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Intercity Passenger Rails: Facilitating the Spatial Spillover Effects of Population and Employment Growth in the United States, 2000–2010

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Abstract

This research examines the association that intercity passenger rails have with population and employment growth 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 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 associations that intercity passenger rails have with population and employment change are both direct and indirect. Intercity passenger rails have a negative and direct association with population and employment change from 2000 to 2010. The Great Recession during this period may have compelled people to move out of their home county in search of jobs; having intercity passenger rails facilitated this process. The results also indicate that intercity passenger rails have a positive and indirect association with population and employment change. Population and employment change in one county influences those in the adjacent counties. This indirect association shows the spatial spillover effect of population and employment growth through passenger rails. The indirect association does not come from within the county; rather, it is a spread effect from its neighbors. This research suggests that intercity passenger rails, although built long ago, still play an important role in facilitating the spread of change and the integration of local communities into a larger regional economy.

Keywords

Intercity passenger rail; transportation; population change; employment change; spatial econometrics; spatial spillover effect

Introduction

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 railroads also 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 railroads when they were the principal modes of long-distance transportation, carrying goods and people. Passenger trains dominated the locomotive world at that time, but now the glory has vanished. 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). However, recently intercity passenger rail ridership has grown quickly in the United States, making it one of the fastest growing modes of transportation (Puentes et al., 2013).

The experiences of many countries in Europe and Asia show 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). In 2009, the United States government recognized the economic vitality of passenger rails and considered the expansion and development of a passenger rail system as a stimulus to the macro economy (Goetz, 2012; Grunwald, 2010; Hurst, 2014). Provision of federal funding for the improvement of the passenger rails system was made through the American Recovery and Reinvestment Act of 2009, and it was expected that this provision would fight the economic crisis at that time by creating new jobs and promoting economic growth (Gama 2017). Even though in 2017 the Trump administration proposed a different mechanism for the federal funding, the administration has a high priority to rebuild and modernize infrastructure including railroads (Friedberg 2018; White House 2017, 2018).

Most research on railroads in the United States focuses on freight trains, as intercity passenger trains are not currently considered a primary mode of passenger transportation. 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 the population density is low (Levinson, 2012; Peterman et al., 2009). Therefore, an understanding of the relationship between intercity passenger trains and population and employment change is crucial. This study is important in this context because it examines the association that intercity passenger rails have with population and employment change (growth or decline).

It should be noted that in this study we focus on the associations that passenger rails have with growth rather than the bi-directional causal relationships between rails and growth. Specifically, we separate the relationships into a direct association that passenger rails have with growth and an indirect association through spatial spillover effects to be achieved in an integrated spatial regression approach at the county level using continental U.S. data from 2000 to 2010. The results suggest that intercity passenger rails, although built long ago, still play an important role in facilitating the spread of growth and the integration of local communities into a larger regional economy.

Literature Review

Transportation is one of the factors that link economy and population, by providing access to different geographical areas (Lichter and Fuguitt, 1980; Thompson and Bawden, 1992; van den Heuvel et al., 2014). In both strong and weak economies, transportation plays a 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 et al., 2006; van den Heuvel et al., 2014). Access to transportation has a positive association with employment growth, labor supply, and the willingness of individuals to supply labor. The economic impact is not necessarily limited to areas adjacent to rail terminals; 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, rural and urban development, and geography (Boarnet and Haughwout, 2000; Chi et al., 2006).

Demographics and economy in the 2000s

In terms of population change, the population of the United States jumped from 281.4 million in 2000 to 308.7 million in 2010, indicating a 9.7% growth (U.S. Census Bureau, 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. In 2010, most of the population (83.7%) 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 (Housing Assistance Council, 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 reduced significantly (U.S. Bureau of Labor Statistics, 2012). The country faced one of the longest and 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 in particular experienced dramatic increases in unemployment rates (Housing Assistance Council, 2012). The Great Recession reshaped employment (and population) distribution throughout the country (Hertz et al., 2014; Rickman and Guettabi, 2015; U.S. Bureau of Labor Statistics, 2012).

Previous research

Earlier works on the relationship between transportation and population growth were conducted from the perspective of human ecology (Duration and Turner, 2012; Lichter and Fuguitt, 1980; Mark and Schwirian, 1967; Schnore, 1957; White, 2008). The human ecological perspective essentially argues that demographic change is the response to changes in the available technologies and local environments. Even though there are multiple studies on transportation from the human ecological perspective, those works do not explore the relationship between transportation and population growth (or decline) in a systematic way. Some works are from the perspective of the impact of transportation (highways) on population growth during the 1970s, but the results of these works are ambiguous (Voss and Chi, 2006), partly because of their limited scope and failure to adopt a holistic approach (Chi, 2010; Voss and Chi, 2006; White, 2008). For example, the studies are 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 impacts 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 housing and perhaps affecting the population composition of the area. The indirect impacts come through the growth or decline in the economy, changes in employment opportunities, and changes in the physical environment. Access to the transportation infrastructure plays an important role in these economic changes, which are ultimately linked with population distribution and redistribution (Boarnet and Haughwout, 2000; Lichter and Fuguitt, 1980).

Theories of transportation

The role of transportation in population and employment changes has long been debated in the context of urban development, suburban sprawl, central cities' decline, and inter/intrametropolitan accessibility (Boarnet and Haughwout, 2000). The relationships between transportation and change (growth or decline) in population and employment are 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 relationships between the urban area and adjacent rural areas in terms of economic growth and development (Henry et al., 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 role 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, 2010; Chi et al., 2006; Voss and Chi, 2006). These studies incorporate formal spatial dimensions, a research method that has been neglected in the past.

Impacts of railroads

Because the research on intercity passenger rails is limited, we expand the scope of our literature review to include passenger rails in general. Some studies have examined the impacts of railroads on population and employment changes (Atack and Margo, 2011; Bollinger and Ihlanfeldt, 1997; Levinson, 2008a; Levinson 2008b; White, 2008). The results of such studies show great variation in the impacts 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 changes in station areas in Atlanta; 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 compositions: 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, 2008a; 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 raise the population (Israel and Cohen-Blankshtain, 2010; Levinson, 2008a; 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 suburban populations of commuters who work in metropolitan downtowns (Pucher and Renne, 2003).

Vast literature on passenger rails outside the United States show the influence of railroads on local as well as regional growth (Chen, 2012; Knowles, 2012; Kotavaara et al., 2011; Mejia-Dorantes et al., 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 by Mejia-

Dorantes et al. (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, the accessibility to transportation infrastructure, including railroads, influenced population change (Kotavaara et al., 2011). However, the relationships of transportation accessibility and population change vary by geographic scales: at the regional level, transportation accessibility including railroads increases the (overall) population, while it has the opposite effect at the urban or local level.

In China, the development of intercity passenger 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 passenger rails eventually alter the compositions of employment and population at the local level as well as at the regional level. 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 evolved from but different than earlier assumptions of monocentric urban growth (Auimrac, 2005; Mejia-Dorantes et al., 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 scale. This research is likely the first to offer a systematic exploration of the associations that intercity passenger rails have with population and employment changes at the national scale. This research thus contributes to broadening scholarly understanding of the relationships between passenger rails and population and employment changes.

Methods

Data

For this study, the associations that intercity passenger rails have with population and employment changes are examined at the county level for the continental United States. The intercity passenger rail data were obtained from the Intermodal Passenger Connectivity Database (IPCD) (Research and Innovative Technology Administration, 2012), a national-level database for the passenger transportation system. Although freight and passenger rails run on the same tracks, the IPCD database provides information on passenger rail terminals that have intercity service facilities, which allows us to separate passenger rail terminals from freight ones. The extracted data are complete but only have information for the intercity passenger rail terminals and do not provide the quality and quantity of service (Figure 1).

Data for county-level population and employment were obtained from the decennial censuses of 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 generally consistent over time (White 2008). The exception is that 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 used to generate respective data for Broomfield County. Several government programs related to agriculture, social welfare, education, taxes, and transportation construction and maintenance operate at the county level. The classification of metro and non-metro counties was based on the 2000 definition of the U.S. Office of Management and Budget (2003).

Population and employment growth are also influenced by land use and development (Chi and Ho, 2014). In this research, the variable labeled Land Developability Index (Chi and Ho, 2018) 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 calculated on the basis of geophysical characteristics (water, wetland, and slope), the amount of built-up lands (residential, commercial, and industrial areas; transportation infrastructure), cultural lands (e.g., Indian reservations), and federal and state lands.

Analytical approach

The analysis started with the standard regression method. The ordinary least squares (OLS) regression models are estimated to examine the general associations of intercity passenger rails with population and employment changes. 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 better linearity with the independent variables. The visual representations of population and employment change during the 2000s are shown in Figures 2 and 3, respectively.

The explanatory variable is the number of intercity passenger rail terminals. The rationale behind choosing intercity rail terminals is that there is a close association between the number of intercity passenger rail terminals and the volumes of population they serve. In general, both the size of the population and the number of intercity passenger rail terminals are greater in metropolitan than in nonmetropolitan counties. The greater the number of terminals, the bigger the population they serve. It would also be important to consider the quantity and quality of the service that each terminal provides. Unfortunately, we do not have access to such information. Therefore, in this study we utilize the number of terminals per county, which is publicly available. Also, many intercity passenger rails existed long before 2000, and their growth impacts might have fully materialized in earlier decades. Focusing on rails that opened shortly before 2000 would better capture passenger rail systems' association with population and employment growth. However, we do not have access to such information. The number of passenger rail terminals varies across counties,

and on average each county has 0.22 terminals (Table 2). The descriptive statistics are provided in Table 2.

The OLS 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 that is 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. 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 changes in a county are 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 weight matrix is needed. Four different spatial weight matrices were established for each model. Rook and queen contiguity weight matrices with orders 1 and 2 were created and tested. This helped with the comparison of results of different weight matrices and selecting the most appropriate one. The weight 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).

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 values 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).

It should be noted that in the spatial lag model and the SEMLD, the spatial lag term (i.e., the coefficient that the spatially lagged dependent variable has on the dependent variable) captures the spread effect of the growth from the neighboring counties. This helps separate the direct association that rails have with growth from the indirect association via the spread effect.

Results

Exploratory spatial data analysis

The spatial dependence of population change and employment change can be measured by the Moran's *I* statistic (Moran, 1948). 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. Moran's *I*

for population change and employment change are both relatively high, at 0.46 and 0.41, respectively (Figures 4 and 5), based on the 1st-order queen contiguity weight matrix.

The spatial dependence of population change and employment change is further illustrated by the local indicators of spatial association (LISA) at the county level (Anselin, 1995). Figures 6 and 7 display the spatial dependence of population change and employment change, respectively, based on the LISA statistic and the 1st-order queen contiguity weight matrix. They are in four categories by the combinations of high-high (i.e., high-growth counties surrounded by high-growth counties), low-low (i.e., low-growth counties surrounded by low-growth counties), low-high (i.e., low-growth counties surrounded by high-growth counties), and high-low (i.e., high-growth counties surrounded by low-growth counties), showing only those counties where the local Moran's *I* statistic is statistically significant at the 0.05 level based on a randomization procedure. High-high population-growth counties are mainly in the Wyoming-Utah-Arizona region, northeastern Florida, and metropolitan areas of the District of Columbia, Atlanta, and Dallas- Houston-San Antonio. Low-low population-growth counties are mainly in the two Dakotas, Nebraska, Kansas, and the Mississippi Delta region. The local spatial dependence of employment change exhibits a different pattern: the high-high employment-growth counties are primarily in the southwestern states and lower Texas, and the low-low employment-growth counties are primarily in the entire lower Michigan area, the Appalachian region, and parts of Mississippi, Louisiana, Arkansas, and Tennessee.

Spatial regression models

To examine the associations that passenger rails have with population and employment changes, we first fit OLS regression models. The statistically significant Moran's *I* indicates the existence of significant spatial dependence in the residuals of the OLS regression models (the second columns of Tables 3 and 4). This suggests the 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 it exists, may lead to unreliable conclusions (Chi, 2010; Chi and Zhu, 2008). We therefore fit three spatial regression models—a spatial lag model, a spatial error model, and a SEMLD—for population change and employment change. The SEMLD 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 AIC and BIC are the lowest (Table 3). The SEMLD results show a significant association of intercity passenger rails with 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 in the 2000s.

Similarly, results from Table 4 indicate that the SEMLD is the best model to interpret the regression coefficients of employment change because the value of the log likelihood is the highest and the values of AIC and BIC are the lowest. The SEMLD results suggest that intercity passenger rails have a negative association with employment change; intercity passenger rails play a role in taking employed people out of the county. The results show

that for every one additional intercity passenger rail terminal, a county experienced 0.4% employment decline in the 2000s.

In response to the Great 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 burst. 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; U.S. Bureau of Labor Statistics, 2012). The recession period was also high in mass layoffs (U.S. Bureau of Labor Statistics, 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.

These results are similar to those of 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, both spatial lag and spatial error effects are statistically significant. The spatial lag effects come from the population and employment changes 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 3). Similarly, the number of workers in each county grows by 1.081% for each percentage point of weighted employment growth in its neighboring counties (Table 4). 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, they are the effect of a “gift” from the county’s 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 that intercity passenger rails have 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.

Discussion and Conclusions

Summary and discussion

Many studies have been conducted to examine the relationships between transportation infrastructure and changes in population and employment (Chi et al., 2006). Most research on the demographic and economic impacts of rails focuses on freight rails rather than passenger rails. At a time when the federal government is considering rebuilding and modernizing the transportation infrastructure including intercity passenger rails within the U.S., this study contributes to the literature by examining the associations that intercity passenger rails—an understudied transportation mode—have with population and employment changes.

This study analyzes both direct and indirect associations that intercity passenger rails have with population and employment changes (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 one 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 associations of passenger rails with changes 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 associations that intercity passenger rails have with changes in population and employment. The major contribution of this study is in the separation of the direct and indirect associations through a spatial lag term capturing spread effects from neighboring counties. Intercity passenger rails exerted direct associations with changes in population and employment at the county level in the 2000s, even after controlling for 14 socioeconomic variables. The associations were strong enough to influence changes in population and employment independently. However, these associations were negative, suggesting that intercity passenger rails helped in population and employment outflows. The results indicate that the declines in population and employment occurred by 0.3% and 0.4%, respectively, for each additional intercity passenger rail terminal. Intercity passenger rails act as a facilitator of population and employment outflows in a weak economy.

This research also indicates the indirect associations that intercity passenger rails have with population and employment changes. The indirect associations are measured by the spatial lag effect of the SEMLD. 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 changes and in integration of small communities into a larger regional economy. These findings support the spread effect of growth pole theory, which suggests that population and

employment increases in one area help population and employment increases in adjacent areas. This has important implications for urban planning and transportation planning. Demographic and economic changes in nearby areas affect neighboring areas; therefore, planners for one area should also pay close attention to their surrounding areas during the planning process.

Another possible explanation for the negative direct and positive indirect associations that passenger rails have on population and employment changes could be related to the “straw” effects. The straw effects of transportation infrastructure lower economic productivity in lagging areas because of the increased local dependency on the vibrant surrounding areas (Kim and Han, 2016). Intercity passenger rails do not contribute to making a county an attractive place; rather, they help move out local population and employment. The variable of land developability is positive and significant for both population and employment changes, indicating that counties with higher potential for land development have magnetic powers to attract additional population and employment.

In this context, intercity passenger rails can be viewed as a change agent that is neither a boom factor nor a bust factor; rather, their 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 similar impacts of passenger rails on urban economic growth. According to their study, passenger rails are more a distributive than a generative force. To realize positive economic growth, other factors such as the magnitude of public capital investment and the quality of urban planning play vibrant roles. During the Great Recession period, when employment growth was weak and uneven and employers were conducting mass layoffs, intercity passenger rails might have helped job-seeking populations move out of their origin counties. The findings of this study are important during this time when debate about whether intercity passenger rails should be rebuilt, upgraded, and expanded is growing.

Future research

This study could be extended in several directions. First, the association between intercity passenger rails and growth 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 associations that intercity passenger rails have with population change across urban, suburban, and rural areas. Second, future research could analyze the associations between intercity passenger rails and changes in population and employment for other decades, such as the 1980s and 1990s, as well as for the whole period of 1980 to 2010. That would provide an understanding of the rails-growth relationship over a long time period. 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 changes in population and employment. Fourth, future research could consider the possible impacts of intercity passenger rails on social inequality as measured by education, income, and race and ethnicity. Fifth, the causality from population and employment growth to passenger rail (terminal) development as well as the endogeneity between growth and rail development should be carefully addressed.

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Fig. 1.
Passenger rail routes, United States.

Fig. 2. Population change from 2000 to 2010 at the county level in the United States.

Note: Population change is measured as the natural log of the 2010 census population over the 2000 census population.

Fig. 3. Employment change from 2000 to 2010 at the county level in the United States.

Note: Employment change is measured as the natural log of the 2010 employment over the 2000 employment.

Fig. 4. Moran's I scatterplot of population change, 2000–2010.
Note: The 1st-order Queen's contiguity weight matrix is used.

Fig. 5. Moran's I scatterplot of employment change, 2000–2010.

Note: The 1st-order Queen's contiguity weight matrix is used.

Fig. 6. Local indicators of spatial association of population change from 2000 to 2010 at the county level in the United States.

Fig. 7. Local indicators of spatial association of employment change from 2000 to 2010 at the county level in the United States.

Table 1

Variable descriptions and data sources.

Variables	Descriptions	Data Sources
Demographic characteristics		
Population change	Natural log of the ratio of 2010 population over 2000 census population	Decennial Censuses 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 Censuses 2000 and 2010
Population density	Number of persons per square miles in 2000	Decennial Census 2000
Young	Percent young (age 15–19) in 2000	Decennial Census 2000
Old	Percent old (age 65) in 2000	Decennial Census 2000
Whites	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's degree	Percent population (age 25) with bachelor's degrees or higher in 2000	Decennial Census 2000
Intercity passenger rail	Number of intercity passenger rail terminals	Intermodal Passenger Connectivity Database
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	Metropolitan county (1 = Yes, 0 = No)	United States Census Bureau

Table 2Descriptive statistics ($N = 3,109$).

Variables	Median	Mean	Standard deviation	Percentile (10%)	Percentile (90%)
Dependent variables					
Population change (ln)	0.03	0.04	0.12	-0.08	0.19
Employment change (ln)	0.04	0.05	0.13	-0.10	0.21
Independent variable					
# Intercity passenger rail terminals	0.00	0.22	0.87	0.00	1.00
Control variables					
Population density	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
Whites	89.30	81.62	18.69	54.20	97.80
Blacks	2.10	9.14	14.65	0.20	31.20
Hispanics	1.80	6.21	12.05	0.60	16.00
Female-headed households	5.80	6.26	2.34	3.90	9.20
Bachelor's degree	14.50	16.51	7.80	9.30	26.70
Employment	61.70	60.94	7.04	51.60	69.30
Household 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

Table 3

Regressions of intercity rail terminals on population change from 2000 to 2010.

	OLS	SLM	SEM	SEMLD
<i>Explanatory Variable</i>				
Intercity rail terminals	-0.001 (0.002)	-0.003 (0.002)	-1.19E-4 (0.002)	-0.003 * (0.001)
<i>Control Variables</i>				
Population density	-4.74E-6 *** (1.09E-6)	-3.31E-6 *** (9.24E-7)	-5.29E-7 (1.25E-6)	-1.23E-6 * (5.37E-7)
Young	-0.009 *** (0.002)	-0.004 ** (0.001)	-0.002 (0.001)	6.97E-4 (9.51E-4)
Old	-0.012 *** (6.20E-4)	-0.008 *** (5.41E-4)	-0.008 *** (6.52E-4)	-0.003 *** (3.54E-4)
Whites	3.99E-4 (3.15E-4)	4.11E-4 (2.69E-4)	9.19E-4 ** (3.35E-4)	1.64E-4 (1.68E-4)
Blacks	-8.23E-6 (2.84E-4)	-5.59E-4 * (2.42E-4)	-0.001 *** (3.19E-4)	-4.58E-4 ** (1.53E-4)
Hispanics	7.84E-4 * (3.23E-4)	3.67E-4 (2.76E-4)	9.67E-4 ** (3.65E-4)	-7.94E-5 (1.70E-4)
Female-headed households	-0.003 * (0.002)	3.68E-4 (0.001)	0.006 *** (0.001)	8.36E-4 (9.26E-4)
Bachelor's degree	6.56E-4 * (3.33E-4)	0.001 *** (2.84E-4)	0.001 *** (3.04E-4)	0.001 *** (1.96E-4)
Employment	-0.001 *** (3.82E-4)	-0.001 *** (3.25E-4)	-7.28E-4 (3.81E-4)	-6.17E-4 ** (2.12E-4)
Household income	3.82E-6 *** (3.70E-7)	2.29E-6 *** (3.23E-7)	4.65E-6 *** (4.09E-7)	2.53E-7 (2.00E-7)
Land developability	-2.24E-4 ** (7.65E-5)	1.37E-4 * (6.53E-5)	2.11E-4 * (9.99E-5)	2.53E-4 *** (3.83E-5)
Metro	-0.004 (0.004)	-0.002 (0.003)	-1.17E-4 (0.003)	-7.06E-4 (0.003)
Constant	0.223 *** (0.046)	0.098 * (0.039)	-0.081 (0.044)	0.014 (0.026)
Spatial lag effects	—	0.559 *** (0.018)	—	1.027 *** (0.012)
Spatial error effects	—	—	0.683 *** (0.017)	-0.828 *** (0.028)
<i>Diagnostic Tests</i>				
Moran's I (error)	0.379 ***	0.0293 ***	-0.048 ***	-0.023 ***
Lagrange Multiplier (lag)	1011.03 ***	—	—	—

	OLS	SLM	SEM	SEMLD
Robust LM (lag)	2.32	–	–	–
Lag Multiplier (error)	1241.85***	–	–	–
Robust LM (error)	233.14***	–	–	–
<i>Measures of Fit</i>				
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
Spatial Weight Matrix	1 st -order queen	1 st -order queen	1 st -order queen	1 st -order rook

OLS = ordinary least squares. SLM = spatial lag models. SEM = spatial error models. SEMLD = spatial error models with lag dependence. AIC = Akaike's Information Criterion. BIC = Schwartz's Bayesian Information Criterion.

* Significant at $p < 0.05$ for a two-tail test

** significant at $p < 0.01$ for a two-tail test

*** significant at $p < 0.001$ for a two-tail test; standard errors in parentheses.

Table 4

Regressions of intercity rail terminals on employment change from 2000 to 2010.

	OLS	SLM	SEM	SEMLD
<i>Explanatory Variable</i>				
Intercity rail terminals	-0.004 (0.003)	-0.004 (0.002)	-2.56E-4 (0.002)	-0.004 * (0.002)
<i>Control Variables</i>				
Population density	-4.65E-6 *** (1.35E-6)	-3.08E-6 ** (1.18E-6)	-1.43E-6 (1.61E-6)	-1.23E-6 (8.82E-7)
Young	0.005 * (0.002)	0.002 (0.002)	0.002 (0.002)	0.001 (0.001)
Old	-0.004 *** (7.64E-4)	-0.004 *** (6.67E-4)	-0.004 *** (8.26E-4)	-0.004 *** (4.68E-4)
Whites	-0.002 *** (3.90E-4)	-0.001 *** (3.40E-4)	-8.29E-4 * (4.21E-4)	-2.45E-5 (2.55E-4)
Blacks	-0.002 *** (3.53E-4)	-0.001 *** (3.10E-4)	-0.002 *** (4.06E-4)	-4.74E-4 * (2.27E-4)
Hispanics	0.001 ** (4.02E-4)	3.52E-4 (3.52E-4)	0.001 ** (4.63E-4)	-3.43E-4 (2.49E-4)
Female-headed households	-0.012 *** (0.002)	-0.005 ** (0.002)	-1.71E-4 (0.002)	5.17E-4 (0.001)
Bachelor's degree	0.002 *** (4.06E-4)	0.001 *** (3.54E-4)	0.001 *** (3.88E-4)	5.68E-4 * (2.82E-4)
Household income	1.47E-6 *** (4.15E-7)	9.83E-7 ** (3.65E-7)	3.10E-6 *** (4.95E-7)	2.44E-7 (2.46E-7)
Land developability	-3.38E-4 *** (8.89E-5)	-1.85E-5 (7.76E-5)	8.17E-5 (1.23E-4)	1.66E-4 *** (4.97E-5)
Metro	-2.23E-4 (0.005)	1.56E-4 (0.004)	-8.93E-5 (0.004)	-7.46E-5 (0.004)
Constant	0.293 *** (0.055)	0.140 ** (0.048)	0.044 (0.056)	0.019 (0.036)
Spatial lag effects		0.551 *** (0.020)		1.081 *** (0.018)
Spatial error effects			0.620 *** (0.019)	-0.973 *** (0.039)
<i>Diagnostic Tests</i>				
Moran's I (error)	0.32 ***	0.001	-0.03 ***	-0.007
Lagrange Multiplier (lag)	838.45 ***	—	—	—
Robust LM (lag)	6.21 *	—	—	—

	OLS	SLM	SEM	SEMLD
Lag Multiplier (error)	885.49***	–	–	–
Robust LM (error)	53.25***	–	–	–
<i>Measures of Fit</i>				
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
Spatial Weight Matrix	1st-order queen	1st-order queen	1st-order queen	2nd-order rook

OLS = ordinary least squares. SLM = spatial lag models. SEM = spatial error models. SEMLD = spatial error models with lag dependence. AIC = Akaike's Information Criterion. BIC = Schwartz's Bayesian Information Criterion.

* Significant at $p < 0.05$ for a two-tail test;

** significant at $p < 0.01$ for a two-tail test;

*** significant at $p < 0.001$ for a two-tail test; standard errors in parentheses.