SPATIAL ECONOMETRIC ANALYSIS OF HIGHWAY AND REGIONAL ECONOMY IN MISSOURI

A Dissertation
presented to
the Faculty of the Graduate School
University of Missouri-Columbia

In Partial Fulfillment
of the Requirements for the Degree

Doctor of Philosophy

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by
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AUGUST 2006

The undersigned, appointed by the Dean of the Graduate School,
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Presented by Yong-Lyoul Kim

A candidate for the degree of [Doctor of Philosophy of Agricultural Economics]

And hereby certify that in their opinion it is worthy of acceptance.

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ACKNOWLEDGMENTS

My greatest appreciation is expressed to my dissertation supervisor, Dr. Thomas G. Johnson and second advisor, Dr. Dennis P. Robinson, for their thoughtful and constructive advices and suggestions. Grateful appreciation is also expressed to the other committee members, Dr. Joseph L. Parcell, Dr. Patrick Westhoff and Dr. Paul L. Speckman, for their helpful suggestions and criticisms.

To my parents, DongBin Kim and JunNam Lee, I give my thanks for my existence and the fortitude with which they imbued me. My deep appreciation is also extended to my wife's father and mother, DongHo Jeon and DanWon Shin. My gratitude goes to my high-school teacher, HeeJun Son, for empowering me to change my life. I would like to thank my brothers, JongLyoul and HaengLyoul and sisters, HaeSuk and HaeKyung (HaengSuk). Finally, I take pleasure in expressing my deep gratitude and affection to JeongEyun, my wife, and to GyuHyuk, GyuMin and GyuRi, our children, for their support and patience throughout my graduate studies and professional endeavors. It is to them that I dedicate this dissertation.

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ABSTRACT

The dissertation consists of four chapters: first, highway and economic development; second, spatial effects of highways and employment in Missouri; third, highway and industrial establishment in Missouri; finally, simultaneous spatial model of highway-employment for economic growth in Missouri. Spatial econometric methods are used in order to investigate the relationship between highways and regional economy.

The first chapter shows that the reduced transportation cost due to highway improvements makes production and distribution efficient, and has good effects on economies of scale, specialization and cost reduction. As for the second chapter, interstate highways in Missouri don't have positive effects on employment growth. The variable of mileage of road with four lanes has significantly negative sign but two lanes show insignificantly negative sign and it of surrounding counties has insignificantly positive sign. Spatial autoregressive coefficient (ρ) is significantly positive. In the third chapter, the spatially autoregressive coefficients (LAMBDA) show all significantly positive. Highway investments have insignificant negative effects on firm establishments in all models. Highway investments of neighboring counties are significant negative. This result doesn't provide evidence that highways have positive effects on regional economy related to firm establishments in Missouri. With respect to the fourth chapter using a simultaneous highway-employment spatial econometric model, the coefficients on the highway variable of population is statistically significant positive and others are insignificant. Spatial lag coefficients on manufacturing and population are significantly positive. The employment of retail trade depends on the population in the neighboring counties, and the county population relies on the employment of retail trade and wage positively in the neighboring counties. The results show that highways in a county have negative effects on employment growth of manufacturing and retail trade. But highways in a county are important factors in attracting the population in Missouri. Highways in Missouri may serve as firm amenity to increase wages rather than household amenity to increase labor supply.

INTRODUCTION

The dissertation consists of four chapters: first, highway and economic development; second, spatial effects of highways and employment in Missouri; third, highway and industrial establishment in Missouri; finally, simultaneous spatial model of highway-employment for economic growth in Missouri. Spatial econometric methods are used in order to investigate the relationship between highways and regional economy.

The first chapter investigates the relationship between highways and economic development. It illustrates general benefits of highways, the relationship between transportation costs and production, and empirical evidence of the effects of public capital or highway investment. The reduced transportation costs, due to highway improvements, provide more efficient production and distribution, and have positive effects on economies of scale, specialization, and cost reduction.

Many studies supported the hypothesis that highway improvement is a key factor to develop the economy. The evidence was provided by production function, cost function, simultaneous equation and industry studies. This chapter also explains how the reduced transportation costs resulting from highway improvements can lead to economic development.

It began with a discussion of general benefits of highways. Weiss and Figura proposed that highways facilitate linking function, efficient flows, communication systems, efficient accessibility, quality of life, diversity of economy and firm location.

The discussion extended to the reduced transportation cost due to highway improvements. The reduction of transportation costs can lower prices of goods, increase final demand, lead to larger market size and increased production, and foster economic development.

The previous studies generally supported the proposition that highways played a role in economic development. Some studies showed that public capital or highway investment has no significant effect on economic growth. These results were derived using various methods such as production function, cost function, simultaneous equations, etc.

The production function method has limitations such as omitting private input prices and having too many restrictions on firms' technology and behavior. The limitation of cost function method is that it is related to input prices but does not illustrate where those input prices come from and how they are organized.

Therefore, analytical approaches to estimating the effect of transportation investment on economic development have to overcome these limitations and need to provide a more comprehensive view to preserve the spatial correspondence between transportation infrastructure and economic activity.

The second chapter considers a relationship between highway development and the spatial pattern of employment growth in Missouri. To determine if there is a spatial pattern to the employment growth in the county, a spatial lag model was estimated and contrasted with a simpler model that did not consider spatial relationships. This chapter investigates the extent to which employment growth in a county is affected by highway investment spillovers from neighboring counties as well as in the county itself.

Interstate highways in Missouri are shown not to have positive effects on employment growth. In the model, the variable "mileage of four-lane roads in a county" has significant and negative effects on employment growth. "County mileages of two-lane roads" have insignificant and negative effects and "two-lane road mileages in surrounding counties" have insignificant and positive effects. It may indicate that the investment of two-and four-lane roads may encourage a decrease in employment growth among counties, contrary to expectations. It shows that there are no significant geographic highway investment externalities across boundaries.

The spatial autoregressive coefficient (ρ) is significant and positive, implying that there is positive spatial interaction between the counties and indicating that employment of neighboring counties affects a county's employment positively.

Results suggest that too-dense road networks can have negative impacts on employment growth in a county, and that highway overinvestment may lead to diminishing employment returns in Missouri. This research supports the general hypothesis that a mature transportation network does not provide a region with additional benefits from an increase of lane-miles and new highway construction.

The third chapter investigates the effects of highway infrastructure on the economic performance of Missouri counties. The research investigates if there is a relationship between highways and industrial establishment (all industry, manufacturing, and retail trade) in Missouri, and explains how highways affect the spatial distribution of firm establishments.

This chapter develops spatial econometric models and spatial error models for the period between 1990 and 2000 that relate various economic performance indicators to various explanatory variables.

Estimated spatially autoregressive coefficients are all significant and positive, indicating that significant spatial dependence in the error terms also was present and needed to be accounted for in order to provide efficient results.

Highway investments have insignificant and negative effects on firm establishments in all three sectors. Highway investments of neighboring counties are significant and negative. This result does not provide evidence that highways have positive effects on the regional economy due to firm establishments. This research concludes that the effects of neighboring highways are significant and negative in three models from the spatially-weighted highway density coefficients. Therefore, the results illustrate that more highway investments in a county or neighboring counties may not attract more firm establishments in all industry, manufacturing, and retail trade sectors in Missouri, indicating that the effects of highway investments seem to be contained within a county area.

With respect to agglomeration economies, sector specializations in all three models are significant and positive, indicating that there are externalities taken from the spatial concentration of all industry, manufacturing and retail trade sectors. Industry shares in retail trade reveal that higher county industry shares bring more establishments, indicating that a larger county industrial base attracts more establishments in Missouri. Results of agglomeration economies, except for area specialization, have the same effects in all industry, manufacturing, and retail trade. Therefore, there is a unique conclusion that spatial concentration and big regional economy have strong positive effects on the relationship between agglomeration economies and firm establishments.

The conclusion of the insignificant and negative contributions of highways is obtained from a state-level model in this chapter. However, this chapter does not demonstrate nor conclude that highways are not productive.

The fourth chapter analyzes the interdependency between highway and industrial sectors, manufacturing, and retail trade in Missouri through a simultaneous highway-employment spatial econometric model. This chapter focuses on the highway mileage density, the spatially-lagged highway mileage density, and highway access variable. The coefficient on the "highway" variable of population is statistically significant and positive, but those of manufacturing and retail trade employment equations are insignificant. The results show that highways in a county have negative effects on employment growth of manufacturing and retail trade. But, highways in a county are important factors in attracting the population in Missouri. Highways may serve as assist in increasing wages rather than assisting households to increase the labor supply. The coefficients on interstate highway accessibility are also all insignificant.

Spatial lag coefficients on manufacturing and population are significant and positive. The employment of retail trade depends on the population in the neighboring counties, and the county population relies on the employment of retail trade and wage positively in the neighboring counties.

The county manufacturing employment is not shown to have a positive effect on the employment of retail trade, population and wage in the neighboring counties. The employment of retail trade depends on the population in the neighboring counties. The county population increases with the employment in retail trade and wages in the neighboring counties.

The area specialization in manufacturing and retail trade suggests that if fewer sectors are specialized in the county, the more attractive the area may be for manufacturing establishments. The positive adjustment coefficients in population and wages indicate that these variables distribute in space such that people maximize their profits.

Unlike other research, the results of this chapter suggest that highways may not directly contribute to employment growth of manufacturing and retail trade in Missouri. However, highways may affect retail trade employment indirectly because highways contribute to population growth positively and this population has positive effects on retail trade employment. Therefore, the relationship between highway investments and economic development is highly complex.

The fourth chapter suggests that highway investments should be considered in the areas that travelers can recognize time and cost savings, and that highways can consistently provide firms with incentives for establishment and location decision.

Finally, at the current stage of my research into spatial effects of highways in Missouri, there are some questions to reflect. It is necessary to research the differences between using population centroids, cities and the distance decay due to proximity to highways. Highway capital at the county level in Missouri is needed to investigate the effects of highways on the regional economy. Highway capital data may lead to more precise results on highway effects. Spatial econometric model with space-time data (panel data) like time series data must be adopted because this model will remove the problems of spatial data analysis due to the absence of more time dimension when space-time data are used.

CHAPTER I

HIGHWAY AND ECONOMIC DEVELOPMENT

ABSTRACT

This research investigates the relationship between highways and economic development. It illustrates general benefits of highways, the relationship between transportation costs and production, and empirical evidence of the effects of public capital on highway investments.

Many studies support the hypothesis that highway improvement is a key factor to develop the economy. The evidence is provided by production function, cost function, simultaneous equation, and industry studies. This paper also explains how the reduced transportation costs resulting from highway improvements can lead to economic development.

Key words: Highway, Economic development, Transportation cost, Highway benefits.

1.1. General Benefits

We can consider highway improvements as an important factor in developing the regional economy. The better highway systems make production and distribution efficient, and have positive effects on economies of scale, specialization, and cost reduction (Jiang, 2001). David A. Aschauer (1989), Alica H. Munnell (1990), and M. Ishaq Nadiri and Theofanis P. Mamuneas (1996) found that public capital has important contributions to output and economic growth.

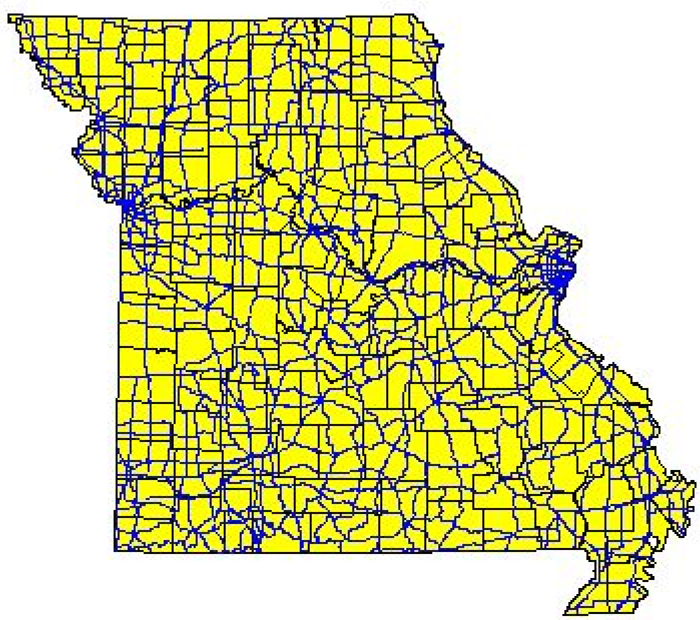
The relationship between highway investment and economic development extends beyond moving an object from one location to another in space and time (Haskins, 2002). This usually enhances a highway's value more than relocation costs. The increase in value should prevail for the aggregate. Economic development has broad aspects like growth in income, employment, wealth, etc. One consistent factor in any consideration of development is economic growth, which is the sustainable increase in regional income and wealth (Anderson and Lakshmanan, 2004).

Highways can be seen in the economic terms of supply, as provision of service, and demand, as requirement for service (Nadri, 1996). Whereas there is no doubt that highway improvements foster improvements in the business environment, we need to understand that an efficient highway can improve the regional economy. We may also doubt that highways are a major factor for economic development. Researchers such as Moomaw, Mullen and Williams (1995), Wallker and Greenstreet (1991), and Bartik (1989) suggested that highway infrastructure has negative effects on economic growth. The relationship between highways and economic development is thus difficult to formally establish. The estimated impacts in empirical studies vary from the positive to the negative.

The highway provides important economic benefits to people and industry. The efficient highway networks provide economic and social benefits that influence the economy. The lack of highway infrastructure can be a factor to hamper development (Kelejian and Robinson, 2006; Rodrigue, 2006).

There are many economic benefits that come from highway systems. Some benefits are related to income, highway accessibility, the direct employment of highway construction, highway cost reductions, travel time savings, and the improvement of industry productivity (Weiss and Figura, 2003).

Figure 1-1. Missouri Highways



We can summarize the general relationship between highway systems and economic development on the basis of Weiss and Figura's suggestions. Weiss and Figura (2003) suggested the general proposition that highway improvements bring economic development to the region in the following ways: first, "*link key centers in region to national markets thus helping to make the corridor areas competitive for growth.*" Second, "*provide for more efficient flows of commerce through the region to enhance the development potential of areas traversed by the improved highway facility.*" Third, "*facilitate the commutation of people to new jobs and public services to be developed along the corridor*." Fourth, "*open up new sites for commercial/industrial development.*" Fifth, "*provision of local access roads to stimulate retail development.*" Sixth, "*provide quality of life benefits by providing access to new services and employment opportunities.*" Seventh, "*promote tourism/recreational development.*" Eighth, "*enhance the flow of goods and services within a sub-regional trade area to increase economic multiplier effects.*" Ninth, "*strengthen and diversify the local economy.*" Tenth, "*support new business initiatives.*" Finally, "*enhance economic development with regard to state supported incentives for business investment.*"

1.2. Transportation Cost and Production

Looking at a firm establishment model, the firm would examine various components such as the logistical, labor force, and consumer market for its establishment. The firm can consider its location in that area, assuming that the highway networks are enough, and other factors such as labor force, utility costs, and housing costs are also sufficient. The need for highway improvement can be justified on the basis that highway improvement is likely to create job growth or income growth.

The economic impacts of highways can be direct and indirect (Rodrigue, 2006). With respect to direct economic impacts, good highway systems support economic growth by reducing the transport costs. Direct user benefits include reductions in travel time, increased reliability, and increased safety in the movement of people and goods. As highway costs are lowered, resources are freed for other purposes (Dalenberg and Partridge, 1997). Therefore, people can benefit from increased employment options as their range of feasible commuting patterns is expanded.

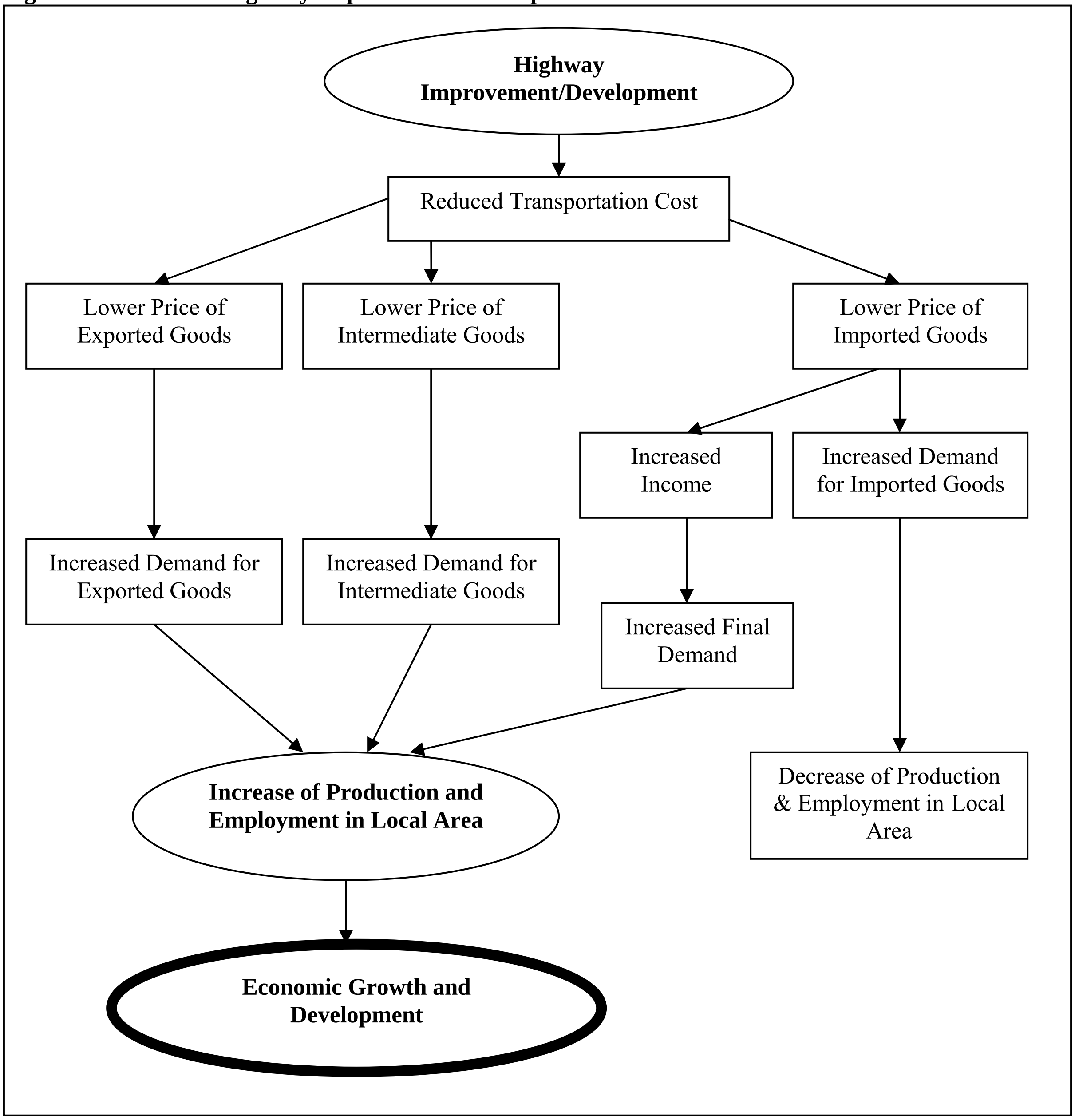
There are also indirect effects of the highway system on economic growth. These secondary effects may include the expansion of existing businesses as reduced transport costs result in increased market share. This can lead to increased employment and incomes as businesses grow. Furthermore, economic activity may expand as these growing businesses in turn demand more raw materials and components from their suppliers. Finally, retail and service businesses can grow as employees spend their additional income.

We can also see the benefits of highways with respect to markets. Highway cost reductions due to highway improvements can make a market larger (Lakshmanan and Anderson, 2004). The industry can try to achieve economies of scale in production due to the presence of a larger market. Input cost may be decreased due to the reduction of transportation costs. It can make the region accessible for specialization.

In commodity markets, a good highway infrastructure can improve firms' accessibility to raw materials and to their consumers. Therefore, highways increase opportunities to buy and sell goods and services necessary for industry. In labor markets, highway improvements can provide efficient access to labor and reduce access costs. Thus, it can improve the commuting system and decrease labor cost.

The reduced transportation cost due to highway improvements may have various impacts on the regional economy (Kelejian and Robinson, 2006; Rietveld, 1989). Figure 1-2 illustrates the relationship between highway improvement or development and local economic development. Transportation cost reduction provides price advantages to exported goods because of reduced production cost, to intermediate goods due to declined delivery cost, and to imported goods due to decreased importing cost.

Figure 1-2. **Effects of Highway Improvement/Development**



Source: Kelejian & Robinson, 2006; Kovalyova & Robinson, 2004; Lakshmanan and Anderson, 2004

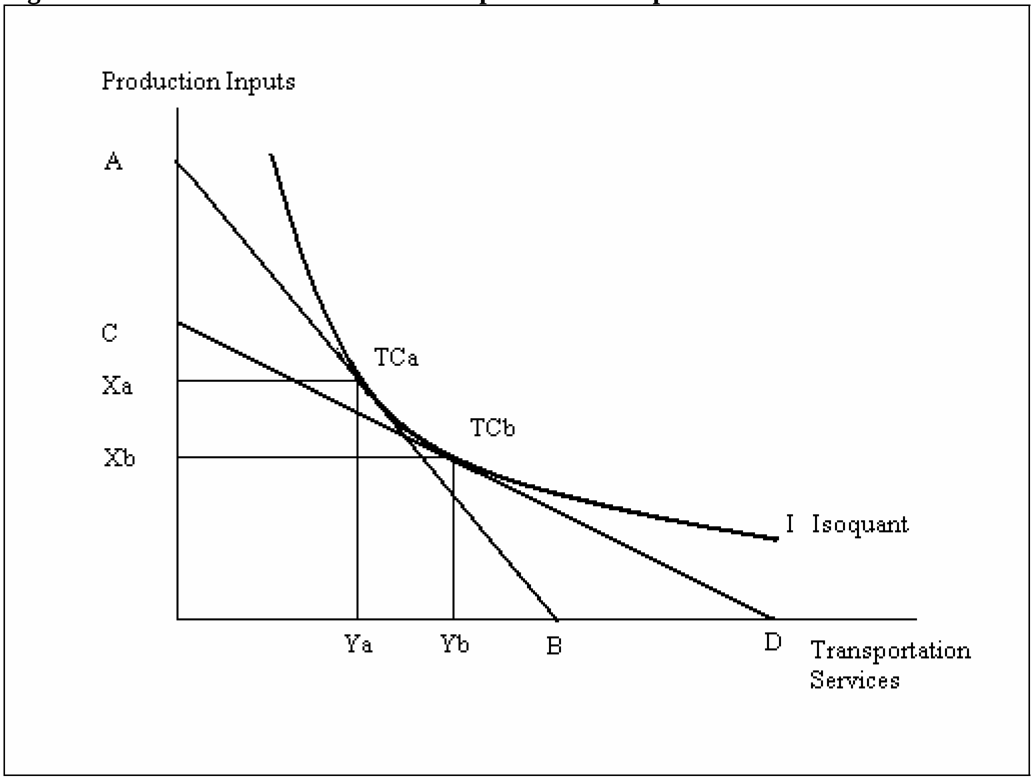
The cheaper exported goods can have an increase in demand, expansion in market size, and enhancement in local production and employment. The cheaper imported goods have both positive and negative effects on regional economic growth. The positive impacts include increased income due to the lower price of the imported goods. This increased income can lead to increased final demand in the local area, and then increased local production and economic growth. The negative impacts include a decrease in the consumption of more expensive goods produced in the local area, which can make local firms that produce the same goods less competitive, and ultimately decrease local production and employment.

One of the key components in regional development is employment or job growth. If a region can create more jobs and then attract more people, the demand for goods and services can be increased by the population growth. Therefore, job creation in a region attracts more people and more people are thus able to find employment. New highways and highway improvements can improve the accessibility and contribute to regional employment growth and economic development (Stephan, 1997; Islam, 2003).

Another example is that reduction of transportation costs from highway improvements can motivate a firm to move to a particular area so that it can take advantage of scale economies. An important thing in industrial location is the trade-off between scale economies and transportation costs (Anderson and Lakshmanan, 2004).

If a manufacturing firm sells its goods in urban markets scattered throughout a region or nation and has scale economies, it can have two methods for cost minimization. The first is to minimize production cost through locations at fewer, but larger, sites. The second is to minimize transportation costs through smaller facilities with short distances to major markets.

Figure 1-3. **Combination of Production Inputs and Transportation Services**



Source: Anderson & Lakshmanan, 2004; Kelejian & Robinson, 2006; Kovalyova & Robinson, 2004; Varian, 1992

Consider a combination case between production inputs and transportation services (Figure 1-3). A firm can achieve scale economies by consolidating facilities. Because of this, the firm can use fewer inputs needed to produce goods and choose more transportation services.

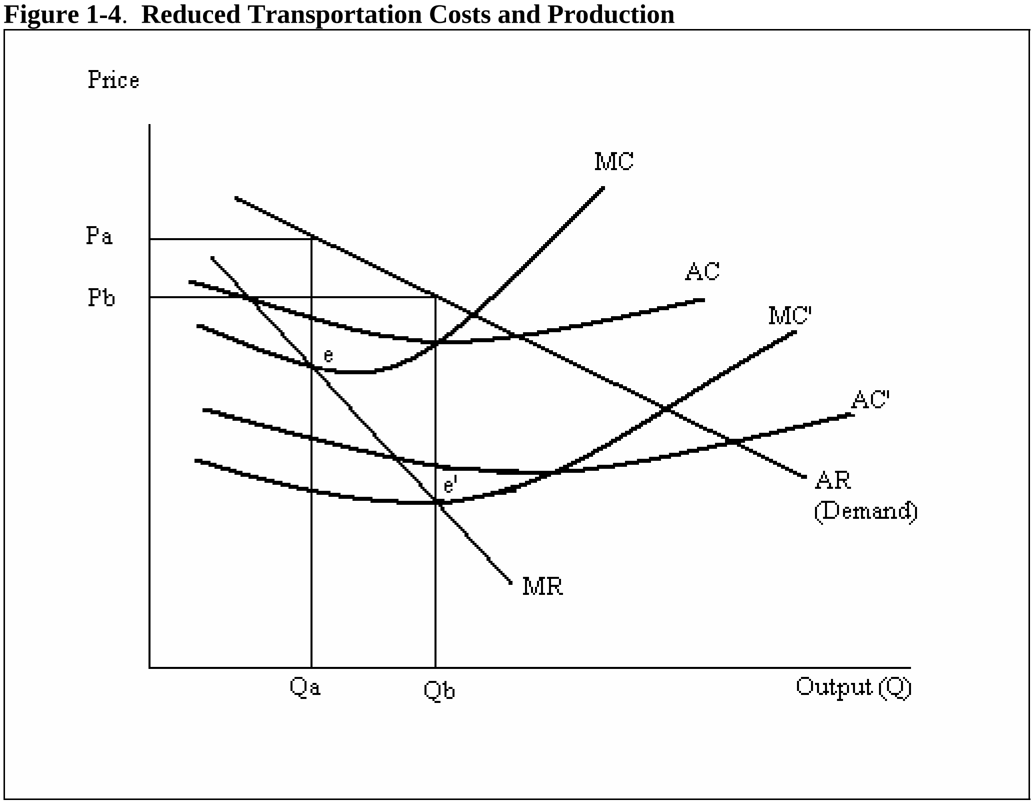
Figure 1-3 shows the combination by the isoquant I that defines the ability to substitute between production inputs and transportation services that can be needed to produce a given production level. All points on the isoquant line I show the cost-minimization points for producers.

The savings in production inputs due to reduced transportation costs can be transferred into a change of combination of input factors (Kelejian and Robinson, 2006). If transportation costs are reduced, the slope of the isocost line AB is reduced to the line CD

(Figure 1-3). The points of tangency (TCa and TCb) are the optimal choices for the before cost (TCa) and the after cost (TCb) due to a reduction in transportation costs. In this case, the firm should decrease the amount of production inputs from Xa to Xb (labor or capital) and increase the quantity of transportation services from Ya to Yb.

The reduced transportation costs can lower production costs. This reduced production cost can motivate a firm to increase the production quantity of goods. Figure 1-4 shows the effects of cost change and production change due to the reduced transportation costs (Kelejian and Robinson, 2006).

Figure 1-4. **Reduced Transportation Costs and Production**



Source: Kelejian & Robinson, 2006; Varian, 1992

Suppose there is a manufacturing firm in the market. Its demand curve is the average revenue curve (AR). Average cost (AC) and marginal cost (MC) are the respective cost or supply curves. The usual equilibrium condition is that marginal revenue (MR) equals marginal cost (MC), (MR=MC). In Figure 1-4, MR and MC have intersected at point *e* which is the equilibrium point. At this point the firm produces and supplies output quantity Q, which is the only profit-maximizing condition for this firm. The transportation cost reduction will reduce the production costs. Thus, AC and MC will move to AC' and MC', output quantity Qa to Qb, and also the equilibrium point *e* to *e'*.

1.3. Empirical Evidence

1.3.1. Production Function

Aschauer (1989) estimates the relationship between public infrastructure capital and the productivity capacity of the private sector investment through a Cobb-Douglas production function. He uses the U.S. national time series data, 1949 to 1985. The results indicate that the infrastructure has strong positive effects on the private sector. His coefficient of the infrastructure is 0.39.

Munnell (1990a) investigates the impacts of public capital on labor productivity, using a Cobb-Douglas production function with time series data (1948-1987). The results show that a 1% increase in public capital increases output by 0.34%. She suggests that it indicates a marginal productivity of public capital of roughly 60%.

Munnell (1990b) looks at the relationship between public capital and measures of economic activity at the state level by using a Cobb-Douglas production function with panel data of 48 states, 1970 to 1986. In her research, public capital has a significant and positive impact on the output. Her coefficient on public capital is 0.15. This is smaller than the 0.39

estimated by Aschauer (1989). She suggests that public capital stimulates the productivity of private capital, and public capital is a substitute for private capital.

McGuire (1992) specifies a state-level Cobb-Douglas function. The public capital used in his paper consists of highways, water and sewers, and other. Highways have strong positive impacts on private output.

Stephan (1997) provides an estimation of road infrastructures' impact on production in the manufacturing sector from an ex-post perspective and takes econometric issues such as autocorrelation, heteroskedasticity and cross-sectional correlation, and nonstationarity of data into account. He uses a Cobb-Douglas production function and a translog production function with panel data from 1970 to 1993. He finds a strong positive and significant correlation between road infrastructure and the manufacturing sector's output. The coefficient of road infrastructure is 0.325.

The above researchers have suggested empirical evidence for a strong positive relationship between public capital and the private sector. They have hypothesized that the decrease of governmental public investment may cause the productivity growth to decline.

Researchers such as Garcia-Mila, McGuire and Porter (1996) and Moomaw, Mullen and Williams (1995), however, find that the aggregate public capital or highway investment has no significant effect on economic growth unlike most other researchers. Boarnet (1998) shows negative output spillovers of "street-and-highway capital" at the state level.

Garcia-Mila, McGuire and Porter (1996) use panel data for the 48 states from 1970 to 1983 through a Cobb-Douglas production function with public capital as an input. The data consist of GSP, total employment, total private capital, and total public capital. The total public capital is split into highways, water and sewers, and other, like McGuire (1992). The results show that the public capital has no significant effects on private output unlike McGuire (1992).

Moomaw, Mullen and Williams (1995) use a translog function with panel data (1970, 1980 and 1986) in order to capture the effects of public capital and highway capital. The results reveal that the aggregate public capital has significant positive effects on state output, but highway capital has insignificant and negative effects.

Boarnet (1998) tests for the existence of negative output spillovers from “street-and-highway capital,” using the production function with data for California counties for the year 1969-1988. The results illustrate that “street-and-highway capital” affects output in California counties, and that this infrastructure has negative output spillovers across similar urban counties. This means that infrastructure investment is productive for counties, but public capital also reduces the output effects at the state level due to negative output spillovers.

Holtz-Eakin and Schwartz (1995) and Kelejian and Robinson (1997) adopt production functions with spatial econometric model in order to estimate the spatial spillover effects of transportation. They argue that the models including spatial effects have smaller magnitudes in estimating the influence of infrastructure.

Holtz-Eakin and Schwartz (1995) examine how state highways provide productivity benefits beyond the narrow confines of each state’s borders. They use state-level production function and panel data for the 48 states from 1969 to 1986. They estimate basic production function ignoring spillover effects in state highways and including spillover effects. In the basic production function regressions, the results do not show empirical support for the notion that public infrastructures have significant cross-state effects on output and productivity. In the production function including full spillover effects, the results do not support the notion that a state's effective stock of highways depends upon the provision of highways by its neighbors, indicating there is no evidence of spillovers of highway investment crossing state boundaries.

Kelejian and Robinson (1997) try to formulate an empirical production function model with spatial variables. They consider the Cobb-Douglas production function and spatial correlation model by using U.S. national level panel data, 1969 to 1986. Their results show that the important factor to determine if elasticity estimates in production function models involving infrastructure variables are significant is whether econometric problems are considered. They suggest that accommodating spatial correlation also reduces the magnitude and significance of the estimated productivity impacts.

Table 1-1. Production Function Studies

Author	Data	Results
Aschauer (1989)	Time series data, 1945-1985	Coefficient of the infrastructure is 0.39
Munnell (1990a)	Time series data, 1948-1987	Coefficient of public capital is 0.34
Munnell (1990b)	Panel data, 48 states, 1970-1986	Coefficient of public capital is 0.15
Stephan (1997)	Panel data, 1970-1993	Coefficient of road infrastructure is 0.325
Garcia-Milla, McGuire and Porter (1996)	Panel data, 48 states, 1970-1983	Public capital has insignificant effects on private output
Moomaw, Mullen and Williams (1995)	Panel data, 1970, 1980 and 1986	Highway capital is insignificant and negative
Boarnet (1998)	Panel data, 1969-1988	Infrastructure is productive for counties, but public capital is negative on state level
Holtz-Eakin and Schwartz (1995)	Panel data, 48 states, 1969-1986	Public infrastructure has insignificant and negative effects on productivity
Kelejian and Robinson (1997)	Panel data, 1969-1986	Accommodating spatial correlation reduces the magnitude and significance of the estimated productivity impacts

1.3.2. Cost Function

Berndt and Hanson (1991) investigate the influences of public infrastructure on private output (private business sector and manufacturing) and productivity growth, using cost function with data for Sweden from 1960 to 1988. They show that the reduction of infrastructure capital in Sweden since 1974 has lowered the speed of productivity growth in the private business sector. They conclude that an increase of public infrastructure investment reduces private cost.

Lynde and Richmond (1992) use a translog cost function in order to estimate the relationship between production cost and public capital. They use data for U.S. nonfinancial business data from 1958 to 1989. The results imply that infrastructure investment affects the reduction of production cost in the nonfinancial business.

Morrison and Schwarz (1996) compute a direct cost-benefit measure of infrastructure investment and analyze the rates of return on investment by using a cost function framework. They use panel data from the 48 states from 1969 to 1986 and focus on modeling and measuring the returns of public infrastructure investment in highways, and water and sewers. Their analysis is based on cost-side marginal products and productivity-growth measures. They measure the impacts of these effects on costs and, thus, on productivity. Their results show that the return to public capital is both positive and significantly different from zero, and the direct cost-saving impact of investment is significant.

Nadiri and Mamuneas (1996) identify the contribution of output demand, relative input prices, technical change, and publicly financed capital to the total factor productivity growth, and provide a general framework for analyzing and measuring the contribution of highway capital to private sector productivity growth using cost functions. They use data of 35 sectors of the U.S. economy for 1950-1989. The results reveal that highway capital affects the reduction of production costs and has positive effects on demand of capital, labor and materials.

Tortorice (2002) analyzes the role of government infrastructure in the production process. He finds its effect on the variable costs of private industries and overall TFP (Total Factor Productivity) growth by using a cost function. The results indicate that the changes in government capital stocks have a significant role in the production process of the economy. The elasticity of labor costs with respect to government capital is 0.02 and the elasticity of productivity with respect to government capital is 0.003.

Authors such as Berndt and Hanson (1991), Lynde and Richmond (1992), Nadiri and Mamuneas (1996), Morrison and Schwarz (1996), and Tortorice (2002) conclude that the public infrastructure contributes positively to the reduced production cost and the output growth.

Table 1-2. Cost Function Studies

Author	Data	Results
Berndt and Hanson (1991)	Sweden data, 1960-1988	Public investment reduces private cost
Lynde and Richmond (1992)	US nonfinantial business data, 1958-1989	Production cost savings from public infrastructure
Morrison and Schwarz (1996)	Panel data, 48 states, 1970-1987	Direct cost savings from infrastructure investment
Nadiri and Mamuneas (1996)	35 sectors, 1950-1989	Production cost savings from highway capital
Canaleta et al (1998)	Spain, 1964-1991	Public capital reduces private production costs
Cohen and Paul (2002)	Manufacturing, 1986-1992	Public capital is productive

Canaleta et al. (1998) examine the impact of infrastructure on productivity in the various regions of Spain and provide an approximate estimation of the impact of various types of infrastructure on Spanish regional production costs in the agricultural, industrial, and services sectors during the period of 1964-1991. They examine how both the industry and service sectors show similar cost/public capital elasticities, which are slightly higher in the secondary sector and greater than in agriculture. The results show that public capital reduces private production costs. They reveal the presence of spillover effects of transportation infrastructure.

Cohen and Paul (2002) reevaluate the "public capital hypothesis" for the U.S. manufacturing sector for the time period of 1986-1992. The results show that intra-state public infrastructure investment is significantly productive. Spatial spillovers complement the cost-saving impacts of within-state public infrastructure capital. They argue that output growth by the cost-depressing impact of infrastructure investment may stimulate capital investment and labor employment.

Canaleta et al (1998) and Cohen and Paul (2002) investigate the spatial spillover effects of transportation infrastructure. They also suggest that the infrastructure investment contributes to the cost savings.

1.3.3. Simultaneous Equations

Carlino and Mills (1987) focus on determinants of population and employment growth by using simultaneous equations. They compute elasticities for total employment, manufacturing employment, and population. The results show that population and employment are very interactive, and for manufacturing employment, regional growth depends on economic and demographic conditions rather than regional and policy variables. They suggest that amenities should be considered in analyzing the relationship between population and employment. Interstate highway density as transportation infrastructure has positive effects on employment and population.

Boarnet (1994a) focuses on studying population and employment growth in intrametropolitan aspects by using simultaneous equations. The data in this study are on the 365 municipalities in the northern 13 counties of the state of New Jersey. He adapts spatial econometrics to a Carlino and Mills (1987) model in order to consider spatial dependence. His reduced form has spatial lags as the dependent variables. The results show that transportation access, poverty and crime rates, and housing stock age have positive effects on population growth. Transportation access, crime rates, and agglomeration economies are important determinants of employment growth.

Boarnet (1994b) focuses on testing the monocentric model that assumes exogenous employment locations to population locations through simultaneous equations of population and employment on 365 municipalities in northern New Jersey. The simultaneous regression in this paper uses spatial econometric methods. Unlike the monocentric assumption, the results reveal that employment growth within northern New Jersey is endogenous to population changes in neighborhood labor markets. Major highways have a positive influence on population and employment growth.

Bollinger and Ihlanfeldt (2000) explore how government interventions affect the intrametropolitan locations of population and employment in the seven-county Atlanta Region by using simultaneous equations. The government interventions in this study are property taxes, school quality, local public safety expenditures, highways, major road improvements, rapid rail stations, job tax credits, commercial/industrial enterprise zones, and housing enterprise zones. They also use crime as a locational determinant. The results show that new highways affect total population and total employment in a strongly positive manner. Road improvements have positive effects on employment, but not on population.

Dalenberg and Partridge (1997) investigate the amenity and productivity effects of public capital, applying the wage-rent model of Roback (1982). They use state-level data for the 48 contiguous states during the 1972-1991 period for a total of 960 observations. Real estate per capita public infrastructure consists of the stock of public highways and public infrastructure net of highways including sewer and water facilities, hospital buildings, and education facilities. They suggest that greater public capital as a firm amenity should increase wages, but infrastructure as a household amenity increases labor supply and then decreases wages. The results show that highway public capital has negative impacts on aggregate private sector wages, indicating increased highway reduces wages throughout the county, and net public capital has positive effects on them. However, highway capital affects manufacturing wages positively, but net public capital is statistically insignificant. These results indicate that highway infrastructure acts as a household amenity by attracting people to that area, but with respect to manufacturing, highways serve as a firm amenity.

Table 1-3. Simultaneous Equation Studies

Author	Determinants	Results
Carlino and Mills (1987)	Population and employment growth	Interstate highway density: positive
Boarnet (1994a)	Population and employment growth	Transportation access: positive
Boarnet (1994b)	Population and employment	Major highways: positive
Bollinger and Ihlanfeldt (2000)	Population and employment	Road improvements: positive on employment but not on population
Dalenberg and Patridge (1997)	Amenity and wage	Highway capital: - negative impacts on aggregate private sector wage - positive impacts on manufacturing sector wage
Kelejian an Robinson (2006)	Energy consumption, price of energy, employment and wages	Increase of navigation capital: - lowers factor cost in labor and energy - wage increases and price of energy decreases

Kelejian and Robinson (2006) analyze the importance of transportation infrastructure (navigation) through a simultaneous “state-level spatial econometric infrastructure productivity model” in order to avoid biases of previous production function and cost function studies. Their model consists of four equations (energy consumption (BTU), price of energy per BTU, employment, and wages) and uses the data of 49 states from 1980 to 1994. The results indicate that an increase in navigation capital lowers factor costs in both labor and energy, and then it assists in increasing wages and the decreasing the price of energy. As for spatial effects, they suggest that navigation investment in surrounding states reduces jobs and energy consumption, increases wages, and lowers the price of energy in a given state.

These simultaneous models illustrate the relationship between transportation infrastructure and the economy, or the interdependency between population and employment. The research provides evidence that highways as transportation infrastructure positively influence population, employment growth, and economic development.

1.3.4. Industry Studies

Wasylenko (1980) examines the decision of firms that relocated from a Milwaukee central city to its suburbs between 1964 and 1974, using a logistic model, and tests whether fiscal variables are statistically significant in deciding firm location when areas that “zone out” industrial firms are excluded from the sample. He mentions two types of industry. The first type includes construction, manufacturing, and wholesale trade that focus on consumer demand for output, and thus, these firm’s revenues “do not vary with intrametropolitan locations.” The second type includes retail trade, finance, and services in which profits are affected by intrametropolitan location because of "variations in both cost and consumer demand among locations." The results show that when areas that "zone out" industrial firms are excluded from the sample, fiscal variables are statistically significant factors to decide a firm's relocation for manufacturing and wholesale trade firms, but not for construction, retail trade, finance, and service firms. In highways, manufacturing firms have a positive coefficient and choose areas for firm locations that have easy access to highways.

Bartik (1985) analyzes the effect of a state's characteristics on the decision to open a new branch plant, using a conditional logit model. The results indicate that unionization and state taxes negatively affect opening new plants. Unionization variables have a much stronger negative effect than taxes on new firms. In public services, the "road miles" variable has a positive effect. This result suggests that road infrastructure can attract new business.

Holl (2004) analyzes the impact of road infrastructure on the location of new manufacturing establishments in Spanish municipalities from 1980 to 1994. The empirical results suggest that road transportation infrastructure is important, motorways affect the spatial distribution of new manufacturing establishments, and road infrastructure has a differential impact across manufacturing sectors.

The above studies find that transportation infrastructure, such as a highway system has positive impacts in attracting new firm establishments, which indicates that highway infrastructure is an important factor for a firm's location decision.

However, Wallker and Greenstreet (1991), Bartik (1989), and Forkenbrock and Foster (1996) show that road infrastructure has a negative effect on small firm establishment and does not have a strong influence on business location.

Wallker and Greenstreet (1991) analyze the role of government incentives and programs on job creation and location decision-making of the manufacturing industry in the Appalachian region. The results suggest that government assistance has a significant and positive effect on location decisions and job growth. In road infrastructure, this variable has a negative effect.

Bartik (1989) investigates the effects of the characteristics of U.S. states on small business start-ups. In this study, Bartik estimates specific small business start-up decisions by using micro data. The study also improves on an existing methodology by using panel data to analyze business location decisions, and illustrating the relationship between local public policies and business location decisions. The results suggest that this panel data model is more reasonable than a cross-section analysis. Market demand and taxes have a strong effect on small business start-ups, but the “highway” variable has an insignificant and negative effect on start-ups.

Forkenbrock and Foster (1996) analyze how investments in high-capacity highways affect business location decisions. The authors survey business facilities in Missouri and Iowa through direct mailings. They conclude that proximity to an interstate or other four-lane highway does not have a large effect on business location decision-making. Therefore, highways are not an essential factor in choosing business location.

Table 1-4. Industry Studies

Author	Determinants	Results
Wasylenko (1980)	Fiscal variable and firm location	Highways: positive on manufacturing location
Bartik (1985)	State characteristics and new branch plant	Road miles: positive
Holl (2004)	Road and manufacturing establishment	Road transportation infrastructure: positive
Wallker and Greenstreet (1991)	Government incentive and job creation	Road infrastructure: negative
Bartik (1989)	State characteristics and small business start-ups	Highways: insignificant and negative
Forkenbrock and Foster (1996)	Investments in high-capacity highways and business location	Proximity to an interstate or four-lane highway: not an essential factor for business location

1.4. Summary and Conclusion

This research studies the relationship between highway infrastructure and economic development. It began with a discussion of the general benefits of highways. In general, many studies suggest that highway improvements are key components to developing the local economy. Weiss and Figura proposed that highways facilitate a linking function, efficient flows, communication systems, efficient accessibility, quality of life, diversity of economy, and firm location.

The discussion continued to the reduced transportation costs, which are due to highway improvements. The reduction of transportation costs can lower prices of goods, lead to larger market size, increase production, and foster economic development.

The previous studies generally supported the proposition that highways played a role in economic development. Some studies showed that public capital or highway investment has no significant effect on economic growth. These results were derived using various methods such as the production function, cost function, and simultaneous equations.

The production function method has limitations such as omitting private input prices and having too many restrictions on a firm's technology and behavior (Kelejian and Robinson, 2006; Moreno et al, 2002; Munnell, 1992). The limitation of the cost function method is that it is related to input prices but does not illustrate where those input prices come from and how they are organized (Kelejian and Robinson, 2006).

Therefore, analytical approaches to estimating the effect of transportation investments on economic development have to overcome these limitations and need to provide a more comprehensive view to preserve the spatial correspondence between transportation infrastructure and economic activity.

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CHAPTER II

SPATIAL EFFECTS OF HIGHWAYS AND EMPLOYMENT IN MISSOURI

ABSTRACT

The purpose of this paper is to determine if there is a relationship between highway development and the spatial pattern of employment growth in Missouri. In order to determine if there is a spatial pattern to the employment growth in the county, a spatial lag model was estimated and contrasted with a simpler model that did not consider spatial relationships. My intention is to figure out how highways in a county and neighboring counties affect employment of that county. Interstate highways in Missouri are shown not to have positive effects on employment growth. The "mileage of four-lane roads in a county" variable has significant and negative effects on employment growth. The "number of miles of two-lane roads within a county" variable has an insignificant and negative effect. In addition, "two-lane road mileage in surrounding counties" has insignificant and positive effects. The spatial autoregressive coefficient (ρ) is significantly positive, implying that there is a positive spatial interaction between the counties. Results suggest that road networks that are too dense can have negative impacts on employment growth in a county, and that highway overinvestment may lead to diminishing employment returns in Missouri.

Key words: Employment, Highway, Spatial lag model, Missouri.

2.1. Introduction

State highway investment projects are often justified on the grounds that such efforts will have positive economic impacts. In particular, road network improvements are considered useful means of bringing development to undeveloped areas, including rural areas. Transportation routes are often promoted as support for commerce in the U.S. For rural areas experiencing economic distress, such policies are often welcomed with open arms by residents. Empirical evidence suggests that there is a close relationship between the presence of infrastructure (i.e., highways) and economic development. In general, however, evidence is less certain as to whether road investments play a specific role in the economic growth of rural areas specifically.

Figure 2-1. **Missouri Highway Capital Outlay (Highway Statistics Publication, 1990-2003)**

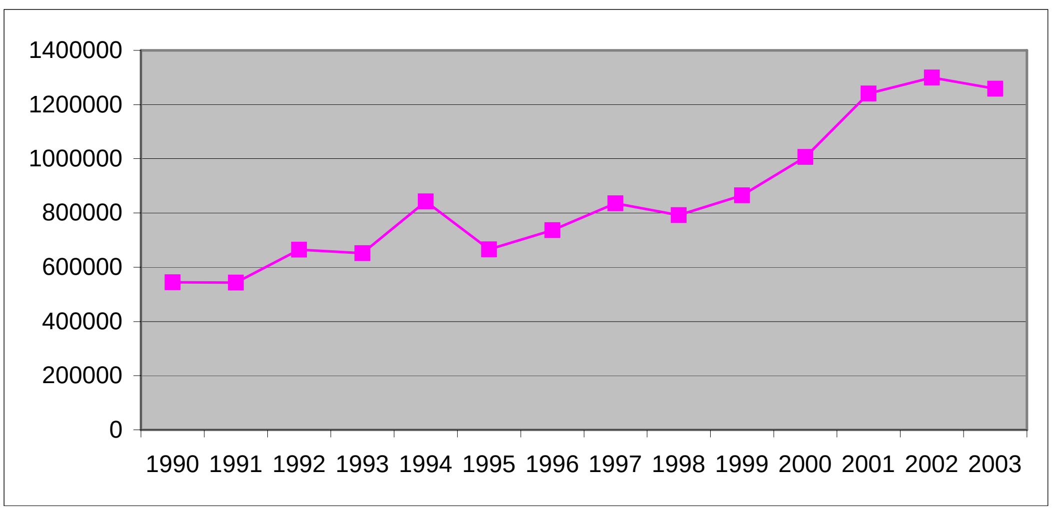


Figure 2-1 shows the trend of highway capital outlay in Missouri State during the period of 1990 to 2003. Highway outlay in 2003 was $1.26 million, down 3.2% from the previous year. Missouri had increased highway capital outlay by an average of 9.4% per year for 13 years during this period. The annual outlay has been more than $1 billion since 2000.

Section two of this chapter explains the research objective. Section three discusses the model and data. Section four describes the results. Finally, Section five summarizes the main conclusion of the chapter.

2.2. Research Objective

The goal of this paper is to study how highways of a county and neighboring counties affect employment in that county.

Using a spatial econometric method, this paper analyzed spatial patterns in the employment growth process in Missouri. The OLS model was run and spatial effects were examined. A spatial lag model was used in order to correct for spatial dependence. A spatial lag model was adopted through diagnostic tests for the robustness of the results. Finally, maps of employment growth residuals were made to analyze whether the spatial patterns respond to the socioeconomic trends in the region from 1990 to 2000. The model uses employment growth[1] between 1990 and 2000 as the dependent variable.

2.3. Model and Data

This research was executed for cross-sectional units (114 counties) in Missouri. The empirical models have an OLS model (Equation 2-1) and a spatial lag model (Equation 2-3) with a spatially-weighted lag.

[1] Employment growth = (total employment in 2000 - total employment in 1990)/ total employment in 1990.

$$EMPGRT = \alpha_0 + \alpha_1 (EDRT90) + \alpha_2 (LnPOPD90) + \alpha_3 (LnPVRT90) + \alpha_4 (LnHHIM90) + \alpha_5 (UNEMP90) + \alpha_6 (LnAWPJ90) + \alpha_7 (4LANED90) + \alpha_8 (2LANED90) + \alpha_9 (W4LANED90) + \alpha_{10} (W2LANED90) + DVRL + DVIS + \varepsilon_i$$

………(Equation 2-1)

Table 2-1. Independent Variables[2]

Variable	Definition	Scale	Expected effect	Data Source
EDRT90	Percentage of people, 25 and older, with High school degree or higher in 1990	County	+	US Census
LnPOPD90	Log of person per square mile of land area in 1990	County	+	US Census
LnPVTY90	Log of number of people below poverty level in 1990	County	-	US Census
LnHHIM90	Log of household income in 1990	County	+	US Census
UNEMP90	Unemployment rate in 1990	County	-	US Census
LnAWPJ90	Log of average wage per job in 1990	County	-	US Census
4LANED90[1)]	Mileage density of four-lane roads in 1990	County	+	MO Dept. of Transportation
2LANED90	Mileage density of two-lane roads in 1990	County	+	MO Dept. of Transportation
W4LANED90[2)]	Spatially-weighted mileage density of four-lane roads in 1990	County	+	Calculated
W2LANED90	Spatially-weighted mileage density of two-lane roads in 1990	County	+	Calculated
DVRL	Dummy to reflect rural county	County	-	US Census
DVIS	Dummy variable for county with Interstate highways	County	+	GIS

* 1) Mileage density of road with 4 lanes in 1990 = Miles of road with 4 lanes in 1990 / county land area (square miles).
* 2) Spatially-weighted mileage density ($[Wx]_i$) = ($[Wx]_i = \sum_j w_{ij} x_{uj}$, where w_{ij} is an (i, j) element of the spatial weights matrix W (spatial queen matrix).

Anselin's (1988a) methodology to construct a spatial lag model is adapted in this paper. Anselin (1988a) and Anselin and Bera (1998) define spatial lag models as autoregressive models of the following form:

$$y = \rho Wy + X\beta + u, \qquad u \sim N(0, \sigma^2_v I) \qquad \text{(Equation 2-2)}$$

[2] These independent variables are related to industrial location factors. Industrial location factors (Smith, 1981) are land, capital, materials, labor, market, transportation infrastructure, agglomeration, public policy, organization, and cost.

where the dependent variables are spatially lagged by being weighted with a predetermined spatial weight matrix: W, of J*J elements; y is a J*1 vector of endogenous measure for the J regions; X is a J*k matrix of exogenous variables; β is a k*1 vector of corresponding coefficients; and u is a J*1 vector of error terms.

For the spatial lag model, there is a distinction between the residual and prediction error. The latter is the difference between the observed value and the predicted value that uses only exogenous variables, rather than treating the spatial lag Wy as observed. To determine the extent of spatial spillovers, I will use geographic queen contiguity[3] as the weights matrix (W) to assign structure to the spatial interdependence that is likely present across the counties sharing a same boundary in the region. In this model, when only direct neighbors interact, the local spatial multiplier WX or $(1 - \rho W)^{-1}X$ measures the spatial spillovers. ρ is the spatial autoregressive coefficient that reflects the reaction of Y to economic growth in neighboring regions, i.e., spatial spillovers.

$$EMPGRT = \alpha_0 + \rho\,(W\_EMPGRT) + \alpha_1\,(EDRT90) + \alpha_2\,(LnPOPD90) + \alpha_3\,(LnPVRT90) + \alpha_4\,(LnHHIM90) + \alpha_5\,(UNEMP90) + \alpha_6\,(LnAWPJ90) + \alpha_7\,(4LANED90) + \alpha_8\,(2LANED90) + \alpha_9\,(W4LANED90) + \alpha_{10}\,(W2LANED90) + DVRL + DVIS + \varepsilon_i \quad \text{……… (Equation 2-3)}$$

The dependent variable is the total employment growth for the sum of all industries (EMPGRT) between 1990 and 2000. This paper uses employment of the civilian labor force, published by the Economic & Policy Analysis Research Center (EPARC) at the University of

[3] Queen contiguity adds a spatial corner relationship between two neighbors without a common border. An example for queen contiguity would be the two states Arizona and Colorado.

Missouri-Columbia. Employment growth is used to reflect economic development because job growth is a common policy objective for regional development.

The demographic and socio-economic data, such as educational achievement, population density, poverty status, household income, unemployment rates, and average wage per job, were obtained from the Missouri QuickFacts from the U.S. Bureau of the Census, Economic Research Service of the USDA, the U.S. Bureau of Economic Analysis, and the U.S. Department of Labor. Mileage densities of roads with two and four lanes came from the Missouri Department of Transportation. Spatially-weighted mileage densities of two- and four-lane roads were calculated from the GeoDa program. Table 2-1 describes explanations of the explanatory variables.

Mileage density of two- and four-lane roads (4LANED90 and 2LANED90), spatially-weighted mileage density of two- and four-lane roads (W4LANED90 and W2LANED90) and the dummy variable for counties with interstate highways (DVIS) are used to explain highway investment impacts on employment indirectly. Those W4LANED90 and W2LANED90 variables were calculated using the GeoDa program in order to investigate how two- and four-lane roads of neighboring counties that share the same boundary affect the employment within a county, using queen spatial contiguity weight matrix.

The education achievement (EDRT90) is measured in terms of the percentage of people, 25 years of age and older, who have high school degrees or higher in 1990 to investigate labor force qualification. The population density (LnPOPD90) is the measure of labor market size. Poverty level (LnPVTY90) considers the possibility of low-skilled workers, implying that it may have a negative effect on attracting firms to a local area.

Household income (LnHHIM90) shows the consumption power of the region. Wage (LnAWPJ90) is the average wage per job, which reflects local cost factors.

2.4. Results

The preliminary results of OLS (Table 2-2) do not correspond with the expected outcomes, according to transportation factors like 4LANED90, 2LANED90, and DVIS.

As for the other independent variables, population density (LnPOPD90) and household income (LnHHIM90) have statistically significant coefficients with the expected signs.

Table 2-2. **OLS Regression Results**

Variable	Coefficient	Std.Error	t-Statistic	Probability
CONSTANT	0.7221	1.6254	0.4442	0.6578
EDRT90	0.0244	0.1832	0.1332	0.8942
LnPOPD90	0.2670	0.1405	1.9007	0.0601
LnPVTY90	-0.0493	0.1159	-0.4252	0.6715
LnHHIM90	0.8273	0.3023	2.7360	0.0073
UNEMP90	0.0070	0.0083	0.8445	0.4003
LnAWPJ90	-1.0194	0.3367	-3.0274	0.0031
4LANED90	-1.0468	0.4153	-2.5205	0.0132
2LANED90	-0.4917	0.3330	-1.4766	0.1428
W4LANED90	-0.3108	0.4549	-0.6832	0.4959
W2LANED90	0.2619	0.5270	0.4971	0.6201
DVRL	-0.0467	0.0489	-0.9562	0.3411
DVIS	-0.0755	0.0355	-2.1235	0.0361

Among the variables that are significant, population density and household income have positive signs, implying that an increase would lead to an increase in employment.

Anselin and Rey (1991) tried to figure out how the Moran I and Lagrange multiplier tests are used by different situations, different sample sizes, alternative spatial structure, and under the non-standard error distributions. Their results are highly sensitive to the properties of the tests by using what kinds of spatial weights matrix. They suggest that the Lagrange multiplier tests are the most powerful in deciphering between a spatial error model and a spatial lag model.

Kelejian and Robinson (1992) test a large sample for spatial autocorrelation in terms of error terms of regression models. Their results indicate that omitted independent variables may bring spatial autocorrelation in the error terms. Nass and Garfinkle (1992) introduce the localized autocorrelation diagnostic statistic (LADS), which is an error diagnostic. They suggest that the LADS is a good method to diagnose localized residuals and to identify omitted variables in models.

For this paper, Anselin's methods were used to analyze and quantify spatial effects. GeoDa has two tests for diagnostics of spatial dependence: Moran's I and the Lagrange Multiplier test.

The Moran's I statistic is used (Moran, 1948; Cliff and Ord, 1981) to estimate and test hypotheses. Moran's I measures spatial autocorrelation in regression residuals.

$$I = \frac{n}{\sum_i \sum_j w_{ij}} . \frac{\sum_i \sum_j w_{ij}(y_i - \mu)(y_j - \mu)}{\sum_i (y_i - \mu)^2} \qquad \text{(Equation 2-4)}$$

where w_{ij} is equal to the elements of the spatial weight matrix, W; μ is the mean of all y observations; and i, j = 1,….,n. A positive and significant value of Moran's I indicates positive spatial correlation, showing that counties have levels of employment (high or low) similar to their neighboring counties. A negative and significant value for Moran's I indicates negative spatial correlation, showing that counties have levels of employment unlike neighboring counties, and a low value may be surrounded by high values in nearby counties.

Moran's I test on the OLS yields a significant and positive result of 0.1731 ($z = 3.6611$ and $p < 0.00025$). These show a significant and positive spatial relationship (Anselin, 1988 and 1995). The diagnostics for spatial dependence in OLS suggest a spatial lag correlation.

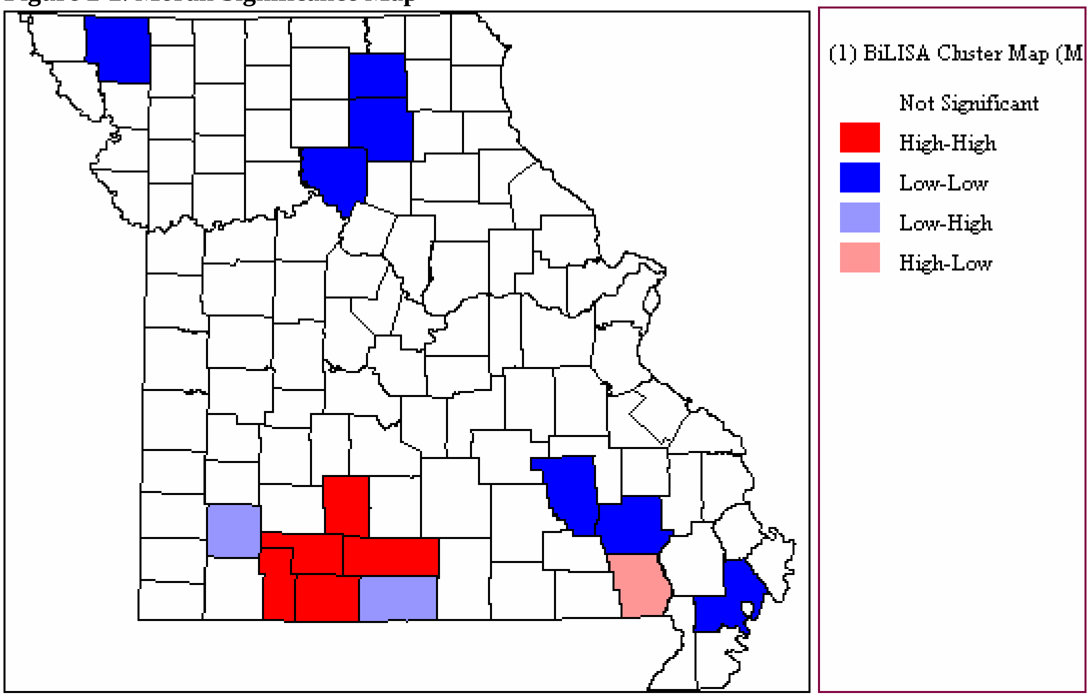
Table 2-3. Diagnostics for Spatial Dependence

Test	MI/DF	z-value	Probability
Moran's I (error)	0.173096	3.6610536	0.0002512
Lagrange Multiplier (lag)	1	10.4792339	0.0006752
Robust LM (lag)	1	3.5441000	0.0597576
Lagrange Multiplier (error)	1	8.2130226	0.0041591
Robust LM (error)	1	0.2006887	0.6541655

Lagrange Multiplier (LM) was used for choosing spatial lag or error model. Lagrange Multiplier tests on the OLS show that LM (lag) and robust LM (lag) are both significant and positive values of 10.4792 ($p < 0.0068$) and 3.5441 ($p < 0.05976$), respectively. LM error is significant and positive at 8.2130 ($p < 0.00416$) and robust LM (error) is insignificant. The test indicates that the spatial lag model is better than the spatial error model for spatial econometric model because LM-lag tests have higher significant values than LM-error tests.

The local Moran's I test was suggested by Anselin (1995). The local Moran's I investigates whether the values for each county (from the global Moran's I) are significant and how influential they are individually for the overall spatial autocorrelation. Figure 2-2 displays an interesting pattern with significant clusters of counties with large rates of employment growth (High-High) in the south-central area of Missouri. Areas with a low rate of employment growth (Low-Low) are apparent in the western and central north, as well as in the south east.

Figure 2-2. Moran Significance Map



The residuals of employment growth were mapped from the OLS model in order to determine if there was a spatial pattern. Residuals can be obtained by subtracting the predicted values from the actual values. A residual map gives an indication of systematic over-prediction or under-prediction in counties, indicating there is spatial autocorrelation. The OLS residuals make a standard deviational map for the residuals.

Figure 2-3 suggests that similarly-colored areas tend to be clustered throughout Missouri, indicating positive spatial autocorrelation (Anselin, 2005). Also, it indicates a tendency to over-predict (negative residuals) in most northern areas and in scattered central and southern areas, as well as a tendency to under-predict (positive residuals) in the central and southern areas. This implies the possible presence of spatial heterogeneity (Anselin, 2005). A negative standard deviation means that the predicted values exceeded the actual values.

Figure 2-3. **Mapping the OLS Residuals of Employment Growth**

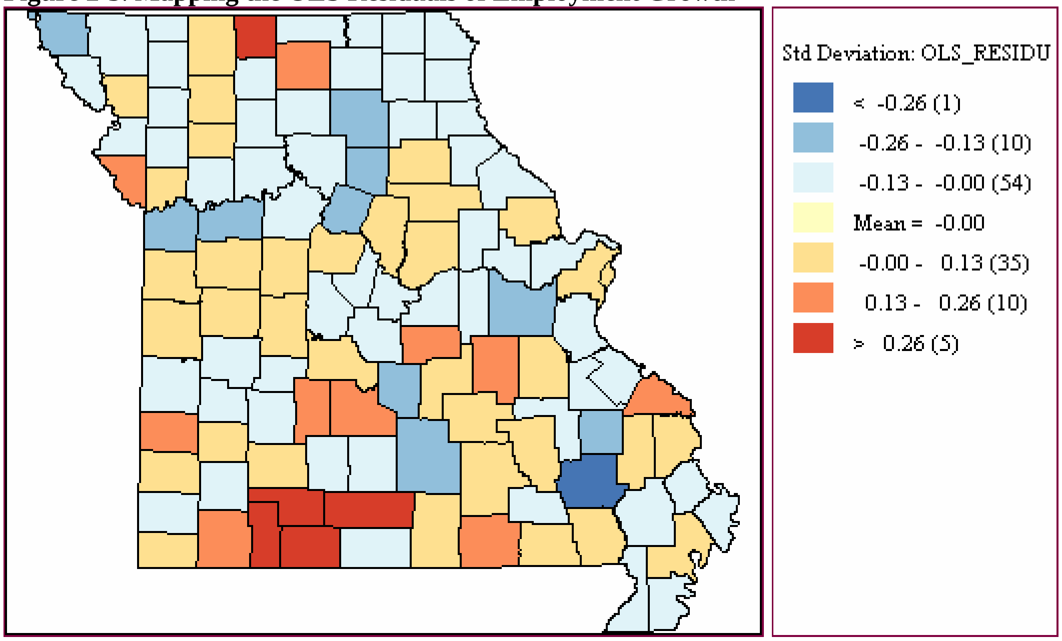


Figure 2-3 shows a similar portion of over-predictions and under-predictions of employment growth in the OLS model. Similarly, there is some clustering.

Spatial dependence exists when the dependent variable or error term at each location is correlated with the dependent variable or the error term at other locations (Anselin 2001, Islam 2003).

The spatial lag model reflects misspecifications similar to omitting a significant explanatory variable in the regression model. In this case, however, the OLS is biased and all inferences based on the standard regression model will be inconsistent.

The spatial lag model attempts to explain spatial dependence in stock-like variables for a cross-section of spatial units at one point in time. The spatial lag model directly specifies the concept of "neighborhood" for each region with the introduction of the spatial weight matrix, W. The elements of the weight matrix reflect the relative importance of spatial dependence between regions. Assuming that the spatial dependence between regions decreases with the distance between them, a distance weight matrix can be used for the spatial lag model.

Explanatory variables for spatial lag models include exogenous variables similar to the propulsive and attractive factors used in spatial interaction models.

Table 2-4. **Spatial Lag Model - Maximum Likelihood Estimation**

Variable	Coefficient	Std.Error	z-value	Probability
W_EMPGRT	0.3743	0.1068	3.5043	0.0004
CONSTANT	0.3570	1.4464	0.2468	0.8050
EDU90	0.0087	0.1623	0.0535	0.9572
LnPOPD90	0.2286	0.1245	1.8349	0.0665
LnPVRT90	-0.0581	0.1027	-0.5656	0.5716
LNHHIM90	0.6740	0.2756	2.4452	0.0144
UNEMP90	0.0046	0.0074	0.6285	0.5296
LnAWPJ90	-0.7664	0.2996	-2.5577	0.0105
4LANED90	-0.9906	0.3679	-2.6924	0.0070
2LANED90	-0.4275	0.2950	-1.4491	0.1472
W4LANED90	-0.1852	0.4049	-0.4576	0.6472
W2LANED90	0.2230	0.4672	0.4775	0.6330
DVRL	-0.0438	0.0433	-1.0132	0.3109
DVIS	-0.0647	0.0316	-2.0471	0.0406

The spatial autoregressive coefficient (ρ) of the spatially-weighted lag employment growth (W_EMPGRT) is estimated as 0.374 and is significant ($p < 0.0004$). This positive spatial autoregressive coefficient indicates that a higher level of employment in a county significantly increases employment in the neighboring counties. Therefore, there exists a positive spatial interaction between county employments of surrounding regions.

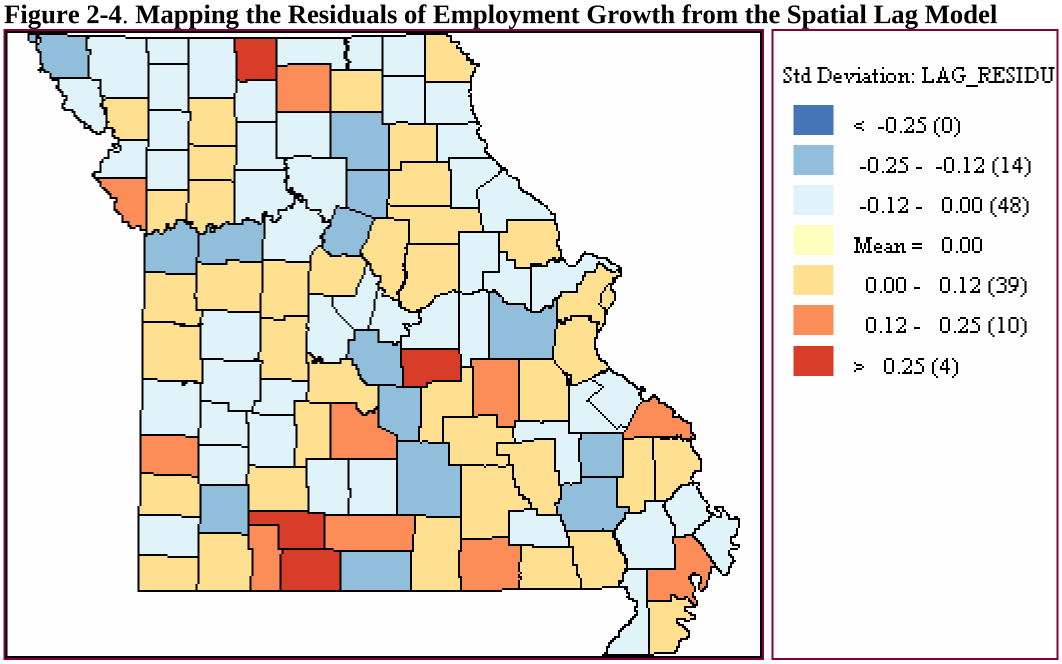
As LANES2, LANES4 and DVIS served as proxies for highway improvement in a county, the variable of “mileage of road with four lanes” (4LANED90) has a significant and negative effect, but “two lanes” shows an insignificant and negative sign. This indicates that “two lanes” and “four lanes” are not effective factors in attracting employment. The ”dummy” variable (DVIS) for counties with interstate highways are significant and negative.

It shows that interstate highways in a county have negative effects on employment, implying that interstate highways are also not a key complement to attract employment.

With respect to the spatially-lagged variables of “mileage of road with four lanes” (W4LANED90) and “two lanes (W2LANED90), those coefficients are limited to the spatial effects via four- and two-lane roads on employment spillovers. While the “four-lane road mileage in its neighboring counties” has an insignificant and negative effect on employment in the county, the “two-lane roads in its surrounding counties” has an insignificant and positive impact on employment in the county.

Population density (LnPOPD90) and household income (LnHHIM90) have both significant and positive signs, indicating that greater market size and higher consumption power attract more jobs to local areas. “Average wage per job” (LnAWPJ90) is significant and negative, suggesting that higher local costs lead to a decrease in employment.

Figure 2-4. **Mapping the Residuals of Employment Growth from the Spatial Lag Model**



Considering the order of the Wald (W), Likelihood Ratio (LR), and Lagrange Multiplier (LM) statistics on the spatial autoregressive error coefficient as a way to compare the MLE results to the OLS results, it was found that W = 12.280 (the square of the z-value of the asymptotic t-test, 3.50431^2), LR = 11.5564, and LM = 10.4792. This corresponds to the expected order (W > LR > LM) (Anselin, 1988 and 2005) and therefore indicates that this Maximum Likelihood Estimation (MLE) is better than the OLS.

Maps of the spatial lag model residuals (Figure 2-4) show that the spatial patterns of employment growth are slightly different than the OLS model. Across Missouri, the portion of under-predicted and over-predicted areas in employment growth is similar to the OLS model.

2.5. Summary and Conclusion

Though this research analyzes only the state of Missouri, the results may have expanded adaptation. Economic development advocates and public officials often advance the notion that more highways will automatically lead to more development. The results of this research may help in developing consistent regional policies that ensure greater efficiency of highway capital and better evaluate user benefits. It appears that highways do not contribute to regional growth and development. However, the relationship between highway investment and economic development is multifaceted and highly complex.

This paper has investigated the extent to which employment growth in a county is affected by highway investment spillovers from neighboring counties as well as in the county itself.

In this analysis, interstate highways in Missouri have negative effects on employment growth. Both “two lane highways” and “four lane highways” in a county have a negative sign. It may indicate that the investment of two- and four-lane roads may induce a decrease in employment growth among counties, contrary to expectations. Those of surrounding counties are insignificant and negative in "four-lane highways" and positive in "two-lane highways." It shows that there are no significant geographic highway investment externalities across boundaries.

Therefore, it can be generalized that too-dense road networks can be detrimental to local areas, and that highway over-investment can lead to diminishing employment returns.

The positive spatial autoregressive coefficient (ρ) implies positive spatial dependence between counties, indicating that employment in neighboring counties affects a county's employment positively.

It is expected that this research helps identify and quantify potential spatial relationships between highway investments and economic growth. This study implies that road lane improvement may be a good tool to develop regional economy, but that additional new highway miles may be harmful to the employment growth, indicating that the results do not support additional lane miles. Therefore, state-level transportation officials may reconsider funding and construction plans of new highways that justify the expenditures as a means to aid economic growth.

The general hypothesis that a mature transportation network does not provide a region with additional benefits from an increase of lane-miles and new highway construction is supported by this research.

Still, this paper has explored a limited number of econometric and spatial econometric specifications, and further investigation may prove profitable.

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CHAPTER III

HIGHWAY AND INDUSTRIAL ESTABLISHMENT IN MISSOURI

ABSTRACT

This paper investigates the effects of highway infrastructure on the economic performance of Missouri counties. The research investigates if there is a relationship between highways and industrial establishment (all industry, manufacturing, and retail trade) in Missouri, and explains how highways affect the spatial distribution of firm establishments. This study develops spatial econometric models and spatial error models for the period from 1990 to 2000 that relate various economic performance indicators to various explanatory variables. Estimated spatially-autoregressive coefficients (LAMBDA) are all significant and positive. Highway investments have insignificant and negative effects on firm establishments in all three sectors. Highway investments of neighboring counties are significant and negative. With respect to agglomeration economies, sector specializations in all three models are significant and positive. This research does not provide evidence that highways have positive effects on firm establishments in Missouri.

Key words: Highway, Establishment, Spatial effects, Spatial error model, Missouri.

3.1. Introduction

Many researchers suggest that regional highway investments may produce positive economic impacts. In particular, transportation system improvements are considered an important means of bringing economic development to regions with distressed economies.

In the classical location theory, Weberians suggested that an industry desires a location where both costs of transportation and production factors are minimized (Weber, 1929), which could explain the relationship between highways and industrial establishment. The Loschian model explains that production market area is important, and minimization of both transportation and production costs is an important factor in industrial location (Losch, 1959). Christaller (1933) emphasizes the minimization of transportation cost and the achievement of a minimum market size.

Effective planning for spatial and transportation infrastructure requires information of the effects of road infrastructure on firm location. Better transportation systems can make regional areas more competitive for attracting firms.

Many factors affect firm establishment decisions. Firms may prefer areas in close proximity to product markets or input markets. Transportation infrastructure improvements potentially foster economic development and provide local governments with cost effective services. Even though transportation cost reductions promote regional economic development, some people doubt that transportation systems and accessibility to highways are primary location factors (Holl, 2004).

The chapter is organized as follows: section two describes the research objective; section three illustrates the spatial error model; sections four and five describe the spatial empirical models for analyzing spatial effects and the results, respectively; finally, section six summarizes the main conclusions of the chapter.

3.2. Research Objective

This paper investigates the effects of highway infrastructure on the economic performance of Missouri counties. Using establishment data on aggregate industry, manufacturing, and retail trade in Missouri counties from 1990 to 2000, the chapter investigates the impacts of highways in a county and in neighboring counties on firms' establishment decisions, and attempts to explain how highways affect the spatial distribution of these locations. The spatial econometric models take into account highway infrastructure, as well as other factors such as population, education, and agglomeration economies.

3.3. Spatial Error Model

The spatial error model pertains to errors that are not homoskedastic and uncorrelated, as assumed. The spatial error model is shown in Equation 3-1, where the disturbances exhibit spatial dependence.

$$y = X\beta + u$$

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

$$\varepsilon \sim N(0; \sigma^2 I_n) \qquad \text{(Equation 3-1)}$$

In this equation, y contains an "n*1" vector of dependent variables and X represents the usual "n*k" data matrix containing explanatory variables. W is a known spatial weight matrix and the parameter λ is a coefficient on the spatially correlated errors analogous to the serial correlation problem in time series models.

Equation 3-1 can be rewritten as below:

$$(I - \lambda W)u = \varepsilon$$

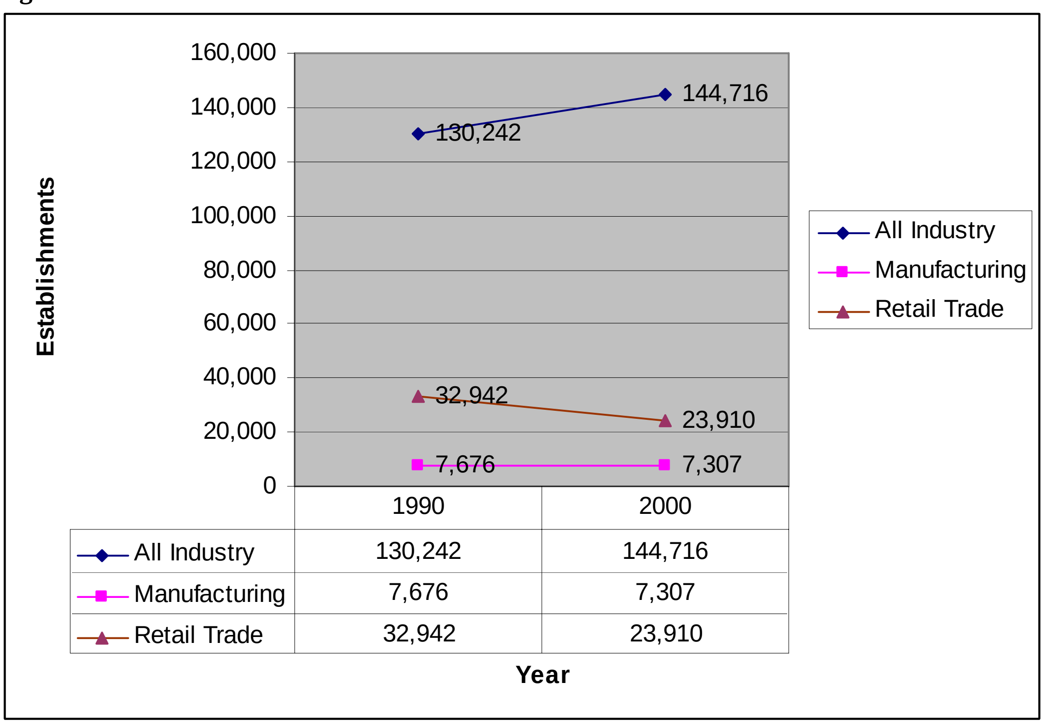
$$u = (I - \lambda W)^{-1} \varepsilon$$

$$y = X\beta + (I - \lambda W)^{-1} \varepsilon \qquad \text{(Equation 3-2)}$$

The spatial autocorrelation coefficient λ thus displays the strength of correlation between the disturbance term u and the weighted average of the disturbance terms of neighboring counties Wu. The parameters β reflect the influence of the explanatory variables on variation in the dependent variable y.

In this model (Equation 3-2), the OLS is still unbiased, but no longer efficient. Anselin (1988) provides a maximum likelihood method for this model. Therefore, I will apply Anselin's maximum likelihood estimation.

Figure 3-1. **Establishments of Missouri in 1990 and 2000**



	1990	2000
All Industry	130,242	144,716
Manufacturing	7,676	7,307
Retail Trade	32,942	23,910

3.4. Empirical Model and Data

This paper executed cross-sectional units (e.g., 114 counties) in Missouri. The models displayed the relationship between highways and industrial location establishments. Establishment data are the aggregate of all industries, as well as manufacturing and retail trade sectors.

$$LnALLIND_{it} = \alpha_0 + \alpha_1 LnPOPD_{it-1} + \alpha_2 EDU_{it-1} + \alpha_3 SPCLTNmanf_{it-1} + \alpha_4 SPCLTNrt_{it-1} + \alpha_5 ARSPNmanf_{it-1} + \alpha_6 ARSPNrt_{it-1} + \alpha_7 ISall_{it-1} + \alpha_8 LnHWD_{it-1} + \alpha_9 WLnHWD_{it-1} + DVRL + DVIS + (I - \lambda W)^{-1}\varepsilon_{t-1}$$

$$LnMANF_{it} = \beta_0 + \beta_1 LnPOPD_{it-1} + \beta_2 EDU_{it-1} + \beta_3 SPCLTNmanf_{it-1} + \beta_4 ARSPNmanf_{it-1} + \beta_5 ISmanf_{it-1} + \beta_6 LnHWD_{it-1} + \beta_7 WLnHWD_{it-1} + DVRL + DVIS + (I - \lambda W)^{-1}\varepsilon_{t-1}$$

$$LnRT_{it} = \gamma_0 + \gamma_1 LnPOPD_{it-1} + \gamma_2 EDU_{it-1} + \gamma_3 SPCLTNrt_{it-1} + \gamma_4 ARSPNrt_{it-1} + \gamma_5 ISrt_{it-1} + \gamma_6 LnHWD_{it-1} + \gamma_7 WLnHWD_{it-1} + DVRL + DVIS + (I - \lambda W)^{-1}\varepsilon_{t-1}$$

* i = (1, ….,114), t = 2000 and t-1 = 1990

The models are spatial econometric models with data from 1990 to 2000. Therefore, these models consist of three spatial error models for all industry, manufacturing sector, and retail trade sector.

Some explanatory variables for agglomeration economies were tested in Holl (2004) to explain the relationship between manufacturing location establishment and road transportation infrastructure. Details on all variables are included on Table 3-1.

The dependent variables include location establishment data (LnALLIND, LnMANF and LnRT) from the County Business Patterns. Data for education level and population density came from the U.S. Census. The highway investment (LnHWD) at the county level is approximated by highway mileage data from the Missouri Department of Transportation

(MDOT). The spatially-weighted highway density (WLnHWD) is calculated from the GeoDa program. This allows one to investigate how highways in neighboring counties affect location establishment in a county, through the use of the queen spatial contiguity weight matrix.

Table 3-1. Variables

Variable	Definition	Scale	Expected effect	Data Source
$LnALLIND_t$	Log of firm establishments of all **industry** in 2000	County	Dependent variable	County Business Patterns
$LnMANF_t$	Log of firm establishments of **manufacturing** in 2000	County	Dependent variable	County Business Patterns
$LnRT_t$	Firm establishments of **retail trade** in 2000	County	Dependent variable	County Business Patterns
$LnPOPD_{t-1}$	Log of population density in 1990	County	+	US Census
EDU_{t-1}	Percent of people, 25 years of age and older, with a high school degree or higher in 1990	County	+	US Census
$SPCLTNmanf_{t-1}$ 1)	Specialization of **manufacturing** sector in 1990	County	+	Calculated
$SPCLTNrt_{t-1}$ 2)	Specialization of **retail trade** sector in 1990	County	+	Calculated
$ARSPNmanf_{t-1}$ 3)	Area specialization of **manufacturing** in 1990	County	-	Calculated
$ARSPNrt_{t-1}$ 4)	Area specialization of **retail trade** in 1990	County	-	Calculated
$ISall_{t-1}$ 5)	Industry share of **all industry** in 1990	County	+/-	Calculated
$ISmanf_{t-1}$ 6)	Industry share of **manufacturing** in 1990	County	+/-	Calculated
$ISrt_{t-1}$ 7)	Industry share of **retail trade** in 1990	County	+/-	Calculated
$LnHWD_{t-1}$ 8)	Log of highway density in 1990	County	+	MDOT
$WLnHWD_{t-1}$ 9)	Spatially-weighted highway density in 1990	County	+	Calculated
DVRL	Dummy to reflect rural county	County	-	US Census
DVIS	Dummy variable for county with interstate highways	County	+	GIS

* 1) and 2): Sector (manufacturing and retail trade) specialization = [(employment of manufacturing or retail trade in county / total employment in county) / (employment of manufacturing or retail trade in Missouri / total employment in Missouri)].

* 3) and 4): Area specialization of manufacturing and retail trade = ½|(employment of manufacturing or retail trade in county / total employment in county) - (employment of manufacturing or retail trade in Missouri / total employment in Missouri)|.

* 5), 6) and 7): Industry share of total industry, manufacturing and retail trade = (total employment of total industry, manufacturing or retail trade in county / total employment of total industry, manufacturing or retail trade in Missouri).

* 8) Highway density = (Interstate mileage + US highway mileage) / County land area (sq. miles).

* 9) Spatially-weighted average highway density ($[Wx]_i$) = ($[Wx]_i = \sum_j w_{ij} x_{uj}$, where w_{ij} is an (i, j) element of the spatial weights matrix, W (spatial queen matrix).

The education qualification (EDU90) is the percentage of people, 25 years of age and older, with a high school education or higher in 1990, which aids in measuring labor force qualifications. The population density (LnPOPD90) reflects labor market size. The labor market size provides industry with a labor supply, implying that a greater population can supply more labor.

Agglomeration economies such as spatial juxtaposition, localization, or urbanization economies are important establishment factors (Holl, 2004; Gabe, 2004; Guimaraes et al, 2000). These are often viewed as externalities. Localization economies arise when several plants or firms locate near each other in order to save costs or increase sales. An index of sector specialization (manufacturing, SPCLTNmanf; and retail trade, SPCLTNrt) introduces localization economies.

An index of area manufacturing specialization (ARSPNmanf) and retail trade specialization (ARSPNrt) reflects the structure of the regional (county) industrial environment, indicating industrial diversity. This index implies that when fewer sectors locate in the county, the value approaches "1," whereas a value of "0" is captured when the sectoral structure of a county is identical to that of the entire nation.

The industry share in total national (Missouri) industrial employment (ISall, ISmanf and ISrt) shows the size of the regional industrial foundation and is an indicator for the potential agglomeration energy.

3.5. Results

The OLS models are run first and then the spatial effects are examined on the three separate models. Finally, the spatial error models are estimated in order to remove a spatial dependence indicated in the OLS.

3.5.1. Tests of Spatial Dependence

Exploratory spatial data analysis is implemented in order to test for spatial autocorrelation (spatial dependence). In this way we may confirm or reject the hypothesis that counties with similar establishments tend to cluster more than expected. In this paper, the Moran's I was used as a global test for spatial autocorrelation.

This paper shows five tests for spatial dependence: the Moran's I test; two Lagrange Multiplier tests against spatial error and spatial lag dependence; and two robust Lagrange Multiplier tests for spatial error and spatial lag dependence that are robust to the local presence of the other form of spatial dependence.

The Moran's I statistic is used (Moran, 1948; Cliff and Ord, 1981) to estimate and test hypotheses. Moran's I measures spatial autocorrelation in regression residuals. Moran's I is shown as

$$I = \frac{n}{\sum_i \sum_j w_{ij}} \cdot \frac{\sum_i \sum_j w_{ij}(x_i - \mu)(x_j - \mu)}{\sum_i (x_i - \mu)^2} \qquad \text{(Equation 3-3)}$$

where n is the number of observation;. x_i and x_j are the observed establishments at locations i and j with a mean μ; w_{ij} is the elements of the spatial weight matrix, W; and i, j = 1,….,n. Moran's I tests on the OLS yields significant and positive values in models of all industry, manufacturing, and retail trade.

Table 3-2. Diagnostics for Spatial Dependence on OLS Estimates

	All Industry	Manufacturing	Retail Trade
Moran's I (error)	0.166***	0.246***	0.172***
Lagrange Multiplier (lag)	0.109	4.852**	0.073
Robust LM (lag)	3.174*	0.384	3.963**
Lagrange Multiplier (error)	**10.577*****	**16.533*** **	**8.145*** **
Robust LM (error)	**10.686*** **	**12.065*** **	**12.036*** **

Notes: Significant coefficients are indicated by ***, **, * for significance at the 1, 5 and 10% levels, respectively.

These show significant and positive spatial relationships in all industry, manufacturing, and retail trade (Anselin, 1988a and 1995). These positive and significant values for Moran's I indicate that counties have levels of location establishment similar to neighboring counties, and a high value in the county of interest may be surrounded by high values in nearby counties.

Nass and Garfinkle (1992) introduce the localized autocorrelation diagnostic statistic (LADS). The LADS is an error diagnostic. They suggest that the LADS is a good method to diagnose localized residuals and to identify omitted variables in models.

This Moran's I test reveals the general presence of spatial dependence, and does not allow us to discriminate between the spatial error and spatial lag models (Anselin and Rey, 1991). Anselin and Rey (1991) suggest how the Moran I and Lagrange Multiplier tests are used in different situations, different sample sizes, alternative spatial structure, and under the nonstandard error distributions. They suggest that the Lagrange Multiplier tests are the most powerful in deciding the choice between a spatial error model and a spatial lag model.

In addition to the Moran's I test, therefore, the Lagrange Multiplier (LM) is used to test for a specific form of spatial dependence and to check which spatial lag model and spatial error model is best for robust estimation (Anselin and Rey, 1991). If both tests for spatial error and spatial lag are significant, the larger of the two statistics implies the better model, and the better of the two robust tests indicates the more reasonable model (Anselin and Rey, 1991; Anselin and Florax, 1995; Anselin, 2005; Florax and Folmer, 1992). The Lagrange Multiplier test is an asymptotic test which follows a χ^2 distribution with one degree of freedom and tests for error dependence. This test is only valid under assumptions of normality (Anselin, 1988a) and is asymptotic in nature.

The LM error test assesses the null hypotheses that there is no spatial correlation in the residuals (Burridge, 1980). Burridge suggested the LM error test model and Anselin developed it (Anselin, 1988a; Anselin and Rey, 1991). The LM error test model is

$$LM_{error} = (\mathbf{e'We} / \sigma^2)^2 / tr(\mathbf{W^2} + \mathbf{W'W}) \qquad \text{(Equation 3-4)}$$

where e represents the OLS residuals; W is an n×n spatial weights matrix; and tr is the matrix trace operator. This is asymptotically χ^2 distributed with one degree of freedom.

The LM lag test was suggested by Anselin (1988b). The LM lag test model is

$$LM_{lag} = (e'Wy / \sigma^2)^2 / B \qquad \text{(Equation 3-5)}$$

where $B = [(WXb)'(I-X(X'X)^{-1}X')(WXb)/ \sigma^2] + tr\ (W^2 + W'W)$, with b as the OLS estimate for β in Equation 3-1; X as the usual n×k data matrix containing explanatory variables; and others are the same as before (Anselin, 1988a; Anselin and Rey, 1991). The LM lag test is also distributed as a χ^2 variate with one degree of freedom (Anselin, 1988a). It tests the absence of the spatial dependence of the endogenous variable.

Lagrange Multiplier tests on the OLS (Table 3-2) show that LM *error* tests or robust LM *error* tests have significantly higher values than LM *lag* tests or robust LM *lag* tests in all three models. This indicates that the spatial *error* model is preferable to the spatial *lag* model.

Kelejian and Robinson (1992) test a large sample for spatial autocorrelation in terms of error terms of regression models. Their results indicate that omitted independent variables may lead to spatial autocorrelation in the error terms.

3.5.2. Results of Spatial Error Model

The spatial autoregressive coefficients (LAMBDA) are significant and positive, with results of 0.557 in all industry, 0.5621 in manufacturing, and 0.5483 in retail trade.

Highway investment (LnHWD), by proxy of highway mileage density, has an insignificant and negative sign in all three models, indicating more highways may not attract more firm location establishments.

The spatially-weighted highway density coefficients (WLnHWD) that show influences of neighboring counties' highways are all significant and negative in all three models, implying that the increased highway investments of neighboring counties decreases firm location establishments in a county in all industry, manufacturing, and retail trade sectors. Therefore, it reveals there is no evidence that the effects of highway investment externalities on county firm establishment spill over from its surrounding counties.

"Dummy variables for county with interstate highways," DVIS, are all insignificant and negative in all industry, manufacturing, and retail trade.

As for agglomeration economies, sector specializations (SPCLTNmanf and SPCLTNrt) are significant and positive with expected signs, showing that there are externalities taken from the spatial concentration of all industry, manufacturing, and retail trade.

As expected, the area specialization (ARSPNmanf) in manufacturing is insignificant and negative, suggesting that the less the sectors are specialized in the county, the less attractive the area is for manufacturing establishment. However, area specialization (ARSPNrt) in all industry and retail trade is significant but with an unexpected positive sign.

Industry share coefficients of all industry (ISall) and retail trade (ISrt) are statistically significant with an expected positive sign. This means that higher county industry share of all industry and retail trade bring more establishments, indicating that a larger county industrial base of all industry and retail trade attract more establishments in Missouri. Industry share coefficient of manufacturing (ISmanf) is insignificant and positive.

Table 3-3. Spatial Error Models – Maximum Likelihood Estimation

	All Industry	**Manufacturing**	**Retail Trade**
LAMBDA (λ)	0.5571***(5.7449)	0.5621***(5.8360)	0.5483***(5.5898)
LnPOPD	0.8446***(14.9619)	0.9374***(11.6959)	0.8285***(14.0488)
EDU	0.2109(1.4474)	-0.0433(-0.1822)	-0.0362(-0.2275)
SPCLTNmanf	0.1313***(4.3450)	0.2909***(5.7288)	
SPCLTNrt	0.6569***(8.1327)		0.6874***(7.9472)
ARSPNmanf	0.3255(0.6265)	-0.3919(-0.4564)	
ARSPNrt	0.8396**(2.3269)		3.2562**(2.4714)
ISall	1.9391***(4.5125)		
ISmanf		0.9785(1.2361)	
ISrt			2.0887***(4.5416)
LnHWD	-0.1242(-1.1322)	-0.2578(-1.3985)	-0.1077(-0.8938)
WLnHWD	-0.7283**(-3.0032)	-0.6742*(-1.8306)	-0.8678***(-3.2543)
DVRL	-0.0703*(-1.8199)	-0.0988(-1.5324)	-0.0321(-0.7606)
DVIS	-0.0066(-0.2323)	-0.0188(-0.3908)	-0.0005(0.0170)

Notes: Significant coefficients are indicated by ***, **, * for significance at the 1, 5 and 10% levels, respectively.
Z-value is in parentheses.

With respect to other variables, population density coefficients that imply labor supply power are significant and positive with expected signs in all three models, indicating that larger labor forces attract more firms. However, education coefficients that illustrate labor quality have statistically insignificant and positive signs in all industry, and are insignificant and negative in manufacturing and retail trade, indicating that higher education may lead to more establishments in all pooled industry.

3.6. Summary and Conclusion

The aim of this study was to investigate the impacts of highways in a county and the surrounding counties on the industrial location establishment in Missouri, and to explain how highways affect the spatial distribution of these firm establishments.

The spatial autocorrelation coefficients (LAMBDA) in all industry, manufacturing, and retail trade have significant and positive results, indicating that significant spatial dependence in the error terms also was present and needed to be accounted for in order to provide efficient results.

The results of the highway mileage density (LnHWD) show insignificant effects. The research concludes that the effects of neighboring highways are significant and negative in three models from the spatially-weighted highway density coefficients (WLnHWD). Therefore, the results illustrate that more highway investments in a county or in the neighboring counties may not attract more firm establishments in all industry, manufacturing, and retail trade sectors in Missouri, indicating that the effects of highway investments seem to be contained within the county area itself.

As for agglomeration economies, sector specializations show that there are externalities taken from the spatial concentration of all industry, manufacturing, and retail trade sectors. Industry shares in retail trade reveal that higher county industry shares bring more establishments, indicating that a larger county industrial base attracts more establishments in the state of Missouri.

In this analysis, results of agglomeration economies except for area specialization have similar effects in all industry, manufacturing, and retail trade. Therefore, there is a unique conclusion that spatial concentration and large regional economy have strong positive effects on the relationship between agglomeration economies and firm location establishments.

The results of this research may help create consistent regional policies that guarantee greater efficiency of highway investments. This research does not provide evidence that highways contribute to regional economy through firm establishments in Missouri. This is in contrast to many previous studies that conclude that highways have positive impacts on economic growth.

This conclusion of insignificant and negative contributions of highways is obtained from state-level models in this study. However, this research has not demonstrated nor concluded that highway systems are not productive.

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CHAPTER IV

SIMULTANEOUS SPATIAL MODEL OF HIGHWAY-EMPLOYMENT FOR ECONOMIC GROWTH IN MISSOURI

ABSTRACT

This paper analyzes the interdependency between highways and the industrial, manufacturing, and retail trade sectors in Missouri through a simultaneous highway-employment spatial econometric model. The coefficient on the highway variable of population is statistically significant and positive, but those of manufacturing and retail trade employment equations are insignificant. The coefficients on interstate highway accessibility are also all insignificant.

Spatial lag coefficients on manufacturing employment and population equations are significantly positive. The manufacturing employment level within a county does not appear to have a positive effect on the employment level of retail trade, population, or wage in the neighboring counties. The employment of retail trade depends on the population in the neighboring counties. The county population increases with the employment level in retail trade and wages in the neighboring counties.

The results show that highways in a particular county have negative effects on employment growth in manufacturing and retail trade within that county. However, highways within a county are important factors in attracting additional population. Highways in Missouri may aid in increasing wages rather than assisting households to increase the labor supply.

Key words: Highway, Spatial econometric simultaneous model, Missouri.

4.1. Introduction

During the 21st Century, most major cities in the Western world began to decentralize parly as a result of a decrease in transportation costs. Therefore, people have begun to live further away from the central cities and rely more heavily on transportation systems. Applications of the monocentric model show that reductions in transportation costs lead to decentralization of residential settlements (Alonso, 1964; Fujita, 1989; Boarnet, 1994a).

The monocentric economy model considers the relationship between transportation improvements and land use (Boarnet, 1994b). The model originated with Von Thunen (1826) and analyzes how farmers locate themselves across the plain. Each farmer wants to be as close to the city as possible to minimize transportation costs. Since land prices are highest near the city and fall as you move further from the urban center, each farmer thus faces a trade-off between land prices and transportation costs.

The bid-rent approach implies an efficient allocation of land. The efficiency of land allocation in the monocentric model hinges on the assumption that there are no externalities of location. The monocentric model assumes exogenous employment location to population location. Unlike the monocentric assumption, however, Boarnet (1994b) revealed that employment growth within northern New Jersey is endogenous to population changes in neighborhood labor markets.

According to Fujita et al. (1999), the monocentric economy occurs when the labor force in the manufacturing sector is not too large and centripetal forces are strong enough to disperse centrifugal force in agriculture, thus allowing the manufacturing agglomeration in a central city.

Therefore, areas with better accessibility to an employment center have higher bid-rents for the location and are more intensive in land use. Where highway accessibility is better, (ceteris paribus), we would expect an agglomeration economy and concentration of economic activity. This concern is consistent with the idea that highways affect employment location.

This research analyzes the interdependency between highways and industrial, manufacturing, and retail trade sectors in Missouri through a simultaneous highway-employment spatial model. The goal of this paper is to test the hypothesis that highways facilitate employment corridors throughout Missouri. The test is based on a simultaneous regression model of population and employment in a sample of 114 counties across the state of Missouri.

The model that this research uses is an adaptation of the Carlino and Mills simultaneous population and employment location model. Carlino and Mills (1987) study determinants of population and employment growth using simultaneous equations. They compute elasticities for total employment, manufacturing employment, and population. The results show that population and employment are highly interactive, and for manufacturing employment, regional growth depends on economic and demographic conditions rather than regional division. They suggest that amenities should be considered when analyzing the relationship between population and employment.

The model in this study uses spatial econometric techniques. This paper suggests new evidence in the relationship between highways and employment based on a spatial econometric model of employment locations throughout Missouri.

The chapter is organized as follows: section two describes data; section three contains empirical model; section four illustrates spatial effects and the results; finally, section five summarizes the main conclusions of the paper.

4.2. Data

The data are from observations in the 114 counties in Missouri. The dependent variables are the population density and employment within manufacturing and retail trade in the year 2000. The independent variables used to measure transportation infrastructure (H, h, and T) and other local amenities (A, a, and S) are listed in Table 4-1. Table 4-1 describes how each independent variable was measured and shows the data sources.

Transportation infrastructure is measured using three variables: 1) highway mileage density in 1990 (LnHWDTY90); 2) spatially-weighted average highway mileage density in 1990 (WLnHWDTY90); and 3) interstate highway accessibility (DVIS), which is a dummy variable that equals "1" if the observed county contains interstate highways. This spatially-weighted average highway mileage density was used in order to capture the effect of highway investment in neighboring counties.

The vectors (A, a, and S) measure non-transportation amenities that affect employment distribution. The variables used to measure "A" were based on firm location theory and previous studies (e.g., Carlino and Mills, 1987; Boarnet, 1994a and 1994b; Bollinger and Ihlanfeldt, 2000; and Vermeulen and Ommeren, 2004).

The local characteristics for employment include average wage per manufacturing and retail trade job (LnWAGEmanf90 and LnWAGErt90), agglomeration economies (ASPMANF90 and ASPRT90), poverty level (LnPVTY90), highway density

(LnHWDTY90), spatially-weighted average highway mileage density (WLnHWDTY90), and a highway access dummy variable (DVIS).

Table 4-1. Variables

Variable	Definition	Equation	Source
LnEMANF00	Log employment of **manufacturing** industry in *2000*	All	EPARC
LnEMANF90	Log employment of **manufacturing** industry in *1990*	Manufacturing	EPARC
LnERT00	Log of employment of **retail trade** in *2000*	All	EPARC
LnERT90	Log of employment of **retail trade** in *1990*	Retail trade	EPARC
LnPOPD00	Log of population density in 2000	All	US Census
LnPOPD90	Log of population density in 1990	Population	US Census
LnWAGEmanf00[1)]	Log of average wage per **manufacturing** job in *2000*	All	U.S. Dept. of Commerce
LnWAGEmanf90	Log of average wage per **manufacturing** job in *1990*	Wage of manufacturing	U.S. Dept. of Commerce
LnWAGErt00	Log of average wage per **retail trade** job in *2000*	All	U.S. Dept. of Commerce
LnWAGErt90	Log of average wage per **retail trade** job in *1990*	Wage of retail trade	U.S. Dept. of Commerce
LnHWDTY90[2)]	Log of highway density in 1990	All	MDOT
WLnHWDTY90[3)]	Spatially-weighted average highway density in 1990	All	Calculated
EDU90	Percent of people, 25 years of age and older, with a high school degree or higher in 1990	Population & Wage	US Census
LnPVRTY90	Log of number of people below poverty level in 1990	All	US Census
LnHINC90	Log of household income in 1990	Population & Wage	US Census
LnHOUSE90	Log of median values ($) of specified renter-occupied housing units in 1990	Population & Wage	US Census
LnCRM90[4)]	Log of crime index offense rate per 100,000 in 1990	Population	MO Statistical Analysis Center
ASPMANF90[5)]	Area specialization for **manufacturing** in 1990	Manufacturing	Calculated
ASPRT90	Area specialization for **retail trade** in 1990	Retail trade	Calculated
DVIS	Dummy variable for county with interstate highways	All	GIS

* 1) Average wage per manufacturing job = Manufacturing earnings / Manufacturing employment.
* 2) Highway density = (Interstate mileage + US highway mileage) / County land area (sq. miles).
* 3) Spatially-weighted average highway density ($[Wx]_i$) = ($[Wx]_i = \sum_j w_{ij} x_{uj}$, where w_{ij} is an (i, j) element of the spatial weights matrix W (spatial queen matrix).
* 4) Crime index offense rate per 100,000 = (# of crime index offense reported × 100,000) / population of reporting agencies
* 5) Area specialization of manufacturing = ½|(employment of manufacturing in county / total employment in county) - (employment of manufacturing in Missouri / total employment in Missouri)|.

The average wage-per-job variable (manufacturing and retail trade) is used to measure labor cost. An index of area specialization of manufacturing and retail trade reflects the structure of the regional (county) industrial environment, indicating industrial diversity. This index implies that when fewer sectors locate in the county, the value approaches "1," whereas a value of "0" is captured when the sectoral structure of a county is identical to that of the nation entirely. The poverty rate is introduced to proxy low-skilled workers in a county. The highway density and highway access dummy capture the transportation infrastructure power to support firms' economic activity and the transportation investment and improvement.

The local characteristics for a population consist of the following: median values of specified renter-occupied housing units in 1990 (LnHOUSE90); household income (LnHINC90); education level (EDU90); poverty level (LnPVTY90); crime rate (LnCRM90); highway density (LnHWDTY90); spatially-weighted average highway mileage density (WLnHWDTY90); and a highway access dummy variable (DVIS).

The median values of specified renter-occupied housing units provide strong indicators of the local housing market. Household income levels reflect the local consumption power. The crime rate captures regional security. The education rate measures the quality of education and labor force qualification, which attracts a particular segment of the population to reside in the area.

The local characteristics for wages (manufacturing and retail trade) consist of: median values of specified renter-occupied housing units in 1990 (LnHOUSE90); household income (LnHINC90); education level (EDU90); poverty level (LnPVTY90); highway density (LnHWDTY90); spatially-weighted average highway mileage density (WLnHWDTY90); and a highway access dummy variable (DVIS).

This paper focuses on the highway mileage density (LnHWDTY90), spatially-weighted average highway mileage density (WLnHWDTY90), and highway access (DVIS). Thus the "highway mileage density" represents a simple measure of highway investment improvement, and the "highway access" variable represents transportation access. If highway investment and accessibility in a county attract more employment in that county, the coefficients on LnHWDST90 and DVIS should be positive and statistically significant. If highway investments in *surrounding* counties attract more employment in an observed county, the coefficient on WLnHWDST90 should be statistically significant and positive.

4.3. Empirical Model

4.3.1. Simultaneous Static Spatial Lag Model

The spatial lag model reflects misspecifications similar to omitting a significant explanatory variable in the regression model. In this case, however, the OLS is biased and all inferences based on the standard regression model will therefore be inconsistent.

Spatial lag models attempt to explain spatial dependence in stock-like variables for a cross-section of spatial units at one point in time. Spatial lag models directly specify the concept of "neighborhood" for each region through the introduction of spatial weight matrices, W. The elements of the weight matrix reflect the relative importance of spatial dependence between regions. Assuming that the spatial dependence between regions decreases with the distance between them, a distance weight matrix can be used for the spatial lag model. Explanatory variables for spatial lag models include exogenous variables similar to the propulsive and attractive factors used in spatial interaction models.

Anselin's (1988a) methodology to construct a spatial lag model is adapted in this paper. Anselin (1988a) and Anselin and Bera (1998) define spatial lag models as autoregressive models of the following form:

$$y = \rho Wy + X\beta + u, \qquad u \sim N(0, \sigma^2_v I) \qquad \text{(Equation 4-1)}$$

where the dependent variables are spatially lagged by being weighted with a predetermined spatial weight matrix, W, of J*J elements; y is a vector of J*1 endogenous measure for the J regions; X is a J*k matrix of exogenous variables; β is a k*1 vector of corresponding coefficients; and u is a J*1 vector of error terms.

Equation 4-2 implies that the dependent variable "y" depends not only on the values of the explanatory variable X in that region, but also on the values of the explanatory variables in other regions, subject to distance decay. This can be expressed through the model in reduced form. The reduced form of this equation would be:

$$(I - \rho W)y = X\beta + u$$

$$y = (I - \rho W)^{-1}X\beta + (I - \rho W)^{-1}u \qquad \text{(Equation 4-2)}$$

and,

$$E\,[y|X] = (I - \rho W)^{-1}X\beta$$

For the spatial lag model, there is a distinction between the residual and the prediction error. The latter uses the *predicted* (rather than the *observed*) value. This indicates that the prediction error uses only exogenous variables, rather than treating the spatial lag Wy as observed. To determine the extent of spatial spillovers, this research uses geographic queen contiguity as the weights matrix (W) to assign structure to the spatial interdependence that is likely present across the counties in the region. The queen contiguity weight matrix assumes that spatial dependence between regions occurs only between regions that share a common border. In the model, when *direct* neighbors interact, the local spatial multiplier WX or $(1–\rho W)^{-1}X$ measures the spatial spillovers. The spatial lag coefficient (ρ) is the spatial autoregressive coefficient that reflects the reaction of Y to economic growth in neighboring regions. That means spatial spillovers.

This research adapts this spatial lag model for the simultaneous static single spatial lag models (Equations 4-3, 4-4, 4-5, and 4-6), and the simultaneous static multiple spatial lag models (Equations 4-7, 4-8, 4-9, and 4-10) as described below:

$$LnEMANF_{i,t} = \rho_{11} W\_LnEMANF_{i,t} + \alpha_{11} LnERTi_{,t} + \alpha_{12} LnPOPD_{i,t} + \alpha_{13} LnWAGE_{i,t} + \beta_{11} M_{i,t-1} + \varepsilon_{1t} \quad \text{(Equation 4-3)}$$

$$LnERT_{i,t} = \rho_{21} W\_LnERT_{i,t} + \alpha_{21} LnEMANF_{i,t} + \alpha_{22} LnPOPD_{i,t} + \alpha_{23} LnWAGE_{i,t} + \beta_{21} R_{i,t-1} + \varepsilon_{2t} \quad \text{(Equation 4-4)}$$

$$LnPOPD_{i,t} = \rho_{31} W\_LnPOP_{i,t} + \alpha_{31} LnEMANF_{i,t} + \alpha_{32} LnERT_{i,t} + \alpha_{33} LnWAGE_{i,t} + \beta_{31} O_{i,t-1} + \varepsilon_{3t} \quad \text{(Equation 4-5)}$$

$$LnWAGE_{i,t} = \rho_{41} W\_LnWAGE_{i,t} + \alpha_{41} LnEMANF_{i,t} + \alpha_{42} LnERT_{i,t} + \alpha_{43} LnPOPD_{i,t} + \beta_{41} S_{i,t-1} + \varepsilon_{4t} \quad \text{(Equation 4-6)}$$

Where,

$LnEMANF_{i,t}$: log of county **manufacturing** employment
$LnERT_{i,t}$: log of county **retail trade** employment
$LnPOPD_{i,t}$: log of county population density
$LnWAGE_{i,t}$: log of county wage per job
M, R, O and S : vectors of exogenous variables
W : queen spatial weight matrix
ρ_{11}, ρ_{21}, ρ_{31} and ρ_{41}: the spatially autoregressive parameters (spatial lag coefficients)
α_{11}, α_{12}, α_{21}, α_{22}, α_{31}, α_{32}, α_{41} and α_{42}: coefficients of endogenous variables
β_{11}, β_{21}, β_{31} and β_{41}: coefficients of exogenous variables
ε = error term
i = county
t = 2000 and t-1 = 1990

The spatial lag vectors ($W\_LnEMANF_{i,t}$, $W\_LnERT_{i,t}$, $W\_LnPOPD_{i,t}$ and $W\_LnWAGE_{i,t}$) contain a weighted average of the values in neighboring counties of each observation, with the matrix W (queen contiguity weight matrix) defining the concept of 'neighbor' and the specific spatial dependence that is assumed between counties.

This model assumes that each dependent variable in a county is affected by the endogenous variables and exogenous variables in that county and also the spatially-lagged dependent variable of surrounding counties.

For example, the manufacturing employment in a county is influenced by the manufacturing employment in surrounding counties, but also by the retail trade employment, wage, and population in that county.

The simultaneous static multiple spatial lag models account for how the employment, population and wage in a county are influenced by those in the surrounding counties:

$$LnEMANF_{i,t} = \rho_{11}W\_LnEMANF_{i,t} + \rho_{12}W\_LnERT_{i,t} + \rho_{13}W\_LnPOPD_{i,t} + \rho_{14}W\_LnWAGE_{i,t} + \beta_{11}M_{i,t-1} + \varepsilon_{1t} \quad \text{(Equation 4-7)}$$

$$LnERT_{i,t} = \rho_{21}W\_LnERT_{i,t} + \rho_{22}W\_LnEMANF_{i,t} + \rho_{23}W\_LnPOPD_{i,t} + \rho_{24}W\_LnWAGE_{i,t} + \beta_{21}R_{i,t-1} + \varepsilon_{2t} \quad \text{(Equation 4-8)}$$

$$LnPOPD_{i,t} = \rho_{31}W\_LnPOPD_{i,t} + \rho_{32}W\_LnEMANF_{i,t} + \rho_{33}W\_LnERT_{i,t} + \rho_{34}W\_LnWAGE_{i,t} + \beta_{31}O_{i,t-1} + \varepsilon_{3t} \quad \text{(Equation 4-9)}$$

$$LnWAGE_{i,t} = \rho_{41}W\_LnWAGE_{i,t} + \rho_{42}W\_LnEMANF_{i,t} + \rho_{43}W\_LnERT_{i,t} + \rho_{44}W\_LnPOPD_{i,t} + \beta_{41}S_{i,t-1} + \varepsilon_{4t} \quad \text{(Equation 4-10)}$$

with the variables as defined in the simultaneous static single spatial lag model.

The multiple spatial lag model shows that all spatially-lagged endogenous variables affect the dependent variable. In the case of Equation 4-7, manufacturing employment in a county is influenced by the spatial distribution of retail trade employment, population, and wage levels in the adjacent counties.

In previous equations, the dependent variables are end-of-period values (year 2000) whereas most independent variables have beginning-of-period values (year 1990). It helps these equations to diminish the simultaneity and to remove the ambiguous causation issue because dependent variables with end-of-period values can't influence the independent variables with beginning-of-period values (Carlino and Mills, 1987).

4.3.2. Simultaneous Dynamic Spatial Lag Model

The simultaneous dynamic spatial lag model begins with a description of equilibrium population, employment, and wage levels at locations within a county area. Equilibrium population, employment, and wage models assume functions of transportation infrastructure, non-transportation amenities, and each other as shown below.

$$EMP^{*}_{i,t} = f\,(h_{i,t}, a_{i,t}, POP_{i,t}, WAGE_{i,t}) \qquad \text{(Equation 4-11)}$$

$$POP^{*}_{i,t} = f\,(H_{i,t}, A_{i,t}, EMP_{i,t}, WAGE_{i,t}) \qquad \text{(Equation 4-12)}$$

$$WAGE^{*}_{i,t} = f\,(T_{i,t}, S_{i,t}, EMP_{i,t}, POP_{i,t}) \qquad \text{(Equation 4-13)}$$

Where,

$EMP^{*}_{i,t}$ = equilibrium employment
$EMP_{i,t}$ = county employment
$POP^{*}_{i,t}$ = equilibrium population
$POP_{i,t}$ = county population
$WAGE^{*}_{i,t}$ = equilibrium wage
$WAGE_{i,t}$ = county wage
$H_{i,t}$ = measures of **transportation** infrastructure for *residents*
$h_{i,t}$ = measures of **transportation** infrastructure for *firms*
$T_{i,t}$ = measures of **transportation** infrastructure for *wage*
$A_{i,t}$ = measures of **non-transportation** infrastructure for *residents*
$a_{i,t}$ = measures of **non-transportation** infrastructure for *firms*
$S_{i,t}$ = measures of **non-transportation** infrastructure for *wage*
i subscripts indicate counties
t subscripts indicate time

The model can be solved to give a simultaneous model.

$$EMP^{*}_{i,t} = \alpha_E \, POP_{i,t} + \beta_P \, M_{i,t} \qquad \text{(Equation 4-14)}$$

$$POP^{*}_{i,t} = \alpha_P \, EMP_{i,t} + \beta_E \, O_{i,t} \qquad \text{(Equation 4-15)}$$

$$WAGE^{*}_{i,t} = \alpha_W \, WAGE_{i,t} + \beta_W \, S_{i,t} \qquad \text{(Equation 4-16)}$$

Where,

$EMP^{*}_{i,t}$ = equilibrium employment
$EMP_{i,t}$ = county employment
$POP^{*}_{i,t}$ = equilibrium population
$POP_{i,t}$ = county population
$WAGE^{*}_{i,t}$ = equilibrium wage
$WAGE_{i,t}$ = county wage
α_E, α_P and α_W = coefficients of the endogenous variables
M, O and S = vectors of exogenous variables ($h_{i,t}$, $a_{i,t}$, $H_{i,t}$, $A_{i,t}$, $T_{i,t}$ and $S_{i,t}$)
β_P, β_E and β_W = vectors of coefficients of exogenous variables
i subscripts indicate counties
t subscripts indicate time

According to Carlino and Mills (1987), Boarnet (1994), Henry et al. (2001), and Kedejian and Robinson (2006), population, employment, and wage adjust towards equilibrium with substantial lags. The distributed lag adjustment equations are:

$$EMP_{i,\,t} = EMP_{i,\,t-1} + \lambda_1(EMP^*_{i,\,t} - EMP_{i,\,t-1}) \qquad \text{(Equation 4-17)}$$

$$POP_{i,\,t} = POP_{i,\,t-1} + \lambda_2(POP^*_{i,\,t} - POP_{i,\,t-1}) \qquad \text{(Equation 4-18)}$$

$$WAGE_{i,t} = WAGE_{i,t-1} + \lambda_3(WAGE^*_{i,t} - WAGE_{i,t-1}) \qquad \text{(Equation 4-19)}$$

Where,

t-1 = the indicated variable lagged on period
λ_1, λ_2 and λ_2 = “speed-of-adjustment coefficients”, [0, 1]

The simultaneous dynamic single spatial lag model can be derived from Equations 4-1, 4-14, 4-15, and 4-16. Carlino and Mills (1987) suggest lagging most independent variables to a base year to identify the resulting regression system. For this model, the transportation infrastructure and non-transportation amenity variables (M, R, O, and S) were lagged to the base year "t-l."

$$EMANF^*_{i,t} = \rho_{11}W\_EMANF_{i,t} + \alpha_{11}ERT_{i,t} + \alpha_{12}POPD_{i,t} + \alpha_{13}WAGE_{i,t} + \beta_{11}M_{i,t-1} + \varepsilon_{1t}$$
(Equation 4-20)

$$ERT^*_{i,t} = \rho_{21}W\_ERT_{i,t} + \alpha_{21}EMANF_{i,t} + \alpha_{22}POPD_{i,t} + \alpha_{23}WAGE_{i,t} + \beta_{21}R_{i,t-1} + \varepsilon_{2t}$$
(Equation 4-21)

$$POPD^{*}_{i,t} = \rho_{31} W\_POPD_{i,t} + \alpha_{31} EMANF_{i,t} + \alpha_{32} ERT_{i,t} + \alpha_{33} WAGE_{i,t} + \beta_{31} O_{i,t-1} + \varepsilon_{3t}$$

(Equation 4-22)

$$WAGE^{*}_{i,t} = \rho_{41} W\_WAGE_{i,t} + \alpha_{41} EMANF_{i,t} + \alpha_{42} ERT_{i,t} + \alpha_{43} POPD_{i,t} + \beta_{41} S_{i,t-1} + \varepsilon_{4t}$$

(Equation 4-23)

Where,

$EMANF^{*}_{i,t}$ = equilibrium manufacturing employment
$EMANF_{i,t}$ = county manufacturing employment
$ERT^{*}_{i,t}$ = equilibrium retail trade employment
$ERT_{i,t}$ = county retail trade employment
$POP^{*}_{i,t}$ = equilibrium population
$POP_{i,t}$ = county population
$WAGE^{*}_{i,t}$ = equilibrium wage per job
$WAGE_{i,t}$ = county wage per job
M, R, O and S = vectors of exogenous variables
W = queen contiguity spatial weight matrix
ρ_{11}, ρ_{21}, ρ_{31} and ρ_{41} = the spatially-autoregressive parameters (spatial lag coefficients)
α_{11}, α_{12}, α_{21}, α_{22}, α_{31}, α_{32}, α_{41} and α_{42} = coefficients of endogenous variables
$\beta_{11,}$ $\beta_{21,}$ β_{31} and β_{41} = coefficients of exogenous variables
ε = error term
i = county
t = 2000 and t-1 = 1990

Substituting Equations 4-20, 4-21, 4-22, and 4-23 for $EMANF^{*}_{i,t}$, $ERT^{*}_{i,t}$, $POPD^{*}_{i,t}$, and $WAGE^{*}_{i,t}$ in Equations 4-17, 4-18, and 4-19, we get the simultaneous dynamic single spatial lag equations as follow:

$$LnEMANF_{i,t} = \lambda_1 \rho_{11} W\_LnEMANF_{i,t} + (1-\lambda_1) LnEMANF_{i,t-1} + \lambda_1 \alpha_{11} LnERT_{i,t} + \lambda_1 \alpha_{12} LnPOPD_{i,t} + \lambda_1 \alpha_{13} WAGE_{i,t} + \lambda_1 \beta_{11} M_{i,t-1} + \mu_{1t}$$

(Equation 4-24)

$$LnERT_{i,t} = \lambda_2\rho_{21}W\_LnERT_{i,t} + (1-\lambda_2)LnERT_{i,t-1} + \lambda_2\alpha_{21}LnEMANF_{i,t} + \lambda_2\alpha_{22}LnPOPD_{i,t} + \lambda_2\alpha_{23}WAGE_{i,t} + \lambda_2\beta_{21}R_{i,t-1} + \mu_{2t}$$

(Equation 4-25)

$$LnPOPD_{i,t} = \lambda_3\rho_{31}W\_LnPOPD_{i,t} + (1-\lambda_3)LnPOPD_{i,t-1} + \lambda_3\alpha_{31}LnEMANF_{i,t} + \lambda_3\alpha_{32}LnERT_{i,t} + \lambda_3\alpha_{33}WAGE_{i,t} + \lambda_3\beta_{31}O_{i,t-1} + \mu_{3t}$$

(Equation 4-26)

$$LnWAGE_{i,t} = \lambda_4\rho_{41}W\_LnWAGE_{i,t} + (1-\lambda_4)LnWAGE_{i,t-1} + \lambda_4\alpha_{41}LnEMANF_{i,t} + \lambda_4\alpha_{42}LnERT_{i,t} + \lambda_4\alpha_{43}LnPOPD_{i,t} + \lambda_4\beta_{41}S_{i,t-1} + \mu_{4t}$$

(Equation 4-27)

Where,

$LnEMANF_{i,t}$ = log of county **manufacturing** employment
$LnERT_{i,t}$ = log of county **retail trade** employment
$LnPOPD_{i,t}$ = county population density
$LnWAGE_{i,t}$ = county wage per job
M, R, O and S = vectors of exogenous variables
W = queen spatial weight matrix
ρ_{11}, ρ_{21}, ρ_{31} and ρ_{41} = the spatially autoregressive parameters (spatial lag coefficients)
α_{11}, α_{12}, α_{21}, α_{22}, α_{31}, α_{32}, $\alpha_{41}$and α_{42} = coefficients of endogenous variables
β_{11}, β_{21}, β_{31} and β_{41} = coefficients of exogenous variables
ε = error term
i = county
t = 2000 and t-1 = 1990
λ_1, λ_2 and λ_3 = "speed-of-adjustment coefficients", [0, 1]

The simultaneous dynamic multiple spatial lag models are considered so we may investigate how the employment, population, and wage in a county are affected by the same variables in the neighboring counties.

$$EMANF^{*}_{i,t} = \rho_{11}W\_EMANF_{i,t} + \rho_{12}W\_ERT_{i,t} + \rho_{13}W\_POPD_{i,t} + \rho_{14}W\_WAGE_{i,t} + \beta_{11}M_{i,t-1} + \varepsilon_{1t} \quad \text{(Equation 4-28)}$$

$$ERT^{*}_{i,t} = \rho_{21}W\_ERT_{i,t}+\rho_{22}W\_EMANF_{i,t}+\rho_{23}W\_POPD_{i,t}+\rho_{24}W\_WAGE_{i,t}+\beta_{21}R_{i,t-1}+\varepsilon_{2t} \quad \text{(Equation 4-29)}$$

$$POPD^{*}_{i,t} = \rho_{31}W\_POPD_{i,t}+\rho_{32}W\_EMANF_{i,t}+\rho_{33}W\_ERT_{i,t}+\rho_{34}W\_WAGE_{i,t}+\beta_{31}O_{i,t-1}+\varepsilon_{3t} \quad \text{(Equation 4-30)}$$

$$WAGE^{*}_{i,t}=\rho_{41}W\_WAGE_{i,t}+\rho_{42}W\_EMANF_{i,t}+\rho_{43}W\_ERT_{i,t}+\rho_{44}W\_POPD_{i,t} +\beta_{41}S_{i,t-1}+\varepsilon_{4t} \quad \text{(Equation 4-31)}$$

Where,

$EMANF^{*}_{i,t}$ = equilibrium **manufacturing** employment
$EMANF_{i,t}$ = county **manufacturing** employment
$ERT^{*}_{i,t}$ = equilibrium **retail trade** employment
$ERT_{i,t}$ = county **retail trade** employment
$POP^{*}_{i,t}$ = equilibrium population
$POP_{i,t}$ = county population
$WAGE^{*}_{i,t}$ = equilibrium wage per job
$WAGE_{i,t}$ = county wage per job
M, R, O and S = vectors of exogenous variables
W = queen contiguity spatial weight matrix
ρ = the spatially-autoregressive parameters (spatial lag coefficients)
β = coefficients of exogenous variables
ε = error term
i = county
t = 2000 and t-1 = 1990

Substituting Equations 4-28, 4-29, 4-30, and 4-31 for $EMANF^{*}_{i,t}$, $ERT^{*}_{i,t}$, $POPD^{*}_{i,t}$ and $WAGE^{*}_{i,t}$ in Equations 4-17, 4-18, and 4-19, we get the simultaneous dynamic single spatial lag equations as follow:

$$LnEMANF_{i,t} = \lambda_1\rho_{11}W\_LnEMANF_{i,t} + (1-\lambda_1)LnEMANF_{i,t-1} + \lambda_1\rho_{12}W\_LnERT_{i,t} + \lambda_1\rho_{13}W\_LnPOPD_{i,t} + \lambda_1\rho_{14}W\_WAGE_{i,t} + \lambda_1\beta_{11}M_{i,t-1} + \mu_{1t}$$

(Equation 4-32)

$$LnERT_{i,t} = \lambda_2\rho_{21}W\_LnERT_{i,t} + (1-\lambda_2)LnERT_{i,t-1} + \lambda_2\rho_{22}W\_LnEMANF_{i,t} + \lambda_2\rho_{23}W\_LnPOPD_{i,t} + \lambda_2\rho_{24}W\_WAGE_{i,t} + \lambda_2\beta_{21}R_{i,t-1} + \mu_{2t}$$

(Equation 4-33)

$$LnPOPD_{i,t} = \lambda_3\rho_{31}W\_LnPOPD_{i,t} + (1-\lambda_3)LnPOPD_{i,t-1} + \lambda_3\rho_{32}W\_LnEMANF_{i,t} + \lambda_3\rho_{33}W\_LnERT_{i,t} + \lambda_3\rho_{34}W\_WAGE_{i,t} + \lambda_3\beta_{31}O_{i,t-1} + \mu_{3t}$$

(Equation 4-34)

$$LnWAGE_{i,t} = \lambda_4\rho_{41}W\_LnWAGE_{i,t} + (1-\lambda_4)LnWAGE_{i,t-1} + \lambda_4\rho_{42}W\_LnEMANF_{i,t} + \lambda_4\rho_{43}W\_LnERT_{i,t} + \lambda_4\rho_{44}W\_LnPOPD_{i,t} + \lambda_4\beta_{41}S_{i,t-1} + \mu_{4t}$$

(Equation 4-35)

Where,

$LnEMANF_{i,t}$ = log of county **manufacturing** employment
$LnERT_{i,t}$ = log of county **retail trade** employment
$LnPOPD_{i,t}$ = county population density
$LnWAGE_{i,t}$ = county wage per job
M, R, O and S = vectors of exogenous variables
W = queen spatial weight matrix
ρ = the spatially autoregressive parameters (spatial lag coefficients)
β = coefficients of exogenous variables
ε = error term
i = county
t = 2000 and t-1 = 1990
λ_1, λ_2, λ_3 and λ_4 = "speed-of-adjustment coefficients", [0, 1]

They are not simultaneous with the dependent variables, because all explanatory variables are lagged to a base year (time "t-1", or the year 1990).

4.4. Results

Considering the simultaneity due to spatial lag and the endogeneity in all equations, the models have the instrumental variables in all equations with single and multiple spatial lag variables. The instrumental variables are the spatially lagged variables and the time-lagged variables in each equation. The spatially-lagged explanatory variables as instruments are efficient methods and bring better estimators (Kelejian and Robison, 1993).

The results of the maximum likelihood estimation (MLE) for the simultaneous static spatial models are shown in Table 4-2. As for highway investments, the highway coefficient (LnHWDTY90) of the population equation in the simultaneous static spatial lag model is both statistically significant and positive, indicating that highways play a role in attracting the population to a local area. It implies that people prefer to reside in counties that provide better transportation infrastructure. Highways in neighboring counties (WLnHWDTY90) have negative effects on retail trade employment in an observed county. It may indicate that a county serves as a home base for surrounding counties, indicating that improved highways can save commuting time and make people commute longer distances.

According to Dalenberg and Partridge (1997), when increased highway investments lead to an increase in wage, highways assist firms rather than households. This indicates that improved highway transportation systems may be much more important in the production of goods, by reducing transportation costs. They suggested that transportation infrastructure as a household amenity increases labor supply and decreases wages. The results of highway density (LnHWDTY90) on static wage equations of manufacturing and retail trade show that highway investment has insignificant and positive impacts on employments of manufacturing and retail trade. This indicates that highways in Missouri may function as a firm amenity. The coefficients on the interstate highway accessibility (DVIS) are all insignificant.

With respect to the spatial autoregressive coefficients (ρ) used to capture the spatial effect in manufacturing, retail trade, population and wage equations, spatial lag coefficients in "manufacturing" and "population" (WLnMANF00 and WPOPD00) are significant and positive for the static single lag model. The coefficients of "retail trade" (WLnRT00) and "wage of retail trade" (WLnWAGErt00) are significant and negative, but that of "wage of manufacturing" (WWAGEmanf00) is insignificant and positive.

These positive spatially-weighted coefficients mean that a higher level of manufacturing employment and population in a county are increased by manufacturing employment and population in the neighboring counties. In other words, observed counties and their neighboring counties will both have either high or low values of employment and population. Therefore, there exists a positive spatial interaction and a clustering tendency between the neighboring counties for "manufacturing employment" and "population." However, there is a negative spatial relationship in "retail trade sector" and "wage of retail trade."

Results were significant and positive with spatial coefficients of 0.325 in the manufacturing employment equation and 0.301 in the population equation. The magnitude of the coefficient indicates that when manufacturing employment and population go up by 10% roughly 3.25% and 3.01% respectively, could be attributed to the spatial effect.

As for the coefficients of endogenous variables, the coefficient for "retail trade" (LnERT00) is significant and positive, but that for "population" (LnPOPD00) it is significant and negative on the manufacturing equation in the static single spatial lag model. The coefficients for the spatially-lagged variable of "retail trade" (WLnERT00) and “manufacturing wage” (WLnWAGEmanf00) in the static multiple spatial lag models are significant and negative, but “population” (WLnPOPD00) is significant and positive. This implies that the county manufacturing employment does not rely on the employment of retail trade, population, and manufacturing wage in the neighboring counties.

In the retail trade equations, coefficients for “manufacturing” variable (LnEMANF00) and “population” variable (LnPOPD00) in the static single spatial lag model are significantly positive, but wage variable (LnWAGE00) is insignificant. The coefficient for the spatial lagged variable (WPOPD00) of population is significantly positive in the static multiple spatial lag models. Dense population in a county and its neighbors attracts retail trade jobs in a county. We see that the employment of retail trade depends on the population in the neighboring counties.

In the population equations, coefficients for manufacturing employment (LnEMANF00) is significantly negative, but those of retail trade (LnERT00) and manufacturing wage (LnWAGEmanf00) in the static single spatial lag model are significantly positive. In the static multiple spatial lag models, the coefficient for the spatial lagged variable (WLnEMANF00) of manufacturing is insignificantly negative, the retail trade and population are insignificantly positive, and wages of manufacturing and retail trade are significantly positive. This indicates that the county population is related to the employment of retail trade and wages of manufacturing and retail trade in the neighboring counties positively. Therefore, the hypothesis that counties with high employment of retail trade and with high wage attract more people to the region is supported.

Table 4-2. The Results of Simultaneous Static Spatial Lag Model (MLE)

Variable	Static single spatial lag model					Static multiple spatial lag model				
	Manufacturing	Retail trade	Population	Wage of manufacturing	Wage of retail trade	Manufacturing	Retail trade	Population	Wage of manufacturing	Wage of retail trade
WLnEMANF00	0.325*** (3.798)					0.294*** (2.801)	-0.038 (-0.654)	-0.051 (-1.602)	-0.037 (0.236)	-0.012 (-0.702)
WLnERT00		-0.136** (-2.062)				-1.411*** (-2.585)	-0.093 (-0.762)	0.072 (0.709)	-0.219* (-1.719)	-0.050 (-0.717)
WLnPOPD00			0.301*** (5.383)			2.289*** (3.118)	0.736*** (4.245)	0.059 (0.499)	0.323** (2.016)	0.071 (0.813)
WLnWAGEmanf00				0.136 (1.074)		-2.039*** (-2.612)		0.415** (2.439)	0.156 (1.235)	
WLnWAGErt00					-0.263* (-1.936)		-2.024*** (-3.053)	1.147*** (3.073)		-0.178 (-1.233)
LnEMANF00		0.112*** (4.674)	-0.049*** (-2.764)	0.013 (0.662)	-0.00007 (-0.007)					
LnERT00	1.381** (5.559)		0.301*** (4.192)	-0.108 (-1.349)	0.051 (1.207)					
LnPOPD00	-0.944*** (-2.815)	0.901*** (11.411)		0.119 (1.332)	0.067 (1.429)					
LnWAGEmanf00	0.399 (1.073)		0.179** (2.046)							
LnWAGErt00		0.146 (0.626)	0.266 (1.619)							
EDU90			0.324*** (2.622)	0.132 (1.013)	-0.154** (-2.213)			0.469*** (3.572)	0.071 (0.563)	-0.121* (-1.739)
LnPVRTY90	0.377 (1.461)	0.208** (2.467)	0.471*** (5.139)	0.155 (1.449)	0.006 (0.106)	1.131*** (6.524)	1.064*** (13.354)	0.795*** (16.301)	0.145*** (3.062)	0.115*** (4.424)
LnHINC90			0.721** (2.458)	0.836*** (2.704)	-0.021 (-0.127)			1.467*** (5.360)	0.738*** (2.712)	0.165 (1.104)
LnHOUSE90			-0.254 (-0.826)	-0.403 (-1.236)	-0.102 (-0.587)			-0.117 (-0.358)	-0.344 (-1.076)	-0.046 (-0.261)
LnCRM90			-0.027 (0.799)					-0.013 (-0.354)		
ASPMANF90	-8.829*** (-4.747)					-10.786*** (-5.283)				
ASPRT90		-3.541*** (-2.667)					-3.708* (-1.917)			
LnHWDTY90	-0.296 (-0.702)	-0.086 (-0.613)	0.177* (1.798)	0.118 (1.155)	0.053 (0.972)	-0.486 (-1.067)	0.195 (0.973)	0.260** (2.549)	0.091 (0.923)	0.065 (1.203)
WLnHWDTY90	1.107 (1.305)	-0.557* (-1.887)	0.337 (1.538)	-0.303 (-1.468)	0.032 (0.288)	-0.807 (-0.765)	-0.725 (-1.526)	0.197 (0.854)	-0.217 (-0.938)	0.031 (0.242)
DVIS	-0.059 (-0.553)	-0.021 (-0.613)	-0.004 (-0.167)	-0.035 (-1.366)	0.017 (1.257)	-0.025 (-0.223)	0.029 (0.606)	-0.037 (-1.447)	-0.035 (-1.459)	0.011 (0.829)

Notes: Significant coefficients are indicated by ***, **, * for significance at the 1, 5 and 10% levels, respectively.
z-value is in parentheses.

As expected, agglomeration economies of the area specialization in both manufacturing (ASPMANF90) and retail trade (ASPRT90) are significantly negative, suggesting that if fewer specialized sectors are in the county, it can attract more manufacturing and retail trade employment.

Table 4-3. The Results of Simultaneous Dynamic Spatial Lag Model (MLE)

Variable	Dynamic single spatial lag model					Dynamic multiple spatial lag model				
	Manufacturing	Retail trade	Population	Wage of manufacturing	Wage of retail trade	Manufacturing	Retail trade	Population	Wage of manufacturing	Wage of retail trade
WLnEMANF00	0.193** (2.533)					0.133 (1.381)	0.036* (1.915)	0.003 (0.226)	-0.037 (-1.266)	-0.015 (-0.984)
WLnERT00		0.004 (0.111)				-0.392 (-0.891)	0.024 (0.239)	0.061 (1.274)	-0.220* (-1.841)	-0.026 (-0.432)
WLnPOPD00			0.068** (2.489)			0.819 (1.433)	-0.131 (-1.489)	-0.054 (-0.839)	0.332** (2.199)	0.045 (0.593)
WLnWAGEmanf00				0.087 (0.708)		-1.587*** (-2.678)		-0.098 (-1.288)	0.095 (0.779)	
WLnWAGErt00					-0.258** (-2.064)		0.482** (2.224)	0.264* (1.649)		-0.169 (0.209)
LnEMANF00		0.018 (1.514)	-0.011 (-1.481)	-0.006 (-0.317)	0.002 (0.171)					
LnERT00	0.595*** (2.644)		0.134*** (4.460)	-0.039 (-0.515)	0.042 (1.142)					
LnPOPD00	-0.506* (-1.808)	0.063 (1.123)		0.116 (1.372)	0.049 (1.178)					
LnWAGEmanf00	0.574* (1.909)		-0.045 (-1.254)							
LnWAGErt00		0.028 (0.259)	0.102 (1.549)							
LnEMANF90	0.941*** (8.015)					1.054*** (9.593)				
LnERT90		1.039*** (20.289)					1.146*** (32.794)			
LnPOPD90			0.875*** (24.249)					0.917*** (23.789)		
LnWAGEmanf90				0.474*** (3.885)					0.463*** (4.084)	
LnWAGErt90					0.758*** (6.079)					0.763*** (6.076)
EDU90			0.011 (0.222)	0.076 (0.613)	-0.128** (-2.088)			0.067 (1.176)	0.062 (0.525)	-0.105* (-1.730)
LnPVRTY90	-0.177 (-0.808)	-0.119*** (-2.808)	-0.066 (-1.537)	0.035 (0.329)	-0.022 (-0.441)	-0.037 (-0.211)	-0.164*** (-3.681)	0.042 (1.115)	0.066 (1.366)	0.061** (2.486)
LnHINC90			-0.004 (-0.029)	0.322 (1.002)	0.002 (0.017)			0.263** (2.083)	0.278 (0.994)	0.140 (1.073)
LnHOUSE90			0.148 (1.191)	-0.179 (-0.574)	-0.022 (-0.142)			0.158 (1.163)	-0.076 (-0.246)	0.023 (0.147)
LnCRM90			-0.009 (-0.658)		-0.019 (-1.135)			0.003 (0.198)		
ASPMANF90	-0.252 (-0.136)					-0.736 (-0.391)				
ASPRT90		0.259 (0.403)					0.496 (0.813)			
LnHWDTY90	-0.328 (-0.959)	-0.028 (-0.424)	-0.021 (-0.509)	0.078 (0.802)	0.039 (0.815)	-0.343 (-0.999)	0.003 (0.045)	-0.015 (-0.338)	0.064 (0.688)	0.033 (0.694)
WLnHWDTY90	0.500 (0.729)	0.007 (0.049)	0.067 (0.755)	-0.239 (-1.233)	0.011 (0.115)	-0.249 (-0.313)	0.131 (0.882)	0.33 (0.348)	-0.208 (-0.962)	0.008 (0.069)
DVIS	-0.048 (-0.592)	-0.032** (-2.020)	-0.021** (-2.089)	-0.027 (-1.119)	0.009 (0.754)	0.002 (0.028)	-0.033** (-2.164)	-0.023** (-2.204)	-0.028 (-1.216)	0.007 (0.574)

Notes: Significant coefficients are indicated by ***, **, * for significance at the 1, 5 and 10% levels, respectively.
z-value is in parentheses.

Table 4-4. Identified Coefficients for Equilibrium Values

Coefficient	Dynamic single spatial lag model					Dynamic multiple spatial lag model				
	Manu fac turing	Retail trade	Popula tion	Wage of manufact uring	Wage of retail trade	Manu fac turing	Retail trade	Popula Tion	Wage of manufact uring	Wage of retail trade
λ_1	0.059					-0.054				
λ_2		-0.039					-0.146			
λ_3			0.125					0.537		
λ_4				0.526					0.537	
λ_5					0.242					
ρ_{11}	3.271					-2.463				
ρ_{12}		0.103				7.259				
ρ_{13}			0.544			-15.167				
ρ_{14}				0.165		29.389				
ρ_{15}					-1.066		-0.164			
ρ_{21}							-0.247			
ρ_{22}							0.897			
ρ_{23}							-3.301			
ρ_{24}								0.177		
ρ_{31}								-0.069		
ρ_{32}								-0.410		
ρ_{33}								0.618		
ρ_{34}									0.177	
ρ_{41}									-0.069	
ρ_{42}									-0.410	
ρ_{43}									0.618	
ρ_{44}										-0.713
α_{11}	10.085									-0.063
α_{12}	-8.576									-0.110
α_{13}	9.729									0.190
α_{21}		-0.462								
α_{22}		-1.615								
α_{23}		0.718								
α_{31}			-0.088							
α_{32}			1.072							
α_{33}			-0.360							
α_{34}			-0.816							
α_{41}				-0.011	-0.008					
α_{42}				-0.074	0.174					
α_{43}				0.221	0.202					
β EDU90			0.008	0.144	-0.529			0.807	0.115	-0.443
β LnPVRTY90	-3.000	3.051	-0.528	-0.067	-0.091	0.685	1.123	0.506	0.123	0.257
β LnHINC90			0.032	-0.612	0.008			3.169	0.518	0.591
β LnHOUSE90			1.184	-0.340	-0.091			1.904	-0.142	0.097
β LnCRM90			-0.072					0.036		
β ASPMANF90	-4.271					13.630				
β ASPRT90		-6.641					-3.397			
β LnHWDSTY90	-5.559	0.718	-0.168	0.148	0.161	6.352	-0.021	-0.181	0.119	0.139
β WLnHWDSTY90	-8.475	-0.192	0.536	-0.454	-0.045	4.611	-0.897	3.976	-0.387	0.034
β DVIS	-0.814	0.821	-0.168	-0.051	-0.037	-0.037	0.226	-0.277	-0.052	0.030

People position themselves in counties with well-designed highway infrastructure, safe environments (low crime rates), high-quality education, high income, and low cost of living. These components may affect wage increases in a local area.

The results of the simultaneous dynamic spatial model are shown in Table 4-3 and Table 4-4. Table 4-3 shows the results for Equations 4-24 to 4-31, and Table 4-4 reveals the results for Equations 4-20, 4-21, 4-22, and 4-23. The beginning year's (1990) effects were the following: $1 - \lambda_1 = 0.941$ for LnEMANF90; $1 - \lambda_2 = 1.039$ for LnERT90; $1 - \lambda_3 = 0.875$ for LnPOPD90; $1 - \lambda_4 = 0.474$ for LnWAGEmanf90; and $1 - \lambda_5 = 0.758$ for LnWAGErt90.

These time-lagged coefficients on the variables for manufacturing, retail trade, population, and wages are significant and positive. This implies that economic activity of manufacturing and retail trade in 1990 brought more jobs in those sectors, and that the counties with high population densities and wages in 1990 have higher population densities and wages in manufacturing and retail trade after a decade.

With respect to the speed of adjustment coefficients in the simultaneous dynamic spatial lag model, the coefficients of population are positive, $\lambda_3 = 0.125$ in single spatial lag and $\lambda_3 = 0.083$ in multiple spatial lag. Those of wages are also positive, $\lambda_4 = 0.526$ and $\lambda_5 = 0.242$ in single spatial lag and $\lambda_4 = 0.537$ and $\lambda_5 = 0.237$ in multiple spatial lag. This positive speed of adjustment indicates that these distribute in space such that people maximize their profits and that they are also moving toward a stable state.

However, the coefficients of manufacturing and retail trade have negative values in single or multiple lag models. These negative signs on a speed of adjustment coefficient are inconsistent with the models because most researchers (Carlino and Mills, 1987; Deller at al, 2001; Gujarati, 1995) suggest the value is $0 < \lambda < 1$.

4.5. Summary and Conclusion

The aim of this study was to investigate new evidence in the relationship between highways and employment based on a simultaneous spatial econometric model of employment location in Missouri. This paper focuses on the highway mileage density, the spatially-lagged highway mileage density and highway access variable.

The coefficient on the highway variable of population is significant and positive and all others are insignificant. It indicates that highways in a county are important factors in attracting the population in Missouri. Retail trade employment in a county is negatively affected by highways of neighboring counties. Therefore, we can conclude that people prefer to be located in counties with transportation infrastructure improvements, that a county functions as a home base, and that improved highways can save travel time.

We can consider highways in Missouri as assisting firms in increasing wages rather than aiding "households amenity" to increase the labor supply. However, highways do not contribute directly to growth in employment of manufacturing and retail trade sectors. Interstate highways have insignificant effects in all equations.

The positive spatially-weighted coefficients illustrate that a higher level of manufacturing employment and population in a county depends on employment and population in the neighboring counties positively, indicating a positive spatial interaction.

Through the coefficients of endogenous variables, we can see that the county manufacturing employment does not rely on employment in retail trade, population, and manufacturing wage in neighboring counties, but that the employment of retail trade does depend on the population in the neighboring counties, and that the county population is positively related to the employment of retail trade and wages in those neighboring counties.

The area specialization in manufacturing and retail trade suggests that if there are fewer specialized sectors in the county, the area becomes more attractive for manufacturing establishments. The positive adjustment coefficients in population levels and wages indicate that population and wage levels distribute in space such that people maximize their profits.

Unlike other studies, the findings of this research suggest that highways may not directly contribute to employment growth of manufacturing and retail trade in Missouri. However, highways may affect retail trade employment indirectly because highways contribute to population growth positively and this population has positive effects on retail trade employment. Therefore, the relationship between highway investment and economic development is highly complex.

The results suggest that highway investments should be held in areas in which travelers recognize both time and cost savings and firms recognize location establishment incentives and benefits.

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