Economic and Demographic Impacts of Passenger Rail Systems: The Impact of Intercity Passenger Rails on Population and Employment Change in the United States, 2000–2010

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ABSTRACT

This research examines the impact of intercity passenger rails on change in population and employment at the county level in the continental United States from 2000 to 2010. This research adopts an integrated spatial regression approach that incorporates both spatial lag and spatial error dependence. The data come from the U.S. Census Bureau, the Bureau of Transportation Statistics, the National Land Developability Index, and the National Atlas of the United States. Population and employment change are regressed on intercity passenger rails, controlling for 14 socioeconomic variables. Intercity passenger rails are measured by the number of intercity passenger rail terminals in each county. The results suggest that the impacts of intercity passenger rails on population and employment change are both direct and indirect. Intercity passenger rails have a negative and direct effect on population and employment change from 2000 to 2010. Intercity passenger rails facilitate moving residents and workers out of the county. The economic recession during this period may have compelled people to move out of their home county in search of jobs. Having intercity passenger rails helped this process. The results also indicate that intercity passenger rails have a positive and indirect effect on population and employment change. Population and employment change in one county influences those in the adjacent counties. This indirect effect does not come from within the county; rather, it is a spread effect from its neighbors. This research suggests that intercity passenger rails play an important role in facilitating the spread of change and the integration of local communities into a larger regional economy.

Keywords: Passenger rail, transportation, population change, employment change, spatial econometrics

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INTRODUCTION

Transportation is one of the factors that link economy and population, through providing access to different geographic areas (Thompson and Bawden 1992, van den Heuvel et al. 2014). In both strong and weak economies, transportation plays some role in the distribution and redistribution of population and employment (Ory and Mokhtarian 2007). Many scholars believe transportation is an essential factor for economic growth as well as for the social well-being of communities (Lichter and Fuguitt 1980). Research shows that areas with access to transportation infrastructure have higher average economic growth rates (Briggs 1981, Ozbay, Ozmen and Berechman 2006, van den Heuvel et al. 2014). Access to transportation has a positive association with employment growth, labor supply, and willingness of individuals to supply their labor. The economic impact is not necessarily limited to the adjacent areas, but neighboring counties could also benefit from the increased levels of accessibility. Such developmental impacts of transportation have been discussed for a long time in various academic disciplines, including sociology, economics, demography, and geography (Boarnet and Haughwout 2000, Chi, Voss and Deller 2006).

Although passenger rail ridership has grown quickly in the United States, making it one of the fastest growing modes of transportation (Puentes, AdieTomer and Kane 2013), most research on railroads in the United States focuses on freight trains. Furthermore, of the writings on passenger rails, most are motivated by a vested interest, and very few are objective (Levinson 2012). Proponents focus on the social and economic benefits, and opponents highlight the huge costs as well as the impracticality of the infrastructure, as the size of the country is large and population density is low (Levinson 2012, Peterman, Frittelli and Mallett 2009). This study is important in this context because it examines the role of intercity passenger rails in population and employment change in the continental United States.

OBJECTIVE

This study analyzes the impact of intercity passenger rails on population and employment change (growth or decline) in a systematic way by applying the ordinary least-squares regression model, spatial lag model, spatial error model, and spatial error with lag dependence model in sequence. Most prior research on the demographic and economic impacts of rails focuses on freight rails rather than passenger rails. Because the federal government is currently giving substantial consideration to high-speed passenger rails, this study helps fill the gap in the literature by examining the relationship between existing intercity passenger rails and change in population and employment.

SCOPE

Railroads are considered one of the most important innovations of American economic growth (Fogel 1962, White 2008). They influenced the rise of corporations, development of agriculture, and growth of the manufacturing industry and interregional trade. The rise of railroads was influenced by economic growth as well. Railroads played a significant role in the patterns of early settlement, migration, population growth, and urbanization of the United States (Fogel 1962, Hedges 1926, Jenks 1944, Kirby 1983, White 2008).

Railroads flourished in the United States during the 1840s, and the prosperity lasted throughout the nineteenth century (Itzkoff 1985). It was a prime time for both freight and passenger rails. They were the principal modes of long-distance transportation, carrying goods and people. Passenger trains once dominated the locomotive world, but now no longer do. Several factors played important roles in the demise of passenger rails. Some of these were the unequal distribution of public funds, absence of a dedicated funding source, competition with private vehicles, availability of a strong intercity passenger bus and aviation network, failed marketing, inadequate infrastructures, and high fares (Hurst 2014, Itzkoff 1985).

The experience of many countries in Europe and Asia shows that passenger rails exert a positive impact on urban development and redevelopment (Okada 1994), as they are helpful in increasing employment (Loukaitou-Sideris et al. 2013, Topalovic et al. 2012), enhancing economic productivity (Ryder 2012), boosting real estate markets (Loukaitou-Sideris et al. 2013), and increasing tourism (Loukaitou-Sideris et al. 2013, Okada 1994, Ryder 2012). Similarly, high-speed passenger trains are energy-efficient and environment-friendly vehicles, emitting few harmful exhaust gases (Okada 1994, Preston 2009). High-speed trains save time for millions of passengers and reduce traffic congestion on highways that follow similar paths (Bhattacharjee and Goetz 2012, Preston 2009). High-speed passenger rails also can help business complexes and industries move inward to utilize less expensive land and labor without compromising time (Jiao, Harbin and Li 2013). In most countries, high-speed passenger rails are a part of broader regional economic development planning and are included in national industrial policy to stimulate economic growth in depressed areas (Ryder 2012). The United States can take advantage of other countries' technological advances and learn from the economic impacts of high-speed passenger rails elsewhere (Jiao, Harbin and Li 2013).

The United States government recognizes the economic vitality of passenger rails and considers high-speed passenger rails a stimulus to the macroeconomy (Goetz 2012, Grunwald 2010, Hurst 2014). Provision of federal funding for high-speed passenger rails was made through the American Recovery and Reinvestment Act (ARRA) of 2009. This funding is designated for investing in research and development of high-speed rail services. In addition, the government has envisioned ten high-speed rail corridors (Hurst 2014, Lee 2009). Moreover, there are growing debates over whether passenger rails should be expanded and whether high-speed rails should be built in the United States. Therefore, an understanding of the impact of passenger trains is crucial.

Demographics and Economy in the 2000s

The population of the United States jumped from 281.4 million in 2000 to 308.7 million in 2010, indicating a 9.7% growth (USCB 2011). But, the population growth was not uniform across the country. During this period, most of the growth occurred in the South and the West, accounting for 84.4% of the total population growth. Most of the population (83.7%) in 2010 lived in 366 metropolitan areas; the rest (16.3%) were in nonmetropolitan areas. Major population growth (83%) between 2000 and 2010 occurred in suburban areas (HAC 2012), indicating continuation of the suburbanization process during the 2000s. Population growth was uneven not only at the regional level but also at the county level. The counties that gained population are concentrated along the coasts (Pacific, Atlantic, and Gulf) as well as along the southern borders. The counties that lost population are concentrated in Appalachian, Great Plains, Mississippi Delta, Great Lakes, and northern border areas.

One of the most important events of the 2000s economy was the Great Recession, in which U.S. economic activities slowed and the amount of goods produced and services offered were significantly reduced (USBLS 2012). The country faced one of the longest and the most severe recessions since World War II (Brown 2009). During this decade, the housing market deteriorated, most of the states faced employment decline, and the unemployment rate escalated. Rural counties experienced a dramatic increase in unemployment rate (HAC 2012). The Great Recession reshaped employment (and population) distribution throughout the country (Hertz et al. 2014, Rickman and Guettabi 2015, USBLS 2012).

Previous Research

Earlier works on the relationship between transportation and population growth were conducted from the perspective of human ecology (Lichter and Fuguitt 1980, Mark and Schwirian 1967, Schnore 1957). The human ecological perspective essentially argues that demographic change is the response to changes in the available technologies and local environment. Even though there are several studies from the human ecological perspective, those works did not explore the relationship between transportation and population growth (or decline) in a systematic way. Some works were from the perspective of the impact of transportation (highways) on population growth during the 1970s (Lichter and Fuguitt 1980), but the results of these works were ambiguous (Voss and Chi 2006), partly because of their limited scope and failure to adopt a holistic approach (Chi

2010, White 2008). For example, the studies were limited to interstate highways, to one stage of highway development, to rural areas, or to only one direction (e.g., the impact of transportation on population growth and not the other way).

The impact of transportation on population can be direct and indirect (Chi 2010, Voss and Chi 2006). The direct impact includes imposition of rights-of-way on residential housing, agricultural lands, and natural wilderness (Coffin 2007, Moore et al. 1964). This impact is mostly negative, causing demolition of residential housings and perhaps affecting the population composition of the area. The indirect impact comes through the growth or decline in the economy, change in employment opportunities, and change in the physical environment. Access to transportation infrastructure plays an important role in these economic changes, which are ultimately linked with population distribution and redistribution (Boarnet and Haughwout 2000, Duration and Turner 2012).

Theories of Transportation

The role of transportation on population and employment change has long been debated in the context of urban development, suburban sprawl, central cities' decline, and inter/intra-metropolitan accessibility (Boarnet and Haughwout 2000). The relationship between transportation and change (growth or decline) in population and employment is well described in the regional economics literature, especially with regard to growth pole theory. A "growth pole" is an urban location that is the hub of economic growth, constantly interacting with surrounding areas for the distribution and/or redistribution of growth (Darwent 1969, Thiel 1962). This theory has two main concepts—spread and backwash. *Spread* refers to the situation when the growth of one place causes growth in the surrounding areas, and *backwash* refers to when growth in a location occurs at the cost of surrounding areas' development. These concepts identify the geographic relationship between the urban area and adjacent rural areas in terms of economic growth and development (Henry, Barkley and Bao 1997); if growth is more dependent on transportation, the effects of spread and backwash will be stronger (Chi 2010).

The study of the relationship between transportation and population growth is becoming more specific. Contemporary research explores the impact on population change from different perspectives—for example, the dual roles of transportation (as an agent to redistribute population across locations), the double causal relationship (the impact of transportation on population change and vice versa), various developmental stages (preconstruction, construction, and post-construction of highways), and the expansion of the transportation infrastructure, focusing on highways (Chi, Voss and Deller 2006, Chi 2010, Voss and Chi 2006). These studies incorporate formal spatial dimensions, a research method that has been neglected in the past.

Impact of Railroads

Some studies have examined the impact of railroads on population and employment change (Atack and Margo 2011, Bollinger and Ihlanfeldt 1997, Levinson 2008b, Levinson 2008b, White 2008). The results of such studies show great variation in the impact of railroads on local economic development. For example, Bollinger and Ihlanfeldt (1997) did not find any impact of the Metropolitan Atlanta Rapid Transit Authority (MARTA) on population and employment change in station areas; most likely, MARTA does not increase accessibility effectively because the city is already served by a well-established network of highways. But their study did find an alteration in public and private employment composition: even though the total employment did not change, public sector employment increased in the vicinity of transit stations (Bollinger and Ihlanfeldt 1997).

Railroads have a positive effect on employment growth, and on office and housing construction, that eventually alters population composition (Casson 2013, Levinson 2008b, Levinson 2008b). Such impact varies with location; for example, central cities see a rise in business complexes that increases the concentration of jobs, while suburban areas experience an increase in housing complexes that helps increase the population (Israel and Cohen−Blankshtain 2010, Levinson 2008b, Levinson 2008b). Commercial development increases land value, making downtown a very expensive place to live, and migrants select the periphery or suburban areas. Under such conditions, passenger rails offer fast, comfortable, dependable, and stress-free travel at peak office hours to the population in suburban areas, the commuters who work in metropolitan downtowns (Pucher and Renne 2003).

A vast literature on high-speed passenger rails is available outside the United States. These studies show the influence of railroads on local as well as regional growth (Chen 2012, Knowles 2012, Kotavaara, Antikainen and Rusanen 2011, Mejia-Dorantes, Paez and Vassallo 2012). Knowles (2012) shows that the railway has helped Copenhagen's economic growth by attracting substantial investment in housing, retail, education, and leisure facilities, as well as creating thousands of new jobs. Similarly, the study of Mejia-Dorantes, Paez and Vassallo (2012) shows the economic impact of the Madrid metro line in Spain: it positively impacted the economic activity and changed the mix of business establishments in the Alcorcon municipality, and it is associated with an increase in retail activities over time, which displaced manufacturing firms within the territory. In Finland, accessibility of transportation infrastructure, including railroads, influenced population change (Kotavaara, Antikainen and Rusanen 2011). However, the relationship between transportation accessibility and population change varies by geographic scales: at the regional level transportation accessibility, including railroads, increases the (overall) population, while it has opposite effect at the urban or local level.

In China, the development of high-speed trains positively contributes to regional economic growth by reducing travel time between cities for millions of commuters (Chen 2012). However, the benefits are not universal and equally distributed. Predictive and observational studies show that large industrialized cities receive more benefits than small and intermediate cities (Loukaitou-Sideris et al. 2013). These large cities observe growth in employment, the real estate market, and tourism. These economic impacts of high-speed passenger rails eventually alter the composition of employment and population at the local as well as the regional level. High-speed passenger rails, with the help of revolutionary development in information technology (or a digital network), connect businesses of multiple urban areas that contribute to polycentric urban growth, which is different than, and evolved from, earlier assumptions of monocentric urban growth (Auimrac 2005, Mejia-Dorantes, Paez and Vassallo 2012).

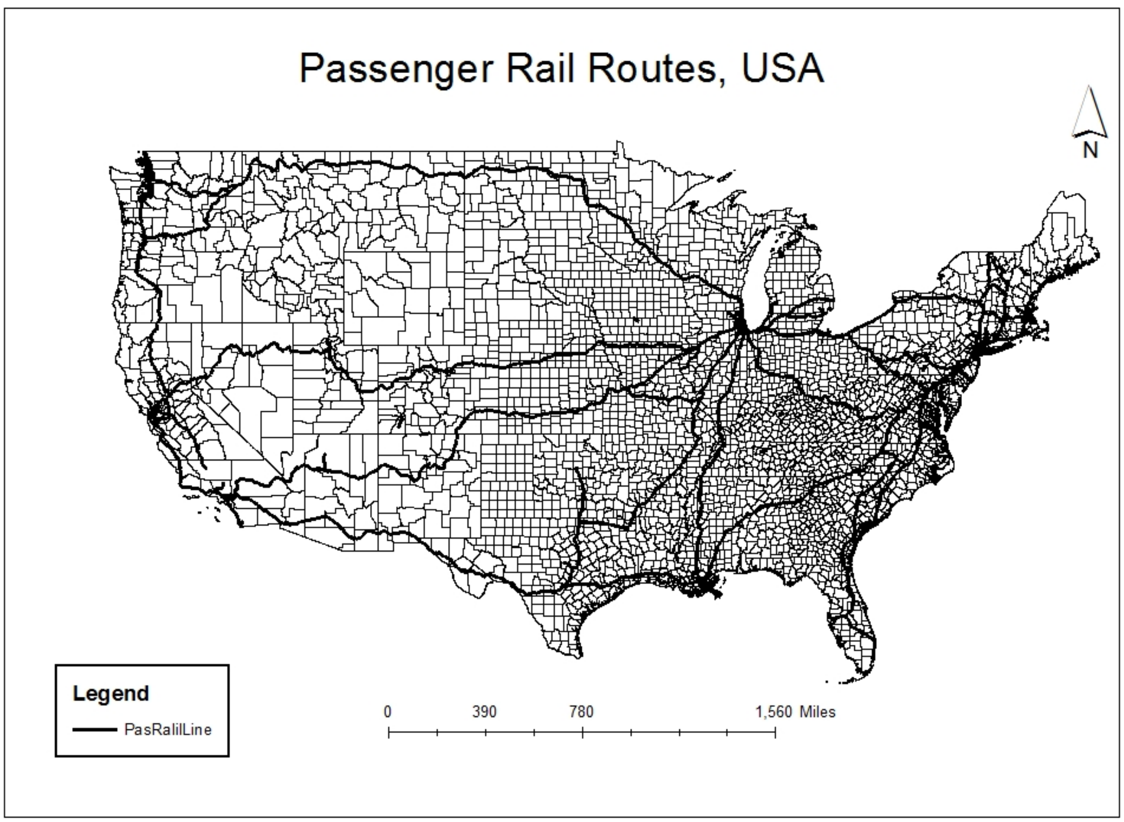
In the United States, no work has been done on the economic impact of high-speed passenger rails because no such service exists in the country (Jiao, Harbin and Li 2013, Levinson 2012). Among the studies carried out on railroads in the United States, some are explicitly done on passenger rails, but others do not distinguish between freight and passenger trains. Moreover, these studies are based on limited geographical areas, such as a city or region. No study has been done at the national level. This research is likely the first to offer a systematic exploration of the impact of passenger rails on population and employment change at the national level. This research thus contributes to broadening scholarly understanding of the relationship between passenger rails and population and employment change.

METHODOLOGY

Data

The impact of intercity passenger rails on population and employment change is examined at the county level for the continental United States. For this study, intercity passenger rail data were obtained from the Intermodal Passenger Connectivity Database (IPCD) (RITA/BTS 2012), a national-level database for the passenger transportation system. This data set is the only one available that has complete data for intercity passenger rail terminals (Figure 1).

Figure 1: Passenger Rail Routes, United States



Digital data for county-level population and employment were obtained from the decennial censuses of 1990, 2000, and 2010 (Table 1). Counties are considered in this research because they are important governmental units where social and economic data are rich, easily available, and consistent over time (White 2008). Several government programs related to agriculture, social welfare, education, taxes, and transportation construction and maintenance operate at the county level.[1] For the identification of metro and non-metro counties, the U.S. Census Bureau's cartographic boundary files were used.

Population and employment growth are also influenced by land use and development (Chi 2010). In this research, the variable labeled Land Developability Index (Chi and Ho 2014) captures this concept; it is controlled for, along with other socioeconomic variables. The Land Developability Index can be understood as the potential for land development and conversion in a geographical area. It is based on several factors, such as geophysical characteristics (slope, wetland), the amount of built-up lands (residential, commercial, and industrial areas; transportation infrastructure), culture, natural amenities (lakes, forests, favorable weather), and governmental policies.

[1] County borders may change over time (White, 2008). In 2001, Broomfield County, Colorado, was created from parts of Adams, Boulder, Jefferson, and Weld counties. The average proportion of demographic and socioeconomic data for these counties is calculated and applied to generate respective data for Broomfield County.

Table 1. Variable Description and Data Sources

Variables	Descriptions	Data Sources
Demographic characteristics		
Population change	Natural log of the ratio of 2010 population over 2000 census population	Decennial Census 2000 and 2010
Employment change	Natural log of the ratio of 2010 population (age ≥ 16) in labor force over 2000 population (age ≥ 16) in labor force	Decennial Census 2000 and 2010
Population density	Number of persons per square miles	Decennial Census 2000
Young	Percent young (15–19) in 2000	Decennial Census 2000
Old	Percent old (≥ 65) in 2000	Decennial Census 2000
White	Percent Whites in 2000	Decennial Census 2000
Blacks	Percent Blacks in 2000	Decennial Census 2000
Hispanics	Percent Hispanics in 2000	Decennial Census 2000
Female–headed households	Percent female–headed households with own children under 18 years old in 2000	Decennial Census 2000
Bachelor degree	Percent population (age ≥ 25) with bachelor degrees and higher in 2000	Decennial Census 2000
Intercity passenger rail	Number of intercity passenger rails terminals	Intermodal Passenger Connectivity Database (IPCD)
Socioeconomic conditions		
Employment	Percent population (age ≥ 16) in labor force in 2000	Decennial Census 2000
Household income	Median household income in 2000	Decennial Census 2000
Land development	*Land Developability Index*	Land developability http://www.landdevelopability.org/
Metro	Metro county	United States Census Bureau

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Analytical Approach

The analysis started with the standard regression method. Full ordinary least-squares (OLS) regression models are estimated to examine the general causality from intercity passenger rails on population and employment change. Population change and employment change are the dependent variables. Population change is expressed as the natural log of the 2010 census population over the 2000 census population (Table 2). Similarly, employment change is measured by the natural log of the 2010 employment over the 2000 employment (Table 2). The natural log helps to achieve a bell-shaped distribution and better linearity with the independent variables. The visual representation of population and employment change during 2000s are shown in Figures 2a and 2b, respectively.

Table 2. Descriptive Statistics (N = 3109)

Variables	Median	Mean	Stan Dev	Percentile (10%)	Percentile (90%)
Dependent variables					
Population change (ln)	0.03	0.04	0.12	−0.08	0.19
Change in Employed people (ln)	0.04	0.5	0.13	−0.10	0.21
Independent variable					
# Intercity passenger rail terminal	0.00	0.22	0.87	0.00	1.00
Control variables					
Population Density 2000	43.25	245.75	1,681.36	4.64	343.72
Young	14.97	15.08	1.81	13.05	17.19
Old	14.40	14.81	4.11	10.00	20.20
White	89.30	81.62	18.69	54.20	97.80
Black	2.10	9.14	14.65	0.20	31.20
Hispanic	1.80	6.21	12.05	0.60	16.00
Female HH	5.80	6.26	2.34	3.90	9.20
Bachelor degree	14.50	16.51	7.80	9.30	26.70
Employment	61.70	60.94	7.04	51.60	69.30
HH Income	40,597	42,043.86	9,821	31,746	53,676
Land Developability	79.53	70.75	26.56	27.33	96.99
Metro	1.00	0.67	0.47	0.00	1.00

Figure 2a: Population Change from 2000 to 2010 at the County Level in the United States

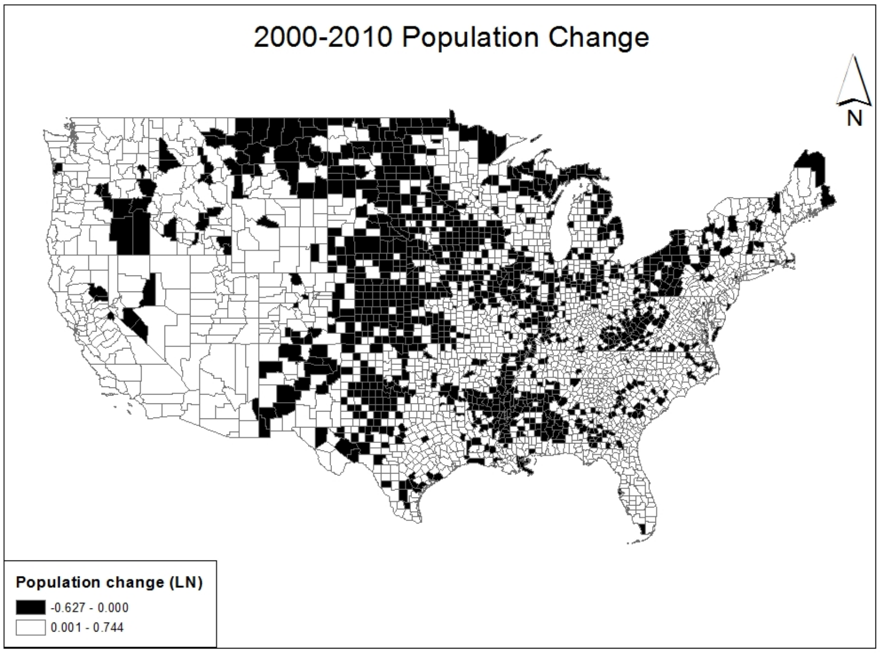
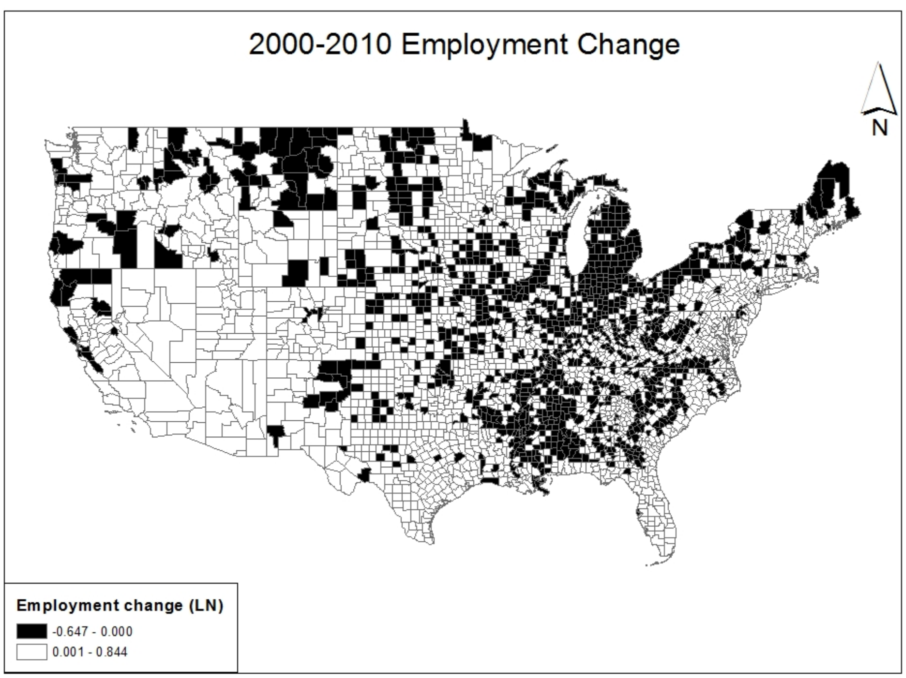


Figure 2b. Employment Change from 2000 to 2010 at the County Level in USA



The explanatory variable is the number of intercity passenger rail terminals. There is a close relationship between the number of intercity passenger rail terminals and the volume of population they serve. In general, both the size of the population and the number of intercity passenger rail terminals is greater in metropolitan than in nonmetropolitan counties. The greater the number of terminals, the bigger the population served. The number of passenger rail terminals varies across counties, and on average each county has 0.22 terminals (Table 2).

The models include 12 demographic and socioeconomic control variables, including population density in 2000 (the number of people per square mile); percentages of young (15 to 19 years of age) and old (65 years of age and above) in the population; percentages of non-Hispanic Whites, non-Hispanic Blacks, and Hispanics in the population; percentage of households that are female-headed with children under 18; percentage of the population with bachelor's degrees or higher; percentage of the population employed; median household income; Land Developability Index; and the metropolitan or non-metropolitan status of the county (Table 1).

Spatial regression models are used to control for spatial dependence in the OLS model residuals. A positive value of spatial dependence indicates that counties with high (or low) values of a certain attribute are surrounded by counties with high (or low) values, and a negative spatial dependence suggests that counties with high (or low) values of a certain attribute are surrounded by counties with low (or high) values.

Spatial lag and spatial error are the two most common forms of spatial dependence (Chi and Zhu 2008). For this study, spatial lag dependence occurs when population and employment change in a county is affected by changes in population and employment in its neighboring counties; spatial error dependence refers to situations when model residuals are spatially correlated. To address spatial effects, a neighborhood weights matrix is needed. Four different spatial weights matrices were established for each model. Rook and queen contiguity weights matrices with orders 1 and 2 were created and tested. This helped with comparison of results of different weights matrices and selecting the most appropriate one. The weights matrix that is the most appropriate is the one that produces a high value of spatial autocorrelation along with a high level of statistical significance (Chi 2010).

Moran's I for population change and employment change are both relatively high, at 0.46 and 0.41, respectively (Figure 3a and 3b). Figures 4a and 4b show the clustering of counties with high and low values. The statistically significant Moran's I indicates the existence of significant spatial dependence in the residuals of the OLS regression models. This suggests the possible violation of the OLS independence assumption. From a methodological perspective, the issue of spatial dependence needs to be addressed, as statistical inference without the consideration of spatial dependence, if exists, may lead to unreliable conclusions (Chi and Zhu 2008). In this study, we used three spatial regression models: a spatial lag model, a spatial error model, and a spatial error model with lag dependence (SEMLD). The assessment of the three different spatial regression models was based on the value of log likelihood, Akaike's Information Criterion (AIC), and Schwartz's Bayesian Information Criterion (BIC). The appropriate model has the highest log likelihood value and the lowest AIC and BIC values (Chi and Zhu 2008).

Figure 3a: Moran Scatterplot of Population Change, 2000—2010

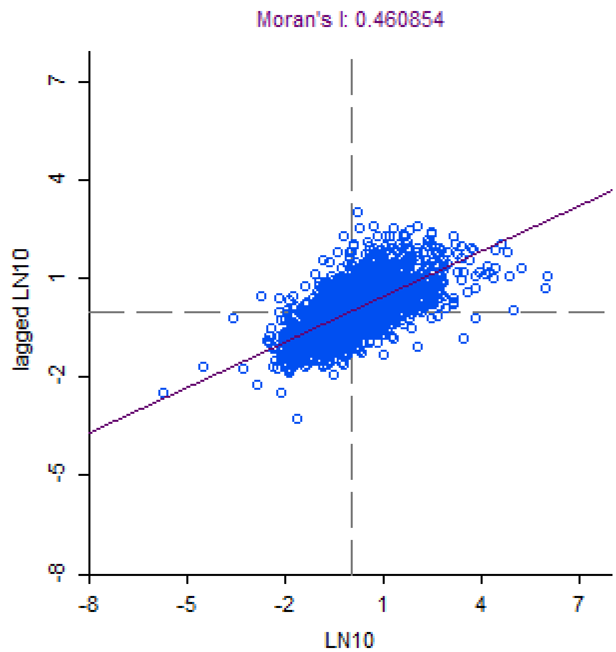
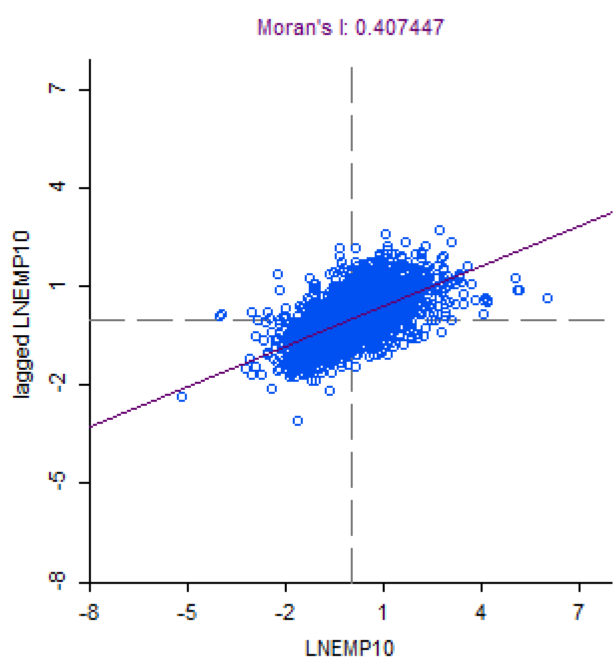


Figure 3b: Moran Scatterplot of Employment Change, 2000—2010



DISCUSSION OF RESULTS

Tables 3a and 3b show the results of all four regression models, the one OLS and three spatial models for population change and employment change. The SEMLD model is the best to interpret the regression coefficients of population change because the value of the log likelihood is the highest and the values of the AIC and BIC are the lowest. The SEMLD model results show a significant effect of intercity passenger rails on population change, and the effect is negative. It indicates that intercity passenger rails help population outflow at the county level. For every one additional intercity passenger rail terminal, a county experienced 0.3% population decline.

Similarly, results from Table 3b indicate that the SEMLD model is the best to interpret the regression coefficients of employment change because the value of the log likelihood is the highest and the values of the AIC and BIC are the lowest. The SEMLD model results suggest that intercity passenger rails have a negative effect on employment change; intercity passenger rails play a role in taking employed people out of the county. The result shows that for every one additional intercity passenger rail terminal, a county experienced 0.4% employment decline.

In response to the economic recession during the studied period, people might have moved out of the county in search of jobs (Rickman and Guettabi 2015). During this period, employment growth was weak and uneven, and population growth and housing market bubbles had occurred but then broken. Areas that were dependent on the construction business and that had high shares of employment in retail and food service were especially affected during the recession (Gabe and Florida 2013, USBLS 2012). The recession period was also high on mass layoffs (USBLS 2012). Employers were involved in thousands of mass layoff actions, forcing workers to leave industries. It is probable that intercity passenger rails as an additional means of transportation served in the movement of those people who were looking for jobs in other places.

Table 3a: Regressions of Intercity Rail Terminals on Population Change from 2000 to 2010

	Full OLS	SLM	SEM	SEMLD
Explanatory Variable				
Intercity rail terminals	−0.001	−0.003	−1.19E−4	−0.003*
	(0.002)	(0.002)	(0.002)	(0.001)
Control Variables				
Population density	−4.74E−6***	−3.31E−6***	−5.29E−7	−1.23E−6*
	(1.09E−6)	(9.24E−7)	(1.25E−6)	(5.37E−7)
Young	−0.009***	−0.004**	−0.002	6.97E−4
	(0.002)	(0.001)	(0.001)	(9.51E−4)
Old	−0.012***	−0.008***	−0.008***	−0.003***
	(6.20E−4)	(5.41E−4)	(6.52E−4)	(3.54E−4)
White	3.99E−4	4.11E−4	9.19E−4**	1.64E−4
	(3.15E−4)	(2.69E−4)	(3.35E−4)	(1.68E−4)
Blacks	−8.23E−6	−5.59E−4*	−0.001***	−4.58E−4**
	(2.84E−4)	(2.42E−4)	(3.19E−4)	(1.53E−4)
Hispanics	7.84E−4*	3.67E−4	9.67E−4**	−7.94E−5
	(3.23E−4)	(2.76E−4)	(3.65E−4)	(1.70E−4)
Female–headed household	−0.003*	3.68E−4	0.006***	8.36E−4
	(0.002)	(0.001)	(0.001)	(9.26E−4)
Bachelor degree higher	6.56E−4*	0.001***	0.001***	0.001***
	(3.33E−4)	(2.84E−4)	(3.04E−4)	(1.96E−4)
Employment	−0.001***	−0.001***	−7.28E−4	−6.17E−4**
	(3.82E−4)	(3.25E−4)	(3.81E−4)	(2.12E−4)
Household income	3.82E−6***	2.29E−6***	4.65E−6***	2.53E−7
	(3.70E−7)	(3.23E−7)	(4.09E−7)	(2.00E−7)
Land developability	−2.24E−4**	1.37E−4*	2.11E−4*	2.53E−4***
	(7.65E−5)	(6.53E−5)	(9.99E−5)	(3.83E−5)
Metro	−0.004	−0.002	−1.17E−4	−7.06E−4
	(0.004)	(0.003)	(0.003)	(0.003)
Constant	0.223***	0.098*	−0.081	0.014
	(0.046)	(0.039)	(0.044)	(0.026)
Spatial lag effects	−	0.559***	−	1.027***
		(0.018)		(0.012)
Spatial error effects	−	−	0.683***	−0.828***
			(0.017)	(0.028)
Diagnostic Test				
Moran's I (error)	35.64***	−	−	−
Lagrange Mult (lag)	1011.03***	−	−	−
Robust LM (lag)	2.32	−	−	−
Lag Mult (error)	1241.85***	−	−	−
Robust LM (error)	233.14***	−	−	−
Measures of Fit				
Log likelihood	2872.01	3263.72	3375.63	3566.46
AIC	−5716.02	−6497.43	−6723.25	−7102.92
BIC	−5631.43	−6406.80	−6638.67	−7012.29

AIC = Akaike's Information Criterion. BIC = Schwartz's Bayesian Information Criterion. * Significant at $p \leq 0.05$ for a two−tail test; ** significant at $p \leq 0.01$ for a two–tail test; *** significant at $p \leq 0.001$ for a two–tail test; standard errors in parentheses.

Table 3b: Regressions of Intercity Rail Terminals on Employment in all counties from 2000 to 2010

	Full OLS	SLM	SEM	SEMLD
Explanatory Variable				
Intercity rail terminal	−0.004	−0.004	−2.56E−4	−0.004*
	(0.003)	(0.002)	(0.002)	(0.002)
Control Variables				
Population density	−4.65E−6***	−3.08E−6**	−1.43E−6	−1.23E−6
	(1.35E−6)	(1.18E−6)	(1.61E−6)	(8.82E−7)
Young	0.005*	0.002	0.002	0.001
	(0.002)	(0.002)	(0.002)	(0.001)
Old	−0.004***	−0.004***	−0.004***	−0.004***
	(7.64E−4)	(6.67E−4)	(8.26E−4)	(4.68E−4)
White	−0.002***	−0.001***	−8.29E−4*	−2.45E−5
	(3.90E−4)	(3.40E−4)	(4.21E−4)	(2.55E−4)
Blacks	−0.002***	−0.001***	−0.002***	−4.74E−4*
	(3.53E−4)	(3.10E−4)	(4.06E−4)	(2.27E−4)
Hispanics	0.001**	3.52E−4	0.001**	−3.43E−4
	(4.02E−4)	(3.52E−4)	(4.63E−4)	(2.49E−4)
Female−headed households	−0.012***	−0.005**	−1.71E−4	5.17E−4
	(0.002)	(0.002)	(0.002)	(0.001)
Bachelor degree higher	0.002***	0.001***	0.001***	5.68E−4*
	(4.06E−4)	(3.54E−4)	(3.88E−4)	(2.82E−4)
Household income	1.47E−6***	9.83E−7**	3.10E−6***	2.44E−7
	(4.15E−7)	(3.65E−7)	(4.95E−7)	(2.46E−7)
Land developability	−3.38E−4***	−1.85E−5	8.17E−5	1.66E−4***
	(8.89E−5)	(7.76E−5)	(1.23E−4)	(4.97E−5)
Metro	−2.23E−4	1.56E−4	−8.93E−5	−7.46E−5
	(0.005)	(0.004)	(0.004)	(0.004)
Constant	0.293***	0.140**	0.044	0.019
	(0.055)	(0.048)	(0.056)	(0.036)
Spatial lag effects	−	0.551***	−	1.081***
		(0.020)		(0.018)
Spatial error effects	−	−	0.620***	−0.973***
			(0.019)	(0.039)
Diagnostic Test				
Moran's I (error)	30.11***	−	−	−
Lagrange Mult (lag)	838.45***	−	−	−
Robust LM (lag)	6.21*	−	−	−
Lag Mult (error)	885.49***	−	−	−
Robust LM (error)	53.25***	−	−	−
Measures of Fit				
Log likelihood	2192.64	2514.85	2559.95	2601.20
AIC	−4359.29	−5001.71	−5093.90	−5174.4
BIC	−4280.74	−4917.12	−5015.35	−5089.81

AIC = Akaike's Information Criterion. BIC = Schwartz's Bayesian Information Criterion. * Significant at $p \leq 0.05$ for a two−tail test; ** significant at $p \leq 0.01$ for a two−tail test; *** significant at $p \leq 0.001$ for a two−tail test; standard errors in parentheses.

This result is similar to another railroad study conducted at the county level. White (2008) found a negative impact of railroads on the early 20th century population change in the Great Plains region. That research shows that railroads helped move people out of more densely populated counties and brought people into counties with lower population density. Hence, railroads served both roles—they helped in population growth and in population decline.

In the SEMLD models, both spatial lag and spatial error effects are statistically significant. The spatial lag effects come from the population and employment change that occurred in the neighboring counties. The population of each county grows by 1.027% for each percentage point of weighted population growth in its neighboring counties (Table 3a). Similarly, the number of workers in each county grows by 1.081% for each percentage point of weighted employment growth of neighboring counties (Table 3b). In other words, each county will observe 10.27% population growth and 10.81% employment growth if adjacent counties gain 10% in population and employment growths, respectively. These increases do not come from within the county; rather, it is the effect of a "gift" from its neighbors. This phenomenon is consistent with the spread effect of growth pole theory, i.e., that population and employment increases in one area help to increase population and employment in nearby areas. In this context, the spatial lag effect is an indirect effect of intercity passenger rails on population and employment growth. But, this effect is not entirely because of intercity passenger rails; other modes of transportation could have contributed to the process of population and employment growth.

Intercity passenger rails can be best seen as a facilitator of population and employment flows. A county with a strong economy can attract residents from other counties, and a county with a weak economy cannot maintain its population base. Thus, intercity passenger rails act as a facilitator in the process of population and employment redistribution.

Figure 4a: LISA Cluster Map of Population Change from 2000 to 2010 at the County Level in the United States

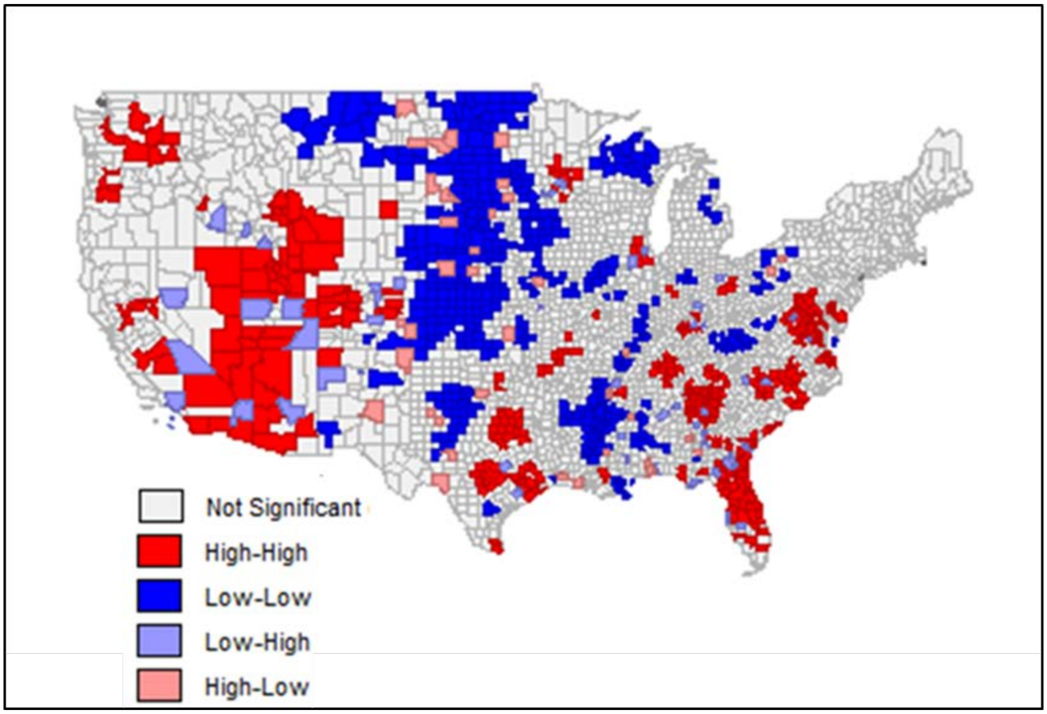
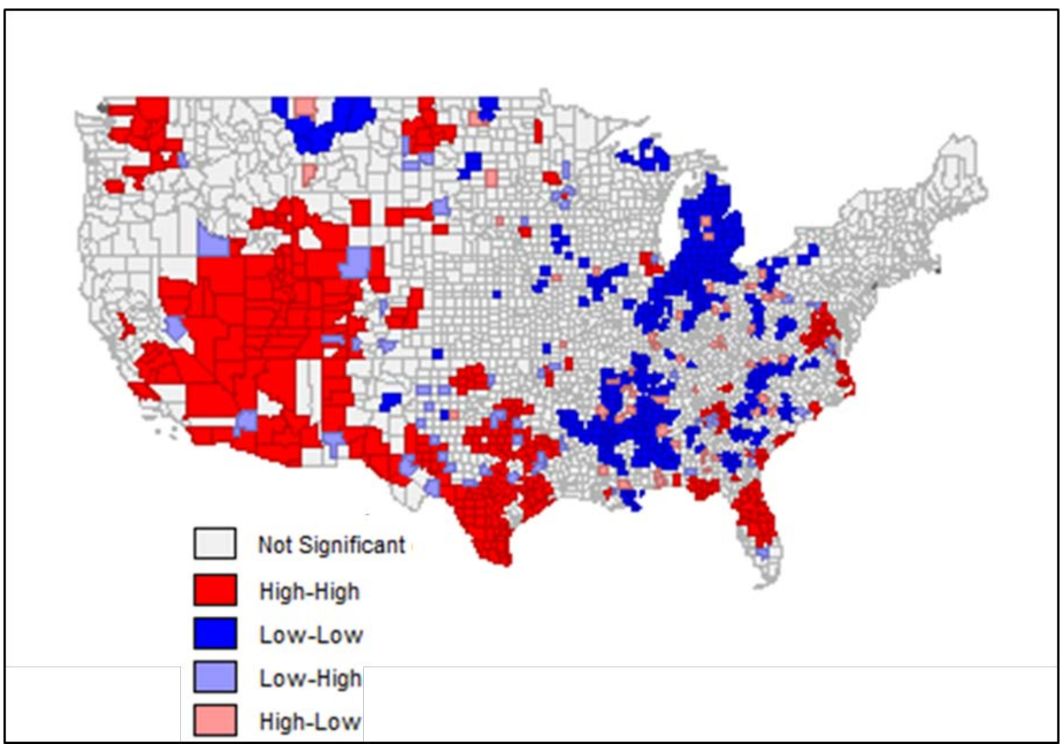


Figure 4b: LISA Cluster Map of Employment Change from 2000 to 2010 at the County Level in the United States



CONCLUSIONS

Many studies have been conducted in geography, sociology, economics, and other disciplines to explain the relationship between transportation infrastructure and change in population and employment (Chi, Voss and Deller 2006). Most research on the demographic and economic impacts of rails focuses on freight rails rather than passenger rails. Because the federal government is currently giving substantial consideration to high-speed passenger rails, this study helps fill the gap in the literature by examining the relationship between existing intercity passenger rails and change in population and employment.

This study analyzes the impact of intercity passenger rails on population and employment change (growth or decline) in a systematic way by applying the ordinary least-squares regression model, spatial lag model, spatial error model, and spatial error with lag dependence model in sequence. The systematic application of these models is the strength of this study. This approach identifies and addresses the weaknesses of the models involved in the analysis. Likewise, the application of these models supports the identification of the most appropriate model to provide a better understanding of the impacts of passenger rails on change in population and employment. Based on the higher value of log likelihood and lower values of AIC and BIC, the spatial error model with lag dependence stands out as the best fit. In addition, the simultaneous application of the spatial lag and spatial error models helps to identify indirect effects of intercity passenger rails and the potential effects of variables that are not included in the model.

The results of this study show direct as well as indirect impacts of intercity passenger rails on change in population and employment. Intercity passenger rails exerted a direct effect on change in population and employment at the county level in the 2000s, even after controlling for 14 socioeconomic variables. The effect of intercity passenger rails was strong enough to influence change in population and employment independently. However, this effect was negative, suggesting that intercity passenger rails helped in population and employment outflow. The results indicate that the decline in population and employment occurred by 0.3% and 0.4%, respectively, for having each additional intercity passenger rail terminal. Intercity passenger rails act as a facilitator of population and employment outflow in a weak economy.

This research also indicates the indirect effect of intercity passenger rails on population and employment change. The indirect effect is measured by the spatial lag effect of the SEMLD model. Population and employment in counties are spatially connected. Changes in one county affect its neighboring counties. Neighboring counties are connected not only geographically, but also socially and economically. Intercity passenger rails, along with other modes of transportation, play an important role in facilitating the spread of the change and in integration of small communities into a larger regional economy. These findings support the spread effect of the growth pole theory, which suggests that population and employment increase in one area helps population and employment increase in adjacent areas.

Intercity passenger rails can be viewed as a change agent that is neither a boom factor nor a bust factor; rather, its role is determined by the national socioeconomic context. This finding is consistent with the results of research on other modes of transportation such as railroads and highways (Chi 2010, Levinson 2008b). Even though transportation infrastructure previously was considered a growth factor, recent research studies have shown mixed results, indicating that transportation infrastructure could be viewed as a facilitator of change. Loukaitou-Sideris et al. (2013) also find a similar impact of passenger rails on urban economic growth. According to them, passenger rails are more a distributive than a generative force. To realize positive economic growth, other factors such as magnitude of public capital investment and quality of urban planning play vibrant roles. During the Great Recession period, when employment growth was weak and uneven and employers were having mass layoffs, intercity passenger rails might have helped the job-seeking population move out of their counties. The findings of this study are important during this time when debates on intercity passenger rails expansion and high-speed rails construction is growing.

RECOMMENDATIONS

This study could be extended into several directions. First, the impact of intercity passenger rails could be compared in different geographical areas, such as urban, suburban, and rural areas. This can be done through a spatial regime model that deals with spatial heterogeneity, allowing comparison of the direct and indirect effects of intercity passenger rails on population change across urban, suburban, and rural areas. Second, future research could analyze the impact of intercity passenger rails on change in population and employment for other decades, such as the 1980s, 1990s, as well as for the whole period, i.e., 1980 to 2010. That would provide an understanding of the impact of intercity passenger rails on change in population and employment over a time. Third, future research could address the issue of intermodality. In this study, intercity passenger rails are considered in isolation from other modes of transportation. In future research, the impact of intercity passenger rails could be examined while controlling for the impacts of highways and airways on change in population and employment. Fourth, future research could consider the possible impact of intercity passenger rails on social inequality as measured by education, income, and race and ethnicity.

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