USDOT Region V Regional University Transportation Center Final Report

NEXTRANS Project No. 029PY02

TRANSPORTATION AND SOCIOECONOMIC IMPACTS OF BYPASSES ON COMMUNITIES: AN INTEGRATED SYNTHESIS OF PANEL DATA, MULTILEVEL, AND SPATIAL ECONOMETRIC MODELS WITH CASE STUDIES

revised from original working title of

TRANSPORTATION AND SOCIOECONOMIC IMPACTS OF BYPASS ON COMMUNITIES: AN INTEGRATED SYNTHESIS OF SPATIAL ECONOMETRIC METHODS AND AGENT-BASED SIMULATION

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TECHNICAL SUMMARY

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Title

Transportation and Socioeconomic Impacts of Bypasses on Communities: An Integrated Synthesis of Panel Data, Multilevel, and Spatial Econometric Models with Case Studies. The title used at the start of this project was "Transportation and Socioeconomic Impacts of Bypasses on Communities: An Integrated Synthesis of Spatial Econometric Methods and Agent-Based Simulation". The revised title reflects the methods used during the project and the findings that resulted.

Introduction

This paper will describe an integrated approach to documenting and quantifying the impacts of bypasses on small communities, with a focus on what economic impacts, if any, occur, and how these impacts change over time. Two similarly sized communities in Indiana, a subset of twelve communities analyzed in a previous report (Fricker and Mills 2009), will be discussed in this report. One of these communities has had a bypass in place for 40 years, and the other community has been a candidate for a bypass for several years. The socioeconomics impacts on the community with the bypass will be documented in terms of (1) the decisions made by public officials as learned through case study interviews, and (2) the changes in employment in various industry sectors, as quantified by the development of random effects statistical models. The long-term impacts and lessons learned concerning the bypassed community will then be used to offer suggestions on how communities could benefit from a bypass. The integrated approach of combining case studies with advanced statistical methodologies was found to be helpful in painting a clearer picture of how communities with bypasses were impacted.

Findings

The policies implemented by public officials following the opening of a bypass were found to play a key role in the type and magnitude of long-term impacts. Wabash refocused its downtown around the popular Honeywell Center and implemented TIF districts to attract and retain industry. The city of Warsaw has maintained its dominance in the orthopedics industry, which, according to local officials, may have left the city had the US-30 bypass not been built. Washington, like Warsaw, renovated historic downtown buildings and capitalized on the local tourism and entertainment industries. In Huntington, the implementation of a pedestrian mall failed to improve its downtown, and local politics and community sentiments have hindered industrial development.

The impacts of bypasses on the downtown areas of these small- and medium-sized communities cannot be easily captured by statistical models alone, due to aggregation data, a by-product of Census disclosure laws limiting the availability of local, more disaggregate data, and due to the difficulty in identifying and quantifying the decisions made in the past by public officials. Even with these downsides, the statistical models have largely confirmed the claims made by public officials interviewed for this study. The combination of the county-level and ZIP Code-levels, in conjunction with the case study interviews, have shown that bypasses can have positive and statistically significant economic impacts on communities. The panel data and multilevel models showed significant variance over space. The panel data models and the multilevel models indicated that between-county and between-ZIP variance accounted for a considerable portion of the overall model variance. The spatial econometric models identified significant negative spillover effects and indicated that spatial autocorrelation is present at the ZIP Code level.

Columbia City has experienced significant growth in employment since the opening of the US-30 bypass, although this growth may have come at the cost of a declining downtown. Angola may be able to handle the problem of heavy truck traffic using the proposed traffic calming measures, but should a bypass be built, public officials should be prepared to implement effective land use policies that can help stimulate growth in employment while maintaining the downtown area's economic vitality. The statistical models show that there are significant economic impacts and that these impacts change over time. Multiple methods – multilevel models, spatial econometric analysis, panel data analysis – yielded the same results. Bypasses, over time, will lead affected areas to contribute more to the state's economy, both at the county and ZIP Code levels. Bypasses, in short, will provide the public with an opportunity to expand the local employment base, although these impacts may not be realized for many years.

The lessons learned from case study interviews should be considered by public officials of communities with proposed bypasses. For Boonville, access to the bypass, once it has opened, should be controlled, in order to prevent the loss of mobility that occurred in Warsaw due to retail development. Retail activity in all four bypassed communities profiled declined, due both to retail consolidation (which played a bigger role in the decline in Washington than the bypass) and more convenient access to the bypass. Community officials in Boonville should take steps to prepare for a similar decline in downtown retail activity.

Recommendations

The long-term impact of a bypass on a community is largely dependent on the policies enacted by local officials. A bypass's primary raison d'être may be to divert through traffic from city streets unable to handle large volumes of traffic, but from a local official's point of view, the combination of enhanced mobility (which lowers transportation costs, a key selling point for attracting basic industry) and newly accessible land provides an opportunity for growth. Local officials may choose to implement land use controls and public investments that favor development along the bypass, beginning with basic industry and followed by retail development. With limited access to/from the bypass, mobility is maintained, satisfying state DOT interests, while the new facility can generate new employment and more tax dollars, which satisfies local interests.

Other issues should be considered for communities with proposed bypasses. Local officials should be consulted to determine the status of the city or county Comprehensive Plan and the plans for downtown and outlying areas once the bypass is constructed. If a bypass is not warranted, local officials should have a "backup plan" for dealing with increased downtown traffic volumes, particularly if safety is an issue. Local land use and zoning policies should ensure that development does not impede mobility. The views of local businesses and residents should also be considered.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Bypasses, which redirect through traffic around a community's downtown area, could have substantial impacts. Identifying these impacts and attributing these impacts solely to the presence of a bypass has posed a challenge to decision-makers and researchers. The economic impacts have the potential to be long-term and far-reaching. Because impacts take place over a long period of time, and because these impacts cannot be easily isolated due to economic externalities (such as recessions), researchers have found it difficult to establish a standard estimation framework for determining bypass impacts. Recent studies (have used econometric and other quantitative methods to determine the extent of these economic impacts. This study will use longitudinal mixed-effects models to study the economic impacts of eight bypasses located in north central Indiana.

CHAPTER 1. INTRODUCTION

Bypasses, which redirect through traffic around a community's downtown area, could have substantial impacts. Identifying these impacts and attributing these impacts solely to the presence of a bypass has posed a challenge to decision-makers and researchers. The economic impacts have the potential to be long-term and far-reaching. Because impacts take place over a long period of time, and because these impacts cannot be easily isolated due to economic externalities (such as recessions), researchers have found it difficult to establish a standard estimation framework for determining bypass impacts. Recent studies (Mills and Fricker 2009, for example) have used econometric and other quantitative methods to determine the extent of these economic impacts. This study will use longitudinal mixed-effects models to study the economic impacts of eight bypasses located in north central Indiana.

This paper will describe an integrated approach to documenting and quantifying the impacts of bypasses on small communities, with a focus on what economic impacts, if any, occur, and how these impacts change over time. Two similarly sized communities in Indiana, a subset of twelve communities analyzed in a previous report (Fricker and Mills 2009), will be discussed in this paper. One of these communities has had a bypass in place for 40 years, and the other community has been a candidate for a bypass for several years. The socioeconomics impacts on the community with the bypass will be documented in terms of (1) the decisions made by public officials as learned through case study interviews, and

(2) the changes in employment in various industry sectors, as quantified by the development of random effects statistical models. The long-term impacts and lessons learned concerning the bypassed community will then be used to offer suggestions on how communities could benefit from a bypass. The integrated approach of combining case studies with advanced statistical methodologies was found to be helpful in painting a clearer picture of how communities with by-passes were impacted.

CHAPTER 2. LITERATURE REVIEW

Branham et al. (1953) analyzed the traffic impacts, safety impacts, land use impacts, land value impacts, and effects on local businesses of the bypass around Kokomo, Indiana. Volumes on the original route through downtown Kokomo not only did not decrease, but were projected to experience congestion worse than before the bypass was opened in 1951. Travel times on the original route actually increased following the bypass's opening.

Furthermore, it was found that most traffic on the Kokomo bypass was local traffic, likely due to "a shortage of north-south streets." The report recommended that "...some method, such as limited access, should be employed to control development along the route so as to insure safer facilities and maximum economic return to the state and to the users of the facility… (Branham et al. 1953). The study also noted that "…the Kokomo Planning Commission is attempting to control the development and the access points by the use of an intelligent zoning ordinance and a required platting procedure."

Nevertheless, retail and service establishments proliferated along the Kokomo bypass. Congestion has become so severe on the 1951 Kokomo bypass that a limited-access facility, referred to as a "bypass of a bypass," is being built to the east of the current bypass.

Burress (1996) found that only travel-dependent businesses were adversely impacted by the presence of a bypass. Over the long-term, cities and counties with bypasses experienced growth in basic industries, which later brought about “second-round effects” of growth in the retail and service industries. Yeh et al. (1998) found that “bypasses rarely have created adverse economic impacts on communities.” The study found that only towns with populations of 2,000 or less were likely to be adversely impacted by the construction of bypasses. A Washington State study (Gillis 1994) found that some bypassed communities “adapted” their downtown to the presence of the bypass, such as by making the central business district (CBD) a tourist destination. The study also recommended strict building design guidelines and restriction of development along highways. Kleymeyer (2001) found that retail sales were not significantly impacted by the presence of a bypass, except for gasoline service stations.

Srinivasan and Kockelman (2000) used a one-way random effects panel data model structure to determine the economic impacts of “relief routes” in Texas, finding that a higher traffic split had a more adverse impact on the bypassed community’s economy, although total sales for eating and drinking places increased with increasing traffic split. A Kentucky study (Thompson et al. 2001) found that the CBDs of bypassed communities had a significantly smaller share of retail stores compared to the CBDs of communities without bypasses. Additionally, it was found that, of the retail businesses located along bypasses, 90 percent were new to the area, and only 7.6 percent of all businesses along a bypass had relocated from the CBD.

Babcock and Davalos (2004) used ordinary least squares (OLS) regression to quantify the impact on annual average total employment in bypassed cities in Kansas. Local business owners were also interviewed. Bypasses did not have a statistically significant effect on total employment. However, the majority (76 percent) of storeowners and managers interviewed believed that retail sales levels in bypassed cities would have been higher had the bypass not been constructed. Comer and Finchum (2003) used a before-and-after approach to determine whether population or housing demographics of bypassed communities and non-bypassed communities were significantly different. It was found that income levels in non-bypassed communities were higher than in bypassed communities. Rogers and Marshment (2000), in a separate study, found that the business mix of bypassed communities did not significantly change. Interviews with local business owners found that while a few traffic-dependent businesses had closed, most businesses stayed in operation, with a few businesses "chang[ing] the orientation of their merchandise subsequent to the construction of the bypass," (Rogers and Marshment 2000).

Numerous other studies analyzing the impacts of highway investment from different perspectives are present in the literature. Sanchez (2004) analyzed aerial photographs and estimated a logit model to determine how capacity-increasing highway projects affected land use growth in Oregon, finding that areas near state highway project corridors had a larger conversion rate of vacant to urban land uses when compared to the conversion rate for all other highways in the state. Mathur (2008) found that housing prices were higher in areas with lower automobile travel times (and thus higher automobile accessibility) to downtown Seattle, while increased accessibility to low-paying retail jobs decreased prices of high-quality housing. Ozbay et al. (2003) found that county-level employment and earnings growth in the New York City metropolitan area were both positively impacted by improved accessibility (defined primarily in terms of travel time).

Chandra and Thompson (2000) found that interstate highway construction, over time, caused economic activity to gravitate toward the counties with interstates. Age indicator variables were used to represent how long interstates had been open in each county. While manufacturing earnings increased in both counties with interstates and adjacent counties, only counties with interstate experienced growth in FIRE (finance, insurance, and real estate) and TCPU (transportation, communications, and public utilities) earnings whereas adjacent counties had corresponding decreased earnings in these industries. Nunn (1995) examined the extent of interjurisdictional cooperation and competition between the city of Indianapolis and its suburbs, focusing on the different economic development incentives used by the major cities in the area and how infrastructure policies varied, finding that Indianapolis and its suburbs were in competition with each other. This issue of competition between cities is discussed, albeit indirectly, in a related study by Mills and Fricker (2009), in which a proposed manufacturing establishment, due to local politics and opposition in Huntington, ultimately established a presence at Peru, a nearby city on the same major highway corridor. Both of these cities are included in the study area described in the following sections.

Other studies have focused on the impacts of highway investment in general and whether investment in highway construction has significant economic impacts. Gkritza et al. (2008) developed models to measure statewide change in employment, income, output, business sales, and gross regional product for 117 highway projects in Indiana. It was found that added travel lanes in rural areas and interstate highway improvements had the largest impacts. Weisbrod (2008) developed a comprehensive framework for evaluating the economic impacts of proposed transportation projects. Rietveld and Boonstra (1995) examined the causal relationship between transportation infrastructure improvements and regional economic development for a set of regions in the European Union, focusing on how socioeconomic factors can explain the spatial distribution of transportation infrastructure in those regions. They found that regional policies did not have a significant impact on the infrastructure stock (comprising both highway and railway facilities) whereas the high level of aggregation used for analysis masked underlying economic trends.

Jiwattanakulpaisarn et al. (2009) also examined the causal relationship between transport infrastructure investment and regional economic development, focusing on how state-level employment levels for the 48 contiguous states were impacted over time by increases in roadway capacity. Accounting for spatial autocorrelation using spatial filtering methods, it was found that travel demand induced by increases in employment had the potential to lead to new highway construction and capacity expansions of existing highways. However, the authors cautioned that "one cannot make a clear-cut prediction for the direction of causality…evidence of state employment [is] temporarily influenced by growth in non-interstate major roads, as well as the other way around," (Jiwattanakulpaisarn et al. 2009).

Thorsen (1998) studied spatial locational structure changes as a result of changes in transportation network characteristics for 11 municipal regions in Norway. A variant of the Lowry model adapted to macroeconomic analysis used for analysis found that new highway construction, bridge and tunnel construction, and the realignment of a multimodal highway-ferry route, municipalities that gained a better sense of "relative centrality" from these improvements resulted in an expansion of both basic and local economic activity as well as increases in population. A key finding was that "a tendency is revealed that basic sector expansion benefits zones which are peripherally located relative to new road connections." Municipalities not located near these "new road connections" experienced adverse economic impacts.

Ezcurra et al. (2005) estimated a set of regional, longitudinal cost and production functions to determine whether infrastructure investment had a significant impact on productivity on various regions in Spain. It was found that public capital expenditures reduced private production costs and that industrial (basic) sectors experienced the largest magnitude of production cost savings.

Button et al. (1995) considered how transportation improvements impacted the location decisions of firms exploring new sites. Respondents were asked to rank varying factors, including market access, site amenities, access to suppliers and support services, among other factors. It was found that regional policies (such as tax incentives) played the biggest role in attracting industry, and that the quality and nature of the local transport infrastructure were key criteria used by firms in deciding whether to relocate.

CHAPTER 3. APPROACH TO STUDY AND STUDY AREA

3.1. Approach to Study

To obtain a more complete and accurate picture of a bypassed city's changes over time, statistical analyses were augmented by a case study approach. A total of fifteen communities in Indiana were selected based on suggestions by officials at the state department on transportation. Several of these communities are discussed here. The full set of case study profiles can be found in the final research report (Fricker and Mills 2009). Interviews were conducted with individuals who were knowledgeable about the community, the county, the region, local industry, and representative local and downtown businesses. Each city's profile covers the following characteristics:

(1) A general background of the city, including principal industries and noteworthy attractions.

(2) Descriptions of how the city was impacted by the presence of a bypass or what impacts are expected if a bypass were to be built. The descriptions in this paper are based on comments made by those interviewed, who are identified and quoted in the full research report (see Fricker and Mills 2009).

(3) The policies that have been implemented in response to the bypass's construction.

To establish a statistical link between the presence of a bypass and a notable change in the affected area's economy, several different estimation techniques were considered. Panel data, used primarily in econometrics, combine both cross-sectional and time-series data. Random-effect panel data models can account for unobserved characteristics of each county or time period. Mixed-effects/multilevel models (MLM) are a more general form of panel data models and can more easily accommodate the presence of autocorrelation and heteroskedasticity. Mixed models can also include multiple levels of random effects (multilevel/hierarchical models), each with its own set of variable intercepts and coefficients. Generalized additive mixed models (GAMMs) can be used when the appropriate transformation for a covariate are not directly evident. These models apply smoothing functions, such as splines or tensor products, to explanatory variables. Spatial econometric methods will be used to identify potential spillover effects. These three estimation techniques will be used to quantify the economic impacts of bypasses both at the county and ZIP Code levels.

This paper's approach to statistical modeling differs in several ways from previous studies:

(1) Impacts on employment and payroll in various industry sectors would serve as the main focus of the modeling process, as opposed to sales figures.
(2) Multiple metrics are used to measure impacts, including employment, payroll, and location quotients.
(3) In addition to analyzing "absolute" numbers (such as manufacturing employment in a given county), economic data were normalized against state totals to account for external economic factors.

(4) Emphasis is placed on how economic impacts changed over time.

The majority of the studies outlined above focused on travel-dependent businesses, in particular, eating and drinking places, gasoline service stations, and hotels and motels. Both Thorsen (1998) and Chandra and Thompson (2000) found that businesses tended to gravitate toward newly constructed highways. The use of age indicators by Chandra and Thompson showed that earnings for counties with newly constructed interstates grew over time. The study by Chandra and Thompson used high-level (state-level or higher) variables as explanatory variables in addition to the use effect of age indicators. This study will modify that approach. Different types of models were estimated using county-level employment and payroll data. Instead of using the "raw" data, a normalization factor was used in which county-level figures were divided against statewide figures to gain insight into how each county's contribution to the state's overall economy changed over time. The use of the age indicators was also modified; instead of using individual year dummies, groupings of years were used, most commonly in 5-10 years. The resulting models of the economic characteristics of these bypassed communities could reveal the long-term economic implications of constructing a bypass.

3.2. StudyArea and Sources of Data

The study area in north central Indiana (see Figure 1) includes several major US routes (the majority of which are four-lane divided highways) and state roads (most of which are two-lane roads). A total of 65 ZIP codes, including eight communities with bypasses, comprise the study area. The study area is roughly bordered by South Bend and Elkhart to the north, Fort Wayne to the east, Kokomo and Marion to the south, and the White County-Cass County border to the west. An additional county in southwestern Indiana, Daviess County, was also selected for analysis based on the case study interviews. Howard County, containing the city of Kokomo, was also included in the study area for the county-level models to gauge long-term impacts (since its bypass opened in 1951).

Employment, payroll, and establishment data for various industry sectors were gathered from County Business Patterns (CBP) and Zip Business Patterns (ZBP), annual sets of economic data published by the US Census Bureau. Because true ZIP Codes do not have "polygon"-type definitions, the actual unit of aggregation for ZBP data are Zip Code Tabulation Areas (ZCTA), a unit of aggregation defined by the Census Bureau that generally conform to the actual boundaries of ZIP Codes. Because of their basic equivalence, the terms ZCTA and ZIP Code will be used interchangeably. The ZBP are similar to County Business Patterns (CBP), with one major difference. County Business Patterns include employment and payroll data for all industry sectors, as well as number of establishments by number of employees (e.g. 1-4 employees, 5-10 employees, etc.). Due to disclosure laws, only industry-specific establishment by employment size are available for Zip Business Patterns, although total employment and total payroll figures are still available for each ZIP Code. Methods for converting ZIP Code-level establishment data to employment data are discussed briefly in the following section.

ZIP Code-level economic data were collected for the years 1998-2007. Other data were gathered from long-form Census 2000 population, income, education, commute, and tax data from Summary File 1 and Summary File 3. These data were converted and aggregated by SAS-based online applications developed by the Missouri Census Data Center. County-level economic data were collected for the years 1970-1997. The difference in time horizons is present for several reasons:

(1) Industries were classified based on the Standard Industrial Classification system until 1998. Economic data thereafter are classified based on the North American Industrial Classification System (NAICS).
(2) ZIP Business Patterns were only published beginning in 1994.
(3) While methods do exist to "convert" SIC-based data to NAICS-based data and vice versa, significant measurement error could potentially be introduced.

In addition, preliminary testing of models revealed that models based on the ZIP Code-level data and models based on the county-level data, despite the different time horizons and different industrial classification systems, yielded similar results.

Other data were gathered from long-form Census 2000 population, income, education, commute, and tax data from Summary File 1 and Summary File 3, converted and aggregated by the Missouri Census Data Center. Transportation network-related variables were computed and aggregated using the TransCAD transportation planning package. Mileage and capacity (number of lanes) data were grouped by FHWA Functional Classification Guidelines. Local roads in each ZCTA were classified and aggregated by Census Feature Class Codes (CFCC), which are used in TIGER/Line files provided by the U.S. Census Bureau. The most common type of local road, CFCC Code A41 (Local, neighborhood, and rural road, city, street, unseparated) was used in the statistical models.

The study area is shown in Figure 1. The map shown in Figure 1 illustrates the advantage of using ZIP Code-level data as opposed to county-level data. While the study area encompasses several counties, the affected area consists of 65 distinct ZIP Codes. Selection of ZIP Codes for the study was based on a subjective examination of the ZIP Codes most likely to be affected by the study area. Population figures and percentage change over time are shown below in Table 1.

3.3. Data Conversions, in Brief

Establishment data provided by ZBP are grouped by nine employment size ranges (e.g. establishments with 1-4 employees, establishments with 5-9 employees, etc.), to make a distinction between smaller and larger establishments. Two alternative estimation methods were considered to estimate industry-level employment using the distribution of establishments by employment-size class. The first method, the Midpoint Method, uses the midpoint of the employment size ranges as follows:

$$Employment = \sum_{k=1}^{9} \left(\frac{r_k^1 + r_k^2}{2} \right) Est_k$$

where r_k^1 represents the lower bound of the employment size range k, r_k^2 represents the upper bound of the employment size range k, and Est_k represents the number of establishments for employment size range k. Written out fully, we have:

$$\begin{aligned} Employment = & \left(\frac{1+4}{2}\right)Est_{1-4} + \left(\frac{5+9}{2}\right)Est_{5-9} + \left(\frac{10+19}{2}\right)Est_{10-19} + \left(\frac{20+49}{2}\right)Est_{20-49} \\ & + \left(\frac{50+99}{2}\right)Est_{50-99} + \left(\frac{100+249}{2}\right)Est_{100-249} + \left(\frac{250+499}{2}\right)Est_{250-499} \\ & + \left(\frac{500+999}{2}\right)Est_{500-999} + \left(1000\right)Est_{1000} \end{aligned}$$

The second method used a combination of county-level employment data and county-level distributions of establishments by employment-size class to develop statistical models that estimated individual coefficients for each class. Statistical models were estimated using county-level employment as the dependent variable and the distributions of establishments by employment-size class as the independent variables, modifying the above equation as follows.

$$\begin{aligned} Employment = & \beta_1 \cdot Est_{1-4} + \beta_2 \cdot Est_{5-9} + \beta_3 \cdot Est_{10-19} + \beta_4 \cdot Est_{20-49} \\ & + \beta_5 \cdot Est_{50-99} + \beta_6 \cdot Est_{100-249} + \beta_7 \cdot Est_{250-499} \\ & + \beta_8 \cdot Est_{500-999} + \beta_9 \cdot Est_{1000} \end{aligned}$$

A number of statistical methods for estimating the coefficients of this equation were investigated, with the goal of minimizing forecast errors across the majority of industries.

Three main types of models were investigated: truncated normal regression models with sample selection (Heckman 1976), quantile regression (Koenker 2005), and various robust estimators to account for outliers (Rousseeuw and Leroy 2003). It was found that quantile regression best minimized forecast errors for the majority of the industries tested.

While these models indicate that statistical methods can be used to estimate employment data from establishment data at the county level, "transferring" these models to the ZIP Code levels requires strong assumptions to be made, that the distribution of employment at the county level has the same characteristics at the ZIP Code level. However, given that the Midpoint Method is used in practice and that the quantile regression methods (mostly) improve upon this method with respect to minimizing forecast errors, it was concluded that these estimated employment figures would provide accurate enough results to address the questions outlined in the introduction. The statistical models described in the following section examine the economic impacts of bypasses for the manufacturing sector, which serves as an important sector in the three-state study area. ZIP Code-level manufacturing employment was estimated using the coefficients from the quantile regression estimates.

CHAPTER 4. STATISTICAL MODELS USED IN ANALYSIS

4.1. The General Model

The general model for evaluating economic impacts will take the following form:

$$y_{it} = CITY_{it} \cdot \beta + INDUSTRY_{it} \cdot \psi + BYPASS_{it} \cdot \xi + \mu_i + \lambda_t + v_{it}$$
$$i = 1, \ldots, N, t = 1, \ldots, T$$

where

y_{it} is the dependent variable,

$CITY_{it}$ represents characteristics relating to the bypassed community (such as population and the distance to the nearest large city) with associated vector of coefficients β,

$INDUSTRY_{it}$ represents characteristics of related industries, such as employment and payroll levels, with associated vector of coefficients ψ,

$BYPASS_{it}$ represents characteristics of the bypass of each county seat, primarily in the form of indicators representing how many years the bypass had been open, with associated vector of coefficients ξ,

μ_i represents unobserved cross-sectional (individual) effects for N cross-sections,

λ_t represents unobserved time-series effects for T time periods, and

v_{it} represents random or idiosyncratic disturbances.

Employment, payroll, and establishment data for various industry sectors served as dependent variables. Instead of using absolute numbers (levels), these figures were normalized against the state, yielding a "county-to-state ratio." These figures divide employment or payroll figures against corresponding values for the state overall. For example, the county-to-state ratio of manufacturing employment for Whitley County in 1971 is computed as the ratio of manufacturing employment in the county that year to manufacturing employment in the entire state that same year.

The use of county-to-state ratios is advantageous for a number of reasons. Normalizing county figures against the state accounts for external economic factors, such as recessions and overall industry trends, such as the decline of the American auto industry. County-to-state ratios provide insight into how much each county is contributing to the entire state's economy. For example, if Whitley County has a 1 percent manufacturing employment county-to-state ratio in 1971, the county contributes 1 percent to the state's economy with respect to manufacturing employment for that year. Because they normalize out a number of externalities, county-to-state ratios have greater practical meaning than the absolute figures, particularly in the manufacturing sector.

For modeling purposes, the manufacturing sector was chosen as a starting point. Manufacturing employees make up part of what is referred to in the literature as basic workers, or workers who "are employed in industry, commercial, and office facilities whose location selections are based on considerations other than locally required access," (Brail 1987). Basic industries, when deciding where to locate, are sensitive to a number of factors outlined by officials interviewed in the previous chapter, such as market and labor access, transportation costs, and the availability of "shovel-ready" sites.

Service employees, in contrast, "are employed in firms which derive income from proximity to basic industry," according to Brail. Examples of service industries include offices and retail trade (which includes eating and drinking places). Accounting for the relationships between basic and service workers, most models for service industries include some aspect of the manufacturing industry as an explanatory variable.

Through trial and error, it was found that the use of additional indicators representing the bypass's age provided more meaningful results than the use of a continuous linear or nonlinear function representing the number of years the bypass has been open. These age indicators were grouped into different age groups, the size of each age group also determined by trial and error for each model.

To illustrate, consider a county that has had a bypass open for the last 13 years of data stored in the database. Assume this county has three separate bypass age indicators, one indicator for years 1-5, another indicator for years 6-10, and another indicator for years 11-15. The indicator for years 1-5 would be set to 1 for the first 5 years the bypass is open. Thereafter, the indicator would be set equal to 0. For the next 3 years, only the age 6-10 indicator would be set to 1. This indicator would then be set to 0 after those 5 years. For the last 3 years in the database, the age 11-15 indicator would be set to 1. This brief example shows that at most one indicator is "switched on" for a given observation. Age indicators had previously been used by Chandra and Thompson (2000) in their study of the county-level economic impacts of interstate highway construction.

4.2. Panel Data Models

Panel data combine both time-series data (in this case, for years 1970-1997) and cross-sectional data (in this case, for seven counties). Panel data are typically analyzed in two ways that account for data heterogeneity: one-way error component models (which account for either cross-sectional effects or time-series effects) or two-way error component models (which account for time-series effects, or serial correlation, and cross-sectional effects). Both one-way and two-way error component models can be specified under fixed effects or random effects.

Fixed-effects models differ from random-effects models in that any inferences made from a fixed-effects model "are conditional on the particular cross-sectional units sampled," (Washington et al., 2003). Random-effects models, on the other hand, assume the cross-sectional units are randomly drawn from a "large" population. In other words, the random-effects specification assumes that each cross-section (each county in this case) comes from a random sampling distribution (Wooldridge 2002). Fixed-effects models cannot be generalized to other cross-sectional units outside the sample. Such is not the case with random-effects models. In other words, for this study, the random-effects model would be more appropriate; the findings from a random-effects model can be generalized to other counties outside the sample; that is, other counties that have bypasses.

The random-effects specification imposes the orthogonality condition that the set of explanatory variables $\mathbf{X}'_{it}$ are independent of μ_i, λ_t, and v_{it} for all cross-sections (N = 7) and years (T = 28). Error terms μ_i, λ_t, and v_{it} are assumed to be independently and identically distributed (IID) with zero means and variances $\sigma^2_\mu, \sigma^2_\lambda$, and σ^2_v, respectively (Washington et al., 2003). The sum of these variances is equal to the variance of the overall disturbance term u_{it}. Furthermore, it is assumed that the unconditional variance of the idiosyncratic errors is constant over time and is serially uncorrelated.

4.3. Mixed Effects Models

Mixed-effects models can be used to capture within-group and between-group variation. These types of models are similar to panel data models in that both types of models allow for estimated coefficients to vary by individual (or cross-section) or over time period. Mixed-effects models differ from panel data models in that while panel data models focus on accounting for unobserved heterogeneity through the use of different intercepts for each cross-section or time-period, mixed-effects models allow for covariates to vary by group. The other key difference between panel data models and mixed-effects models lies in the method of estimation. Panel data models have closed-form, analytical solutions which can be solved via linear algebra. In contrast, mixed models do not have closed-form, analytical solutions and thus must be solved by nonlinear numerical optimization (Croissant and Millo 2008). While general serial correlation and heteroskedasticity can be controlled for using feasible GLS (FGLS) in the panel data framework, the mixed effects framework allows for a more general specification of heteroskedasticity (such as allowing the variance to have nonlinear covariates) and within-group serial correlation (through the use of ARMA correlation structures).

The definition of "fixed effects" and "random effects" in the mixed models literature differ from that in the panel data literature. In the mixed effects literature, "fixed effects" refer to covariates whose coefficients do not vary by group (in other words, the β vector), whereas the "random effects" include any covariates, including the intercept, that do vary by group. The fixed effects are used to model the mean of the dependent variable, and the random effects are used to construct the variance-covariance matrix of the model (McCulloch and Searle 2001). Multilevel models can accommodate different levels of groupings in the same model. For example, a multilevel model for crash data could include coefficients or intercepts that can vary at the region, highway classification, and individual levels. With panel/longitudinal data, there are at minimum two “levels” of grouping: time periods nested within each county. The linear mixed model can be generalized to include smoothing terms, which are used when the appropriate transformation of a covariate is not directly evident, to create Generalized Additive Mixed Models (GAMMs), which use smoothing terms (calculated in various ways, such as through splines or tensors) to determine nonparametric representations of coefficients (Faraway 2006).

Diagnostic plots were used to check for the presence of heteroskedasticity and autocorrelation. A combination of variance functions (as defined in Pinheiro and Bates 2000) and residual covariance structures can be used to correct for both heteroskedasticity. Variance functions take the form:

$$Var \ \varepsilon_{ijk} \,|\, b_{i,j}, b_{ij} \ = \sigma^2 g^2 \ \ \mu_{ijk}, v_{ijk}, \delta$$

where Λ_{ij} represents a positive-definite matrix, δ represents a vector of variance parameters, v_{ijk} represents a matrix of variance covariates $g(\cdot)$ represents some continuous variance function, and $\mu_{ijk} = E\left[y_{ijk} \,|\, b_{i,j}, b_{ij} \right]$

Of the various autocorrelation structures available (such as ARMA models), Antedependence models are of particular interest. The typical AR(1) correlation structure assumes that the autocorrelation process is stationary and thus has uniform variance among observations with decaying correlation over time. Antedependence correlation structures are used when within-group autocorrelation is nonstationary, or when correlations between within-group observations do not uniformly decrease over time (Zimmerman et al. 1995; Zimmerman and Nuñez-Antón 2009). The Toeplitz model typically results as the result of a moving average process and retains the stationarity assumptions of the typical ARMA(p,q) models (Zimmerman and Nunez-Anton 2009).

Three main types of random parameters were used at the county and ZIP Code levels: intercepts, time indicators, and duration variables. An intercept was used to capture unobserved heterogeneity. For the county-level data, a time indicator representing the decade in which a particular observation resides (the 1970s, the 1980s, or the 1990s) was used. The use of this indicator was found to correct for autocorrelation more fully than the use of ARMA, Toeplitz, or ante-dependence models. The second random parameter used in the ZIP Code-level data was a duration variable representing how many years a bypass had been open. Maps of the study area with the magnitude and significance of these random parameters are shown for the ZIP Code-level models.

Removing Model Bias: Contextual Variables

A Hausman-type test for MLMs is more difficult to conduct than the Hausman test in the panel data framework. Monette (2009a) demonstrates how including contextual variables, or the variables for the within-group mean of an explanatory variable, can serve as a proxy for the Hausman test. If the contextual variable is significant, than not including the variable in the model specification is analogous to estimating a panel random effects model when the Hausman test rejects the null hypothesis. In other words, an omitted variable will cause the model to be biased and inconsistent. This is an important oversight overlooked in the classical MLM applications, which assume that the between-group effect and the within-group effect are equal (Monette 2009b).

Including a contextual variable removes the bias of the estimated within-group effect, which is influenced by the between-group effect (Monette 2009a). The contextual variable can be represented as the between-group effect of comparing two "individuals" that have the same X value (e.g. retail employment), but their respective group's (e.g. county's) mean X value differs by one unit (Monette 2009a). For the specified MLMs, contextual variables stratified by county compare differences between counties, and contextual variables stratified by time compare differences between time periods.

4.4. Spatial Econometric Models

Spatial dependence can take the form of spatial lag, in which spatial correlation is present in the dependent variable, or spatial error, in which spatial correlation is present in the error term. Spatial lag models represent the "equilibrium outcome of processes of social and spatial interaction," (Anselin 2006). The correlation structure of these interactions can represent the impacts of neighboring spatial units (such as how a new manufacturing plant in one county can affect the surrounding counties) or spatial externalities, which are not directly observable. The spatial lag model takes the form:

$$y = \rho W y + X\beta + \varepsilon \qquad (1)$$

where y represents the response variable, β represents the vector of coefficients, X represents the matrix of covariates, ε represents the vector of residuals, ρ represents the spatial weights matrix and W numerically represents how locations are spatially related. The weights matrix can be constructed based on distance or contiguity. Distance-based spatial weights are calculated based on the distance between points or between polygon centroids, using criteria such as distance bands k-nearest neighbors. Contiguity-based spatial weights, on the other hand, are calculated based on common boundaries to determine a location's neighbor (Anselin 2005).

The reduced form of Eq. 1 removes the spatially lagged dependent variables from the right side of the equation, resulting in a "spatial multiplier" $(I - \rho W)^{-1}$:

$$y = (I - \rho W)^{-1} X\beta + (I - \rho W)^{-1}\varepsilon \qquad (2)$$

Eq. 2 shows that the dependent variable for a given location is affected both by the value of the explanatory variables at that location but also by the values of those explanatory variables at all other locations (3). In other words, the extent of the impacts of all other locations is "dampened" for higher orders. This is logical; for example, a new manufacturing plant will have a greater effect on the economy of nearby counties but not counties far away from the plant.

The spillover effects inherent in spatial lag models can be interpreted using marginal effects (LeSage and Pace 2009), which measure the effect a one-unit change in a covariate has on the dependent variable. For spatial lag models, marginal effects can be divided into direct impacts, or the impacts on the spatial unit (in this case, ZIP Code/ZCTA) being analyzed, and indirect impacts, or the impacts on neighboring spatial units (surrounding ZIP Codes/ZCTAs). These direct and indirect impacts provide considerable insight into how certain factors, such as distance from a bypass or commute time, impact not just the region being analyzed but also surrounding regions. Markov Chain Monte Carlo (MCMC) methods were used to generate sampling distributions for these marginal effects (LeSage and Pace 2009).

Lagrange Multiplier (LM) tests are use to determine whether spatial lag, spatial error, or spatial ARAR models (which combine both spatial lag and spatial error specifications) should be used (Bivand et al. 2008). Weights matrices were chosen based primarily on distance. In general, two-nearest-neighbors and first-order queen contiguity weights matrices provided the most significant results. This intuitively makes sense; total employment in a ZCTA, for example, is likely most greatly impacted by that ZCTA's nearest neighbors. This is logical, since the transportation network in the region is well-defined, with several highly traveled state routes, US routes, and four-lane highways. Any change in one community's transportation network would thus impact surrounding areas.

CHAPTER 5. COUNTY-LEVEL RESULTS

5.1. Introduction

Four industry sectors served as the focus for county-level analysis: Total employment, proprietors' employment, manufacturing, and retail trade. Key demographic variables included the ratio of the population of the county with the bypassed city of interest to the population of the county with the nearest large city and the ratio of the county with the nearest large city's population to that city's distance to the bypassed city. While a general "bypass indicator" representing whether or not a bypass had opened in the county of interest was used in preliminary models, it was found that the use of bypass age indicators yielded better statistical fits. Four types of models were estimated: One- or two-way random effects panel data models (with associated Hausman and Lagrange Multiplier specification tests), a linear mixed model without corrections for heteroskedasticity, a linear mixed model with corrections for heteroskedasticity, and, when significant, a generalized additive mixed model with one of the exogenous variables being used as a a smoothing parameter.

A rough indicator of whether the group-level variation (in this case, the county level) is significant is the intraclass correlation (ICC), which is simply (Faraway 2006):

$$ICC = \frac{\sigma_{\alpha}^{2}}{\sigma_{\alpha}^{2} + \sigma_{y}^{2}}$$

A high value of the ICC occurs when the between-group correlations are significantly larger than the within-group correlations (Faraway 2006). For example, in a mixed effects model using random intercepts for each county, if the county-level variance component has an ICC value of 75 percent, then there is much greater variation between counties, relative to within-county variation. A similar measure is used for panel data models in the following sections.

5.2. Total Employment: County to State Ratio (Natural Log)

Turning first to the two-way random effects model (Model 1, see Table 2), it is noted that the individual (county-level) variance accounts for a significant share of the total variance (approximately 94 percent). The random-effects specification itself is verified by the Hausman test. As indicated by the bypass age indicators, total employment (relative to the state) is positively impacted by the presence of a bypass. The presence of a nearby larger city also positively contributes to employment. Even with the US30 indicator in place, which could be expected to produce a lower p-value for the Hausman test, the test statistic still factors the random-effects specification. The coefficient of the indicator is positive. Being located on the same corridor as other cities (e.g., Columbia City and Warsaw both lie along US-30) positively impacts total employment (relative to the state). The US-30 indicator's negative coefficient reflects unobserved characteristics of the bypasses along US-30 not captured by the model. As indicated by the negative coefficient on the number of turns variable, even with the bypass in place, the more difficult it is to get through the affected city's CBD, the more negative the impact on total employment. The magnitude of the bypass age indicators are similar, showing that the presence of a bypass will benefit total employment (relative to the state) in the long term.

The autocorrelation functions (ACFs) indicated that autocorrelation was statistically significant, particularly in the time period from 1990-1997. To correct for autocorrelation, it was found that including an indicator variable (the90s) for observations in the 1990s (1 if the observation took place between 1990-1997, 0 otherwise) as a random coefficient removed any significant autocorrelation from the model. Comparing Model 3 (random intercept and coefficients) to Model 2 (random intercept only), the US-30 indicator becomes statistically insignificant, and the coefficients for the bypass age indicators decrease by a statistically significant magnitude. The larger magnitudes of the AIC, BIC, and log-likelihood values show that Model 3 is a better fit to the data than Model 2, which is also confirmed by the likelihood ratio test. The random "decade" coefficients were not significant as fixed effects but were significant as random effects. In other words, the mean of these coefficients is not significant, but the variance across counties is significant. This variance indicates that some counties experienced economic growth relative to the state whereas other counties were less fortunate.

Proprietors' Employment: County to State Ratio (Natural Log)

Proprietors' employment represents the number of sole proprietorships and partnerships in a given county or city. Such establishments are often mom-and-pop businesses and other smaller business operations. Consolidation has occurred to a large extent in retail trade. With this in mind, it is expected that the bypass age indicator variables will have negative coefficients for all models. The estimated model, though, does not show this trend. Interestingly, impacts are more positive in the first 15 years the bypass is open, become insignificant between 16-20 years, and become negative from 21-35 years (see Table 3).

The GAMM model (Model 4) included a smoothing parameter for the ratio of the bypassed city's population to the population of the nearest large city. This ratio was insignificant in its raw form in Models 2 and 3, but the smoothed function in Model 4 is statistically significant. This indicates that a nonlinear function of the population-distance ratio should be specified, and this is confirmed in the smoothed plot (see Figure 2). However, even with this transformed function, the AIC, BIC, and log-likelihood values only marginally improve.

The variance components of the panel model (Model 1) and the LME models (Models 2-4) are significantly different in magnitude (by a factor of 5-6 at the county level). In addition, the ICC of the county-level variance in the panel model is 50.4 percent, whereas the corresponding ICC in the mixed-effects model without variance correction (Model 2) is 91.9 percent. After correcting for heteroskedasticity and autocorrelation, the county-level decade indicator (the80s) variance begins to comprise a significantly larger portion of the overall variance. The inclusion of the between-county effect of manufacturing payroll was statistically significant, rendering the within-county effect insignificant.

5.3. Manufacturing Payroll: County to State Ratio (Natural Log)

The coefficient of the study city to large city population ratio variable is positive in all models. This shows that manufacturing payroll (relative to the state) will be positively impacted as the affected city grows over time (see Table 4). The positive coefficient on the large city distance ratio indicates that, the closer a larger city is, the more positive the impacts on manufacturing payroll. This is to be expected. A bypass has negative impacts on manufacturing payroll for the first 20 years the bypass is open, as shown by the negative coefficient for the 1-20 years age indicator. These negative impacts, however, are canceled out in later years as shown by the positive coefficients for the other age indicators (years 26-30, 31-35, and 36-40). In other words, while initial impacts on manufacturing payroll will be negative, there are also positive impacts, though they do not occur until a bypass had been open for more than 25 years.

Significant autocorrelation was present in the model. Similar to the model for proprietors' employment, including an indicator variable, varying by county, for each decade in which autocorrelation was present, in this case the 1980s and 1990s, removed this within-county autocorrelation. Furthermore, specifying different variances for each county greatly improved the overall fit of the model, as noted by the AIC, BIC, and log-likelihood statistics. The GAMM specification (Model 4) did not improve the overall statistical fit, confirmed by the effective degrees of freedom (EDF) of the smoothed population ratio variable (see Figure 3).

5.4. Retail Trade Employment: County to State Ratio

As shown by the negative coefficient of the number of turns variable, a harder-to-navigate downtown will negatively impact retail trade employment (relative to the state), even with a bypass in place, though the impact is not severe and is only marginally significant after correcting for heteroskedasticity and autocorrelation (Model 3, see Table 5). As expected, the presence of basic industry and other industries positively impact retail trade employment, because workers in these industries form the local customer base. The bypass age indicators for years 1-20 were positive statistically significant, though they decreased in magnitude after correcting for autocorrelation and heteroskedasticity (Model 3). The coefficients of the 21-30 and 31-40 age indicators and the bypass indicator are also positive, showing that the presence of a bypass will positively impact retail trade employment (relative to the state). All bypass age indicators are of similar magnitude except for the variance-corrected model (Model 3), indicating that the impacts are largely consistent over time. These positive impacts are evident when one drives down US-31 in Kokomo, US-30 in Columbia City, or US-24 in Huntington; these bypasses have all attracted development from large retail chain stores such as Wal-Mart. The presence of a nearby large city will also positively impact retail trade employment (relative to the state). This is also logical, because the population of these larger cities also constitute a portion of retail's customer base.

CHAPTER 6. ZIP CODE LEVEL RESULTS

6.1. Introduction

These models utilized a greater number of transportation network-related variables to capture the economic impacts at the ZIP Code level. Five types of models were estimated for three sectors: total employment (ZIP to State Ratio, percentage), manufacturing employment (ZIP to State Ratio, percentage), and retail trade employment (ZIP to State Ratio, percentage). Spatial econometric models were estimated using contiguity-based weights matrices. Cross-sectional models (using data from the year 2000) were estimated using Ordinary Least Squares (OLS) to test for the presence of spatial autocorrelation. Lagrange Multiplier tests for all three sectors indicated that the spatial lag specification would be most appropriate. Spatial lag models with White's heteroskedasticity-consistent estimator were estimated using spatial two-stage least squares (spatial 2SLS), which uses spatial lags of the exogenous variables (Bivand et al; 2010; Kelejian and Prucha 1998) as instruments. Non-parametric heteroskedasticity and autocorrelation consistent (HAC) estimators using the Epanechinkov kernel function were also calculated (Kelejian and Prucha 2007; Piras 2010). Marginal effects for the spatial 2SLS model are also presented as well as associated trace and density plots for selected variables from the MCMC sampling algorithms.

Multilevel models utilizing the full set of 1998-2007 data were estimated using three types of autocorrelation covariance structures: first-order antedependence, banded Toeplitz, and AR(1). It was generally found that the first-order antedependence models provided the best statistical fit. A random intercept was used for the total employment model. The manufacturing and retail trade models used a random parameter representing how many years a bypass had been open. This duration variable is equivalent for both bypassed communities as well as surrounding areas; in other words, it is assumed that time-related effects are uniform (but still drawn from a normal distribution) irrespective of whether a bypass is actually present in the ZIP Code. Other bypass-related variables included the lane-miles of the bypass present in the ZIP, an indicator representing whether a bypass was present in the ZIP and a spatially lagged version of this indicator (to represent economic impacts of nearby bypasses).

6.2. Total Employment: ZIP to State Ratio (Percentage)

The bypass-related variables presented conflicting results in both the multilevel models and the spatial models (see Table 6). The bypass indicator for the antedependence model, for example, shows that ZIP Codes with a bypass have a total employment ZIP to State Ratio that is 2.5 percent higher than surrounding ZIP Codes. However, this positive effect is less positive for each additional lane-mile of bypass present in the ZIP. These results could indicate that longer lengths of bypasses have more deleterious effects on bypassed communities because such bypasses are, by definition, farther away from the bypassed city. Thus, the possibility exists that bypasses located far away from the communities they are bypassing may not have the same types of impacts as bypasses located closer to the bypassed city – or, such highways may not be bypasses at all. The age indicators have different interpretations than the county-level models due to the different time frames used. For example, the Huntington bypass, which was opened in the 1960s and thus was only 10-15 years old in the 1970s is now 40-45 years old in the 2000s. Only Logansport in the study area had been open for 1-10 years in the 1998-2007 timeframe and thus the values of the age indicators correspond only to Logansport and generalization is limited. While there are initial negative impacts, these impacts are small in magnitude (only a few hundredths of a percent) compared to the magnitude of the bypass indicator.

The antedependence model provided the best statistical fit (see Table 7). The values of the covariance parameters for each of the three models can be found in Table 8. Plots of the levels of statistical significance and the signs of the random intercepts are shown in Figure 4, with positive and significant values having darker shades, negative and significant values with lighter shades, and insignificant values shown in white. Intercept values are positive in significant in the ZIP Codes around Huntington and Columbia City (on the east boundary of the study area near Fort Wayne) as well as ZIP Codes near South Bend (past the north boundary of the study area). This could indicate that the random intercepts are capturing positive unobserved effects of being near larger cities.

The spatial lag models yielded a negative spatial autoregressive coefficient. This indicates, as shown by the marginal effects (with MCMC traces and plots shown in Figure 5), that a positive change in a ZIP Code containing a bypass could have a negative change in surrounding areas and vice versa. This can be directly observed through analysis of the direct and indirect impacts, which show that the presence of a bypass increases total employment by 1.456 percent but decreases total employment in surrounding areas by a net -0.366 percent.

These models or the previous county-level models, however, do not fully address the issue of causality – a community of the average size described previously, for example, could already have higher employment relative to adjacent areas and thus higher local and through traffic levels, which would in turn lead to the construction of a bypass. However, previous studies (Mills and Fricker 2009, for example) have showed that this process does not follow a simple cause-and-effect framework. For example, in the case of Warsaw, Indiana, the orthopedic industry had established a presence there prior to the opening of the US-30 bypass. The bypass, once it opened, brought about "second-round" effects (as defined in Burress 1996), in which growth in basic industry (primarily the orthopedic industry) brought about additional development in the service and retail sectors. The orthopedic industry also continued to grow in Warsaw once the bypass opened. Thus, to assume a simple cause-and-effect process is to oversimplify the nature of economic impacts that take place over time. The focus of these models is placed on determining the magnitude of economic impacts. Previous work has placed emphasis on studying the economic development policies put in place by local and state officials in response to the construction and opening of a bypass, and the reader is referred to those studies for further details.

6.3. Manufacturing Employment: ZIP to State Ratio (Percentage)

The magnitudes of the bypass indicator (see Table 7) and the lane-miles of a bypass variable are both larger than the corresponding model for total employment for all five models. These differences indicate that the manufacturing sector is more sensitive to the nature of the local transportation network (although the variables for miles of interstate highways and miles of Urban Principal Arterial highways are no longer significant when compared to the total employment model). Each of the multilevel models has a bypass indicator larger in magnitude compared to the spatial lag models, which could indicate that not accounting for spatial autocorrelation overstates the impact of a bypass (this is also observed in the total employment model). The marginal effects for the spatial model illustrate how the manufacturing sector has a larger "reaction" to the presence of a bypass. Manufacturing employment in ZIP Codes with bypasses grow by 3.133 percent whereas nearby ZIP Codes decline by a net of -0.910 percent. These are both roughly three-fold increases in magnitude when compared to the total employment model. The coefficient maps for the random duration variable shed additional insight (see Figure 6). The magnitude of this variable is more positive in Logansport and Wabash but is negative in Peru. This could indicate that Peru, over the long term, may be losing potential manufacturing employers to Logansport and Wabash, depending on the tax incentives offered by those areas' respective economic development corporations. Such policy issues are discussed in the following section. Warsaw also has a positive and significant coefficient, which is expected given its continued growth in the orthopedic industry.

6.4. Retail Trade Employment: ZIP to State Ratio (Percentage)

The models for retail trade employment (Table 8) show generally similar magnitudes of coefficients as compared to the total employment model. The bypass-related variables, such as the bypass indicator and the lane-miles of a bypass, both show signs and levels of significance similar to the retail trade model. Differences between the spatial distribution of the random duration parameter of the retail trade and manufacturing models are noticeable (see Figure 7). While positive impacts are observed in Logansport and Wabash, impacts are no longer significant in Warsaw, a greater percentage of ZIP Codes show no significant impacts, particularly for the AR(1) model (far right). This indicates that manufacturing employment is more greatly impacted by the presence of a bypass over time compared to the retail sector. This result is not surprising, given the higher magnitudes of both the coefficients and the marginal effects in the manufacturing model.

Overall fit statistics for the multilevel models for all three industry sectors can be found in Table 9. The antedependence models provided the best overall fit. As shown in Table 10, all three sectors displayed non-uniform and statistically significant autocorrelation. The total employment model displayed the highest magnitude of autocorrelation. It is likely that accounting for this non-uniformity in autocorrelation is what led to higher fit values for all three industry sectors. Autocorrelation parameter values for the Toeplitz and AR(1) models are shown in Tables 11 and 12, respectively.

CHAPTER 7. BACKING UP THE MODELS: CASE STUDY ANALYSIS

7.1. Introduction

Two of the twelve communities analyzed are profiled here; the remainder of the community profiles can be found in the full research report (Fricker and Mills 2009). Angola, located in northeastern Indiana, has experienced a significant increase in truck traffic in recent years. Trucks use Angola's main thoroughfare as a free alternative to a nearby toll road. This increase in truck traffic has damaged city streets and posed a safety hazard to residents. A bypass of the city has been proposed for several years, but due to funding issues and uncertain benefits, the bypass project has been tabled. Community officials, however, have taken steps to update the city's Comprehensive Plan to explicitly address the issue of the bypass, both what actions should be taken if the bypass were built, and what traffic-calming measures should be implemented should the bypass not be built. Maps of both communities are shown in Figure 9.

Columbia City, a town similar in size to Angola, has had a bypass in place for nearly 50 years. While the downtown area declined over time, community officials have implemented several Tax Increment Finance (TIF) districts to encourage industrial development. While retail activity has relocated to the bypass and the city continues to attract industry, congestion along the bypass has increased and, according to local officials, the city is beginning to grow toward the bypass. The potential positive and negative impacts experienced by Columbia City can serve as an example to the public officials of Angola, if a bypass of the city is eventually constructed. Details are provided in the sections below.

7.2. Angola

7.2.1. Background

Angola is located in northeastern Steuben County, approximately 85 miles east of South Bend and 60 miles north of Fort Wayne. The city is host to a number of industries, including Powerscreen, a manufacturer of portable screening equipment for waste reprocessing, metal spinning companies, and a number of transportation equipment companies. Local attractions include Hamilton Lake and Pokagon State Park.

Principal routes through the city's CBD include US-20, IN-127, and IN-827 (see Figure 1). Travelers through the CBD must pass through the traffic circle in the center of town, located at the junction of US-20 and IN-127. Throughout the city, US-20 is a two-lane highway with no center turn lane, with parallel parking on the west side of downtown and angled parking near the Monument Circle.

7.2.2. The Need for a Bypass

A combination of local industry and increasing costs on the Indiana Toll Road (to the north) had led to an increase in truck traffic on US-20 over the years. Recent counts averaged 1,419 semi trailers per day, according to a Regional Planning Organization study (Region III-A, 2005). Many of these trucks carry hazardous materials, according to Mayor Richard Hickman. The trucks travel past the local middle school, the high school, two hospitals, and around the traffic circle in the CBD. The truck traffic poses problems for local residents traveling to the CBD, he said.

Drivers often experience great difficulty when getting in and out of both parallel and angled parking spots. The trucks hinder pedestrian traffic. The local residents have grown accustomed to the semis, but one can tell when "somebody new is in town," Hickman said. The trucks move at a "pretty good clip" and also cause issues for school traffic in the morning, according to Hickman. Additionally, the trucks tear up roads and have damaged the mound in the center of the traffic circle, Hickman said. The noise from the use of jake brakes when slowing down frequently disrupts conversations for residents.

No "tragic" incidents have occurred, but there have been a "series of mishaps" involving semis and automobiles, Hickman said. Hickman noted a recent incident in which two semis collided in front of the hospital and blocked the entrance to the emergency room. Only one semi-related fatality has occurred, he said. Given the situation and the nature of the cargo the trucks carry, the city is one accident away from disaster, he said.

7.2.3. Recent Developments

Discussions for a bypass around Angola began as early as 15 years ago, Hickman said. When Hickman first came into office in 2001, he held two meetings with the public and a private meeting with Congressman Mark Souder. He found that most residents agreed that a bypass was needed, although a few citizens voiced concern about the downtown dying as a result of the bypass's construction. For a study commissioned by INDOT, an Indianapolis-based consulting firm was hired to facilitate a series of meetings to determine the principal problems caused by the trucks, possible ways of rerouting them, and possible alignments of the bypass.

At a recent meeting between local officials and INDOT, it was learned that, after analyzing the results of the study, the plans for the bypass would not proceed, due to a lack of money. Costs were estimated at approximately $30-40 million, and because US-20 is part of the federal highway system, the bypass could have potentially been built and then have been rejected by the federal government as being a "viable bypass," thus resulting the alignment of US-20 remaining on the original route (City of Angola 2008). However, the bypass idea is not a "dead issue," according to Hickman.

Currently, Angola is in the middle of a revitalization program to enhance the attractiveness of the downtown, Hickman said. Many of the buildings feature a New England motif, and many of the buildings are quite old. However, even though the bypass has been tabled for the time being, plans are currently underway to lessen the problems caused by the truck traffic. This sentiment is highlighted in the *Angola Downtown Action Agenda 2006*: "The leadership of the community should be commended for their diligent efforts to have a truck route created. However, it should be realized that - if, for some reason, the truck route does not become a reality - Downtown Angola can still be enhanced so that it is a thriving business district" (HyettPalma, 2006).

Traffic calming measures have been proposed as an alternative solution, using such measures as patrols, weigh stations, noise level restrictions, and strict speed limit enforcement. These "non-capital intensive solutions" would aim to reduce the attractiveness of US-20 as a shortcut route for semi-trucks wishing to avoid the Indiana Toll Road (City of Angola 2008).

Should a bypass be built, public officials from Angola need to be adequately prepared to ensure the downtown area remains economically viable while through traffic is diverted. Angola officials noted that "bypasses have not been kind to historic downtowns," (City of Angola 2008) but the adverse impacts of diverted traffic could be mitigated with the proper land use measures put in place.

Columbia City, located 60 miles southwest of Angola, has had a bypass in place for approximately 40 years. The impacts of the bypass on its local economy will now be discussed.

7.3. Columbia City

7.3.1. Background

The county seat of Whitley County, Columbia City is located 20 miles west of Fort Wayne and 20 miles east of Warsaw. The city's principal industries include agriculture and manufacturing. Prominent employers in the area include Reelcraft Industries, Inc., UnderSea Sensor Systems, Inc., and Acme Industrial Maintenance & Machine.

7.3.2. Impacts of the US-30 Bypass

The original routing of US-30 ran south of the current bypass through the CBD of Columbia City. The original routing, now designated Business US-30, is a two-lane road through downtown with angled parking. The bypass has had a "two-edged effect" on Columbia City, according to Lowell Teska, President of Whitley County Economic Development Corporation. While the downtown has declined, the bypass has served as a means of attracting additional businesses that are dependent on through traffic. A row of chain restaurants and hotels runs along US-30 on frontage roads. The retail that established a presence in Columbia City may not have located there had they been limited to a downtown location, Teska said.

The relocation of most commercial activity to the bypass resulted in less emphasis placed on maintaining the downtown building stock. Many buildings in the downtown have remained empty over several years, Teska said. As a result, many of the buildings downtown have become rundown and have structural issues. A number of these buildings are privately owned; many of their owners also have properties along the US-30 bypass. These owners want to invest any spare funds into the locations along US-30 to generate revenue, Teska said. Businesses that have remained downtown include attorneys, doctors' offices, and restaurants that cater to the downtown lunch crowd.

Public perception of the bypass is primarily positive, due principally to the convenience factor of having stores and restaurants adjacent to each other, Teska said. On the flip side, older residents of the community are not comfortable with having to cross US-30 to get from their homes to stores and services. Most of the city's residences are located south of the bypass, whereas most stores and restaurants are located north of the bypass.

The presence of frontage roads limits the number of curb cuts, and the US-30 bypass has only 4-5 traffic signals, according to Teska. However, traffic on US-30 is usually congested, and it can be "tough" to go through more than one intersection at a time, he added.

Columbia City has grown since the bypass was opened, Teska said, but as a result, there are "two forces working against each other." Manufacturing companies and other local industry appreciate the routing and geometry of the bypass due to decreased travel time and consequently decreased transportation costs, but at the same time, with the city growing toward the bypass, the US-30 bypass is in danger of becoming a part of the downtown, Teska said.

The scenario of US-30 becoming a part of downtown is unlikely, according to Teska, due to several factors. Businesses want visibility along the bypass, driving up land prices (because land owners want a large return on their investment) to the point that only wealthy businesses, which happen to be big-box stores such as Wal-Mart, can afford the land. Smaller businesses are consequently forced to locate 3-4 blocks away from the bypass. The market conditions work to prevent a "mass exodus from the downtown area," Teska said. As a result, the high land prices along the bypass have separated small and large businesses, each of which have a separate customer base, according to Teska.

Larger businesses have more immediate access to the bypass, thus giving them a competitive edge over smaller businesses dependent on through traffic.

The bypass has been a factor in Columbia City's growth. A new business district has been created as through traffic and, consequently, the customer base has grown. The city "live[s] bigger than it really is," with services that could have never before been economically justified, Teska said. Before the bypass was built, the city was not large enough to warrant attention from many national chains, Teska said. As the community grew, businesses looking for new markets in which to compete, such as Blockbuster Video, located on the bypass, resulting in similar chain stores, such as Family Video, locating along the bypass. Only the chain stores can afford the land. The chain video stores are more conveniently located than the old mom-and-pop video stores, and eventually the mom-and-pop video stores are driven out of business.

The bypass has provided "more convenient traffic flow for commercial products" and resulted in the relocation of companies that might have otherwise relocated to a different city. While smaller businesses have been put at a disadvantage or have gone out of business altogether, the bypass has helped expand overall commercial activity in Columbia City, thus creating additional jobs, Teska said.

The pattern of urban sprawl and the pattern of relocated businesses has resulted in the downtown losing its position as a central core of activity, causing the city to become an "amorphous blob," Teska said. Residents running errands have to drive to one store on the extreme west side of town and then drive to another store on the extreme east side of town. Urban sprawl has also increased utility costs for residents. Typically, to attract businesses, the city provides a discount on utilities. As a result, the parties who have caused utilities to become more expensive end up paying less than long-time residents, according to Teska.

To ensure continued job growth and to keep younger people in Columbia City, a Tax Increment Financing (TIF) district was established near the US-30 bypass, the largest such TIF district in the state, according to Teska. A business park providing "shovel-ready" building sites was built in this district, attracting businesses such as the Steel Dynamics, Inc. plant, which employs hundreds of people. Recently, additional companies, such as Novae Corporation (trailer manufacturing) and Steel Plus Distribution (steel fabrication) have located to Columbia City (Whitley County EDC 2009). As described earlier, the "flip side" of these new developments is that, due to incentives provided to attract businesses, residents may end up paying increased utility bills and increased taxes.

The increase in industrial and retail activity in Columbia City confirms the trends shown in the statistical models. As revealed in the interviews, the implementation of TIF districts and the efforts of community officials to attract industry likely played a role in promoting economic development. While a bypass provided the opportunity for economic development, the actions taken by decision-makers are the key factor in whether any such development will occur. The potential positive and negative impacts experienced by Columbia City can serve as an example to the public officials of Angola of, if a bypass of the city is eventually constructed, what actions should be taken to promote economic development while maintaining the economic vitality of the city's downtown district. These "lessons learned" are further discussed in the following section.

CHAPTER 8. LESSONS LEARNED: IMPLICATIONS FOR COMMUNITIES WITH PROPOSED BYPASSES

8.1. Discussion

The policies implemented by public officials following the opening of a bypass were found to play a key role in the type and magnitude of long-term impacts. Wabash refocused its downtown around the popular Honeywell Center and implemented TIF districts to attract and retain industry. The city of Warsaw has maintained its dominance in the orthopedics industry, which, according to local officials, may have left the city had the US-30 bypass not been built. Washington, like Warsaw, renovated historic downtown buildings and capitalized on the local tourism and entertainment industries. In Huntington, the implementation of a pedestrian mall failed to improve its downtown, and local politics and community sentiments have hindered industrial development.

The lessons learned from case study interviews should be considered by public officials of communities with proposed bypasses. For Boonville, access to the bypass, once it has opened, should be controlled, in order to prevent the loss of mobility that occurred in Warsaw due to retail development. Retail activity in all four bypassed communities profiled declined, due both to retail consolidation (which played a bigger role in the decline in Washington than the bypass) and more convenient access to the bypass. Community officials in Boonville should take steps to prepare for a similar decline in downtown retail activity.

A proactive approach should be taken to mitigate any adverse impacts of a bypass, or in the case of Angola, the lack of a bypass. Communities should update their Comprehensive Plans to account for the presence of a bypass. The city of Huntington has not updated its comprehensive plan for several decades, according to local officials. The lack of a central, current plan may have contributed to its hindered economic growth. The city of Angola, on the other hand, updated its Downtown Revitalization Action Plan, a part of its Comprehensive Plan, to explicitly address both the proposed bypass and what actions the city takes should the bypass not be built. The city has implemented stricter speed limit enforcement, noise ordinances, and other traffic-calming measures to decrease the attractiveness of US-20 to trucks.

The lessons learned from the profiled communities can also be applied to other communities with proposed bypasses. A few such communities are briefly discussed below as examples.

Mt. Vernon: This community is geographically similar to Boonville in that IN-62 is a four-lane highway connecting each community to Evansville. Both communities also have large volumes of truck traffic. The high volumes to coal truck traffic in downtown Boonville left soot deposits on downtown buildings and houses. Quality-of-life issues should be investigated in the case of Mt. Vernon. Local officials and residents should be interviewed to determine whether the large truck volumes passing through town are having any adverse impacts on the local economy.

Delphi: The proposed alignment of the HHC connecting Lafayette to Logansport will bypass the city of Delphi to the south. The city, however, has taken a recent hit to its economy with the loss of several manufacturers. The models have shown a bypass can provide an opportunity for growth in the manufacturing sector, but external economic factors still play a large role. While the loss of jobs in Delphi may not have been preventable, the future IN-25 bypass will open up land for economic development and industrial parks.

Rushville: In anticipation of the opening of the Honda plant in Greensburg, local economic development officials have stepped up efforts to attract additional industry. The city is likely to have spillover effects from the Honda plant, but there may be a lag in development, though the models show that manufacturing employment would aid this increase should the IN-44 bypass be constructed.

Nelsonville, Ohio: A limited-access bypass of US-33 will shift its alignment from a two-lane road passing through the town. This bypass will comprise a major realignment of US-33 in southeastern Ohio connecting Columbus, Ohio to Ravenswood, West Virginia (Lane 2009). Two other US-33 bypasses, around the cities of Lancaster and Logan, were opened in the past 15 years. The Nelsonville bypass is being constructed to divert increasing volumes of truck traffic similar in magnitude to the truck volumes on US-20 in Angola, and the route is the eighth busiest truck route in Ohio (Ohio Department of Transportation 2009). The project is being used by the state to promote economic development along the new route, similar to the Hoosier Heartland Corridor in Indiana. Citizens in Nelsonville have expressed concern about whether the bypass will draw business away from downtown (Lane 2009), concerns similar to those expressed by residents of Angola. Community leaders of Nelsonville should take a proactive approach, like Angola, and update the city's Comprehensive Plan to account for the new bypass and capitalize on its existing tourism base of a nearby scenic railway and a revitalized downtown with a newly vibrant arts district (Leingang 2009).

Previous studies have focused primarily on the impact of bypasses on traffic-dependent businesses, with an emphasis on how sales are impacted, particularly in the retail sector. This project aimed to build on previous findings and focus on how other parts of a bypassed community's economy were affected.

Many of the bypasses in Indiana are at least 30 years old, and three bypasses (Lebanon, Kokomo, and Lafayette) are more than 50 years old. Many of the economic impacts from these bypasses came well after the bypasses were opened. (Mills and Fricker 2008) As learned from the interviews, many of the traffic management measures put in place, such as frontage roads, have been reactive (rather than proactive) measures.

One of the primary lessons from this study is the importance of planning in anticipation of a bypass. Where will the access points be along the bypass right-of-way? What changes in zoning and other land use strategies will allow the local economy to take advantage of (or at least minimize the harmful economic effects of) the bypass?

A common issue raised by local residents with a bypass in general is whether retail and other businesses will leave the downtown. The attitudes of downtown businesses should be investigated to identify these and any other issues regarding the downtown's continued vitality. The downtown revitalization efforts of other Indiana communities such as Washington and Wabash (as described in the previous section) should be pointed out to local officials as examples of what could be done to maintain a downtown's economic vitality.

The long-term impact of a bypass on a community is largely dependent on the policies enacted by local officials. A bypass's primary raison d'être may be to divert through traffic from city streets unable to handle large volumes of traffic, but from a local official's point of view, the combination of enhanced mobility (which lowers transportation costs, a key selling point for attracting basic industry) and newly accessible land provides an opportunity for growth. Local officials may choose to implement land use controls and public investments that favor development along the bypass, beginning with basic industry and followed by retail development. With limited access to/from the bypass, mobility is maintained, satisfying state DOT interests, while the new facility can generate new employment and more tax dollars, which satisfies local interests.

Other issues should be considered for communities with proposed bypasses. Local officials should be consulted to determine the status of the city or county Comprehensive Plan and the plans for downtown and outlying areas once the bypass is constructed. If a bypass is not warranted, local officials should have a "backup plan" for dealing with increased downtown traffic volumes, particularly if safety is an issue. Local land use and zoning policies should ensure that development does not impede mobility. The views of local businesses and residents should also be considered.

Without access control and land use restrictions, mobility is compromised by increased traffic volumes and at-grade intersections. As development intensifies, travel times increase, and the bypass degenerates into just another main thoroughfare in the community. In the cases of Kokomo and Warsaw, this change can bring about widespread delays and safety issues, especially when large trucks are prevalent. In extreme cases, such as Kokomo, a lack of access control and land use controls can result in a need for the bypass itself to be bypassed. The degradation of mobility does not necessarily mean that development along a bypass is a "bad" thing. It just may mean that the bypass has become an arterial that is helping to maintain the economic vitality of the city.

Development along a bypass, with or without access control, will draw retail business away from the central business district of the affected community. A bypass may benefit the affected county as a whole by increasing overall employment, but communities must take proactive measures to ensure that their downtown does not "die." Measures such as refocusing the downtown on entertainment, in the case of Wabash, or renovating upper floors of existing building stock to attract new residents, in the case of Washington, are good examples.

It is uncertain whether a bypass can act as a “savior” of a community without basic employment, which may occur if a primary employer, such as a manufacturing or mining company, has closed down. Throughout the interviews conducted for this study, the growth of the manufacturing sector in communities with bypasses was frequently mentioned. Examples include the continued expansion of the orthopedic manufacturing industry in Warsaw and the new industrial park recently opened near the bypass at Logansport. Communities with existing basic employment will likely benefit from the presence of a bypass, as noted in this. In the case of Warsaw, it is likely DePuy and other companies would have left Warsaw had the US-30 bypass, with its truck-friendly geometry, not been constructed, even if it no longer functions as a bypass today.

8.2. Limitations

While the findings of this study provide insight into how economic impacts of bypasses change over time, the methodology and data used do have their limitations. A small sample size of counties (N = 7) was used, and even though the models pass the Hausman specification test, generalization to other cases should be done with caution. The county level is a high level of aggregation and may mask underlying impacts. While there may be a net increase in employment within a county, negative impacts could be occurring within certain areas within that county. This is highlighted by the negative spatial lag coefficients in the ZIP Code-level models. A limited number of industrial sectors was analyzed for this study, and the contemporaneous relationships between these industry sectors were not captured in the models. Future studies should consider a wider spectrum of industries. The explanatory variables used for modeling county-level impacts are primarily based on how many years the bypass had been open and on population figures. While the ZIP Code-level models do include transportation infrastructure-related variables, additional transportation variables, such as cross-sectional characteristics, traffic signal density, and traffic volumes would contribute additional information.

8.3. Concluding Remarks

The impacts of bypasses on the downtown areas of these small- and medium-sized communities cannot be easily captured by statistical models, due to aggregation data, a by-product of Census disclosure laws limiting the availability of local, more disaggregate data, and due to the difficulty in identifying and quantifying the decisions made in the past by public officials. Even with these downsides, the statistical models have largely confirmed the claims made by public officials interviewed for this study. The combination of the county-level and ZIP Code-levels, in conjunction with the case study interviews, have shown that bypasses can have positive and statistically significant economic impacts on communities. The panel data and multilevel models showed significant variance over space. The panel data models and the multilevel models indicated that between-county and between-ZIP variance accounted for a considerable portion of the overall model variance. The spatial econometric models identified significant negative spillover effects and indicated that spatial autocorrelation is present at the ZIP Code level.

Columbia City has experienced significant growth in employment since the opening of the US-30 bypass, although this growth may have come at the cost of a declining downtown. Angola may be able to handle the problem of heavy truck traffic using the proposed traffic calming measures, but should a bypass be built, public officials should be prepared to implement effective land use policies that can help stimulate growth in employment while maintaining the downtown area’s economic vitality. The statistical models show that there are significant economic impacts and that these impacts change over time. Multiple methods – multilevel models, spatial econometric analysis, panel data analysis – yielded the same results. Bypasses, over time, will lead affected areas to contribute more to the state's economy, both at the county and ZIP Code levels.. Bypasses, in short, will provide the public with an opportunity to expand the local employment base, although these impacts may not be realized for many years.

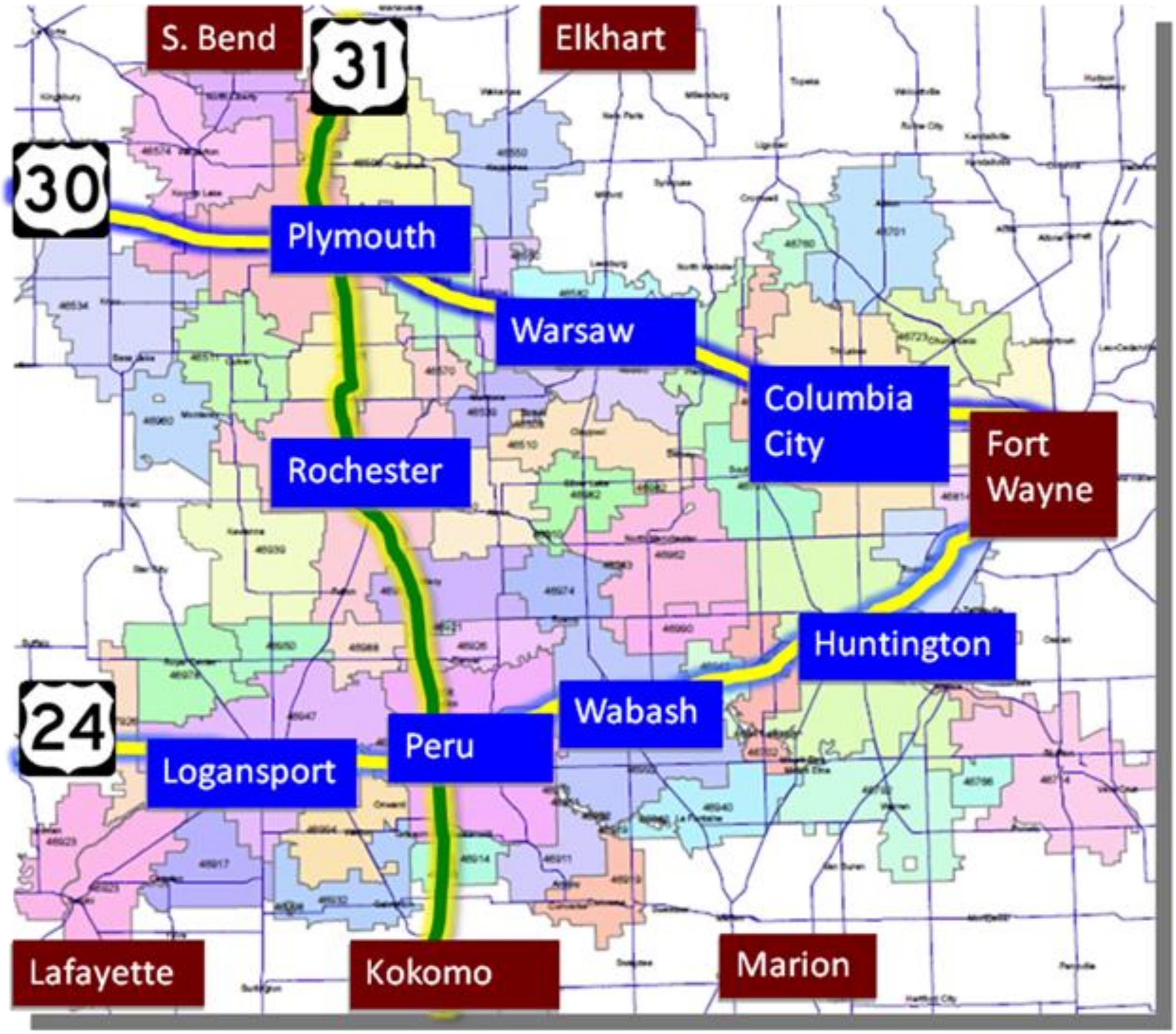

Figure 1: Study area selected for analysis, with principal routes. Bypassed communities are coded blue, and nearby large cities are coded red.

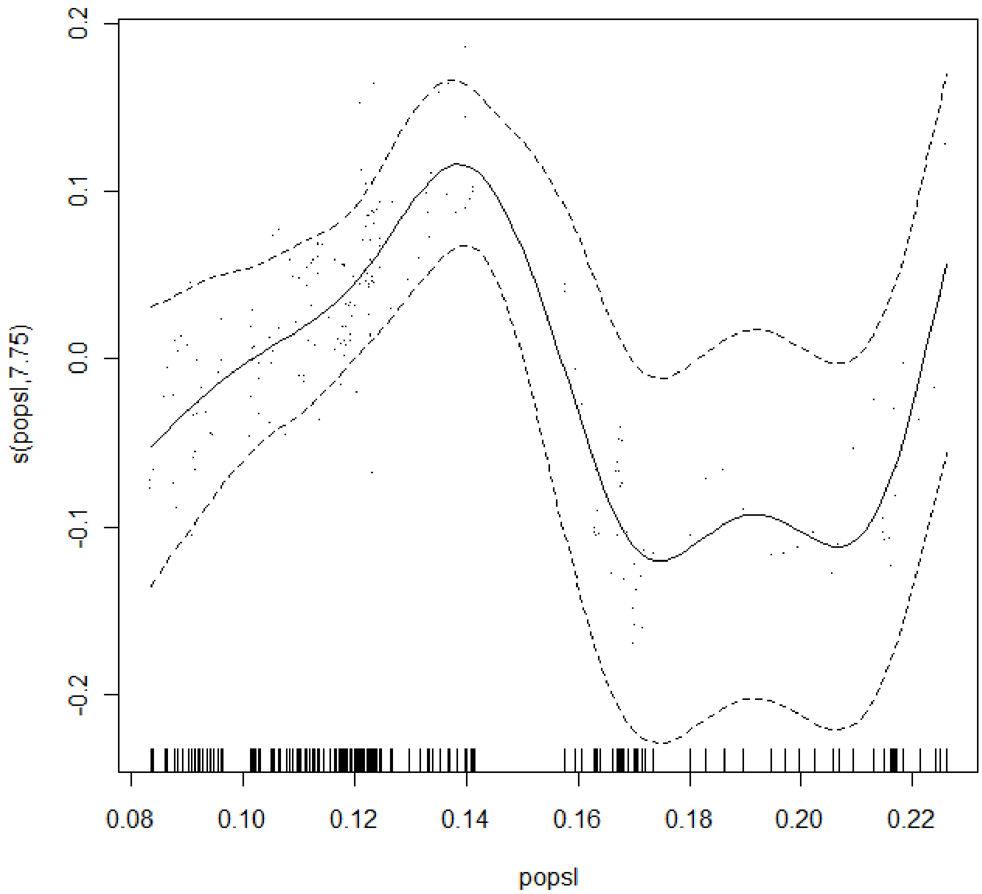

Figure 2: Smoothing Parameter Plot for Ratio of Population of bypassed city to population of nearest large city for proprietors' employment model.

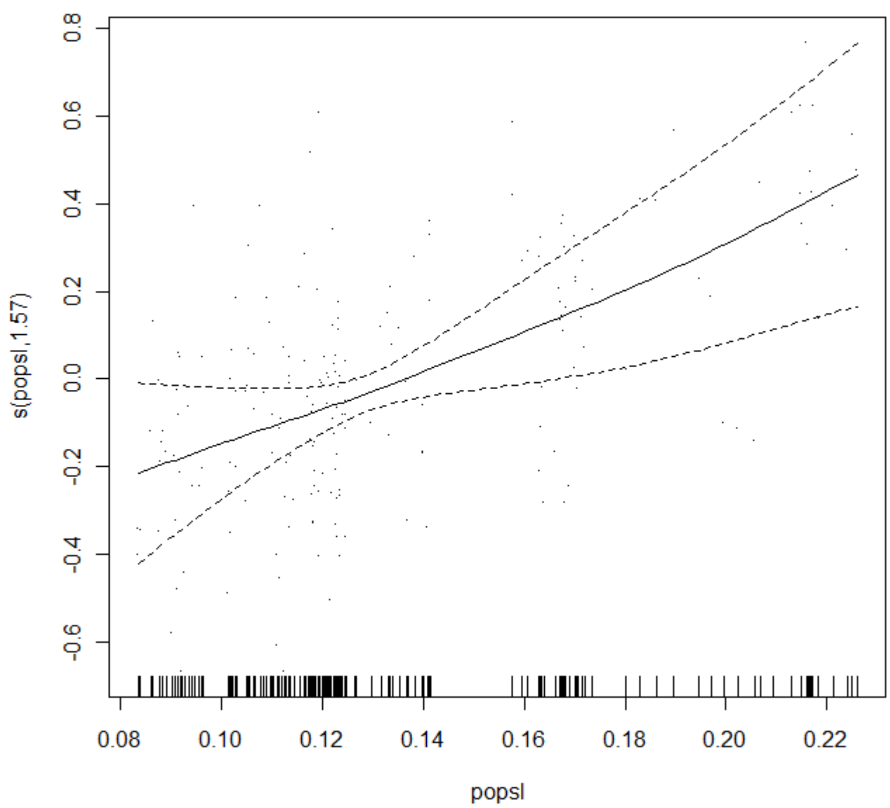

Figure 3: Smoothing Parameter Plot for Ratio of Population of bypassed city to population of nearest large city for manufacturing payroll model.

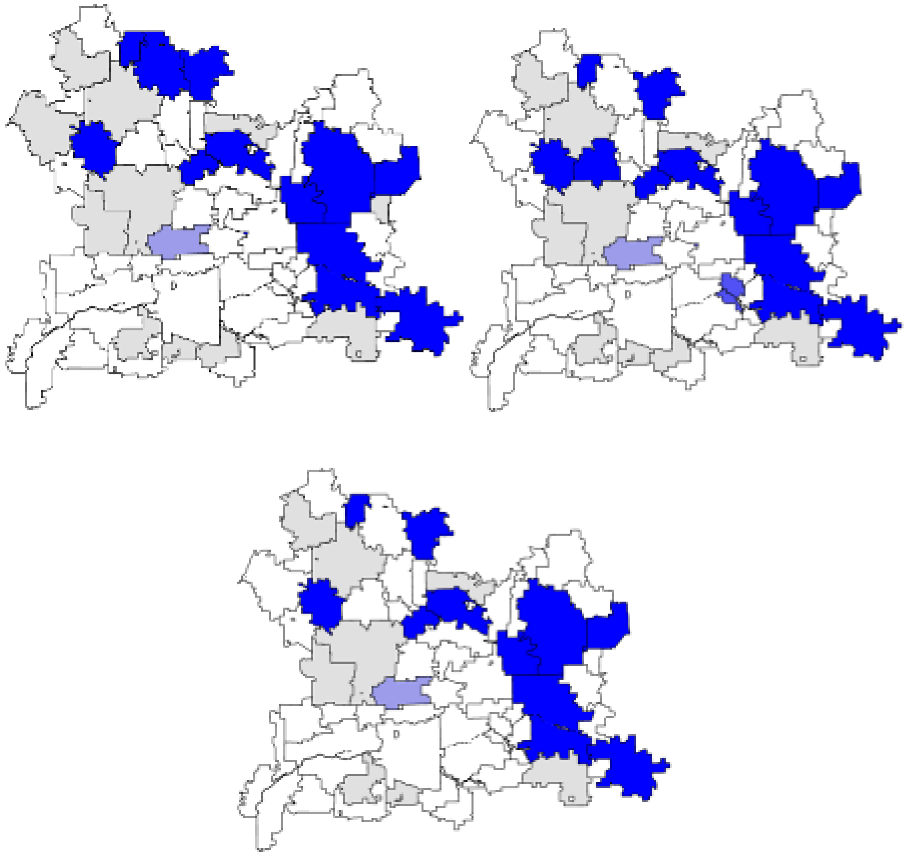

Figure 4: Estimates for Total Employment, random intercept for antedependence model (left), Toeplitz model (middle), and AR(1) model (right). Darker values are positive, lighter values negative. White indicates the intercept was not statistically significant.

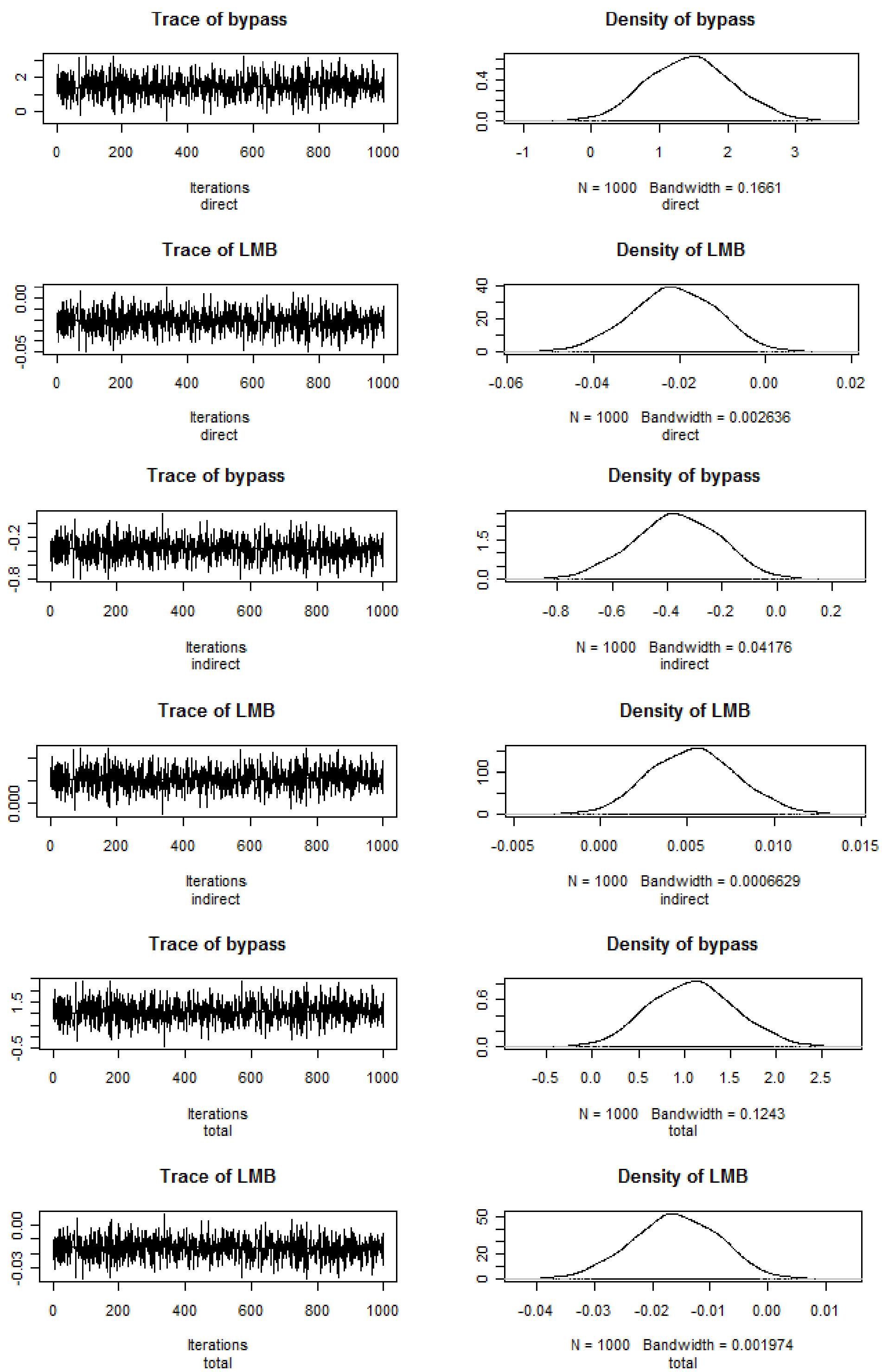

Figure 5: Markov Chain Monte Carlo trace and density simulation plots for marginal effects of bypass indicator variable and interaction of bypass indicator and lane-miles of bypass variable for direct impacts (top), indirect impacts (middle), and total impacts (bottom).

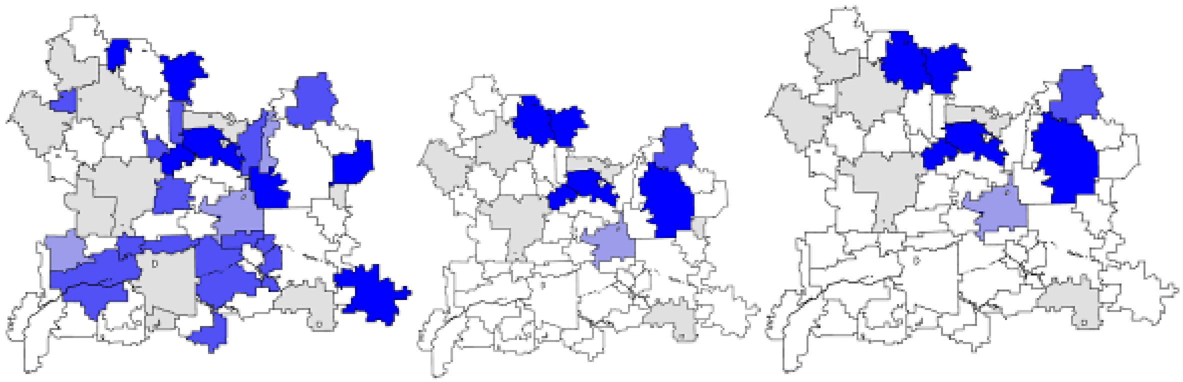

Figure 6: Estimates for Manufacturing Employment, random bypass age duration variable for antedependence model (left), Toeplitz model (middle), and AR(1) model (right). Darker values are positive, lighter values negative. White indicates the coefficient was not statistically significant.

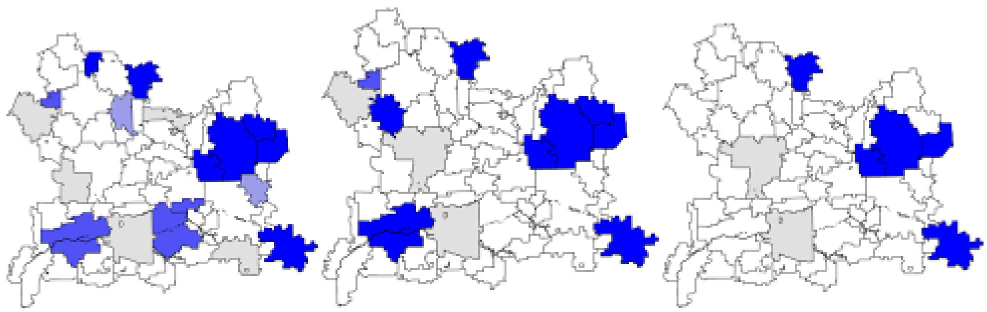

Figure 7: Estimates for Retail Trade Employment, random bypass age duration variable for antedependence model (left), Toeplitz model (middle), and AR(1) model (right). Darker values are positive, lighter values negative. White indicates the coefficient was not statistically significant.

Figure 8: Maps of Angola (left) and Columbia City (right). Source: Google Maps

Table 1: Descriptive statistics for bypasses communities in study area.

City	Population			% Change 1990-2000	% Change 2000-2008	County	Year By-pass Opened
	1990	2000	2008				
Logansport	16,812	19,684	18,663	17.1%	-5.2%	Cass	1999
Peru	12,843	12,994	12,301	1.2%	-5.3%	Miami	1979
Wabash	12,127	11,743	10,815	-3.2%	-7.9%	Wabash	1964
Huntington	16,389	17,450	16,521	6.5%	-5.3%	Huntington	1964
Columbia City	5,706	7,077	8,283	24.0%	17.0%	Whitley	1963
Warsaw	10,968	12,415	13,627	13.2%	9.8%	Kosciusko	1972
Plymouth	8,303	9,840	11,038	19.0%	12.0%	Marshall	1975
Rochester	5,969	6,414	6,457	7.0%	1.0%	Fulton	1975
Kokomo	44,962	46,113	45,694	2.6%	-0.9%	Howard	1951
Washington	10,838	11,380	11,397	5.0%	0.1%	Daviess	1991

Table 2: Models for County-level Total Employment: County to State Ratio (Natural Log)

	One-way random-effects panel (Amemiya estimator) (Model 1)			LME with random intercept (REML estimation) (Model 2)			LME random intercept and random coefficients (REML estimation) (Model 3) *Variance Function: By County*		
Variable	**Estimate**	**Std. Error**	**t-value**	**Value**	**Std.Error**	**t-value**	**Value**	**Std.Error**	**t-value**
Intercept	-7.153	0.269	-26.567	-7.268	0.233	-31.140	-6.803	0.234	-29.116
Population of nearest large city / Natural log of distance (miles) from study city to nearest large city	1.05E-05	2.13E-06	4.938	1.17E-05	1.87E-06	6.237	1.07E-05	1.99E-06	5.370
Population of study city / Population of nearest large city	8.321	0.717	11.598	8.377	0.715	11.721	5.391	0.465	11.595
Indicator: 1 if the study city is bypassed by US-30, 0 otherwise	-0.109	0.061	-1.783	-0.113	0.061	-1.857	0.024	0.032	0.739
Bypass Indicator*Number of turns along original route in study city CBD	0.008	0.009	0.847	0.010	0.009	1.025	0.004	0.008	0.471
Bypass Indicator*Distance from study city CBD to bypass along original route	-0.041	0.007	-5.648	-0.042	0.007	-6.060	-0.031	0.006	-5.343
Indicator: 1 if the bypass has been open for 1 to 15 years, 0 otherwise	0.182	0.028	6.508	0.191	0.027	7.012	0.099	0.024	4.033
Indicator: 1 if the bypass has been open for 16 to 20 years, 0 otherwise	0.156	0.027	5.731	0.162	0.027	6.033	0.110	0.021	5.164
Indicator: 1 if the bypass has been open for 21 to 25 years, 0 otherwise	0.126	0.025	5.041	0.130	0.025	5.251	0.070	0.019	3.602
Indicator: 1 if the bypass has been open for 26 to 30 years, 0 otherwise	0.109	0.026	4.146	0.113	0.026	4.286	0.052	0.026	1.998

Indicator: 1 if the bypass has been open for 31 to 35 years, 0 otherwise.	0.124	0.025	4.910	0.127	0.025	4.995	0.033	0.025	1.302
Variance Components									
	Variance	**ICC**		**Variance**	**ICC**		**Variance**	**ICC**	
idiosyncratic	0.005	0.032	idiosyncratic	0.005	0.057	idiosyncratic	0.004	0.033	
individual	0.145	0.968	individual	0.080	0.943	individual	0.119	0.874	
theta (individual)	0.966					the90s	0.013	0.093	
Model Diagnostics									
Test	**Value**	**p-val**	**Statistic**	**Value**		**Statistic**	**Value**		
Hausman	4.007	0.947	AIC	-350.902		AIC	-410.068		
LM (BP)	264.327	0.000	BIC	-309.038		BIC	-352.441		
R-squared	0.853		LL	188.451		LL	226.034		
			R-squared			R-squared			
			Likelihood ratio test			Ratio	75.166		
			(Model 3 vs. Model 2)			p-value	0.000		

Table 3: Model Results for County-Level Proprietors' Employment: County to State Ratio (Natural Log)

	Two-way random effects panel (Wallace-Hussein estimator) (Model 1)			**LME with random intercepts for county, time (REML estimation) (Model 2)**			**LME random intercepts and random coefficients (REML estimation) (Model 3)**			**GAMM random intercepts and random coefficients (Model 4)**		
							Variance Function: By County			*Variance Function: By County*		
Variable	**Estimate**	**Std. Error**	**t-value**	**Value**	**Std.Error**	**t-value**	**Value**	**Std.Error**	**t-value**	**Value**	**Std.Error**	**t-value**
Intercept	-4.948	0.143	-34.579	-4.941	0.178	-27.751	-4.649	0.131	-35.407	-4.255	0.126	-33.646
Population of nearest large city / Natural log of distance (miles) from study city to nearest large city	-2.95E-06	1.41E-06	-2.097	-3.57E-07	1.87E-06	-0.190	-8.23E-06	1.34E-06	-6.158	*0.000*	*0.000*	*-5.776*
Population of study city / Population of nearest large city	2.291	0.529	4.327	1.244	0.548	2.270	2.470	0.342	7.222	0.332	0.056	5.980
Bypass Indicator*Number of turns along original route in study city CBD	0.019	0.006	2.917	0.021	0.007	2.938	0.049	0.008	6.395	0.048	0.008	5.929
Bypass Indicator*Distance from study city CBD to bypass along original route	-0.022	0.004	-4.969	-0.034	0.004	-8.317	-0.020	0.003	-7.626	-0.014	0.004	-3.305
Manufacturing First-Quarter Payroll (County to State Ratio)	-1.460	1.620	-0.901	-0.793	1.601	-0.495	-0.310	0.962	-0.322	0.015	0.999	0.015
Indicator: 1 if the bypass has been	0.065	0.015	4.190	0.101	0.015	6.529	0.061	0.011	5.498	0.061	0.013	4.745

open for 1 to 10 years, 0 otherwise												
Indicator: 1 if the bypass has been open for 11 to 15 years, 0 otherwise	0.043	0.016	2.645	0.062	0.016	3.855	0.037	0.011	3.545	0.034	0.010	3.312
Indicator: 1 if the bypass has been open for 21 to 25 years, 0 otherwise	-0.039	0.015	-2.571	-0.033	0.015	-2.234	-0.044	0.009	-5.055	-0.045	0.009	-5.183
Indicator: 1 if the bypass has been open for 26 to 35 years, 0 otherwise	-0.067	0.013	-5.026	-0.059	0.013	-4.462	-0.106	0.009	-12.244	-0.103	0.011	-9.294
Contextual Variable: County Average of Manufacturing First-Quarter Payroll, County to State Ratio	28.123	4.169	6.746	19.747	7.255	2.722	44.242	5.999	7.375	46.665	6.596	7.074

Variance Components

	Variance	**ICC**		**Variance**	**ICC**		**Variance**	**ICC**		**Variance**	**ICC**
idiosyncratic	0.004	0.385	idiosyncrat-ic	0.001	0.015	idiosyncrat-ic	0.003	0.077	idiosyncratic	0.001	0.031
individual	0.005	0.504	individual	0.033	0.919	individual	0.028	0.671	individual	0.034	0.736
time	0.001	0.111	time	0.002	0.067	the80s	0.010	0.253	the80s	0.011	0.233
theta (individual)	0.837										
theta (time)	0.423										
theta(total)	0.419										

Model Diagnostics

Test	**Value**	**p-val**	**Statistic**	**Value**	**Statistic**	**Value**	**Statistic**	**Value**
Hausman (No cvar)	2090.053	0.000	AIC	-465.114	AIC	-585.756	AIC	-599.150
Hausman (With cvar)	8.9256	0.4442	BIC	-420.029	BIC	-518.128	BIC	-528.302
LM (BP)	565.114	0.695	LL	246.557	LL	313.878	LL	321.575

R-squared	0.554	R-squared	-	R-squared	-	R-squared	0.993
		Likelihood ratio test		Ratio	134.642	**Spline Smoothed Parameter (popsl)**	
		(Model 3 vs. Model 2)		p-value	0.000	**EDF**	7.751
						F-test	16.25***
						Scale Parameter	0.001

Table 4: Model Results for County-Level Manufacturing Payroll: County to State Ratio (Natural Log)

	Two-way random effects panel (Wallace-Hussein estimator) (Model 1)			LME with random intercepts for county, time (REML estimation) (Model 2)			LME random intercepts and random coefficients (REML estimation) (Model 3)			GAMM random intercepts and random coefficients (Model 4)		
							Variance Function: By County			*Variance Function: By County*		
Variable	**Estimate**	**Std. Error**	**t-value**	**Value**	**Std.Error**	**t-value**	**Value**	**Std.Error**	**t-value**	**Value**	**Std.Error**	**t-value**
Intercept	-2.748	1.390	-1.976	-2.587	1.379	-1.875	-2.844	0.972	-2.926	-2.100	0.896	-2.344
Population of nearest large city / Natural log of distance (miles) from study city to nearest large city	1.86E-05	4.71E-06	3.950	1.69E-05	4.32E-06	3.924	1.33E-05	3.30E-06	4.036	0.000	0.000	3.686
Population of study city / Population of nearest large city	6.998	2.042	3.428	6.861	2.035	3.371	5.110	1.619	3.157	*0.191*	*0.073*	*2.605*
Annual earnings, Agricultural Services (County to State Ratio)	0.176	6.243	0.028	-0.503	6.201	-0.081	-11.708	4.320	-2.710	-11.456	4.369	-2.622
Retail Trade First-Quarter Payroll, County to State Ratio (Natural Log)	0.973	0.176	5.525	0.969	0.176	5.491	0.773	0.135	5.730	0.768	0.137	5.596
Bypass Indicator*Distance from study city CBD to bypass along original route	0.044	0.014	3.080	0.044	0.014	3.118	0.027	0.012	2.189	0.027	0.012	2.158
Indicator: 1 if the bypass has been open for 1 to 20 years, 0 otherwise	-0.078	0.038	-2.025	-0.081	0.038	-2.116	-0.092	0.029	-3.219	-0.087	0.029	-3.012

Indicator: 1 if the bypass has been open for 26 to 30 years, 0 otherwise	0.059	0.051	1.147	0.059	0.052	1.140	0.094	0.047	1.980	0.095	0.048	1.978
Indicator: 1 if the bypass has been open for 31 to 35 years, 0 otherwise.	0.058	0.051	1.135	0.060	0.052	1.165	0.095	0.053	1.783	0.096	0.054	1.783
Indicator: 1 if the bypass has been open for 36 to 40 years, 0 otherwise.	0.168	0.087	1.927	0.169	0.088	1.922	0.146	0.073	2.000	0.144	0.074	1.946

Variance Components

	Variance	ICC		Variance	ICC		Variance	ICC		Variance	ICC
idiosyncratic	0.029	0.061	idiosyncratic	0.006	0.018	idiosyncratic	0.058	0.186	idiosyncratic	0.057	0.191
individual	0.446	0.939	individual	0.282	0.907	individual	0.184	0.593	individual	0.177	0.588
time	0.000	0.000	time	0.023	0.075	the80s	0.034	0.111	the80s	0.033	0.109
theta(individual)	0.95186					the90s	0.034	0.110	the90s	0.034	0.112

Model Diagnostics

Test	**Value**	**p-val**	**Statistic**	**Value**	**Statistic**	**Value**	**Statistic**	**Value**
Hausman	10.867	0.285	AIC	-41.632	AIC	-146.904	AIC	-138.340
LM (BP)	884.832	0.000	BIC	0.302	BIC	-72.712	BIC	-60.922
R-squared	0.483		LL	33.816	LL	96.452	LL	93.170
			R-squared		R-squared		R-squared	0.977
			Likelihood ratio test		Ratio	125.272	**Tensor Smoothed Parameter (popsl)**	
			(Model 3 vs. Model 2)		p-value	0.000	**EDF**	1.575
							F-test	6.713**

Table 5: Model Results for Retail Trade Employment: County to State Ratio

Variable	Two-way random effects panel (Amemiya estimator) (Model 1)			LME with random intercepts for county, time (REML estimation) (Model 2)			LME random intercepts and random coefficients (REML estimation) (Model 3) *Variance Function: Combination of (1) Exponential of years bypass has been open, by county (2) Variance by time*		
	Estimate	Std. Error	t-value	Value	Std.Error	t-value	Value	Std.Error	t-value
Intercept	-0.00247	0.00160	-1.54343	-0.00229	0.00129	-1.77592	-0.00142	0.00120	-1.19173
Population of nearest large city / Natural log of distance (miles) from study city to nearest large city	7.22E-08	1.42E-08	5.09386	7.03E-08	1.17E-08	6.00771	6.60E-08	1.04E-08	6.34883
Bypass Indicator*Number of turns along original route in study city CBD	0.00002	0.00006	0.34517	0.00002	0.00006	0.37212	-0.00006	0.00005	-1.18114
Bypass Indicator*Distance from study city CBD to bypass along original route	-0.00033	0.00006	-5.43642	-0.00033	0.00006	-5.77942	-0.00024	0.00004	-5.31034
Number of Manufacturing establishments: County to State Ratio	0.13304	0.04048	3.28683	0.12990	0.03909	3.32268	0.09400	0.02688	3.49704
Annual Earnings, Health Services (County to State Ratio)	0.22244	0.05141	4.32678	0.23423	0.05089	4.60286	0.24718	0.04502	5.49098
Manufacturing First-Quarter Payroll (County to State Ratio)	0.04784	0.01071	4.46474	0.04799	0.01078	4.45296	0.02315	0.00900	2.57329
Indicator: 1 if the bypass has been open for 1 to 15 years, 0 otherwise	0.00104	0.00026	4.06458	0.00103	0.00025	4.15188	0.00080	0.00018	4.50046
Indicator: 1 if the bypass has been open for 16 to 30 years, 0	0.00111	0.00023	4.91681	0.00107	0.00022	4.79787	0.00093	0.00017	5.54793

otherwise									
Indicator: 1 if the bypass has been open for 31 to 40 years, 0 otherwise	0.00109	0.00020	5.46823	0.00105	0.00020	5.29530	0.00102	0.00016	6.35209
Variance Components									
	Variance	**ICC**			**Variance**	**ICC**		**Variance**	**ICC**
idiosyncratic	1.534E-07	0.026	idiosyncratic	2.779E-08	0.009		idiosyncratic	2.860E-07	0.084
individual	5.683E-06	0.971	individual	3.014E-06	0.950		individual	3.020E-06	0.882
time	1.813E-08	0.003	time	1.305E-07	0.041		the90s	1.192E-07	0.035
Model Diagnostics									
Test	**Value**	**p-val**	**Statistic**	**Value**			**Statistic**	**Value**	
Hausman (No cvar)	6.010	0.739	AIC	-2302.086			AIC	-2328.008	
LM (BP)	319.457	0.000	BIC	-2260.151			BIC	-2173.172	
			LL	1164.043			LL	1212.004	
R-squared	0.547		LL(0)				LL(0)		
			R-squared				R-squared		
			Likelihood ratio test				Ratio	95.921	
			(Model 3 vs. Model 2)				p-value	0.000	

Table 6: Model Results for ZIP Code-level Total Employment: ZIP to State Ratio (Percentage)

Total Employment	OLS		Antedependence		Toeplitz		AR(1)		Spatial 2SLS			Marginal Effects (Spatial 2SLS)		
	Estimate	*t*	*Estimate*	*t*	*Estimate*	*t*	*Estimate*	*t*	*Estimate*	*t (Robust)*	*t (HAC)*	*Direct*	*Indirect*	*Total*
Intercept	0.158	3.49	0.059	0.58	0.069	0.66	0.067	0.64	0.166	3.24	4.37	-	-	-
Miles of interstate highway within ZIP	0.007	2.19	0.006	1.74	0.006	1.77	0.006	1.78	0.006	2.13	1.72	0.006	-0.001	0.004
Miles of highways classified as Urban Principal Arterial within ZIP	0.024	3.01	0.025	3.05	0.023	2.81	0.023	2.83	0.028	1.99	2.07	0.029	-0.007	0.021
Bypass Indicator: 1 if a bypass is present in the ZIP, 0 otherwise	1.560	3.55	2.497	5.50	2.017	4.37	2.052	4.44	1.428	2.33	2.96	1.456	-0.366	1.090
Lane-miles of bypass in ZIP with nearest bypassed community	-	-	0.002	1.01	0.002	0.99	0.002	1.00	-	-	-	-	-	-
Interaction: Bypass Indicator * Lane-miles of bypass in ZIP with nearest bypassed community	-0.024	-3.32	-0.038	-5.12	-0.031	-4.08	-0.032	-4.15	-0.021	-2.16	-2.67	-0.021	0.005	-0.016
Miles of local roads within ZIP	0.000	3.84	0.000	3.48	0.000	3.55	0.000	3.56	0.000	4.83	7.27	0.000	0.000	0.000
Interaction: Bypass Indicator * Miles of local roads within ZIP	-0.001	-3.88	-0.001	-5.80	-0.001	-4.59	-0.001	-4.68	-0.001	-3.39	-5.72	-0.001	0.000	-0.001
Bypass Indicator (Spatially Lagged, Two Nearest Neighbors)	0.050	1.45	0.066	1.91	0.059	1.71	0.060	1.73	0.081	2.31	2.36	0.083	-0.021	0.062
Percentage rural population in ZIP	-0.184	-4.49	-0.174	-4.28	-0.182	-4.41	-0.182	-4.38	-0.164	-3.38	-4.65	-0.168	0.042	-0.125
Percentage of population with a PhD Degree	-4.631	-2.44	-3.779	-2.01	-4.214	-2.20	-4.244	-2.21	-4.369	-1.94	-2.49	-4.457	1.121	-3.337

Indicator: 1 if the by-pass has been open 1 to 5 years, 0 otherwise	-	-	-0.017	-2.55	-0.020	-2.19	-0.018	-1.84	-	-	-	-	-	-
Indicator: 1 if the by-pass has been open 6 to 10 years, 0 other-wise	-	-	-0.046	-5.26	-0.052	-5.14	-0.051	-4.00	-	-	-	-	-	-
Indicator: 1 if the by-pass has been open 21 to 25 years, 0 other-wise	-	-	0.003	0.93	0.000	0.02	0.006	1.30	-	-	-	-	-	-
Indicator: 1 if the by-pass has been open 31 to 35 years, 0 other-wise	-	-	-0.005	-1.47	0.003	0.72	0.004	1.11	-	-	-	-	-	-
Spatial Lag Parameter (Rho)	-	-	-	-	-	-	-	-	-0.309	-2.19	-3.03	-	-	-
Sample Size	65		650		650		650		65					

Table 7: Model Results for ZIP Code-Level Manufacturing Employment: ZIP to State Ratio (Percentage)

Manufacturing Employment	OLS		Antedependence		Toeplitz		AR(1)		Spatial 2SLS			Marginal Effects (Spatial 2SLS)		
	Estimate	*t*	*Estimate*	*t*	*Estimate*	*t*	*Estimate*	*t*	*Estimate*	*t (Robust)*	*t (HAC)*	*Direct*	*Indirect*	*Total*
Intercept	0.241	2.58	0.486	2.32	0.343	1.73	0.345	1.74	0.250	2.49	3.25	-	-	-
Miles of interstate highway within ZIP	0.010	1.37	0.023	1.83	0.018	1.72	0.016	1.63	0.006	0.95	1.04	0.006	-0.002	0.004
Miles of highways classified as Urban Principal Arterial within ZIP	0.014	0.82	0.018	0.79	0.031	1.62	0.030	1.60	0.024	1.11	1.45	0.024	-0.007	0.017
Bypass Indicator: 1 if a bypass is present in the ZIP, 0 otherwise	3.488	3.83	3.472	2.32	5.055	4.20	4.665	3.92	3.045	2.31	3.60	3.133	-0.910	2.223
Lane-miles of bypass in ZIP with nearest bypassed community	-	-	-0.001	-0.38	-0.002	-0.77	-0.002	-0.78	-	-	-	-	-	-
Interaction: Bypass Indicator * Lane-miles of bypass in ZIP with nearest bypassed community	-0.054	-3.63	-0.056	-2.30	-0.078	-3.95	-0.072	-3.72	-0.045	-2.15	-3.14	-0.046	0.013	-0.033
Miles of local roads within ZIP	0.001	4.17	0.001	5.61	0.001	4.83	0.001	4.91	0.001	6.03	8.99	0.001	0.000	0.001
Interaction: Bypass Indicator * Miles of local roads within ZIP	-0.002	-3.78	-0.002	-2.40	-0.003	-4.80	-0.003	-4.40	-0.002	-2.75	-5.36	-0.002	0.001	-0.001
Bypass Indicator (Spatially Lagged, Two Nearest Neighbors)	0.116	1.63	-0.003	-0.04	0.046	0.59	0.049	0.64	0.172	2.25	2.28	0.177	-0.051	0.125
Percentage rural population in ZIP	-0.300	-3.55	-0.551	-4.42	-0.335	-3.25	-0.335	-3.29	-0.249	-2.80	-4.03	-0.257	0.075	-0.182
Percentage of population with a PhD Degree	-7.551	-1.92	-2.350	-0.41	-4.748	-0.96	-5.382	-1.10	-7.056	-1.96	-2.09	-7.259	2.109	-5.151
Spatial Lag Parameter (Rho)	-	-	-	-	-	-	-	-	-0.370	-2.22	-2.97	-	-	-

Sample Size	65	650	650	650	65

Table 8: Model Results for ZIP Code-Level Retail Trade: ZIP to State Ratio (Percentage)

Retail Employment	OLS		Antedependence		Toeplitz		AR(1)		Spatial 2SLS			Marginal Effects (Spatial 2SLS)		
	Estimate	*t*	*Estimate*	*t*	*Estimate*	*t*	*Estimate*	*t*	*Estimate*	*t (Robust)*	*t (HAC)*	*Direct*	*Indirect*	*Total*
Intercept	0.115	2.76	0.088	1.25	0.094	1.47	0.082	1.01	0.121	2.59	3.16	-	-	-
Miles of interstate highway within ZIP	0.002	0.49	0.012	2.04	0.005	1.38	0.004	1.08	0.001	0.23	0.17	0.001	0.000	0.000
Miles of highways classified as Urban Principal Arterial within ZIP	0.015	2.07	-0.039	-3.70	0.007	1.10	0.013	1.78	0.019	1.81	2.02	0.019	-0.004	0.015
Bypass Indicator: 1 if a bypass is present in the ZIP, 0 otherwise	1.988	4.92	4.111	6.11	2.421	5.69	2.196	4.97	1.905	2.69	4.58	1.928	-0.395	1.533
Lane-miles of bypass in ZIP with nearest bypassed community	-	-	0.000	-0.10	0.000	-0.01	0.000	0.26	-	-	-	-	-	-
Interaction: Bypass Indicator * Lane-miles of bypass in ZIP with nearest bypassed community	-0.030	-4.55	-0.066	-6.04	-0.037	-5.27	-0.033	-4.57	-0.028	-2.50	-4.56	-0.028	0.006	-0.023
Miles of local roads within ZIP	0.000	3.81	0.000	8.00	0.000	8.20	0.000	8.12	0.000	4.08	5.92	0.000	0.000	0.000
Interaction: Bypass Indicator * Miles of local roads within ZIP	-0.001	-4.48	-0.001	-2.57	-0.001	-4.55	-0.001	-4.29	-0.001	-2.75	-4.05	-0.001	0.000	-0.001
Bypass Indicator (Spatially Lagged, Two Nearest Neighbors)	0.062	1.95	0.007	0.34	0.030	1.38	0.037	1.36	0.089	2.42	2.27	0.090	-0.018	0.072
Percentage rural population in ZIP	-0.142	-3.77	-0.094	-1.96	-0.110	-3.10	-0.118	-3.10	-0.128	-2.75	-3.08	-0.130	0.027	-0.103
Percentage of population with a PhD Degree	-3.165	-1.81	0.215	0.11	-1.609	-1.00	-2.230	-1.25	-2.999	-1.49	-1.85	-3.036	0.622	-2.414

Spatial Lag Parameter (Rho)	-	-	-	-	-	-	-	-	-0.242	-2.09	-2.73	-	-	-
Sample Size	65		650		650		650		65					

Table 9: Overall Fit Statistics for Multilevel Models

	Antedependence Model			**Toeplitz Model**			**AR(1) Model**		
	Total	*Manufacturing*	*Retail*	*Total*	*Manufacturing*	*Retail*	*Total*	*Manufacturing*	*Retail*
-2 * Log Likelihood	-9709.90	-7003.15	-8813.21	-9577.89	-6936.40	-8725.76	-9527.22	-6884.25	-8710.45
AIC (smaller is better)	-9669.90	-6963.15	-8773.21	-9565.89	-6920.40	-8709.76	-9521.22	-6878.25	-8704.45
BIC (smaller is better)	-9626.72	-6919.97	-8730.03	-9552.94	-6903.13	-8692.48	-9514.75	-6871.78	-8697.97
CAIC (smaller is better)	-9606.72	-6899.97	-8710.03	-9546.94	-6895.13	-8684.48	-9511.75	-6868.78	-8694.97
HQIC (smaller is better)	-9652.89	-6946.14	-8756.20	-9560.79	-6913.60	-8702.95	-9518.67	-6875.70	-8701.89

Table 10: Variance and Autocorrelation Parameters for Antedependence Models

Total Employment		Manufacturing		Retail	
Parameter	*Value*	*Parameter*	*Value*	*Parameter*	*Value*
Intercept	3.48E-07	x1	8.60E-09	x1	3.35E-09
Variance Parameters					
Var(1)	3.55E-08	Var(1)	2.68E-07	Var(1)	7.00E-08
Var(2)	5.33E-08	Var(2)	2.97E-07	Var(2)	1.08E-07
Var(3)	6.12E-08	Var(3)	3.07E-07	Var(3)	1.12E-07
Var(4)	4.77E-08	Var(4)	2.47E-07	Var(4)	2.27E-08
Var(5)	5.78E-08	Var(5)	1.46E-07	Var(5)	2.15E-08
Var(6)	2.08E-08	Var(6)	9.39E-09	Var(6)	9.86E-09
Var(7)	2.10E-08	Var(7)	9.75E-08	Var(7)	2.32E-09
Var(8)	1.06E-08	Var(8)	1.21E-07	Var(8)	2.45E-08
Var(9)	4.08E-08	Var(9)	5.89E-07	Var(9)	3.95E-08
Var(10)	1.69E-08	Var(10)	6.60E-07	Var(10)	6.44E-08
Autocorrelation Parameters					
Rho(1)	0.895	Rho(1)	0.906	Rho(1)	0.913
Rho(2)	0.960	Rho(2)	0.540	Rho(2)	0.921
Rho(3)	0.969	Rho(3)	0.423	Rho(3)	0.791
Rho(4)	0.941	Rho(4)	0.182	Rho(4)	0.408
Rho(5)	0.903	Rho(5)	-0.760	Rho(5)	0.415
Rho(6)	0.883	Rho(6)	0.244	Rho(6)	-0.017
Rho(7)	0.850	Rho(7)	0.710	Rho(7)	0.875
Rho(8)	0.829	Rho(8)	0.788	Rho(8)	0.847
Rho(9)	0.764	Rho(9)	0.882	Rho(9)	0.644

Table 11: Autocorrelation parameters for Toeplitz models

Total Employment		Manufacturing		Retail	
Parameter	*Value*	*Parameter*	*Value*	*Parameter*	*Value*
Intercept	3.58E-07	x1	2.86E-09	x1	3.38E-10
Residual	1.83E-08	Residual	4.38E-07	Residual	6.43E-08
Autocorrelation Parameters					
TOEP(2)	1.32E-08	TOEP(2)	3.39E-07	TOEP(2)	5.08E-08
TOEP(3)	1.09E-08	TOEP(3)	3.04E-07	TOEP(3)	4.30E-08
TOEP(4)	6.24E-09	TOEP(4)	2.41E-07	TOEP(4)	3.11E-08
TOEP(5)	3.24E-09	TOEP(5)	1.72E-07	TOEP(5)	2.38E-08
TOEP(6)	-	TOEP(6)	1.24E-07	TOEP(6)	1.22E-08
TOEP(7)	-	TOEP(7)	5.66E-08	TOEP(7)	8.63E-09

Table 12: Variance and autocorrelation parameters for AR(1) model

Total Employment		**Manufacturing**		**Retail**	
Parameter	*Value*	*Parameter*	*Value*	*Parameter*	*Value*
Intercept	3.53E-07	x1	2.76E-09	x1	2.76E-10
Residual	2.48E-08	Residual	4.34E-07	Residual	6.43E-08
Autocorrelation Parameters					
AR(1)	0.803	AR(1)	0.774	AR(1)	0.897

REFERENCES

Anselin, L. (2005). *Exploring Spatial Data with GeoDa™: A Workbook*. Center for Spatially Integrated Social Science. Spatial Analysis Laboratory, University of Illinois, Urbana-Champaign, Urbana IL.

Anselin, L. (2006). *Spatial Regression*. Spatial Analysis Laboratory, University of Illinois, Urbana-Champaign, Urbana IL.

Babcock, M.W., Davalos, J.A., 2004. Case Studies of the Economic Impact of Highway Bypasses in Kansas. Kansas State University. *Journal of the Transportation Research Forum, Vol. 43, No. 1, Spring 2004*.

Bivand, R., et al. (2010). spdep: Spatial dependence: weighting schemes, statistics and models. R package version 0.5-4. http://CRAN.R-project.org/package=spdep

Bivand, R.S. Pebesma, E.J., and V. Gómez-Rubio (2008). *Applied Spatial Data Analysis with R*. Springer Science + Business Media, LLC, New York, NY.

Brail, R.K. (1987). Microcomputers in Urban Planning and Management. Center for Urban Policy Research, New Brunswick, NJ.

Branham, A.K., A.D. May, Jr., and Michael, H.L. (1953). “Economic Evaluation of Two Indiana Bypasses.” *Highway Research Board Bulletin, 1953, No. 67*. Joint Highway Research Project, Purdue University, West Lafayette, IN.

Burress, D. (1996). “Impacts of Highway Bypasses on Kansas Towns.” Kansas Department of Transportation, October 1996, Report No. 226.

Button, K.J., Leitham, S., McQuaid, R.W., and J.D. Nelson (1995). ‘Transport and Industrial and Commercial Location,’ *Annals of Regional Science* (1995) 29:189-206.

Chandra, A., and E. Thompson (2000). ‘Does Public Infrastructure Affect Economic Activity? Evidence from the Rural Interstate Highway System,’ *Regional Science and Urban Economics* 30 (2000) 457-490.

City of Angola, Indiana (2008). Downtown Revitalization Master Plan: The Downtown 20/20 Plan. Coordinated by Region III-A. Accessed April 6, 2009, from http://www.angolain.org/Downloads/Planner/Angola_DowntownPlan_LoRes.pdf.

Comer, J.C., and G. A. Finchum (2003). Socioeconomic Impacts of Highway Bypasses in Oklahoma. *Papers of the Applied Geography Conferences, Vol. 26*, Colorado Springs CO.

Croissant, Y., and G. Millo (2008). Panel Data Econometrics in R: The plm Package. Journal of Statistical Software, July 2008, Vol. 27, Issue 2.

Ezcurra, R., Gil, C., Pascual, P., and M. Rapún (2005). Public Capital, Regional Productivity and Spatial Spillovers, *Annals of Regional Science* (2005) 39:471-494.

Faraway, J.J. (2006). Extending the Linear Model with R: Generalized Linear, Mixed Effects and Nonparametric Regression Models. Chapman & Hall/CRC.

Fricker, J.D., and J.B. Mills (2009). Effects of Bypasses. Final Report, FHWA/IN/JTRP-2008/16.

Gillis, W.R, Ph.D (1994). "Lessons from Eastern Washington: State Route Main-streets, Bypass Routes, and Economic Development in Small Towns." EWITS Research Report No. 2, Washington State University, Pullman, WA.

Gkritza, K., Sinha, K.C., Labi, S., and F.L. Mannering. 'Influence of Highway Construction Projects on Economic Development: An Empirical Assessment,' *Annals of Regional Science*, (2008) 42:545-563.

Heckman, J.J. (1976). *The Common Structure of Statistical Models of Truncation, Sample Selection and Limited Dependent Variables and a Simple Estimator for Such Models*, Annals of Economic and Social Measurement, 5, 4, 120-137.

HyettPalma, City of Angola, and Indiana Downtown (2006). *Angola Downtown Action Agenda 2006*. Accessed July 14, 2010, from http://www.angolain.org/Planning/Angola_Downtown_Action_Agenda.htm.

Jiwattanakulpaisarn, P., Noland, R.B., Graham, D.J., and J.W. Polak (2009). Highway Infrastructure and State-Level Employment: A Causal Spatial Analysis. *Papers in Regional Science* (2009), 88, 1:133-159.

Kelejian, H.H. and I.R. Prucha (1998). A generalized spatial two stage least squares procedure for estimating a spatial autoregressive model with autoregressive disturbances. *Journal of Real Estate Finance and Economics*, 17, 99-121.

Kelejian, H.H. and Prucha, I.R. (2007) HAC estimation in a spatial framework, *Journal of Econometrics*, 140, 131–154.

Kleymeyer, J.E. (2001). "Impact of By-Passes to Ohio Communities Under 35,000 Population." Prepared for the Ohio Department of Transportation by John E. Kleymeyer and Associates.

Koenker, R. (2005). Quantile Regression, Cambridge University Press.

Lane, M.B. (2009). Nelsonville Bypass Back on Track. The Columbus Dispatch, March 28, 2009.

Leingang, M. (2009). Stimulus Forces Ohio City to Rethink Future. Associated Press, August 9, 2009.

LeSage, J., and R.K. Pace (2009). Introduction to Spatial Econometrics, CRC Press, Boca Raton FL.

Mathur, S. (2008). Impact of Transportation and Other Jurisdictional-Level Infrastructure and Services on Housing Prices. *Journal of Urban Planning and Development*, March 2008, Vol. 134, No.1, 32-41.

McCulloch, C.E., and S.R. Searle (2001). Generalized, Linear, and Mixed Models. Wiley Series in Probability and Statistics.

Monette, G. (2009a). Exercises for SPIDA 2009: Mixed Models with R. Summer Program in Data Analysis (SPIDA) 2009, York University, Toronto ON. Accessed July 14, 2010, from http://wiki.math.yorku.ca/index.php/SPIDA_2009:_Mixed_Models_with_R.

Monette, G. (2009b). Hierarchical Models to Mixed Models. Accessed July 14, 2010, from http://wiki.math.yorku.ca/index.php/SPIDA_2009:_Mixed_Models_with_R.

Mills, J., and J.D. Fricker (2010). *An Analysis of the Socioeconomic Impacts of By-passes on Small- and Medium-Sized Communities Incorporating Spatial Econometric Methods*, Paper 10-0672, Transportation Research Board 89th Annual Meeting, January 2010, Washington DC.

Mills, J., and J.D. Fricker (2009). *The Effects on Bypasses on Communities: An Integrated Approach*, Proceedings of the 12th Conference on Transportation Planning Applications, May 2009, Houston TX.

Nunn, S. (1995). Role of Local Infrastructure Policies and Economic Development Incentives in Metropolitan Interjurisdictional Cooperation. *Journal of Urban Planning and Development*, June 1995, Vol. 121, No. 2, 41-56.

Ohio Department of Transportation (2009). Nation's Top Highway Official Breaks Ground on US 33 Nelsonville Bypass. Press Release, October 13, 2009.

Ozbay, K., Ozmen-Ertekin, D., and J. Berechman (2003). Empirical Analysis of Relationship Between Accessibility and Economic Development. *Journal of Urban Planning and Development*, June 2003, Vol. 129, No. 2, 97-119.

Pinheiro, J.C., and D.M. Bates (2000). Mixed-Effects Models in S and S-PLUS. Springer.

Piras, G. (2010). sphet: Spatial Models with heteroskedastic innovations. R package version 0.1-22. http://CRAN.R-project.org/package=sphet

Rietveld, P., and J. Boonstra (1995). On the Supply of Network Infrastructure. *Annals of Regional Science* (1995) 29:207-220.

Rogers, C.L., and R.M. Marshment (2000). Measuring Highway Bypass Impacts on Small Town Business Districts, *Review of Urban and Regional Development Studies*, Vol. 12, No. 3.

Rousseeuw, P.J., and A.M. Leroy (2003). Robust Regression and Outlier Detection, Wiley.

Sanchez, T.W. (2004). Land Use and Growth Impacts from Highway Capacity Increases, *Journal of Urban Planning and Development*, June 2004, Vol. 130, No. 2, 75-82.

SAS Institute Inc. (2008). The MIXED Procedure, SAS/STAT 9.2® User's Guide. Cary, NC.

Srinivasan, S., and K. Kockelman, (2000). The Impacts of Bypasses on Small-And Medium-Sized Communities: An Econometric Analysis. *Journal of Transportation and Statistics*, Vol. 5, No. 1.

Thompson, E., Miller, J., and J. Roenker, (2001). The Impact of a New Bypass Route on the Local Economy and Quality of Life. Center for Business and Economic Research, Kentucky Transportation Center, College of Engineering, University of Kentucky.

Thorsen, I. (1998). Spatial Consequences of Changes in the Transportation Network: Theoretical Analysis and Numerical Experiments within a Multizonal Three Sector Model, *Papers in Regional Science* (1998) 77, 4:375-406.

Washington, S.P., Karlaftis, M.G., Mannering, F.L., 2003. Statistical and Econometric Methods for Transportation Data Analysis. Chapman & Hall/CRC, Boca Raton, FL.

Weisbrod, G. (2008). Models to Predict the Economic Development Impact of Transportation Projects: Historical Experience and New Applications, *Annals of Regional Science*, (2008) 42:519-543.

Whitley County Economic Development Corporation (2010). News Releases. Accessed June 30, 2010, from http://www.whitleybiz.com/.

Wooldridge, J.M. (2002). Econometric Analysis of Cross Section and Panel Data. The MIT Press.

Yeh, D., Gannon, M., and D. Leong (1998). "The Economic Impacts of Highway Bypasses on Communities." Wisconsin Department of Transportation, Madison, WI.

Zimmerman, D.L., Nuñez-Antón, V., and H. El-Barmi (1995). *Computational Aspects of Likelihood-Based Estimation of First-Order Antedependence Models*, Journal of Statistical Computation and Simulation, 60, 1, 67-84.

Zimmerman, D.L., and V. Nuñez-Antón (2009). Antedependence Models for Longitudinal Data, Chapman & Hall/CRC Monographs on Statistics & Applied Probability.