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Fiscal Federalism and Spatial Interactions among Governments

Longjin Chen
University of Kentucky, longjin.chen@uky.edu

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Dr. William H. Hoyt, Major Professor

Dr. Aaron S. Yelowitz, Director of Graduate Studies

FISCAL FEDERALISM AND SPATIAL INTERACTIONS AMONG GOVERNMENTS

DISSERTATION

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the College of Business and Economics at the University of Kentucky

By
Lóngjìn Chén
Lexington, Kentucky

Director: William H. Hoyt, Professor of Economics
Lexington, Kentucky
2012

ABSTRACT OF DISSERTATION

FISCAL FEDERALISM AND SPATIAL INTERACTIONS AMONG GOVERNMENTS

This dissertation examines multiple state and local expenditure categories in the United States to expand understanding of fiscal federalism and spatial interactions among governments. First, the author investigates the relationship between police expenditures and crime rates from a spatial perspective. Both police expenditures and crime rates in one state are found to exhibit a similar pattern to that in neighboring states. Spatial correlation is also detected between police expenditures and crime rates. As police of neighbors in fact deter crime at home, there are positive externalities present among the states. Second, the author conducts new tests on the Leviathan hypothesis, i.e., more competition, smaller government. While cost efficiency is used in place of government size to capture the idea that fiscal decentralization reduces wasteful expenditures, spatial interaction is taken as another measure for decentralization. The hypothesis is supported by some evidence from total, police, highway, and welfare expenditures.

KEYWORDS: Fiscal Federalism, Spatial Interaction, Intergovernmental Competition, Spatial Econometrics, Stochastic Frontier Analysis

Author's Signature: Lóngjìn Chén

Date: July 24, 2012

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By
Lóngjìn Chén

Director of Dissertation: William H. Hoyt

Director of Graduate Studies: Aaron S. Yelowitz

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Chapter 1 Introduction

1.1 Background

On April 13, 2011, following a visit to India, Governor Steve Beshear of Kentucky announced that he had brought a New Delhi company to the city of Elizabethtown with an investment of 150 million dollars. The media also mentioned a tax-incentive package in return up to 20 million dollars over the next decade[1]. On the same day in Ohio, General Electric was reported to anticipate receiving 8.8 million dollars in public funds as incentives, 1.2 million dollars of which were to come from Montgomery County and the city of Dayton, to build a 51-million-dollar research facility[2]. It might be coincidental to see that two states announced a similar incentive plan on the same day to stimulate investment. The fact, however, that governments in a federalist system do not make their fiscal decisions in isolation is well-known in the public economic literature.

As a result of tax competition for mobile resources, e.g. capital, among governments at the same level, taxes across jurisdictions tend to be set too low, causing public goods being underprovided (Wilson, 1986; Zodrow and Mieszkowski, 1986; Wilson, 1999). On the other hand, tax competition between higher- and lower-level governments may result in tax rates being too high, since the negative impacts on the higher level's tax base are shared by its all jurisdictions (Flowers, 1988; Keen, 1998). The policy suggestion that prevails in this literature is tax coordination by a

[1] "Gov. Steve Beshear Inks Deal with India Firm for New Plan." *Boston Herald*, April 13, 2011.
[2] "GE Receiving $8.8M in Funds to Build Dayton Research Facility." *Dayton Daily News*, April 13, 2011.

higher-level government.

From another perspective, if government, analogous to typical monopoly, is assumed as a Leviathan maximizing net revenues (Brennan and Buchanan, 1980), tax competition may reduce excess revenues, wasteful expenditures, and political rents. In particular, Rauscher (1998), Wilson (2005), and Besley and Smart (2007) put forward the possibility of tax competition for capital together with expenditure competition in institutions to tame a Leviathan.

Alternatively, government expenditures may be the strategic instrument in fiscal games among jurisdictions (Wildasin, 1988). Case et al. (1993) find that, in the United States, an average state raises its total expenditures by over seventy cents in response to a one-dollar increase by neighbors. Case and her coauthors also examine four spending categories, i.e., health and human services, administration, highways, and education, which together account for 75% of total state expenditures. Their estimates of spatial correlation are positive and statistically significant for all the four categories. Baicker (2005) addresses the same issue, but takes advantage of federal mandates on state medical spending as the instrument in identifying the budget-spillover effect. She shows that the average spending response between a state and its neighbors is almost ninety cents for one dollar.

Spatial interaction in government expenditures may exist for a number of reasons, including benefit/cost spillovers, welfare migration, and yardstick competition (Brueckner, 2003; Revelli, 2005). Along with Haughwout (1999)'s evidence that infrastructure in American central cities significantly increase property value in suburbs, Solé-Ollé (2006) finds sizable benefit spillovers of local facilities between Spanish urban municipalities and suburbs. With the presence of benefit spillovers and the resulting free-rider problem, public provision across jurisdictions tends to be set at a level lower than optimal (Sandier, 1975; Sandier and Cauley, 1976).

Welfare migration has to do with the fact that welfare programs tend to shrink tax bases by driving the wealthy away but attracting the poor in. It thus raises a concern that decentralization induces competing governments to “race to the bottom”, i.e., providing minimum welfare benefits to needy residents (Brown and Oates, 1987). Figlio et al. (1999) show that US states are responsive to their neighbors and afraid of taking the lead in various welfare expenditures. The evidence of underprovided welfare benefits is also presented by Saavedra (2000) and Wheaton (2000), who both look at interstate competition in the spending on the Aid to Families with Dependent Children (AFDC) program.

Because of asymmetric information, citizens often find it difficult to monitor the effort of government officials. However, they can evaluate their competence based on their performance relative to that in neighboring jurisdictions. There has been evidence of yardstick competition for tax rates (Besley and Case, 1995; Bordignon et al., 2003; Allers and Elhorst, 2005; Bosch and Solé-Ollé, 2007), for intergovernmental grants (Boarnet and Glazer, 2002), and for efficiency in local public-good provision (Geys, 2006; Revelli and Tovmo, 2007). In 1984, the Texas governor asked the state legislature for a one-billion-dollar increase in school spending, when he found out his state ranked last among all states in public-education expenditures (Case et al., 1993). This anecdote suggests that governments also tend to mimic their neighboring jurisdictions in making spending decisions.

1.2 Organization

Despite a large body of literature on various spatial interactions among governments, there are still important issues, including the relationship between police resources and crime rates, the Leviathan hypothesis, that can be redefined and readdressed from a spatial perspective. For example, how do police and crime interact with each other across jurisdictions? Do police in nearby jurisdictions help deter crime or simply drive crime to an adjacent jurisdiction? Are government expenditures larger, if there are sizable public sectors in neighboring jurisdictions? Is there spatial diffusion in cost efficiency among decentralized governments? This dissertation seeks answers to these questions in its exploration to multiple government expenditures.

Expenditure categories to be examined here include elementary and secondary education, police protection, highways, and public welfare. Chapter 2 describes some stylized facts category by category about US state and local government expenditures between 1977 and 2008. Over the thirty-two years, government expenditures in each category grew fast in both nominal and real terms. Further, state governments play an increasingly significant role in education and welfare. Using Kentucky and its neighboring states as an example, Chapter 2 also illustrates how to construct an average neighbor to study spatial interaction across jurisdictions. Education, police, highway, and welfare expenditures in Kentucky are found to be higher, if its average neighbor spends more in the same category.

Chapter 3 focuses on police protection expenditures and its interactions with crime rates. At the beginning, a theoretical framework is constructed to facilitate empirical investigation on spatial interactions between police expenditures and crime rates. Prior to spatial analysis, two instrumental variables are employed to address the endogeneity between police and crime. With supportive evidence of both "more crime, more police" and "more police, less crime", two spatially weighted police and crime variables are introduced. Both police expenditures and crime rates are found to exhibit spatial autocorrelation. Meanwhile, higher police expenditures in neighboring states are found to be significantly correlated with lower crime rates at home, evidence of positive spillovers across states. Crime rates in neighboring states, however, do not seem to have a substantial impact on how much police spend at home.

Chapter 4 examines government expenditures on elementary and secondary education, police protection, highways, and public welfare. First, this chapter tests the Leviathan hypothesis, i.e., the predicted inverse relationship between government size and fiscal decentralization, using the conventional approach. Second, it redefines the hypothesis as the direct relationship between government efficiency and fiscal decentralization. Stochastic cost frontier analysis is then applied to conducting new tests. Third, arguing that fiscal decentralization should be measured not only within a jurisdiction but also across jurisdictions, this chapter introduces a term of spatially weighted government size to testing the original Leviathan hypothesis. Last, techniques in both stochastic frontier analysis and spatial econometrics are employed to test the direct relationship between government efficiency and fiscal decentralization, with both within- and across-jurisdiction measures included. Some findings in this chapter confirm the Leviathan hypothesis.

1.3 Contribution

First, this dissertation expands understanding of spatial interactions among jurisdictions. A large body of the existing literature has explored spatial autocorrelation in various government expenditures. A question on how government expenditures in neighboring jurisdictions affect a common policy target in the surrounded jurisdiction, for example, leads to an avenue of research to better understand some new aspects of spatial effects. Chapter 3 finds that police expenditures next door deter crime at home, which also lays out an analytical framework that may be applied to studying spatial interactions between education expenditures and graduation rates, for example. As another extension, Chapter 4 turns to a couple of subtle aspects of spatial interaction in government expenditures, using the measures of the expenditure share in personal income and of cost efficiency in government spending. These two measures are more relevant to policy-decision making in addressing the extent of government intervention.

Second, this dissertation contributes to two strands of literature that have not been developed in a spatial perspective. The current deterrence research focuses on breaking the simultaneity between police and crime within a jurisdiction. Chapter 3 suggests that the deterrence effect cannot be fully understood without examining the role of police in neighboring jurisdictions. In terms of the incidence of crime, police next door may theoretically correspond to a benefit-spillover situation or a beggar-thy-neighbor behavior. Chapter 3 shows that the former case turns out to be present among US states. In another literature in which the Leviathan hypothesis is tested, decentralization is measured only within a jurisdiction by number of local government in a state, for example. In this context, decentralization is not fully captured without taking into account the impact of neighboring states. Besides, the Leviathan hypothesis predicts that government is less wasteful with more decentralization and resulting competition. In fact, wastefulness is ambiguously proxied by government size in many previous studies. Government efficiency has not been seriously taken in testing the Leviathan hypothesis. Chapter 4 answers the calls by having measures for intergovernmental competition both within a state and among states in testing their impacts on both government size and cost efficiency.

Third, this dissertation helps policy-makers better understand important factors affecting policy efficacy. To sell a spending proposal, government officials might typically discuss factors such as personal income or tax dollars to support this spending, expected outcomes, and so on. Also, they would try to justify their proposal by comparing the same or similar spending across borders. In many instances, various spatial effects of a regional policy are more often casually described than formally evaluated in policy decision-making. Results derived from this dissertation research indicate that various spatial interactions exist among governments, and policy outcomes in a jurisdiction may be under- or over-estimated without considering the spatial impact of neighboring governments. Although the estimates presented in Chapters 3 and 4 are the averages over the 48 continental states across a number of years, the impact of a particular state on another, for example, can be estimated or forecast by locating and interpreting the proper cell in the spatial-weight matrix.

Chapter 2 Some Facts about State and Local Government Expenditures

The data on government expenditures to be used in later chapters are collected from the Annual Survey of State and Local Government Finances and Census of Governments conducted by the US Bureau of the Census. This chapter first exhibits the time trends of the US state and local government expenditures between 1977 and 2008, and then performs simple spatial analysis to build some intuition about spatial interactions among states.

2.1 Time Trends in State and Local Government Expenditures

Over the thirty-two years, total expenditures of all state and local governments in the continental United States grew from 324,554 million to 2,838,836 million dollars (Panel 1, Figure 2.1), with an average growth rate of 25.7% per year. Corrected for inflation by consumer price index (CPI) using the average price level of 1983 and 1984 as the base, the dollar amounts of the start and end years are adjusted to 535,568 million and 1,318,531 million, respectively (Panel 2, Figure 2.1), which lead to an average growth rate of 4.9% per year.

In 1977, the total expenditures per capita were 1,477 dollars (Panel 3, Figure 2.1), with its CPI- converted value being 2,437 dollars (Panel 3, Figure 2.1). In 2008, the total expenditures per capita increased to 9,327 dollars (Panel 3, Figure 2.1), with its CPI-converted value being 4,332 (Panel 4, Figure 2.1). Thus, the nominal and real average annual growth rates of total state and local expenditures per capita are 17.7% and 2.6%, respectively.

This dissertation focuses on four government expenditure categories, in particular. Namely, they are elementary and secondary education, police protection, highways, and public welfare. The rest of this chapter explores the trend in each category in turn.

2.1.1 Elementary and Secondary Education Expenditures

Elementary and secondary education in the United States includes kindergarten through high school. Education, especially elementary and secondary education, is known to generate large externalities to those who do not bear the tuition. Elementary and secondary education not only gives students better career prospects, but also benefits their neighbors and future colleagues, for example. According to the classic theory, the existence of externalities and the resulting underprovision problem call for government provision at an optimal level higher than that determined in the private market. Put public education under a microscope, and another sort of externalities can be seen among different governments. For example, high-school graduates in rural areas choosing to go to a central city for work leave their local governments few incentives to provide quality education. In such circumstances, state governments can transfer a portion of revenues from the central city to rural areas through matching grants to resolve regional distortion. The federal government as well provides assistance to elementary and secondary education through programs such as No Child Left Behind (NCLB).

From 71,546 million dollars in 1977 to 565,631 million dollars in 2008 (Panel 1, Figure 2.1), the nominal growth rate of this category of expenditures by state and local governments averages twenty-three per cent per year. The real growth rate, however, is 4.1%, based on the CPI-converted 118,063 million dollars of 1977 and 262,714 million dollars of 2008 (Panel 2, Figure 2.1). Meanwhile, with per-capita amount rose annually by 15.7% on average from 326 dollars to 1,858 dollars over the thirty-two years (Panel 3, Figure 2.1), its CPI-converted value grew annually by two per cent on average from 537 dollars to 863 dollars (Panel 4, Figure 2.1). As aggregated to the state level, the budget share for elementary and secondary education was twenty-two per cent in 1977 and 19.9% in 2008, respectively (Figure 2.2).

Despite roughly the same budget share of total state and local expenditures in 1977 and in 2008, the structure of elementary and secondary education expenditures changed dramatically over the years. Elementary and secondary education has been funded mainly by local governments. It was not until 1982 that all the state governments started to share the responsibility in funding (Panel 1, Figure 2.3). Over the thirty-two years, state and local expenditures on elementary and secondary education increased annually by 441.0% and by 4.1% on average, respectively, with inflation taken into account (Panel 2, Figure 2.3). In terms of CPI-converted values per capita, state and local governments spent 317.2% and two per cent more on average each year, respectively. The dramatic shift in the responsibility can also be been here: In 1977, only sixteen state governments had this spending category on budget, which amounts to 0.9% of the total expenditures. In 2008, this share extended to 35.5% (Figure 2.4).

2.1.2 Police Protection Expenditures

Police protection expenditures are used to preserve law and order as well as to promote traffic safety. Public safety in most cases satisfies the two characteristics of public goods. Due to strong tax-benefit linkages (Tiebout, 1956; Oates, 1972), police expenditures are expected to be more efficient if they are determined locally rather than by the state. On the other hand, with the existence of externalities across localities, state governments have a role in information sharing, finance equalization, and so on to ensure local public safety.

All state and local governments together spent 10,445 million and 89,676 million dollars in 1977 and in 2008 on police protection (Panel 1, Figure 2.1). Adjusted by CPI, police spending was 17,237 million dollars in 1977 and 41,651 million dollars in 2008 (Panel 2, Figure 2.1). As opposed to the nominal rate of 25.3%, the real annual average growth rate of this category of expenditures is 4.7%. In per-capita terms, 48 dollars in 1977 and 295 dollars in 2008 were spent on police protection (Panel 3, Figure 2.1). Their CPI-converted values are seventy-eight dollars and 137 dollars, respectively (Panel 4, Figure 2.1). The nominal and real annual growth rates of per-capita police spending average to 17.2% and 2.5%, respectively. The share of total state and local expenditures that police protection accounted for in 1977 and in 2008 were both 3.2% (Figure 2.2).

Police protection has been primarily a local function. While state governments spent from 2,788 million dollars to 6,314 million dollars between 1977 and 2008, local governments increased their expenditures on police protection from 14,650 million to 36,066 million dollars (Panel 1, Figure 2.5). The annual average growth rate of local police spending is 4.9%, which is seven per cent higher than that of state police spending. The per-capita amounts were twenty-one dollars by state governments and 118 dollars by local governments in 2008, while they were thirteen dollars and sixty-seven dollars, respectively, thirty-two years ago (Panel 2, Figure 2.5). Local governments thus spent 2.5% more on average per year, 0.4% higher than state governments did, over the thirty-two years. Despite that police protection expenditures grew at both state and local levels, the share between the two levels did not change dramatically — local government made up eighty-four per cent in 1977, and 85.1% thirty-two years later (Figure 2.6).

2.1.3 Highway Expenditures

Highway expenditures are used to construct and maintain highways, streets, an so on. Similar to education, highways are excludable and rival by nature, but made free because of vast externalities. For this reason, state governments, rather than local governments, are largely responsible for this category of spending. In addition, the federal government supports state and local governments in constructing and maintaining the nationwide highway system, usually through matching grants.

In 1977, 23,058 million dollars were spent in this category, from which the expenditures amounted to 153,515 million dollars in 2008 (Panel 1, Figure 2.1). The nominal growth rate of highway expenditures is thus 18.9% per year on average. With CPI-converted values of 38,049 million and 71,302 million dollars in the start and end years, respectively, the adjusted average growth rate becomes 2.9% per year (Panel 2, Figure 2.1). In 1977, per-capita highway expenditures were 105 dollars, and they were 504 dollars thirty-two years later (Panel 3, Figure 2.1). As CPI-converted highway expenditures per capita were 173 and 234 dollars in 1977 and in 2008, respectively, the nominal average growth rate per year, 12.7%, is roughly ten times higher than the real rate, 1.2% (Panel 4, Figure 2.1). Highway expenditures accounted for 7.1% of total state and local expenditures in 1977, and 5.4% thirty-two years later (Figure 2.2).

State governments always play a larger role in funding highways and related structures. State government were responsible for 28,851-million and 49,640-million-dollar, converted by CPI, highway expenditures in 1977 and in 2008, respectively, while local governments contributed 15,235 million and 29,462 million dollars (Panel 1, Figure 2.7). However, this spending grew faster at the local level as 3.1% per year on average than 2.4% at the state level. With state government spending 132 and 163 CPI-converted dollars per capita in 1977 and in 2008, respectively, and local governments spending sixty-nine and ninety-seven CPI-converted dollars per capita in the same two years, respectively, the average growth rate at the local level, 1.4%, is two times higher than that at the state level (Panel 2, Figure 2.7). Nevertheless, the finance structure remains stable. State governments made up sixty-five per cent of total highway expenditures in 1977, and 62.8% thirty-two years later (Figure 2.8).

2.1.4 Public Welfare Expenditures

Public welfare expenditures aim to support needy individuals through Temporary Assistance for Needy Families (TANF), previously Aid to Families with Dependent Children (AFDC) in effect from 1935 to 1996, Supplemental Security Income (SSI), Medicaid, and other government welfare programs. Given its nature of income redistribution, welfare expenditures should be more efficient if they are determined by state and federal governments (Oates, 1972). The AFDC program was operated based on a matching-grant formula between federal and state governments. The 1996 welfare reform created the TANF program in place of the AFDC. Based on a block-grant arrangement, the TANF leaves state governments wide latitude in how to provide assistance to needy families with children, how to end the dependence on government benefits, how to reduce out-of-wedlock births, and how to promote two-parent families.

From 1977 to 2008, with an average annual rate of 34.7%, public welfare expenditures grew from 35,906 million to 409,346 million dollars (Panel 1, Figure 2.1). The CPI-converted 59,250 million and 190,126 million dollars for the start and end years, respectively, point to an average 7.4% increase per year (Panel 2, Figure 2.1). As per-capita spending in this category grew from 163 to 1,345 dollars, public welfare expenditures were 24.2% higher per year on average in the thirty-two years (Panel 3, Figure 2.1). The CPI-converted growth rate for per capita spending was 4.4% on average per year, given 270 dollars in 1977 and 625 dollars in 2008 (Panel 4, Figure 2.1). State and local governments together spent 11.1% of their total expenditures on public welfare in 1977, and 14.4% in 2008 (Figure 2.2).

State and local governments spent 54,091 million and 20,571 million CPI-converted dollars, respectively, in 1977, and 191,419 million and 27,650 million dollars, respectively, in 2008, which yield average annual growth rates of 8.5% and of 1.1%, respectively, at each level of government (Panel 1, Figure 2.9). State governments feature public welfare expenditures by their increasingly important role over the years. Since the early 1990s, the federal government has shifted more responsibility to states. At the same time, local governments exhibit a flat trend in this expenditure category. Whereas CPI-converted state spending per capita rose by 5.2%, from 247 dollars in

1977 to 630 dollars in 2008, local spending was actually three dollars less in 2008 than ninety-four dollars thirty-two years ago (Panel 2, Figure 2.9). In 1977, state governments contributed 72.4% of public welfare expenditures, to which fifteen per cent more was added in 2008 (Figure 2.10).

2.2 Spatial Interactions in State and Local Government Expenditures

To obtain some intuition about spatial interactions in state and local government expenditures, Kentucky and its neighboring states are used for illustration. As shown in Figure 2.11, Kentucky is geographically enclosed by seven other states, i.e., Virginia, West Virginia, Ohio, Indiana, Illinois, Missouri, and Tennessee.

Based on a simple contiguity relation, the seven states are assigned a spatial weight of $\frac{1}{7}$, respectively, in determining their average impact on Kentucky. In 2008, the CPI converted state and local total expenditures per capita of the seven states are \$3.783 (Virginia), \$3.503 (West Virginia), \$4.162 (Ohio), \$3.588 (Indiana), \$4.163 (Illinois), \$3.544 (Missouri), and \$3.672 (Tennessee), respectively. The 2008 CPI-converted state and local total expenditures per capita of Kentucky's average neighbor then are

$$\begin{aligned} & \$3.783 \times \frac{1}{7} + \$3.503 \times \frac{1}{7} + \$4.162 \times \frac{1}{7} + \$3.588 \times \frac{1}{7} \\ & + \$4.163 \times \frac{1}{7} + \$3.544 \times \frac{1}{7} + \$3.672 \times \frac{1}{7} \\ = \ & \$3.774. \end{aligned}$$

For Kentucky in the same year, the CPI-converted state and local total expenditures per capita are \$3.738.

The simple contiguity relation assumes that each neighboring state has an equal share of the total spatial impact on Kentucky. It is maybe the case, however, that

Ohio and Illinois have greater influences than West Virginia on Kentucky, because the former two are larger states in terms of population. For this consideration, the simple contiguity relation is adjusted by annual average population between 1977 and 2008. The population-adjusted spatial weights for the seven neighboring states of Kentucky are 0.135 (Virginia), 0.039 (West Virginia), 0.233 (Ohio), 0.122 (Indiana), 0.250 (Illinois), 0.112 (Missouri), and 0.109 (Tennessee), respectively, based on which the 2008 CPI-converted state and local total expenditures per capita of Kentucky's average neighbor then are

$$\begin{aligned} & \$3.783 \times 0.135 + \$3.503 \times 0.039 + \$4.162 \times 0.233 + \$3.588 \times 0.122 \\ & + \$4.163 \times 0.250 + \$3.544 \times 0.112 + \$3.672 \times 0.109 \\ = \; & \$3.893. \end{aligned}$$

Each method of assigning spatial weights has its benefits and costs. The population adjusted spatial weights are more sophisticated than simple contiguity ones. However, using this method, Missouri is assigned a larger weight than Tennessee. Tennessee in fact shares much longer borders with Kentucky than Missouri, and longer shared borders are conjectured to promote more spatial interactions. Although it is not considered in the following chapters, the simple contiguity relation may also be adjusted by border length. Besides contiguity spatial weights, using inverse distance between two geographic centers to define spatial relations is another common method in practice. Simple inverse-distance spatial weights too may to adjusted by population, personal income, immigration flows, and so on. In formal analysis, a square matrix is constructed with such spatial weights in it. Zeros are assigned to the cells on the diagonal of the spatial matrix to reflect the fact that there is no spatial relation between a state and itself.

The CPI-converted state and local total expenditures per capita of Kentucky and its average neighbor between 1977 and 2008 are graphed in Figure 2.12. In the upper panel, these two sequences move up together with a time trend. To detrend these two sequences, they are regressed on a linear time trend and their regression residuals are plotted in the lower panel. Kentucky and its average neighbor are shown intertwined with possibly positive correlation. Figure 2.13 visualizes simple correlation between Kentucky and its average neighbor in CPI-converted state and local total expenditures per capita. The upper and lower panels are based on raw and detrended data, respectively, both showing positive spatial correlation.

Using the same approach to individual categories of government expenditures, similar results are found between Kentucky and its average neighbor. CPI-converted state and local total expenditures per capita on elementary and secondary education (Figure 2.14), on police protection (Figure 2.16), on highways (Figure 2.18), and on public welfare (Figure 2.20) are all seen move together closely on time-series plots, both with and without a time trend. Meanwhile, on scatter plots, positive correlation between Kentucky and its average neighbor holds for CPI-converted state and local total expenditures per capita on elementary and secondary education (Figure 2.15), on police protection (Figure 2.17), on highways (Figure 2.19), and on public welfare (Figure 2.21), both with and without a time trend.

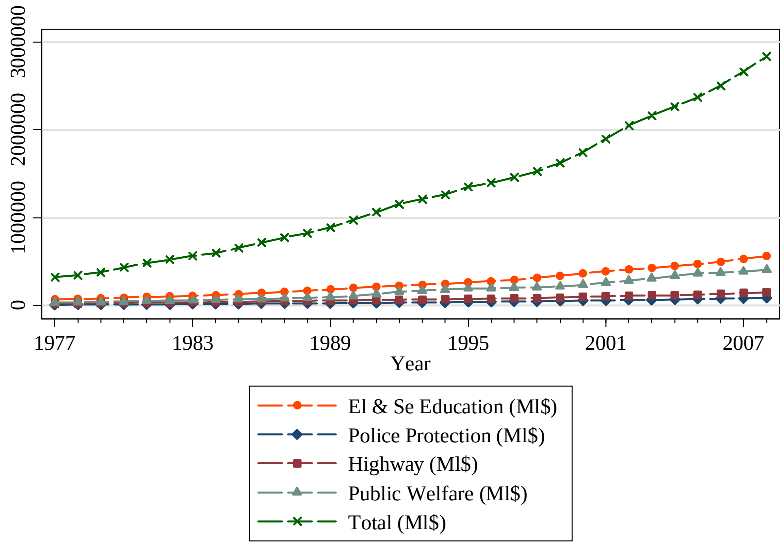
2.3 Summary

As shown in this chapter, state and local government expenditures increased significantly during the past thirty-two years. Elementary and secondary education as well as police protection remains a local government function, despite of substantial education transfers from state governments. State governments play a large role in highways and in public welfare. Especially in public welfare, more discretion has been granted from the federal government, since the 1996 welfare reform.

Based on population-adjusted contiguity relations between Kentucky and each of its neighboring states, namely Virginia, West Virginia, Ohio, Indiana, Illinois, Missouri, and Tennessee, an average neighbor is created for Kentucky to provide some illustrative analysis on spatial interactions among states. Positive spatial correlation is found in state and local government expenditures on elementary and secondary education, on police protection, on highways, as well as on public welfare.

In the following two chapters, various spatial interactions among governments are studied formally, using the state and local government finance data described above. In Chapter 3, police protection expenditures are further examined with crime rates from a spatial perspective. In Chapter 4, expenditures on elementary and secondary education, highways, and public welfare are taken as the costs of multiple publicly provided goods and services to estimate a stochastic frontier and generate efficiency scores.

Figure 2.1: Time Trends in State-Local Government Expenditures: Total



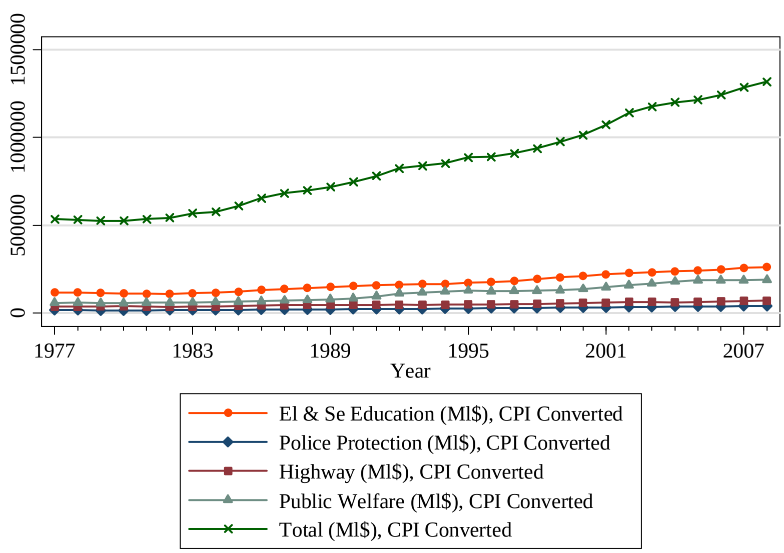
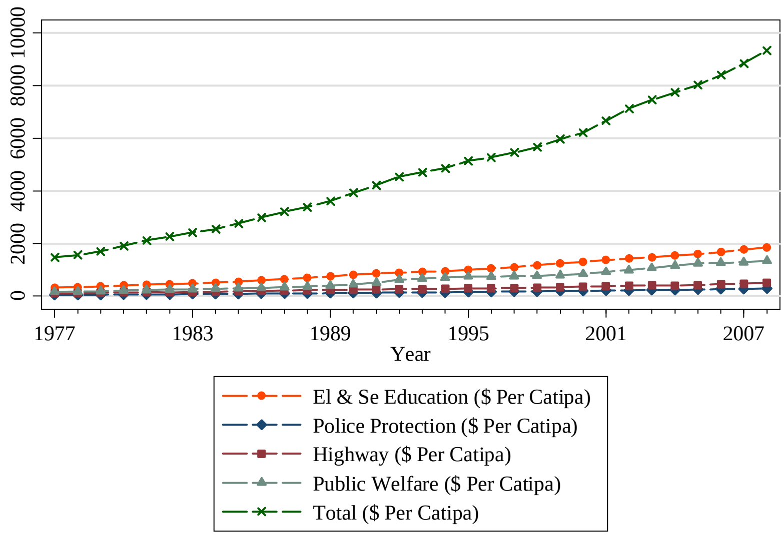


Figure 2.1: Time Trends in State-Local Government Expenditures: Total (Continued)



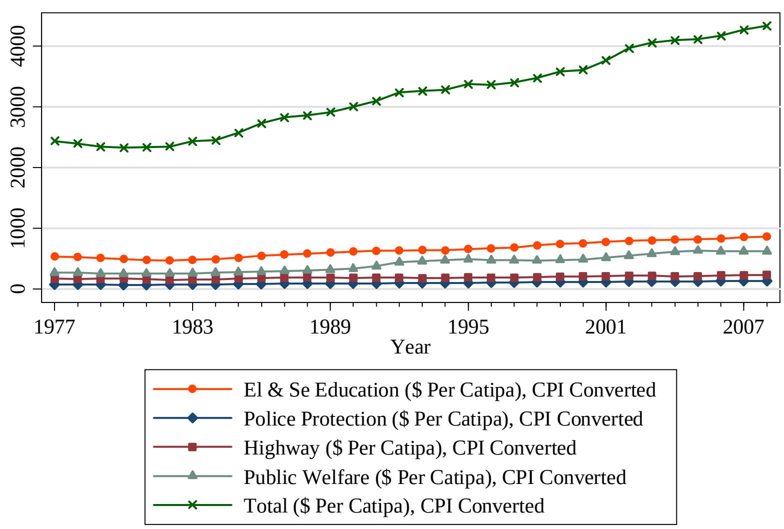


Figure 2.2: Decomposition of State-Local Government Expenditures: Total

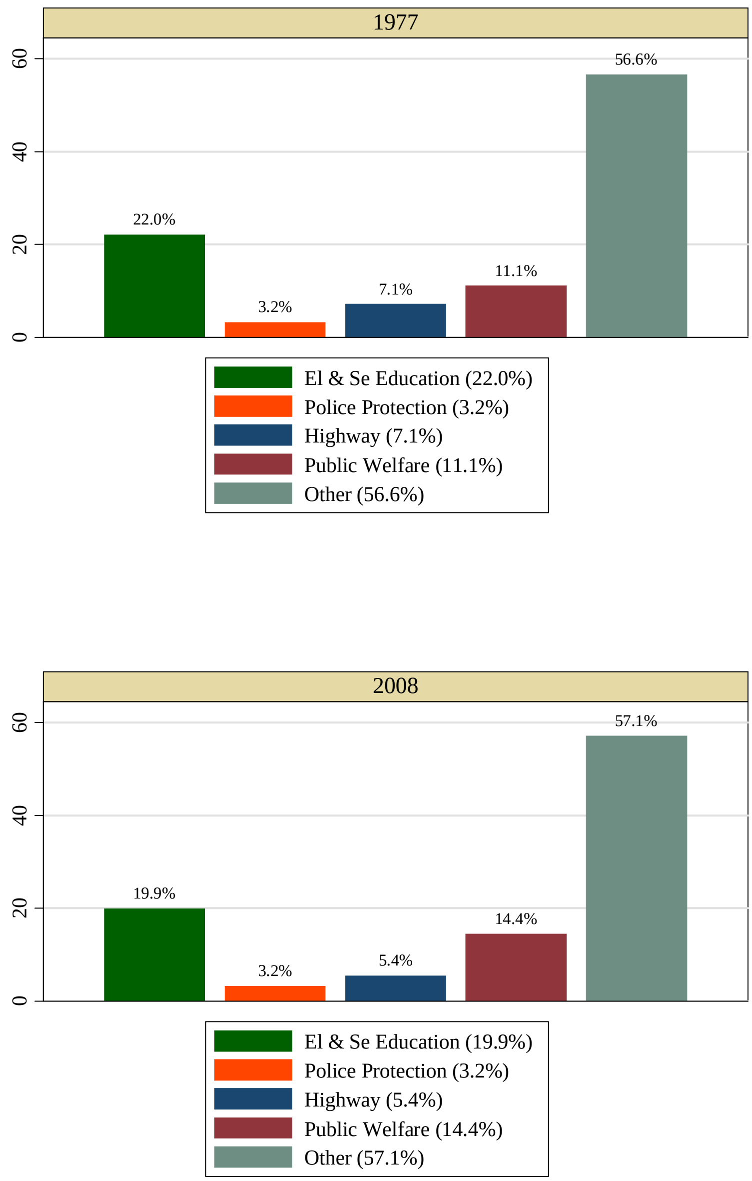
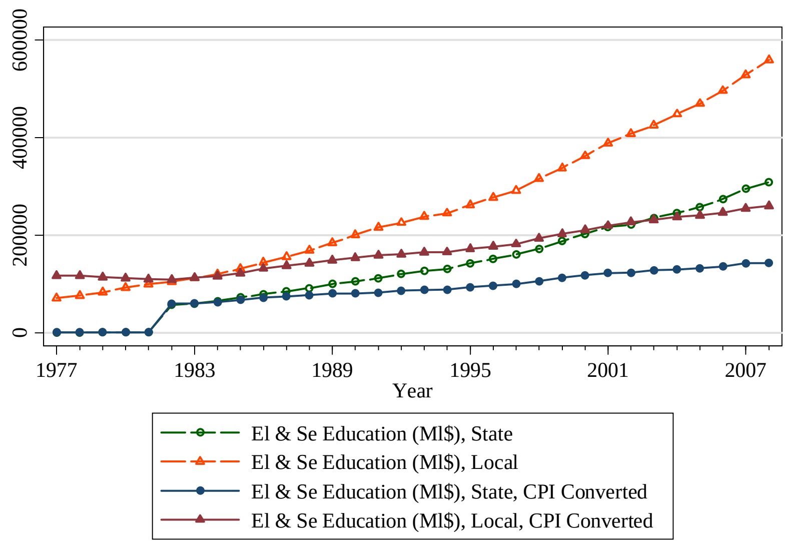


Figure 2.3: Time Trends in State-Local Government Expenditures: Elementary and Secondary Education



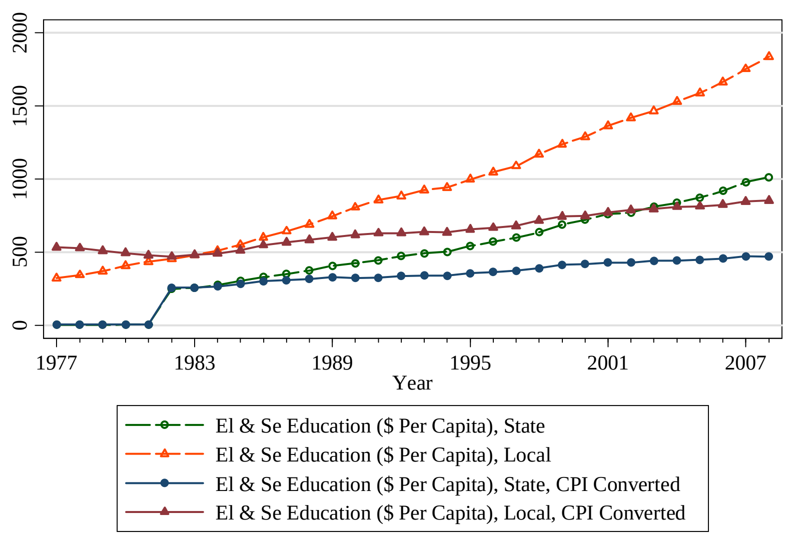
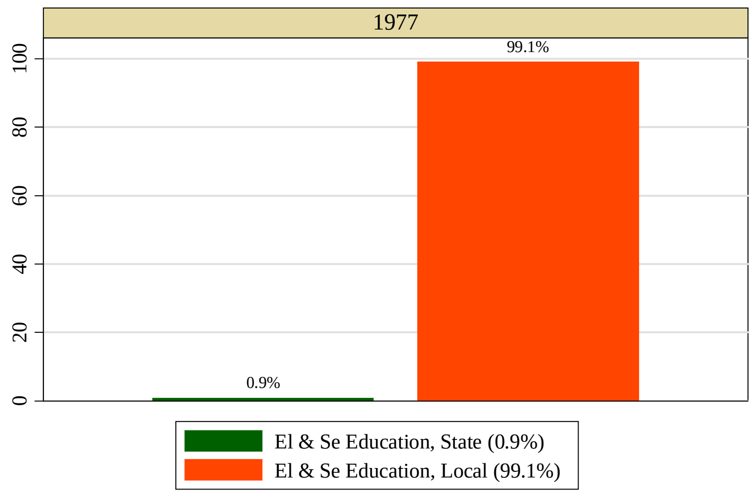


Figure 2.4: Decomposition of State-Local Government Expenditures: Elementary and Secondary Education



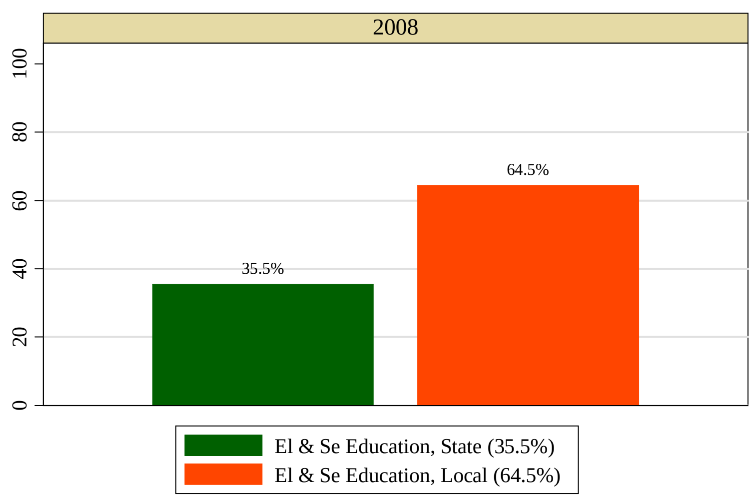
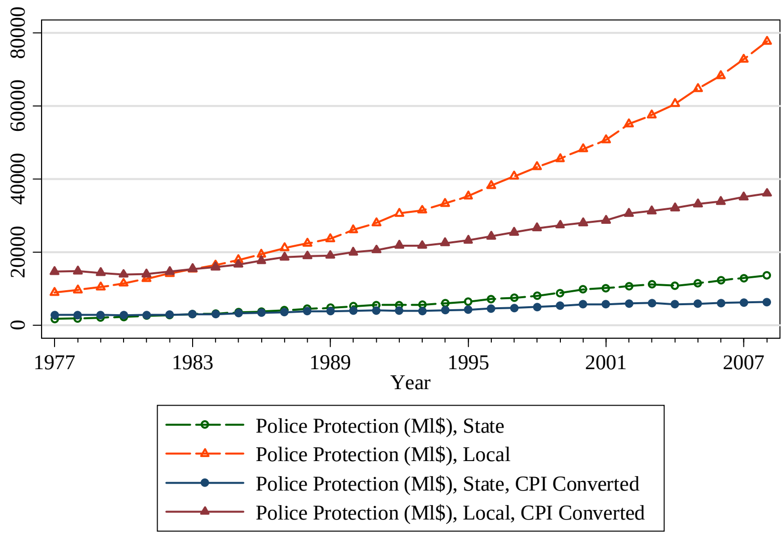


Figure 2.5: Time Trends in State-Local Government Expenditures: Police Protection



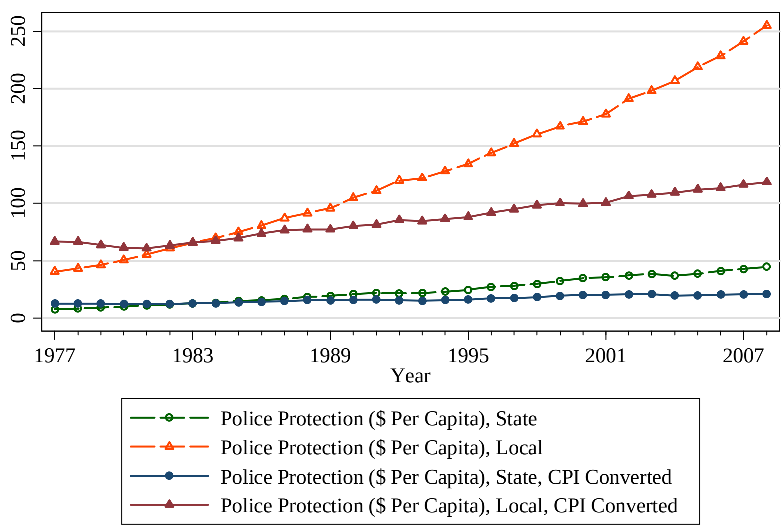
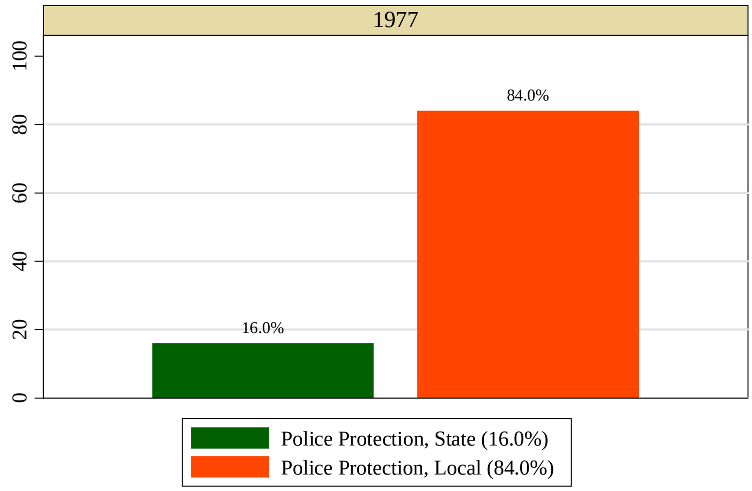


Figure 2.6: Decomposition of State-Local Government Expenditures: Police Protection



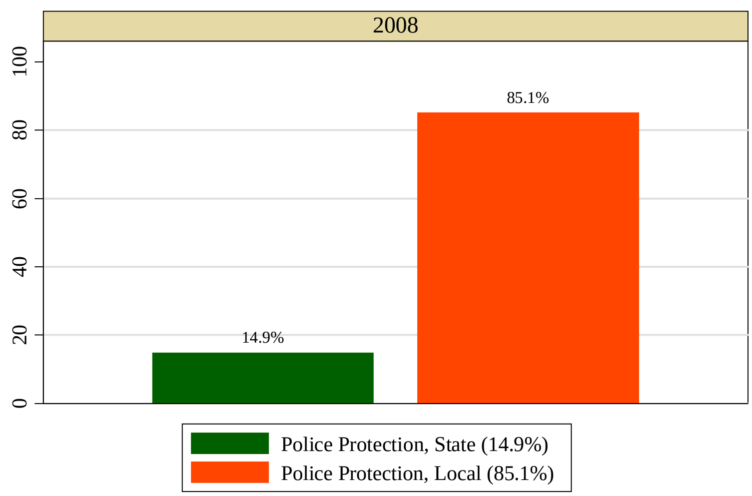
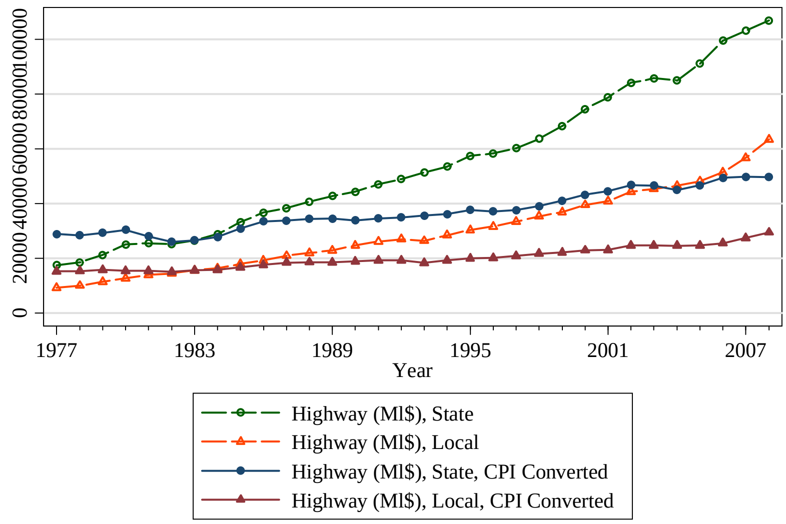


Figure 2.7: Time Trends in State-Local Government Expenditures: Highway



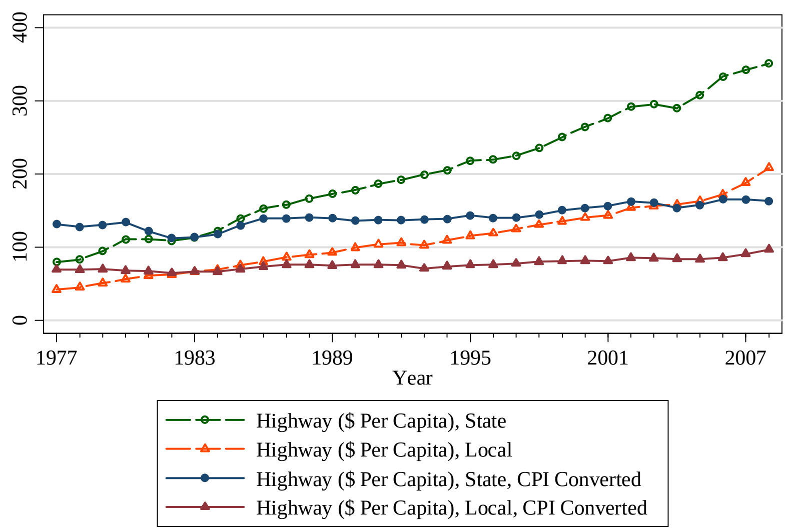


Figure 2.8: Decomposition of State-Local Government Expenditures: Highway

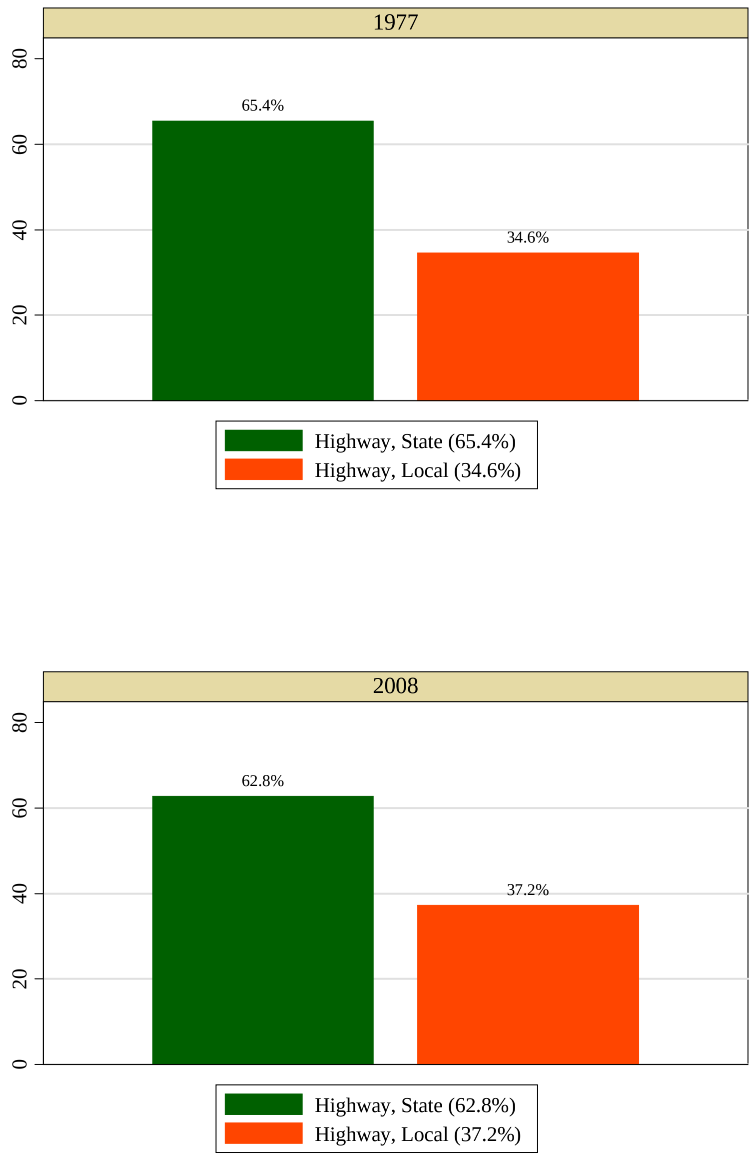
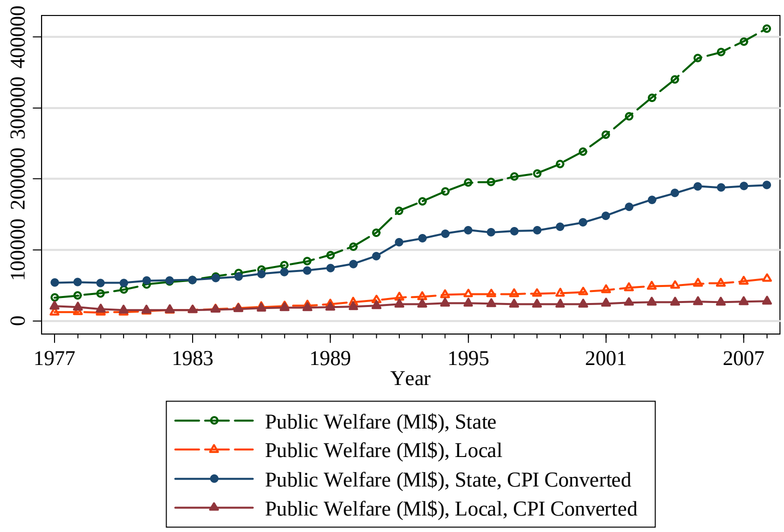


Figure 2.9: Time Trends in State-Local Government Expenditures: Public Welfare



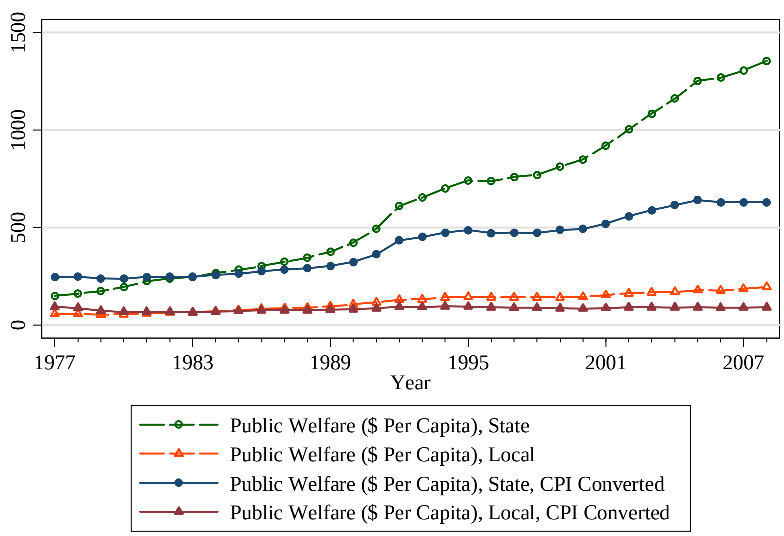
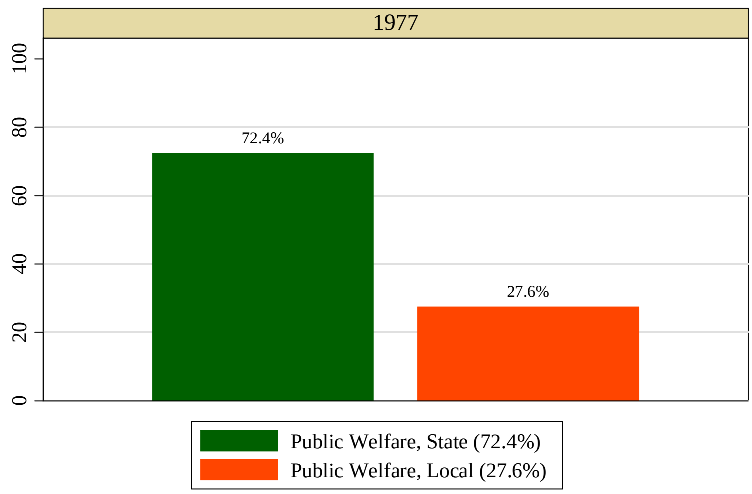


Figure 2.10: Decomposition of State-Local Government Expenditures: Public Welfare



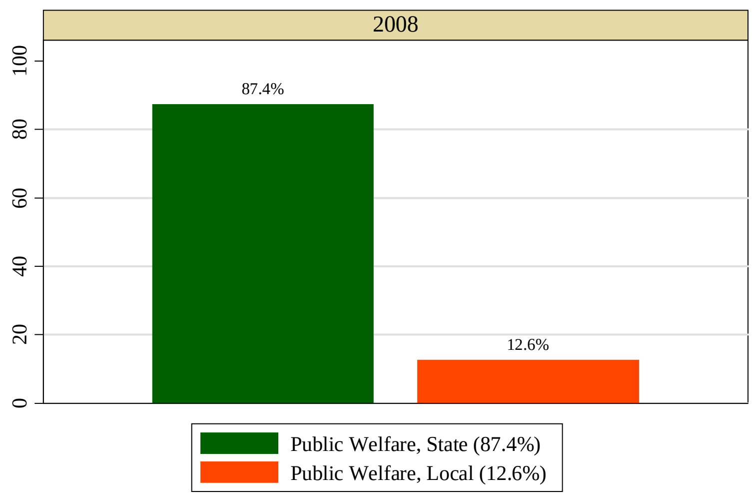


Figure 2.11: Kentucky and Its Neighboring States

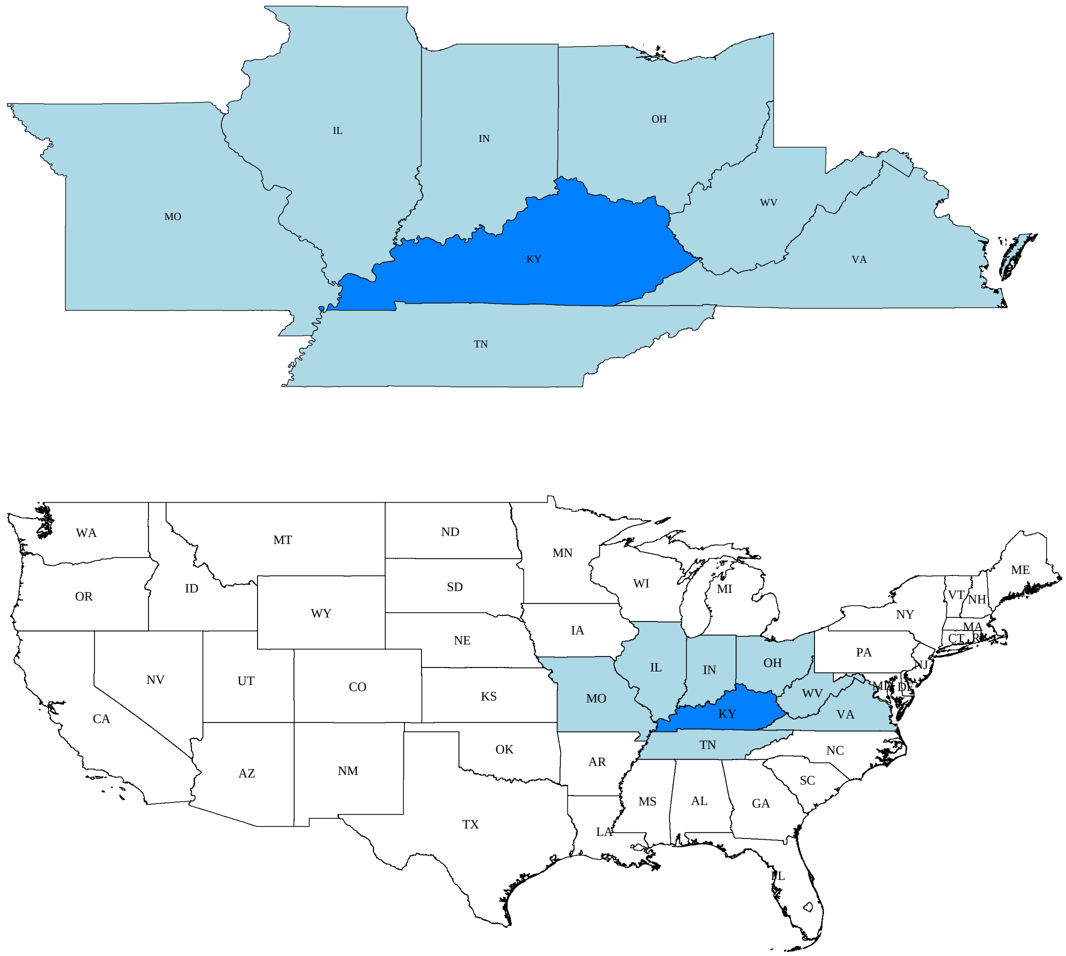
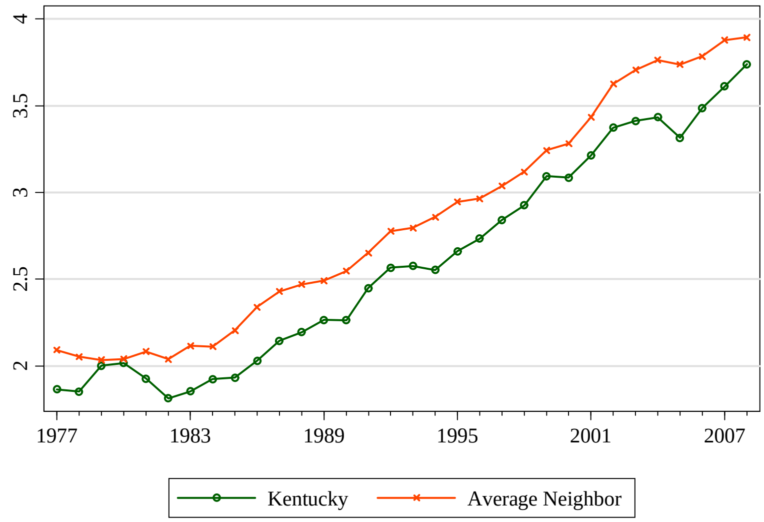


Figure 2.12: Spatial Interactions in State-Local Government Expenditures: Total (a)



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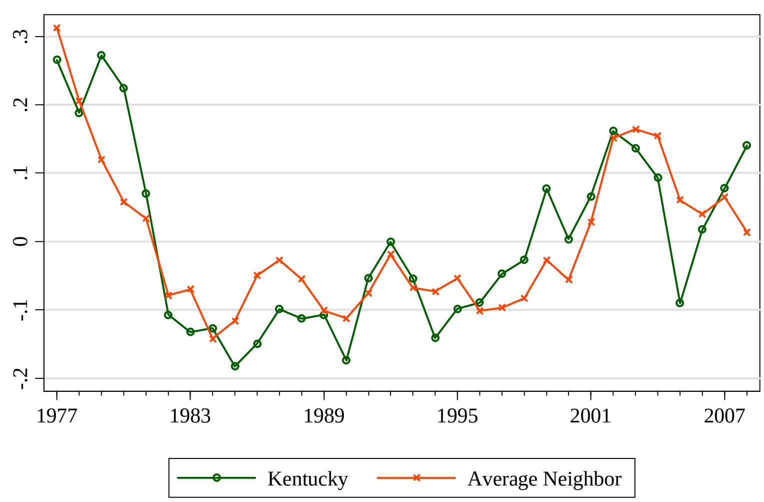
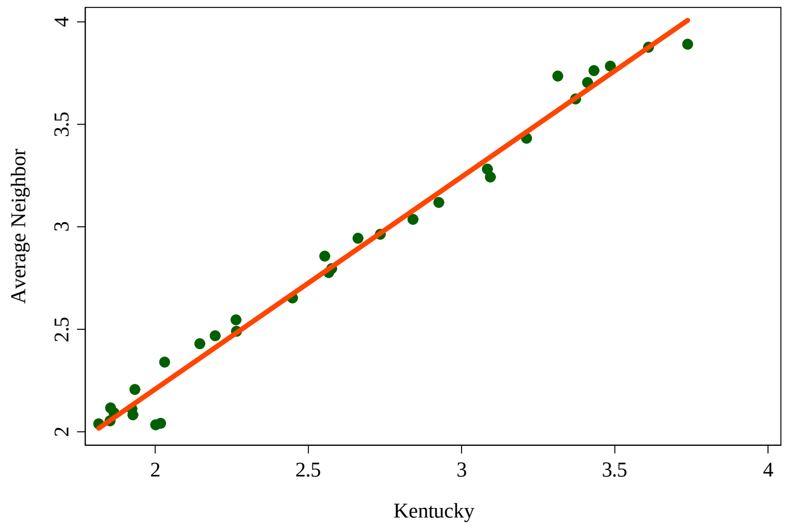


Figure 2.13: Spatial Interactions in State-Local Government Expenditures: Total (b)



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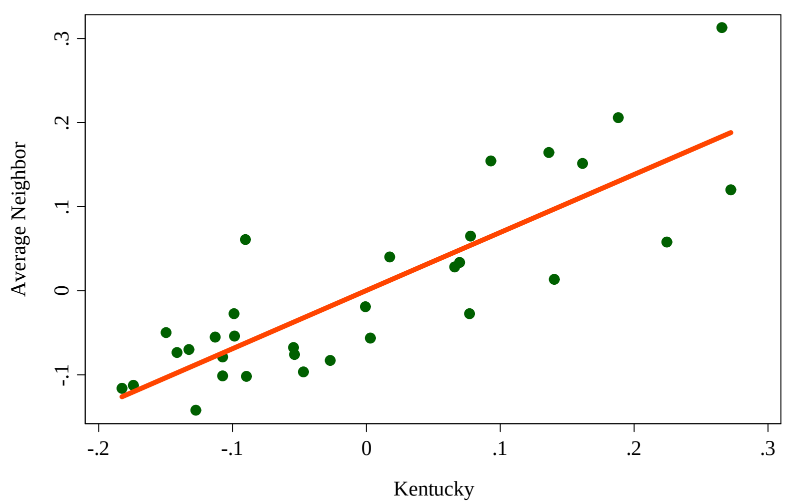
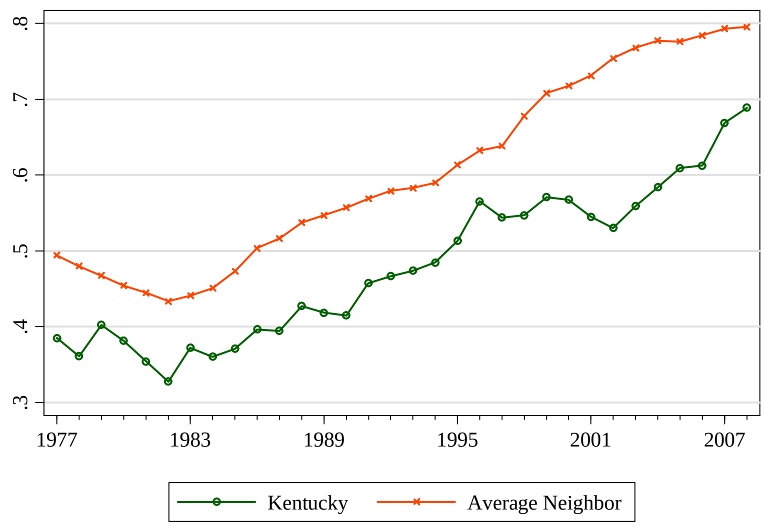


Figure 2.14: Spatial Interactions in State-Local Government Expenditures: Elementary and Secondary Education (a)



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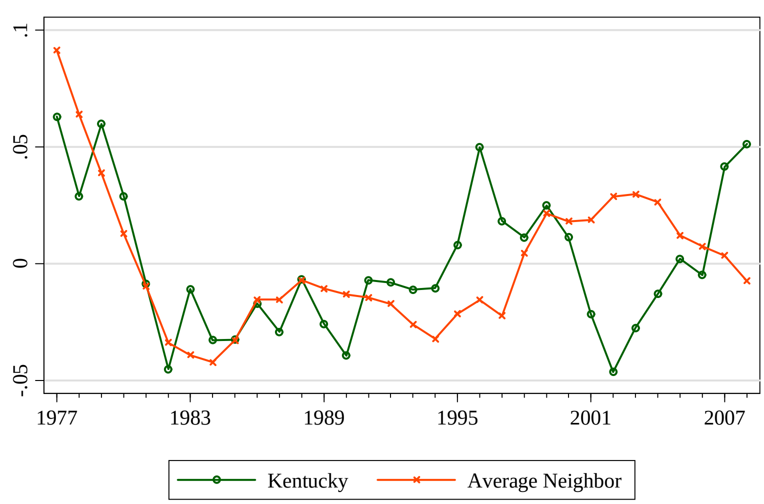
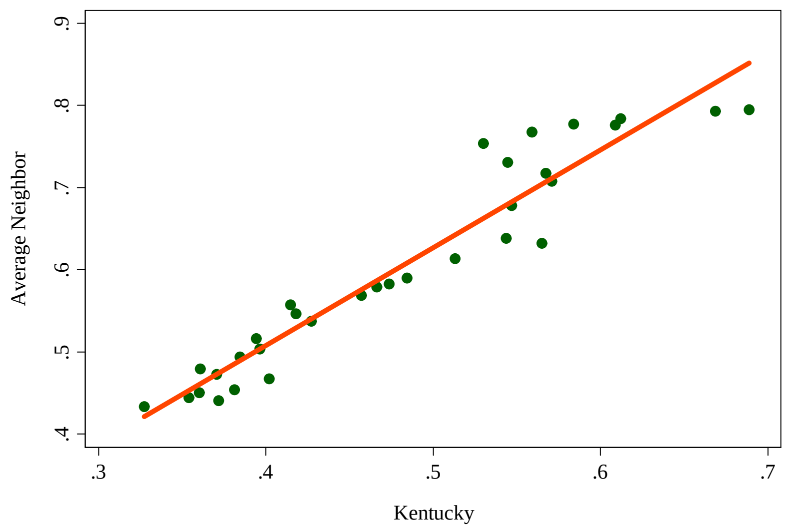


Figure 2.15: Spatial Interactions in State-Local Government Expenditures: Elementary and Secondary Education (b)



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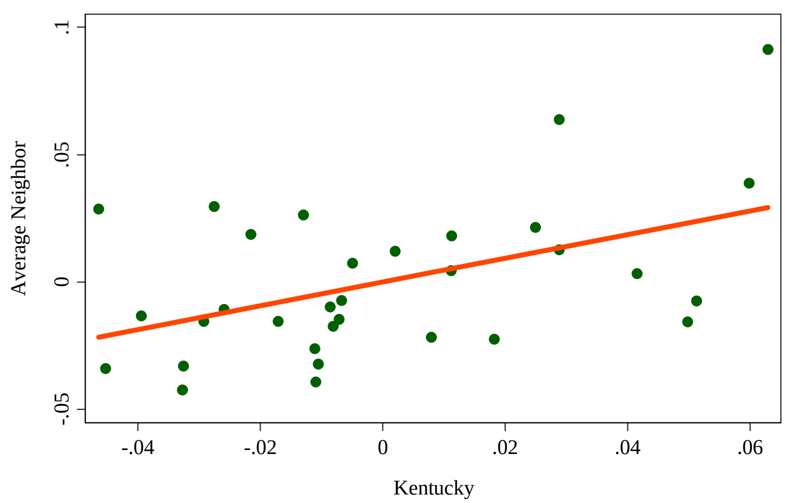
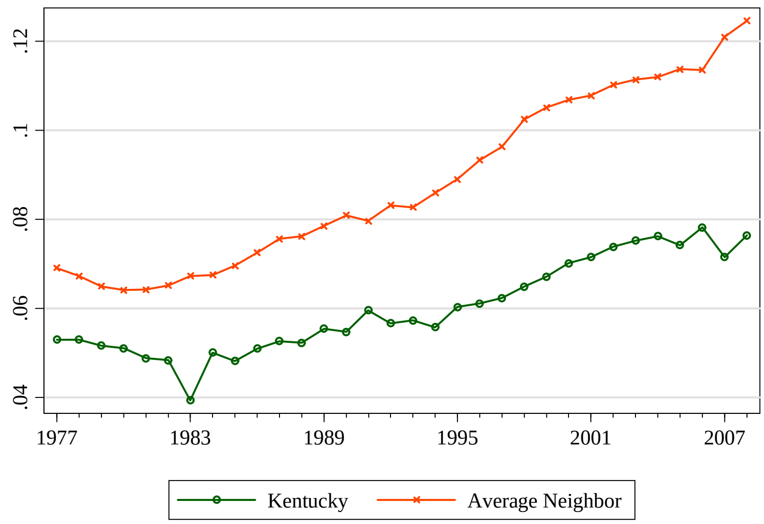


Figure 2.16: Spatial Interactions in State-Local Government Expenditures: Police Protection (a)



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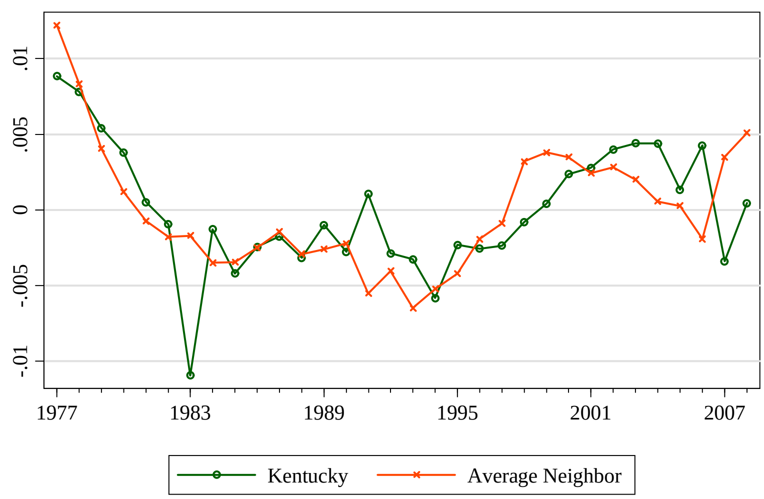
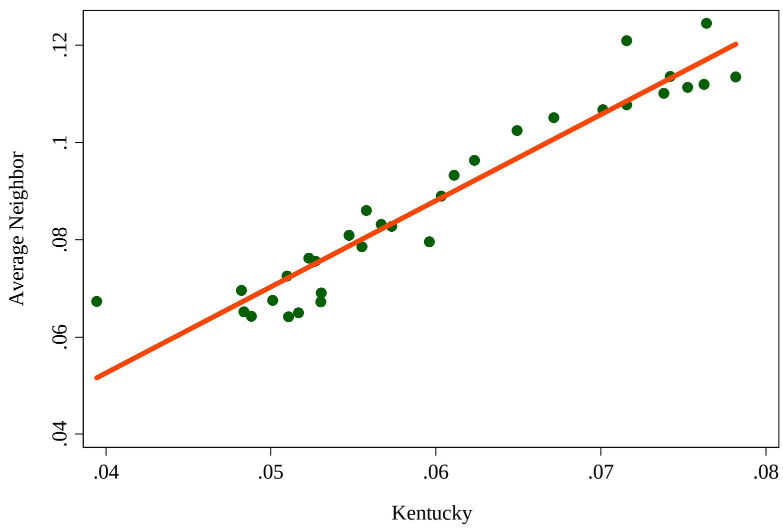


Figure 2.17: Spatial Interactions in State-Local Government Expenditures: Police Protection (b)



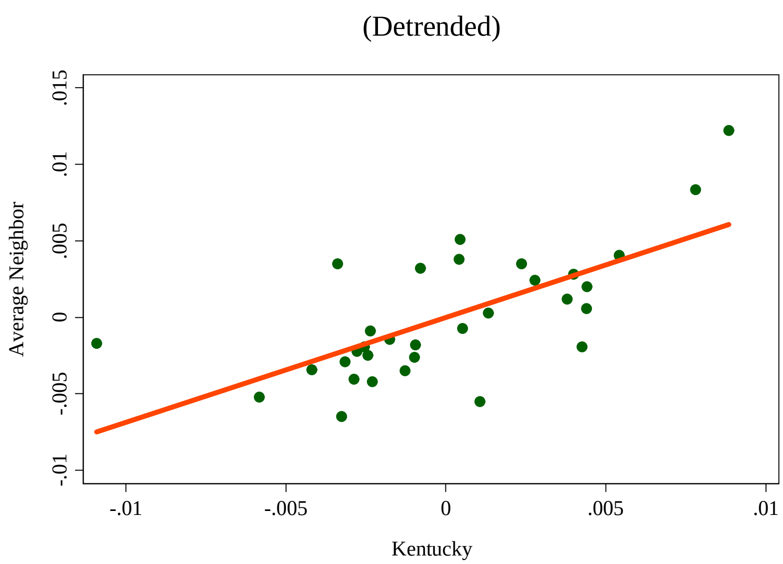
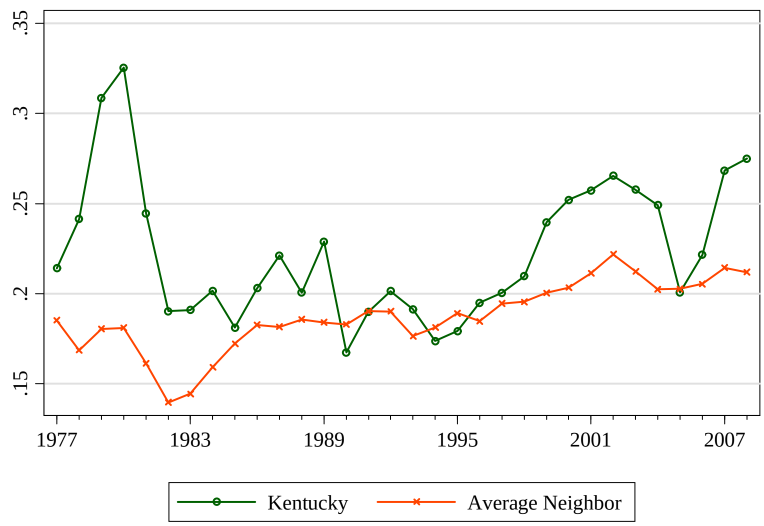


Figure 2.18: Spatial Interactions in State-Local Government Expenditures: Highway (a)



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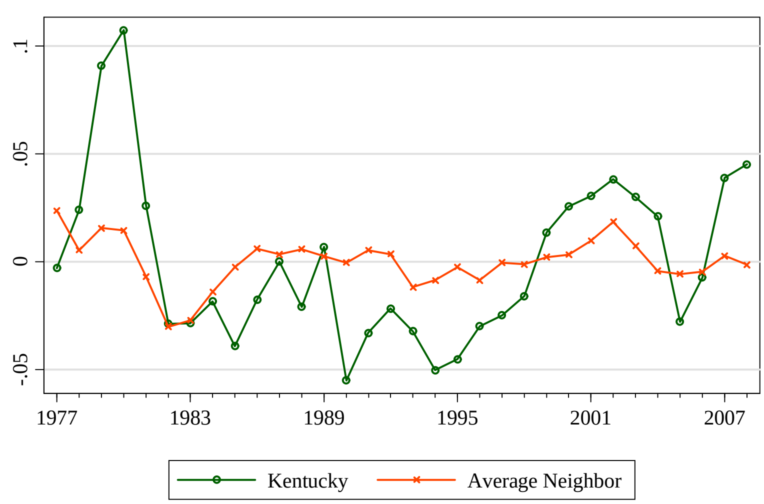
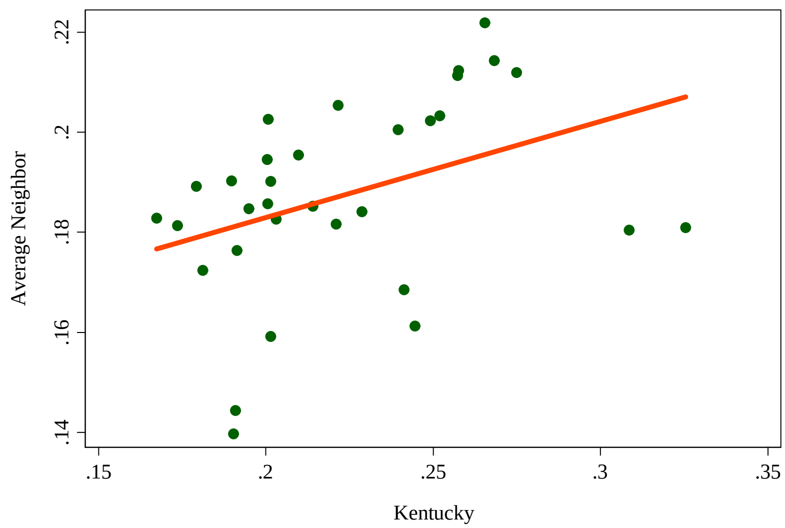


Figure 2.19: Spatial Interactions in State-Local Government Expenditures: Highway (b)



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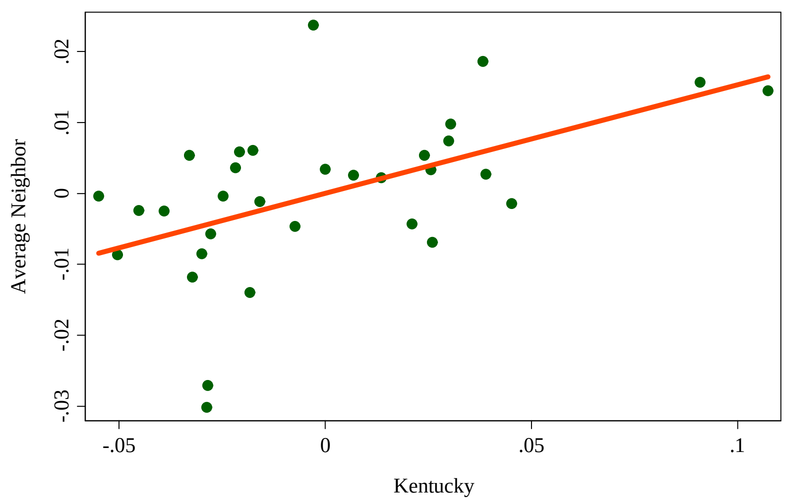
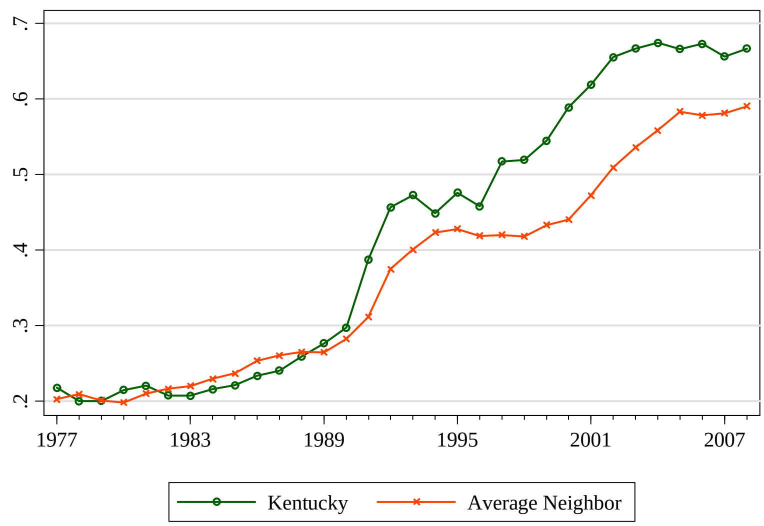


Figure 2.20: Spatial Interactions in State-Local Government Expenditures: Public Welfare (a)



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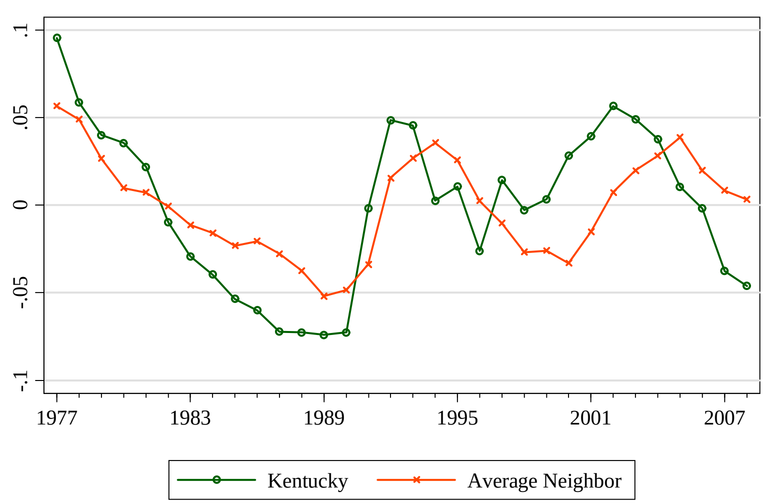
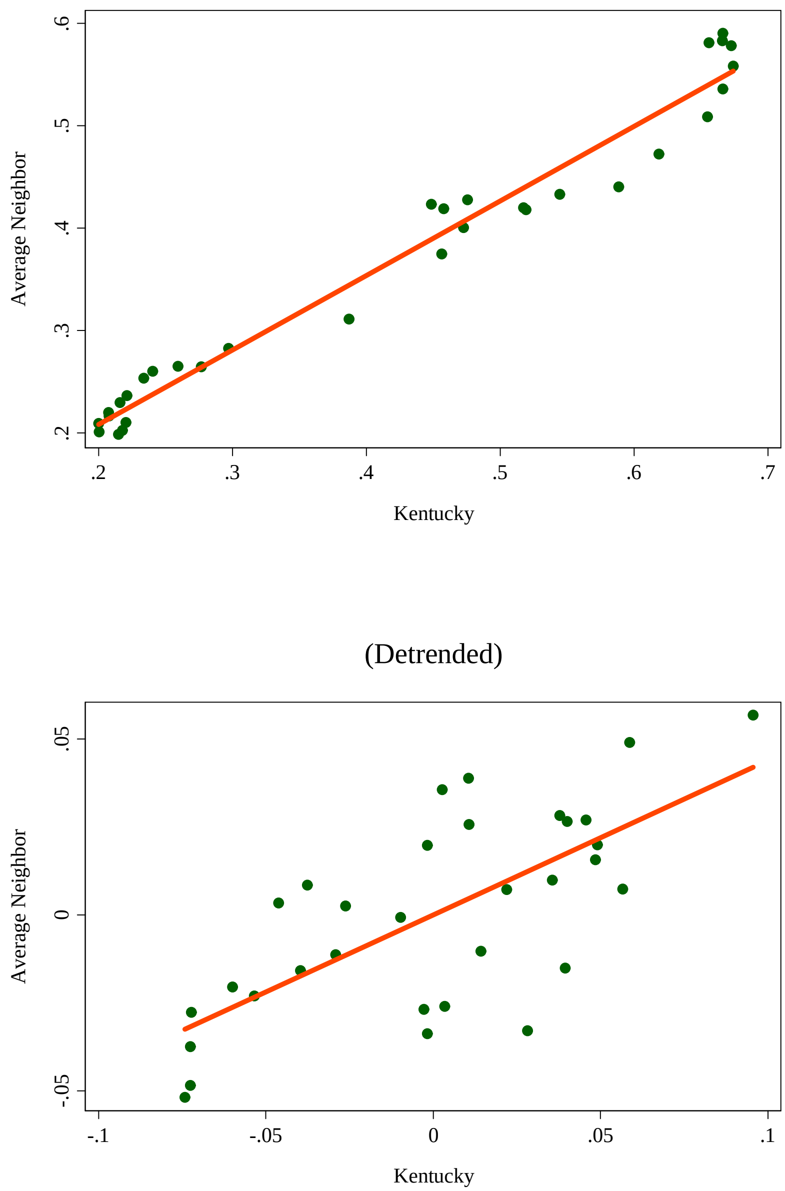


Figure 2.21: Spatial Interactions in State-Local Government Expenditures: Public Welfare (b)



Chapter 3 The Game between Police and Crime: When Neighbors Come into Play

3.1 Introduction

Where there is more crime, we tend to see more police. With more police, crime should be reduced. This intuition is not hard to comprehend for criminologists, sociologists, or economists. They, however, find it difficult to identify the expected causal relationship between police resources and crime rates with solid evidence. More surprisingly, police are even shown to result in more crime in a number of studies. As its first task, this chapter is to use the instrumental-variable approach in a simultaneous system to revisit the conventional wisdom of "more crime, more police" and "more police, less crime" with empirical evidence.

Whether police expenditures and crime rates share a similar pattern among neighboring jurisdictions is another question to explore in this chapter. To justify their proposal to hire ten new officers, the police chief of Richland Township in Bucks County, PA claimed that their force was understaffed compared to neighboring departments[1]. Illegal activities, on the other hand, may exhibit spatial correlation too. For example, thefts and drug dealing that start in one place often sneak into neighboring communities and even develop into an epidemic of crime. This chapter is also to uncover the evidence of spatial diffusion in police expenditures and in crime rates.

Theoretically, reenforced police in one place may either crack down on crime or drive it out into neighboring communities. In a dramatic story according to the police

[1] "More Police Could Mean More Taxes." *The Intelligencer*, March 23, 2008.

department of Fayetteville County, NC, their police officers chased suspects in a car for forty-five minutes, during which they drove into neighboring Harnett, Spring Lake and Fort Bragg Counties and back into Fayetteville, until the chased car ran out of gas[2]. This can be seen as a benefit-spillover situation in which Harnett, Spring Lake, and Fort Bragg benefit from dutiful police officers of Fayetteville without payment. If the Fayetteville police officers had stopped at their county borders, it would be taken as a beggar-thy-neighbor behavior that leaves alone surrounding communities with more crime. Overall, do police of neighbors help to reduce crime at home? The answer to this question is to be revealed in this chapter too.

This chapter contributes to the existing literature by using the instrumental-variable approach to confirm the intuition of "more crime, more police" "more police, less crime" and by using generalized spatial three-stage least squares to explore the relationship between police resources and crime rates from a spatial perspective. More specifically, this chapter detects spatial autocorrelation in both police expenditures and crime rates. The results also show that more police expenditures of neighbors drive down crime rates at home, a benefit-spillover situation with positive externalities. Crime rates of neighbors, however, do not seem to be a critical decision factor affecting the police budget at home.

The remainder of this chapter is organized as follows. Section 3.2 briefly reviews the existing literature on the relationship between police resources and crime rates. A theoretical framework is presented in Section 3.3. It is followed by empirical estimation based on various non-spatial and spatial specifications in Section 3.4. Section 3.5 concludes.

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[2] http://local.nixle.com/alert/4771066

3.2 Literature Review

Police and crime are believed to have a impact on each other. Researchers, however, have found much less evidence of "more police, less crime" than of "more crime, more police". In an early survey by Cameron (1988), only 4 out of 22 studies are reported finding a significant negative impact of police on crime. Among the research surveyed by Marvell and Moody (1996), while 15 out of 21 studies suggesting "more crime, more police", only 10 out of 29 pieces provide the evidence of "more police, less crime". Although it sounds like an obvious and important question that needs to be addressed, the answer to whether police deter crime largely remains a puzzle to researchers.

Among puzzled researchers, one thing seems clear though — the simultaneous determination of police and crime, which is likely to bias the estimates, if not controlled for. Omitted-variable bias is another specification problem in the deterrence research. Marvell and Moody (1996) suggest four categories of proxies to deal with incomplete control variables, namely individual fixed effects, time fixed effects, time trends, and lagged dependent variables. Individual fixed effects, for example, cannot be meaningfully specified for either time-series or cross-section data; the advantage of panel data to controlling for unobserved heterogeneity is actually discussed earlier by Cornwell and Trumbull (1994).

Marvell and Moody (1996) employ vector autoregressions and test for Granger causality[3] between police and crime. Besides police employment, crime rates, and their lagged values, various other control variables are included in their specifications.

[3] As Marvell and Moody (1996) point out, Granger causality can differ from standard causality in that (1) a third factor may cause Granger causality between two factors, (2) Granger causality does not account for adjustments based on accurate expectations, and (3) Granger causality understates instantaneous causation by using lagged values only.

Including state or city dummies, year dummies, and state or city trends, but not other control variables, turns out to change the results dramatically. Their tests detect Granger causation in both directions, with the impact of police employment on crime rates stronger than the impact of the latter on the former. Kovandzic and Sloan (2002) later apply the same idea to county-level data, and confirm the Marvell and Moody (1996) conclusions.

Greenwood and Wadycki (1973) estimate a simultaneous system to allow for two-way causation between police and crime. They, however, show that, no matter in which direction, police expenditures and crime rates have a positive relationship. Taking a simultaneous-equation approach too, Hakim et al. (1979) find that the elasticity of per-capita police expenditures with respect to property crime rates is 1.91, while a one-dollar increase in per-capita police expenditures actually leads to a 33% decrease in property crime rates. Craig (1987) suggests that the distinction made between actual and reported crime is essential to identifying a significant deterrent effect with his elasticity estimate of -0.57.

In alternative single-equation estimations of the deterrent effect, instrumental variables correlated with police resources but not with crime rates are heavily relied on. Levitt (1997) believed that election-year dummies served the purpose for identification, until McCrary (2002) detects a coding error by Levitt (1997) that reverses all the findings. Levitt (2002) later proposes firefighter employment as a plausible instrument for police employment, whereas Lin (2009) considers tax rates set at a higher level of government. Both Levitt (2002) and Lin (2009) find police deterring crime. In addition, taking the Community Oriented Policing Services (COPS) grants as the instrument, Evans and Owens (2007) and Worrall and Kovandzic (2010) provide the evidence of reduced crime by added police.

Police take terrorist attacks seriously. So do researchers. Di Tella and Schargrodsky (2004) and Klick and Tabarrok (2005) argue that a terrorist attack, either actual or potential, creates a quasi-natural experiment by which the deterrent effect can be tested for. According to their results, crime declines significantly, as more police go on street patrols.

There have been studies on spatial autocorrelation in both police expenditures and crime rates. For example, Rincke (2010) shows that police spending in New England is spatially correlated and robust to various specifications of the spatial weight matrix. On the other hand, Morenoff et al. (2001) and Baller et al. (2001) present evidence of homicide diffusion in Chicago neighborhoods and in southern US counties, respectively. Thus far, however, the literature on the relationship between police resources and crime rates pays little attention to spatial analysis. Hakim et al. (1979) make an early attempt to incorporate spatial thinking into their general-equilibrium analysis on police and crime. Using the average value of per-capita police expenditures with estimated coefficients that determine the derived slope of a reaction function, they demonstrate that per-capita police expenditures raise by five cents in response to a one-dollar increase by neighbors. However, due to informal econometric treatment, they were unable to make inference with their spatial estimate. This chapter fills the gap in the existing literature by investigating whether and how police expenditures next door affect crime rates at home, and vice versa.

3.3 Theoretical Framework

Suppose that the total utility of the residents in the ith jurisdiction is a function of crime rates C_i and other attributes z_i, i.e., $U_i = U(C_i, z_i)$. C_i is assumed to be a function of police expenditures at home P_i and the weighted average of police expenditures of neighboring jurisdictions WP, i.e.,

$$C_i = C(P_i, WP), \text{ where } \frac{\partial C_i}{\partial P_i} < 0. \tag{3.1}$$

The government of the ith jurisdiction is then assumed to maximize the total utility of its residents by choosing optimal spending on P_i and z_i, given the budget constrained by m_i, i.e.,

$$\begin{aligned} \max U(C_i, z_i) &= \max_{P_i, z_i} U[C(P_i, WP), z_i] \\ \text{s. t. } P_i + z_i &= m_i \end{aligned}$$

Solving this maximization problem leads to the equilibrium characterized by

$$P_i^* = P^*(WP), \tag{3.2}$$

$$C_i^* = C^*(WP). \tag{3.3}$$

Total differentiating using Equations (3.1), (3.2) and (3.3) yields

$$dP_i^* = \frac{\partial P_i}{\partial C_i} \cdot dC_i^* + \frac{\partial P_i}{\partial WP} \cdot dWP, \tag{3.4}$$

$$dC_i^* = \frac{\partial C_i}{\partial P_i} \cdot dP_i^* + \frac{\partial C_i}{\partial WP} \cdot dWP. \tag{3.5}$$

Solving Equations (3.4) and (3.5) gives

$$\frac{dP_i^*}{dWP} = \frac{\frac{\partial P_i}{\partial C_i} \cdot \frac{\partial C_i}{\partial WP} + \frac{\partial P_i}{\partial WP}}{1 - \frac{\partial P_i}{\partial C_i} \cdot \frac{\partial C_i}{\partial P_i}}, \tag{3.6}$$

$$\frac{dC_i^*}{dWP} = \frac{\frac{\partial C_i}{\partial P_i} \cdot \frac{\partial P_i}{\partial WP} + \frac{\partial C_i}{\partial WP}}{1 - \frac{\partial P_i}{\partial C_i} \cdot \frac{\partial C_i}{\partial P_i}}, \tag{3.7}$$

where $\left(1 - \frac{\partial P_i}{\partial C_i} \cdot \frac{\partial C_i}{\partial P_i}\right) > 0$.

The sign of $\frac{dP_i^*}{dWP}$ could be positive, negative, or zero. $\frac{dP_i^*}{dWP} > 0$ is interpreted as positive spatial interaction in police expenditures. That is, if its neighbors increase police expenditures, the locality will respond with the same policy. With respect to $\frac{dC_i^*}{dWP}$, a positive sign in front suggests that police of neighbors drive crime into a surrounded jurisdiction, a beggar-thy-neighbor behavior with negative externalities, while a negative sign indicates that police next door help to reduce crime at home, a benefit-spillover situation with positive externalities.

If crime of neighbors is alternatively taken as an exogenous determinant, the decision-making function of police expenditures then becomes $P_i = P\left(C_i, WC\right)$, and the "production function" of crime rates now is $C_i = C\left(P_i, WC\right)$, where WC is the weighted average of crime rates of neighbors. By total differentiation and substitution, the slopes of two other best-response functions are obtained, i.e.,

$$\frac{dP_i^*}{dWC} = \frac{\frac{\partial P_i}{\partial C_i} \cdot \frac{\partial C_i}{\partial WC} + \frac{\partial P_i}{\partial WC}}{1 - \frac{\partial P_i}{\partial C_i} \cdot \frac{\partial C_i}{\partial P_i}}, \tag{3.8}$$

$$\frac{dC_i^*}{dWC} = \frac{\frac{\partial C_i}{\partial P_i} \cdot \frac{\partial P_i}{\partial WC} + \frac{\partial C_i}{\partial WC}}{1 - \frac{\partial P_i}{\partial C_i} \cdot \frac{\partial C_i}{\partial P_i}}. \tag{3.9}$$

The sign of $\frac{dP_i^*}{dWC}$ reflects how crime next door affects the financial decision on police protection, which could be positive or negative. $\frac{dP_i^*}{dWC} = 0$ would imply that the decision-making on police expenditures does not take into account the impact of crime next door. As for $\frac{dC_i^*}{dWC}$, its sign is expected to be positive, if an epidemic of crime is present.

3.4 Empirical Implementation

3.4.1 Data Description

The data for empirical analysis are from the 48 continental US states from 1989 to 2008. Summary statistics for each variable are listed in Table 3.1.

State and local police expenditures and the total crime rate are the dependent variable for each equation. Since final decisions on police protection are actually made by government of counties, cities, and their equivalents, it would be better to analyze police spending at the local level, given data availability. This chapter proposes the incarceration rate and the highway fatality rate as the instruments for endogenous crime and police variables, respectively. The data on these two instrumental variables, to the author's knowledge, are either unavailable or incomplete at the local level. Data on educational attainment and some other attributes are in shortage too for counties and their equivalents. Missing values raise more concern in spatial analysis than in other topics, because they result in a failure of calculating spatial weighted averages in a meaningful way. There has been research on the relationship between police resources and crime rates at the state level. If Marvell and Moody (1996) are correct in pointing out that the relationship between police resources and crime rates is likely to be understated in state-level analysis, the significant results from this chapter are expected to be confirmed with richer policy implications in future local-level inquiries.

On the other hand, the total crime rate, dependent variable in the other equation, is not free of criticism either. The total number of crimes reported to police is aggregated not only from counties and their equivalents, but also from four types of violent crimes, i.e., murder and nonnegligent manslaughter, forcible rape, robbery, and aggravated assault, and three types of property crimes, i.e., burglary, larceny-theft, and motor vehicle theft. Beside aggregation bias, reporting bias is another potential problem (Levitt, 1998) with this crime index. Since state-local police expenditures are chosen as one dependent variable, the total crime rate in a state is accordingly selected to be the other dependent variable in the simultaneous system.

As a control variable in the police equation, personal income is expected to be associated with greater demand for public safety. The percentage of House Democrats and the dummy for Democrat governors, which are not highly correlated in these data, control for the political environment in a state. The highway fatality rate is used as an instrumental variable for police expenditures, as the former is likely to be negatively correlated with the latter, but not correlated with the crime rate.

For the reason of crime likely to prevail in highly populated areas, population density accounts for the location choice of crime. Demographic characteristics such as population by age and by race are included in almost all the studies reviewed previously. Higher educational attainment tends to increase the opportunity costs of crime (Witte and Tauchen, 1994; Lochner and Moretti, 2004; Lochner, 2004), while a higher unemployment rate is believed to go opposite (Witte and Tauchen, 1994; Raphael and Winter-Ember, 2001; Gould et al., 2002). Expected to be correlated with the crime rate (Marvell and Moody, 1994; Levitt, 1996), but not correlated with police expenditures, as correctional expenditures are another spending category, the incarceration rate serve as an instrumental variable for the crime rate.

The statistics on government expenditures per capita, total population and land area, population by age and by race, and educational attainment are accessible at the Bureau of the Census. The Bureau of Economic Analysis and the Bureau of Labor

Statistics are responsible for the data on personal income and labor force, respectively. The information on the party affiliation of state legislators and governors is kept track of at the Council of State Governments. Some of the state characteristics data are pooled and maintained by the University of Kentucky Center for Poverty Research, which are publicly available at their Website[4]. Crime rates are published in the Uniform Crime Reports by Federal Bureau of Investigation, while incarceration rates are monitored at the Bureau of Justice Statistics. Highway fatality rates are obtained from the National Highway Traffic Safety Administration.

3.4.2 Impacts on Police Expenditures: Single-Equation Estimation

In conventional studies on the determinants of police expenditures, the regression equation would take a form as

$$\ln P_{it} = \theta \ln C_{it} + \mathbf{x}_{it}^T \boldsymbol{\beta} + a_i + \zeta_t + \varepsilon_{it}, \tag{3.10}$$

where jurisdictions are indexed by subscripts i and j, and time periods by t. $\ln P$ and $\ln C$ denote police protection expenditures per capita and the total crime rate reported, respectively, in natural logarithmic form. In this chapter, control variables in $\mathbf{x}_{it}^T$ include the natural logarithm of per-capita personal income, the percentage of House Democrats, and a dummy for Democrat governors. a_i and ζ_t are dummies to control individual effects and time effects, respectively. ε_{it} is an error term assumed normally distributed. θ and $\boldsymbol{\beta}$ are unknown parameters.

Since there is simultaneity between police and crime, $\ln C$ should be handled as an endogenous variable by one or more instrumental variables that are correlated with $\ln C$, but not with $\ln P$. The incarceration rate is commonly used as a con-

[4] http://www.ukcpr.org/AvailableData.aspx

trol variable in estimating the impact of police on crime (e.g., Marvell and Moody, 1996; Levitt, 2002). Using an instrumental-variable approach, Levitt (1996) identifies strong and negative causal effect of prison population on crime. Marvell and Moody (1994) demonstrate that larger state prison population Granger-causes less crime, although they acknowledge the causality theoretically in the other direction. As shown in Table 3.2, the correlation between the incarceration rate and the crime rate is statistically significant but positive. If, as the positive sign suggests, simultaneity is present between prison population and crime, having the incarceration rate as a control variable for the crime rate would demand extra instruments. Excluding the incarceration rate, however, not only avoids searching for extra instruments for the crime equation, but also saves an instrument for the crime rate in the police equation. On the other hand, correctional expenditures are a separate category of government spending. As prison population that is highly correlated with crime is believed to affect police expenditures through crime only, the incarceration rate is a legitimate instrumental variable for the crime rate.

Empirical results based on ordinary least squares (OLS) and on two-stage least squares (2SLS) using the incarceration rate as an instrumental variable are presented in Table 3.3. While the positive relationship between crime and police remains, the impact on police expenditures enlarges from 0.21% to 0.56% in response to a 1% higher crime rate. In addition, as seen here and later as well, personal income is a strong predictor of police expenditures.

To take into account the spatial impact of police expenditures, Equation (3.10) is extended to

$$\begin{aligned} \ln P_{it} &= \rho \sum_j w_{ij} \ln P_{jt} + \phi \sum_j w_{ij} \ln P_{jt} \cdot \ln C_{it} \\ &\quad + \theta \ln C_{it} + \mathbf{x}_{it}^T \boldsymbol{\beta} + a_i + \zeta_t + \varepsilon_{it}, \end{aligned} \tag{3.11}$$

with

$$\varepsilon_{it} = \lambda^{\varepsilon} \sum_j w_{ij} \varepsilon_{jt} + \mu_{it}, \tag{3.12}$$

where w_{ij} denotes a weight matrix element determining the relative influence of the jth jurisdiction on the ith, ρ measures the impact of police expenditures by average neighbor, ϕ accounts for the interaction between police expenditures of neighbors and crime rates at home, λ^{ε} captures potential spatial autocorrelation in the error term ε, and μ_{it} is assumed normally distributed.

The spatial-weight matrix to create an average neighbor may take various forms in defining spatial relations. For a contiguity matrix, for example, if the ith jurisdiction is adjacent to the jth, the ith is assigned a weight $w_{ij} = \frac{1}{N_i}$, where N_i is the total number of the ith's neighbors. If the ith and the jth are non-neighbors, both are assigned a weight $w_{ij} = 0$. Note that a jurisdiction is not considered to be a neighbor of itself, i.e., $w_{ii} = 0$. Employed this chapter is a population-adjusted contiguity matrix. In contrast to a regular contiguity matrix treating each neighbor equally, a population-adjusted contiguity matrix gives more weight on populous jurisdictions that are probably of greater influence on others, i.e., $w_{ij} = \frac{\overline{Pop}_j}{\overline{Pop}_{N_i}}$ for i's neighbor j, where $\overline{Pop}_j$ and $\overline{Pop}_{N_i}$ refer to the average annual populations of the jth and of all N_i neighbors of the ith, respectively, between 1989 and 2008.

For Equations (3.11) and (3.12), imposing $\lambda^{\varepsilon} = 0$ leads to a spatial-lag model, while with $\rho = 0$ and $\phi = 0$, a spatial-error model is formed. OLS, if applied to spatial-lag models, will give biased estimates by ignoring spatial lags. The OLS estimates from spatial-error models are consistent in general. However, they are inefficient even for large samples, and thus responsible for misleading hypothesis test results. Kelejian and Prucha (1998) propose a generalized spatial two-stage least squares (GS2SLS) procedure to deal with both spatial lags and errors. The first step is to implement 2SLS to estimate Equation (3.11), with endogenous spatial lags instrumented by the weighted averages of neighbors' exogenous characteristics $\mathbf{x}$. In the current case, $\ln C$ needs instrumenting by incarceration rate first. $\ln P$ is then predicted using the fitted value of $\ln C$, along with the natural logarithm of population density, the percentage of ages between 18 and 24, the percentage of African American population, the percentage of ages 25 and over with a bachelor's degree or higher, the unemployment rate, and the incarceration rate. It is followed by using 2SLS residuals to estimate the spatial-error parameter λ^{ε}. Then multiply the matrix of right-hand-side variables on the left by $\left(\mathbf{I} - \hat{\lambda}^{\varepsilon}\mathbf{W}\right)$ to correct for spatial errors, where $\mathbf{I}$ is an $NT \times NT$ identity matrix, $\mathbf{W}$ is an $NT \times NT$ block–diagonal spatial-weight matrix, N is the total number of states, and T is the total number of time periods. Lastly, apply 2SLS again to the transformed equation. The estimates produced by this procedure are expected to be both consistent and efficient. The GS2SLS technique was originally developed for a cross-section setting. This chapter extends its application to panel data, using state and year dummies to control for two-way fixed effects.

In Column (1) of Table 3.4, the interaction term $\sum_j w_{ij} \ln P_{jt} \cdot \ln C_{it}$ is not included in the GS3SLS procedure. Police expenditures are found spatial correlated at a significance level lower than 1%. Other things being equal, a home state raises its police budget by 0.65% on average, in response to an average neighbor increasing police expenditures by 1%. "More crime, more police" remains the case, despite of lower statistical and economic significance. In a single-equation setup, how police expenditures of neighbors affect crime rates at home can be seen by having an interaction term. In Column (2) of Table 3.4, the coefficient estimate of the interaction term is negative and statistically significant, indicating a case of positive externalities. Spatial autocorrelation in the error term is shown statistically insignificant in both columns.

Alternatively, to see how crime rates of neighbors interact with both police expenditures and crime rates at home in a single-equation setup, spatial terms $\sum_j w_{ij} \ln P_{jt}$ and $\sum_j w_{ij} \ln P_{jt} \cdot \ln C_{it}$ in Equation (3.11) are replaced with $\sum_j w_{ij} \ln C_{jt}$ and $\sum_j w_{ij} \ln C_{jt} \cdot \ln C_{it}$, respectively, such that

$$\begin{aligned} \ln P_{it} &= \tilde{\rho} \sum_j w_{ij} \ln C_{jt} + \tilde{\phi} \sum_j w_{ij} \ln C_{jt} \cdot \ln C_{it} \\ &\quad + \theta \ln C_{it} + \mathbf{x}_{it}^T \boldsymbol{\beta} + a_i + \zeta_t + \varepsilon_{it}, \end{aligned} \tag{3.13}$$

with Equation (3.12) still applying, where $\tilde{\rho}$ measures the impact of crime rates of neighbors on police expenditures at home, and $\tilde{\phi}$ highlights spatial interaction in crime rates.

As the only endogenous variable, $\ln C$ is instrumented by incarceration rate in the first step of implementing GS2SLS. In Column (3) of Table 3.4, crime rates of neighbors do not show an statistically significant impact on police expenditures at home. In Column (4) of Table 3.4, however, crime rates are seen highly spatially correlated through the interaction term $\sum_j w_{ij} \ln C_{jt} \cdot \ln C_{it}$. Still in a single-equation setup, spatial autocorrelation in crime rates is to be more formally examined in the following subsection.

3.4.3 Impacts on Crime Rates: Single-Equation Estimation

A regression on crime rates in terms of police expenditures and other potential determinants, a counterpart to Equation (3.10), is written as

$$\ln C_{it} = \delta \ln P_{it} + \mathbf{y}_{it}^T \boldsymbol{\gamma} + d_i + \xi_t + \eta_{it}, \tag{3.14}$$

where, $\ln P$ and $\ln C$, as well as i, j, and t, are defined as before. Control variables included in $\mathbf{y}_{it}^T$ are the natural logarithm of population density, the percentage of ages between 18 and 24, the percentage of African American population, the percentage of ages 25 and over with a bachelor's degree or higher, the unemployment rate. d_i and ξ_t are dummies for two-way fixed effects. η_{it} is a normally distributed error term. δ and $\boldsymbol{\gamma}$ are unknown parameters.

In the deterrence literature, researchers have been hunting for instruments for police variables (e.g., Levitt, 2002; Evans and Owens, 2007; Lin, 2009; Worrall and Kovandzic, 2010). This chapter proposes the highway fatality rate as an instrumental variable for police expenditures. Traffic fatalities are expected to be correlated with highway policing and control, but not with crime, which meet the criteria for a valid instrument. Table 3.5 presents the results of police expenditures regressed on highway fatality rates, both in natural logarithm. In Column (1), when year dummies are included, neither state nor year dummies pass the F-test for joint insignificance. Plus, the coefficient estimate in front of the fatality rate is statistically insignificant. If state dummies are specified only, as seen in Column (2), fatality rates and police expenditures are highly correlated.

The OLS results in Column (1) of Table 3.6 show a statistically significant and positive relationship between police expenditures and crime rates, probably due to uncontrolled endogeneity of police expenditures. With year dummies included and 2SLS implemented, the coefficient estimate of police expenditures becomes surprisingly positive with a huge standard error. After insignificant year dummies are dropped, the deterrence effect of police on crime is seen statistically significant. That is, as police expenditures rise by 1%, crime rates fall by 0.44% on average, holding other factors constant.

To account for the spatial impact of crime rates, Equation (3.14) is modified as

$$\begin{aligned} \ln C_{it} &= \pi \sum_j w_{ij} \ln C_{jt} + \varphi \sum_j w_{ij} \ln C_{jt} \cdot \ln P_{it} \\ &\quad + \delta \ln P_{it} + \mathbf{y}_{it}^T \boldsymbol{\gamma} + d_i + \xi_t + \eta_{it}, \end{aligned} \tag{3.15}$$

with

$$\eta_{it} = \lambda^{\eta} \sum_j w_{ij} \eta_{jt} + \nu_{it}, \tag{3.16}$$

where w_{ij} denotes a weight matrix element defined as before, π measures the strength of spatial interaction in crime rates, φ comes along with the interaction term of crime rates of neighbors and police expenditures at home, λ^{η} is a spatial-error parameter similar to λ^{ε}, and ν_{it} is assumed normally distributed.

In the first step of the GS2SLS procedure, $\ln P$ is instrumented by fatality rate in natural logarithmic form, and then $\ln C$ is instrumented by a set of variables including the fitted value of $\ln P$, the natural logarithm of per-capita personal income, the percentage of House Democrats, and a dummy for Democrat governors. The GS2SLS results are presented in the first two columns of Table 3.7.

Consistent with what the coefficient estimate of the interaction term $\sum_j w_{ij} \ln C_{jt} \cdot \ln C_{it}$ suggests in Column (4) of Table 3.4, spatial interaction in crime rates is seen significant, both statistically and economically, in Column (1) of Table 3.7. That is, if crime rates are 1% higher on average in neighboring states, the surrounded state will face a 1.63% jump in crime rates, other things being equal. With the deterrence effect continuing to hold, inclusion of the interaction term $\sum_j w_{ij} \ln C_{jt} \cdot \ln P_{it}$ in Column (2) of Table 3.7 identifies a positive relationship between crime of neighbors and police at home. This spatial relationship, however, was found insignificant in Column (3) of Table 3.4.

Replacing $\sum_j w_{ij} \ln C_{jt}$ and $\sum_j w_{ij} \ln C_{jt} \cdot \ln P_{it}$ with $\sum_j w_{ij} \ln P_{jt}$ and $\sum_j w_{ij} \ln P_{jt} \cdot \ln P_{it}$, respectively, to examine the spatial impact of police expenditures, Equation (3.15) becomes

$$\begin{aligned} \ln C_{it} &= \tilde{\pi} \sum_j w_{ij} \ln P_{jt} + \tilde{\varphi} \sum_j w_{ij} \ln P_{jt} \cdot \ln P_{it} \\ &\quad + \delta \ln P_{it} + \mathbf{y}_{it}^T \boldsymbol{\gamma} + d_i + \xi_t + \eta_{it}, \end{aligned} \tag{3.17}$$

with Equation (3.16) still applying, where $\tilde{\pi}$ and $\tilde{\varphi}$ point to the interaction between police expenditures of neighbors and crime rates and police expenditures, respectively, at home.

When implementing GS2SLS in the first step, the only endogenous variable $\ln P$ is instrumented by natural logarithm of the fatality rate. Column (3) of Table 3.7 suggests that police of neighbors help to deter crime at home, a case of externalities previously seen in Column (2) of Table 3.4. More interestingly, neighbors play a larger role in cracking down crime at home. Include the interaction term into the regression, and the coefficient estimate is found statistically significant but negative in Column (4) of Table 3.7. This finding is contradictory to positive spatial autocorrelation in police expenditures revealed in Column (1) of Table 3.4.

3.4.4 Interactions between Police Expenditures and Crime Rates in a Simultaneous System

Compared to single equations, a simultaneous-equation system not only produces more efficient estimates in general, but also facilitates the investigation on various spatial interactions between police and crime. Before examining these spatial interactions, Equations (3.10) and (3.14) are jointly estimated to provide some baseline results for later comparison. The conventional simultaneous system to investigate the relationship between police resources and crime rates takes the form as

$$\begin{cases} \ln P_{it} = \theta \ln C_{it} + \mathbf{x}_{it}^T \boldsymbol{\beta} + a_i + \zeta_t + \varepsilon_{it}, & (3.10) \\ \ln C_{it} = \delta \ln P_{it} + \mathbf{y}_{it}^T \boldsymbol{\gamma} + d_i + \xi_t + \eta_{it}. & (3.14) \end{cases}$$

The baseline 3SLS results are given in Table 3.8. In Column (1.2), with year dummies included in the crime equation, more police are seen producing more crime, even though the instrumental variable is at work. Since, as shown before, year dummies are not jointly significant in Equation (3.14), they are dropped in Column (2.2) for an reexamination. With both year and state dummies in Equation (3.10), but year dummies only in Equation (3.14), 1% higher crime rates lead to on average 0.51% higher police expenditures and 1% higher police expenditures result in on average 0.46% lower crime rates, respectively, holding other factors constant in the system. In other words, using instrumental variables to break simultaneity between police and crime, both "more crime, more police" and "more police, less crime" are identified in the simultaneous system. The 3SLS results are similar to the 2SLS results in Tables 3.3 and 3.6.

To allow for neighbors coming into play, the simultaneous system above is reformed as

$$\begin{cases} \ln P_{it} = \rho \sum_j w_{ij} \ln P_{jt} + \phi \sum_j w_{ij} \ln P_{jt} \cdot \ln C_{it} \\ \qquad + \theta \ln C_{it} + \mathbf{x}_{it}^T \boldsymbol{\beta} + a_i + \zeta_t + \varepsilon_{it}, \qquad (3.11) \\ \ln C_{it} = \pi \sum_j w_{ij} \ln C_{jt} + \varphi \sum_j w_{ij} \ln C_{jt} \cdot \ln P_{it} \\ \qquad \delta \ln P_{it} + \mathbf{y}_{it}^T \boldsymbol{\gamma} + d_i + \xi_t + \eta_{it}, \qquad (3.15) \end{cases}$$

with spatial terms of police expenditures in Equation (3.11) and spatial terms of crime rates in Equation (3.15). In addition, to take into account potential spatial autocorrelation in errors, a spatial-error parameter λ is jointly estimated using the information of all residuals, i.e.,

$$\begin{bmatrix} \varepsilon_{it} \\ \cdots \\ \eta_{it} \\ \cdots \end{bmatrix} = \lambda \begin{bmatrix} \sum_j w_{ij} \varepsilon_{jt} \\ \cdots \\ \sum_j w_{ij} \eta_{jt} \\ \cdots \end{bmatrix} + \begin{bmatrix} \mu_{it} \\ \cdots \\ \nu_{it} \\ \cdots \end{bmatrix}. \qquad (3.18)$$

Based on GS2SLS (Kelejian and Prucha, 1998) for a single-equation setup, Kelejian and Prucha (2004) propose a generalized spatial three-stage least squares (GS3SLS) procedure to deal with simultaneous systems containing both spatial lags and spatial errors. In the current context, the first step is to implement 2SLS to estimate Equations (3.11) and (3.15), with endogenous police and crime variables instrumented by fatality rate and incarceration rate, respectively, and then with their spatial lags instrumented by their fitted values and weighted averages of neighbors' exogenous characteristics, respectively. It is followed by using 2SLS residuals to jointly estimate the spatial-error parameters λ. Then multiply the matrix of all right-hand-side variables on the left by $\left(\mathbf{I} - \hat{\lambda}\mathbf{W}\right)$ to correct for spatial errors, where $\mathbf{I}$ is an $NT \times NT$ identity matrix, $\mathbf{W}$ is an $NT \times NT$ block–diagonal spatial-weight matrix with the population-adjusted contiguity matrices on the principal diagonal, N is the total number of jurisdictions, and T is the total number of periods. Lastly, apply 2SLS again to the transformed equations to obtain both unbiased and efficient estimates.

Shown in Table 3.9, the expected relationships of "more crime, more police" and "more police, less crime" both remain within a state. Meanwhile, both police expenditures and crime rates exhibit strong spatial autocorrelation. On average, police expenditures and crime rates at home jump up by 1.38% and by 1.42%, respectively, as a response to a 1% increase in police expenditures and crime rates, respectively, of neighbors, other things being equal. A more careful interpretation of this large spatial coefficient estimate calls for further investigation. The relationships captured by interaction terms are as found before. That is, police of neighbors negatively interact with crime at home, while crime of neighbors positively interact with police at home, both being statistically significant. GS3SLS results in Table 3.9 are consistent with GS2SLS results in Columns (1) and (2) of Table 3.4 and of Table 3.7 combined. Last but not least, the estimate of spatial-error parameters is statistically significant, which is in favor of GS3SLS accounting for both spatial-lag or -error models.

To focus on the spatial impacts of police expenditures, Equations (3.11) and (3.17) are put into a simultaneous system, i.e.,

$$\begin{cases} \ln P_{it} = \rho \sum_j w_{ij} \ln P_{jt} + \phi \sum_j w_{ij} \ln P_{jt} \cdot \ln C_{it} \\ \qquad + \theta \ln C_{it} + \mathbf{x}_{it}^T \boldsymbol{\beta} + a_i + \zeta_t + \varepsilon_{it}, & (3.11) \\ \ln C_{it} = \tilde{\pi} \sum_j w_{ij} \ln P_{jt} + \tilde{\varphi} \sum_j w_{ij} \ln P_{jt} \cdot \ln P_{it} \\ \qquad \delta \ln P_{it} + \mathbf{y}_{it}^T \boldsymbol{\gamma} + d_i + \xi_t + \eta_{it}, & (3.17) \end{cases}$$

with Equation (3.18). Columns (1.1) and (1.2) of Table 3.10, show that higher police expenditures of neighbors lead to higher police expenditures and lower crime rates at home. The latter indicates a case of positive externalities, in which police next door help to reduce crime at home. The deterrence effect across borders even overwhelms that at home, so that police expenditures at home are found insignificantly keeping crime rates down. With the interaction term added in Column (2.1), police expenditures of neighbors driving down crime rates at home is confirmed. However, the spatial interaction term of police expenditures in Column (2.2) again has an negative sign, which confronts the positive estimate of the spatial-lag term in Column (1.1). Findings in Table 3.10 are consistent with that in Columns (1) and (2) of Table 3.4 and Columns (3) and (4) of Table 3.7 combined.

Alternatively, to examine the spatial impact of crime rates only, Equations (3.13) and (3.15) are jointly estimated, i.e.,

$$\begin{cases} \ln P_{it} = \tilde{\rho}\sum_j w_{ij} \ln C_{jt} + \tilde{\phi}\sum_j w_{ij} \ln C_{jt} \cdot \ln C_{it} \\ \qquad +\theta \ln C_{it} + \mathbf{x}_{it}^T \boldsymbol{\beta} + a_i + \zeta_t + \varepsilon_{it}, & (3.13) \\ \ln C_{it} = \pi \sum_j w_{ij} \ln C_{jt} + \varphi \sum_j w_{ij} \ln C_{jt} \cdot \ln P_{it} \\ \qquad \delta \ln P_{it} + \mathbf{y}_{it}^T \boldsymbol{\gamma} + d_i + \xi_t + \eta_{it}, & (3.15) \end{cases}$$

with Equation (3.18). Consistent with single-equation results in Column (3) of Table 3.4 and in Column (1) of Table 3.7, crime of neighbors is shown adding more crime at home, but having little impact on police budget at home in Columns (1.1) and (1.2) of Table 3.11. With interaction terms included in Columns (2.1) and (2.2), positive spatial interaction in crime rates is seen once again, while the statistically insignificant relationship between crime of neighbors and police at home shown in Column (1.1) becomes not only positive but also substantial. Similar results were found in Column (4) of Table 3.4 and Column (2) of Table 3.7.

3.5 Conclusion

The relationship between police resources and crime rates is straightforward in theory, but puzzling in empirics. In the existing literature, less evidence of "more police, less crime" has been found than that of "more crime, more police". Endogeneity is believed to be the challenge, especially in estimating the deterrence effect. This chapter makes its first contribution in proposing the fatality rate and the incarceration rate as the instruments for endogenous police and crime variables, respectively. Using state-local data from the United States, this chapter succeeds in offering evidence of both "more police, less crime" and "more crime, more police".

In addition, applying the GS2SLS and GS3SLS techniques, this chapter reveals strong spatial autocorrelation in police expenditures as well as in crime rates. Furthermore, it examines the relationship between police resources and crime rates from a spatial perspective. The results show that higher police expenditures of neighbors significantly push down crime rates at home, which suggests positive externalities among neighboring states. On the other hand, crime rates of neighbors seem not directly taken as a factor to determine the police budget.

As a state benefits from policing of neighbors, but is unwilling to spend more in return to tackle crime next door, police protection across states may be provided at a lower level than optimal. A textbook solution to this underprovision problem with decentralization would be a call for coordination or assistance from a higher level of government. The Federal Bureau of Investigation, despite of its own jurisdictions over states, in fact benefits individual states in cracking down on criminal activity across state borders. Moreover, the Community Oriented Policing Services (COPS) program overseen by Department of Justice was established in 1994 to help states and local governments hire police officers, obtain equipments, and so on.

To explore more policy implications, especially based on a time path of interactions, an impulse-response analysis may be conducted. Marvell and Moody (1994, 1996) have employed reduce-form vector autoregressions and Granger-causality tests to examine non-spatial interactions between incarceration and crime and between police and crime. In future work, a recursive vector autoregression with spatial terms of police and crime may be performed not only to reveal contemporaneous spatial estimates, but also to derive impulse-response functions to visualize the dynamics of spatial interactions between police and crime among average states. In case of one particular state of a researcher's interest, this state can be examined with its average neighbor in a time-series, the original setting for vector autoregressions and impulse-response functions.

Table 3.1: Summary Statistics

(48 Contiguous US States, 1989-2008)

Variable	Mean	Std Dev	Min	Max
Police Expenditures (Thousand Dollars per Capita)	174.164	67.803	46.991	428.562
Income (Thousand Dollars per Capita)	26.727	7.531	12.495	56.272
House Democrats (%)	53.707	15.971	16	100
Democrat Governor (=1)	0.008	0.091	0	1
Fatality Rate (Fatalities per Million Vehicle-Miles)	0.186	0.656	0.067	20.434
Crime Rate (Crimes per Thousand Capita)	43.633	12.450	19.460	88.108
Population Density (Population per Mile^2)	277.801	961.854	4.671	10081.230
Age 18-24 (%)	9.984	0.917	7.791	14.464
African Americans (%)	10.430	9.537	0.301	37.617
Bachelor's + (%)	23.902	5.141	11.100	40.400
Unemployment Rate (%)	5.077	1.352	2.300	11.300
Incarceration Rate (%)	0.346	0.148	0.062	0.865

Table 3.2: Impacts on Police Expenditures: 2SLS First-Stage Estimates

	(1)
ln(Crime Rate)	OLS
ln(Incarceration Rate)	0.297***
	(0.068)
ln(Income)	0.005
	(0.100)
House Democrats	-0.0025***
	(0.0004)
Democrat Governor	0.046
	(0.039)
Constant	4.051***
	(0.274)
State Dummies	Yes
Year Dummies	Yes
Observations	960

Notes: (1) Standard errors in parentheses.
(2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3.3: Impacts on Police Expenditures: Single-Equation Non-Spatial Estimates

	Equation (3.10)	
	(1)	(2)
ln(Police Expenditure)	OLS	2SLS
ln(Crime Rate)	0.205***	0.556***
	(0.023)	(0.171)
ln(Income)	0.360***	0.339***
	(0.069)	(0.075)
House Democrats	-0.0004	0.0006
	(0.0003)	(0.0006)
Democrat Governor	-0.040	-0.055
	(0.027)	(0.030)
Constant	2.643***	1.224
	(0.211)	(0.721)
State Dummies	Yes	Yes
Year Dummies	Yes	Yes
Observations	960	960

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3.4: Impacts on Police Expenditures: Single-Equation Spatial Estimates

	Equations (3.11) and (3.12)		Equations (3.13) and (3.12)	
	(1)	(2)	(3)	(4)
ln(Police Expenditure)	GS2LS	GS2SLS	GS2LS	GS2SLS
Wln(Police Expenditure) (WP)	0.651**	1.777***		
	(0.225)	(0.319)		
WP×C		-0.146***		
		(0.030)		
Wln(Crime Rate) (WC)			0.223	-0.176
			(0.124)	(0.153)
WC×C				0.176***
				(0.041)
ln(Crime Rate) (C)	0.394*	1.106***	0.429*	-0.227
	(0.170)	(0.222)	(0.173)	(0.228)
ln(Income)	0.291***	0.166*	0.347***	0.277***
	(0.073)	(0.076)	(0.071)	(0.072)
House Democrats	0.0005	-0.0001	0.001	0.0005
	(0.0006)	(0.0006)	(0.001)	(0.0005)
Democrat Governor	-0.049	-0.052	-0.050	-0.053
	(0.029)	(0.029)	(0.029)	(0.029)
Constant	-0.647	-6.303***	1.880**	3.868***
	(1.234)	(1.677)	(0.693)	(0.826)
W(Error)	-0.073	-0.060	-0.112	-0.113
	(0.064)	(0.061)	(0.065)	(0.064)
State Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Observations	960	960	960	960

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3.5: Impacts on Crime Rates: 2SLS First-Stage Estimates

	(1)	(2)
ln(Police Expenditure)	OLS	OLS
ln(Fatality Rate)	0.001	-0.248***
	(0.012)	(0.027)
ln(Population Density)	0.022***	0.017
	(0.006)	(0.014)
Age 18-24	0.015***	0.016
	(0.004)	(0.009)
African Americans	-0.010	0.080***
	(0.005)	(0.012)
Bachelor's +	0.0003	0.069***
	(0.0015)	(0.002)
Unemployment Rate	-0.006*	-0.032***
	(0.003)	(0.005)
Constant	4.424***	1.080*
	(0.144)	(0.311)
State Dummies	Yes	Yes
Year Dummies	Yes	No
Observations	960	960

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3.6: Impacts on Crime Rates: Single-Equation Non-Spatial Estimates

	Equation (3.14)		
	(1)	(2)	(3)
ln(Crime Rate)	OLS	2SLS	2SLS
ln(Police Expenditure)	0.431***	77.085	-0.442***
	(0.045)	(1053.736)	(0.073)
ln(Population Density)	-0.017*	-1.678	0.004
	(0.008)	(22.829)	(0.010)
Age 18-24	0.015*	-1.122	-0.001
	(0.006)	(15.629)	(0.006)
African Americans	0.001	0.738	0.001
	(0.007)	(10.142)	(0.010)
Bachelor's +	-0.005*	-0.031	-0.001
	(0.002)	(0.369)	(0.006)
Unemployment Rate	0.015***	0.496	0.009*
	(0.004)	(6.627)	(0.004)
Constant	1.980***	-337.006	5.957***
	(0.278)	(4659.884)	(0.225)
State Dummies	Yes	Yes	Yes
Year Dummies	Yes	Yes	No
Observations	960	960	960

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3.7: Impacts on Crime Rates: Single-Equation Spatial Estimates

	Equations (3.15) and (3.16)		Equations (3.17) and (3.16)	
	(1)	(2)	(3)	(4)
ln(Crime Rate)	GS2SLS	GS2SLS	GS2SLS	GS2SLS
Wln(Police Expenditure) (WP)			-0.774***	2.537***
			(0.032)	(0.185)
WP×P				-0.650***
				(0.037)
Wln(Crime Rate) (WC)	1.634***	-0.834**		
	(0.067)	(0.308)		
WC×P		0.537***		
		(0.061)		
ln(Police Expenditure) (P)	-0.410***	-2.546***	-0.442***	2.981***
	(0.075)	(0.250)	(0.075)	(0.203)
ln(Population Density)	0.000002	-0.001	-0.004	0.002
	(0.009260)	(0.009)	(0.009)	(0.008)
Age 18-24	0.009	0.017*	0.010	0.013*
	(0.008)	(0.008)	(0.008)	(0.007)
African Americans	0.009	0.035**	0.009	0.034***
	(0.011)	(0.011)	(0.011)	(0.009)
Bachelor's +	0.007	0.014*	0.010	0.007
	(0.006)	(0.006)	(0.006)	(0.005)
Unemployment Rate	0.004	0.005	0.005	0.012**
	(0.005)	(0.005)	(0.006)	(0.005)
Constant	1.890***	5.861***	6.278***	-2.257***
	(0.178)	(0.473)	(0.143)	(0.513)
W(Error)	0.562***	0.613***	0.570***	0.485***
	(0.035)	(0.036)	(0.035)	(0.039)
State Dummies	Yes	Yes	Yes	Yes
Year Dummies	No	No	No	No
Observations	960	960	960	960

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 3.8: Interactions between Police Expenditures and Crime Rates: Simultaneous-Equation Non-Spatial Estimates

	Equations (3.10) and (3.14)			
	(1.1)	(1.2)	(2.1)	(2.2)
	3SLS		3SLS	
	ln(Police Expenditure)	ln(Crime Rate)	ln(Police Expenditure)	ln(Crime Rate)
ln(Police Expenditure)		0.878***		-0.460***
		(0.042)		(0.071)
ln(Crime Rate)	0.379**		0.510***	
	(0.152)		(0.154)	
ln(Income)	0.340***		0.329***	
	(0.068)		(0.068)	
House Democrats	0.001		0.001	
	(0.001)		(0.001)	
Democrat Governor	-0.054*		-0.056*	
	(0.027)		(0.027)	
ln(Population Density)		-0.035***		-0.004
		(0.008)		(0.009)
Age 18-24		0.005		-0.003
		(0.006)		(0.006)
African Americans		0.008		0.007
		(0.006)		(0.010)
Bachelor's +		-0.005**		-0.0001
		(0.002)		(0.0056)
Unemployment Rate		0.018***		0.009*
		(0.004)		(0.004)
Constant	1.928**	(Omitted)	1.424*	5.931***
	(0.643)		(0.648)	(0.221)
State Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	No
Observations	960	960	960	960

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, $p < 0.01$, *** $p < 0.001$.

Table 3.9: Interactions between Police Expenditures and Crime Rates: Simultaneous-Equation Spatial Estimates (a)

	Equations (3.11), (3.15) and (3.18)			
	(1.1)	(1.2)	(2.1)	(2.2)
	GS3SLS		GS3SLS	
	ln(Police Expenditure)	ln(Crime Rate)	ln(Police Expenditure)	ln(Crime Rate)
Wln(Police Expenditure) (WP)	1.379***		2.284***	
	(0.249)		(0.323)	
WP×C			-0.142***	
			(0.034)	
Wln(Crime Rate) (WC)		1.419***		-1.385***
		(0.063)		(0.295)
WC×P				0.580***
				(0.058)
ln(Police Expenditure) (P)		-0.358***		-2.642***
		(0.074)		(0.239)
ln(Crime Rate) (C)	0.611***		1.168***	
	(0.172)		(0.214)	
ln(Income)	0.336***		0.288***	
	(0.077)		(0.078)	
House Democrats	0.001		0.0001	
	(0.001)		(0.0006)	
Democrat Governor	-0.058*		-0.055	
	(0.029)		(0.028)	
ln(Population Density)		-0.0002		-0.001
		(0.0092)		(0.009)
Age 18-24		0.005		0.012
		(0.008)		(0.008)
African Americans		0.010		0.040***
		(0.011)		(0.011)
Bachelor's +		0.006		0.014*
		(0.006)		(0.005)
Unemployment Rate		0.002		0.002
		(0.005)		(0.005)
Constant	-0.004	1.840***	-1.739	7.301***
	(0.839)	(0.209)	(0.920)	(0.581)
W(Error)	0.481***		0.505***	
	(0.028)		(0.030)	
State Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	No	Yes	No
Observations	960	960	960	960

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, $p < 0.01$, *** $p < 0.001$.

Table 3.10: Interactions between Police Expenditures and Crime Rates: Simultaneous-Equation Spatial Estimates (b)

	Equations (3.11), (3.17), and (3.18)			
	(1.1)	(1.2)	(2.1)	(2.2)
	GS3SLS		GS3SLS	
	ln(Police Expenditure)	ln(Crime Rate)	ln(Police Expenditure)	ln(Crime Rate)
Wln(Police Expenditure) (WP)	1.320***	-0.708***	2.085***	2.197***
	(0.244)	(0.028)	(0.317)	(0.131)
WP×C			-0.148***	
			(0.032)	
WP×P				-0.544***
				(0.026)
ln(Police Expenditure) (P)		-0.087		2.783***
		(0.071)		(0.149)
ln(Crime Rate) (C)	0.589***		1.142***	
	(0.172)		(0.218)	
ln(Income)	0.330***		0.229**	
	(0.077)		(0.077)	
House Democrats	0.001		-0.00004	
	(0.001)		(0.00058)	
Democrat Governor	-0.057*		-0.052	
	(0.029)		(0.028)	
ln(Population Density)		-0.008		-0.002
		(0.009)		(0.007)
Age 18-24		0.004		0.013*
		(0.007)		(0.005)
African Americans		0.001		0.022**
		(0.010)		(0.008)
Bachelor's +		-0.001		-0.006
		(0.005)		(0.004)
Unemployment Rate		0.012*		0.020***
		(0.005)		(0.004)
Constant	-0.172	5.906***	-4.074**	-4.625***
	(0.873)	(0.157)	(1.243)	(0.529)
W(Error)	0.444***		0.271***	
	(0.029)		(0.033)	
State Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	No	Yes	No
Observations	960	960	960	960

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, $p < 0.01$, *** $p < 0.001$.

Table 3.11: Interactions between Police Expenditures and Crime Rates: Simultaneous-Equation Spatial Estimates (c)

	Equations (3.13), (3.15), and (3.18)			
	(1.1)	(1.2)	(2.1)	(2.2)
	GS3SLS		GS3SLS	
	ln(Police Expenditure)	ln(Crime Rate)	ln(Police Expenditure)	ln(Crime Rate)
Wln(Crime Rate) (WC)	-0.065	1.392***	-0.681**	-1.432***
	(0.073)	(0.063)	(0.235)	(0.293)
WC×P				0.584***
				(0.058)
WC×C			0.179**	
			(0.064)	
ln(Police Expenditure) (P)		-0.351***		-2.649***
		(0.074)		(0.238)
ln(Crime Rate) (C)	0.464**		-0.238	
	(0.173)		(0.303)	
ln(Income)	0.300***		0.260**	
	(0.078)		(0.079)	
House Democrats	0.0005		0.0003	
	(0.0006)		(0.0006)	
Democrat Governor	-0.047		-0.046	
	(0.029)		(0.029)	
ln(Population Density)		-0.0002		-0.001
		(0.0092)		(0.009)
Age 18-24		0.004		0.012
		(0.008)		(0.008)
African Americans		0.010		0.040***
		(0.011)		(0.011)
Bachelor's +		0.006		0.014*
		(0.006)		(0.005)
Unemployment Rate		0.002		0.002
		(0.005)		(0.005)
Constant	4.376***	1.835***	5.735***	7.461***
	(0.370)	(0.214)	(0.582)	(0.592)
W(Error)	0.469***		0.493***	
	(0.029)		(0.030)	
State Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	No	Yes	No
Observations	960	960	960	960

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, $p < 0.01$, *** $p < 0.001$.

Chapter 4 The Leviathan Hypothesis, Cost Efficiency, and Spatial Interactions among Governments

4.1 Introduction

The general public, politicians, and economists as well have mixed opinions about the consequences of fiscal competition. On the one hand, it is concerned that tax reduction to attract investment, for example, may be escalated to a “race to the bottom”, leaving competing governments shorthanded on providing indispensable goods or services to their residents. On the other hand, it is often believed that decentralization and resulting competition rein in wastefulness in government spending and growth of the public sector. The latter argument is also known as the Leviathan hypothesis among economists and other researchers.

Fiscal competition may bring about reduction in taxes and probably in the quantity of goods and services publicly provided as well. It is not impossible, however, that intergovernmental competition improves the quality of public provision, even though expenditures reduce, and thus increases the welfare of residents across jurisdictions. The Leviathan hypothesis is all about this possibility, via which the public sector, the same as the private sector, is more cost efficient due to competition. In many previous studies, the Leviathan hypothesis is interpreted and tested as the inverse relationship between government size and fiscal decentralization. Government size reflects the costs of running the public sector, but not necessarily the wastefulness involved with government. To take the Leviathan hypothesis more seriously, a researcher should employ empirical models that capture the idea of cost efficiency in public provision.

Another problem with the previous tests for the Leviathan hypothesis is that fiscal decentralization is measured only within a jurisdiction. For example, in some studies on taxes or expenditures aggregated to the state level, the number of local jurisdictions is taken to measure the degree of decentralization. Interaction among states, another aspect of decentralization, is overlooked. To fully understand the impact of fiscal decentralization on either government size or government efficiency, a researcher should also bring in a spatial perspective on the Leviathan hypothesis.

This chapter answers the need for efficiency considerations and spatial perspectives in testing the Leviathan hypothesis. More specifically, it includes measures for intergovernmental competition both within a jurisdiction and among jurisdictions in testing their impacts on both government size and cost efficiency. Supplementary to the existing studies on total expenditures, this chapter examines multiple spending categories of US state and local governments, including elementary and primary education, police protection, highways, and public welfare. Some findings in this chapter confirm the Leviathan hypothesis.

The remainder of this chapter is structured as follows. Section 4.2 reviews the literatures related to the Leviathan hypothesis. It is followed by data description in Section 4.3. Sections 4.4, 4.5, 4.6, and 4.7 present the empirical models and results based on the original approach, a stochastic frontier setup, a spatial component, and a comprehensive stochastic frontier and spatial analysis in turn. Section 4.8 concludes.

4.2 Literature Review

In a prevailing view of fiscal federalism, intergovernmental competition for mobile resources is inefficient. To attract capital, for example, to flow into a jurisdiction, the government would have to lower tax rates on investment. As each government pursues the same strategy, taxes across jurisdictions are driven too low in a Nash equilibrium to finance indispensable public goods and services (Wilson, 1986; Zodrow and Mieszkowski, 1986). In this theory, each government is assumed benevolent, maximizing the total utility of all the residents within its jurisdiction.

Alternatively, Brennan and Buchanan (1980) characterize government, analogous to typical monopoly, as a revenue-maximizing monster. They predict that "Total government intrusion into the economy should be smaller, *ceteris paribus*, the greater the extent to which taxes and expenditures are decentralized (p. 185)." The inverse relationship between government size and fiscal decentralization is also known as the Leviathan hypothesis. In contrast to the prevailing view, the Leviathan hypothesis suggests that fiscal competition helps to cut off excess revenues and wasteful expenditures, and thus improve accountability in government (Rauscher, 1998; Wilson, 2005; Besley and Smart, 2007)[1].

Since Oates (1985), economists have been vigorously searching for the footprints of Leviathan, and various approaches have been taken to measuring the size of government and the degree of decentralization. While quantifying government size by state-local taxes as a fraction of personal income, Oates (1985) uses three measures of fiscal decentralization, namely, the state share of state-local general revenues, the state share of state-local total expenditures, and the number of local jurisdictions.

[1]Edwards and Keen (1996) made the first attempt to bring together these two distinct perspectives. They demonstrate that tax competition is preferred to tax coordination, if the marginal propensity to finance unproductive public expenditures exceeds the marginal excess burden of taxation. Taking a theoretical model to Swiss data, Brülhart and Jametti (2008) show that government fragmentation has a positive relationship with tax rates in direct democratic municipalities, but is found negatively correlated with tax rates in delegated municipalities. While the former case is consistent with the benevolence hypothesis, the latter alludes to revenue-maximizing behavior under the Leviathan hypothesis.

Controlling for personal income per capita, population size, the extent of urbanization, intergovernmental grants, He finds that the predicted inverse relationship is not statistically significant in either case. Besides the tax measure of government size, Nelson (1987) uses government expenditures as a fraction of personal income. Also, he differentiates the general-purpose from the single-function in counting the number of local jurisdictions. More general-purpose local jurisdictions are found contributing to a smaller public sector, which supports the Leviathan hypothesis. It is, however, not the case for single-function local jurisdictions. Zax (1989) refers to the share of own-source local revenues as the measure of "centralism" and to the number of local jurisdictions as the measure of "fragmentation". His empirical results show that local public sectors with a higher degree of centralism or a lower degree of fragmentation tend to be larger. In the following research, Marlow (1988) and Grossman (1989), for example, turn to the growth of expenditures aggregated to the highest level of government for investigation. Ehdaie (1994) then examines decentralization of revenues and expenditures combined, and provides further empirical support.

One criticism of the Leviathan hypothesis is that the inverse relationship between government size and fiscal decentralization could be due to interjurisdictional competition among benevolent governments that maximize the welfare of their own residents. If, for example, there are benefit spillovers of publicly provided goods or services, each government involved tends to invest less with its money but free-ride on its neighboring jurisdictions (Sandier, 1975; Sandier and Cauley, 1976). There has been evidence that central cities in the United States contribute to higher property value in surrounding suburbs (Haughwout, 1999), and suburbs in Spain largely benefit from local facilities in urban municipalities (Solé-Ollé, 2006). In addition, Oates

(1985) mentions a point on welfare migration made by Richard A. Musgrave. That is, to maintain a favorable tax base, governments across jurisdictions tend to cut down the budget of welfare programs to deter the poor but to attract the wealthy. The concern over fiscal decentralization and underprovided welfare benefits (Brown and Oates, 1987) is supported by empirical evidence from US state governments (Figlio et al., 1999; Saavedra, 2000; Wheaton, 2000). Last, to signal better governance capability and win the support from voters with asymmetric information, government officials tend to cut down taxes, for example, especially when neighboring governments are doing so (Besley and Smart, 2007). In empirical findings, jurisdictional governments are found engaged in the so-called "yardstick competition" and exhibit mimicking behavior in setting tax rates (Besley and Case, 1995; Bordignon et al., 2003; Allers and Elhorst, 2005; Bosch and Solé-Ollé, 2007).

Under the Leviathan hypothesis, intergovernmental competition helps to cut off excess revenues and wasteful expenditures, and thus promotes accountability in government. It then seems more relevant to define this hypothesis as the direct relationship between government efficiency and fiscal decentralization. The concept of government efficiency not only comprises government size as an evaluation component, but also incorporates the information about to what extent the given tax money is efficiently used to provide goods and services. In a large body of empirical literature, various stochastic frontier models have been employed to examine technical/cost efficiency of government, the extent to which production/cost in the public sector is below/above the maximum/minimum possible, given the inputs/outputs. Education is probably the most explored government expenditure category. For example, Kang and Greene (2002) look into the impact of public and private competition on technical efficiency among high schools in the state of New York. Abbott and Doucouliagos (2009) are interested in whether competition for international students enhances technical efficiency in universities in Australia and New Zealand. Dodson and Garrett (2004) investigate whether consolidating school districts improves cost efficiency in Arkansas. While Robst (2001) examines multiple issues with cost efficiency in American public universities, Izadi et al. (2002) estimate a more complex constant-elasticity-of-substitution (CES) cost function for British higher-education institutions.

As the first extension to the literature, this chapter plans to test the Leviathan hypothesis by stochastic cost frontier models for multiple government expenditure categories. The second extension has to do with spatial interactions among government, of which tax competition, benefit/cost spillovers, welfare migration, and yardstick competition are particular cases. With the previous findings of positive spatial autocorrelation in state government expenditures (Case et al., 1993; Baicker, 2005), this chapter is to investigate whether government size is spatially correlated, with the control for the number of local jurisdictions.

Geys (2006) brings together techniques in stochastic frontier and spatial analysis to spatial interaction in efficiency enhancement in government provision among the Flemish municipalities in Belgium. He first estimates a stochastic cost frontier, taking total current government expenditures as the costs of producing four measures of goods and services — namely, the number of subsistence grant beneficiaries, the number of students in local primary schools, the surface of public recreational facilities, and the length of municipal roads. Then, by transforming inefficiency estimates, an efficiency measure is obtained. In his second step specifying the efficiency determinants, Geys (2006) introduces a spatially weighted efficiency term to examine the impact of municipal competition on efficiency enhancement. With different specifications and estimation methods, his statistically significant estimates of the spatial-lag parameter vary roughly between 0.2 and 0.7. The similar spatial pattern of government efficiency is detected by Revelli and Tovmo (2007) too. Taking a similar strategy as Geys (2006), this chapter plans to test the Leviathan hypothesis by examining the relationship between government efficiency and fiscal decentralization.

As Schmidt and Sickles (1984) point out, panel data in stochastic frontier analysis help to gain consistency of the estimates, relax the distributional assumptions on inefficiency, and ease the concerns over the correlation between inefficiency and other dependent variables. Extending Geys (2006)'s cross-section analysis, this chapter uses panel data and takes fixed effects into account in estimating time-varying (in)efficiency. Moreover, alternative to Geys (2006), a cost frontier is estimated with environmental factors under certain model specifications. Last, when it comes to spatial analysis, both spatial lags and errors are taken care of.

4.3 Data Description

The data are from the 48 continental US states from 1991 to 2008. Summary statistics for each variable are listed in Table 4.1.

This chapter considers total expenditures as well as expenditures on elementary and secondary education, police protection, highways, and public welfare. All spending categories are examined at the aggregate state-local level. Since education and police are primarily a local function, the government expenditures on them are also examined at the local level with total expenditures.

Oates (1985), Nelson (1987), and Zax (1989) all take the number of local jurisdictions in a state to measure the degree of fiscal decentralization in a cross-section setting. As there is little yearly variation in this variable, the numbers of counties or their equivalents[2] and of school districts as of 2007 are used for all the years. A limitation of this treatment is that state fixed effects are no longer identifiable, which could in turn affect the accuracy of available estimates. The Leviathan hypothesis suggests that, due to greater competition, more local governments lead to smaller government size and higher cost efficiency. The same prediction, however, may be generated under diseconomies of scale. To identify one effect from another, more careful examination is needed.

In line with Oates (1985), Nelson (1987), and Zax (1989), total intergovernmental revenues will be divided by general revenues to obtain the percentage of intergovernmental grants corresponding to total expenditures. Since the amount of revenues for individual government functions is not reported, the share of intergovernmental expenditures for each government function will be computed instead. The grant share may be taken as another measure for fiscal decentralization. Grants sometimes raise the concern over reduced incentives. To interpret a positive coefficient estimate as evidence in support of the Leviathan hypothesis, one needs to have the flypaper effect addressed. When it comes to stochastic frontier analysis, a negative coefficient estimate of the transfer share is consistent with the Leviathan hypothesis. A positive sign then suggests that intergovernmental grants increase efficiency by internalizing externalities, for example.

Other independent variables include personal income per capita, population den-

[2] For Connecticut and Rhode Island, where there are no organized county governments, the number of their subcounties is used for approximation.

sity, the percentage of Democrats in the House, and a dummy for Democratic governor. Suppose that personal income is found to be positively correlated with government size. Rather than being wasteful, more government expenditures may be used to provide public goods and services with higher quality. This possibility can be taken into account in stochastic analysis by having an measure for quality outputs.

Six output measures of publicly provided goods and services are used to estimate stochastic cost frontiers, with government expenditures being the cost measure. The total enrollment of public elementary and secondary schools and the averaged freshman graduation rate (AFGR) for public high schools are used to measure the scale and quality of public elementary and secondary education. As an estimate of the percentage of an entering freshman class obtaining the high school diploma, the AFGR is calculated by dividing the total number of diploma recipients in an school-year end by the average enrollment of the 10th-grade class two years ago, the 9th-grade class three years ago, and the 8th-grade class four years ago. The annual vehicle-mileage of travel and the total number of registered drivers reflect of the role of government in transportation. If clear-up crime rates were recorded, they may be taken as an output measure for police protection. Unfortunately, only crime rates are available. For this reason, the current chapter does not include police protection expenditures. The distribution function of government are captured by total number of Temporary Assistance for Needy Families (TANF), or previously Aid to Families with Dependent Children (AFDC) recipients and by total number of Supplemental Security Income (SSI) recipients. The TANF/AFDC and SSI are federal assistance programs with large involvement of state governments. State governments usually provide additional funds and services to those recipients who are in poverty, in disability, or in some other hardships. The corresponding cost measures to the six output measures are elementary and secondary education expenditures, highway expenditures, and public welfare expenditures, respectively.

The statistics on government finances, government structure, population, and land area are accessible at the Bureau of the Census. The Bureau of Economic Analysis is responsible for reporting personal income. The information on the party affiliation of state legislators and governors is kept track of at the Council of State Governments. The enrollment data for public schools are from the National Center for Education Statistics. The data on vehicle-mileage of travel and driver registration are made available by National Highway Traffic Safety Administration. The numbers of TANF/AFDC recipients and SSI recipients are reported at the Department of Health and Human Services and the Social Security Administration, respectively.

4.4 Government Size and Fiscal Decentralization: The Original Approach

4.4.1 Model Specification

In line with Oates (1985) and Nelson (1987), the share of government expenditures in personal income is taken to measure government size in this chapter. Since this measure is bounded between 0 and 1, the logit transformation, i.e., logit $(y) = \ln\left(\frac{y}{1-y}\right)$, where y is the variable to be transformed, is applied to generate a dependent variable with a possible range of all real numbers. Alternatively, government expenditures per capita in natural logarithmic form may be used as the dependent variable, which is an exercise left to future work.

Both Oates (1985) and Nelson (1987) consider state-local total expenditures. Nelson (1987) also looks into fire protection expenditures, a local spending category, in particular. In this chapter, local total expenditures aggregated to the state level are examined first, and then aggregate state-local total expenditures. The same procedure applies to expenditures on elementary and secondary education and on police protection expenditures as well, two essentially local spending categories. As state governments rein expenditures on highways and on public welfare, these two spending categories are examined only at the aggregate state-local level.

Oates (1985), Nelson (1987), and Zax (1989) all use cross-section data of a particular year in conducting their tests. Extensions are made in this section to panel data. Since the data on the number of counties or of school districts per capita are based on a single year, state fixed effects cannot be either identified or removed. In this case, only year fixed dummies are specified, whenever they are jointly significant. The share of intergovernmental transfers in local or state-local finances is taken as a control variable in all the three studies, in which the predicted positive relationship between government size and intergovernmental grants are assumed due to the mysterious flypaper effect[3]. However, more intergovernmental grants from a higher-level government, for better or worse, is also an indication of greater dependence and less decentralization, and thus is hypothesized to cause larger government size. Perhaps intergovernmental grants should be paid more attention to as a measure for fiscal decentralization.

Besides personal income per capita, Oates (1985) and Nelson (1987) include the percentage of urban population as a control variable. As the latter index is not reported annually, population density is computed instead. To control for political

[3]Hines and Thaler (1995) reviews the evidence of the so-called "flypaper effect", a term coined by Arthur M. Okun to metaphorize the prediction that grants stimulate local spending.

environment in a state, the percentage of Democrats in the House and a dummy for Democratic governor are added to the list of independent variables.

4.4.2 Estimation Results

Total government expenditures are examined first at the local level, and then at the aggregate state-local level. The estimation results are presented in Table 4.2. In Column (1) are the baseline results without the number of counties. While dropping state dummies, Column (2) includes the number of counties as a measure for fiscal decentralization. Year dummies of joint statistical significance are included in both specifications. The number of counties in Column (2) is seen negatively and significantly correlated with government size. This significant inverse relationship that supports the Leviathan hypothesis holds for total government expenditures at the state-local level as well. In Column (4), despite that the coefficient estimate of the number of counties reduces, the marginal impact on government size remains strong. The share of intergovernmental revenues is insignificant at the local level, but significant and positive at the aggregate state and local level. Grants may correct for positive externalities and the resulting underprovision problem. Grants may also reduce incentives at the local level to maintain a hard budget constraint. Without further information, the nature of increased expenditures by grants is unclear. Personal income per capita is significantly but negatively correlated with the expenditure share in each column.

Both Nelson (1987) and Zax (1989) make the distinction between general-purpose and single-function government units. When it comes to elementary and secondary education, the number of public school districts is used. This spending category is examined at both local and state-local levels too. The coefficient estimates of our main interest in Table 4.3 are positive, statistically significant, and almost identical. The positive sign does not support the Leviathan prediction, but may indicate diseconomies of scale in public education. In principle, to single out the impact of fiscal decentralization on government size, either a measure for (dis)economies of scale needs to be included, or a better measure for intergovernmental competition is expected. The sign and significance level of the intergovernmental expenditure share vary with or without the number of school districts. Personal income per capita remains its negative relationship with the expenditure share at certain significance levels.

Police protection is another spending category mainly at the local level. Nelson (1987) considers fire protection expenditures, and finds supporting evidence. Comparing Column (2) with Column (4) of Table 4.4, the inverse relationship between the share of police expenditures and the number of counties is stronger when this category is examined at the local level than at the aggregate state-local level. Note that, since year dummies are not jointly statistically significant when the number of counties is present, they are thus excluded with state dummies. With the number of counties included, the expenditure share is found to have a significant but negative relationship with intergovernmental grants. Meanwhile, the expenditure share is larger if personal income per capita is higher.

Since highway and public welfare are two spending categories mainly at the state level, they are examined at the state-local level only. Shown in Table 4.5 and Table 4.6, respectively, government size and the number of counties are positively correlated. This positive relationship is stronger for highway expenditures than for welfare expenditures. While the results on intergovernmental grants are mixed, the negative impact of personal income on the expenditure share is robust to data and specifications.

4.5 Government Efficiency and Fiscal Decentralization: Stochastic Frontier Estimation

4.5.1 Model Specification

To capture the idea that fiscal decentralization reduces wasteful expenditures, the Leviathan hypothesis is redefined as the direct relationship between government efficiency and fiscal decentralization. Stochastic frontier models suit well the present research purpose. With government expenditures being the costs for publicly provided goods and services, a stochastic cost frontier in a cross-section setting may take a transcendental logarithmic (translog) form as

$$\ln c_i = \alpha + \sum_p \beta_p \ln y_{i,\,p} + \frac{1}{2} \sum_p \sum_q \gamma_{pq} \ln y_{i,\,p} \ln y_{i,\,q} + v_i + u_i, \tag{4.1}$$

where c_i denotes the costs to the ith government, y with a subscript p or q represents the pth or qth good or service publicly provided, v_i is an error term assumed independent and identically normally distributed with a zero mean, i.e., $v_i \sim N(0, \sigma_v^2)$, u_{it} is the inefficiency term that adds more costs, and α, β's, and γ's are unknown parameters. By imposing $\gamma_{pq} = 0$, a Cobb–Douglas cost function may be formed as a special case.

Different distributional assumptions on the inefficiency lead to a variety of stochastic frontier models. In this chapter, u_{it} is assumed either half-normal, i.e., $u_i \sim N(0, \sigma_u^2)^+$, or truncated-normal, i.e., $u_i \sim N(\mu_u, \sigma_u^2)^+$, where μ_u and σ_u stand for the mean and the standard deviation, respectively. Given the distributional assumptions on v_i and u_i, a stochastic cost frontier may be estimated by maximum likelihood (ML) without considering efficiency determinants at this stage. The estimator of cost efficiency $E\{\exp[u_i|(v_i+u_i)]\}$ is interpreted as the archived percentage of cost efficiency. Mathematically, it is written as

$$
\begin{aligned}
E\{\exp[u_i|(v_i+u_i)]\} &= \left[\frac{1-\Phi\left(-\frac{\mu_i+\sigma^2}{\sigma}\right)}{1-\Phi\left(-\frac{\mu_i}{\sigma}\right)}\right]\exp\left(\mu_i+\frac{\sigma^2}{2}\right),\\
\sigma &= \frac{\sigma_v\sigma_u}{\sqrt{\sigma_v^2+\sigma_u^2}},\\
\mu_i &= \frac{(v_i+u_i)\,\sigma_u^2}{\sigma_v^2+\sigma_u^2}, \text{ if } u_i\sim N\left(0,\sigma_u^2\right)^+,\\
\mu_i &= \frac{(v_i+u_i)\,\sigma_u^2+\mu_u\sigma_v^2}{\sigma_v^2+\sigma_u^2}, \text{ if } u_i\sim N\left(\mu_u,\sigma_u^2\right)^+,
\end{aligned}
$$

where $\Phi(\cdot)$ is the cumulative distribution function of the standard normal distribution. With obtained efficiency estimates from Equation (4.1), the impacts of various environmental factors on efficiency achievement can be evaluated in a multivariate regression.

The approach of estimating a stochastic frontier and evaluating its efficiency determinants separately assumes independence. However, as Wang and Schmidt (2002, p. 130) put it, "the position of the frontier may depend on things other than those typically thought of as inputs, and the inputs may be among the factors that also affect technical efficiency". Among many others, Wang and Schmidt (2002) argue that first-step estimates are biased downward, if frontier and efficiency determinants are correlated. Moreover, second-step estimates are biased toward zero, even though frontier determinants are independent of efficiency determinants in the first step. These claims are supported by their simulation results.

Two alternative one-step strategies have been taken to simultaneously estimate the two steps. Kumbhakar et al. (1991), Huang and Liu (1994), and Battese and Coelli (1995), for example, parameterize the non-zero mean of the truncated normally distributed inefficiency term, i.e., $u_i \sim N\left(\mathbf{x}_i^T\boldsymbol{\delta}, \sigma_u^2\right)^+$. In contrast, Reifschneider and Stevenson (1991), Caudill and Ford (1993), and Caudill. et al. (1995), for example, parameterize the variance of the half-normal distribution for the inefficiency term, i.e., $u_i \sim N\left[0, \exp\left(\mathbf{x}_i^T\boldsymbol{\delta}\right) \cdot \sigma_u^2\right]^+$. The efficiency measure is accordingly modified by replacing μ_u with $\mathbf{x}_i^T\boldsymbol{\delta}$ in the former case, and by replacing σ_u^2 with $\exp\left(\mathbf{x}_i^T\boldsymbol{\delta}\right) \cdot \sigma_u^2$ in the latter case, respectively.

The rest of this subsection is devoted to accommodating fixed effects for panel data analysis implementing the above approaches. Fixed effects may either go into the cost function, the mean of the inefficiency term, or the variance of the inefficiency term. In each case, the inefficiency term may or may not be specified as a function of environmental factors.

In the case of fixed effects in the cost function, Equation (4.1) is modified such that

$$\ln c_{it} = \alpha + \sum_p \beta_p \ln y_{it,\,p} + \frac{1}{2}\sum_p \sum_q \gamma_{pq} \ln y_{it,\,p} \ln y_{it,\,q} + \varphi_i + \varsigma_t + v_{it} + u_{it}, \quad (4.2)$$

where t indexes time periods, φ_i and ς_t control for two-way fixed effects with φ_i being a state dummy for individual effects and ς_t being a year dummy for time effects. The distribution of the inefficiency term may be assumed half-normal, i.e., $u_{it} \sim N\left(0, \sigma_u^2\right)^+$, or truncated-normal, $u_{it} \sim N\left(\mu_u, \sigma_u^2\right)^+$, without heterogeneity in either the mean or variance. Alternatively, one may choose to parameterize the variance of the half-normal inefficiency term, i.e., $u_{it} \sim N\left[0, \exp\left(\mathbf{x}_{it}^T\boldsymbol{\delta}\right) \cdot \sigma_u^2\right]^+$, or the mean of the truncated-normal inefficiency term, i.e., $u_{it} \sim N\left(\mathbf{x}_{it}^T\boldsymbol{\delta}, \sigma_u^2\right)^+$, with environmental factors. To summarize, given fixed effects in the cost function, the scenarios of whether the inefficiency term is assumed of a half-normal or truncated-normal distribution and whether heterogeneity is introduced to the inefficiency term by environmental factors, lead to four models labeled (1a), (1b), (2a), and (2b), i.e.,

$$\text{Model (1a):} \quad \begin{cases} \ln c_{it} = \alpha + \sum_p \beta_p \ln y_{it,\,p} + \frac{1}{2}\sum_p \sum_q \gamma_{pq} \ln y_{it,\,p} \ln y_{it,\,q} \\ \qquad +\varphi_i + \varsigma_t + v_{it} + u_{it}, \\ \qquad u_{it} \sim N\left[0, \sigma_u^2\right]^+ ; \end{cases}$$

$$\text{Model (1b):} \quad \begin{cases} \ln c_{it} = \alpha + \sum_p \beta_p \ln y_{it,\,p} + \frac{1}{2}\sum_p \sum_q \gamma_{pq} \ln y_{it,\,p} \ln y_{it,\,q} \\ \qquad +\varphi_i + \varsigma_t + v_{it} + u_{it}, \\ \qquad u_{it} \sim N\left[0, \exp\left(\mathbf{x}_{it}^T \boldsymbol{\delta}\right) \cdot \sigma_u^2\right]^+ ; \end{cases}$$

$$\text{Model (2a):} \quad \begin{cases} \ln c_{it} = \alpha + \sum_p \beta_p \ln y_{it,\,p} + \frac{1}{2}\sum_p \sum_q \gamma_{pq} \ln y_{it,\,p} \ln y_{it,\,q} \\ \qquad +\varphi_i + \varsigma_t + v_{it} + u_{it}, \\ \qquad u_{it} \sim N\left[\mu_u, \sigma_u^2\right]^+ ; \end{cases}$$

$$\text{Model (2b):} \quad \begin{cases} \ln c_{it} = \alpha + \sum_p \beta_p \ln y_{it,\,p} + \frac{1}{2}\sum_p \sum_q \gamma_{pq} \ln y_{it,\,p} \ln y_{it,\,q} \\ \qquad +\varphi_i + \varsigma_t + v_{it} + u_{it}, \\ \qquad u_{it} \sim N\left[\mathbf{x}_{it}^T \boldsymbol{\delta}, \sigma_u^2\right]^+ ; \end{cases}$$

As fixed effects are placed in the mean of the inefficiency term, Equation (4.2) reduces to

$$\ln c_{it} = \alpha + \sum_p \beta_p \ln y_{it,\,p} + \frac{1}{2}\sum_p \sum_q \gamma_{pq} \ln y_{it,\,p} \ln y_{it,\,q} + v_{it} + u_{it}, \tag{4.3}$$

where $u_{it} \sim N\left[\left(\varphi_i + \varsigma_t\right), \sigma_u^2\right]^+$, if no environmental factors are specified, and $u_{it} \sim N\left[\left(\mathbf{x}_{it}^T \boldsymbol{\delta} + \varphi_i + \varsigma_t\right), \sigma_u^2\right]^+$, if environmental factors are considered. The models accommodate these two placements of fixed effects in the mean of u_{it} are labeled Models (3a) and (3b), i.e.,

$$\text{Model (3a):} \quad \begin{cases} \ln c_{it} = \alpha + \sum_p \beta_p \ln y_{it,\,p} + \frac{1}{2}\sum_p \sum_q \gamma_{pq} \ln y_{it,\,p} \ln y_{it,\,q} \\ \qquad + v_{it} + u_{it}, \\ \qquad u_{it} \sim N\left[\left(\varphi_i + \varsigma_t\right), \sigma_u^2\right]^+ ; \end{cases}$$

$$\text{Model (3b):} \quad \begin{cases} \ln c_{it} = \alpha + \sum_p \beta_p \ln y_{it,\,p} + \frac{1}{2}\sum_p \sum_q \gamma_{pq} \ln y_{it,\,p} \ln y_{it,\,q} \\ \qquad + v_{it} + u_{it}, \\ \qquad u_{it} \sim N\left[\left(\mathbf{x}_{it}^T \boldsymbol{\delta} + \varphi_i + \varsigma_t\right), \sigma_u^2\right]^+ ; \end{cases}$$

A model allowing for variation in both the mean and variance of the inefficiency term cannot be empirically identified. To bring fixed effects into its variance, the inefficiency term turns back to the distribution assumption of half-normality. Depending on whether environmental factors are included, the exact distribution of the inefficiency term can be written as $u_{it} \sim N\left[0, \exp\left(\varphi_i + \varsigma_t\right) \cdot \sigma_u^2\right]^+$, or as $u_{it} \sim N\left[0, \exp\left(\mathbf{x}_{it}^T \boldsymbol{\delta} + \varphi_i + \varsigma_t\right) \cdot \sigma_u^2\right]^+$. As before, if environmental factors are not considered in estimating the cost frontier, they are then used in the following analysis on efficiency determination, and vice versa. Resulting Models (4.a) and (4.b) resemble Models (3a) and (3b), except for the distribution assumption on the inefficiency term, i.e.,

$$\text{Model (4a):} \quad \left\{ \begin{array}{c} \ln c_{it} = \alpha + \sum_p \beta_p \ln y_{it,\,p} + \frac{1}{2} \sum_p \sum_q \gamma_{pq} \ln y_{it,\,p} \ln y_{it,\,q} \\ + v_{it} + u_{it}, \\ u_{it} \sim N\left[0, \exp\left(\varphi_i + \varsigma_t\right) \cdot \sigma_u^2\right]^+ ; \end{array} \right.$$

$$\text{Model (4b):} \quad \left\{ \begin{array}{c} \ln c_{it} = \alpha + \sum_p \beta_p \ln y_{it,\,p} + \frac{1}{2} \sum_p \sum_q \gamma_{pq} \ln y_{it,\,p} \ln y_{it,\,q} \\ + v_{it} + u_{it}, \\ u_{it} \sim N\left[0, \exp\left(\mathbf{x}_{it}^T \boldsymbol{\delta} + \varphi_i + \varsigma_t\right) \cdot \sigma_u^2\right]^+ ; \end{array} \right.$$

Below is a list of the eight models introduced in this section. As there is little theoretical guidance in the literature on model selection, which of the eight models actually works will be found out through experimentation.

Model (1a): *Fixed effects in the cost function, half-normal u_{it}, without environmental factors in frontier estimation.*

Model (1b): *Fixed effects in the cost function, half-normal u_{it}, with environmental factors in frontier estimation.*

Model (2a): *Fixed effects in the cost function, truncated-normal u_{it}, without environmental factors in frontier estimation.*

Model (2b): *Fixed effects in the cost function, truncated-normal u_{it}, with environmental factors in frontier estimation.*

Model (3a): *Fixed effects in the mean of u_{it}, truncated-normal u_{it}, without environmental factors in frontier estimation.*

Model (3b): *Fixed effects in the mean of u_{it}, truncated-normal u_{it}, with environmental factors in frontier estimation.*

Model (4a): *Fixed effects in the variance of u_{it}, half-normal u_{it}, without environmental factors in frontier estimation.*

Model (4b): *Fixed effects in the variance of u_{it}, half-normal u_{it}, with environmental factors in frontier estimation.*

4.5.2 Estimation Results

It turns out that education data do not fit any model, highway data fit Models (1a), (1b), (2b), and (3b), and welfare data fit Models (1a) and (2b). Short of data on appropriate output measures such as clearance rates, this analysis is not feasible for police protection. For the same reason, total expenditures are not considered either[4]. State dummies are replaced to accommodate the number of local jurisdictions, whenever it is appropriate. However, no specification with this decentralization measure ends up with success in one-step stochastic cost frontier estimation. The two-step approach is then largely relied on to produce comparable results to Oates (1985), Nelson (1987), and Zax (1989).

The estimation results for state-local highway expenditures are shown in Table 4.7. The upper half of Columns (1) and (2) are identical, which gives Model (1a)

[4] Total expenditures on police protection, highways, and public welfare were attempted. Same as what happened with education data, all the models fail to converge in stochastic cost frontier estimation.

estimates with both state and year fixed dummies jointly statistically significant in the cost function. The estimated cost function takes a Cobb-Douglas form without translog terms, since the latter is not jointly statistically significant. The estimated $\sigma_{v_{it}}$ and $\sigma_{u_{it}}$ are 0.067 and 0.133, respectively, in Model (1a), suggesting less variation on the frontier across states, but more variation in costs above the frontier, i.e., inefficiency. The p-value associated with the likelihood-ratio test is less than 0.001, which provides solid evidence of the existence of the inefficiency component u_{it}.

With a mean of 1.114 and a standard deviation of 0.079, the efficiency estimates vary from 1.012 to 1.803, which is outside the theoretically possible range of [0, 1]. This is less concerned here, because this chapter does not rely on interpreting these estimates but uses them for comparison across jurisdictions. The kernel density of the efficiency estimates are shown in the upper-left panel of Figure 4.1. As expected, the density curve is skewed to the right.

In Column (1) of Table 4.8, the 48 continental states are ranked based on the 18-year annual average efficiency scores. Massachusetts, New Mexico, and Georgia are in lead, while Nebraska, Michigan, and Ohio are left behind. The spatial distribution of this ranking is labeled in the first map in Figure 4.2. Although not shown on the map, the state names corresponding to this ranking can be found in Table 4.8.

Now, let us go back to Table 4.7. The lower half of Columns (1) and (2) are the second-step estimates of efficiency determinants. Year dummies are dropped due to joint statistical insignificance. Not in favor of the Leviathan hypothesis, the number of counties does not have a significant inverse relationship with cost efficiency. However, intergovernmental grants are seen negatively affecting cost efficiency.

Column (3) of Table 4.7 gives the one-step Model (1b) estimates for highway expenditures, in which estimation of efficiency scores and evaluation of environmental factors are conducted simultaneously. Despite that the number of counties is unable to fit into these stochastic cost frontier models, the significant negative impact of intergovernmental grants on cost efficiency is quite interesting, especially if it is interpreted as an indicator of fiscal intervention from a higher level of government, or simply of fiscal centralization. The efficiency estimates are bounded between 1.014 and 2.127, with a mean of 1.110 and a standard deviation of 0.104, whose kernel density is estimated and visualized in the upper-right panel of Figure 4.1. According to Column (2) of Table 4.8, Massachusetts, Georgia, and New Mexico remain the top three in cost efficiency in highway expenditures, despite of the position switch between the latter two states. Michigan now is joined by Arizona and Oregon among the bottom three. The second map in Figure 4.2 illustrates the spatial distribution of the Model (1b) annual average efficiency scores by state.

Highway data also fit Model (2b). The impact of intergovernmental grants on cost efficiency remains negative, but no longer statistically significant, as seen in Column (4) of Table 4.7. The efficiency estimates lie between 1.012 and 2.186, with a mean of 1.106 and a standard deviation of 0.112. The kernel density function in the lower-left panel of Figure 4.1 exhibits a similar shape to the previous estimates. In Column (3) of Table 4.8, Massachusetts, Georgia, and New Mexico hold their exact positions as in Column (2). Meanwhile, Nebraska, Ohio, and Michigan are rated the least cost efficient states in highway expenditures this time. This ranking is put on the third map in Figure 4.2 to demonstrate how efficiency score are geographically distributed.

The estimated results of the last stochastic cost frontier model using highway expenditures are offered in Column (5) of Table 4.7. Although the translog terms are jointly statistically insignificant, dropping them leads to a failure of convergence. These translog terms are thus kept as a compromise. The evidence of intergovernmental grants undermining cost efficiency is confirmed once again. The efficiency estimates, however, fall into a much wider range of [1.014, 10.098]. The mean efficiency score is 3.332, while the standard deviation is 1.417. Seen in the lower-right panel of Figure 4.1, the kernel density function takes a much longer tail there than in other panels. Models (3b) estimates also shuffle the ranking in Column (4) of Table 4.8 as well as on the last map in Figure 4.2. That is, Wyoming, South Dakota, and North Dakota stand out above the rest, while Michigan, Texas, and California meet each other at the bottom of the list.

Now, we switch to state-local public welfare expenditures. Columns (1) and (2) of Table 4.9 present the Model (1a) results. Their upper half is based on the first-step estimation of efficiency scores. With the fact of the estimated $\sigma_{v_{it}}$ and $\sigma_{u_{it}}$ being 0.095 and 0.045, respectively, the likelihood-ratio test for a non-zero inefficiency term is not passed. Using the efficiency scores with a minimum of 1.010, a maximum of 1.136, a mean of 1.037, and a standard deviation of 0.008, the kernel density function is nevertheless plotted in the upper panel of Figure 4.3. Using the 18-year annual average, cost efficiency by state is ranked in Column (1) of Table 4.8 and labeled on the first map of Figure 4.4. While New Hampshire, Oklahoma, and New Mexico exhibit the most cost efficiency in welfare expenditures, Iowa, Idaho, and Arkansas fall into the bottom three. The second-step evaluation of efficiency determinants is nevertheless carried out as well. Year dummies are dropped, because of joint statistical insignificance. As found by same model using highway expenditures, the number of counties is not seen having a significant positive impact on cost efficiency, so that the Leviathan hypothesis is not supported.

With environmental factors except the number of counties, welfare data also fit Model (2b). As before, more intergovernmental grants do not seem to promote cost efficiency. The minimum and maximum of the efficiency estimates are 1.013 and 1.941, respectively, with a mean of 1.450 and a standard deviation of 0.148. The kernel density function estimated is not seen right-skewed in the lower panel of Figure 4.3. Based on the annual average efficiency scores, Idaho, Wyoming, and Utah are the most efficient users of welfare expenditures. The bottom three go to Colorado, New York, and California. The efficiency ranking is also represented on the second map of Figure 4.4.

In both highway and welfare data, intergovernmental grants are negatively correlated with cost efficiency. This suggests that intergovernmental grants may have an incentive effect that causes lower-level governments to care less about cost saving. Personal income per capita in general does not have substantial impacts on cost efficiency.

4.6 Government Size and Fiscal Decentralization: A Spatial Perspective

4.6.1 Model Specification

In the literature thus far, fiscal decentralization has had its measures for subjurisdictions within a jurisdiction, e.g., the number of counties in a state. What has been missing in testing the Leviathan hypothesis is a measure for fiscal relations across states, in addition to a measure for decentralized counties within each state. To investigate whether government size in a state is affected by government size in neighboring states, a regression function is set up as

$$E_{it} = \rho \sum_j w_{ij} E_{jt} + \mathbf{x}_{it}^T \boldsymbol{\delta} + \psi_i + \tau_t + \varepsilon_{it}, \tag{4.4}$$

with

$$\varepsilon_{it} = \lambda \sum_j w_{ij} \varepsilon_{jt} + \eta_{it}, \tag{4.5}$$

where E_{it} denotes the logit of the share of government expenditures in personal income per capita in the ith state in the tth year, w_{ij} is an element of a spatial-weight matrix determining the relative influence of the jth state on the ith, $\mathbf{x}_{it}$ is a vector of control variables including a measure for fiscal decentralization within a state, ψ_i is a state dummy and τ_t is a year dummy, ε_i and η_i are error terms assumed standard normally distributed, and ρ, $\boldsymbol{\delta}$, and λ are unknown parameters. As before, if the time-invariant number of local government units is used, year dummies are automatically dropped. This specification differs from the one in Section 4.4 in that it takes into account the impact of neighboring states, i.e., $\sum_j w_{ij} E_{jt}$, on government size at home, which is captured by spatial-lag parameter ρ. Moreover, this specification allows for spatial autocorrelation is errors, which is reflected by spatial-error parameter λ.

Spatial relations may be defined using a contiguity matrix. If a state i is adjacent to another state j, for example, i is assigned a weight $w_{ij} = \frac{1}{N_i}$, where N_i is the total number of i's neighboring states. If i and j are nonadjacent, both are assigned a weight $w_{ij} = 0$. Note that a jurisdiction is not considered to be a neighbor of itself, i.e., $w_{ii} = 0$. Employed this chapter is a population-adjusted contiguity matrix. In contrast to a regular contiguity matrix treating each neighbor equally, a population-adjusted contiguity matrix gives more weight on populous states that are probably of greater influence on others, i.e., $w_{ij} = \frac{\overline{Pop_j}}{\overline{Pop_{N_i}}}$ for i's neighbor j, where $\overline{Pop_j}$ and $\overline{Pop_{N_i}}$ refer to the average annual populations of j and of all N_i neighbors of i, respectively.

In this chapter all year-end populations between 1991 and 2008 are averaged to adjust the simple contiguity relations.

For Equations (4.4) and (4.5), imposing $\lambda = 0$ leads to a spatial-lag model, while with $\rho = 0$, a spatial-error model is formed. Ordinary least squares (OLS), if applied to spatial-lag models, will give biased estimates by ignoring spatial lags. The OLS estimates from spatial-error models are consistent in general. However, they are inefficient even for large samples, and thus responsible for misleading hypothesis test results.

Kelejian and Prucha (1998) propose a generalized spatial two-stage least squares (GS2SLS) procedure to deal with both spatial lags and errors. The first step is to implement two-stage least squares (2SLS) to estimate Equation (4.4), with endogenous spatial lags instrumented by the weighted averages of neighbors' exogenous characteristics $\mathbf{x}$'s. It is followed by using 2SLS residuals to estimate the spatial-error parameter λ. Then multiply the matrix of right-hand-side variables on the left by $\left(\mathbf{I} - \hat{\lambda}\mathbf{W}\right)$ to correct for spatial errors, where $\mathbf{I}$ is an $NT \times NT$ identity matrix, $\mathbf{W}$ is an $NT \times NT$ block–diagonal spatial-weight matrix, N is the total number of states, and T is the total number of time periods. Lastly, apply 2SLS again to the transformed equation. The estimates produced by this procedure are expected to be both consistent and efficient.

4.6.2 Estimation Results

First, as in Section 4.4, total expenditures are first examined at the local level. In Column (1) of Table 4.11, the estimate of the spatial parameter is positive and statistically significant. Since intergovernmental competition tends to limit government size, a home state would have a smaller public sector, when its neighboring states start to shrink their public sectors. This downsizing effect due to spatial interaction among decentralized governments is consistent with the Leviathan hypothesis. Evidence remains supportive, with the number of counties included and year dummies dropped. The estimates in Column (2) suggest that fiscal decentralization, both within a jurisdiction and across many, helps to rein in government size, with a number of characteristics controlled for, including significant spatial autocorrelation in the error term. Positive spatial interaction in government size holds for state-local total expenditures in Column (3) of Table 4.11. Whereas the number of counties has an expected impact, its inclusion reverses the sign of the spatial-lag term in Column (4). The interpretation of this finding has to be based on further investigation.

Shown in Table 4.12, the size of elementary and secondary education expenditures are positively correlated across states, both at local and state-local levels, when the number of school districts is not included. When it is included, more school districts actually lead to a large government, as found in Section 4.4. Meanwhile, its inclusion wipes off the downsizing effect due to spatial interaction across states.

Shown in Table 4.13, when examined at both local and state-local levels without the number of counties, there is no significant spatial autocorrelation in the size of police expenditures. The number of counties, when included, has a negative and significant impact on the size of police expenditures, as found in Section 4.4. Its inclusion also brings in mixed results at the two levels.

Positive spatial interaction holds in the size of state-local highway expenditures, both with or without the number of counties included, in Table 4.14. As found in Section 4.4, the included number of counties is positively and significantly correlated with government size.

Spatial interaction in the size of state-local welfare expenditures is insignificant until the number of counties included in Table 4.15. The sign, however, suggests a negative response to neighboring states in determining government size at home. The number of counties does not seem critical, when it is included.

Given the mixed results obtained from different expenditure categories, the impact of intergovernmental revenues and expenditures on government size is not yet clear. Personal income per capita in general exhibits negative correlation with government size at various significance levels.

4.7 Government Efficiency and Fiscal Decentralization: Stochastic Frontier and Spatial Analysis

4.7.1 Model Specification

Bringing together the ideas developed in Sections 4.5 and 4.6, this section investigates the impact of fiscal decentralization both within a state and across states on government efficiency.

In a recent study, Geys (2006) estimates an stochastic cost frontier without environmental factors to obtain efficiency scores, and then evaluates the impacts of spatially weighted efficiency scores of neighbors and other environmental factors on efficiency achievement. This procedure can be applied to Models (1a), (2a), (3a), and (4a), if they are successfully estimated. In the first step, Equation (4.2) or (4.3) is estimated by ML. With obtained efficiency scores, Equations (4.4) and (4.5) are estimated by GS2SLS, where E_{it} now denotes the efficiency score of the ith state in tth year, and the definitions of the rest variables and parameters remain the same.

Models (1b), (2b), (3b), and (4b) have included usual environmental factors in stochastic cost frontier estimation. If they are successfully estimated, Equation (4.4) to examine spatial interaction in efficiency scores in the second step reduces to

$$E_{it} = \rho \sum_{j} w_{ij} E_{jt} + \psi_i + \tau_t + \varepsilon_{it}, \tag{4.6}$$

with Equation (4.5) still applying.

4.7.2 Estimation Results

As reported in Section 4.5, only state-local highway and welfare data fit some of the stochastic cost frontier models.

The estimates in Column (1) of Table 4.16 are based on Model (1a) efficiency estimates for highway expenditures. Both spatially weighted efficiency scores and the number of counties in a state are found insignificant. However, the spatial estimates in Columns (3) and (4) based on Models (1b) and Column (2b), respectively, are substantial evidence of diffusion in cost efficiency among states. Column (5) based on Model (3b) fails to provide further support.

Similar results are found for welfare expenditures. Under Model (1a), the impacts of spatially weighted efficiency scores and the number of counties in a state are both trivial. In contrast, the efficiency scores produced by Model (2b) exhibit positive and statistically significant spatial autocorrelation, which, as well as that in Columns (3) and (4) in Table 4.16, is supplementary to and consistent with the Geys (2006) finding.

Intergovernmental grants, as seen in Section 4.5, is found to be associated with lower cost efficiency. As discussed before, the fact that grants increase local expenditures does not provide sufficient information for policy evaluation. It could be efficiency-enhancing, if grants correct for positive externalities and the resulting underprovision problem. If grants turn out to weaken local commitment to a hard budget constraint, there will be wasteful expenditures and a loss in efficiency.

4.8 Conclusion

Whether fiscal decentralization and resulting intergovernmental competition help to cut off wasteful government spending and rein in growth of government size is a widely discussed issue not only within academia, but also among politicians and the general public. The opinions of the affirmative side are put in short by economists as the Leviathan hypothesis.

This chapter experiments with four model specifications, trying to bring in new perspectives on testing the Leviathan hypothesis. Section 4.4 uses the original approach developed in the 1980s but with panel data to test the inverse relationship between the expenditure share in personal income and the number of local jurisdictions. The Leviathan hypothesis is confirmed by results obtained from total expenditures and police protection expenditures. Section 4.5 redefines the Leviathan hypothesis as the direct relationship between government efficiency and fiscal decentralization, and test it using stochastic cost frontier models. Only one stochastic cost frontier model containing environmental factors is successfully estimated and only with highway and with welfare expenditures. The available estimates are not in support of the Leviathan hypothesis. Section 4.6 refers back to the original setup, but incorporates government size in neighboring jurisdictions to capture the spatial impact of decentralization. It is found, in terms of local total expenditures, that government size of a state is smaller, if the state has more competing local governments and borders similar states with smaller public sectors. Section 4.7 combines the models developed in Sections 4.5 and 4.6 to test the direct relationship between government efficiency and fiscal decentralization by both within- and across-jurisdiction measures. Limited evidence from highway and welfare expenditures suggests that a state is more cost-efficient in spending, if its neighbors exhibit cost efficiency too, which is supplementary to and consistent with the Geys (2006) finding.

To make it comparable with previous studies, this chapter uses the number of local jurisdictions as a measure for decentralization. Little variation across years is a notable disadvantage of this measure in a panel-data setting. This chapter in fact collects one-year data only on this variable, which also result in individual fixed effects being unidentifiable. Meanwhile, the number of local jurisdictions does not fully capture decentralization and resulting competition among jurisdictions. The positive/negative relationship between this measure and the running costs in the public sector then could be an indicator of diseconomies/economies of scale. A more appropriate measure for fiscal competition within a jurisdiction is expected in future work.

Spatial analysis using efficiency scores largely depends on successful estimation of a stochastic cost frontier. In a panel-data setting in this chapter, possible treatments to various kinds of heterogeneity, i.e., heterogeneity across observations, across time, and across inefficiency terms, are screened with two popular distribution assumptions on the inefficiency term, i.e., half-normality and truncated-normality. There certainly are model specifications not exhausted, some of which may turn out to better fit the data. Besides examining government expenditures at the local level in the current framework, other stochastic frontier models are to be experimented with or under development in future work.

Table 4.1: Summary Statistics

(48 Contiguous US States, 1991-2008)

Variable	Mean	Std Dev	Min	Max
Local Total Expenditures (Million Dollars)	21000308	30519368	974619	259358520
– Elementary and Secondary Education	7472786	9303990	491909	70271479
– Police Protection	1007463	1540253	26194	13275335
State-Local Total Expenditures (Million Dollars)	37178034	48856514	2284766	415436973
– Elementary and Secondary Education	7504971	9321470	489625	70687156
– Police Protection	1172754	1714378	40755	14891583
– Highways	2063138	2099224	230394	15701894
– Public Welfare	5309665	7193235	152451	54612752
Local General Revenues	18581382	26784929	906894	226689172
State-Local General Revenues	31912644	40314367	2159799	327817087
Total IG Revenues to Local	7172473	11231177	253598	98973232
Total IG Revenues to State and Local	6386330	8057429	412929	57719733
Total IG Expenditures to Local (Million Dollars)	218233	884822	2	9478000
– Elementary and Secondary Education	18602	110529	0	1430380
– Police Protection	73	290	0	5522
Total IG Expenditure to State and Local (Thousand Dollars)	85956	404258	0	3663047
– Elementary and Secondary Education	4039221	5348164	129870	45883599
– Police Protection	21793	46243	0	389140
– Highways	254225	371532	0	4401883
– Public Welfare	1045987	3637597	0	28717980
Counties (per Capita)	0.021	0.020	0.001	0.094
School Districts (per Capita)	0.087	0.096	0.005	0.517
Income (Thousand Dollars per Capita)	27.707	7.244	13.741	56.272
Population Density (Population per Mile^2)	270.331	929.068	4.714	10081.23
House Democrats (%)	53.066	15.825	16	100
Democrat Governor (=1)	0.007	0.083	0	1
School Enrollment (in Thousands)	954.556	1052.809	84.409	6441.557
Graduation Rate (%)	76.296	7.779	54.346	94.927
Vehicle-Mileage (in Millions)	5532.646	5505.732	587	32926.7
Drivers (in Thousands)	3887.482	3979.176	303.357	23697.67
TANF Recipients (in Thousands)	169.528	305.2047	0.49	2679.653
SSI Recipients (in Thousands)	136.5897	184.0154	3.895	1271.916

Table 4.2: Government Size and Fiscal Decentralization: The Original Approach (a)

(Total Expenditures)

	Local		State-Local	
logit(Expenditure Share)	(1)	(2)	(3)	(4)
Counties		-3.050***		-1.741***
		(0.358)		(0.272)
IG Rev Share	0.082	0.163	0.756***	2.332***
	(0.049)	(0.098)	(0.125)	(0.157)
Income	-0.012***	-0.007***	-0.016***	-0.004**
	(0.001)	(0.002)	(0.001)	(0.001)
Population Density	0.000007**	0.000004	0.000009***	0.000025***
	(0.000003)	(0.000007)	(0.000002)	(0.000005)
House Democrats	0.0002	-0.0029***	-0.0001	-0.0011***
	(0.0003)	(0.0004)	(0.0003)	(0.0003)
Democrat Governor	-0.053*	0.367***	-0.049*	0.164**
	(0.025)	(0.082)	(0.024)	(0.055)
Constant	-1.847***	-1.757***	-1.145***	-1.575***
	(0.033)	(0.068)	(0.044)	(0.050)
State Dummies	Yes	No	Yes	No
Year Dummies	Yes	Yes	Yes	Yes
Observations	864	864	864	864

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4.3: Government Size and Fiscal Decentralization: The Original Approach (b)

(Elementary and Secondary Education Expenditures)

	Local		State-Local	
logit(Expenditure Share)	(1)	(2)	(3)	(4)
School Districts		0.404***		0.407***
		(0.043)		(0.044)
IG Expenditure Share	0.021	1.786*	-0.159***	0.076*
	(0.465)	(0.721)	(0.033)	(0.035)
Income	-0.005*	-0.008***	-0.004*	-0.006***
	(0.002)	(0.001)	(0.002)	(0.001)
Population Density	0.000017***	0.000007	0.000020***	0.000011*
	(0.000003)	(0.000004)	(0.000003)	(0.000004)
House Democrats	0.0005	-0.0002	0.0008*	-0.0002
	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Democrat Governor	-0.056	-0.030	-0.052	-0.025
	(0.031)	(0.048)	(0.031)	(0.049)
Constant	-3.098***	-2.943***	-3.028***	-3.016***
	(0.036)	(0.030)	(0.040)	(0.041)
State Dummies	Yes	No	Yes	No
Year Dummies	Yes	Yes	Yes	Yes
Observations	864	864	864	864

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4.4: Government Size and Fiscal Decentralization: The Original Approach (c)

(Police Protection Expenditures)

	Local		State-Local	
logit(Expenditure Share)	(1)	(2)	(3)	(4)
Counties		-5.161***		-4.721***
		(0.421)		(0.316)
IG Expenditure Share	1.015	-41.43**	0.0504	-0.458**
	(3.639)	(13.37)	(0.154)	(0.175)
Income	-0.0234***	0.00538***	-0.0173***	0.00433***
	(0.00162)	(0.00113)	(0.00157)	(0.000838)
Population Density	0.0000114***	-0.0000113	0.0000131***	-0.0000105
	(0.00000288)	(0.00000859)	(0.00000280)	(0.00000651)
House Democrats	0.000508	-0.00184***	0.000435	-0.00141***
	(0.000307)	(0.000514)	(0.000297)	(0.000387)
Democrat Governor	-0.0405	-0.126	-0.0404	-0.0929
	(0.0286)	(0.0964)	(0.0277)	(0.0727)
Constant	-5.022***	-5.227***	-4.942***	-5.019***
	(0.0329)	(0.0470)	(0.0324)	(0.0352)
State Dummies	Yes	No	Yes	No
Year Dummies	Yes	No	Yes	No
Observations	864	864	864	864

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4.5: Government Size and Fiscal Decentralization: The Original Approach (d) (State-Local Highway Expenditures)

	State-Local	
logit(Expenditure Share)	(1)	(2)
Counties		7.102***
		(0.413)
IG Expenditure Share	-0.662***	-0.442***
	(0.112)	(0.078)
Income	-0.017***	-0.031***
	(0.003)	(0.002)
Population Density	0.00001	-0.000005
	(0.00001)	(0.000008)
House Democrats	-0.001	-0.004***
	(0.001)	(0.001)
Democrat Governor	-0.073	-0.152
	(0.054)	(0.092)
Constant	-3.851***	-3.435***
	(0.062)	(0.062)
State Dummies	Yes	No
Year Dummies	Yes	Yes
Observations	864	864

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4.6: Government Size and Fiscal Decentralization: The Original Approach (e) (State-Local Public Welfare Expenditures)

	State-Local	
logit(Expenditure Share)	(1)	(2)
Counties		1.144*
		(0.459)
IG Expenditure Share	-0.665***	0.452***
	(0.101)	(0.074)
Income	-0.023***	-0.024***
	(0.003)	(0.002)
Population Density	0.000004	0.00002*
	(0.000005)	(0.00001)
House Democrats	-0.002**	0.006***
	(0.001)	(0.001)
Democrat Governor	0.088	0.118
	(0.053)	(0.100)
Constant	-3.218***	-3.727***
	(0.062)	(0.063)
State Dummies	Yes	No
Year Dummies	Yes	Yes
Observations	864	864

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4.7: Government Efficiency and Fiscal Decentralization: Stochastic Frontier Estimation (a)

(State-Local Highway Expenditures)

ln(Expenditure)	(1) Model (1a)	(2) Model (1a)	(3) Model (1b)	(4) Model (2b)	(5) Model (3b)
ln(Vehicle-Mileage) (y2a)	0.187*	0.187*	0.078	0.099	0.247
	(0.078)	(0.078)	(0.502)	(0.070)	(0.551)
ln(Drivers) (y2b)	-0.066	-0.066	-0.059	-0.063	-0.730
	(0.043)	(0.043)	(0.033)	(0.033)	(0.774)
0.5×(y2a)×(y2a)					-0.084
					(0.161)
0.5×(y2a)×(y2b)					0.169
					(0.240)
0.5×(y2b)×(y2b)					-0.004
					(0.111)
Constant	4.306***	4.306***	5.191***	5.043***	5.999
	(0.631)	(0.631)	(0.590)	(0.569)	(13.330)
State Dummies	Yes	Yes	Yes	Yes	–
Year Dummies	Yes	Yes	Yes	Yes	–
Counties		-0.219			
		(0.146)			
IG Expenditure Share	-0.458***	-0.125***	-10.125***	-4.399	-0.677***
	(0.079)	(0.028)	(1.920)	(2.433)	(0.109)
Income	-0.0006	0.0003	0.037*	0.003	-0.001
	(0.0005)	(0.0004)	(0.014)	(0.005)	(0.003)
Population Density	0.000002	0.000004	0.0002*	0.0001	0.000003
	(0.000004)	(0.000003)	(0.0001)	(0.0001)	(0.000005)
House Democrats	-0.0009*	0.00001	0.008	0.004	-0.001*
	(0.0004)	(0.00018)	(0.005)	(0.003)	(0.001)
Democrat Governor	-0.057	-0.031	-2.684*	-2.519	-0.064
	(0.039)	(0.033)	(1.301)	(3.803)	(0.052)
Constant	1.227***	1.123***	-4.646***	-0.504	0.803
	(0.036)	(0.018)	(0.516)	(0.508)	(13.238)
State Dummies	Yes	No	–	–	Yes
Year Dummies	No	No	–	–	Yes
Observations	864	864	864	864	864

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Figure 4.1: Kernel Density Estimates of Cost Efficiency (a)

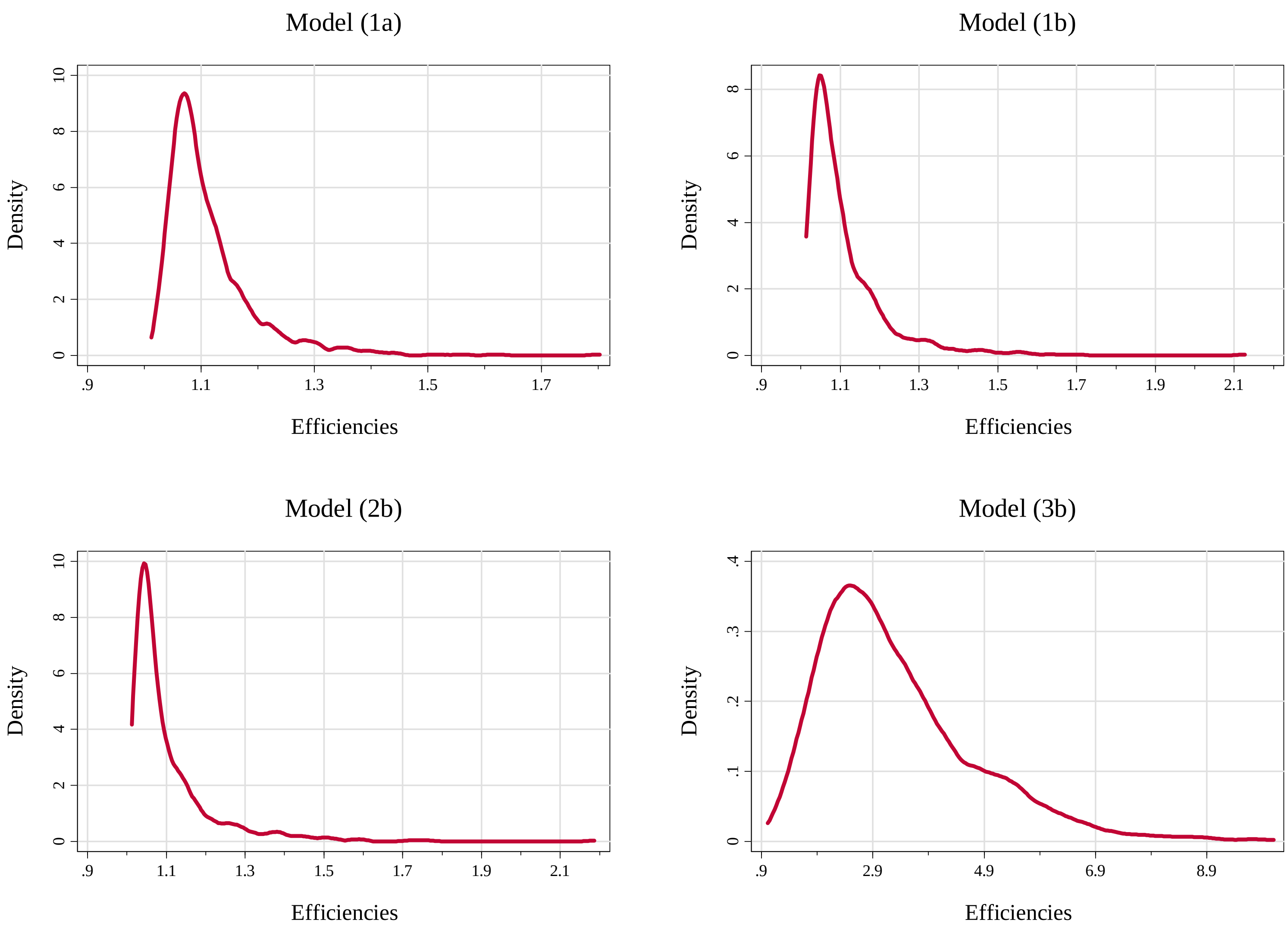


Table 4.8: 18-Year Average Rankings of Cost Efficiency (a)

(State-Local Highway Expenditures)

FIPS	State	(1) Model (1a)	(2) Model (1b)	(3) Model (2b)	(4) Model (3b)
1	Alabama (AL)	44	36	39	36
4	Arizona (AZ)	22	46	38	32
5	Arkansas (AR)	18	29	22	22
6	California (CA)	10	34	23	48
8	Colorado (CO)	9	23	18	18
9	Connecticut (CT)	7	5	5	25
10	Delaware (DE)	27	14	15	6
12	Florida (FL)	30	16	19	42
13	Georgia (GA)	3	2	2	45
16	Idaho (ID)	45	42	44	14
17	Illinois (IL)	25	27	29	35
18	Indiana (IN)	43	43	43	39
19	Iowa (IA)	29	45	40	8
20	Kansas (KS)	31	33	35	9
21	Kentucky (KY)	21	17	14	24
22	Louisiana (LA)	17	10	11	28
23	Maine (ME)	37	20	26	13
24	Maryland (MD)	14	32	24	34
25	Massachusetts (MA)	1	1	1	26
26	Michigan (MI)	47	48	48	46
27	Minnesota (MN)	41	40	42	15
28	Mississippi (MS)	26	30	28	19
29	Missouri (MO)	33	31	37	30
30	Montana (MT)	42	21	27	4
31	Nebraska (NE)	46	41	46	11
32	Nevada (NV)	28	15	20	10
33	New Hampshire (NH)	39	22	32	17
34	New Jersey (NJ)	8	6	7	33
35	New Mexico (NM)	2	3	3	7
36	New York (NY)	35	12	13	37
37	North Carolina (NC)	38	26	30	41
38	North Dakota (ND)	12	28	25	3
39	Ohio (OH)	48	44	47	44
40	Oklahoma (OK)	19	37	33	29
41	Oregon (OR)	20	47	45	21
42	Pennsylvania (PA)	6	9	9	38
44	Rhode Island (RI)	11	4	4	27
45	South Carolina (SC)	5	7	6	43
46	South Dakota (SD)	36	25	34	2
47	Tennessee (TN)	13	38	31	40
48	Texas (TX)	15	8	10	47
49	Utah (UT)	4	11	8	20
50	Vermont (VT)	34	35	36	5
51	Virginia (VA)	16	19	17	31
53	Washington (WA)	24	24	21	23
54	West Virginia (WV)	32	13	12	12
55	Wisconsin (WI)	40	39	41	16
56	Wyoming (WY)	23	18	16	1

Figure 4.2: Spatial Distribution of Efficiency Rankings (a)

(State-Local Highway Expenditures)

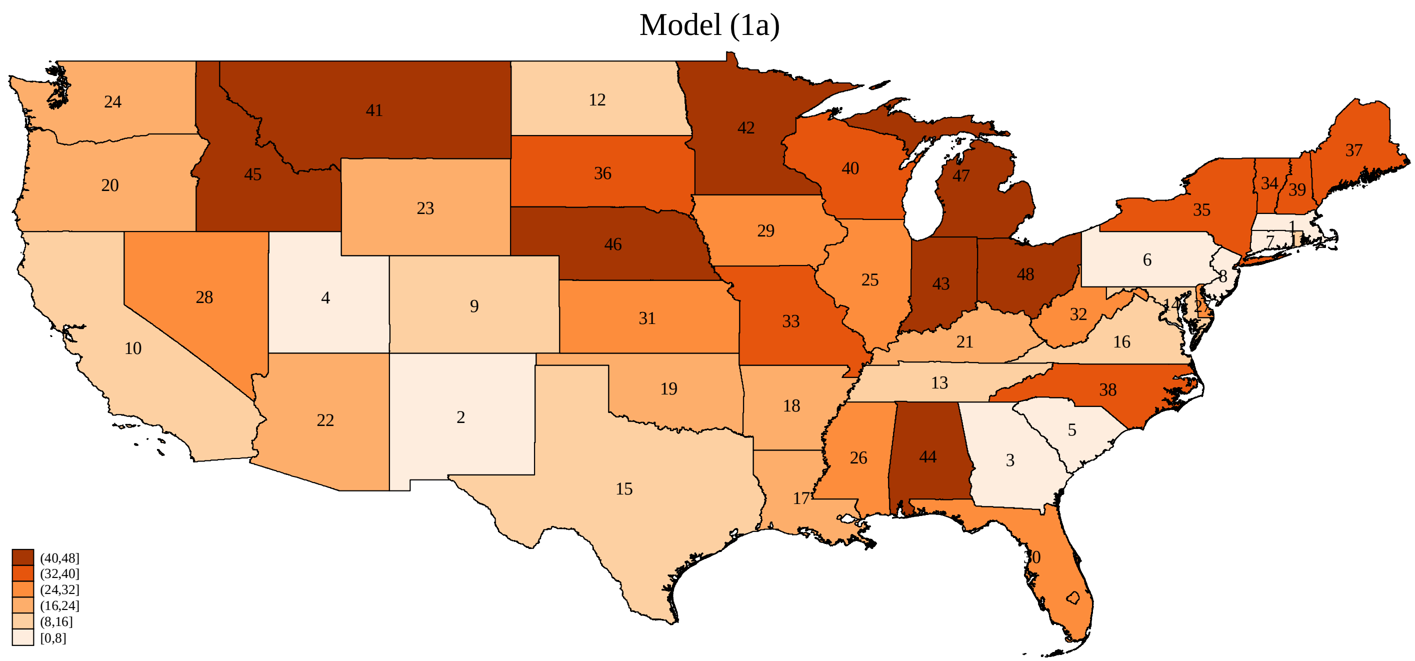


Figure 4.2: Spatial Distribution of Efficiency Rankings (a) (Continued)

(State-Local Highway Expenditures)

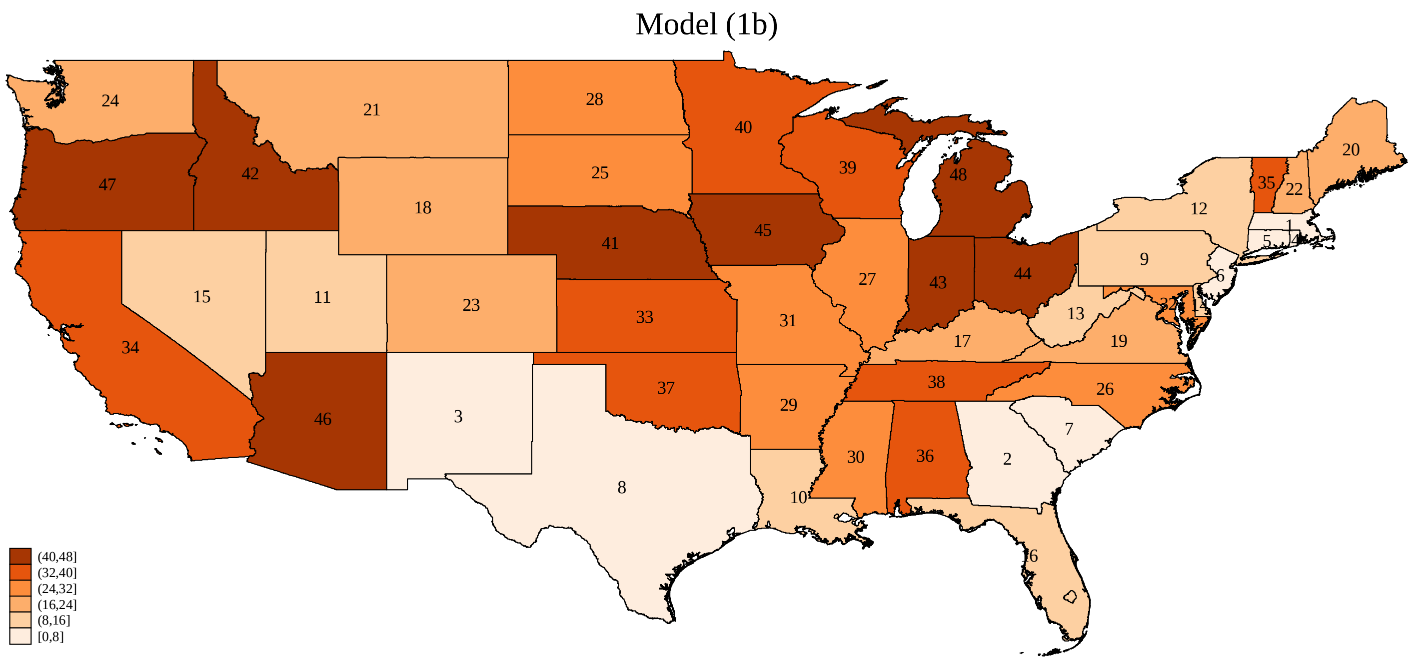


Figure 4.2: Spatial Distribution of Efficiency Rankings (a) (Continued)

(State-Local Highway Expenditures)

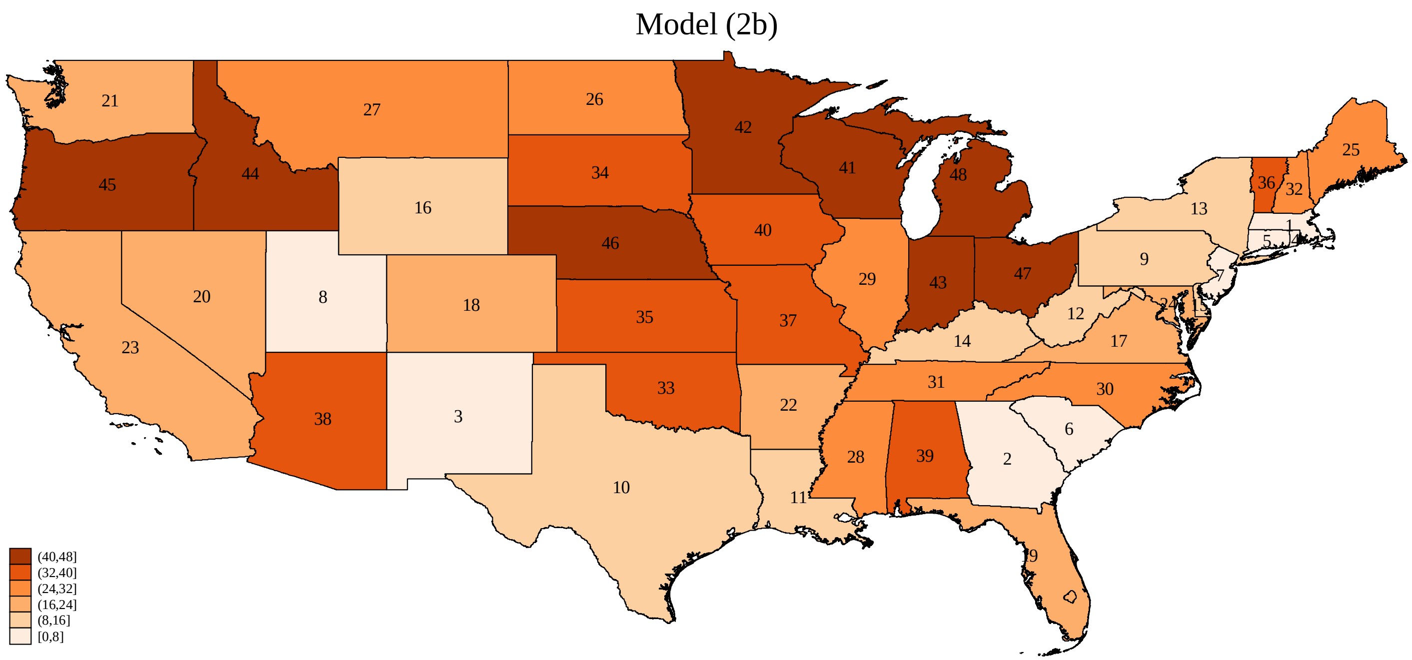


Figure 4.2: Spatial Distribution of Efficiency Rankings (a) (Continued)

(State-Local Highway Expenditures)

Model (3b)

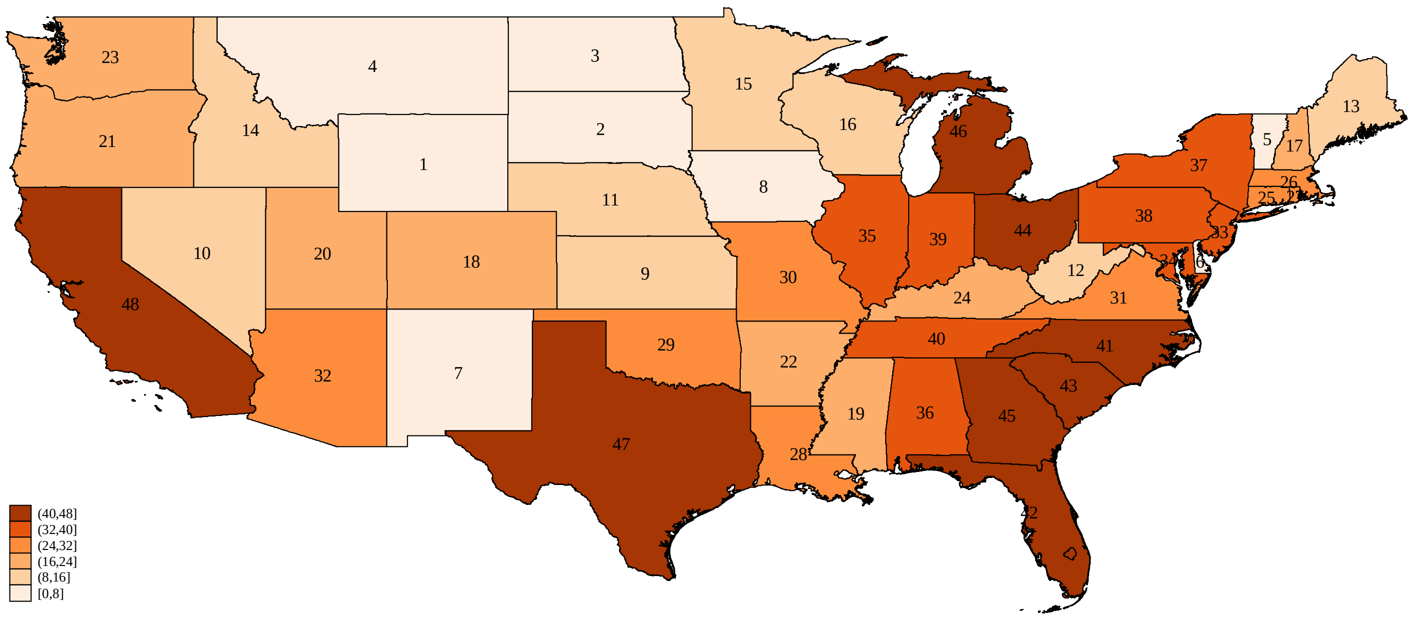


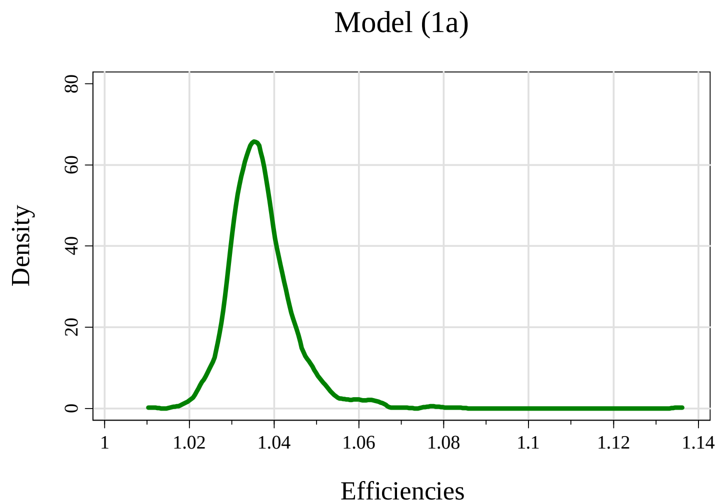
Table 4.9: Government Efficiency and Fiscal Decentralization: Stochastic Frontier Estimation (b)

(State-Local Public Welfare Expenditures)

ln(Expenditure)	(1) Model (1a)	(2) Model (1a)	(3) Model (2b)
ln(TANF Rec) (y3a)	0.022	0.022	0.005
	(0.025)	(0.025)	(0.026)
ln(SSI Rec) (y3b)	-0.016	-0.016	0.155
	(0.125)	(0.125)	(0.118)
0.5×(y3a)×(y3a)	0.088***	0.088***	0.071***
	(0.010)	(0.010)	(0.010)
0.5×(y3a)×(y3b)	-0.136***	-0.136***	-0.101***
	(0.022)	(0.022)	(0.023)
0.5×(y3b)×(y3b)	0.059*	0.059*	0.011
	(0.030)	(0.030)	(0.029)
Constant	5.732***	5.732***	5.029***
	(0.350)	(0.350)	(0.329)
State Dummies	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes
Counties		-0.0288	
		(0.0161)	
IG Expenditure Share	-0.039***	-0.004	-0.866***
	(0.008)	(0.002)	(0.118)
Income	-0.00010*	-0.00003	-0.001
	(0.00005)	(0.00004)	(0.002)
Population Density	0.00000002	0.00000005	0.00000123
	(0.00000043)	(0.00000031)	(0.00000491)
House Democrats	-0.00015***	-0.00003	-0.003***
	(0.00004)	(0.00002)	(0.001)
Democrat Governor	0.005	0.004	0.060
	(0.004)	(0.003)	(0.048)
Constant	1.049***	1.040***	0.610***
	(0.004)	(0.002)	(0.101)
State Dummies	Yes	No	–
Year Dummies	No	No	–
Observations	864	864	864

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Figure 4.3: Kernel Density Estimates of Cost Efficiency (b)



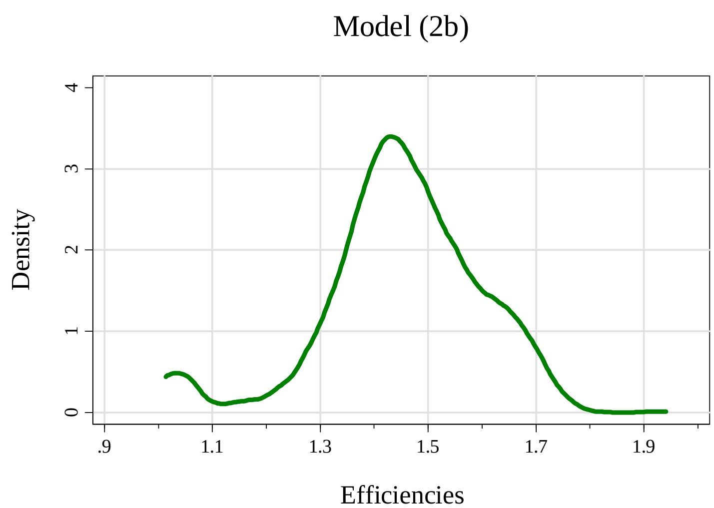


Table 4.10: 18-Year Average Rankings of Cost Efficiency (b)

(State-Local Public Welfare Expenditures)

FIPS	State	(1) Model (1a)	(2) Model (2b)
1	Alabama (AL)	19	21
4	Arizona (AZ)	11	43
5	Arkansas (AR)	48	32
6	California (CA)	26	48
8	Colorado (CO)	9	46
9	Connecticut (CT)	23	37
10	Delaware (DE)	6	7
12	Florida (FL)	22	9
13	Georgia (GA)	30	25
16	Idaho (ID)	47	1
17	Illinois (IL)	36	39
18	Indiana (IN)	16	27
19	Iowa (IA)	46	15
20	Kansas (KS)	13	8
21	Kentucky (KY)	37	19
22	Louisiana (LA)	4	28
23	Maine (ME)	45	17
24	Maryland (MD)	31	31
25	Massachusetts (MA)	5	44
26	Michigan (MI)	18	29
27	Minnesota (MN)	44	38
28	Mississippi (MS)	10	36
29	Missouri (MO)	27	12
30	Montana (MT)	17	13
31	Nebraska (NE)	35	6
32	Nevada (NV)	15	22
33	New Hampshire (NH)	1	26
34	New Jersey (NJ)	7	40
35	New Mexico (NM)	3	16
36	New York (NY)	40	47
37	North Carolina (NC)	25	45
38	North Dakota (ND)	14	5
39	Ohio (OH)	34	33
40	Oklahoma (OK)	2	23
41	Oregon (OR)	8	14
42	Pennsylvania (PA)	33	41
44	Rhode Island (RI)	21	42
45	South Carolina (SC)	32	10
46	South Dakota (SD)	43	4
47	Tennessee (TN)	20	35
48	Texas (TX)	41	20
49	Utah (UT)	28	3
50	Vermont (VT)	24	18
51	Virginia (VA)	38	30
53	Washington (WA)	29	11
54	West Virginia (WV)	12	24
55	Wisconsin (WI)	42	34
56	Wyoming (WY)	39	2

Figure 4.4: Spatial Distribution of Efficiency Rankings (b)

(State-Local Public Welfare Expenditures)

Model (1a)

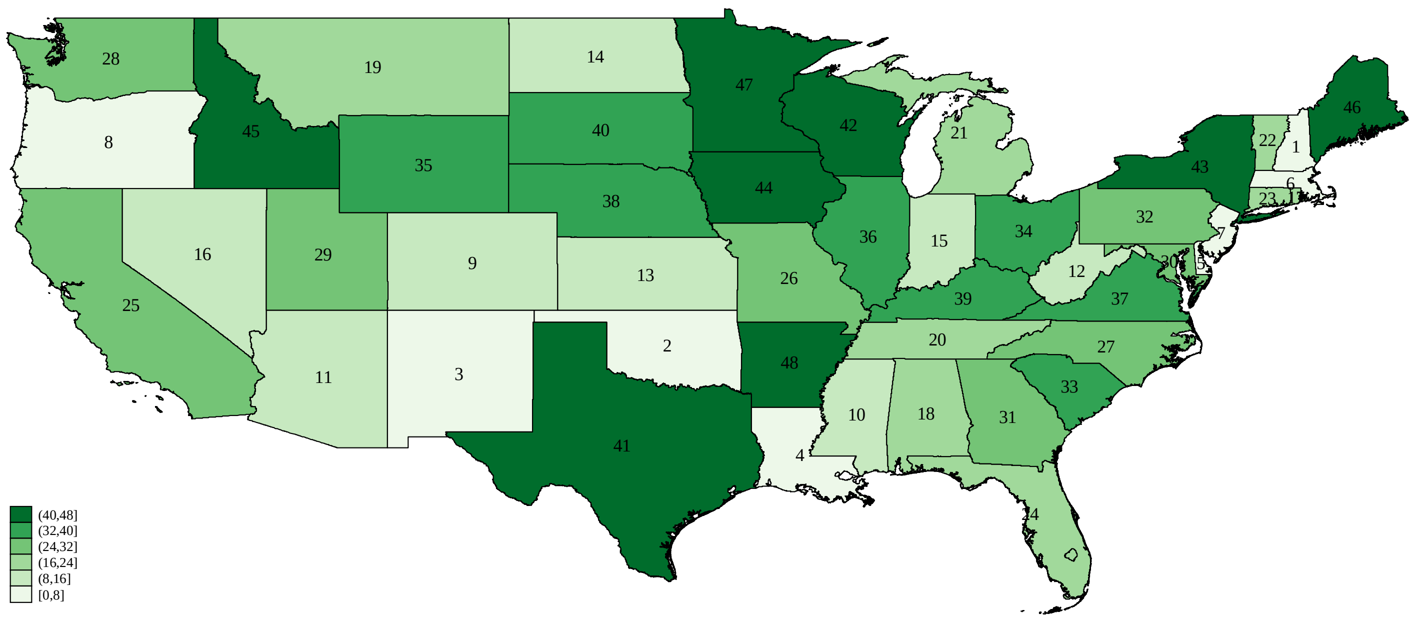


Figure 4.4: Spatial Distribution of Efficiency Rankings (b) (Continued)

(State-Local Public Welfare Expenditures)

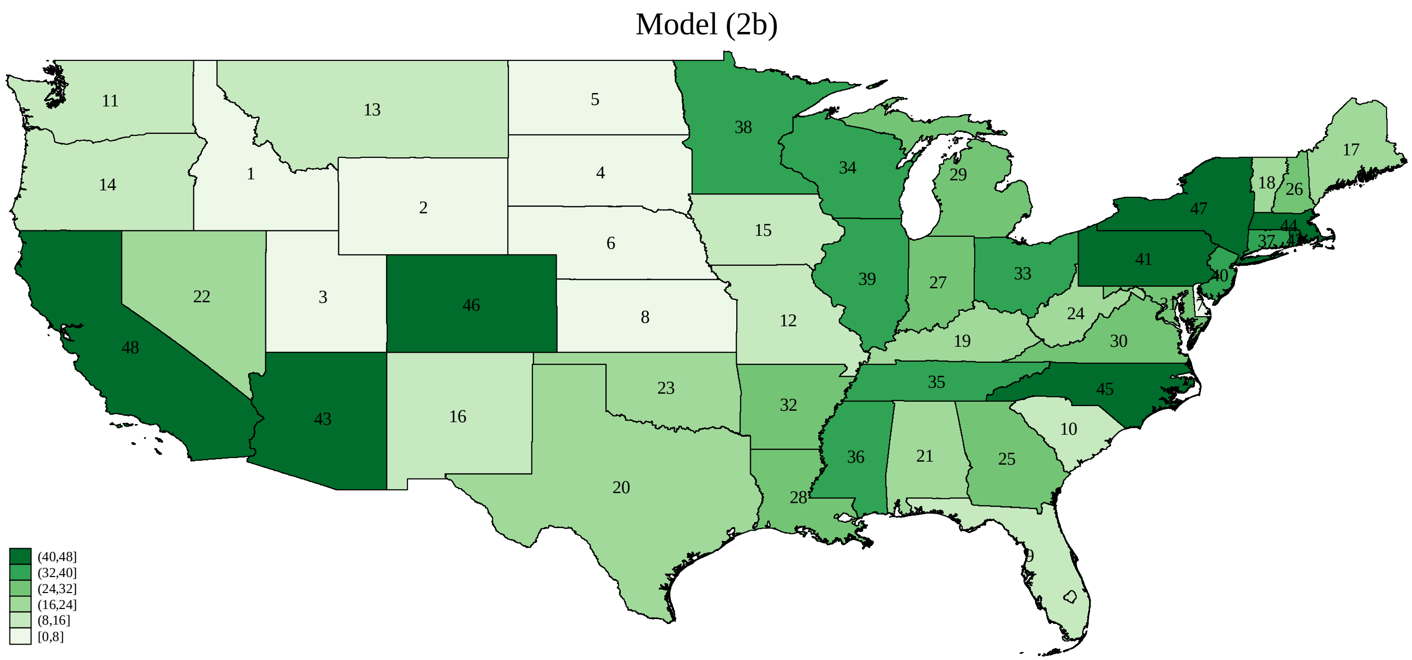


Table 4.11: Government Size and Fiscal Decentralization: A Spatial Perspective (a)

(Total Expenditures)

	Local		State-Local	
logit(Expenditure Share)	(1)	(2)	(3)	(4)
W[logit(Expenditure Share)]	0.751***	1.035***	1.174***	-0.572***
	(0.215)	(0.236)	(0.118)	(0.109)
Counties		-2.387***		-2.007***
		(0.406)		(0.273)
IG Rev Share	0.116*	0.127	0.916***	2.357***
	(0.050)	(0.094)	(0.121)	(0.155)
Income	-0.012***	-0.001	-0.016***	-0.005***
	(0.002)	(0.001)	(0.001)	(0.001)
Population Density	0.000008**	0.000001	0.000014***	0.000028***
	(0.000003)	(0.000007)	(0.000002)	(0.000005)
House Democrats	0.0004	-0.0018***	0.0002	-0.0012***
	(0.0003)	(0.0005)	(0.0003)	(0.0003)
Democrat Governor	-0.044	0.363***	-0.041	0.160**
	(0.025)	(0.081)	(0.024)	(0.054)
Constant	-0.673**	-0.183	-0.074	-2.093***
	(0.247)	(0.402)	(0.085)	(0.140)
W(Error)	0.416***	0.163***	0.472***	0.022
	(0.050)	(0.043)	(0.050)	(0.042)
State Dummies	Yes	No	Yes	No
Year Dummies	Yes	No	Yes	Yes
Observations	864	864	864	864

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4.12: Government Size and Fiscal Decentralization: A Spatial Perspective (b)

(Elementary and Secondary Education Expenditures)

	Local		State-Local	
logit(Expenditure Share)	(1)	(2)	(3)	(4)
W[logit(Expenditure Share)]	1.737***	0.148	1.383***	-0.186
	(0.412)	(0.152)	(0.276)	(0.184)
School Districts		0.401***		0.409***
		(0.045)		(0.046)
IG Expenditure Share	0.019	1.779*	-0.147***	0.113**
	(0.428)	(0.703)	(0.032)	(0.035)
Income	-0.005**	-0.009***	-0.004*	-0.007***
	(0.002)	(0.001)	(0.002)	(0.001)
Population Density	0.000020***	0.000006	0.000022***	0.000009*
	(0.000003)	(0.000004)	(0.000003)	(0.000004)
House Democrats	0.0012***	-0.0001	0.0013***	-0.0004
	(0.0004)	(0.0003)	(0.0004)	(0.0003)
Democrat Governor	-0.044	-0.024	-0.040	-0.010
	(0.031)	(0.048)	(0.031)	(0.049)
Constant	0.212	-2.446***	-0.268	-3.341***
	(0.723)	(0.363)	(0.502)	(0.424)
W(Error)	0.435***	0.198***	0.413***	0.233***
	(0.047)	(0.048)	(0.049)	(0.048)
State Dummies	Yes	No	Yes	No
Year Dummies	Yes	Yes	Yes	Yes
Observations	864	864	864	864

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4.13: Government Size and Fiscal Decentralization: A Spatial Perspective (c) (Police Protection Expenditures)

	Local		State-Local	
logit(Expenditure Share)	(1)	(2)	(3)	(4)
W[logit(Expenditure Share)]	0.179	-1.056***	-0.085	-0.264
	(0.115)	(0.157)	(0.145)	(0.146)
Counties		-6.931***		-5.539***
		(0.470)		(0.376)
IG Expenditure Share	1.493	-25.507*	0.046	-0.499**
	(3.670)	(12.892)	(0.154)	(0.180)
Income	-0.023***	0.012***	-0.017***	0.007***
	(0.002)	(0.001)	(0.002)	(0.001)
Population Density	0.000012***	-0.00002**	0.000013***	-0.00001*
	(0.000003)	(0.00001)	(0.000003)	(0.00001)
House Democrats	0.0006	-0.002**	0.0004	-0.0011**
	(0.0003)	(0.001)	(0.0003)	(0.0004)
Democrat Governor	-0.039	-0.121	-0.041	-0.086
	(0.029)	(0.092)	(0.028)	(0.072)
Constant	-3.285***	-9.437***	-4.547***	-6.054***
	(0.547)	(0.618)	(0.726)	(0.552)
W(Error)	0.057	0.265***	-0.027	0.262***
	(0.072)	(0.047)	(0.065)	(0.048)
State Dummies	Yes	No	Yes	No
Year Dummies	Yes	No	Yes	No
Observations	864	864	864	864

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4.14: Government Size and Fiscal Decentralization: A Spatial Perspective (d) (State-Local Highway Expenditures)

	State-Local	
logit(Expenditure Share)	(1)	(2)
W[logit(Expenditure Share)]	0.516**	0.165**
	(0.180)	(0.055)
Counties		6.915***
		(0.432)
IG Expenditure Share	-0.619***	-0.452***
	(0.112)	(0.080)
Income	-0.014***	-0.030***
	(0.003)	(0.002)
Population Density	0.00001	-0.00001
	(0.00001)	(0.00001)
House Democrats	-0.0002	-0.004***
	(0.0006)	(0.001)
Democrat Governor	-0.069	-0.163
	(0.054)	(0.092)
Constant	-0.492	-2.411***
	(0.781)	(0.213)
W(Error)	-0.095	0.064
	(0.053)	(0.055)
State Dummies	Yes	No
Year Dummies	Yes	Yes
Observations	864	864

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4.15: Government Size and Fiscal Decentralization: A Spatial Perspective (e) (State-Local Public Welfare Expenditures)

	State-Local	
logit(Expenditure Share)	(1)	(2)
W[logit(Expenditure Share)]	-0.006	-0.414***
	(0.151)	(0.113)
Counties		0.223
		(0.497)
IG Expenditure Share	-0.659***	0.340***
	(0.101)	(0.067)
Income	-0.024***	-0.032***
	(0.003)	(0.002)
Population Density	0.000004	0.00001
	(0.000005)	(0.00001)
House Democrats	-0.002**	0.005***
	(0.001)	(0.001)
Democrat Governor	0.087	0.124
	(0.053)	(0.092)
Constant	-2.704***	-3.612***
	(0.493)	(0.213)
W(Error)	0.081	0.480***
	(0.055)	(0.047)
State Dummies	Yes	No
Year Dummies	Yes	Yes
Observations	864	864

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4.16: Government Efficiency and Fiscal Decentralization: Stochastic Frontier and Spatial Analysis (a)

(State-Local Highway Expenditures)

Cost Efficiency	(1) Model (1a)	(2) Model (1a)	(3) Model (1b)	(4) Model (2b)	(5) Model (3b)
W(Cost Efficiency)	0.497	0.446	0.774***	0.735**	-0.053
	(0.278)	(0.327)	(0.197)	(0.268)	(0.217)
Counties		-0.160			
		(0.144)			
IG Expenditure Share	-0.431***	-0.100**			
	(0.077)	(0.031)			
Income	-0.0007	0.0001			
	(0.0005)	(0.0004)			
Population Density	0.000004	0.000005			
	(0.000004)	(0.000003)			
House Democrats	-0.0007*	-0.0001			
	(0.0004)	(0.0002)			
Dem Governor	-0.056	-0.029			
	(0.038)	(0.032)			
Constant	0.615	0.616	0.264	0.292	6.609***
	(0.314)	(0.373)	(0.218)	(0.300)	(0.495)
W(Error)	-0.007	-0.035	-0.007	-0.018	0.541***
	(0.052)	(0.053)	(0.052)	(0.053)	(0.046)
State Dummies	Yes	No	Yes	Yes	Yes
Year Dummies	No	No	No	No	Yes
Observations	864	864	864	864	864

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4.17: Government Efficiency and Fiscal Decentralization: Stochastic Frontier and Spatial Analysis (b)

(State-Local Public Welfare Expenditures)

Cost Efficiency	(1) Model (1a)	(2) Model (1a)	(3) Model (2b)
W(Cost Efficiency)	0.049	-0.273	0.275***
	(0.228)	(0.493)	(0.075)
Counties		-0.029	
		(0.016)	
IG Expenditure Share	-0.039***	-0.004	
	(0.008)	(0.003)	
Income	-0.0001*	-0.00004	
	(0.0001)	(0.00004)	
Population Density	0.00000004	0.0000001	
	(0.00000043)	(0.0000003)	
House Democrats	-0.00015***	-0.00003	
	(0.00004)	(0.00002)	
Democrat Governor	0.005	0.004	
	(0.004)	(0.003)	
Constant	0.995***	1.305**	1.242***
	(0.222)	(0.479)	(0.111)
W(Error)	0.062	0.064	0.016
	(0.049)	(0.049)	(0.054)
State Dummies	Yes	No	Yes
Year Dummies	No	No	No
Observations	864	864	864

Notes: (1) Standard errors in parentheses. (2) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Chapter 5 Conclusion

This dissertation examines multiple state and local expenditure categories in the United States to expand understanding of fiscal federalism and spatial interactions among governments. Chapter 2 serves as a less technical introduction to the data and describes a few stylized facts about government expenditures on elementary and secondary education, police protection, highways, and public welfare. Chapter 2 first exhibits the trends of the US state and local government expenditures between 1977 and 2008. Despite that their budget shares did not change much, government expenditures in all the four categories grew substantially over the past thirty-two years, in both nominal and real terms. Most state governments were not responsible for financing elementary and secondary education until 1982. Although elementary and secondary education remains a primary function of local governments, state government had made up more than one third of the total spending in this category in 2008. Most expenditures on police protection are spent by local governments. Police protection and highways are two categories in which the shares between state and local governments stayed stable over the thirty-two years. Highway expenditures, however, are mainly allocated by state governments. Public welfare expenditures grew fast at the state level, with more responsibility shifted from the federal government. At the local level, the trend in public welfare expenditures has been flat or even declining, with inflation taken into account. Chapter 2 also uses Kentucky and its neighboring states to illustrate spatial correlation in government expenditures. According to the results, Kentucky's government expenditures are positively correlated with its average neighbor in each category examined.

Chapter 3 focuses on police protection expenditures and its interactions with crime rates. In the literature on the relationship between police resources and crime rates, there is less empirical evidence of "more police, less crime" than that of "more crime, more police". To deal with endogeneity, two instrumental variables, the fatality rate and the incarceration rate, are proposed, respectively, for police expenditures and crime rates in single equations as well as in simultaneous systems. The results based on the instrumental-variable approach support the intuition of both "more police, less crime" and "more crime, more police". Furthermore, bringing two literatures together, this chapter examines the relationship between police and crime from a spatial perspective. Specifically, it seeks the answers to whether police expenditures or crime rates in a state are affected by police expenditures or by crime rates of neighboring states. Police expenditures and crime rates are both found exhibiting positive and significant spatial autocorrelation. Meanwhile, it is shown that crime rates significantly decline in a state, if neighboring states spend more on police protection. This across-border deterrence effect is an indication of positive externalities. Last, crime rates of neighboring states, as the coefficient estimate is statistically insignificant, do not seem considered as a factor in determining police expenditures in the surrounded state. The results call attention to spatial spillover effects that may be overlooked in policy decision-making.

Chapter 4 examines government expenditures on elementary and secondary education, police protection, highways, and public welfare. The goal of this chapter is to search for a better model specification to test the Leviathan hypothesis. First, in spirit of the original approach but with panel data, the inverse relationship between the expenditure share in personal income and the number of local jurisdictions is tested. Affirmative evidence is found in total expenditures and police protection expenditures. Second, taking the Leviathan hypothesis more seriously, cost efficiency in government spending is estimated by various stochastic cost frontier models with the number of local jurisdictions being an environmental factor. No direct relationship between cost efficiency and the number of local jurisdictions is found, given a limited number of successfully estimated models. Third, the original setup is reexamined but with government size in neighboring states included to capture the impact of decentralization across states. In local total expenditures, a smaller government size is seen promoted not only by more competing local governments within a state, but also by neighboring states that similarly have smaller public sectors. Finally, techniques in both stochastic frontier analysis and spatial econometrics are combined to test whether cost efficiency in government spending exhibits positive correlation with itself across state borders and with the number of local jurisdictions. In two models supplementary to Geys (2006), similar positive spatial autocorrelation in cost efficiency is found in state-local highway and welfare expenditures.

Despite different focuses, both Chapters 3 and 4 examine government expenditures and their outcomes. Chapter 3 has to do with police protection expenditures and crime rates. In terms of reflecting police productivity, crime rates prevented might be a better measure than crime rates reported. The data on prevented crime, however, are often unobservable. Whereas crime clear-up rates are used instead in some studies (e.g., Barros and Alves, 2005), the data on this measure are not available for most US states and counties. Since crime rates reported are not an direct output of police expenditures, they are not brought to stochastic frontier estimation in Chapter 4. Nevertheless, the question of how fiscal decentralization affects cost efficiency in police spending is important too. Government expenditures and their outcomes covered in Chapter 4, e.g., elementary and secondary education expenditures and high school graduation rates, may be explored in the framework developed in Chapter 3. The main challenge, as with police expenditures and crime rates, would be finding proper instrumental variables to tackle simultaneity. Hanushek (1989), for example, finds that education resources, e.g., class size, teachers' educational background, do not have significant or systematic effects on student performance. Given that simultaneity is properly handled, spatial interactions among expenditure categories, among expenditure outcomes, and between one expenditure category and the outcome of another expenditure category are ready to be investigated in a larger simultaneous system.

The findings in the previous chapters have several implications for policy-making in a federalist system. First, before reaching a decision, policy makers should evaluate how a policy would affect their neighbors, and, more importantly, how their neighbors would react to it. A policy design overlooking potential spillover effects across jurisdictions may end up with reduced effectiveness and unintended consequences. Second, to inefficiency problems resulting from externalities, coordination is a standard solution. Coordination may come from a higher level of government. For example, the federal government founded the Community Oriented Policing Services (COPS) program, aiming to equalize state and local police services. It is also possible that a cooperative mechanism is established by governments at the same level to internalize externalities. For example, Maryland started dialogues with Virginia and

Washington, DC in 2008 on sharing information about violent offenders[1]. Nowadays, this partnership has been extended to more neighboring states, including Delaware, New York, and Pennsylvania[2]. Third, policy makers should not only recognize the role of the federal government, for example, in policy coordination and efficiency restoration, but also be aware of enhancement in efficiency and accountability that results from policy experimentation and diffusion among competing states. When intergovernmental competition is welfare-enhancing is an important question, both theoretically and empirically. Despite not offering a simple answers to this question, spatial analysis in this dissertation should help to widen the perspective on policy making.

As spatial interaction is likely to be stronger at the local level than at the state level, the developed analytical framework is expected to be applied to local-level data in future work to verify the results in this dissertation as well as to search for new findings. Spatial impacts can also been more accurately estimated with more proper measures for both dependent and independent variables. For example, as discussed previously, a time-variant measure for the degree of intergovernmental competition within a state is in need. Besides, the more relevant the output measures of government expenditures, the greater odds of successfully estimating an stochastic frontier model. The search for appropriate output measures, especially of police expenditures, is on the to-do list as well for future work. Last, as a commonly used tool in policy analysis, especially in macroeconomic contexts, impulse-response functions help to understand the dynamic relationship between two variables of interest, e.g., crime rates at home and police expenditures of neighbors. In future work, impulse-response

[1] "Md., Del. to Share Crime Information," *The Baltimore Sun*, August 18, 2011.

[2] "Maryland, Nearby States Sharing More Crime Data." *The Gazette*, June 25, 2012.

analysis is to be conducted to reveal more policy implications.

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Vita

Fields of Concentration:

Public Economics, Regional and Urban Economics, Applied Spatial Econometrics

Education:

MA, University of Mississippi 2007

MA, Southwestern University of Finance and Economics 2004

BA, Southwestern University of Finance and Economics 2001

Teaching and Research Experience:

Instructor of Record, Department of Economics, University of Kentucky Fall, 2008–Spring, 2010; Fall 2011–Spring, 2012

Research Assistant, Martin School of Public Policy and Administration, University of Kentucky Fall, 2010–Spring, 2011

Teaching Assistant, Department of Economics, University of Kentucky Fall, 2007–Spring, 2009

Teaching Assistant, Department of Economics, University of Mississippi Fall, 2005–Spring, 2007

Awards:

Teaching Assistantship, University of Kentucky 2007–2012

Graduate School Intuition Scholarship, University of Kentucky 2007–2012

Max Steckler Fellowship, University of Kentucky 2007

Teaching Assistantship, University of Mississippi 2005–2007

Graduate School Intuition Scholarship, University of Mississippi 2005–2007

Professional Affiliations:

American Economic Association

Southern Economic Association

Kentucky Economic Association