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Spatial Analysis of Local Government Fiscal Condition in Nebraska[1]

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Abstract

Many state governments, local officials, academics and even policy advocacy organizations continue to seek models and approaches that will help them assess the probability of municipal financial distress and crisis as we face an uncertain future. Local communities meet challenges where important decisions will need to be made about how to efficiently and effectively allocate scarce public resources with limited capacity. This research aims at examining the spatial patterns of local governments' fiscal condition. It provides the analysis of municipal fiscal condition based on spatial patterns, more specifically, the proximity of a municipality to the urban centers of Omaha and Lincoln, Nebraska.

Keywords: fiscal condition, spatial analysis, spread-backwash effect.

Introduction

The Great Recession of 2007-09 left scars across the landscape of local governments in the United States. In addition to high-profile bankruptcy filings in Detroit, Michigan and Harrisburg, Pennsylvania, many local governments declared fiscal emergencies, cut spending, and laid off or furloughed workers (Gorina, Maher, and Joffe, 2018). Even today, the state and local government sector remains below where it was relative to 2007 employment. Against this backdrop, many state governments, local officials, academics and even policy advocacy organizations (e.g. Pew) continue to seek models and approaches that will help them assess the probability of municipal financial distress and crisis as we face the uncertain future. Local officials play a critical role in making decisions about local finances – both expenditures and revenues – that have significant economic, social, and environmental outcomes for communities.

In Nebraska, economic and demographic changes are creating new challenges for local governments across the urban-rural continuum. Urban communities are becoming popular places to live (Ehrenhalt, 2012), but continue to struggle with the costs of congestion and service needs. Maher, Park, and Park (2016) show that compared to other regions in the state, Nebraska's rural areas have the highest proportion of population over the age of 65, the lowest percentage of population with a college degree, lower household median income, and higher unemployment rates. In addition, according to the Federal Reserve Bank of Kansas City (2016), Nebraska's overall economy is masking an important divergence between the urban and rural regions. Since 2012-13, Nebraska's farm economy has faced significant drops in crop prices, farm income and value in livestock and meat exports (Federal Reserve Bank of Kansas City, 2016). Thus, local communities are left in a precarious position where important decisions will need to be made about how to efficiently and effectively allocate scarce public resources with limited capacity.

This study offers an analysis of municipal fiscal condition based on spatial patterns, more specifically, the proximity of a municipality to the

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urban centers of Omaha and Lincoln, Nebraska. The design combines fiscal condition literature, regional planning scholarship and environmental resilience work. The paper follows with a literature review, Nebraska context, research design, methodology, findings, and conclusions.

Literature Review

This research aims at examining the spatial patterns of local governments' fiscal condition. The literature on resilience, fiscal health, and spread-backwash effects can contribute to the discussion of the research topic and are discussed in this section. The concept of resilience is getting more and more attention in the public sector, especially after the Great Recession. Governments at all levels are expected to be resilient to weather fiscal distress and economic downturns. The term "resilience" has been widely used in ecology since the 1970s. Holling (1973) defines resilience as the ability of a system to absorb changes and persist. Allen and his colleagues (2016) offer a dynamic systems approach to assessing resilience of midsize cities in the U.S. They describe resilience in terms of the degree of "disturbance a system can withstand without losing essential structure and functioning" and assert that "[a] resilient state can be assessed by measuring a set of key processes and structures within and across relevant domains of scale."

While the principal focus of Allen et al.'s study is ecological and environmental (water, in particular), the discussion of resilience and system modeling includes socio-economic and governance subsystems. In recent years, the concept of resilience has been introduced to other fields, such as emergency management (McCreight, 2010), organizational studies (McCarthy, Collard, and Johnson, 2017), and regional studies and economics (Simmie and Martin, 2010; Bristow and Healy, 2014; Boschma, 2015). Simmie and Martin (2010) suggest that in the fields of regional studies and economics, the broad definition of regional economic resilience was "the ability of a region to anticipate, prepare for, respond to, and recover from a disturbance." However, there are two competing thoughts which have different definitions in detail. The first one is derived from engineering resilience, which focuses on the stability of a system after a disturbance. Under this definition, an economy is expected to retain its function and structure after a disturbance. The second one is derived from ecological resilience. Under this definition, an economy is expected to make changes to its function and structure in order to respond to the disturbance and sustain. Although these two thoughts both agree with the idea of resilience, they have very different perspectives on organizational changes.

In order to make local governments more resilient, it is necessary to assess their fiscal condition. Since the 1970s, there has been a burgeoning literature on the measurement and examination of municipal fiscal condition. The New York City fiscal crisis of the 1970s was the origin of much of the literature on fiscal condition. In the 1980s and 1990s, researchers began using existing data to develop classification models used to identify fiscal condition with the expectation that it would help prevent future fiscal distress. Brown's (1993) ten-point test is an exemplar of this approach. Other examples of this approach include Groves, Godsey, and Shulman (1981), Honadle and Lloyd-Jones (1998), Kleine, Kloha, and Weissert (2003), Kloha, Weissert, and Kleine (2005a and 2005b), and Mead (2006). Typically, these models have used a mixture of economic, demographic and fiscal variables to classify a government's fiscal condition. These models do not use a predictive approach in the sense of having dependent and independent variables and a statistical model. Rather, they use a set of multidimensional indices that include a series of economic and fiscal variables. The municipalities are given a score on the index and then classified as fiscally distressed or not. However, Hendrick (2004) and Clark (2015) both suggest that different indicators of fiscal condition should not be assigned the same weight and should be examined separately in order to construct a more accurate picture of fiscal condition.

The spread-backwash effects may provide a germane theoretical background for this research. The main focus of the spread-backwash effects is the extent to which urban growth helps or hurts surrounding suburban and rural communities. The concept was developed by Myrdal in 1957. Spread effects could be found when positive externalities are realized for rural communities as economic opportunities generated by urban centers expand outward. Conversely, backwash effects could be found when migration flows from rural to urban areas, causing a weakening of the labor force in rural areas. Hirschman (1958) develops a similar framework called the trickling down-polarization effects. A more developed region might have trickling-down effects on a less developed region if its growth helped the less developed region. On the contrary, if a more developed region's growth hurts and isolates a less developed region, it might result in polarization effects.

Whether spread effects exceed backwash effects in urban growth has been long debated since the 1950s, when the frameworks were first proposed.

Myrdal (1957) suggests that negative (backwash) effects might dominate. Hirschman (1958) believes that even though negative (polarization) effects might be seen in the short run, positive (trickling down) effects might be seen in the long run. Different empirical studies have different findings of the spread-backwash effects. Ganning, Baylis, and Lee (2013, p. 465) conclude that most research found more spread than backwash effects of urban growth on rural communities. Gaile (1979, 1980) suggests that spread versus backwash effects should not be dichotomous, but spread effects might be smaller than backwash effects in general. Barkley, Henry, and Bao (1996) also find that backwash effects dominated in rural areas.

Ganning et al. (2013) find that not until the late-1980s did empirical studies on the spread and backwash effects emerge. They suggest that the spread and backwash effects are typically "measured in the context of population change or income change as a function of distance to and growth in the nearest city." Researchers, such as Gaile (1979) and Boarnet (1994), develop several spatial models to examine the spread and backwash effects. Pandey, Pasternack, Majumder, Soupir, and Kaiser (2015) develop a neighborhood statistics model to examine the instream bacteria level in Iowa. This model took the influence of neighboring cites into consideration and might be fruitful for this research. We further discuss the model in the methodology section.

We can conclude some key points from the existing literature on resilience, fiscal health, and spread-backwash effects. First, the literature on resilience agrees that resilience is an entity's ability to weather a disturbance. The concept of resilience can be introduced to the field of public budgeting and finance to examine whether governments can withstand fiscal distress and sustain over time. Second, the literature on fiscal health shows that the concept of fiscal condition is complicated and even defining it requires careful attention. There were many issues in assessing how the various fiscal and economic variables fit together to tell the complete story of fiscal condition. We may need to be careful when we select indicators of fiscal condition for this research. However, over time, knowledge has been gained regarding the types of variables that may be important for the measurement of fiscal condition and they include fiscal, economic, and demographic variables. Last but not least, the literature on spread-backwash effects suggests that urban growth has both positive and negative effects on suburban and rural areas. It is highly debated whether positive effects outweigh negative effects or not. Spread-backwash effects are usually measured by population change and income change. In this research, we would like to expand the discussion to local governments' fiscal condition. We would like to know whether spread-backwash effects can be found in terms of fiscal condition.

Generally speaking, we find that the concepts of resilience and spread-backwash effects can be introduced to the field of public budgeting and finance, especially the research on fiscal condition. There are some issues suggested by the existing literature that need to be taken into consideration by this research. First, there are state and/or regional-specific attributes that need greater consideration, for instance, different revenue structures (cities in North Dakota are quite different from cities in Nebraska due to oil reserves) and/or different revenue-raising limitations imposed by states. The second point is the disconnection between financial conditional analysis offered by academics and policy advocates, and data availability for smaller communities (those with a population less than 10,000). Most of the literature is based on comprehensive annual financial reports (CAFRs) that are only completed for larger government entities. Most municipalities in Nebraska are far too small to have CAFRs and thus their financial condition cannot be examined using this body of literature. Last but not least, the general concept of fiscal distress employed in the literature is that a local government is facing a situation where its ability to pay upcoming financial commitments is at threat. This suggests that short-term metrics are more valuable than long-term measures which makes the current data collected by the Nebraska State and Local Finance Lab highly applicable for this endeavor.

The Nebraska Context

Nebraska is a microcosm of a worldwide trend that has been occurring for centuries, but seems to have ramped up in the past couple of decades – population migration from rural areas to urban centers. In 2010, Nebraska's three urban counties (Douglas, Lancaster, and Sarpy) comprised 52.6 percent on the state's 1.8 million population. The U.S. Census Bureau projects that in 2050, those same three counties will be home to nearly two-thirds (66.4 percent) of the state's 2.3 million inhabitants (Drozd and Deichert, 2015). This means that while the state's population is projected to grow 24.3 percent between 2010 and 2050, the three urban counties are expected to grow 57.1 percent, whereas the remaining counties are expecting a 12 percentage point population decline during this period. In addition, the composition of the population is "graying" more rapidly for the rural counties compared to the three urban counties. In 2010, 10.4 percent of population in the three urban counties was age 65 or older; by 2050, the share is projected to grow to 16.8 percent. During the same period for the remaining 90 Nebraska counties, the percentage of the population age 65 or older is expected to jump from 17.0 percent to 28.2 percent.

Research Design

We examine the fiscal data of 69 municipalities in Nebraska that are in the Omaha-Council Bluffs Metropolitan Statistical Area (hereinafter, the Omaha MSA) and the Lincoln-Beatrice MSA (hereinafter, the Lincoln MSA) from 2001 to 2016. The fiscal data are collected by the office of the Nebraska Auditor of Public Accounts. These data are uniformly reported by all forms of local governments and consist of property valuation, revenues, expenditures, net cash balances and debt. For our purposes, these are the most useful data since most Nebraska municipalities are too small to produce a CAFR (the median sized Nebraska municipality has a population of 314). The downside of these data is that they are self-reported and presented on a cash-basis.

The data analysis focuses on the fiscal condition of municipalities and their proximity to the two urban centers in Nebraska, Omaha and Lincoln. There are several key variable choices that must be made in undertaking this study. One question is related to long-term versus short-term fiscal condition. While there is no doubt that measures of long-term solvency are important, we mostly focus on short-term fiscal condition given the availability of data for this project. However, we do include one measure of long-term fiscal condition: debt. This ties into the recent interest in state abilities to prevent an acute fiscal crisis and the interest in municipal bankruptcy where the test for entry into the process is based on liquidity. The other choice is related to the approach of using a single variable as opposed to an index to identify and measure fiscal condition. Other researchers have typically used an index of variables to identify fiscal condition. However, using an index might be problematic since different variables might be assigned the same weight and some less important variables might be included. Thus, we have decided to examine multiple variables separately instead of constructing an index.

And then, the next step is variable selection. Based on the literature (Brown, 1993; Kloha et al., 2005a), we select a set of variables as the indicators of fiscal condition, including: general expenditures, general revenues, property taxes, net cash balances, and debt service. The five indicators used as the dependent variables are:

- General revenues-general expenditures ratio;
- Debt per capita;
- Debt-property valuation ratio;
- Net cash balances-general expenditures ratio;
- Property taxes-general revenues ratio.

The key independent variable of this research is the municipalities' proximity to the Nebraska urban centers of Omaha or Lincoln, which is measured by the municipalities' distance to the urban centers on Google Map. If a municipality belongs to the Omaha MSA, we measure its distance to Omaha. Conversely, if a municipality belongs to the Lincoln MSA, we then measure its distance to Lincoln. Other independent variables reflect economic, demographic and institutional constructs. Economic variables are the first in line. In some cases, a decline in population or tax base (e.g. property valuation) may be a good predictor of municipal fiscal condition. The Nebraska State and Local Finance Lab database has already built in the following key independent variables for years 2001 to 2016: population[2], median household income, percent of white population, percent of population with a bachelor's degree or higher, and unemployment rate. Two control variables are included in our models. The first one is a dummy variable "Lincoln MSA." If a municipality belongs to the Lincoln MSA, we code it as 1, otherwise 0. The second one is "year." The neighborhood statistics models examine the trends of the indicators over time. The multiple regression models control the years that are viewed as recessions (2001, 2002, 2007, 2008, and 2009) to see if these years matter.

Key questions in this analysis are magnitude and timeliness. Fiscal condition has often been operationalized as a specific quantitative drop in a particular measure over a specific period of time. Given the diversity of choices made previously, the approach used here will be to test various manifestations of these variables in terms of magnitude and timing. For example, does a five percent decrease in fund balance or current ratio indicate poor fiscal condition? A variety of magnitude and timing approaches will be tested once the data are collected to determine the viability of various options including percent changes, baseline changes and other permutations. This is in part the reason to take advantage of the large amount of data already collected by the Nebraska State and Local Finance Lab.

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[2] Population and property value are highly correlated (correlation coefficient = 0.9852). To deal with the problem of multicollinearity, we drop the independent variable "property value."

Research objectives

The study set out to assess the spatial relationship between proximity to the urban centers and municipal fiscal condition using five measures: revenues/expenditures; debt per capita; debt/property valuation; cash reserve/expenditures and property tax/revenues. We employ a spatial neighborhood statistics model, the Markov Random Field model, to assess our central hypotheses that the further the distance from the urban center, the weaker the municipality's fiscal condition. The study is prepared according to the procedure used by Pandey et al. (2015) and tested on 69 Nebraska municipalities over a 16-year time period. We also use this panel data to run multiple regression models for the 5 indicators to ensure the robustness of this study.

There are three primary aims of this study: (1) observe and analyze how five indicators vary over a 16-year time period and 69 municipalities in relation to the google distance between each municipality and its corresponding urban center, population, median household income, ethnicity (% white population relative to total population), educational attainment (% population with bachelor's degree or over relative to population aged over 25), unemployment rate (% unemployed population relative to total labor force), area (Omaha or Lincoln MSA); (2) compare the five indicators between Omaha and Lincoln MSAs and; (3) develop and measure the predictive proficiency of the neighborhood statistics model.

Methodology

This research examines all 69 Nebraska municipalities in the Omaha MSA and the Lincoln MSA. The Omaha MSA consists of five counties in Nebraska (Cass, Douglas, Sarpy, Saunders, and Washington) and three counties in Iowa. We only include the 46 municipalities in the five Nebraska counties (numbered 1 to 46). The Lincoln MSA consists of two counties in Nebraska (Lancaster and Seward). There are 23 municipalities in these two counties (numbered 47 to 69). (Locations of the 69 municipalities, please see Appendix 1.)

To begin this process of observing and analyzing the five indicators, we performed a comparative analysis of the five indicators and eight covariates that were collected for the 69 municipalities locations over a 16-year time period. To assess the proficiency of the neighborhood statistics model, the Mann-Whitney U test, a non-parametric test, is utilized. The Mann-Whitney U test enables us to compare the five indicators across all sites of the eight covariates at each time; Pearson correlation coefficients are estimated to relate the indicators among sampling locations. The next phase of the analysis is developing a neighborhood statistics model to assess the strength of relationship between location and municipal fiscal condition.

Neighborhood Statistics Model:

For this study, we develop a neighborhood statistics model for the 69 municipalities (M=69) over 16 years (T=16). The model was developed by Pandey et al. (2015) to predict the spatial and temporal patterns of instream *E. coli* bacteria levels. We generally follow Pandey et al.'s path to formulate the model. In Equation 1, is a random variable, and $S_i \equiv (l, t)$ where l is the sample municipality (1 to M), and t is the sample year (1 to T). Thus, we have $l = M * T = 1{,}104$ samples.

$$\mathbf{Y} \equiv \{Y(S_i) : \mathbf{i} = \mathbf{1}, ..., l\} \\ = \{Y(l, t) : l = 1, ... M, t = 1, ...T\} \quad (1)$$

Suppose that five indicators' temporal distributions are independent in time. We develop the neighborhood structures, which are shown in Appendix 2. Municipalities with google distance less than 15 miles are defined as neighbors. For example, location 2 (Arlington, NE) has two neighbors: location 19 (Kennard, NE) and location 42 (Washington, NE), since the distance between Arlington, NE and Kennard, NE is 9.36 miles, and the distance between Arlington, NE and Washington, NE is 13.13 miles.

Suppose that the five indicators measurements are also independent in time. We could define neighbors of $Y(S_i)$ as:

$$N_i \equiv \{S_j : \delta_{ij} < 15\} \quad (2)$$

where $\delta_{ij} = D(S_i, S_j)$, D stands for google distance $\delta_{ij} < 15$. Then

$$[Y(S_i)|\{Y(S_j) : j \neq i\}] = [Y(S_i)|\ Y(N_i)] \quad (3)$$

For $i = 1,2,...n(1104)$. Let $Y(S_i)$ have conditional density

$$f(Y(S_\downarrow i)|Y(N_\downarrow i) = Gua(\mu_\downarrow i, y^\uparrow 2)f \quad (4)$$

where

$$C_{ij}(y(S_j)]] - \theta_j \quad (5)$$

subject to $C_{ij} = C_j$ where $\theta = (\theta_1, \theta_2, ..., \theta_n)^T$, $\theta = (\theta)$ is the parameter vector of marginal mean that incorporate the covariates X_k, $k = 1,2, ..., 8$. We used eight covariates: google distance, population, median household income, ethnicity (% white population relative to total population), educational attainment (% population with bachelor's degree or over relative to population aged over 25), unemployment rate (% unemployed population relative to total labor force), area (Omaha or Lincoln metropolitan statistical area). Thus, we have

$$\theta = \beta_0 + \sum_{i=0}^{8} \beta_i X_i = X\beta \quad (6)$$

The joint distribution (Besag, 1974; Cressie, 1993) is:

$$Y \approx Gau\,(\theta; (L - C)^{-1}\, l\gamma^2) \quad (7)$$

where

$$C \equiv [c_{i,j}]_{N\times N} \text{ and } c_{i,j} = 0 \text{ if } j \notin N_i \quad (8)$$

For this model, C has the form

$$C = \eta l_n H \quad (9)$$

where D is a block diagonal matrix of size 11041104, and according to google distance of each municipality's location, the neighborhood structures were developed as each block(size = 16×16). If the locations are neighbor, then defined as 1, otherwise 0.

We apply the maximum likelihood approach to obtain the estimates of these parameters (Kaiser and Nordman, 2012; Kaiser, 2010). The log likelihood function for the above model is:

$$L(\beta, \gamma^2, \eta) = \left(\frac{1}{2}\right) Log(|L - C|) - \left(\frac{N}{2}\right) Log(2\pi\gamma^2) -$$

$$-\left(\frac{1}{2\gamma^2}\right)(y - X\beta)^T(1 - C)(y - X\beta) \quad (10)$$

An advantage of this model specification is that, for any given η, the maximum likelihood estimate (MLE) β and γ^2 are the closed form solutions, which are given by:

$$\hat{\beta} = [X^T(l - C)X]^{-1}[X^T(1 - C)y] \quad (11)$$

$$\hat{\gamma} = \frac{1}{n(y - X\hat{\beta})^T(1 - C)(y - X\hat{\beta})} \quad (12)$$

Once we have MLE of β and γ^2, we can plug these values into Equation 9 to obtain the likelihood for η that gives us MLE for η. Then follow the order of equation number, plugging in our data and calculation output into Equations 11 and 12, we get the estimates of β and γ^2. Based on the maximum likelihood approach described by Kaiser (2010), Cressie (1993), and Besag (1974), we obtain the confidence intervals of the parameters. Appendix 3 presents the values of estimated parameters γ^2, η, β_0, ..., β_8 obtained from the preliminary analysis of the neighborhood statistics models. These values are used for predicting the five indicators at each sampling location.

Results and Findings

In this research, we use the neighborhood statistics models to assess the relationship between our five indicators of municipal fiscal condition and municipalities' proximity to the urban centers of Omaha and Lincoln, NE. In addition, we use the panel data to run several multiple regression models as a robustness check. We find that the neighborhood statistics models and the multiple regression models provide similar results. Those results are presented in Table 1.

In the neighborhood statistics models, our key independent variable – distance between a municipality and its corresponding urban center – is statistically significant in three of our five indicators of fiscal condition. The further a municipality is from the urban centers (Omaha or Lincoln), the lower the revenues-expenditures ratio, debt per capita, and net cash balances-expenditures ratio might be. These indicators are core measures of cash, budgetary and long-term solvency. In the multiple regression models, we also find that distance is negatively significant for the revenues-expenditures ratio and the net cash balances-expenditures ratio, but not significant for debt per capita. In both models, the debt-property valuation ratio is not significant.

Table 1

Results of the Neighborhood Statistics Models and the Multiple Regression Models

	Rev/Exp		Debt per Capita		Debt/Property Value		Net Cash Balance/Exp		Property Tax/ Rev	
	Nbhd	**Reg**	**Nbhd**	**Reg**	**Nbhd**	**Reg**	**Nbhd**	**Reg**	**Nbhd**	**Reg**
Google distance	-	-	-				-	-		-
Population	-		+	+		+	-	-		
Median household income		-	-	+	-				+	
White population			+						-	
Bachelor's degree	+	+	+	+	+	+	+			
Unemployment rate	+	+	+	+				+		
Lincoln MSA	-		-		-		-	-	-	-
Year			+		+		+		-	
Year 2001				-						-
Year 2002				-		-		-		
Year 2007										
Year 2008		-						-		
Year 2009										

Several other independent variables are also significant in both models. Municipalities with larger population may have higher debt per capita and lower net cash balances-expenditures ratio, which may not be good signs for fiscal health. Education is positively associated with revenues-expenditures ratio, debt per capita and debt-property valuation ratio. Unemployment rate is positively associated with revenues-expenditures ratio and debt per capita. Median household income and white population do not have significant influences on the indicators that are consistent across the models.

We also find that municipalities in the Lincoln MSA typically have worse fiscal condition than municipalities in the Omaha MSA. For instance, in both models, municipalities in the Lincoln MSA have lower net cash balances-expenditures ratio and lower property taxes-revenues ratio than municipalities in the Omaha MSA. In the neighborhood statistics models, municipalities in the Lincoln MSA also have lower revenues-expenditures ratio than municipalities in the Omaha MSA. However, interestingly, in the neighborhood statistics models, municipalities in the Lincoln MSA tend to have less debt than their peers in the Omaha MSA.

In the neighborhood statistics models, the control variable "year" is included to examine the time trend. We find that debt per capita, debt-property valuation ratio, and net cash balances-expenditures ratio increase over time, while property tax-revenues ratio decreases over time. In the multiple regression models, we include five dummy variables to examine the effect of the early 2000s recession (2001 and 2002) and the Great Recession (2007, 2008, and 2009). During the early 2000s recession, debt per capita and property tax-revenues ratio were lower in 2001, while debt per capita, debt-property valuation ratio, and net cash balances-expenditures ratio were lower in 2002. During the Great Recession, the revenues-expenditures ratio and the net cash balances-expenditures ratio were lower in 2008.

Conclusions

The analysis offers important findings for policy analysts and from a research design perspective. On the policy side, Nebraska policy makers will be forced to make some difficult decisions as the population continues its migration to the urban centers. As stated earlier, in 2016, the median population of Nebraska's 528 municipalities is 314. It is estimated that by 2050, two-thirds of the state's population will be living in three urban counties, largely comprising the state's two MSAs. Our analysis reveals that even for those municipalities in these MSAs, the further they are from Omaha or Lincoln, the weaker their financial condition (e.g. lower revenues-expenditures ratio and lower net cash balances-expenditures ratio). What should be the state policy? To what extent can these small, rural municipalities afford to provide basic services – protective services, street repairs, utilities, etc., particularly in a state heavily reliant on the property tax?

The analysis also reveals a useful application of natural systems designs to the field of public budgeting and finance. Our neighborhood-based statistical modeling, previously applied to study such things as *E. coli* concentrations in rivers, reveals a robustness in our analysis of municipal fiscal condition. The original intent of this project was to develop a systems approach to the study of the natural environment, the initial phase presented here offers promise.

The study clearly has its limitations, including data availability and generalizability. Regarding the former, we are working with budget data submitted to the State Auditor's office. These data lack the oversight and breadth to which we have grown accustomed when studying audited financial reports. Similarly, the analysis is limited to 69 municipalities in Nebraska, a state with a relatively small population (less than two million) and two population centers that are relatively close to each other. The findings have implications for a handful of similarly-sized states, but not the majority in the United States.

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Spatial Analysis of Local Government Fiscal Condition in Nebraska

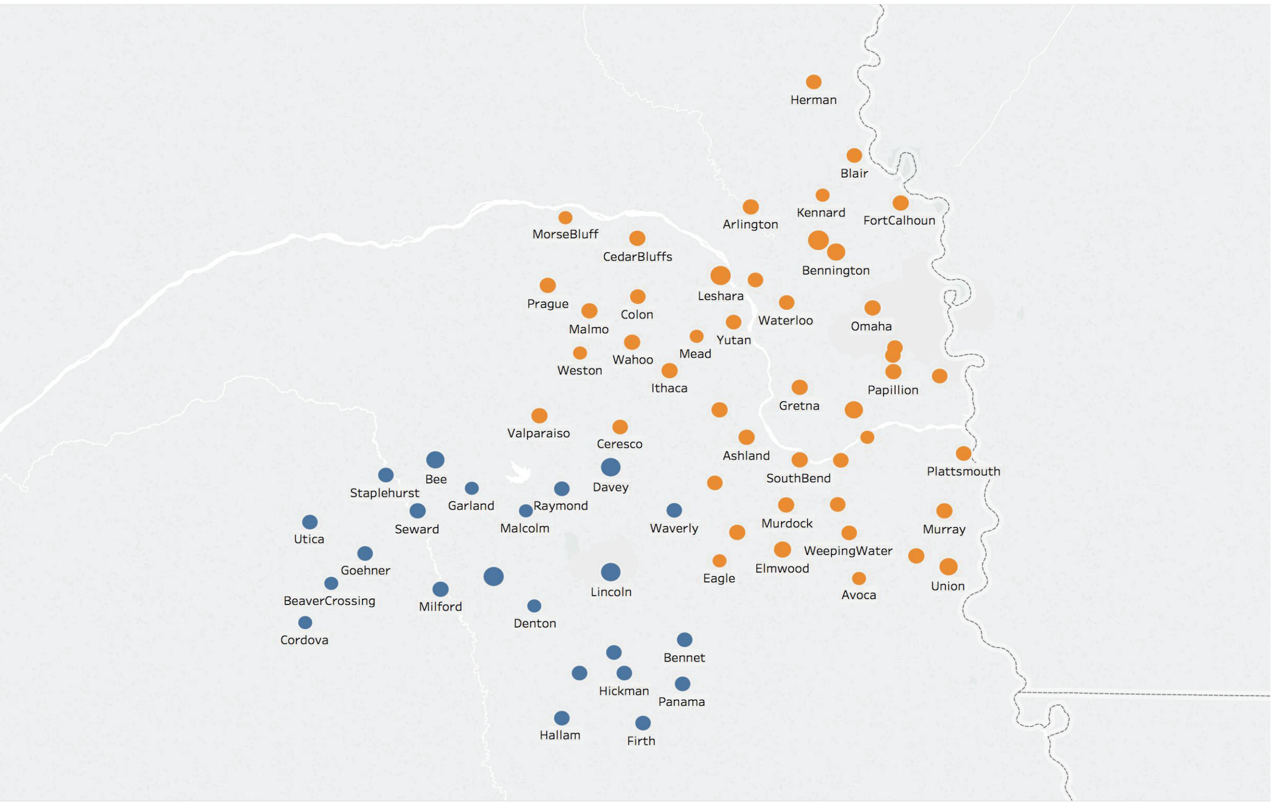
Summary

The effects of urban growth on outlying communities is a long-stand empirical question. Often couched in the concept of spread-backwash effect, Ganning, Baylis and Lee (2013) find that not until the late-1980s did empirical studies on the spread and backwash effects emerge. Most empirical investigations examine this theoretical phenomenon within the context of either population or income change. We propose to consider the spread-backwash effect from the perspective of local government fiscal health. There is a substantial body of research in the public finance literate focusing on government fiscal health/fiscal condition that is applicable and the setting of Nebraska offers a unique case-study. The U.S. state of Nebraska has approximately 1.8 million residents and the state's population is changing (getting older and more diverse), as well as shifting to the urban centers of Omaha and Lincoln. In 1950, two-thirds of the state's population lived outside of the metropolitan counties of Lancaster, Sarpy and Douglas. In 2050, the U.S. Census is projecting the two-thirds of the state's population will reside in these three counties. This is raising a host of challenges and questions that residents and policy-makers are being forced to address.

Methodologically, we propose a spatial neighborhood statistics model, the Markov Random Field model, to assess our central hypotheses that the further the distance from the urban center, the weaker the municipality's fiscal condition. The study is prepared according to the procedure used by Pandey et al. (2015). While the Pandey et al. (2015) research was on E.coli flows through streams, the research design offers a good deal of applicability to this study. We will also run a set of regression models to ensure the robustness of this study. We examined the fiscal data of 69 municipalities in Nebraska that are in the Omaha-Council Bluffs MSA and the Lincoln-Beatrice MSA from 2001 to 2016. The data analysis focuses on the fiscal condition of municipalities and their proximity to the two urban centers in Nebraska, Omaha and Lincoln. The five indicators used as the dependent variables are: general revenues/general expenditures, debt per capita, debt/property valuation, net cash balances/general expenditures and property taxes/general revenues. The key independent variable of this research is the municipalities' proximity to the Nebraska urban centers of Omaha or Lincoln, which is measured by the municipalities' distance to the urban centers on Google Map. Other independent variables will reflect economic, demographic and institutional constructs. Our findings support the backwash effect in that, the further a city is from the urban center, the worse their fiscal condition. More specifically, the greater the distance a city is from Lincoln or Omaha, NE (urban center), the lower the city's revenues to expenditures, the lower its net balance and the lower the city's property tax collections as a percentage of revenues.

Keywords: fiscal condition, spatial analysis, spread-backwash effect.

Appendix 1. Locations of the 69 Municipalities



Appendix 2. Neighborhood Structures of the 69 Municipalities

order	Subdivision	Neighbors	subdivision
1	Alvo	12, 13, 28, 15, 69	Eagle(6.6), Elmwood(6.95), Murdock(9.23), Greenwood(9.53), Waverly(10.83)
2	Arlington	19, 42	Kennard(9.36), Washington(13.13)
3	Ashland	15, 26, 36, 16, 28, 69	Greenwood(6.83), Memphis(6.92), SouthBend(8.09), Gretna(10.93), Murdock(12.08), Waverly(12.39)
4	Avoca	44, 30, 38, 13, 24	WeepingWater(6.20), Nehawka(9.46), Union(11.76), Elmwood(12.31), Manley(12.54)
5	Bellevue	31, 32, 20, 35, 33	Omaha(7.55), Papillion(7.67), LaVista(8.06), Ralston(9.32), Plattsmouth(13.08)
6	Bennington	42, 43, 19, 14	Washington(5.34), Waterloo(11.99), Kennard(12.01), FortCalhoun(13.93)
7	Blair	19, 14, 17, 42	Kennard(6.71), FortCalhoun(9.17), Herman(10.36), Washington(14.18)
8	CedarBluffs	11, 27, 41, 21, 23	Colon(7.69), MorseBluff(11.40), Wahoo(14.06), Leshara(14.11), Malmo(14.76)
9	CedarCreek	22, 37, 24, 36	Louisville(7.65), Springfield(13.47), Manley(13.90), SouthBend(13.97)
10	Ceresco	51, 40, 41, 18, 63	Davey(6.59), Valparaiso(11.39), Wahoo(11.85), Ithaca(12.67), Raymond(14.84)
11	Colon	41, 8, 23, 25, 21, 34, 18, 45	Wahoo(6.75), CedarBluffs(7.57), Malmo(9.96), Mead(10.79), Leshara(11.64), Prague(11.79), Ithaca(12.73), Weston(14.67)
12	Eagle	1, 13, 69, 58, 49	Alvo(6.60), Elmwood(9.41), Waverly(12.78), Lincoln(14.50), Bennet(14.93)
13	Elmwood	28, 1, 12, 24, 4, 36, 44	Murdock(6.27), Alvo(6.95), Eagle(9.43), Manley(12.17), Avoca(12.30), SouthBend(13.41), WeepingWater(14.22)
14	FortCalhoun	7, 19, 6	Blair(9.16), Kennard(10.18), Bennington(13.94)
15	Greenwood	69, 3, 1, 28, 26, 36	Waverly(5.55), Ashland(6.84), Alvo(9.53), Murdock(11.86), Memphis(13.75), SouthBend(13.99)
16	Gretna	37, 3, 32, 43, 20, 35, 36	Springfield(10.48), Ashland(10.95), Papillion(12.19), Waterloo(12.87), LaVista(13.60), Ralston(13.90), SouthBend(14.01)
17	Herman	7	Blair(10.36)
18	Ithaca	25, 41, 26, 10, 11, 46	Mead(7.91), Wahoo(10.04), Memphis(10.62), Ceresco(12.66), Colon(12.73), Yutan(13.25)
19	Kennard	7, 42, 2, 14, 6	Blair(6.71), Washington(8.02), Arlington(9.43), FortCalhoun(10.18), Bennington(12.07)
20	LaVista	35, 32, 5, 31, 37, 16	Ralston(1.47), Papillion(2.59), Bellevue(8.03), Omaha(10.84), Springfield(12.88), Gretna(13.39)
21	Leshara	39, 46, 43, 25, 11, 8	Valley(5.77), Yutan(7.45), Waterloo(10.25), Mead(11.63), Colon(11.64), CedarBluffs(14.00)
22	Louisville	37, 24, 36, 9, 44, 28	Springfield(5.82), Manley(7.19), SouthBend(7.26), CedarCreek(7.65), WeepingWater(12.15), Murdock(13.14)
23	Malmo	45, 34, 41, 11, 8, 27	Weston(6.96), Prague(8.06), Wahoo(9.79), Colon(9.96), CedarBluffs(14.76), MorseBluff(14.92)
24	Manley	44, 22, 28, 36, 13, 4, 37, 29, 9	WeepingWater(4.83), Louisville(7.19), Murdock(7.76), SouthBend(9.55), Elmwood(12.27), Avoca(12.54), Springfield(12.64), Murray(12.71) CedarCreek(13.91)
25	Mead	46, 18, 41, 11, 21, 26, 39	Yutan(6.07), Ithaca(8.03), Wahoo(8.50), Colon(10.80), Leshara(11.70), Memphis(12.63), Valley(14.88)
26	Memphis	3, 18, 46, 25, 15	Ashland(6.92), Ithaca(10.62), Yutan(11.97), Mead(12.60), Greenwood(13.75)
27	MorseBluff	34, 8, 23	Prague(10.70), CedarBluffs(11.40), Malmo(14.79)
28	Murdock	13, 36, 24, 1, 44, 15, 3, 22	Elmwood(6.30), SouthBend(7.03), Manley(7.69), Alvo(9.26), WeepingWater(11.65), Greenwood(11.89), Ashland(12.12), Louisville(13.34)
29	Murray	33, 38, 30, 24, 44	Plattsmouth(8.66), Union(8.80), Nehawka(9.66), Manley(12.70), WeepingWater(14.29)
30	Nehawka	38, 4, 29, 44	Union(4.77), Avoca(9.46), Murray(9.66), WeepingWater(10.51)
31	Omaha	35, 5, 20, 32	Ralstonf(9.33), Bellevue(10.43), LaVista(10.63), Papillion(13.13)
32	Papillion	20, 35, 5, 37, 16, 31	LaVista(2.69), Ralston(3.87), Bellevue(7.70), Springfield(10.87), Gretna(12.20), Omaha(12.67)
33	Plattsmouth	29, 5	Murray(8.65), Bellevue(13.72)
34	Prague	23, 27, 11, 45	Malmo(8.06), MorseBluff(10.70), Colon(11.79), Weston(12.00)
35	Ralston	20, 32, 5, 31, 37, 16	LaVista(1.47), Papillion(3.84), Bellevue(9.24), Omaha(9.68), Springfield(13.96), Gretna(14.78)
36	SouthBend	28, 22, 3, 24, 37, 13, 9, 15, 16, 44	Murdock(6.99), Louisville(7.25), Ashland(8.09), Manley(9.55), Springfield(12.70), Elmwood(13.41), CedarCreek(13.98), Greenwood(13.99), Gretna(14.14), WeepingWater(14.50)
37	Springfield	22, 16, 32, 24, 36, 20, 35, 9	Louisville(5.81), Gretna(10.49), Papillion(11.00), Manley(12.63), SouthBend(12.70), LaVista(12.99), Ralston(13.29), CedarCreek(13.46)
38	Union	30, 29, 4	Nehawka(4.77), Murray(8.74), Avoca(11.76)
39	Valley	43, 21, 46, 42, 25	Waterloo(4.41), Leshara(5.77), Yutan(10.39), Washington(13.30), Mead(14.91)
40	Valparaiso	63, 10, 45, 51	Raymond(11.18), Ceresco(11.39), Weston(14.17), Davey(14.25)
41	Wahoo	11, 45, 25, 23, 18, 10, 46, 8	Colon(6.75), Weston(7.89), Mead(8.52), Malmo(9.75), Ithaca(10.04), Ceresco(11.84), Yutan(13.71), CedarBluffs(13.95)
42	Washington	6, 19, 43, 2, 39, 7	Bennington(5.34), Kennard(7.36), Waterloo(11.61), Arlington(12.52), Valley(13.31), Blair(13.59)
43	Waterloo	39, 21, 46, 42, 6, 16, 25	Valley(4.26), Leshara(9.92), Yutan(10.36), Washington(11.62), Bennington(11.99), Gretna(12.79), Mead(14.88)
44	WeepingWater	24, 4, 30, 28, 22, 13, 29, 36	Manley(4.83), Avoca(6.20), Nehawka(10.5), Murdock(11.44), Louisville(12.15), Elmwood(14.22), Murray(14.29), SouthBend(14.51)
45	Weston	23, 41, 34, 40, 11	Malmo(6.88), Wahoo(7.85), Prague(12.00), Valparaiso(14.11), Colon(14.62)
46	Yutan	25, 21, 39, 43, 26, 18, 41	Mead(6.10), Leshara(7.45), Valley(10.33), Waterloo(10.73), Memphis(11.97), Ithaca(13.28), Wahoo(13.72)
47	BeaverCrossing	50, 55, 68	Cordova(7.95), Goehner(8.48), Utica(11.80)
48	Bee	54, 67, 65	Garland(7.93), Staplehurst(8.39), Seward(9.20)
49	Bennet	61, 64, 57, 12	Panama(6.40), Roca(10.33), Hickman(11.12), Eagle(14.94)
50	Cordova	47, 68, 55	BeaverCrossing(7.95), Utica(12.63)
51	Davey	10, 63, 69, 40	Ceresco(6.58), Raymond(8.49), Waverly(12.48), Valparaiso(14.25)
52	Denton	62, 58, 59, 66	PleasantDale(8.37), Lincoln(12.34), Malcolm(12.59), Sprague(14.34)
53	Firth	57, 56, 61, 64, 66	Hickman(7.62), Hallam(9.91), Panama(10.57), Roca(11.55), Sprague(14.01)
54	Garland	48, 59, 65, 63, 67, 62	Bee(7.93), Malcolm(8.82), Seward(9.13), Raymond(11.66), Staplehurst(11.80), PleasantDale(13.47)
55	Goehner	47, 65, 68, 67, 60	BeaverCrossing(8.51), Seward(11.36), Utica(12.41), Staplehurst(12.42), Milford(13.53)
56	Hallam	66, 53, 57, 64	Sprague(8.37), Firth(9.74), Hickman(14.44), Roca(14.81)
57	Hickman	64, 66, 53, 61, 49, 56	Roca(3.86), Sprague(6.37), Firth(7.43), Panama(8.38), Bennet(11.12), Hallam(14.44)
58	Lincoln	52, 59, 62, 63, 12, 51	Denton(12.33), Malcolm(12.59), PleasantDale(14.18), Raymond(14.24), Eagle(14.49), Davey(14.74)
59	Malcolm	54, 63, 62, 58, 52, 40, 65	Garland(8.82), Raymond(10), PleasantDale(11.97), Lincoln(12.53), Denton(12.59), Valparaiso(14.31), Seward(14.35)
60	Milford	62, 65, 55	PleasantDale(10.79), Seward(12.17), Goehner(13.80)
61	Panama	49, 57, 53, 64, 66	Bennet(6.40), Hickman(8.39), Firth(10.57), Roca(13.28), Sprague(14.52)
62	PleasantDale	52, 60, 59, 54	Denton(8.37), Milford(10.74), Malcolm(11.97), Garland(13.47)
63	Raymond	51, 59, 40, 54, 58, 10	Davey(8.49), Malcolm(8.65), Valparaiso(9.66), Garland(11.66), Lincoln(14.12), Ceresco(14.82)
64	Roca	57, 66, 49, 53, 61, 56	Hickman(3.86), Sprague(6.43), Bennet(10.33), Firth(11.36), Panama(13.28), Hallam(14.56)
65	Seward	67, 54, 48, 55, 60, 68, 59	Staplehurst(8.46), Garland(9.12), Bee(9.20), Goehner(11.36), Milford(12.17), Utica(13.61), Malcolm(14.75)
66	Sprague	57, 64, 56, 53, 52, 61	Hickman(6.37), Roca(6.43), Hallam(8.37), Firth(13.84), Denton(14.34), Panama(14.53)
67	Staplehurst	48, 65, 54, 55, 68	Bee(8.41), Seward(8.49), Garland(11.82), Goehner(12.42), Utica(14.67)
68	Utica	47, 50, 55, 65, 67	BeaverCrossing(11.81), Cordova(12.63), Goehner(12.90), Seward(13.61), Staplehurst(14.67)
69	Waverly	15, 1, 3, 51, 12	Greenwood(5.55), Alvo(10.85), Ashland(12.39), Davey(12.50), Eagle(12.78)

Appendix 3. Results of the Neighborhood Statistics Models

Revenues/ Expenditures

				-	-			+	+	-	
	τ^2	η	β_0 intercept	β_1 google_distance	β_2 population_ln	β_3 medianhouseholdincome_ln	β_4 percentWhitepopulation	β_5 percentbachelordegree	β_6 unemploymentrate	β_7 area	β_8 year
Estimate	0.11231	-0.02	2.277475725	-0.006624427	-0.05015341	-0.118313389	-0.012091875	0.793187905	0.912949346	-0.1083421	0.000350799
lower limit	-0.28765	0.060414	-6.478981735	-0.0086644	-0.06706615	-0.243513942	-0.496949653	0.483877136	0.087126927	-0.1576424	-0.004268499
upper limit	0.491024	0.139586	11.03393319	-0.004584453	-0.03324067	0.006887165	0.472765903	1.102498674	1.738771765	-0.0590417	0.004970098
p-value	0.608713	7.38E-07	0.6102068	1.96E-10	6.16E-09	0.0639997	0.9610146	5.00E-07	0.0302512	1.65E-05	0.8816748

Debt per capita

				-	+	-	+	+	+	-	+
	τ^2	η	β_0 intercept	β_1 google_distance	β_2 population_ln	β_3 medianhouseholdincome_ln	β_4 percentWhitepopulation	β_5 percentbachelordegree	β_6 unemploymentrate	β_7 area	β_8 year
Estimate	2311560	-0.027	-177389.2018	-18.66093	89.60613	-1446.70261	4802.63139	5108.98814	5864.8167	-657.63655	93.95833
lower limit	2082130	0.059422	-216413.7236	-27.85001	13.35663	-2011.86387	2613.8164	3713.08399	2142.32188	-880.15678	73.34239
upper limit	2082130	0.140578	-138364.70	-9.4718560	165.8556	-881.5413	6991.4460	6504.8920	9587.3120	-435.1163	114.5743
p-value	0	1.36E-06	0	3.44E-05	0.010630	2.62E-07	8.52E-06	3.65E-13	0.001008	3.47E-09	0

Debt/Property value

						-		+		-	+
	τ^2	η	β_0 intercept	β_1 google_distance	β_2 population_ln	β_3 medianhouseholdincome_ln	β_4 percentWhitepopulation	β_5 percentbachelordegree	β_6 unemploymentrate	β_7 area	β_8 year
Estimate	1118.354	-0.027	-1513.697	-0.0265480	1.2382050	-25.22486	22.34524	97.164980	69.773210	-10.113180	0.881254
lower limit	1009.921	0.059422	-2373.160229	-0.2289252	-0.4410889	-37.6717846	-25.8605017	66.422043	-12.2098009	-15.013889	0.4272148
upper limit	1009.921	0.140578	-654.2336672	0.1758293	2.9174991	-12.7779317	70.5509861	127.9079142	151.7562112	-5.2124631	1.3352923
p-value	0	1.36E-06	0.000556	0.797091	0.148407	7.12E-05	0.363595	5.84E-10	0.095297	5.24E-05	0.00014226

Cash reserve/Expenditures

				-	-			+		-	+
	τ^2	η	β_0 intercept	β_1 google_distance	β_2 population_ln	β_3 medianhouseholdincome_ln	β_4 percentWhitepopulation	β_5 percentbachelordegree	β_6 unemploymentrate	β_7 area	β_8 year
Estimate	0.072809	-0.055	-10.07497713	-0.007444262	-0.110053314	0.016674952	0.001462891	0.380492514	-0.496692621	-0.1355517	0.00558868
lower limit	-0.43448	0.055853	-16.63008641	-0.009046653	-0.123395146	-0.08268641	-0.383391162	0.135338342	-1.14742767	-0.1746537	0.002107162
upper limit	0.565641	0.144147	-3.519867846	-0.005841871	-0.096711483	0.116036313	0.386316944	0.625646686	0.154042428	-0.0964496	0.009070198
p-value	0.797141	9.01E-06	2.59E-03	0	0	7.42E-01	9.94E-01	0.002349917	1.35E-01	1.09E-11	0.001653647

Property tax/Reveunus

						+	-			-	-
	τ^2	η	β_0 intercept	β_1 google_distance	β_2 population_ln	β_3 medianhouseholdincome_ln	β_4 percentWhitepopulation	β_5 percentbachelordegree	β_6 unemploymentrate	β_7 area	β_8 year
Estimate	0.002443	0.036	1.521600601	-0.000180667	0.001256366	0.060989468	-0.193275475	-0.008433281	-0.117559502	-0.0355337	-0.000942031
lower limit	-6.66675	0.069917	0.001151053	-0.000496754	-0.00134575	0.04193905	-0.266959068	-0.055572854	-0.24464708	-0.0430397	-0.001733842
upper limit	6.671264	0.130083	3.042050149	0.000135421	0.003858482	0.080039887	-0.119591882	0.038706293	0.009528076	-0.0280278	-0.00015022
p-value	0.99947	7.25E-11	4.98E-02	2.63E-01	3.44E-01	3.50E-10	2.73E-07	7.26E-01	6.98E-02	0	0.0197088

Appendix 4. Results of the Multiple Regression Models

	rev/exp	debt per capita	debt/property value	net cash balance/ exp	property tax/ rev
googledistance	-0.0073**	6.19	0.35	-0.0068***	-0.0010**
	(0.0031)	(14.06)	(0.31)	(0.0024)	(0.0005)
lnpopulation	-0.0357	202.08*	4.55**	-0.0944***	-0.0033
	(0.0230)	(103.91)	(2.30)	(0.0176)	(0.0035)
lnmedianhous eholdincome	-0.1716***	904.78***	6.12	-0.0185	-0.0112
	(0.0584)	(278.63)	(5.89)	(0.0496)	(0.0087)
percentwhitep opulation	0.3784	-1751.87	-43.44	0.2912	-0.0385
	(0.3046)	(1448.44)	(30.73)	(0.2568)	(0.0454)
percentbachel orsdegree	0.4443***	2941.93***	46.22***	0.2374	0.0349
	(0.1724)	(821.98)	(17.40)	(0.1461)	(0.0257)
unemployment rate	1.2788***	3829.41**	49.67	0.4971*	-0.0039
	(0.3302)	(1580.25)	(33.34)	(0.2820)	(0.0491)
lincolnbeatrice	-0.1226	-350.78	-5.16	-0.1192**	-0.0446***
	(0.0803)	(360.82)	(8.03)	(0.0606)	(0.0123)
year2001	-0.0280	-413.75***	-4.46	-0.0299	-0.0096**
	(0.0303)	(145.05)	(3.06)	(0.0259)	(0.0045)
year2002	0.0144	-433.68***	-5.91**	-0.0482*	-0.0048
	(0.0296)	(141.50)	(2.98)	(0.0253)	(0.0044)
year2007	-0.0106	-164.42	-0.75	-0.0243	-0.0012
	(0.0284)	(135.95)	(2.87)	(0.0243)	(0.0042)
year2008	-0.0612**	-44.17	0.28	-0.0557**	-0.0028
	(0.0280)	(134.22)	(2.83)	(0.0240)	(0.0042)
year2009	-0.0287	-59.12	-1.28	-0.0296	-0.0010
	(0.0281)	(134.81)	(2.84)	(0.0241)	(0.0042)
Constant	3.0480***	-9171.83***	-48.16	1.0057*	0.2635**
	(0.6977)	(3312.31)	(70.36)	(0.5866)	(0.1041)
Number of observations	1103	1103	1103	1103	1103
Number of groups	69	69	69	69	69
R-squared within	0.0288	0.1064	0.0390	0.0137	0.0108
between	0.0805	0.1614	0.1231	0.3393	0.1613
overall	0.0595	0.1363	0.0897	0.2168	0.1105

Notes: Standard errors are in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$