	-0.17051
Utilities total expenditure	0.2649894	-0.37329
Housing Market Module		
Total occupied housing units	0.4825346	-0.23998
Owner occupied housing units	0.4621138	-0.12996
Median house value	0.9515646	0.390286
Demography Module		
Population	0.4935727	0.032495
School age population	0.5160054	-0.09897
Dependent population	0.5070146	0.212211
Number of people below poverty	0.5202968	-0.01354
Labor Market Module		
Labor force (BLS)	0.4621391	-0.01596
Civilian labor force Female	0.4621237	0.32097
In-commuters	0.3694321	-0.52277
Out-commuters	0.570635	-0.0215
Second jobs	0.2442859	0.166653

Table 4.2. Spatial Simultaneous Model Equations: Variable Specifications

Dependent Variables	Endogenous Explanatory Variable	Exogenous Explanatory Variables
Revenue Module		
Property Value Total	WPVAL(±) COM_OUT(+)	TPI(+) EMP(+)
Retail Sales total	WRSAL(-) COM_IN(+)	TPI(+) EMP(+)
Total business establishments	WTOT_EST(-)	TPI(+) EMP(+) AREA(+)
Retail establishment	WRETAIL_EST(-)	TPI(+) EMP(+)
Finance, insurance and real estate establishment	WFIRE_EST(-)	TPI(+) EMP(+)
Service establishment	WSERV_EST(±)	TPI(+) EMP(+) AREA(+)
Total charges	WCHARGES(±) OWN_OCU	TPI(+)
Intergovernmental revenue	WINTERGOV(±) PVAL(-)	TPI(-) EMP(±)
Other revenue and other taxes	WREV_OTH(±) PVAL(+)	
Utility revenue	WREV_UTL(±)	TPI(+) EMP(+)
Expenditure Module		
Education expenditure	WEXP_EDU(±) POP_SCH(+)	TPI(+) EMP(+) PVAL(+)
Health and hospital expenditure	WEXP_HLT(±) POP_NUM(+) COM_IN(+) INTERGOV(+)	TPI(±) EMP(±)
Transportation expenditures	WEXP_TRN(±) COM_OUT(±)	EMP(+) AREA(+)
Police, protective inspection, judicial and correction	WEXP_POL(±) COM_IN	TPI(+) AREA(±)
Fire protection expenditure	WEXP_FIR(±) PVAL(+) RSAL(+), POP_NUM(-)	TPI(+) AREA(+)
Parks and recreation, total expenditure	WEXP_PRK(-) POP_DEPEN	TPI(+) AREA(+)
Public welfare total expenditure	WEXP_WEL(±) POP_DEPEN(+) INTERGOV(+)	TPI(-)
Sewer and solid waste management total expenditure	WEXP_SAN(±) HOUSE_OCU(+)	TPI(+)
General administration total	WEXP_ADM(±)	TPI(+) EMP(+) AREA(+)
Utilities total expenditure	WEXP_UTL(±) POP_NUM(+)	EMP(+)
Housing Market Module		
Total occupied housing units	WHOUSE_OCU(±) POP_NUM(+)	EMP(+)
Owner occupied housing units	WOWN_OCU(±)	TPI(+) EMP(+)
Median house value	WHOWN_VAL(±) TOT_EST(+) POOR(-)	PCI(+)
Demography Module		
Population	WPOP_NUM(±) LF(+)	
School age population	WPOP_SCH(±) POP_NUM(+)	
Dependent population	WPOP_DEPEN(±) POP_NUM(+)	
Number of people below poverty	WPOOR(±) POP_DEPEN(+)	TPI(-)
Labor Market Module		
Labor force (BLS)	WLF(±)	EMP(+) AREA(+), A_EMP(±) CEMP(+)
Civilian female labor force	WLF_F(±) POP_NUM(+) LF(+)	
In-commuters	WCOM_IN(±)	EMP(+) AREA(-), A_EMP(±) CEMP(-)
Out-commuters	WCOM_OUT(±) LF(+)	EMP(-) AREA(-), A_EMP(±) CEMP(-)
Second jobs	WJOB2(±) LF_F(+)	TPI(±) EMP(±)

Table 4.3A Descriptive Statistics of Variables Used in the Model

Variable	Label	Mean	Std Dev	Minimum	Maximum
PVAL	Property Value Total(0,000)	50009	148449	7	1706209
RSAL	Retail Sales total (0,000)	47333	139452	795	1501274
TOT_EST	Total business establishments	1106	2966	61	29804
RETAIL_EST	Retail establishment	236	569	4	6668
FIRE_EST	Finance, insurance and real estate establishment	107	333	3	3611
SERV_EST	Service establishment	437	1284	15	14452
CHARGES	Total charges(0,000)	1672	4392	34	39542
INTERGOV	State and federal intergovernmental revenue(0,000)	3992	9570	219	78744
REV_OTH	Other revenue and other taxes(0,000)	1345	5570	18	60221
REV_UTL	Utility revenue(0,000)	1073	2999	0	29736
EXP_EDU	Education total(0,000)	5801	15664	237	159538
EXP_HLT	Health and hospital total expenditure(0,000)	706	2252	0	33182
EXP_TRN	Transportation total expenditures(0,000)	906	3001	16	32371
EXP_POL	Police, protective inspection, judicial and correction(0,000)	879	3077	4	26091
EXP_FIR	Fire protection total expenditure(0,000)	317	1294	0	14456
EXP_PRK	Parks and recreation, total expenditure(0,000)	262	1204	0	12084
EXP_WEL	Public welfare1 total expenditure(0,000)	320	1093	0	11646
EXP_SAN	Sewerage and solid waste management total expenditure(0,000)	459	1834	0	23598
EXP_ADM	General administration total(0,000)	896	2555	21	19954
EXP_UTL	Utilities total expenditure(0,000)	1232	3581	0	33228
HOUSE_OCU	Total occupied housing units	17421	41337	1009	404312
OWN_OCU	Owner occupied housing units	12165	28575	773	299670
HOWN_VAL	Median house value ($), census data	61146	22135	20645	156812
POP_NUM	Population 2000 (census)	45029	105313	2382	1016315
POP_SCH	School age population (age 5-17)	8454	19523	410	192093
POP_DEPEN	Dependent population <17 and >65	17821	40401	1113	399476
POOR	Number of people below poverty	5658	11251	341	97585
LF	Labor force (BLS)	23162	57366	1003	563110
LF_F	Civilian labor force Female	10430	26394	431	258337
COM_IN	In-commuters	6517	24651	31	217140
COM_OUT	Out-commuters	6526	16696	189	162772
JOB2	second jobs	4445	14178	0	159724
TPI	Total personal income (0,000)	103348	311461	3695	3502488
UNEMP	Unemployed (BLS)	1066	2377	41	23755
RENT_OCU	Renter occupied housing units	5256	13544	236	104642
EMP	Employment	26522	75785	1255	787265
CEMP	External employment	148701	228599	11096	1338960
PCI_VAL	Per capita personal income	18438	3328	11656	38976

[a]$N = 170$

Table 4.3B Descriptive Statistics of Spatially Lagged Variables

Variables	Label	Mean	Std Dev	Minimum	Maximum
WPVAL	Property Value Total(0,000)	52986	89539	5929	741896
WRSAL	Retail Sales total (0,000)	52623	89884	2960	678883
WTOT_EST	Total business establishments	1207	1921	138	13644
WRETAIL_EST	Retail establishment	257	376	29	3184
WFIRE_EST	Finance, insurance and real estate establishment	118	208	9	1593
WSERV_EST	Service establishment	479	836	36	6609
WCHARGES	Total charges(0,000)	1698	2575	107	16406
WINTERGOV	State and federal intergovernmental revenue(0,000)	4145	6577	571	50515
WREV_OTH	Other revenue and other taxes(0,000)	1425	3120	60	18249
WREV_UTL	Utility revenue(0,000)	1091	1412	30	6990
WEXP_EDU	Education total(0,000)	6286	10612	653	80143
WEXP_HLT	Health and hospital total expenditure(0,000)	738	1114	13	9746
WEXP_TRN	Transportation total expenditures(0,000)	953	1749	74	14080
WEXP_POL	Police, protective inspection, judicial and correction(0,000)	942	1933	41	13430
WEXP_FIR	Fire protection total expenditure(0,000)	360	811	3	5980
WEXP_PRK	Parks and recreation, total expenditure(0,000)	308	707	0	4148
WEXP_WEL	Public welfare1 total expenditure(0,000)	316	603	6	4691
WEXP_SAN	Sewer and solid waste management total expenditure(0,000)	439	873	16	6976
WEXP_ADM	General administration total(0,000)	948	1703	77	11462
WEXP_UTL	Utilities total expenditure(0,000)	1216	1718	32	10446
WHOUSE_OCU	Total occupied housing units	18768	28232	2485	201025
WOWN_OCU	Owner occupied housing units	13204	19678	1902	146591
WHOWN_VAL	Median house value ($), census data	61295	16777	27838	107998
WPOP_NUM	Population 2000 (census)	48525	72705	6166	510446
WPOP_SCH	School age population (age 5-17)	9105	13690	1079	97882
WPOP_DEPEN	Dependent population <17 and >65	19124	28070	2795	201829
WPOOR	Number of people below poverty	5814	6900	820	45616
WLF	Labor force (BLS)	25221	39057	2815	271872
WLF_F	Civilian labor force Female	11343	17968	1187	126704
WCOM_IN	In-commuters	6823	14893	203	106013
WCOM_OUT	Out-commuters	7037	12395	538	81173
WJOB2	Second jobs	4941	8524	567	67218

[a] $N = 170$

Table 4.4. Regression Results of Local Revenue Module.

Model	Variables	OLS		2SLS		3SLS	
		estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Property value	Intercept	3844.445	0.0692	4591.288	0.0373	4755.58	0.0246
	WPVAL	-0.0424	0.134	-0.11986	0.0078	-0.13313	<.0001
	TPI	0.567459	<.0001	0.460838	<.0001	0.431305	<.0001
	EMP	-0.05232	0.6782	0.119266	0.4374	0.203588	0.0236
	COM_OUT	-0.48116	0.2417	0.914585	0.2489	1.086352	0.0035
Retail sales	Intercept	-2163.26	0.1152	-2214.88	0.1131	-2303.08	0.0626
	WRSAL	-0.00507	0.7161	-0.00329	0.8178	-0.00097	0.9269
	TPI	0.241013	<.0001	0.242216	<.0001	0.244944	<.0001
	COM_IN	-1.53437	<.0001	-1.51932	<.0001	-1.5024	<.0001
	EMP	1.439978	<.0001	1.430173	<.0001	1.41472	<.0001
Total business establishments	Intercept	-34.2667	0.552	-35.2035	0.5412	71.298	0.003
	WTOT_EST	0.014359	0.1021	0.014946	0.0892	0.004022	0.5642
	TPI	0.003561	<.0001	0.00356	<.0001	0.003801	<.0001
	AREA	0.193571	0.0377	0.194214	0.0371	0.028521	0.2857
	EMP	0.025241	<.0001	0.025238	<.0001	0.024497	<.0001
Retail establishments	Intercept	45.6047	<.0001	45.30992	<.0001	47.27614	<.0001
	WRETAIL_EST	-0.00166	0.9353	0.00009	0.9965	-0.01236	0.3851
	TPI	0.000509	<.0001	0.000509	<.0001	0.000561	<.0001
	EMP	0.003558	<.0001	0.003556	<.0001	0.003396	<.0001
FIRE establishments	Intercept	3.067849	0.3795	3.09852	0.3749	1.857406	0.5775
	WFIRE_EST	-0.07629	<.0001	-0.07659	<.0001	-0.06342	<.0001
	TPI	0.000691	<.0001	0.000691	<.0001	0.000738	<.0001
	EMP	0.002153	<.0001	0.002153	<.0001	0.001966	<.0001
Service establishments	Intercept	-11.0085	0.6166	-11.0731	0.6146	11.63914	0.3115
	WSERV_EST	0.016301	0.0199	0.016389	0.0194	0.007943	0.203
	TPI	0.001304	<.0001	0.001304	<.0001	0.001402	<.0001
	AREA	0.005158	0.8843	0.005207	0.8832	-0.02742	0.0832
	EMP	0.013586	<.0001	0.013586	<.0001	0.013274	<.0001
Total charges	Intercept	-269.72	0.4658	-434.115	0.2785	-244.585	0.4588
	WCHARGES	0.422489	0.0003	0.586854	<.0001	0.410433	<.0001
	TPI	-0.00791	0.3007	-0.00608	0.5741	-0.00602	0.2212
	OWN_OCU	0.168774	0.0287	0.142014	0.198	0.153913	0.0019
Intergovernmental revenue	Intercept	-356.987	0.1884	-514.798	0.0684	-85.791	0.7336
	WINTERGOV	0.428512	<.0001	0.470146	<.0001	0.346715	<.0001
	EMP	0.218242	<.0001	0.217353	<.0001	0.217678	<.0001
	PVAL	-0.03075	0.002	-0.01937	0.2212	-0.01975	<.0001
	TPI	-0.0159	0.0159	-0.02218	0.0184	-0.02027	<.0001
Other revenues	Intercept	-273.441	0.2409	-268.333	0.2525	-179.45	0.4223
	WREV_OTH	0.240307	0.003	0.201754	0.0167	0.057318	0.2082
	PVAL	0.023165	<.0001	0.024094	<.0001	0.026287	<.0001
Utility revenue	Intercept	260.199	0.2925	115.4456	0.6643	241.4099	0.2793
	WREV_UTL	0.229782	0.0906	0.373765	0.0259	0.241944	0.0045
	TPI	-0.01928	<.0001	-0.01962	<.0001	-0.01749	<.0001
	EMP	0.089619	<.0001	0.089951	<.0001	0.083475	<.0001

Table 4.5. Regression Results of Local Expenditures Module

Model	Variables	OLS		2SLS		3SLS	
		estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Education expenditures	Intercept	-782.269	<.0001	-791.224	<.0001	-727.332	<.0001
	WEXP_EDU	0.0118	0.4328	0.037934	0.0842	0.035024	0.0099
	POP_SCH	0.794483	<.0001	0.713118	<.0001	0.688019	<.0001
	EMP	0.106158	<.0001	0.114729	<.0001	0.116347	<.0001
	TPI	-0.02783	<.0001	-0.03133	<.0001	-0.03095	<.0001
	PVAL	0.005565	0.2991	0.017534	0.0459	0.019315	<.0001
Health expenditures	Intercept	310.5223	0.2456	-5.8584	0.9855	137.1459	0.6073
	WEXP_HLT	0.000696	0.9968	0.934982	0.0052	0.533054	0.0002
	TPI	-0.00425	0.4815	0.000912	0.922	-0.00109	0.8202
	POP_NUM	0.062893	0.0066	0.019325	0.6682	0.03626	0.0702
	COM_IN	0.10054	0.0097	0.06017	0.2439	0.073452	<.0001
	EMP	-0.06335	0.0182	-0.01929	0.6058	-0.03666	0.0021
	INTERGOV	-0.19688	0.0256	-0.17659	0.2169	-0.17718	0.0004
Transportation expenditures	Intercept	-407.073	0.1074	-439.716	0.0863	-599.041	<.0001
	WEXP_TRN	-0.01766	0.7077	-0.02076	0.7594	-0.06778	0.0273
	TPI	-0.03972	<.0001	-0.04024	<.0001	-0.03804	<.0001
	COM_OUT	0.170435	<.0001	0.17713	<.0001	0.172251	<.0001
	EMP	0.149936	<.0001	0.150624	<.0001	0.144168	<.0001
	AREA	0.057205	0.8883	0.095329	0.8177	0.458989	0.0097
Police, protective etc. expenditures	Intercept	-447.628	0.0618	-420.032	0.0803	-220.123	0.0317
	WEXP_POL	0.075909	0.0282	0.088173	0.0125	0.010111	0.6318
	TPI	0.000852	0.0891	0.001129	0.0271	0.002022	<.0001
	COM_IN	0.123032	<.0001	0.118787	<.0001	0.112275	<.0001
	AREA	0.779521	0.0487	0.711304	0.0727	0.440172	0.0009
Fire expenditures	Intercept	121.4075	0.1636	107.419	0.2401	-163.792	0.0023
	WEXP_FIR	-0.31932	<.0001	-0.36148	<.0001	-0.28585	<.0001
	PVAL	0.003057	0.0039	0.00581	0.001	0.006762	<.0001
	RSAL	-0.00899	<.0001	-0.01057	0.0002	-0.01229	<.0001
	POP_NUM	0.024333	<.0001	0.029024	<.0001	0.029208	<.0001
	TPI	-0.00054	0.5409	-0.0028	0.035	-0.00259	<.0001
	AREA	-0.67148	<.0001	-0.71467	<.0001	-0.28366	0.0004
Parks and recreation expenditures	Intercept	-42.1486	0.7301	-26.0083	0.8362	-204.359	0.0005
	WEXP_PRK	-0.30341	<.0001	-0.41766	<.0001	-0.37851	<.0001
	TPI	-0.00151	0.018	-0.00322	<.0001	-0.00246	<.0001
	POP_DEPEN	0.040491	<.0001	0.053758	<.0001	0.048126	<.0001
	AREA	-0.25568	0.2009	-0.33729	0.1025	-0.00513	0.9462
Public welfare expenditures	Intercept	-5.02714	0.8897	-45.7252	0.3132	-92.1095	0.01
	WEXP_WEL	-0.3073	<.0001	-0.39731	<.0001	-0.23996	<.0001
	TPI	0.000061	0.9324	-0.00197	0.082	-0.00248	<.0001
	INTERGOV	0.23058	<.0001	0.223436	<.0001	0.210157	<.0001
	POP_DEPEN	-0.0316	<.0001	-0.01438	0.2082	-0.00905	0.1238
Sanitation and solid waste expenditures	Intercept	-387.438	<.0001	-430.979	<.0001	-430.512	<.0001
	WEXP_SAN	0.215565	0.0382	0.275891	0.0152	0.269562	<.0001
	TPI	-0.0156	<.0001	-0.01663	<.0001	-0.01647	<.0001
	HOUSE_OCU	0.127698	<.0001	0.134214	<.0001	0.13348	<.0001
Administration expenditures	Intercept	-120.647	0.6799	-169.284	0.5639	-225.29	0.0968
	WEXP_ADM	0.35764	<.0001	0.38901	<.0001	0.29312	<.0001
	TPI	-0.00276	0.0456	-0.00284	0.0402	-0.00182	0.0329
	AREA	-0.08135	0.8627	-0.04	0.9324	0.188764	0.2776
	EMP	0.039014	<.0001	0.03891	<.0001	0.036477	<.0001
Utility expenditures	Intercept	355.5686	0.2367	438.7379	0.1851	512.3112	0.0802
	WEXP_UTL	0.206547	0.2005	0.814462	0.0004	0.699665	<.0001
	POP_NUM	-0.01205	0.4242	-0.08729	0.0002	-0.07497	<.0001
	EMP	0.043983	0.0249	0.136534	<.0001	0.119045	<.0001

Table 4.6. Regression Results of Housing Market Module

Model	Variables	OLS		2SLS		3SLS	
		estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Total occupied housing units	Intercept	145.1171	0.195	199.4207	0.0842	287.4182	0.0065
	WHOUSE_OCU	0.005724	0.1665	0.010652	0.0207	0.006572	0.0102
	POP_NUM	0.33308	<.0001	0.318935	<.0001	0.318882	<.0001
	EMP	0.085696	<.0001	0.103524	<.0001	0.10337	<.0001
Owner occupied housing units	Intercept	1919.361	<.0001	1919.253	<.0001	2179.056	<.0001
	WOWN_OCU	0.069287	<.0001	0.069297	<.0001	0.043603	<.0001
	EMP	0.052707	0.0021	0.052706	0.0021	0.05759	<.0001
	TPI	0.084283	<.0001	0.084283	<.0001	0.083905	<.0001
Median house value	Intercept	-50736.9	<.0001	-47884.3	<.0001	-40431.8	<.0001
	WHOWN_VAL	0.549322	<.0001	0.471509	<.0001	0.407225	<.0001
	PCI_VAL	4.713285	<.0001	4.859852	<.0001	4.685699	<.0001
	TOT_EST	-0.19521	0.7752	0.036023	0.961	0.549947	0.4156
	POOR	-0.13631	0.4132	-0.19514	0.291	-0.29766	0.0765

Table 4.7. Regression Results of Demography Module

Model	Variables	OLS		2SLS		3SLS	
		estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Population	Intercept	596.1322	0.2814	600.3016	0.2782	989.9107	0.0599
	WPOP_NUM	0.049884	<.0001	0.049833	<.0001	0.039891	<.0001
	LF	1.786085	<.0001	1.786021	<.0001	1.790698	<.0001
School age population	Intercept	-277.501	0.0023	-285.052	0.0018	-240.991	0.0057
	WPOP_SCH	0.037412	<.0001	0.040165	<.0001	0.030939	<.0001
	POP_NUM	0.187445	<.0001	0.187044	<.0001	0.18799	<.0001
Dependent Population	Intercept	187.5401	0.2269	193.3199	0.2132	223.2551	0.1326
	WPOP_DEPEN	0.007383	0.1659	0.006556	0.2204	0.00522	0.2026
	POP_NUM	0.384874	<.0001	0.385101	<.0001	0.385028	<.0001
Population below poverty	Intercept	-1082.84	0.0008	-1304.18	0.0001	-1473.73	<.0001
	WPOOR	0.016992	0.7104	-0.07102	0.1664	-0.04692	0.0519
	TPI	-0.08516	<.0001	-0.10352	<.0001	-0.10511	<.0001
	POP_DEPEN	0.82082	<.0001	0.961067	<.0001	0.971636	<.0001

Table 4.8. Regression Results of Labor Market Module

Model	Variables	OLS		2SLS		3SLS	
		estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Labor force	Intercept	3177.528	0.0885	3071.462	0.1001	3847.391	0.0002
	WLF	-0.22522	<.0001	-0.1906	0.0002	-0.08586	<.0001
	EMP	0.528464	<.0001	0.515983	<.0001	0.510132	<.0001
	AREA	-5.04849	0.106	-5.03296	0.1076	-5.62642	0.0002
	A_EMP	0.000312	<.0001	0.000335	<.0001	0.000375	<.0001
	CEMP	0.063168	<.0001	0.057918	<.0001	0.035021	<.0001
Women labor force	Intercept	-379.718	<.0001	-399.291	<.0001	-454.338	<.0001
	WLF_F	-0.00008	0.9785	-0.00622	0.0482	-0.00283	0.1984
	POP_NUM	0.100033	<.0001	0.127997	<.0001	0.136992	<.0001
	LF	0.277187	<.0001	0.227507	<.0001	0.210863	<.0001
In-commuters	Intercept	-2835.99	0.0047	-2814.31	0.0051	-2911.2	<.0001
	WCOM_IN	0.056556	0.2931	0.084139	0.1255	0.031571	0.029
	EMP	0.585997	<.0001	0.583521	<.0001	0.576553	<.0001
	AREA	3.521486	0.036	3.576524	0.0334	3.984861	<.0001
	A_EMP	-0.00058	<.0001	-0.00058	<.0001	-0.00056	<.0001
	CEMP	-0.00104	0.7608	-0.00267	0.4399	-0.00114	0.2499
Out-commuters	Intercept	-1929.33	0.0469	-1484.72	0.1325	-1164.42	0.0239
	WCOM_OUT	-0.2398	<.0001	-0.21307	0.0002	-0.08531	<.0001
	LF	0.49479	<.0001	0.460522	<.0001	0.453997	<.0001
	AREA	1.753708	0.2806	0.879858	0.5962	0.714316	0.3475
	A_EMP	-0.00037	<.0001	-0.00032	<.0001	-0.00031	<.0001
	CEMP	0.020907	<.0001	0.021028	<.0001	0.013302	<.0001
Second jobs	Intercept	1005.407	<.0001	742.2873	0.001	536.5253	0.0088
	WJOB2	-0.02579	0.2697	-0.08843	0.0032	-0.04085	0.0197
	TPI	0.072747	<.0001	0.058202	<.0001	0.058339	<.0001
	LF_F	-0.6705	<.0001	-0.35609	0.0003	-0.34553	<.0001
	EMP	0.145563	<.0001	0.096173	<.0001	0.089772	<.0001

Table 4.9. Parameter Estimates of Spatial Lag Variable and Their Statistical Significance

Spatial lag variables	OLS		2SLS		3SLS	
	estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Property value total	-0.0424	0.134	-0.11986	0.0078	-0.13313	<.0001
Retail sales total	-0.00507	0.7161	-0.00329	0.8178	-0.00097	0.9269
Total business establishments	0.014359	0.1021	0.014946	0.0892	0.004022	0.5642
Retail establishment	-0.00166	0.9353	0.00009	0.9965	-0.01236	0.3851
Finance, insurance and real estate establishment	-0.07629	<.0001	-0.07659	<.0001	-0.06342	<.0001
Service establishment	0.016301	0.0199	0.016389	0.0194	0.007943	0.203
Total charges	0.422489	0.0003	0.586854	<.0001	0.410433	<.0001
State and federal intergovernmental revenue	0.428512	<.0001	0.470146	<.0001	0.346715	<.0001
Other revenue and other taxes	0.240307	0.003	0.201754	0.0167	0.057318	0.2082
Utility revenue	0.229782	0.0906	0.373765	0.0259	0.241944	0.0045
Education total	0.0118	0.4328	0.037934	0.0842	0.035024	0.0099
Health and hospital total expenditure	0.000696	0.9968	0.934982	0.0052	0.533054	0.0002
Transportation total expenditures	-0.01766	0.7077	-0.02076	0.7594	-0.06778	0.0273
Police, protective inspection, judicial and correction	0.075909	0.0282	0.088173	0.0125	0.010111	0.6318
Fire protection total expenditure	-0.31932	<.0001	-0.36148	<.0001	-0.28585	<.0001
Parks and recreation, total expenditure	-0.30341	<.0001	-0.41766	<.0001	-0.37851	<.0001
Public welfare1 total expenditure	-0.3073	<.0001	-0.39731	<.0001	-0.23996	<.0001
Sewer and solid waste management total expenditure	0.215565	0.0382	0.275891	0.0152	0.269562	<.0001
General administration total	0.35764	<.0001	0.38901	<.0001	0.29312	<.0001
Utilities total expenditure	0.206547	0.2005	0.814462	0.0004	0.699665	<.0001
Total occupied housing units	0.005724	0.1665	0.010652	0.0207	0.006572	0.0102
Owner occupied housing units	0.069287	<.0001	0.069297	<.0001	0.043603	<.0001
Median house value	0.549322	<.0001	0.471509	<.0001	0.407225	<.0001
Population	0.049884	<.0001	0.049833	<.0001	0.039891	<.0001
School age population (age 5-17)	0.037412	<.0001	0.040165	<.0001	0.030939	<.0001
Dependent population <17 and >65	0.007383	0.1659	0.006556	0.2204	0.00522	0.2026
Number of people below poverty	0.016992	0.7104	-0.07102	0.1664	-0.04692	0.0519
Labor force (BLS)	-0.22522	<.0001	-0.1906	0.0002	-0.08586	<.0001
Civilian labor force Female	-0.00008	0.9785	-0.00622	0.0482	-0.00283	0.1984
In-commuters	0.056556	0.2931	0.084139	0.1255	0.031571	0.029
Out-commuters	-0.2398	<.0001	-0.21307	0.0002	-0.08531	<.0001
Second jobs	-0.02579	0.2697	-0.08843	0.0032	-0.04085	0.0197

Table 4.10. Spatial Lag Three-Stage Least Squares Results Using Different Weight Matrices.

Spatial Lag Variables	Uniform Weight Matrix		Gravity I (Weight/D)		Gravity II (Weight/D2)	
	Parameter Estimates	*p*-value	Parameter Estimates	*p*-value	Parameter Estimates	*p*-value
Property value	-0.13254	<.0001	0.011485	0.1489	0.028381	0.0036
Retail sales total	-0.00054	0.9589	-0.00099	0.7972	0.000853	0.8262
Total business establishments	0.004578	0.5104	0.002974	0.2546	0.003346	0.2039
Retail establishment	-0.01118	0.4354	-0.002	0.7111	-0.00285	0.5978
FIRE establishment	-0.06578	<.0001	-0.02831	<.0001	-0.03041	<.0001
Service establishment	0.008133	0.192	0.00143	0.5411	0.00157	0.5059
Total charges	0.415722	<.0001	0.098619	0.0002	0.101307	0.0001
State and federal intergovernmental revenue	0.358795	<.0001	0.186037	<.0001	0.190374	<.0001
Other revenue and other taxes	0.046366	0.2939	0.011439	0.4175	0.018674	0.1959
Utility revenue	0.239558	0.0048	0.056001	0.0187	0.071225	0.0033
Education total	0.036975	0.0073	0.013744	0.0152	0.012994	0.0194
Health and hospital total expenditure	0.525421	0.0002	0.245343	0.0018	0.247623	0.0007
Transportation total expenditures	-0.06616	0.0319	-0.10187	<.0001	-0.11931	<.0001
Police, protective, judicial and correction	0.012901	0.5436	0.010488	0.2193	0.012346	0.1526
Fire protection total expenditure	-0.29411	<.0001	-0.10265	<.0001	-0.11849	<.0001
Parks and recreation, total expenditure	-0.37643	<.0001	-0.08737	<.0001	-0.08788	<.0001
Public welfare1 total expenditure	-0.25663	<.0001	-0.08501	<.0001	-0.08949	<.0001
Sewer and solid waste mgt. expenditure[a]	0.275613	<.0001	0.034517	0.0727	0.024595	0.1802
General administration total	0.304647	<.0001	0.095454	<.0001	0.104019	<.0001
Utilities total expenditure[a]	0.568264	<.0001	0.051412	0.0179	0.026144	0.2352
Total occupied housing units[a]	0.005625	0.0217	-0.00066	0.5122	-0.00055	0.5885
Owner occupied housing units	0.0465	<.0001	0.026524	<.0001	0.028547	<.0001
Median house value	0.381934	<.0001	0.290629	<.0001	0.279781	<.0001
Population	0.037255	<.0001	0.004298	0.0284	0.004082	0.0379
School age population (age 5-17)	0.034044	<.0001	0.016669	<.0001	0.01806	<.0001
Dependent population <17 and >65	0.003694	0.3664	-0.00183	0.25	-0.002	0.2111
Number of people below poverty	-0.05821	0.0216	-0.06096	<.0001	-0.06572	<.0001
Labor force (BLS)	-0.06055	0.0057	0.06857	<.0001	0.084003	<.0001
Civilian female labor force[a]	-0.00309	0.1622	-0.00284	0.0006	-0.00312	0.0002
In-commuters	0.036274	0.0029	-0.01797	0.0636	-0.0209	0.0356
Out-commuters	-0.0021	0.8263	0.001139	0.8223	-0.00016	0.976
Second jobs	-0.05399	0.0005	-0.03618	<.0001	-0.03862	<.0001

[a]Indicates that the significance of the coefficient change as we change weight matrices.

Table 4.11A. Estimated Impact due to Spatial Interactions and Endogenous Variables Interactions[a].

Equations	Spatial Interaction		Endogenous Variable Interaction		Total Impact
	Positive impact	Negative impact	Positive impact	Negative impact	
Property value (,000)	29.43	-301.50	3889.68	0.00	3617.61
Retail sales total (,000)	0.01	-15.76	11183.70	0.00	11167.95
Total business establishments	0.11	0.00	24.50	0.00	24.61
Retail establishment	0.00	-0.05	3.40	0.00	3.35
Finance, insurance and real estate establishment	0.01	-0.14	1.97	0.00	1.83
Service establishment	0.12	0.00	13.27	0.00	13.40
Total charges(,000)	0.00	0.00	88.64	0.00	88.64
State and federal intergovernmental revenue(,000)	1330.98	0.00	2107.12	-7.13	3430.97
Other revenue and other taxes(,000)	0.00	0.00	102.26	0.00	102.26
Utility revenue(,000)	306.45	0.00	834.75	0.00	1141.20
Expenditure on education(,000)	48.31	0.00	3099.07	0.00	3147.38
Health and hospital total expenditure(,000)	0.00	-477.85	26.30	-98.50	-550.05
Transportation total expenditures(,000)	5.54	-109.89	1735.60	0.00	1631.24
Expenditures on police, protective inspection, judicial and correction(,000)	0.00	0.00	222.93	-1.46	221.47
Fire protection total expenditure(,000)	0.00	0.00	308.96	0.00	308.96
Parks and recreation, total expenditure(,000)	0.00	0.00	266.56	0.00	266.56
Public welfare1 total expenditure(,000)	0.00	0.00	395.22	-4.00	391.22
Sewage and solid waste management total expenditure(,000)	0.00	0.00	750.23	0.00	750.23
General administration total(,000)	174.15	0.00	364.77	0.00	538.92
Utilities total expenditure(,000)	2946.89	0.00	165.78	-53.73	3058.93
Total occupied housing units	0.78	0.00	562.05	0.00	562.83
Owner occupied housing units	3.00	0.00	57.59	0.00	60.59
Median house value ($), census data	0.00	0.00	0.00	-146.71	-146.71
Population	0.00	0.00	1438.40	0.00	1438.40
School age population (age 5-17)	0.00	0.00	270.41	0.00	270.41
Dependent population <17 and >65	0.00	0.00	553.83	0.00	553.83
Number of people below poverty	0.00	0.00	538.13	0.00	538.13
Labor force (BLS)	2.17	-74.22	803.27	0.00	731.23
Civilian labor force Female	0.00	0.00	366.43	0.00	366.43
In-commuters	7.36	0.00	198.57	-1.30	204.63
Out-commuters	19.71	-2.21	170.65	0.00	188.15
Second jobs	0.13	-4.15	0.00	-36.84	-40.86

[a]Effect of 1,000 new jobs created in Green County of Missouri State.

Table 4.11B. An Economic Impact Comparison of Spatial and Nonspatial Model

Variables	Greene County Impact	Total impact		% Difference
		Spatial model	Non-spatial model	
Property Value Total(,000)	3,533	3,618	-2,312	-164
Retail Sales total (,000)	11,164	11,168	11,584	4
Total business establishments	24	25	24	-2
Retail establishment	3	3	3	2
Finance, insurance and real estate establishment	2	2	2	5
Service establishment	13	13	13	-2
Total charges(,000)	89	89	288	226
State and federal intergovernmental revenue(,000)	2,157	3,431	3,666	7
Other revenue and other taxes(,000)	93	102	-64	-162
Utility revenue(,000)	843	1,141	826	-28
Expenditure on education(,000)	3,000	3,147	3,347	6
Health and hospital total expenditure(,000)	-121	-550	-172	-69
Transportation total expenditures(,000)	1,679	1,631	1,859	14
Expenditures on police, protective inspection, judicial and correction(,000)	223	221	266	20
Fire protection total expenditure(,000)	286	309	200	-35
Parks and recreation, total expenditure(,000)	253	267	230	-14
Public welfare1 total expenditure(,000)	395	391	645	65
Sewage and solid waste management total expenditure(,000)	720	750	898	20
General administration total(,000)	371	539	333	-38
Utilities total expenditure(,000)	315	3,059	149	-95
Total occupied housing units	539	563	635	13
Owner occupied housing units	58	61	59	-2
Median house value ($), census data	-139	-147	229	-256
Population 2000 (census)	1,367	1,438	1,647	14
School age population (age 5-17)	257	270	313	16
Dependent population <17 and >65	526	554	635	15
Number of people below poverty	511	538	608	13
Labor force (BLS)	764	731	905	24
Civilian labor force Female	348	366	416	14
In-commuters	199	205	209	2
Out-commuters	137	188	271	44
Second jobs	-31	-41	-78	90

[a]Effect of 1,000 new jobs created in Green County, Missouri.

Appendix II. Variable definitions and data sources

VARIABLES	Variable description	Data source
AREA	Area in square miles	US Census Bureau, 2000
CEMP	External employment	BEA, Regional Economic Accounts
CHARGES	Total charges as source of revenue.	US Census Bureau, Government Census, 2002
COM_IN	Number of in-commuters. In-commuters are people who work in a county and live outside of that county.	U.S. Census Bureau, Population Division, Journey-To-Work and Migration Statistics Branch.
COM_OUT	Number of Out-commuters. Out-commuters are people who live in a county and work outside of that county	U.S. Census Bureau, Population Division, Journey-To-Work and Migration Statistics Branch.
EMP	Employment. It is comprised of estimates of full-time and part-time jobs by place of work with equal weights.	BEA, Regional Economic Accounts
EXP_ADM	Financial administration and general government expenditure. This variable consists of expenditure related to 1) general government and financial administration, 2) central staff, and 3) interest payment on debt.	US Census Bureau, Government Census, 2002
EXP_EDU	Expenditure on education. This includes expenses for elementary, secondary, higher education, and other government educational activities together with expenses of running libraries.	US Census Bureau, Government Census, 2002
EXP_FIR	Fire protection expenditures. It includes the expenses of fire fighting organization, facilities, and auxiliary services	US Census Bureau, Government Census, 2002
EXP_HLT	Health and hospital total expenditures. Health expenditures include out-patient health services other than hospital care. Hospital expenditures include financing, construction, maintenance and operation of hospital facilities	US Census Bureau, Government Census, 2002
EXP_POL	Police and judicial expenditures. These include the expenses related to preservation of law and order, traffic safety and correction.	US Census Bureau, Government Census, 2002
EXP_PRK	Parks and recreation expenditure.	US Census Bureau, Government Census, 2002
EXP_SAN	Sewer and solid wastes expenditures.	US Census Bureau, Government Census, 2002
EXP_TRN	Transportation expenditures which includes expenditure on construction and maintenance of highways and airports.	US Census Bureau, Government Census, 2002
EXP_UTL	Utility total expenditures. These include expenses related to water supply, electric power supply, gas supply and the use of mass transit system.	US Census Bureau, Government Census, 2002
EXP_WEL	Welfare and housing, and public welfare expenditures. These expenditures are related to housing and community development, and public welfare.	US Census Bureau, Government Census, 2002

FIRE_EST	Finance, insurance and real estate establishment	US Census Bureau, 2000
HOUSE_OCU	Total occupied housing units	US Census Bureau, 2000
HOWNVAL	Median house value in dollar	US Census Bureau, 2000
INTERGOV	State and federal intergovernmental revenue.	US Census Bureau, Government Census, 2002
JOB2	Second jobs. Second job= Employment + Out-commuters + Unemployed –Labor force –In-commuters.	Calculated by using BEA, Regional Economic Accounts and Bureau of Labor Statistics data
LF	Total labor force.	Bureau of Labor Statistics
LF_F	Women in labor force	US Census Bureau, 2000
OWNER_OCU	Total owner occupied housing units	US Census Bureau, 2001
PCI_VAL	Per capita income.	US Census Bureau, 2000
POOR	Population below poverty line	US Census Bureau, 2000
POP_DEPEN	Dependent population (Population below 17 and above 65).	Calculated base on data obtained from US Census Bureau, 2000
POP_NUM	Population	US Census Bureau, 2000
POP_SCH	School age population. Population aged 5 to 17 years.	US Census Bureau, 2000
PVAL	Property values	Department of Revenue of Missouri State and surrounding states
RENT_OCU	Total renter occupied housing units	US Census Bureau, 2000
REV_OTH	Other revenue. It includes amount received from sale of property, rents and royalties, and dividends on investment	US Census Bureau, Government Census, 2002
REV_UTL	Revenues from utility services. Revenues obtained from water supply, electric power supply, gas supply and the use of mass transit system	US Census Bureau, Government Census, 2002
RSAL	Retail sales	Department of Revenue of Missouri State and surrounding states
SERV_EST	Number of service establishments	US Census Bureau, 2000
TOT_EST	Total business establishments	US Census Bureau, 2000
TPI	Total personal income (population x PCI_VAL)	BEA, Regional Economic Accounts
WEMP	Spatial lag of employment; weight matrix times employment	BEA, Regional Economic Accounts

Figure 3.1A. Spatial Equilibrium of Labor Market

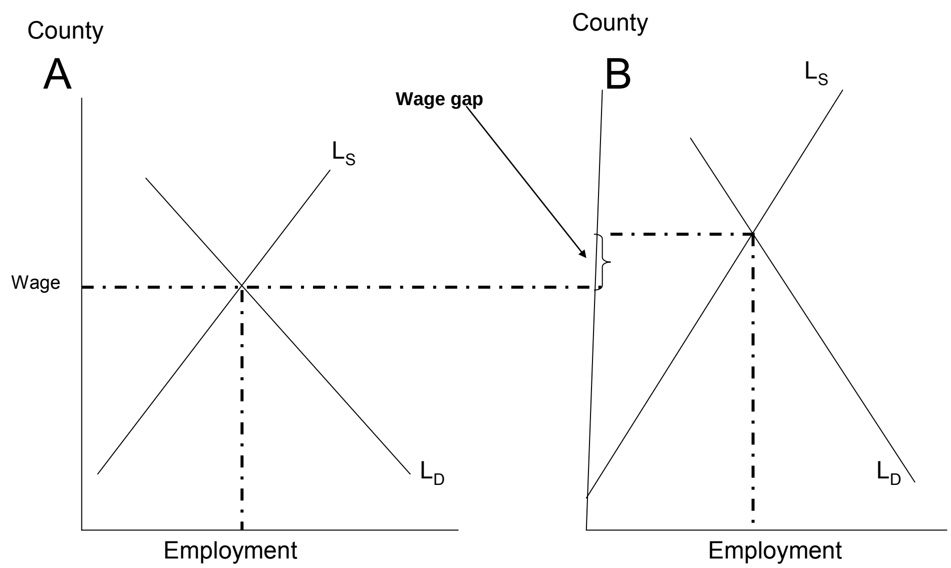


Figure 3.1B. Spatial Equilibrium of Housing Market

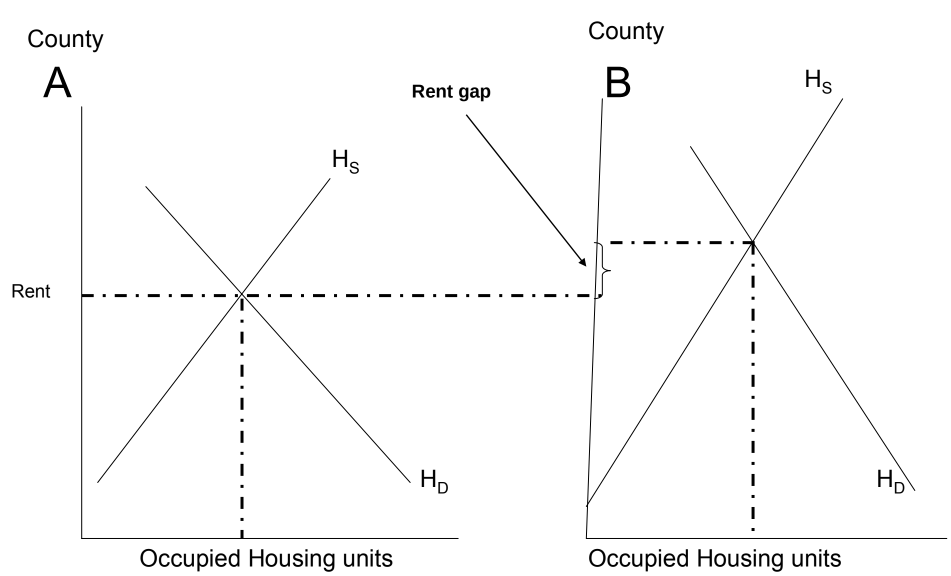
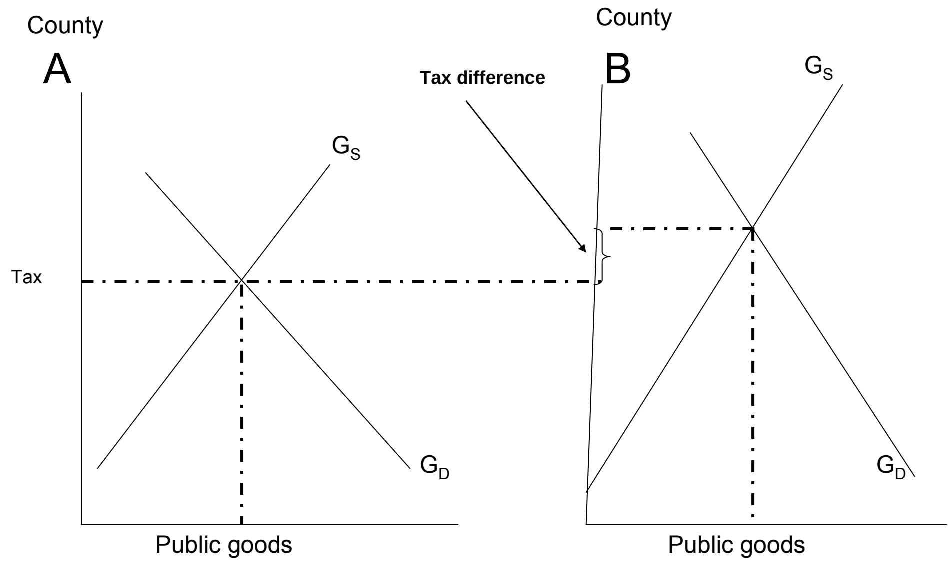


Figure 3.1C. Spatial Equilibrium of Public Goods Market



CHAPTER V

A SPATIAL ECONOMETRIC MODEL OF THE KOREAN ECONOMY

ABSTRACT

Using Korean regional data a spatial simultaneous equation model was developed and estimated using a generalized spatial three-stage least squares procedure. This model contains 10 equations for local finance, the labor market, and the housing market -local revenue, local expenditures, housing units, population, economically active population, number of students, in- and out-commuting, number of firms, and employment in non-basic sectors. Employment and economic development expenditures are the main drivers of the model. A significant cross-county and cross-equation spillover effect is estimated. Reduced form estimates were derived from structural equations, and it is found that additional employment opportunities generated in a certain county will have a positive impact on all sectors of the economy, including local finance, the housing market, demography, and the labor market. The spatial spillover effect is estimated on neighboring counties resulted from the employment opportunities created in a residence county. It appears that the estimated parameters tend to be sensitive to the specification of weight matrices. The model was validated based on forecasting accuracy of in-sample data using mean absolute percentage error.

5.1. Introduction

The development of econometric models for economic impact analysis and economic forecasting has been of continuous interest to regional economists. In this paper such a model is applied to the Korean regional economy. Regions within a country are open economies experiencing extensive inter-area spillovers. For example, employment change in one region may affect the population, commuting pattern, and demand for public services in nearby area. To account for the interregional spillovers, a 'complete' version of spatial model was developed for the Korean economy using generalized spatial three-stage least squares (GS3SLS) procedure.

This model is somewhat similar to other fiscal impact models developed in the United States based on county-level units of analysis, the most common of which are the Show Me Model (Johnson and Scott, 2006), the Virginia Impact Projection Model (Johnson, 1991), the Iowa Economic/Fiscal Impact Modeling System (Swenson and Otto, 1998), the Idaho model (Cooke and Fox, 1994), an Integrated Economic Impact and Simulation Model for Wisconsin Counties (Shields, 1998), and the Small Area Fiscal Estimation Simulator for Texas (Evans and Stallmann, 2006). One of the key elements in these models is employment as an engine of economic growth and change at the local level.

Using Korean data for 2005, a model is estimated using a GS3SLS procedure developed by Kelejian and Prucha (2004). The model contains equations of local revenues, local expenditures, total housing units, population, total students, in- and out-communing, number of firms, and non-basic employment. A simultaneous system of spatially interrelated cross-section equations containing spatial lags in both the dependent variables and their error terms is considered. Feedback effects due to both the simultaneous relationships between equations and the spatial linkages are also investigated. To validate the model, a non-spatial model (NS3SLS), simultaneous spatial lag model (SL3SLS), spatial error model (SE3SLS), and spatial lag and spatial error model (SLE3SLS) are estimated. Using a measure of forecasting accuracy (mean absolute percentage error [MAPE]), the performance of the models is investigated.

The rest of the paper is organized as follows. Section 5.2 outlines the objectives of this research; Section 5.3 discusses the data and data sources; and Section 5.4 outlines the spatial model estimation procedure. Sections 5.5 and 5.6 discuss the model specification and results, respectively, and Section 5.7 summarizes and concludes.

5.2. Research Objectives

The primary objective of this study is to build a rigorous econometric model for the South Korean economy that can be applied to alternative policy scenarios. The specific objectives are:

1. to develop and estimate a GS3SLS model for local regions in Korea,
2. to estimate the interregional spillover effect of the labor market and the local public finance and housing market, and
3. to perform policy analysis based on the reduced form estimates.

5.3. Data

This empirical work focuses on the relationships and spatial interactions among labor market, the local public finance market, and the housing market. Although Korean regions are comparatively centralized entities, it is assumed that these entities are independent decision-making bodies. Administrative divisions of South Korea are divided into 1 Special City (teukbyeolsi), 6 Metropolitan Cities (gwangyeoksi), and 9 Provinces (do). Based on population, these are further subdivided into a variety of smaller entities, including cities (si), counties (gun), wards (gu), towns (eup), districts (myeon), neighbourhoods (dong) and villages (ri). The data used in this study come from 172 local government units that consist of 7 metropolitan cities, 77 cities, and 88 counties. Among the 172 regions, 140 are rural, with a population of less than 270,000, and 32 are urban, with a population of more than 270,000. Thus, the analysis includes all 172 regions in Korea with population over 8,000.

All the data used to conduct this study are secondary data collected by the Korea National Statistical Office. Data related to area, employment, housing units, student population, and number of firms were obtained from Korea's Si or Gun's Statistical Year Book 2005. Employment data is divided into basic and non-basic sectors. Basic sectors in Korean economy area farming and manufacturing; and non-basic sector is service sector. Employment in basic sectors allows us to estimate the multiplier effects in the Korean economy. Local revenue and expenditure data were obtained from Korean Local Financial Year Book 2005. Local revenues consist of local tax receipts, other receipts, local share tax, autonomous district control grants, and subsidies (Local finance, MOGAHA). Generally, cities' tax shares are higher (about 50%) than counties' (about 20%). The revenue structure of local governments is presented in Table 5.1. Population and in-commuters and out-commuters data were obtained from Korean Census of Population data. In this analysis, the cross-sectional data of 172 counties and cities was used for 2005. A list of variables and their summary of statistics such as number of observations, means, standard deviations, and minimum and maximum values for each variable are presented in Table 5.2.

5.4. The Spatial Model Estimation Procedure

To begin with, a single equation spatial econometric model is introduced. This is a commonly used model in economics and other fields. Then the features of a simultaneous system of equations are added. The general specification of the single equation is $Y = \lambda WY + X\beta + \varepsilon$ where $\varepsilon = \rho W\varepsilon + u$ (Anselin, 1988). *Y* is a column vector of observations on a dependent variable; *X* is a vector of explanatory variables that are assumed to be uncorrelated with error terms; *W* is a contiguity weight matrix; λ and ρ are spatial lag and spatial error parameters to be estimated; β is the column vector parameters of explanatory variables; and *u* is an independent and identically distributed error term. ε is a spatial error term that can be solved as $\varepsilon = (I - \rho W)^{-1} u$. Spatial dependence has two sources: both error terms and dependent variables may be correlated across space. However, this single equation model does not serve the purpose because a simultaneous system of equation is needed. Following Kelejian and Prucha (2004), a GS3SLS model is specified as follows:

$$Y_n = Y_n B + X_n C + \bar{Y}_n A + U_n \qquad (1)$$

$$Y_n = (y_{1,n},....., y_{m,n}),\; X_n = (x_{1,n},....x_{k,n}),\; U_n = (u_{1,n},....,u_{m,n}),\; \bar{Y} = (\bar{y}_{1,n},....,\bar{y}_{m,n})$$

$$\bar{y}_{j,n} = W_n y_{j,n} \quad j = 1,....,m \qquad \bar{y}_{ij,n} = \sum_{r=1}^{n} w_{ir,n} y_{rj,n.}$$

where $y_{j,n}$ is the $n \times 1$ vector of cross-sectional observations on the dependent variable, $x_{l,n}$ is the $n \times 1$ vector of cross-sectional observations on the *l*th exogenous variable, $\bar{y}_{j,n}$ is the spatial lag of $y_{j,n}$, $u_{l,n}$ is the $n \times 1$ disturbance vector of in the *j*th equation, W_n is an $n \times n$

weight matrix, and ***B***, ***C, A*** are parameter matrices of mxm, kxm and mxm corresponding variables, respectively. The authors also allow for the spatial autocorrelation in the error term as follows:

$$U_n = \overline{U}_n R + E_n \qquad (2)$$

with $E_n = (\varepsilon_{1,n}, ..., \varepsilon_{m,n})$, $R = diag_{j=1}^{m}(\rho_j)$

$\overline{U}_n = (\overline{u}_{1,n}, ..., \overline{u}_{m,n})$, $\overline{u}_{j,n} = W_n u_{j,n} \quad j = 1,....m,$

where $\varepsilon_{j,n}$ denotes the column vector of independent and identically distributed error terms and ρ_j denotes the spatial autoregressive parameters. $\overline{u}_{j,n}$ is the spatial lag of $u_{j,n}$.

5.4.1 GS3SLS Estimation Procedure

The estimation procedure consists of an initial two-stage least squares (2SLS) estimation, followed by estimation of the spatial autoregressive parameter, a generalized spatial 2SLS estimation, and full information estimation (GS3SLS). The first three steps complete the generalized spatial two-stage least squares (GS2SLS), and the final steps take care of the cross-equation error correlation (Kelejian and Prucha, 2004). GS3SLS procedure accounts for two factors. First, it takes care of the simultaneity bias which arises when a dependent variable is correlated with another equation's error term. Second, it allows correlated errors between equations which improved the efficiency of the parameter estimates.

5.4.2 Initial 2SLS Estimation

The first step in the estimation process consists of the estimation of the model parameter vector β_j in a single-equation spatial econometric model by 2SLS using all exogenous variables, their spatial lag values, and the twice spatially lagged exogenous variables (i.e., $X_n, WX_n, W^2 X_n$). The residual of this step is computed as follows:

$$\tilde{u}_{j,n} = y_{j,n} - Z_{j,n}\tilde{\delta}_{j,n}$$

(3)

where $Z_{j,n}$ includes all the endogenous and exogenous variables included in the 2SLS regression.

5.4.3 Estimation of Spatial Autoregressive Parameter

Equation (2) implies that

$$u_j - \rho_j W u_j = \varepsilon_j \tag{4}$$

and premultiplication of this term by the weights matrix *W* gives

$$Wu_j - \rho_j W^2 u_j = W\varepsilon_j \tag{5}$$

The following three equation system is obtained from the relationships between equations (4) and (5):

$$\frac{\varepsilon_j^{'}\varepsilon_j}{n} = \frac{u_j^{'}u_j}{n} + \rho_j^2 \frac{(Wu_j)^{'}(Wu_j)}{n} - 2\rho_j \frac{u_j^{'}(Wu_j)}{n}$$

$$\frac{(W\varepsilon_j)^{'}(W\varepsilon_j)}{n} = \frac{(Wu_j)^{'}(Wu_j)}{n} - \rho_j^2 \frac{(W^2u_j)^{'}(W^2u_j)}{n} - 2\rho_j \frac{(W^2u_j)^{'}(Wu_j)}{n}$$

$$\frac{\varepsilon_j^{'}W\varepsilon_j}{n} = \frac{u_j(Wu_j)}{n} + \rho_j^2 \frac{(Wu_j)^{'}(W^2u_j)}{n} - \rho_j \frac{u_j^{'}(W^2u_j) + (Wu_j)^{'}(Wu_j)}{n} \tag{6}$$

If the expectations are taken across (6) then the resulting system would be as follows:

$$E\begin{bmatrix} \frac{\varepsilon_j^{'}\varepsilon_j}{n} = \frac{u_j^{'}u_j}{n} + \rho_j^2 \frac{(Wu_j)^{'}(Wu_j)}{n} - 2\rho_j \frac{u_j^{'}(Wu_j)}{n} \\ \frac{(W\varepsilon_j)^{'}(W\varepsilon_j)}{n} = \frac{(Wu_j)^{'}(Wu_j)}{n} - \rho_j^2 \frac{(W^2u_j)^{'}(W^2u_j)}{n} - 2\rho_j \frac{(W^2u_j)^{'}(Wu_j)}{n} \\ \frac{\varepsilon_j^{'}W\varepsilon_j}{n} = \frac{u_j(Wu_j)}{n} + \rho_j^2 \frac{(Wu_j)^{'}(W^2u_j)}{n} - \rho_j \frac{u_j^{'}(W^2u_j) + (Wu_j)^{'}(Wu_j)}{n} \end{bmatrix} \tag{7}$$

$$
E\begin{bmatrix} \sigma_{\mathrm{j}}^2 \\ \rho_{\mathrm{j}}^2 \dfrac{tr(W'W)}{n} \\ \rho_{\mathrm{j}}^2 \dfrac{tr(W)}{n} = 0 \end{bmatrix} = E\begin{bmatrix} \dfrac{u_j^{'}u_j}{n} + \rho_j^2 \dfrac{(Wu_j)^{'}(Wu_j)}{n} - 2\rho_j \dfrac{u_j^{'}(Wu_j)}{n} \\ \dfrac{(Wu_j)^{'}(Wu_j)}{n} - \rho_j^2 \dfrac{(W^2u_j)^{'}(W^2u_j)}{n} - 2\rho_j \dfrac{(W^2u_j)^{'}(Wu_j)}{n} \\ \left[\dfrac{u_j(Wu_j)}{n} + \rho_j^2 \dfrac{(Wu_j)^{'}(W^2u_j)}{n} - \rho_j \dfrac{u_j^{'}(W^2u_j) + (Wu_j)^{'}(Wu_j)}{n} \right] \end{bmatrix}
$$

(8)

$$
E\begin{bmatrix} \dfrac{u_j^{'}u_j}{n} \\ \dfrac{(Wu_j)^{'}(Wu_j)}{n} \\ \dfrac{u_j(Wu_j)}{n} \end{bmatrix} = E\begin{bmatrix} 2\rho_j \dfrac{E(u_j^{'}(Wu_j))}{n} & -\rho_j^2 \dfrac{E((Wu_j)^{'}(Wu_j))}{n} & \sigma_{\mathrm{j}}^2 \\ 2\rho_j \dfrac{E((W^2u_j)^{'}(Wu_j))}{n} & -\rho_j^2 \dfrac{(W^2u_j)^{'}(W^2u_j)}{n} & \rho_{\mathrm{j}}^2 \dfrac{tr(W'W)}{n} \\ \rho_j \dfrac{E(u_j^{'}(W^2u_j) + (Wu_j)^{'}(Wu_j))}{n} & -\rho_j^2 \dfrac{E((Wu_j)^{'}(W^2u_j))}{n} & 0 \end{bmatrix}
$$

(9)

$$
E\begin{bmatrix} \dfrac{u_j^{'}u_j}{n} \\ \dfrac{(Wu_j)^{'}(Wu_j)}{n} \\ \dfrac{u_j(Wu_j)}{n} \end{bmatrix} = E\begin{bmatrix} 2\dfrac{E(u_j^{'}(Wu_j))}{n} & -\dfrac{E((Wu_j)^{'}(Wu_j))}{n} & 1 \\ 2\dfrac{E((W^2u_j)^{'}(Wu_j))}{n} & -\dfrac{(W^2u_j)^{'}(W^2u_j)}{n} & \dfrac{tr(W'W)}{n} \\ \dfrac{E(u_j^{'}(W^2u_j) + (Wu_j)^{'}(Wu_j))}{n} & -\dfrac{E((Wu_j)^{'}(W^2u_j))}{n} & 0 \end{bmatrix} \begin{bmatrix} \rho_j \\ \rho_j^2 \\ \sigma_j^2 \end{bmatrix}
$$

(10)

The right-hand side of equation (10) can be written in the following form:

$$
\frac{1}{n}\begin{bmatrix} 2\tilde{u}'_{j,n}\tilde{\bar{u}}_{j,n} & -\tilde{\bar{u}}'_{j,n}\tilde{\bar{u}}_{j,n} & n \\ 2\tilde{\bar{u}}'_{j,n}\tilde{\bar{\bar{u}}}_{j,n} & -\tilde{\bar{\bar{u}}}'_{j,n}\tilde{\bar{\bar{u}}}_{j,n} & Tr(W_n'W_n) \\ \tilde{u}'_{j,n}\tilde{\bar{\bar{u}}}_{j,n} + \tilde{\bar{\bar{u}}}'_{j,n}\tilde{\bar{u}}_{j,n} & -\tilde{\bar{u}}'_{j,n}\tilde{\bar{\bar{u}}}_{j,n} & 0 \end{bmatrix} \begin{bmatrix} \rho_j \\ \rho_j^2 \\ \sigma_j^2 \end{bmatrix} \qquad (11)
$$

This system of equation can be written as

$$
\gamma_{j,n} = \Gamma_{j,n}\alpha_j \quad \rightarrow \alpha_j = \Gamma_{j,n}^{-1}\gamma_{j,n} \qquad (12)
$$

where $\Gamma_{j,n} = \frac{1}{n}\begin{bmatrix} 2\tilde{u}'_{j,n}\tilde{\tilde{u}}_{j,n} & -\tilde{\tilde{u}}'_{j,n}\tilde{\tilde{u}}_{j,n} & n \\ 2\tilde{\tilde{u}}'_{j,n}\tilde{\tilde{\tilde{u}}}_{j,n} & -\tilde{\tilde{\tilde{u}}}'_{j,n}\tilde{\tilde{\tilde{u}}}_{j,n} & Tr(W'_nW_n) \\ \tilde{u}'_{j,n}\tilde{\tilde{\tilde{u}}}_{j,n} + \tilde{\tilde{u}}'_{j,n}\tilde{\tilde{u}}_{j,n} & -\tilde{\tilde{u}}'_{j,n}\tilde{\tilde{\tilde{u}}}_{j,n} & 0 \end{bmatrix}$

The parameter vector $\rho_j, \rho_j^2, \sigma_j^2$ would be determined in terms of the relation in equation (12). They minimize the following equation:

$$\left[g_{j,n} - \Gamma_{j,n} \begin{bmatrix} \rho_{j,n} \\ \rho_{j,n}^2 \\ \sigma_{jj} \end{bmatrix} \right]' \left[g_{j,n} - \Gamma_{j,n} \begin{bmatrix} \rho_{j,n} \\ \rho_{j,n}^2 \\ \sigma_{jj} \end{bmatrix} \right]$$

$$\Gamma_{j,n} = \frac{1}{n}\begin{bmatrix} 2\tilde{u}'_{j,n}\tilde{\tilde{u}}_{j,n} & -\tilde{\tilde{u}}'_{j,n}\tilde{\tilde{u}}_{j,n} & n \\ 2\tilde{\tilde{u}}'_{j,n}\tilde{\tilde{\tilde{u}}}_{j,n} & -\tilde{\tilde{\tilde{u}}}'_{j,n}\tilde{\tilde{\tilde{u}}}_{j,n} & Tr(W'_nW_n) \\ \tilde{u}'_{j,n}\tilde{\tilde{\tilde{u}}}_{j,n} + \tilde{\tilde{\tilde{u}}}'_{j,n}\tilde{\tilde{u}}_{j,n} & -\tilde{\tilde{u}}'_{j,n}\tilde{\tilde{\tilde{u}}}_{j,n} & 0 \end{bmatrix}, \qquad g_{j,n} = \frac{1}{n}\begin{bmatrix} \tilde{u}'_{j,n}\tilde{u}_{j,n} \\ \tilde{\tilde{u}}'_{j,n}\tilde{\tilde{u}}_{j,n} \\ \tilde{u}'_{j,n}\tilde{\tilde{u}}_{j,n} \end{bmatrix} \qquad (13)$$

Where $\tilde{\tilde{u}}_{j,n} = W_n\tilde{u}_{j,n}$ and $\tilde{\tilde{\tilde{u}}}_{j,n} = W_n^2$.

5.4.4 Estimation of GS2SLS

In this stage, a Cochrane-Orcutt type transformation is applied to dependent, endogenous, and exogenous variables of the single-equation spatial econometric model by using estimated spatial autoregressive parameters to account for the spatial correlation. Let $y^*_{j,n} = y_{j,n} - \tilde{\rho}_j W_n y_{j,n}$ and $Z^*_{j,n} = Z_{j,n} - \tilde{\rho}_j W_n Z_{j,n}$. Then the equation becomes:

$$y^*_{j,n}(\rho_j) = Z^*_{j,n}(\rho_j)\delta_j + \varepsilon_{j,n} \quad \rightarrow \quad \hat{\delta}_{j,n} = \left[\hat{Z}^*_{j,n}(\rho_j)'\hat{Z}^*_{j,n}(\rho_j)\right]^{-1}\hat{Z}^*_{j,n}(\rho_j)'y^*_{j,n}(\rho_j)$$

(14) where $\hat{Z}^*_{j,n}(\rho_j) = P_H Z^*_{j,n}(\rho_j)$ with $P_H = H_n(H'_n H_n)^{-1}H'_n$ assuming ρ_j is known. This $\hat{\delta}_{j,n}$ becomes the GS2SLS estimator. The feasible GS2SLS estimator for ρ_j,

(say $\hat{\rho}_j^F$) is now defined by substituting the generalized moments estimator $\tilde{\rho}_{j,n}$ for ρ_j in equation (14), that is

$$\hat{\delta}_{j,n}^F = \left[\hat{Z}_{j,n}^*(\tilde{\rho}_j)'\hat{Z}_{j,n}^*(\tilde{\rho}_j)\right]^{-1}\hat{Z}_{j,n}^*(\tilde{\rho}_j)'y_{j,n}^*(\tilde{\rho}_j) \qquad (15)$$

5.4.5 Full Information Estimation (GS3SLS)

Up to this point, our model accounts for the potential spatial correlation, but it does not take into account the potential cross-equation correlation in the innovation vector ε_j. To account for this, it is helpful to stack the equations in (14) as

$$y_n^*(\rho) = Z_n^*(\rho)\delta + \varepsilon_n \qquad (16)$$

where

$$y_n^*(\rho) = (y_{1,n}^*(\rho_1)',....,y_{m,n}^*(\rho_m)')',$$

$$Z_n^*(\rho) = diag_{j=1}^m(Z_{j,n}^*(\rho_j)) \quad ; \quad \rho = (\rho_1,....,\rho_m)' \text{ and } \delta = (\delta_1',.....,\delta_m')'$$

It is assumed that $E\varepsilon_n = 0$ and $E\varepsilon_n\varepsilon_n' = \Sigma \otimes I_n$. If ρ and Σ are known, a natural system of instrumental variables estimator of δ would be

$$\breve{\delta}_n = [\hat{Z}_n^*(\rho)'(\Sigma^{-1} \otimes I_n)(\hat{Z}_n^*(\rho)]^{-1}\hat{Z}_n^*(\rho)'(\Sigma^{-1} \otimes I_n)y_n^*(\rho) \qquad (17)$$

Where $\hat{Z}_n^*(\rho) = diag_{j=1}^m(\hat{Z}_{j,n}^*(\rho_j))$ and $\hat{Z}_{j,n}^*(\rho_j) = P_H Z_{j,n}^*(\rho_j)$

To estimate equation (16), the estimators for ρ and Σ are needed to be found. Let $\tilde{\rho}_n = (\tilde{\rho}_{1,n},....,\tilde{\rho}_{m,n})'$ where $\tilde{\rho}_{j,n}$ denotes the generalized moments estimator for ρ_j. The consistent estimator of Σ is $\hat{\Sigma}_n$ where $\hat{\Sigma}_n$ is estimated as a $m \times m$ matrix whose $(j,l)^{\text{th}}$ element is $\hat{\sigma}_{jl,n} = n^{-1}\tilde{\varepsilon}_{j,n}\tilde{\varepsilon}_{l,n}$ and $\tilde{\varepsilon}_{j,n} = y_{j,n}^*(\tilde{\rho}_{j,n}) - Z_{j,n}^*(\tilde{\rho}_{j,n})\hat{\delta}_{j,n}^F$. (18)

Replacing the value consistent estimator in equation (17), a feasible GS3SLS estimator is obtained as

$$\breve{\delta}_n^F = [\hat{Z}_n^*(\widetilde{\rho})'(\hat{\Sigma}^{-1} \otimes I_n)(\hat{Z}_n^*(\widetilde{\rho})]^{-1} \hat{Z}_n^*(\widetilde{\rho})'(\hat{\Sigma}^{-1} \otimes I_n) y_n^*(\widetilde{\rho}_n) \qquad (19)$$

5.5. Model Specification

The model developed, specified, and estimated below is a combination of labor markets, housing markets, demography, and local public finance variables; however, the labor markets play the central role in this modeling framework. The model is built on the assumption that economic growth is largely caused by an exogenous increase in employment. Employers create local jobs while the residential choices of employees create local labor forces. Each employer faces a short-run labor supply within commuting distance from the plant, known as the commuting shed. Other employers within the commuting shed share the same workforce. Similarly, each member of the local labor force faces a demand for labor that consists of the sum of all jobs within his or her commuting shed. Also, other workers within the commuting shed share the same labor demand forces but may be subject to labor demands form outside the commuting shed of the first worker.

Individual workers make residential decisions based on job availability, relative costs of living, local amenities, quality of public services, and other items that affect their quality of life. The workers also choose among available jobs based on skill requirements, wage rates, job security, and commuting costs. As the same time, employers locate their plants based on cost of doing business, marketing considerations, and the availability of workers and other resources. The labor market allocates jobs among the currently employed, in-commuters, out-commuters, and in-migrants. Some new jobs are also taken by currently employed workers who change positions.

As Tiebout (1956) points out, the workers also choose a residence community that offers a mix of local public goods and services best suited to their tastes. By choosing to relocate, or "voting with their feet," consumers reveal their preferences for local public goods. Together with the labor market and public goods market equilibrium, the population of local areas is determined.

Our model has 10 structural equations, each of which has the following general form that is similar to the standard Cliff and Ord (1973) type model with a spatial dependent variable lag and a spatial autoregressive error term:

$$Y_k = a_{k,0} + \lambda_k \overline{Y}_k^N + \sum_{j=1}^{J} \beta_{k,j} Z_{k,j} + \varepsilon_k$$
$$\varepsilon_k = \rho_k W \varepsilon_k + u_k$$

(20)

For the k th equation, Y_k is an $n \times 1$ column vector of observations on the dependent variable, $\overline{Y}_k^N = W \times Y_k$ is an $n \times 1$ column vector of observations on the spatially weighted averages of the dependent variable, $Z_{k,j}$ is an $n \times j$ matrix of observations on the endogenous and exogenous variables for the k th dependent variable, W is an $n \times n$ matrix of spatial weights that relate all locations in our cross-section sample to their neighboring locations. The parameters a, λ, β, and ρ are the GS3SLS estimates, ε is a spatially related regression error term, and u is a regression error term with the usual independent and identically distributed statistical properties. Furthermore, the spatially related error term (ε_k) can be solved in terms of ρ_k and W: $\varepsilon_k = \left(I - \rho_k W\right)^{-1} u_k$.

The spatial lag variables for a county are defined as the weighted average values for the set of neighboring counties (i.e., if they are located with 30 km of radial distance). These neighbors' average values for all geographic units are computed by postmultiplying a "row-normalized" spatial weights matrix by a column vector of cross-sectional observations of a variable. A spatial weights matrix is a square matrix that relates each cross-sectional unit to its unique set of neighbor areas. A row-normalized spatial weights matrix (W) is one whose row sums are all equal to one. Three types of row-normalized spatial weights matrices are investigated in this paper.

First, a "simple" gravity (weighted inverse distance) row-normalized spatial weights matrix is used, whose typical values are

$$W_{G1} = \left[w_{ij}\right] = \frac{X_j / D_{ij}}{\sum_{J=1}^{N} X_J / D_{iJ}} \tag{21}$$

if j is a neighbor of i, otherwise $w_{ij} = 0$.

Second, a more typical gravity row-normalized (weighted inverse distance squared) spatial weights matrix was used, whose common elements are

$$W_{G2} = \left[w_{ij}\right] = \frac{X_j / D_{ij}^2}{\sum_{J=1}^{N} X_J / D_{iJ}^2} \tag{22}$$

if j is a neighbor of i, otherwise $w_{ij} = 0$.

The weight variable in the gravity calculation (X) is used to account for issues related to size or mass. Larger and heavier objects are more attractive than are smaller and lighter objects, and places closer together have greater attraction. To measure this size or mass, employment total is used. D_{ij} is the distance (in miles) between locations i and j. Distance is calculated from one population centroid to another.

Third, a row-normalized spatial weights matrix with uniform values was used, whose typical values are $W_U = [w_{ij}] = 1/N_i$ if location j is within 30 km from location i or $w_{ij} = 0$ if not (N_i is the number of location i's neighbors).

As Kelejian and Robinson (1995) point out, two of the estimated parameters in equation (20) need special mention: λ_k and ρ_k (the spatial lag and spatial autoregressive parameters, respectively). The parameter spaces for these estimated coefficients have a restricted range: $1/\psi^*_{k,neg} < \lambda_k, \rho_k < 1/\psi^*_{k,pos}$, where $\psi^*_{k,neg}$ is the largest negative eigenvalue of the spatial weights matrix (W) and $\psi^*_{k,pos}$ is the smallest positive eigenvalue of the spatial weights matrix (W). This range will always provide a "clear" parameter space that includes the value zero. If the spatial weights matrix is "row-normalized" (i.e., the row elements of W sum to 1 or, in other words, form a proportion distribution) then the smallest positive eigenvalue will always equal 1 ($\psi^*_{k,pos} = 1$). However, except for a few theoretical types of spatial weights matrices, the largest negative eigenvalue is greater than −1 ($-1 < \psi^*_{k,neg} < 0$). This means that the parameter space for the spatial lag and spatial autoregressive parameters will be, in general, between some value less than −1 and +1 when the spatial weights matrix is row-normalized.

The expanded version of equation (20) is as follows. The expected signs are presented in the parenthesis just below each explanatory variable.

$$REVLOC = \alpha_1 + \underset{(-)}{\alpha_2 WREVLOC} + \underset{(+)}{\alpha_3 POPTOT} + \underset{(+)}{\alpha_3 EMPNBAS} + \underset{(-)}{\alpha_4 COMIN} + \varepsilon$$

$$EXPLOC = \beta_1 + \underset{(\pm)}{\beta_2 WEXPLOC} + \underset{(+)}{\beta_3 POPTOT} + \underset{(+)}{\beta_4 COMIN} + \underset{(+)}{\beta_5 EMPNBAS} + \varepsilon$$

$$HOUSTOT = \delta_1 + \delta_2 WHOUSTOT + \delta_3 POPTOT + \delta_4 COMIN + \varepsilon$$
$$\qquad (\pm) \qquad (+) \qquad (-)$$

$$POPTOT = \gamma_1 + \gamma_2 WPOPTOT + \gamma_3 POPEAP + \varepsilon$$
$$\qquad (\pm) \qquad (+)$$

$$POPEAP = \lambda_1 + \lambda_2 WPOPEAP + \lambda_3 POPTOT + \lambda_4 EMPNBAS + \varepsilon$$
$$\qquad (\pm) \qquad (+) \qquad (+)$$

$$STDTTOT = \mu_1 + \mu_2 WSTDTTOT + \mu_3 POPTOT + \varepsilon$$
$$\qquad (\pm) \qquad (+)$$

$$COMOUT = \nu_1 + \nu_2 WCOMOUT + \nu_3 POPEAP + \nu_4 EMPTOT + \nu_5 AREA + \nu_6 AEMP +$$
$$\qquad (\pm) \qquad (+) \qquad (-) \qquad (+) \qquad (\pm)$$
$$\nu_7 CEMP + \nu_8 EXPED + \varepsilon$$
$$(+) \qquad (-)$$

$$COMIN = \pi_1 + \pi_2 WCOMIN + \pi_3 POPEAP + \pi_4 EMPTOT + \pi_5 CEMP + \pi_6 AREA + \pi_7 AEMP + \varepsilon$$
$$\qquad (\pm) \qquad (-) \qquad (+) \qquad (-) \qquad (+) \qquad (\pm)$$

$$FIRMTOT = \rho_1 + \rho_2 WFIRMTOT + \rho_3 POPTOT + \rho_4 AREA + \rho_5 AEMP + \varepsilon$$
$$\qquad (\pm) \qquad (+) \qquad (+) \qquad (\pm)$$

$$EMPNBAS = \sigma_1 + \sigma_2 WEMPNBAS + \sigma_3 EMPTOT + \sigma_4 AREA + \sigma_5 EXPED + \sigma_6 AEXPED +$$
$$\qquad (\pm) \qquad (+) \qquad (+) \qquad (+) \qquad (\pm)$$
$$\sigma_7 CEXPED + \varepsilon$$
$$(+)$$

Variables' names and descriptions are presented in Table 5.2.

5.6. Model Estimation Results and Discussion

As mentioned in the previous section, a GS3SLS procedures is applied to estimate the parameter value of our model, which consists of 10 spatially interrelated simultaneous equations. Before estimating the model using GS3SLS, the different models were estimated using ordinary least squares (OLS) and GS2SLS and evaluated individually based on several criteria (adjusted R^2, correct signs, statistical significance). Table 5.3

presents the parameters estimates and their significance by OLS, GS2SLS, and GS3SLS procedures. Overall the signs of the parameter estimates appeared to be robust; however the magnitudes of these estimates vary across different estimation procedure used. In some cases, not only the magnitude of the coefficient change, but also the sign of the coefficients flip as the estimation procedure is changed. For example, the variable in-commuters appears to be significant and positive in explaining local revenue in OLS model, however it is negative and significant in GS3SLS model. The same variable appears to be non-significant in local expenditure equation using OLS procedure, however it is highly significant and negative in GS3SLS. Likewise, spatial lag of local revenue is negative and significant in local revenue equation when used OLS procedure, however it is positive and significant when used GS3SLS procedure. This shows that when spatial interaction and cross-equation interaction are taken into account, the unbiased parameter estimates may be estimated. Compared to GS2SLS, it is found that the magnitude of the GS3SLS coefficients of many explanatory variables appear to have changed significantly. Most estimated parameter values are significant at the 1% level and a few at the 5% and 10% levels. The fact that all equations have a R^2 value higher than 0.90 indicates that our model possesses reasonably high explanatory power. Most of the estimated parameter values have signs that would be expected or can be explained. The results are based on a gravity-based row-normalized weight matrix (weight divided by distance); however, different weight matrices have been tried. A separate section is devoted to a detailed sensitivity analysis of weight matrices. The following results and their interpretations are based on simultaneous spatial lag model (SL3SLS).

The majority of spatial lags of dependent variables appear to be significant at the 5% level. This shows evidence of significant spatial spillover in Korean regions. Based on the magnitude of the estimated coefficients, the positive spatial pattern appears to be strongest for population, students' numbers, out-commuters, and in-commuters. The negative spatial pattern appears to be strongest for local expenditures and number of firms. The negative sign of the spatial lag of local expenditure supports previous studies in which local public expenditures (e.g., transport, education, parks and recreation) have spillover effects in the neighborhood (Case, Hines, and Resen, 1993; Murdoch, Rahmatian, and Thayer, 1993).

The spatial lag of local revenue is insignificant. This may be partly due to (1) overdependence of local regions on central government for revenue generation; (2) less flexibility on the part of local government for policy making; and (3) formula-driven revenue collection. The coefficients of spatial lag of population and the number of students are not significant. As expected, spatial dependence for in-commuting and out-commuting is positive and significant.

As expected, local revenue is positively and significantly impacted by population, and non-basic employment, whereas it is negatively impacted by in-commuting. Local expenditure is found to be dependent on and influenced by population and employment in non-basic sectors significantly and positively. Unexpectedly, it is negatively impacted by in-commuting. It is hypothesized that in-commuting will exert a positive influence on local expenditure because it represents the daytime population of the area, and higher demand for services by employer which further pushes the demand for local services. This may be due to lack of an income variable in the local expenditure equation. Due to the lack of an income variable, it is not possible to test the hypothesis that more affluent communities demand higher quality services and are more willing to pay for them.

The total housing units equation is estimated as a function of spatial lag of itself, population, and in-commuting. As expected, total population is found to be the most important determinant of housing units. It is estimated that in-commuting is significantly and negatively associated with total housing units; which is expected.

A population equation is estimated as a function of spatial lag of itself and economically active population. Because labor force data is not available, the economically active population is used as a proxy of labor force. As expected, economically active population is found to be significant to explain the population.

As a proxy of labor force, economically active population equation is estimated as a function of spatial lag of itself, population, and employment in non-basic sectors. As expected, economically active population is positively impacted by population and employment in non-basic sectors. Student numbers is estimated as a function of spatial lag of itself and population. As expected, student number is positively and significantly impacted by population.

Out-commuting equation is estimated as a function of spatial lag of itself, economically active population, employment, area, area×employment, external employment, and economic development expenditures. The variable area × employment is also called as expansion variable which captures the structural changes that are caused by the different sizes of counties. All variables are significant. The signs of all variables are as expected. It appears that external employment drives the out-commuting up whereas economic development expenditures drive it down. The estimated parameter of the expansion variable (area × employment) is significant and negative. This implies that for larger counties, the area variable decreases the marginal effect of employment on out-commuting even though the area variable alone may not be significant. In this case, the area variable is also significant and positive. As expected, the positive sign of the coefficient for the area variable shows that as the county area increases, out-commuting also increases.

In-commuting is estimated as a function of the spatial lag of itself, economically active population, employment, external employment, area, area × employment. The signs of all variables are as expected except for external employment. An increase in economically active population tends to decrease the in-commuting; which is logical. As expected, the employment variable is found to be significant and positive. This implies that increased employment opportunities in residence counties create increased in-commuting. Surprisingly, the external employment is positive and significant. Area variable has an unexpected positive sign but it not significant. The expansion variables (area × employment) have a significant and negative coefficient. It appears that for larger counties the area variable decreases the marginal effect of employment on in-commuting.

The number of firms is modeled as a function of spatial lag of itself, population, area, and area×employment. All variables have expected signs and are significant. It appears that number of firms increases as the area, population, area × employment increase. As expected, the number of firm variable is strongly and negatively impacted by spatial lag of itself. This implies that there is competition among firms located in residence counties and neighboring counties.

Employment in non-basic sectors is estimated as a function of the spatial lag of itself, employment total, area, economic development expenditures, external economic development expenditures, and expansion variable—area × economic development expenditures. All explanatory variables are found to be significant except spatial lag of dependent variable and external economic development expenditures. The negative sign of the spatial lag variable indicates that increased non-basic employment in neighboring regions negatively impacts the residence county. As expected, employment total variable significantly and positively impacts non-basic employment. The economic development expenditures appear to impact significantly and positively. The coefficient of area × economic development expenditures appear to be negative and significant. This implies that for larger counties the area variable decreases the marginal effect of economic development expenditure on non-basic employment.

5.6.1 Sensitivity of Choice of Spatial Linkages

The many alternative methods of specification of spatial linkages creates difficulties and controversies in spatial data analysis. Sensitivity analysis is used to determine how "sensitive" a model is to changes in the weight matrices representing different spatial linkages. It is possible to build the confidence in the model by studying uncertainties that are associated with different weight matrices. As mentioned earlier, three spatial weight matrices are used based on distance, weight and inverse distance, and weight and inverse distance squared. The latter two are also called gravity based matrices. The total employment is used as a weight variable. Using different matrices, the model (Table 5.4) is estimated using GS3SLS procedure. Overall results appear to be robust across different spatial linkages**.** However, the magnitude and significance of coefficients of some variables are found to be sensitive to the choice of spatial matrices. For example, spatial lag of local expenditure is significant and negative in the model that used the gravity based weight matrices, whereas it is not significant in the model that used uniform weight matrix. The spatial lag of economically active population is negative and significant when used with uniform weight matrices, however it is not significant when gravity based weight matrices were used. However the sign remains the same. Likewise, spatial lag of employment in non-basic sectors is significant and negative in a model that used uniform spatial weight matrix whereas the same variable is not significant in both the models that used gravity based weight matrices. In some cases, it appears that the magnitude of the variables are also changed, which shows that analytical results may be sensitive to the specification of spatial weight matrix.

5.6.2 Model Validation

The fact is that in general model validation and model building processes move together. Before deciding on a "ideal" model, MAPE was used as a measure of the forecast accuracy to evaluate these models (Table 5.7). Based on MAPE criterion used in in-sample data, it appears that not all equations consistently perform well (see Table 5.8). Predictive accuracy of local revenue, local expenditures, population, out-commuters, number of firms and employment in non-basic sectors are found to be better in the SLE3SLS model, whereas housing units, economically active population, total students are better forecasted by the SL3SLS model. None of the equations in a SE3SLS model and NS3SLS model have better forecasting accuracy than the SLE3SLS model, and SL3SLS model except in-commuting variable. This implies that there exists a significant spatial spillover effect in Korean local economies. Although both SL3SLS and SLE3SLS models appeared to be similar in terms of overall MAPE statistic, SL3SLS model have an advantage of being parsimonious. Another advantage of SL3SLS over SLE3SLS is that the reduced form solutions are easy to handle and make intuitive sense. Therefore, reduced form estimates is estimated using structural equation obtained from SL3SLS model.

5.6.2 Reduced Form Estimates

The reduced form equations are obtained by solving structural equations derived from SL3SLS model. In this case, all endogenous variables are functions of exogenous variables. Solving spatial structural equations to obtain a reduced form equation is a daunting task. However, by following Kelejian and Prucha (2004), we[6] obtained a reduced form estimate of spatial simultaneous lag model which is as follows.

$$Y_n = Y_n B + X_n C + \bar{Y}_n A + U_n \qquad (1)$$

$$Y_n = (y_{1,n}, \ldots, y_{m,n}),\ X_n = (x_{1,n}, \ldots x_{k,n}),\ U_n = (u_{1,n}, \ldots, u_{m,n}),\ \bar{Y} = (\bar{y}_{1,n}, \ldots, \bar{y}_{m,n})$$

$$\bar{y}_{j,n} = W_n y_{j,n} \quad j = 1, \ldots, m \qquad \bar{y}_{ij,n} = \sum_{r=1}^{n} w_{ir,n} y_{rj,n.}$$

where *n* is regions, *m* endogenous variables, and *k* exogenous variable. The dimension of coefficient as follows: $B_{(m\times m)}$, $C_{(k\times m)}$, $A_{(m\times m)}$

$$y_n = vec(Y_n) = \begin{pmatrix} y_{1,n} \\ \vdots \\ \vdots \\ y_{m,n} \end{pmatrix} \qquad x_n = vec(X_n) = \begin{pmatrix} x_{1,n} \\ \vdots \\ \vdots \\ x_{k,n} \end{pmatrix}$$

If A_1 and A_2 are conformable matrices, then $vec(A_1\ A_2) = (A_2' \otimes I)vec(A_1)$ (Berck et al 1993).

Following this rule, reduced form solution of equation (1) would be as follows.

[6] Dr. Dennis Robinson with the help of Kelejian and Prucha (2004) developed the equation (24).

$$y_n = \left[(B' \otimes I_n) + (A' \otimes W_n)\right] y_n + (C' \otimes I_n) x_n \qquad (23)$$

$$y_n = \left\{(I_m \otimes I_n) - [(B' \otimes I_n) + (A' \otimes W_n)]\right\}^{-1} (C' \otimes I_n) x_n \qquad (24)$$

The dimension of coefficient matrices are as follows:

$$B'_{(m \times m)} = \begin{bmatrix} 0 & \beta_{12} & \cdots\cdots & \beta_{1m} \\ \beta_{21} & 0 & & \vdots \\ \vdots & & \ddots & \vdots \\ \vdots & & \ddots & \vdots \\ \beta_{m1} & \cdots & \beta_{m,m-1} & 0 \end{bmatrix} \qquad A'_{m \times m} = \begin{bmatrix} \lambda_1 & 0 & \cdots & 0 \\ 0 & \lambda_2 & & 0 \\ \vdots & & \ddots & \vdots \\ 0 & \cdots & \cdots\ 0 & \lambda_m \end{bmatrix}$$ when only the dependent variable has spatial lag.

Reduced form estimate is very huge to present in a table, however the results of impact estimates are presented in the next section.

5.6.3 Impact Estimation

The uniqueness of the solution is that cross-county spatial spillover effect can be estimated through this model. Once the reduced form equation is obtained, it can be used for impact analysis purpose. Although there are seven exogenous variables in the model, employment is one of the main driving forces for all sectors of the economy. Changes in employment lead to increases in population and wage levels, which ultimately alter demands for public services and the revenues available to fund these services. To demonstrate how the model works, and to determine a reasonable estimate of the impact, a 1000 jobs increase is hypothesized in Gujang county of Punsan Province. As a test community, Gijang County is a fairly small county with a population of approximately 73,000. Using the reduced form coefficients of our model, the impacts of an employment change was estimated on the Gijang County economy. Change in employment also changes the external employment for other counties. It also affects the expansion variable area × employment. After accounting for these changes, the impact of 1,000 new jobs was estimated using a reduced form equation of spatial lag simultaneous equation model.

The creation of additional jobs caused an increase in local revenue of 3.6 billion won and an increase in expenditures of 3.2 billion won. The new jobs also caused the following increases:

- total housing units by 482;
- economically active population by 1660;
- number of students by 356;
- in-commuters by 319;
- out-commuters by 267;
- number of firms by 191;
- non-basic employment by 813.

Also estimated was the spatial spillover effect of additional 1000 jobs to neighboring regions. It is found that 10 neighboring counties impacted by this change in employment; however only four counties appeared to have sizable impact (Table 5.6). Once the spatial impact spillover to counties (other than Gijang) is removed, the impacts estimated from spatial and non-spatial model can be compared. The results show that the intra-county impact estimates of the non-spatial model are 10% to 9% lower than the impacts estimated by the spatial model for four dependent variables (local revenue, local expenditure, housing units, and number of firms) (Table 5.6b). This implies that if the spatial spillover effect is ignored, we may be underestimating the impact on these variables. In in-and out-commuting, non-spatial model overestimate the impact- 19% and 24% respectively. Population related variables such as total population, total students and economically active population, both model predictions found to be comparable. This implies that there is little spatial spillover effect in these variables. This shows that accounting for spatial interactions is imperative to improve model performance.

5.7. Summary and Conclusion

As stated previously in the research objective, the primary goal of this study was to develop and estimate a model that accounts for the cross-county and cross-equation spillover effects in local regions in Korea. The different versions of a spatial model is estimated, that accounts for the interregional spillover effect. The model-building process began with the estimation and evaluation of each equation using criteria such as R^2 and *t*-statistics. Then all equations were collapsed into one system and estimated model using GS3SLS. Before finalizing, the model was validated based on predictive accuracy as measured by MAPE statistic. A SL3SLS model is found to be the 'best' model for Korean regions. The model contains equations for local revenue, local expenditures, total housing units, population total, economically active population, number of students l, in- and out-commuting, total firms, and non-basic employment and assumes that employment is the main driver of the Korean regional economy. Other exogenous variables included in this model were economic development expenditures, area, and expansion variables. It is found that a significant cross-county and cross-equation spillover effects exist in Korean regions. The results in some cases appear to be sensitive to the choice of spatial linkages as defined by weight matrices.

Table 5.1. Revenue Structure of Local Government in Korea

	Year				
Sources of Revenue (%)	2000	2001	2002	2003	2004
Local tax	35.3	37.2	37.4	34.3	35.1
Non-tax revenue	28.9	25.6	26.2	33.1	34.5
Transfer revenue from central government	34.4	35.8	35.6	32.1	29.8
Local bond	1.4	1.1	0.7	0.6	0.6

Sources: *Financial Yearbook of Local Government, 2000-2004*.

Table 5.2. Variables, Variable Descriptions, and Descriptive Statistics[a]

Variable	Label	Mean	SD	Minimum	Maximum
AREA	Area in square kilometers	591	334	33	1818
POP_TOT2	Population squared (million)	792206	7429204	69	96435758
EMP_TOT	Total employed people	118789	357844	4871	4363664
A_EMP	Area × employment	71211531	230541742	353440	2640000000
EXP_ED	Economic development expenditures	126575	256145	16683	2874672
C_EMP	External employment	676840	1461423	0	7237904
A_EXPED	Area × economic development expenditures	80169595	177829596	1012324	1740000000
REV_LOC	Local Annual Revenue	638431	1480464	51330	17800000
EXP_LOC	Local annual expenditures	495175	1342015	91257	16200000
HOUS_TOT	Total housing units	75301	206345	2890	2321949
POP_TOT	Total population	277547	848148	8331	9820171
POP_EAP	Economically active population	197650	637780	5597	7432406
STDT_TOT	No. of total students	48960	138099	1193	1528649
COM_OUT	Out-commuters	20950	50672	0	464489
COM_IN	In-commuters	21122	79203	0	1006101
FIRM_TOT	Total number of firms	31010	79595	1914	946620
EMP_NBAS	Non basic employment other than farm and manufacturing employment	77538	313949	3119	3878251
W_REV_LOC	Spatial lag of local revenue	671322	662841	0	3336419
W_EXP_LOC	Spatial lag of local expenditures	528140	572401	0	2902942
W_HOUS_TOT	Spatial lag of total housing units	80325	97291	0	470909
W_POP_TOT	Spatial lag of total population	301585	398613	0	1890502
W_POP_EAP	Spatial lag of economically active population	216128	297233	0	1403936
W_STDT_TOT	Spatial lag of total students	52591	67634	0	317318
W_COM_OUT	Spatial lag of out-commuters	22754	36490	0	153646
W_COM_IN	Spatial lag of in-commuters	24781	41251	0	180649
W_FIRM_TOT	Spatial lag of firm total	33087	33851	0	169629
W_EMP_NBAS	Spatial lag of employment in non-basic sectors	87971	132658	0	630065

[a]*N* = 172

Table 5.3. Regression Results: Ordinary Least Squares and Generalized Spatial Two-Stage and Three-Stage Least Squares

Model	Variables	OLS Estimates	*p*-value	GS2SLS Estimates	*p*-value	GS3SLS Estimates	*p*-value
Local Revenue	Intercept	208493.2	<.0001	206064.8	<.0001	215844.7	<.0001
	W_REV_LOC[a]	-0.01289	0.0004	-0.00799	0.0619	0.000245	0.9495
	POP_TOT	1.21358	<.0001	1.190056	<.0001	0.9272	<.0001
	EMP_NBAS	1.206571	<.0001	1.645595	0.0003	2.797318	<.0001
	COM_IN[a]	0.984833	0.0241	-0.58531	0.3378	-2.46465	<.0001
	Adj R^2	0.99311		0.99246			
Local Expenditure	Intercept	133054.6	<.0001	122873.5	<.0001	125231	<.0001
	W_EXP_LOC	-0.01538	<.0001	-0.01398	0.0002	-0.00759	0.0199
	POP_TOT	0.77954	<.0001	0.93104	<.0001	0.828126	<.0001
	COM_IN[a]	-0.35441	0.2903	-1.27861	0.0087	-2.75825	<.0001
	EMP_NBAS	2.256863	<.0001	2.072154	<.0001	2.696653	<.0001
	Adj R^2	0.99496		0.9942			
Total Housing Units	Intercept	6814.276	<.0001	6323.118	<.0001	6234.474	<.0001
	W_HOUS_TOT	0.001455	0.4146	0.002575	0.1666	0.002704	0.1291
	POP_TOT	0.269944	<.0001	0.276472	<.0001	0.278249	<.0001
	COM_IN	-0.31962	<.0001	-0.39366	<.0001	-0.41414	<.0001
	Adj R^2	0.99794		0.99779			
Population	Intercept	13715.63	<.0001	13833.41	<.0001	13857.61	<.0001
	W_POP_TOT	0.001232	0.0646	0.001251	0.0609	0.00118	0.0749
	POP_EAP	1.329447	<.0001	1.328766	<.0001	1.328956	<.0001
	Adj R^2	0.99969		0.99969			
Economically Active Population	Intercept	-6524.46	<.0001	-7211.04	<.0001	-8084.37	<.0001
	W_POP_EAP	0.000526	0.1009	0.000198	0.5647	-0.00027	0.4188
	POP_TOT	0.678005	<.0001	0.69121	<.0001	0.70867	<.0001
	EMP_NBAS	0.201956	<.0001	0.166249	<.0001	0.118865	<.0001
	Adj R^2	0.99993		0.99992			
Total students	Intercept	2867.04	0.0101	2980.941	0.0077	3044.891	0.0064
	W_STDT_TOT	0.007795	0.0255	0.008244	0.0187	0.007748	0.026
	POP_TOT	0.162	<.0001	0.161355	<.0001	0.161384	<.0001
	Adj R^2	0.99199		0.99187			

Table 5.3 (Continued)

Model	Variables	OLS Estimates	p-value	GS2SLS Estimates	p-value	GS3SLS Estimates	p-value
Out-commuters	Intercept	2500.981	0.5075	4573.762	0.3178	5416.765	0.0738
	W_COM_OUT	0.074225	0.0022	0.076689	0.0027	0.049511	0.0089
	POP_EAP	0.275318	<.0001	0.325594	<.0001	0.293916	<.0001
	EMP_TOT	-0.19169	<.0001	-0.25209	0.002	-0.18701	0.0001
	AREA	13.08926	0.0061	14.75031	0.0048	11.60425	0.0013
	A_EMP	-0.00015	<.0001	-0.00015	0.0001	-0.00019	<.0001
	C_EMP[a]	0.004082	0.0099	0.002917	0.1313	0.003467	0.0054
	EXP_ED	-0.13358	<.0001	-0.17435	0.0032	-0.14554	<.0001
	Adj R^2	0.91073		0.90294			
In-commuters	Intercept	-17248	<.0001	-16542.9	<.0001	-14894.8	<.0001
	W_COM_IN	0.022585	0.0824	0.028774	0.0403	0.041301	<.0001
	POP_EAP	-0.20717	<.0001	-0.30485	<.0001	-0.32454	<.0001
	EMP_TOT	0.714042	<.0001	0.847401	<.0001	0.90801	<.0001
	C_EMP	0.006158	0.0002	0.007596	<.0001	0.004096	<.0001
	AREA	8.128212	0.122	2.932154	0.6087	1.666451	0.7437
	A_EMP	-0.00023	<.0001	-0.00016	0.0001	-0.0002	<.0001
	Adj R^2	0.95433		0.94868			
Number of Firms	Intercept	7575.904	<.0001	5505.969	0.0002	5690.407	<.0001
	W_FIRM_TOT	-0.01497	<.0001	-0.0187	<.0001	-0.01549	<.0001
	POP_TOT	0.071471	<.0001	0.083347	<.0001	0.081191	<.0001
	AREA	-1.73317	0.378	1.971042	0.3525	1.2376	0.3895
	A_EMP	0.000083	<.0001	0.00004	0.0085	0.000048	<.0001
	Adj R^2	0.99347		0.99301			
Employment in non-basic sectors	Intercept	-38512.3	<.0001	-38509.1	<.0001	-39312.2	<.0001
	W_EMP_NBAS	0.002703	0.5473	0.001792	0.6901	-0.00042	0.9067
	EMP_TOT	0.86757	<.0001	0.867186	<.0001	0.815499	<.0001
	AREA	21.2381	0.008	21.21444	0.0081	16.74665	0.0051
	EXP_ED	0.231969	0.0009	0.232615	0.0008	0.256987	<.0001
	A_EXPED	-0.00034	<.0001	-0.00034	<.0001	-0.00027	<.0001
	C_EXPED	-0.00378	0.212	-0.0033	0.276	-0.00102	0.6404
	Adj R^2	0.9951		0.99509			

[a]Indicates that the significance of the coefficient change as we change estimation procedures.

Table 5.4. Generalized Spatial Three-Stage Least Squares Results using Different Weight Matrices

Model	Variables	Uniform		Weight and distance		Weight and distance squared	
		estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Local Revenue	Intercept	208901.9	<.0001	215844.7	<.0001	215844.7	<.0001
	W_REV_LOC	0.007976	0.6931	0.000245	0.9495	0.000245	0.9495
	POP_TOT	0.956666	<.0001	0.9272	<.0001	0.9272	<.0001
	EMP_NBAS	2.695301	<.0001	2.797318	<.0001	2.797318	<.0001
	COM_IN	-2.383	<.0001	-2.46465	<.0001	-2.46465	<.0001
Local Expenditure	Intercept	130199.4	<.0001	125231	<.0001	125231	<.0001
	W_EXP_LOC[a]	-0.01917	0.2649	-0.00759	0.0199	-0.00759	0.0199
	POP_TOT	0.755258	<.0001	0.828126	<.0001	0.828126	<.0001
	COM_IN	-2.9486	<.0001	-2.75825	<.0001	-2.75825	<.0001
	EMP_NBAS	2.937372	<.0001	2.696653	<.0001	2.696653	<.0001
Total Housing Units	Intercept	5016.323	<.0001	6234.474	<.0001	6234.474	<.0001
	W_HOUS_TOT[a]	0.022468	0.0031	0.002704	0.1291	0.002704	0.1291
	POP_TOT	0.279945	<.0001	0.278249	<.0001	0.278249	<.0001
	COM_IN	-0.4364	<.0001	-0.41414	<.0001	-0.41414	<.0001
Population	Intercept	12724.93	<.0001	13857.61	<.0001	13857.61	<.0001
	W_POP_TOT	0.007379	0.0099	0.00118	0.0749	0.00118	0.0749
	POP_EAP	1.328597	<.0001	1.328956	<.0001	1.328956	<.0001
Economically Active Population	Intercept	-7554.63	<.0001	-8084.37	<.0001	-8084.37	<.0001
	W_POP_EAP[a]	-0.00288	0.0498	-0.00027	0.4188	-0.00027	0.4188
	POP_TOT	0.707171	<.0001	0.70867	<.0001	0.70867	<.0001
	EMP_NBAS	0.123211	<.0001	0.118865	<.0001	0.118865	<.0001
Students Total	Intercept	2391.439	0.0488	3044.891	0.0064	3044.891	0.0064
	W_STDT_TOT	0.03472	0.0136	0.007748	0.026	0.007748	0.026
	POP_TOT	0.161209	<.0001	0.161384	<.0001	0.161384	<.0001
Out-commuters	Intercept	-1535.2	0.5927	5416.765	0.0738	5416.765	0.0738
	W_COM_OUT	0.237803	<.0001	0.049511	0.0089	0.049511	0.0089
	POP_EAP	0.189387	<.0001	0.293916	<.0001	0.293916	<.0001
	EMP_TOT	-0.06215	0.1223	-0.18701	0.0001	-0.18701	0.0001
	AREA	10.68272	0.0025	11.60425	0.0013	11.60425	0.0013
	A_EMP	-0.00019	<.0001	-0.00019	<.0001	-0.00019	<.0001
	C_EMP	0.003746	0.0003	0.003467	0.0054	0.003467	0.0054
	EXP_ED	-0.06784	0.0066	-0.14554	<.0001	-0.14554	<.0001
In-commuters	Intercept	-16701.9	<.0001	-14894.8	<.0001	-14894.8	<.0001
	W_COM_IN	0.183798	<.0001	0.041301	<.0001	0.041301	<.0001
	POP_EAP	-0.33579	<.0001	-0.32454	<.0001	-0.32454	<.0001
	EMP_TOT	0.925822	<.0001	0.90801	<.0001	0.90801	<.0001
	C_EMP	0.003844	0.0001	0.004096	<.0001	0.004096	<.0001
	AREA	2.334738	0.6465	1.666451	0.7437	1.666451	0.7437
	A_EMP	-0.0002	<.0001	-0.0002	<.0001	-0.0002	<.0001

Table 5.4. (Continued)

Model	Variables	Uniform		Weight and distance		Weight and distance squared	
		estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Firms Total	Intercept	6436.575	<.0001	5690.407	<.0001	5690.407	<.0001
	W_FIRM_TOT	-0.06122	<.0001	-0.01549	<.0001	-0.01549	<.0001
	POP_TOT	0.079388	<.0001	0.081191	<.0001	0.081191	<.0001
	AREA	1.154086	0.4264	1.2376	0.3895	1.2376	0.3895
	A_EMP	0.000055	<.0001	0.000048	<.0001	0.000048	<.0001
Employment in non-basic sectors	Intercept	-35139.4	<.0001	-39312.2	<.0001	-39312.2	<.0001
	W_EMP_NBAS[a]	-0.06311	<.0001	-0.00042	0.9067	-0.00042	0.9067
	EMP_TOT	0.816538	<.0001	0.815499	<.0001	0.815499	<.0001
	AREA	14.66602	0.0137	16.74665	0.0051	16.74665	0.0051
	EXP_ED	0.266305	<.0001	0.256987	<.0001	0.256987	<.0001
	A_EXPED	-0.00029	<.0001	-0.00027	<.0001	-0.00027	<.0001
	C_EXPED[a]	0.00327	0.0756	-0.00102	0.6404	-0.00102	0.6404

[a]Indicates that the significance of the coefficient change as we change weight matrices.

Table 5.6. Economic Impact Estimated From Spatial Lag Model[a].

Province	Gun or Si	REV_LOC	EXP_LOC	HOUS_TOT	POP_TOT	POP_EAP	STDT_TOT	COM_OUT	COM_IN	FIRM_TOT	EMP_NBAS
Pusan	Gijang-Gun	3602.8	3202.5	481.87	2206.21	1660.13	356.00	266.77	319.16	191.57	813.28
Yulsan	Yulju-Gun	-7	-8.14	-1.52	-0.14	-0.09	-0.037	2.268	3.584	0.006	0.016
Gyung-Buk	Pohang-Si	-0.01	-0.01	-0.002	0	0	0	0.004	0.004	0	0
Gyung-Buk	Gyungju-Si	0.18	0.17	0.044	0.01	0	0.002	-0.07	-0.096	0.001	0
Gyung-Nam	Changwon-Si	0	0	-0.001	0	0	0	0	0.001	0	0
Gyung-Nam	Gimhae-Si	0.23	0.23	0.057	0.03	0.02	0.01	-0.008	-0.105	0.004	0.001
Gyung-Nam	Milyang-Si	0	0	-0.001	0	0	0	0	0.001	0	0
Gyung-Nam	Yangsan-Si	-6.98	-7.85	-1.57	-0.35	-0.24	-0.093	2.175	3.539	0.017	0.043
Pusan	Pusan	-6.69	-5	-2.096	-2.83	-1.93	-0.762	0.189	2.878	0.088	0.306
Yulsan	Yulsan	-6.95	-7.59	-1.623	-0.62	-0.42	-0.168	1.879	3.454	0.02	0.067
Gyung-Nam	Jinhae-Si	0	0	0	0	0	0	0	0.001	0	0
Total Impact		3575.58	3174.31	475.156	2202.31	1657.47	354.951	273.206	332.422	191.706	813.709

[a]Effects of 1,000 new jobs created in Gijang County of Punsan Province, Korea

Table 5.6b. Economic Impact Comparison of a Spatial and Non-Spatial Model[a]

Variable	Impact from spatial model	Impact from non-spatial model	Percentage difference
Local revenue (million won)	3603	3144	-13%
Local expenditures (million won)	3203	2587	-19%
Housing units	482	466	-3%
Population	2206	2253	2%
Economically active population	1660	1695	2%
Number of students	356	364	2%
Out-commuters	267	331	24%
In-commuters	319	381	19%
Number of firms	192	172	-10%
Employment in non-basic sector	813	830	2%

[a]Effects of 1,000 new jobs created in Gijang County of Punsan Province, Korea.

Table 5.7. Estimated Coefficients and Probability Value of Non-spatial, Spatial Error, Spatial Lag, and Spatial Lag and Error Models

Model	Variables	Non-spatial 3SLS		Spatial error 3SLS		Spatial lag 3SLS		Spatial lag and spatial error 3SLS	
		estimates	*p*-value	estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Local Revenues	Intercept	248958.7	<.0001	200378.1	<.0001	215844.7	<.0001	202998.7	<.0001
	W_REV_LOC					0.000245	0.9495	-0.00185	0.6453
	POP_TOT	0.514642	<.0001	0.906491	<.0001	0.9272	<.0001	0.920328	<.0001
	EMP_NBAS	4.331033	<.0001	2.904124	<.0001	2.797318	<.0001	2.733832	<.0001
	COM_IN	-4.22237	<.0001	-2.85821	<.0001	-2.46465	<.0001	-2.13439	<.0001
Local Expenditures	Intercept	161408.8	<.0001	144099.9	<.0001	125231	<.0001	130708.3	<.0001
	W_EXP_LOC					-0.00759	0.0199	-0.00744	0.0226
	POP_TOT	0.238276	0.0022	0.511064	<.0001	0.828126	<.0001	0.791542	<.0001
	COM_IN	-5.2472	<.0001	-3.70837	<.0001	-2.75825	<.0001	-2.6689	<.0001
	EMP_NBAS	4.881023	<.0001	3.745249	<.0001	2.696653	<.0001	2.77556	<.0001
Housing Units	Intercept	6752.514	<.0001	6945.258	<.0001	6234.474	<.0001	6283.123	<.0001
	W_HOUS_TOT					0.002704	0.1291	0.001779	0.323
	POP_TOT	0.279791	<.0001	0.270104	<.0001	0.278249	<.0001	0.277602	<.0001
	COM_IN	-0.43113	<.0001	-0.33298	<.0001	-0.41414	<.0001	-0.40934	<.0001
Population	Intercept	14879.16	<.0001	14897.17	<.0001	13857.61	<.0001	12421.59	<.0001
	W_POP_TOT					0.00118	0.0749	0.001284	0.0552
	POP_EAP	1.328957	<.0001	1.32289	<.0001	1.328956	<.0001	1.328152	<.0001
Economically Active Population	Intercept	-8539.31	<.0001	210.484	0.775	-8084.37	<.0001	-7945.61	<.0001
	W_POP_EAP[a]					-0.00027	0.4188	-0.00069	0.0547
	POP_TOT	0.712809	<.0001	0.58699	<.0001	0.70867	<.0001	0.722897	<.0001
	EMP_NBAS	0.107701	<.0001	0.445063	<.0001	0.118865	<.0001	0.080689	<.0001
Students Total	Intercept	4151.407	<.0001	5551.126	<.0001	3044.891	0.0064	3522.026	0.0015
	W_STDT_TOT					0.007748	0.026	0.006017	0.0757
	POP_TOT	0.161446	<.0001	0.15803	<.0001	0.161384	<.0001	0.16096	<.0001
Out-commuters	Intercept	12324.62	0.1878	3614.867	0.0994	5416.765	0.0738	2125.595	0.3771
	W_COM_OUT					0.049511	0.0089	0.049771	0.0128
	POP_EAP	0.479846	0.0213	0.24391	<.0001	0.293916	<.0001	0.225182	<.0001
	EMP_TOT	-0.4823	0.0582	-0.12963	<.0001	-0.18701	0.0001	-0.09711	0.0213
	AREA[a]	12.63693	0.1631	9.860337	0.0066	11.60425	0.0013	11.87638	0.0017
	A_EMP	-0.00017	0.0001	-0.00021	<.0001	-0.00019	<.0001	-0.00019	<.0001
	C_EMP[a]	0.004114	0.282	0.006234	<.0001	0.003467	0.0054	0.003854	0.0016
	EXP_ED[a]	-0.21599	0.2112	-0.09102	<.0001	-0.14554	<.0001	-0.10079	0.0006
In-commuters	Intercept	-12044.8	0.0007	-10000.9	0.0006	-14894.8	<.0001	-11242	0.0004
	W_COM_IN					0.041301	<.0001	0.03773	0.0005
	POP_EAP	-0.33594	<.0001	-0.28069	<.0001	-0.32454	<.0001	-0.35588	<.0001
	EMP_TOT	0.950525	<.0001	0.849605	<.0001	0.90801	<.0001	0.952104	<.0001
	C_EMP	0.00607	<.0001	0.006524	<.0001	0.004096	<.0001	0.004159	0.0002
	AREA	-1.04957	0.8397	2.165106	0.6726	1.666451	0.7437	-0.15282	0.9768
	A_EMP	-0.00024	<.0001	-0.00024	<.0001	-0.0002	<.0001	-0.00019	<.0001

Table 5.7 (Continued)

Model	Variables	Non-spatial 3SLS		Spatial error 3SLS		Spatial lag 3SLS		Spatial lag and spatial error 3SLS	
		estimates	*p*-value	estimates	*p*-value	estimates	*p*-value	estimates	*p*-value
Firms Total	Intercept	4119.179	<.0001	3321.61	0.0003	5690.407	<.0001	4311.7	<.0001
	W_FIRM_TOT					-0.01549	<.0001	-0.01479	<.0001
	POP_TOT	0.076313	<.0001	0.076157	<.0001	0.081191	<.0001	0.082411	<.0001
	AREA	1.765313	0.1887	1.719598	0.2136	1.2376	0.3895	1.778891	0.2243
	A_EMP	0.000066	<.0001	0.000072	<.0001	0.000048	<.0001	0.000045	<.0001
Employment in Non-basic Sectors	Intercept	-37640.7	<.0001	-24941.7	<.0001	-39312.2	<.0001	-17855.5	<.0001
	W_EMP_NBAS[a]					-0.00042	0.9067	-0.00667	0.0932
	EMP_TOT	0.829633	<.0001	0.866989	<.0001	0.815499	<.0001	0.842039	<.0001
	AREA[a]	14.56297	0.0115	13.19979	0.0111	16.74665	0.0051	4.091756	0.4368
	EXP_ED	0.22007	<.0001	0.160258	<.0001	0.256987	<.0001	0.174738	<.0001
	A_EXPED	-0.00024	<.0001	-0.00019	<.0001	-0.00027	<.0001	-0.00019	<.0001
	C_EXPED[a]	-0.00033	0.8019	0.008365	<.0001	-0.00102	0.6404	0.00058	0.7842

[a]Indicates that the significance of the coefficient change as we change estimation procedures.

Table 5.8. Mean Absolute Percentage Error as a Measure of Forecasting Accuracy in Different Models

Equations	Spatial lag and spatial error model	Spatial error model	Spatial lag model	Non-spatial model
REV_LOC	21.8	22.5	21.9	25.1
EXP_LOC	15.0	15.6	15.2	19.1
HOUS_TOT	13.0	13.7	12.7	13.6
POP_TOT	11.0	11.9	11.1	11.9
POP_EAP	10.2	9.1	9.1	9.7
STDT_TOT	48.4	53.0	45.5	53.3
COM_OUT	423.0	544.7	470.2	730.4
COM_IN	173.0	167.4	177.6	183.5
FIRM_TOT	21.3	22.4	23.4	22.6
EMP_NBAS	72.2	86.0	85.8	87.1
Average	81.0	94.7	87.3	115.8
Coefficient of variation	4.0	4.6	4.2	5.1

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CHAPTER VI

General Conclusion

My dissertation consists of three essays on regional economic modeling. The models I developed here are also called community policy analysis models which are mostly used for understanding the local economy, economic impact analysis and forecasting. The first essay enhanced the existing Show Me community policy analysis model undertaken by Johnson and Scott by (a) expanding labor market variables, (b) including additional public revenues and expenditures variables, and (c) adding a housing market module. Using cross-sectional data for Missouri counties, we estimate a three-stage least squares Tobit model of local revenues and expenditures, labor, and housing markets. The model consists of 5 local revenue equations, 10 local expenditure equations, 4 housing market equations, and 9 labor market and demographic equations. The employment and total personal income are the main drivers of the model. This model estimates impacts reasonably that increases in local employment lead to increases in local population, housing demand, local revenues, and demand for public services.

The uniqueness of my dissertation is that it integrates space in the community policy analysis system model. The second essay is an extension of the Show Me Community Policy Analysis model for Missouri counties. Using cross-section data for Missouri's counties and adjacent counties in the surrounding states, we estimate a spatial lag three-stage least squares model. We add two new features to the model by including spatial components and expanding the local finance, housing market, and demographic variables. As in many previously estimated community policy analysis models, employment and income drive the model. Our results show significant cross-county interactions within Missouri in terms of the supply of public goods, labor mobility, retail trade, and the choice of residential location. The uniqueness of this study is that I have solved for the spatial reduced form solution for systems of spatially interrelated simultaneous equations which can disaggregate impacts into two components: endogenous variable interactions and spatial interactions. Our results show that the impact estimates of the nonspatial model are either underestimated or overestimated when it is not accounted for the spatial interactions. The results show that a significant portion of the impact is due to the interactions among endogenous variables. Three different weight matrices are used to specify the spatial linkages. Results appear to be robust across the different spatial weight matrices. This is most likely due to homogeneity of spatial units (i.e. county) in Missouri.

The main objective of my third essay was to develop and estimate a model that accounts for the cross-county and cross-equation spillover effects in local regions in Korea. I estimated different versions of a spatial model that account for the interregional spillover effect. The model-building process began with the estimation and evaluation of each equation using criteria such as R^2 and *t*-statistics. Then we collapsed all equations into one system and estimated model using GS3SLS. Before finalizing, we validated our model based on predictive accuracy as measured by mean absolute percentage error statistic. We found spatial lag three-stage least square model as the 'best' model for Korean regions. This model contains equations for local revenue, local expenditures, total housing units, population total, economically active population, number of students, in- and out-commuting, total firms, and non-basic employment; and model assumes that employment and economic development expenditures are the main drivers of this model.

It is found that significant cross-county and cross-equation spillover effects exist in Korean regions. Our results in some cases appear to be sensitive to the choice of spatial linkages as defined by weight matrices. This is most likely due to the heterogeneity of the size of spatial units of Korean regions.

It appears that adding spatial components add to the model's explanatory power. This addition also improves the accuracy of impact analysis and forecasting. Both the spatial interaction and cross equation interactions are significant. Note that the results are sensitive to the structure of the spatial linkages used when the size of the spatial units were not uniform (in the case of Korea). However, when the size of the spatial units are fairly uniform (i.e., Missouri) the form and structure of the spatial weights matrix does not matter.

VITA

Doleswar Bhandari was born on November 15, 1965, in Tehrathum, Nepal. He completed his secondary education at Tri-Mohan Secondary School in 1982. He enrolled in the Institute of Agriculture and Animal Science, Rampur, and received the degree of Bachelor of Science in Agriculture in 1992. He attended University of the Philippines at Los Banos and earned a Master of Management degree in agribusiness management in 1997. Upon completing the master's degree, he was employed at various national and international non-governmental organizations (ECARDS-Nepal, United Nations' Development Program, and Asia Network for Small Scale Bio-resources). He attended Louisiana State University at Baton Rouge and earned a Master of Science degree in agricultural economics. In August of 2003, he enrolled in the agricultural economics doctoral program at University of Missouri Columbia and earned a Doctor of Philosophy degree in October 2008.