Transportation Networks and the Geographic Concentration of Employment*

Dustin Frye†

Vassar College

February 8, 2021

Abstract

This paper examines the effect of expanding transportation networks on uneven spatial employment growth across the United States from 1953 to 2016. The paper addresses the endogenous placement and timing of interstate construction by instrumenting for highway locations using an historic military map combined with a network theory algorithm to predict construction timing for each highway segment. The results indicate that interstate counties and adjacent counties within the metropolitan periphery experienced significant employment growth relative to non-interstate counties. These differences developed during early interstate construction and are concentrated in traditionally non-traded sectors. The results demonstrate the importance of transportation infrastructure for reshaping the spatial arrangement of economic activity.

KEYWORDS:interstate highways, local labor markets, spatial spillovers

JEL CLASSIFICATION: N72, N92, O18, R12, R23, R40

*The earlier title of this paper is "Transportation Networks and the Geographic Concentration of Industry". Thanks to Nate Baum-Snow, Taylor Jaworski, Carl Kitchens, Murat Iyigun, Lee Alston, Jonathan Hughes, Carol Shiue, Ann Carlos, Edward Kosack, Zachary Ward, Steven M. Smith, and Gisella Kagy, and conference/seminar participants at Vassar College, the US Census Bureau, Haverford College, Columbia University and Barnard College, Northwestern University, University of Wisconsin-Madison, Queens University, the Urban Economics Association Annual Meeting, the Economic History Association Annual Meeting, the All UC Graduate Student Dissertation Conference (UC Davis), and the CSMGEP Dissertation Session AEA Annual Conference for helpful comments and suggestions. I would like to thank Richard Weingroff for generously sharing the PR-511 reports and answering my many questions about it. I would also like to thank Courtney Geiss and Juan Felipe Laso for excellent research assistance. Appendix materials are available through the research page of my personal website. All errors are my own.

†Department of Economics, Vassar College, 124 Raymond Ave, Box 76, Poughkeepsie, NY 12604 (e-mail: dufrye@vassar.edu; website: http://pages.vassar.edu/dustinfrye/)

1 Introduction

Employment growth in the U.S. is characterized by its uneven spatial distribution. Over the last 60 years, nearly 80 percent of growth occurred in just 10 percent of counties.[1] This increasing spatial concentration in growth has continued despite large investments in local economic development (Bartik, 2020). Investments in transportation infrastructure are one form of place based policy used to promote regional growth. Beginning in 1956, construction of the Interstate Highway System in the United States introduced over 40,000 miles of limited access highways, lowering travel costs and improving travel times. By the end of the twentieth century, interstates had reshaped cities by altering the location choices of workers and firms (Baum-Snow, 2007, 2020; Duranton and Turner, 2012) , encouraged trade by connecting regions and international markets (Duranton et al., 2014; Jaworski et al., 2020; Michaels, 2008), and raised aggregate welfare (Allen and Arkolakis, 2014, 2019).

Despite the potential for interstates to support regionally balanced growth, since 1953, over 88 percent of U.S. employment growth has occurred in counties with interstate highways. Evaluating how these cumulative differences develop across space and over time requires a new empirical approach that addresses the endogenous placement and timing of interstate construction. To do so, I instrument for highway locations using an historic military plan combined with a network theory algorithm to predict construction timing for each highway segment. I supplement the empirical approach by introducing a new annual county-level dataset spanning 1953 to 2016 with industry-level employment counts and completed highway mileage.

I estimate the effect of a county being connected to the interstate system on year over year changes in employment using a reduced form analysis, where I instrument for the presence or mileage of interstate highway to address two types of endogeneity. First, highways were often directed to struggling communities to encourage economic growth (Duranton and Turner, 2012; Redding and Turner, 2015). I instrument for eventual interstate highway locations using a proposed 1920s military plan of high priority routes. Second, I address the endogenous allocation of funding by state politicians, which determined when particular segments of interstate highway were constructed. I do so by implementing an algorithm from network theory to predict the

[1] According to the County Business Patterns, between 1953 and 2016, the U.S. added 80.5 million jobs, with over 62 million added in the top 308 counties.

timing of highway construction. The algorithm prioritizes constructing highway segments based on their importance for network connectivity. I use this priority ranking with a simple social planner's problem to predict the construction year for each proposed highway segment from the military plan. The highway instrument predicts both the location and timing of interstate highway construction, which has not been addressed in previous literature.

I implement the empirical strategy using a newly constructed series of County Business Pattern data for every available year from 1953 to 2016. The dataset contains county-level employment for the lower-48 states and for the ten major sectors. To facilitate additional spatial comparisons, I aggregate the county-level data to the commuting zone-level, approximating a local labor market, and estimate the impact of highways using these two alternative units of spatial aggregation.

The results indicate that counties receiving an interstate highway experienced more year over year employment growth relative to counties that were not directly connected to the system. Changing the unit of analysis to the commuting zone level reveals similar differences in employment growth, which suggests that untreated counties within interstate treated labor markets shared similar employment growth differences. Furthermore, these positive employment spillovers are concentrated within commuting zones that overlap with MSA boundaries. This growth in the non-interstate metropolitan periphery is consistent with the decentralized suburban job growth in Baum-Snow (2020) and highlights the connection between interstates and agglomeration spillovers at the labor market level. These positive spillovers do not appear to extend to interstate-adjacent, non-MSA counties, where I find evidence of declining employment, consistent with Chandra and Thompson (2000).

By directly addressing the endogenous timing of highway construction, I am able to examine how differences between highway and non-highway areas evolve over time. I begin by partitioning the 60 years of CBP data into three distinct twenty year eras: initial expansion, highway completion, and post-construction. The initial expansion era includes the first two decades of construction when roughly 75 percent of the system was built. Over this period, much of the network remained disconnected because the authority over construction timing was granted to states.[2]

[2]Appendix Figure A.3.1 illustrates the timing of interstate highway construction. Appendix Figure A.3.2 illustrates the disconnected nature of the interstate system in 1965.

Despite the largely disconnected system, interstate counties experienced positive, but statistically imprecise, year over year employment growth relative to non-interstate counties during the first two decades. The strongest period of employment growth occurred during the completion era, from 1976 to 1995, when both highway counties and counties in the adjacent metropolitan periphery experienced faster employment growth relative to non-interstate counties. The results suggest minimal growth differences after construction.

Previous literature has established that interstate highways were often directed to less developed areas to encourage economic growth (Duranton and Turner, 2012; Redding and Turner, 2015). By addressing endogeneity in both the location and timing of highway construction, I am able to evaluate how state and local funding control influenced construction timing. My findings show, counties receiving highways in the first decade of construction were significantly larger in population and employment, and were already growing much faster prior to interstate construction. They had more urban residents and better access to transportation infrastructure. This suggests that during the construction era, state and local officials prioritized building interstates in developed areas and especially metropolitan interstates, likely contributing to the highway riots of the 1960s (Brinkman and Lin, 2019).

I extend the analysis to evaluate employment growth by sector. The results indicate that early employment growth among highway counties was driven by retail trade, services, and transportation and utilities. The results also reveal early declines in manufacturing employment among counties in the metropolitan periphery. During the interstate completion era, from 1976 to 1995, interstate counties experienced positive increases across several sectors, with the strongest gains in wholesale trade. Non-interstate metropolitan periphery counties experienced significant growth across nearly every traditionally non-traded sector. Overall, the results suggest stronger local and suburban growth early in the construction process, with subsequent growth in trade related industries after the system was connected, consistent with timeline and findings in Michaels (2008).

This paper contributes to our understanding of the spatial and temporal effects of transportation infrastructure.[3] The data incorporates both urban and rural counties, which allows for comparisons across different geographic units. The reduced form interstate highway literature is typ-

[3] For a comprehensive survey of this literature see Redding and Turner (2015).

ically partitioned into studies focusing on these areas separately.[4] This paper includes both types of counties in the analysis and explores the importance along both the extensive and intensive margins of highway expansion to understand how the effects of interstates differ across space. It is also the first paper to aggregate counties to the commuting zone level, which provides insights into how employment spillovers develop within local labor markets. My findings are also consistent with the literature focusing on international road construction programs in Africa (Jedwab and Storeygard, 2020), China (Faber, 2014; Baum-Snow et al., 2020), and India[5], which find similarly important differences across core and periphery areas. My empirical approach focuses on relative differences between treated and untreated areas, which allows for more flexibility in exploring the spatial and temporal effects of interstate highways, but can not speak to general equilibrium effects.[6]

I build on the existing technique of using historic, proposed highway plans to instrument for highway locations (Redding and Turner, 2015) by incorporating an application from network theory that directly addresses the endogenous timing of highway construction. Accounting for the bureaucratic allocation of funding is important when examining the time-path of highway effects with potential contributions to other forms of networked infrastructure like airports[7], historic railroad expansion[8], or the development of commuter or high speed rail systems[9]. The methods are directly relevant to other settings evaluating the contemporary consequences of historic transit development[10] and for networked place based policies that roll out over time (Garin, 2019; Jaworski

[4]Because interstate highways were developed in most large cities, the literature in urban and suburban settings exploit variation along the intensive margin, focusing on increases in mileage or the number of interstate rays (Agrawal et al., 2017; Baum-Snow, 2007, 2020; Duranton et al., 2014; Duranton and Turner, 2011, 2012). The literature examining rural areas focuses more on the extensive margin of whether or not a highway was built in a county (Chandra and Thompson, 2000; Michaels, 2008). Recent work has quantified the effects in rural areas by leveraging changes in market access (Herzog, 2020).

[5]This literature has focused on multiple construction projects including the national Golden Quadrilateral (Alder, 2019; Ghani et al., 2016, 2017), rural road development Aggarwal (2018), and broader transit network development (Alder et al., 2017).

[6]For recent examples across different forms of transit infrastructure and in multiple settings see Donaldson and Hornbeck (2016); Baum-Snow et al. (2017); Alder et al. (2017); Bartelme (2018); Alder (2019); Jaworski and Kitchens (2019); Jaworski et al. (2020); Jedwab and Storeygard (2020); Fajgelbaum and Schaal (2020); Herzog (2020); Rothenberg (2013).

[7]For examples in the U.S. see Blonigen and Cristea (2015); McGraw (2020); Sheard (2014, 2019) and for a recent example in China see Gibbons and Wu (2020).

[8]For the recent literature on U.S. development see Atack et al. (2010); Atack and Margo (2012); Donaldson and Hornbeck (2016); Hodgson (2018); Hornbeck and Rotemberg (2019), examples from European networks include Berger and Enflo (2017); Berger (2019); Bogart et al. (2018), and Donaldson (2018) for colonial Indian railways.

[9]See Ahlfeldt and Feddersen (2018); Baum-Snow et al. (2005); Gonzalez-Navarro and Turner (2018); Heblich et al. (2020); Heuermann and Schmieder (2019); Qin (2017)

[10]These include a literature in Africa (Jedwab and Moradi, 2016; Jedwab et al., 2017; Storeygard, 2016) and Europe

and Kitchens, 2019; Kline and Moretti, 2014).

Finally, the results contribute to the recent literature on industry specific changes induced by U.S. transportation infrastructure. The findings highlight the contribution of interstates to the structural transition of U.S. employment from manufacturing to services by showing that interstates had relatively little impact on manufacturing employment, but large effects on retail and services consistent with findings across a variety of settings (Chandra and Thompson, 2000; Duranton et al., 2014; Michaels, 2008). It also relates to work on urban and suburban industrial development (Baum-Snow, 2020) and changes in employment across traded and non-traded sectors (McGraw, 2020).

2 A History of the Interstate Highway System

2.1 The Pershing Map and the National Interregional Highway Committee

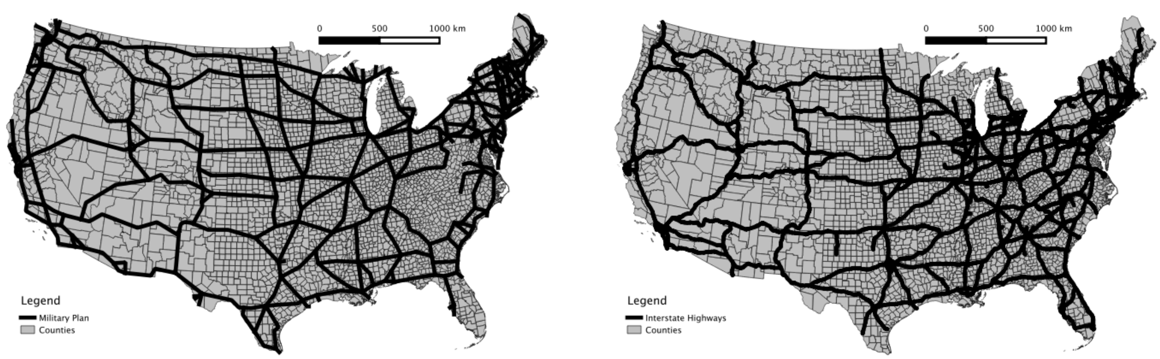
Early proposals of interstate highway locations date back to the early 1920s. Following the First World War, the U.S. government began discussing the merits of a national highway system, similar to the system that existed in Europe. This led Congress and the Bureau of Public Roads to seek input from the War Department regarding a national system of interstate highways (Karnes, 2009). The War Department commissioned General John J. Pershing to provide a network map of high-priority military routes. The army did not value a "transcontinental road which merely crosses the continent", but rather wanted "roads connecting all our important depots, mobilization and industrial centers" (Swift, 2011, 76). The resulting map, depicted in Figure 1a, contained nearly 78,000 miles of highway that the War Department deemed as strategically important. The map emphasized "coastal and border defense and links to major munitions plants" (Swift, 2011, 76). These routes were never built as superhighways but this map influenced future highway location decisions.

National interstate highway programs were reintroduced during the Great Depression as part of New Deal legislation. President Roosevelt formed the National Interregional Highway Committee "to investigate the need for a limited system of national highways to improve the facilities now available for interregional transportation" (U.S. Dept of Transportation, 1977, 273). Commit-

(Garcia-López et al., 2015; Holl, 2004a,b, 2016; Möller and Zierer, 2018).

tee members included engineers, government officials, and highway planners. With the help of state highway departments, the committee produced a new 39,000 mile national highway plan. The committees objectives were to "provide highway transportation to serve the economic and social needs of the nation" (U.S. Dept of Transportation, 1977, 274). The highway network was intended to "serve the Nation's agricultural production, its mineral production, its forest production, its manufacturing centers and ... its population centers and defense establishments" (U.S. Dept of Transportation, 1977, 274). Interest groups on behalf of the farming and trucking industry "lobbied for their own plans to foster particular and local needs" (Rose, 1990, 16). The final plan, published in 1947 and depicted in Figure B.1.1, was the most comprehensive national network map that had been produced and served as the major guide of highway location decisions for the next decade.

Figure 1: Proposed and Constructed National Highway Network Plans



(a) Pershing Military Plan (b) Constructed Interstate Highway Locations

Notes: Proposed Pershing routes digitized from original map housed at the U.S. National Archives. Map of current Interstate Highway System locations from Federal Highway Administration.

Highway construction plans were halted during the war and funding was restricted to high priority maintenance of current roads. Without adequate funding for repairs, the quality of highway infrastructure deteriorated rapidly. Prior to World War II, total road spending was about 1.4 percent of GNP and during the war this amount fell to about 0.2 percent (Karnes, 2009). As the quality of roads decreased, the demand for high quality roads increased rapidly. From 1945 to 1950 vehicle registrations increased nearly 60 percent (Swift, 2011). The Bureau of Public Roads determined that between the mid-1920s and early 1950s traffic had increased by 250 percent and highway demand had increased by a factor of eight (Rose, 1990). This put tremendous strain on the existing infrastructure, which was ill equipped to deal with new faster cars and heavier trucks. Travel times increased dramatically due to elevated levels of congestion and the increased probability of an accident (Kaszynski, 2000).

2.2 Federal Aid Highway Act of 1956

In the early 1950s, several Congressional Committees developed plans for funding and designing a new system of limited access interstate highways. President Eisenhower was influential in helping support these committees and invited Governors and heads of interest groups to participate in the planning process (Rose, 1990). Industry representatives from oil, trucking, and manufacturing were particularly influential in these discussions (Kaszynski, 2000). Congressional representatives were also influential in the system's design. Additional urban mileage was added to appease Congressional representatives with large urban constituencies (Boarnet, 2014).

In 1956, after several prior proposals, construction guidelines and financing terms were introduced. Congress ultimately agreed on legislation that included proposed locations and plans for funding. The system was approximately 90 percent federally funded and was financed with tax revenue from a variety of sources (Kaszynski, 2000). Eisenhower signed the Federal-Aid Highway Act of 1956 into law on June 29th. The final design, presented in Figure 1b, was "a culmination of decades of input and research from auto clubs, civil engineers, and state and federal highway officials" (Kaszynski, 2000, 167). The Highway Act of 1956 placed states in charge of construction and each state's funding was determined based on a formula of population, area, and highway mileage. This allowed states to build their segments of interstate highway at their own pace. The solicitation of opinions from heads of industry and government officials for both the eventual location of interstate highways and the pace of construction have important consequences for empirically estimating the effects of interstate highways.

As interstate highways expanded through the 1960s and 1970s they became an increasingly important part of travel. In 1960, interstate highways constituted 0.3% of total paved roads in the U.S. and only 3.3% of total vehicle miles traveled (VMT) occurred on interstates. Completed interstate mileage nearly tripled during the 1960s and by 1970, interstates carried nearly 15% of total VMT (U.S. Department of Transportation Statistics, 1960, 1970). Today, interstates constitute only 1.1% of total road mileage but they support over 25% of total vehicle miles traveled (U.S. Department of Transportation Statistics, 2017).

3 Data and Descriptive Evidence

To investigate the effects of highway on employment, my empirical analysis relies on county-level annual employment and establishment data collected by the Census Bureau and published in the County Business Patterns (CBP) from 1953 to 2016. These data are combined with contemporary and historical transportation network information, which allows me to estimate the relationship between the expansion of interstate highways and employment growth across two different spatial units of observation: counties and commuting zones.

3.1 County Business Patterns

In 1946, the United States Census Bureau began publishing industry-level employment and establishment size counts by firm size. I collected previously undigitized records from 1953 to 1964 using a combination of OCR scanning and hand collection.[11] Data from 1964 to 1970 are published for a limited number of industries on ICPSR (Ody and Hubbard, 2011).[12] The remaining years are available from the US Census Bureau and the National Archives.[13] I adjust for county boundary changes using 1950 boundary definitions following Hornbeck (2010) and consolidate independent cities into their surrounding counties similar to Jaworski and Kitchens (2019).[14]

To generate the primary outcomes of interest, I construct employment and establishment counts for each available year from 1953 to 2016, for each of the primary Standard Industrial Classification (SIC) economic divisions: agriculture, construction, finance, manufacturing, mining, retail sales, services, transportation and public utilities, wholesale trade, and unclassified occupations.[15] For each broad industry division, I observe the total level of employment and the total number of es-

[11] Prior to 1962, published establishment and employment information was combined for some counties in eight states. I partition the data in these counties using weights from 1964, the first year every county is reported separately.

[12] This series had a few omissions, which I hand collected.

[13] Appendix C.1 provides more detail regarding the construction of the CBP dataset.

[14] County boundary locations from 1950 to 1990 are defined from Long (1995). For changes after 1990, I rely on the reported boundary changes from the US Census Bureau.

[15] After 1997 the Census Bureau no longer used the SIC system, moving to NAICS. I use a SIC to NAICS crosswalk developed by Autor et al. (2013) to incorporate the new classifications.

tablishments for eight employment size groups.[16] For confidentiality purposes the Census Bureau censored the county-level employment data for some smaller industries. Similar to Duranton et al. (2014), I impute employment values using the distribution of establishment count data.[17]

The result is a county-level panel dataset spanning from 1953 to 2016 with employment, establishment counts, and establishments counts by eight employment size groups for each of the ten SIC economic divisions. I also aggregate the ten SIC economic divisions to make a total category containing the employment, number of establishments, and establishment group counts for all sectors in the county.[18] Finally, I aggregate the county-level panel using 1980 commuting zone definitions to construct a larger geographic unit that approximates a local labor market (Economic Research Service, 2019).

3.2 Interstate Highway System Maps

I use several data sources to construct an annual county-level panel dataset with Interstate Highway System location and mileage information from 1953 to 2016. The first data source is current highway location information from NationalAtlas.gov (2016). To incorporate construction timing, I combine this file with highway construction information from several sources. My primary source is the PR-511 collection at the National Archives.[19] The PR-511 reports were not available prior to 1960, so I digitized annual Rand McNally highway maps from 1955 to 1959. For years after 2000, I relied on detailed interstate highway expansion information from the US Department of Transportation.

After combining these sources, I have annual information on the location and timing of the construction of the Interstate Highway System. I intersected this progress with a map of county

[16] Employment size groups vary by year, but typically include: 1-4, 5-9, 10-19, 20-49, 50-99, 100-249, 250-499, and above 500 employees. Note, one limitation of the County Business Patterns data is that it does not include establishments with zero employees.

[17] For each industry, I regress the county sectoral employment on the full set of eight establishment count groups and I use the resulting regression coefficients to impute the number of employees. The R^2 for each regression is between 0.945 and 0.999. My dataset is limited to the major divisions, which does not allow me to integrate the alternative imputation approach from Eckert et al. (2020).

[18] The current dataset includes county-level total employment for every available year and employment by sector for every year except 1956 and 1959.

[19] This series contains maps produced quarterly that show the progress of interstate highway construction. I digitized these maps and traced the annual construction progress of interstate highways in GIS. I denoted a segment of interstate highway completed once construction of that segment was finished and it was completely open to traffic. I used the fall quarter of each year when available. While I tried to be careful to accurately track annual construction progress it is possible that I classified counties as receiving interstate highways either before or after they actually did. This variation is likely to be random and corrected within the next year, which leads to short-term noise in the date of arrival.

locations in 1950, which allows me to know the year a county was connected to the Interstate Highway System.[20] For each county, I determine whether an interstate highway intersects that county and the year of arrival and the completed mileage constructed in each county in each year. Figure 1b shows the current interstate highway locations overlaid on a map of county locations.

3.3 Supplemental Data

To account for factors that are correlated with employment changes and the location and funding of interstate highways, I supplement the economic and highway information with data covering population, geography, and alternative methods of transportation. I use county-level population data from the U.S. Census from 1910 to 1950, including the percent of the population living in urban areas in 1950 from National Historical Geographic Information System (2011).

I constructed several measures for alternative methods of transportation that existed prior to the construction of interstate highways, which could have influenced subsequent economic growth or the highway construction decision. First, using a newly digitized historic map of major highways from 1918 and railroad route information from 1911 from Atack (2016), I calculate the distance from each 1950 county seat to the closest 1918 highway and 1911 railroad. I also calculated the length of railroad track present in each county. Next, I collect location information for airports and ports in 1955 and 1956 from the Statistical Abstract of the United States (U.S. Census Bureau, 1958). I determine the latitude and longitude for each airport and port and calculate the distance from these locations to each 1950 county seat. To account for differences in the proximity to major metropolitan areas, I calculated the distance from each county seat to the centroid of the 1950 Metropolitan Statistical Area boundary. Finally, to address contemporaneous road construction, I collected annual state-level spending reports on non-Interstate Highway road spending from the Annual Survey of State and Local Government Finances from 1943 to 2016.

3.4 Growth Over Time and Evidence of Selection

From the three sources above, I construct two panel datasets from 1953–2016 to evaluate the effects of interstate highways on employment growth across locations, one at the county-level and another at the commuting zone level. Both datasets contain employment, highway location with

[20] I adjust all of the county locations and data to be consistent with the 1950 county borders.

construction timing, historical population and economic data, and geographic measures of alternative methods of transportation infrastructure.

As a preliminary comparison between interstate and non-interstate areas, Figure 2 plots the mean changes in total employment relative to 1953 by eventual highway status. The county level trends in panel (a) and commuting zone level trends in panel (b) show employment in both highway and non-highway counties grew over the period, with highway county growth outpacing non-highway growth. The difference in employment growth is less pronounced when we consider commuting zones in panel (b), where the figure indicates both areas grew similarly until the early-1980s before separating. Both figures illustrate the growing employment gap between interstate and non-interstate areas. Appendix Table A.1.1 reports summary statistics for the full period and shows that on average, employment in interstate counties grew at about 2.2 percent per year compared to 1.7 percent growth in non-interstate counties.

This faster employment growth among highway counties is coupled with significantly higher levels of initial employment. Appendix Table A.1.2 presents summary statistics of the pre-interstate county and commuting zone characteristics by eventual highway type. Not surprisingly, areas that built interstate highways are considerably different from those that did not. The table shows highway counties were more populated, had a higher share of urban population, had more market potential, had better access to alternative forms of transportation, and spent more on other road construction. These differences reinforce the selection concerns regarding interstate locations.

4 Empirical Strategy

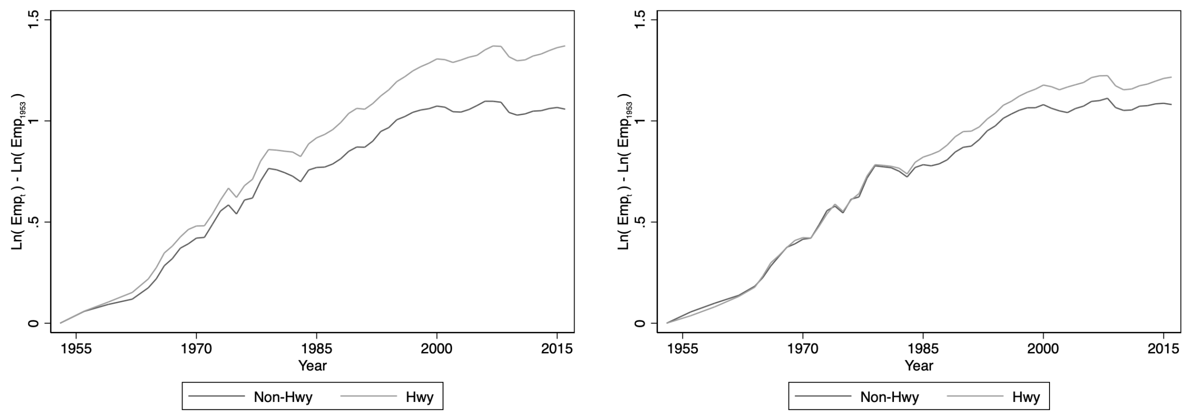
4.1 Estimating Equation

To estimate the effect of the Interstate Highway System on year over year employment growth, I exploit spatial and temporal variation in the location of interstate highways using the following first-difference specification,

$$ln(Y_{ct}) - ln(Y_{ct-1}) = \beta \cdot hwy_{ct} + \theta_s + \delta_{rt} + X'\rho_{ct} + \epsilon_{ct} \tag{1}$$

where Y_{ct} is the outcome of interest in spatial unit c at time t. The variable hwy_{ct} is an indicator

Figure 2: Employment by Highway Status



(a) County-Level Employment

(b) CZ-Level Employment

Notes: Employment data from 1953–2016 County Business Patterns annual reports. Highway designation based on highway status in 2016.

that is equal to one if an interstate highway intersects area c at time t. The coefficient of interest is β, which estimates the average effect of the interstate highway system. The specification includes state fixed-effects, θ_s, census region $\times$ year fixed-effects, δ_{rt}, and a full set of controls, $X'\rho_{ct}$.[21] The controls, which are presented in Appendix Table A.1.2, include the outcome of interest in 1953, log population for each decade from 1910 to 1950, and additional measures to capture pre-highway levels of urbanization, market potential, transportation infrastructure, and geography. The county-level models also include two state-level measures of non-interstate road spending to account for their expansion over time. Section Appendix C.2 describes each measure and its construction in more detail. These covariates are associated with receiving an interstate highway and employment changes relative to 1953. Standard errors are two-way clustered by county and state $\times$ year to account for serial correlation and spatial correlation in the error term (Kelly, 2019, 2020).[22] This specification identifies the effect of an interstate highway for highway counties relative to non-highway counties, while allowing for subsequent endogenous policy decisions (Kline

[21]By including the census region $\times$ year fixed-effects, the treatment effect of an interstate highway is identified using variation within a census region in a year. Including this set of fixed-effects accounts for any region wide changes that affect employment, the opening or closing of businesses, or promote growth in specific industries that change over time and are correlated with the construction of interstate highways. Appendix Table A.2.1 reports results under varying spatial fixed-effects including, commuting zone, and state $\times$ year fixed-effects, and finds larger effects across specifications.

[22]Appendix Table A.2.2 presents OLS results using spatially weighted standard errors proposed by Conley (2010) and Hsiang (2010). These spatially adjusted standard errors are consistently smaller across the alternative distances compared to the preferred two-way clustering.

and Moretti, 2014). This model does not allow me to separately identify the effect of highways on growth and relocation, but rather relative differences between the two types of locations.

4.2 Addressing Highway Endogeneity

Estimating differences between highway and non-highway counties will result in biased estimates because counties selected to receive a highway, and when they received the highway, are likely to differ along unobservable dimensions that are correlated with changing employment. The history of highway construction indicates that the placement and funding of highways was an intensely political process. Politicians, lobbyists, and heads of industry all contributed to the current locations of interstate highways and state politicians were in charge of allocating resources for construction. If these outside contributors viewed highway construction and development as a place-based economic development policy, they may have been more likely to add segments of highway or reroute planned segments to reach less developed counties or start construction earlier to promote more growth. Therefore both location choice and timing of construction are potentially endogenous.

To address endogeneity concerns regarding highway locations, I use the 1921 historic military plan, described in Section 2, as an instrumental variable to predict eventual highway locations. This plan is commonly referred to as the Pershing Map and was designed to prioritize the military needs of the early-1920s (Michaels et al., 2019). Proposed highway location data are based on the digitized Pershing Map from the Bureau of Public Roads collection at the National Archives. Figure 1a depicts the highly prioritized routes drawn in the Pershing Map. The full Pershing Map contains three priority levels, the depicted map shows routes in the two highest priority levels. Section 4.3.4 uses the unbuilt priority three segments as a falsification exercise.

I address the endogenous timing of highway construction using an application from network theory to predict the optimal timing of highway construction. I implement the Newman-Girvan Algorithm[23] to determine a construction priority for each segment of the proposed highway networks. This algorithm was originally used to identify important connections in biological and social networks. To my knowledge this is the first application of this algorithm in the transporta-

[23] For specifics regarding the algorithm see Girvan and Newman (2002); Newman and Girvan (2004); Newman (2001, 2004).

tion economics literature. In order to apply the algorithm to the each of the historical highway network plans, I decompose each planned road system into a mathematical network of nodes and edges, where each node occurs at the intersection of two edges or at the end of an edge. I then weight each edge by it's length in kilometers. The Newman-Girvan Algorithm calculates the edge-betweenness for each edge by determining the shortest path from each node to every other node in the system and then counting the number of shortest paths that move along every edge.[24] Edges with the largest betweenness value are more commonly traveled and therefore are mathematically more important for connecting nodes in the network.

To predict construction timing, my procedure sequentially builds the network edges with the highest betweenness value subject to an annual construction budget. I derive the annual budget appropriation based on estimated construction costs of the entire network equally divided over a fixed construction time horizon. I calculate the total network construction cost by estimating construction costs for each segment based on weighted average costs of the urban and rural mileage for that segment. I use construction cost estimates for urban and rural cost per mile from a 1955 Congressional highway proposal.[25] Urban mileage had an estimated cost of $2,431,818 per mile, while rural costs are significantly lower at $378,787 per mile, both in 1955 dollars.[26] I use historical cost estimates instead of realized costs because it better approximates the decision a social planner would have made at the time of construction. Actual construction costs changed over time for several reasons as detailed by Brooks and Liscow (2019).

I calculate the total cost of construction for each entire network using the computed cost of each segment of the proposed network. I then calculate the annual construction constraint by dividing the total network construction cost over a twenty-five year construction period, which approximates the time-frame of actual highway construction for the mileage of the Pershing Military Plan and the 1947 Plan. Once I have an annual construction constraint, I rank the proposed networks edges with the highest betweenness scores first and build them in that order until the total amount spent on construction equals the annual construction constraint. Unbuilt edges are

[24] Appendix Figure A.3.3 presents two stylized highway graphs to illustrate calculating edge-betweenness. The first panel presents a simplified highway network with ten cities (nodes) connected by thirteen highways (edges). The approximate mileage between each node is printed along each edge. The second panel presents the resulting edge-betweenness calculation for this network, where the betweenness score is presented both as the value on the edge and illustrated by the thickness of the edge, where thicker edges have higher betweenness scores.

[25] Estimates derived from House Document 120, submitted to the 84th Congress during the first session.

[26] The ratio of construction costs is more important to the model than the actual costs.

carried over to the next year and the process repeats. The algorithm allows me to assign a construction year for each edge, which results in a highway instrument that predicts both the location of an interstate highway and the year of construction. Appendix Figure A.3.1 illustrates how the proposed construction horizon compares to the timing of construction for the Interstate Highway System. The figures show that the preferred twenty five year construction horizon more closely matches the actual construction horizon.[27]

Appendix Table A.1.3 shows the overlap between the proposed instrumental variable and the Interstate Highway System. A large majority of observations fall in the matched categories of (No, No) or (Yes, Yes). Importantly the table illustrates the balance in the off-diagonals. The plan shows a balanced likelihood of predicting a highway where a highway was not built and building a highway where the instrument do not predict it should be placed. This is especially important given that the proposed plan feature less mileage than the actual interstate system.

4.3 Instrument Validity

4.3.1 First-Stage

To test whether the proposed network with network determined construction timing sufficiently predicts whether a county will have an interstate highway at time t, I estimate the following first-stage regression,

$$hwy_{ct} = \theta \cdot Plan_{ct} + \psi_s + \lambda_{rt} + V'\mu_{ct} + \upsilon_{ct} \tag{2}$$

The variable $Plan_{ct}$ is an indicator for whether a county c is predicted to have a highway from the proposed network in year t. The specification includes state fixed-effects, ψ_s, and census region $\times$ year fixed-effects, λ_{rt}, and controls from the second-stage, $V'\pi_{ct}$. First-stage coefficients and standard errors are included at the bottom of each set of results in the main specifications. Kleibergen-Paap F-statistics are reported with every specification (Stock and Yogo, 2005).

[27] Appendix Table A.2.4 presents results for the main specifications using a 35-year construction horizon. The findings across specifications are very similar between 25 and 35-year horizons.

4.3.2 Exclusion Restriction

Using planned transportation networks to instrument for eventual highway location is consistent with several recent empirical papers examining the effects of transportation networks.[28] The validity of the Pershing system as a suitable instrument hinges on the degree to which military motives in 1921 are orthogonal to employment growth and industrial development in the latter part of the 20th century. One advantage of using the Pershing system is the strong military influence and the lack of input from outside political and economic agents. These military motivations are evident in the lack of proposed routes extending into southern Florida and the emphasis in roads along the coasts and borders. Another advantage is that the Pershing system was connected with straight lines and was designed to avoid passing through the center of metropolitan areas. This creates a network style graph with straight line connections akin to those evaluated by Banerjee et al. (2020), Faber (2014), and Morten and Oliveira (2018). My empirical strategy continues to condition on historic population, transportation, and spatial controls to account for county characteristics that may have influenced the military route selection.

If the military designed the network around expected employment or industrial growth than the estimates would reflect the military selection process and not the result of a constructed interstate highway. In the following sections, I perform two empirical falsification tests that support using the Pershing Map as a valid location instrument. The first, estimates the effect of interstates prior to their construction and the second, estimates the effect of lower priority routes that were never constructed.

4.3.3 Effects Prior to Construction

Section 2 describes the economic and political considerations that influenced the route design of the Interstate Highway System. An empirical concern is that influential route designers simply identified places that were poised for growth. To directly test whether Pershing routes affected employment prior to construction, I construct at county-level panel dataset from 1930 to 1960 from Haines et al. (2010)[29] and estimate equation 1, using a time-invariant binary interstate highway

[28] See Agrawal et al. (2017); Baum-Snow (2007, 2020); Duranton and Turner (2012); Duranton et al. (2014); Herzog (2020); Michaels (2008); Michaels et al. (2019) for recent examples.

[29] Coverage includes each decade from the Decennial Census and the 1954 County Data Book.

indicator, with the full set of controls and fixed-effects outlined in Section 4. The outcomes of interest decade over decade changes in total county employment, bank deposits, the number of firms engaged in manufacturing, retail sales, wholesale trade, and the number of farms. Table 1 reports coefficient estimates for the OLS and the Pershing IV for each of the six outcomes.

Table 1: Effects of Highways Prior to Construction

	Employment		Bank Deposits		Farms	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: General	OLS	Pershing IV	OLS	Pershing IV	OLS	Pershing IV
Highway (0/1)	0.0021***	0.0005	0.0019***	0.0008	0.0002	-0.0034
	(0.0006)	(0.0027)	(0.0007)	(0.0034)	(0.0005)	(0.0024)
Observations	9,303	9,303	14,613	14,613	15,352	15,352
Counties	3,101	3,101	2,962	2,962	3,092	3,092
Region X Years	147	147	235	235	243	243
KP F-Statistic		81.383		93.093		96.505
	Manufacturing Estab.		Retail Trade Estab.		Wholesale Trade Estab.	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel B: Establishments	OLS	Pershing IV	OLS	Pershing IV	OLS	Pershing IV
Highway (0/1)	0.0008	0.0052	0.0017***	-0.0007	0.0020***	-0.0021
	(0.0008)	(0.0049)	(0.0006)	(0.0027)	(0.0006)	(0.0039)
Observations	12,676	12,676	12,393	12,393	11,891	11,891
Counties	2,559	2,559	3,099	3,099	3,014	3,014
Region X Years	245	245	196	196	196	196
KP F-Statistic		80.341		92.479		89.056

Notes: Every specification reports results from estimating a modified equation 1, which regresses a time invariant binary interstate highway indicator on average year over year changes in the log outcome. Every specification includes state and census region $\times$ year fixed effects, along with the full set of controls outlined in Appendix C.2. Outcome data from 1930–1960 decadal censuses and 1954 County Business Patterns reported at the county-level. Employment reflects the total county employment; Bank Deposits is the total inflation adjusted value of deposits; Farms, Manufacturing, Retail Trade, and Wholesale Trade all the reflect the number of establishments. Each measure is used to calculate the average log change from the prior period. Standard errors are two-way clustered by county and state $\times$ year. *** p<0.01, ** p<0.05, * p<0.1.

The coefficients reflect the estimated effect of interstates prior to their actual construction. Across four of the six outcomes, OLS estimates are positive and significant, reflecting possible selection of faster growing counties or anticipatory growth based on expectations of highway development. Reassuringly, coefficient estimates using the Pershing Map IV are never statistically significant.[30]

[30] Appendix B discusses similar analysis using the proposed 1940s highway plan introduced in Section 2. The results raise concerns that the 1947 Plan does not sufficiently address the endogeneity concerns when considering a national set of counties and measuring highway treatment through a binary indicator.

4.3.4 Planned and Never Built Segments

An additional concern is that employment or economic activity was in some way influenced by the Pershing routes, through a mechanism unrelated to interstate construction. As introduced in Section 4.2, the full Pershing Map was designed with three priority levels and the constructed Pershing IV uses the two highest priorities. As an additional check on the Pershing IV, I isolate the unbuilt segments from the third priority-level and compare them to the rest of the non-interstate counties by estimating equation 1, using these unbuilt segments as the highway treatment. Appendix Figure A.3.4 maps these locations against the set of remaining non-interstate counties. Appendix Table A.2.8 reports OLS results for total county employment. The coefficient estimate is very small and statistically insignificant, supporting the assertion that the Pershing map locations did not directly influence changes in employment.

5 Results

5.1 Highway Treatment Across Space

Table 2 reports results from estimating equation 1, where the first two columns report results using a binary highway indicator for whether the county or commuting zone received an interstate highway and the third and fourth columns add a measure of highway density.[31] Within each pair, the table reports OLS and Pershing IV results. Panels A and B contrast the two spatial units, with Panel A presenting the results at the county level and Panel B presenting results at the commuting zone level. The lower section of each panel reports the Kleibergen-Paap F-Statistic, which indicates the instruments are sufficient predictors of highway status, and column (2) presents the single coefficient estimate of the binary highway treatment from the first-stage regression.

The results from the binary highway treatment in columns (1)–(2) indicate interstate highways induced a significant increase in employment growth for highway counties relative to non-highway counties. Specifically, year over year employment increased 0.44–0.48 percent faster, on average, in highway counties. Given the average employment growth rate of 2.2 percent for interstate counties, this suggests that between 20 and 22 percent of year over year employment growth

[31] Highway density is calculated as the completed kilometers of interstate highway divided by the area of the spatial unit.

in those counties is attributable to interstates. For the median highway county, between 1956 and 2016, employment increased by roughly 13,700 workers and the coefficient estimates suggest that interstates were responsible for between 2,700 and 3,000 of those jobs. Columns (3)–(4) present results after adding a measure of intensive highway expansion. The coefficients indicate that relative increases in employment are driven by counties being connected to the interstate network at the extensive margin with no additional gains at the intensive margin.[32] Consistent with prior work on interstate highways and other large transit investments, the results are larger in magnitude in the IV specifications compared to OLS results. These differences are more pronounced at the commuting zone level compared to the county level, which is consistent with place-based development targeting the level of the labor market.

Differences in the estimation results in Panels A and B are important for understanding the spatial extent of highway benefits and provide insight into the endogenous selection process of highway construction. Across most specifications, estimates at the commuting zone level are slightly smaller in magnitude. This pattern is consistent with highways inducing spatially concentrated gains in employment or a potential reallocation within treated commuting zones toward the interstate counties. The exception to this pattern is in column (2), where the IV estimates using the Pershing plan indicator report very similar coefficient estimates between Panels A and B. This result is consistent with spatially diffuse employment growth shared among counties within the same commuting zone.

I explore the spatial heterogeneity directly by adding adjacency interactions into equation 1. Table 3 builds on the binary highway treatment in Table 2 and adds three different spatial interactions. The first is whether or not a county is spatially adjacent to a treated highway county, which is similar to the spatial comparison in Chandra and Thompson (2000). The second is whether a county is adjacent within a commuting zone, providing a direct comparison of Panels A and B in Table 2. The third restricts the CZ adjacency to those overlapping with 1950 MSA boundaries. This third form of adjacent interaction distinguishes untreated counties within the metropolitan periphery.

The results in Table 3 highlight fundamental differences in how highways affect adjacent

[32] Results using only a density based interstate treatment reveal a positive relationship between interstate highway density and employment growth. Appendix Table A.2.3 shows a slightly stronger relationship between density and employment at the commuting zone level than the county level.

Table 2: Interstate Highways and Year Over Year Employment Growth

Panel A: County-Level	(1) OLS	(2) Pershing IV	(3) OLS	(4) Pershing IV
Highway (0/1)	0.0044***	0.0048*	0.0040***	0.0053*
	(0.0005)	(0.0026)	(0.0006)	(0.0029)
Highway Dist. Per Sq KM			0.0137	-0.0207
			(0.0154)	(0.0402)
Observations	171,999	171,999	171,999	171,999
Counties	3,072	3,072	3,072	3,072
Region X Years	2,744	2,744	2,744	2,744
Pershing First-Stage		0.202		
		(0.016)		
KP F-Statistic		150.943		73.338
Panel B: CZ-Level	**(1) OLS**	**(2) Pershing IV**	**(3) OLS**	**(4) Pershing IV**
Highway (0/1)	0.0025***	0.0052**	0.0015*	0.0038
	(0.0006)	(0.0024)	(0.0008)	(0.0038)
Highway Dist. Per Sq KM			0.0967**	0.0964
			(0.0463)	(0.2191)
Observations	42,672	42,672	42,672	42,672
CZs	762	762	762	762
Region X Years	504	504	504	504
Pershing First-Stage		0.251		
		(0.030)		
KP F-Statistic		70.573		18.866

Notes: Every specification reports results from estimating equation 1, where the outcome of interest is average year over year changes in the log of employment. Columns (1)–(2) report results with a binary interstate highway indicator. Columns (3)–(4) report results with both the binary indicator and a measure of interstate highway density. Every specification includes state and census region $\times$ year fixed effects, along with the full set of controls outlined in Appendix C.2. Panel A includes a national set of counties and Panel B is for the full set of commuting zones (Economic Research Service, 2019). Employment data from 1956–2016 County Business Patterns annual reports. Standard errors are two-way clustered by county and state $\times$ year. *** p<0.01, ** p<0.05, * p<0.1.

neighboring counties. Columns (1)–(2), which include an interaction for general interstate adjacency, provide weak evidence of adjacent county decline, consistent with the relocation findings in Chandra and Thompson (2000).[33] Columns (3)–(4) broaden the adjacency definition to consider counties within adjacent labor markets. The results provide some evidence of positive spillovers to untreated counties within treated commuting zones. Columns (5)–(6) trim the adjacent labor

[33] This weaker general adjacency result is partly driven by differences in sample, where Chandra and Thompson (2000) focus exclusively on rural areas. Appendix Table A.2.5 incorporates multiple spatial interactions together and finds the magnitude of the negative general adjacency result increases when separated from the adjacent labor market interactions.

market sample to those within the metropolitan periphery. The coefficients in the IV specification in column (6) suggest that both interstate highway counties and counties in the metropolitan periphery experienced similar year over year employment grow compared to other non-interstate highways.

Table 3: Year Over Year Employment Growth and Highway Interactions by County Adjacency

	(1) OLS	(2) Pershing IV	(3) OLS	(4) Pershing IV	(5) OLS	(6) Pershing IV
Highway (0/1)	0.0041***	0.0043	0.0040***	0.0057**	0.0045***	0.0052**
	(0.0007)	(0.0031)	(0.0006)	(0.0025)	(0.0006)	(0.0025)
Adjacent to Hwy	-0.0003	-0.0008				
	(0.0006)	(0.0035)				
Adjacent CZ			-0.0006	0.0021		
			(0.0006)	(0.0022)		
Adjacent CZ with MSA					0.0004	0.0049**
					(0.0008)	(0.0020)
Observations	171,999	171,999	171,999	171,999	171,999	171,999
Counties	3,072	3,072	3,072	3,072	3,072	3,072
Region X Years	2,744	2,744	2,744	2,744	2,744	2,744
KP F-Statistic		56.533		59.718		62.125

Notes: Every specification reports results from estimating equation 1 with different adjacent county interactions, where the outcome of interest is average year over year changes in the log of employment. Columns (1)–(2) report results with a binary interstate highway indicator and a binary indicator for adjacent counties. Columns (3)–(4) report results including an adjacency within commuting zones. Columns (5)–(6) focus specifically on adjacent commuting zone counties within large metropolitan areas (MSAs). Every specification includes state and census region $\times$ year fixed effects, along with the full set of controls outlined in Appendix C.2. Employment data from 1956–2016 County Business Patterns annual reports at the county-level. Standard errors are two-way clustered by county and state $\times$ year. *** p<0.01, ** p<0.05, * p<0.1.

5.2 Time Path of Treatment

Constructing a time-varying instrumental variable for interstate highways allows me to extend the prior spatial results to explore the time path of highway treatment. To start, I partition the 60 year sample into three 20 year eras: the expansion era, the completion era, and the post-construction era. During the expansion era, the interstate network remained largely disconnected because construction decisions were made at the state-level.[34] In 1975, roughly 75 percent of the system was complete and remaining segments of the original network plan were officially completed in

[34] Appendix Figure A.3.2 illustrates the fractured nature of the system.

1992.[35] Post-construction interstate expansion mostly consists of additional lane mileage (Turner et al., 2020).

I empirically incorporate these eras by extending my preferred specification with a single binary highway interaction term to include binary interactions term for each era. Columns (1) and (2) of Table 4 reports the three era specific coefficients of interest. The coefficient pattern suggests large, but imprecisely estimated, employment gains during the construction era. These differences significant growth differences persist through the completion era before tapering off during the post-construction era. Columns (3) and (4) extend the specification to consider the time path of spatial spillovers in the metropolitan periphery. These results reinforce the previous pattern of stronger growth during four decades of interstate highway construction and show that employment growth in the metropolitan periphery was strongest during the completion era.[36]

This era specific analysis allows me to evaluate era specific differences in the highway selection process. During the first two eras, the IV estimates are larger than the OLS estimates, consistent with interstate construction targeting lower performing counties (Duranton and Turner, 2012; Redding and Turner, 2015). This pattern flips in the post-construction era, which suggests positive location selection, where the sample includes major metropolitan and urban areas and when identification is based on the extensive margin of being connected to the system. The results highlights the importance of address timing selection when evaluating the effects of interstate highways over time.

There are many differences in the pre-construction economic characteristics between counties constructed in the first and second decades. Appendix Table A.1.4 reveals that state and local officials prioritized constructing interstates in larger, more urban counties, with better access to transportation infrastructure. In comparison, the construction timing predicted using the Pershing IV is nearly balanced across every economic characteristic. State and local officials prioritizing developed areas has important implications for understanding the differences in growth over time.

Columns (5) and (6) of Table 4 replace the time varying highway measure with a fixed measure

[35] Appendix Figure A.3.1 plots the time path of highway construction.

[36] Appendix Figure A.2.1 plots coefficient estimates from an expanded version of Table 4, replacing eras with five year intervals. The results are consistent with large but imprecisely estimated early effects, followed by significant growth during the 1980s, and small insignificant effects in the later periods.

Table 4: Highway Effects on Year Over Year Employment During Three Construction Phases

	Time Varying Highway				Fixed Highway	
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	IV	OLS	IV	OLS	IV
Highway X I(56-75)	0.0039***	0.0066	0.0038***	0.0068	0.0039***	0.0076*
	(0.0013)	(0.0064)	(0.0014)	(0.0064)	(0.0011)	(0.0041)
Adj CZ with MSA X I(56-75)			-0.0008	0.0017		
			(0.0018)	(0.0041)		
Highway X I(76-95)	0.0039***	0.0054*	0.0042***	0.0062**	0.0042***	0.0064**
	(0.0008)	(0.0029)	(0.0008)	(0.0028)	(0.0008)	(0.0029)
Adj CZ with MSA X I(76-95)			0.0017	0.0096***		
			(0.0015)	(0.0033)		
Highway X I(96-16)	0.0050***	0.0035	0.0051***	0.0037	0.0052***	0.0041
	(0.0007)	(0.0027)	(0.0008)	(0.0027)	(0.0007)	(0.0026)
Adj CZ with MSA X I(96-16)			0.0002	0.0023		
			(0.0011)	(0.0023)		
Observations	171,999	171,999	171,999	171,999	171,999	171,999
Counties	3,072	3,072	3,072	3,072	3,072	3,072
Region X Years	2,744	2,744	2,744	2,744	2,744	2,744
KP F-Statistic		53.170		22.148		40.198

Notes: Every specification reports results from estimating equation 1 with era specific interaction terms, where the outcome of interest is average year over year changes in the log of employment. Columns (1)–(2) report results with a binary interstate highway indicator interacted with era specific dummies. Columns (3)–(4) report results adding MSA adjacent commuting zone era interactions. Columns (5)–(6) replace the main binary interstate interactions with time-invariant measure of interstate highway treatment, which are interacted with era specific dummy variables. Every specification includes state and census region × year fixed effects, along with the full set of controls outlined in Appendix C.2. Employment data from 1956–2016 County Business Patterns annual reports at the county-level. Standard errors are two-way clustered by county and state × year. *** p<0.01, ** p<0.05, * p<0.1.

of highway treatment based on whether or not a county would ever be connected to the interstate system. Comparing columns (2) and (6) illustrates the importance of addressing highway construction timing. Estimates using the fixed highway status are larger in magnitude, with the most pronounced differences during the four decades of highway construction. This coefficient pattern indicates that not addressing the endogenous allocation of funding leads to overstating the relative employment benefits of interstate highways.

5.3 Evolution by Industry

The County Business Patterns publishes employment counts at the sector level over the entire period for every county, allowing me to extend the spatial and temporal analysis to the sector level. Building from the specification in columns (3) and (4) of Table 4, which includes spatial and era interactions. Appendix Table A.2.6 presents employment results from traditionally traded sectors and Appendix Table A.2.7 presents employment results from traditionally non-traded sectors.[37] The results suggest highways induced sector specific differences across both locations and time. During the early construction era, highways led to strong employment growth in retail sales, services, transportation & utilities, and imprecise manufacturing growth relative to non-highway counties. The findings in Section 5.2 suggested there was little employment growth in the metropolitan periphery during the construction era. However, the sector level results suggest a more nuanced employment substitution, where manufacturing declined sharply and several non-traded sectors increased. This suggests that early highway expansion changed the composition of employment in the metropolitan periphery.

The second era, during the completion of the network, saw a continuation of the strong employment growth in non-traded sectors in the metropolitan periphery. During the second era there was stronger employment growth among industries in the traded sectors as well. Among highway counties, the fastest growing sector was wholesale trade. In the metropolitan periphery, there were significant employment gains in agriculture and mining, both traditionally traded goods. This employment increase in the traded sector is consistent with growth in regionally and nationally traded goods following the completion of the interstate network (Michaels, 2008; Jaworski et al., 2020). In summary, interstates induced strong labor market level effects in local, non-traded sectors during both the construction and completion phases, whereas employment growth in the traded sector occurs after the network is mostly complete. The strong, local labor market effects are indicative of interstates supporting agglomeration economies though lower commuting and intraregional transit costs (Baum-Snow, 2020).

6 Heterogeneity Across Locations and Measures of Employment

The adjacency results in Section 5.1 introduces the possibility that the relative benefits of interstate highways are influenced by market size. To directly test for heterogeneous treatment effects by initial county conditions, I modify equation 1 to include interaction terms based on 1950 market size quartiles. Across specifications, I use three measures of initial market size: population, per-

[37]Following McGraw (2020) I partition employment into traded and non-traded sectors, where Traded sectors include Agriculture, Mining, Manufacturing, and Wholesale Trade. Non-Traded sectors include Construction, FIRE (Finance, Insurance, Real Estate), Retail Sales, Services, and Transportation & Utilities.

cent urban, and market potential.[38] Table 5 reports the results, where Quartile 1 corresponds to the bottom quartile and Quartile 4 reflects the largest 25 percent of each market size distribution.

Table 5: Heterogeneous Effects on Employment by Initial Market Size

	Population		Percent Urban		Market Potential	
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	IV	OLS	IV	OLS	IV
Highway X I(Quartile 1)	0.0044***	0.0016	0.0045***	0.0017	0.0036***	0.0080*
	(0.0016)	(0.0045)	(0.0011)	(0.0040)	(0.0012)	(0.0041)
Highway X I(Quartile 2)	0.0048***	0.0066**	0.0047***	0.0057*	0.0055***	0.0046*
	(0.0009)	(0.0029)	(0.0009)	(0.0030)	(0.0008)	(0.0026)
Highway X I(Quartile 3)	0.0053***	0.0061**	0.0051***	0.0064**	0.0048***	0.0029
	(0.0007)	(0.0026)	(0.0007)	(0.0025)	(0.0008)	(0.0029)
Highway X I(Quartile 4)	0.0026***	0.0041	0.0030***	0.0068**	0.0034***	0.0017
	(0.0008)	(0.0033)	(0.0007)	(0.0030)	(0.0008)	(0.0034)
Observations	171,999	171,999	171,999	171,999	171,999	171,999
Counties	3,072	3,072	3,072	3,072	3,072	3,072
Region X Years	2,744	2,744	2,744	2,744	2,744	2,744
KP F-Statistic		33.796		34.895		24.969

Notes: Every specification reports results from estimating a modified version of equation 1, where the outcome of interest is average year over year changes in the log of employment. Each specification includes the binary interstate highway indicator interacted with the market size quartile specified in the column heading based on 1950 population. Every specification includes the baseline set of controls and fixed-effects. Employment data from 1956–2016 County Business Patterns annual reports at the county-level. Standard errors are two-way clustered by county and state $\times$ year. *** p<0.01, ** p<0.05, * p<0.1.

Across all three market size conditions, both OLS and IV estimates indicate that interstate highways induced positive employment changes, but the IV results point to key differences by market size. Population quartile interactions in column (2) suggest that most of the employment gains were concentrated among the middle of the population distribution. These are counties with 1950 populations between 10,000 and 36,000 residents. The urbanization interactions in column (4) suggest a similar story, with interstate counties in the first quartile not experiencing significant gains, but large and significant increases across the rest of the urbanization distribution. This suggests that low population counties, with no urban residents in 1950, did not experience significant employment gains from interstates.

Columns (5) an (6) introduce interactions based on a county's market potential in 1950. The results in column (6), suggest that employment gains were concentrated among counties with

[38]Market potential is calculated using county population and the inverse Euclidean distance between the county seat for every two pairs of counties.

initially low market potential, which is reflective of both low surrounding population and being spatially remote. Taken with the results from columns (2) and (4), this suggests that interstates had large employment effects on mid-sized, remote locations, with established urban density.

As an alternative test for market size based heterogeneity, Appendix Table A.2.9 reports results from estimating equation 1 with metropolitan and rural interaction terms from Hines et al. (1975) to test for differences along alternative market size dimensions. The results show no evidence supporting heterogeneous effects by these classifications, suggesting that the relevant heterogeneity is not found in these broader spatial distinctions.

Finally, Appendix Table A.2.10 reports results from population weighted regressions, for several alternative measures of employment. Unweighted regressions are reported in Panel A, with columns (1) and (2) showing the preferred specification from Table 2. Panel B reports coefficients from population weighted regressions. Comparing Panels A and B, the 1950 population weighted specifications are consistently larger in magnitude, suggesting that counties with higher initial populations may have benefited more. These results are in line with the findings in Table 5, which show stronger effects for larger counties, with more urban residents.

7 Conclusion

Global investments in infrastructure have increased in recent decades and these investments have important consequences for the spatial distribution of economic activity within countries and regions (OECD, 2021). The expansion of the Interstate Highway System over the second half of the twentieth century provides insights into how large scale transit infrastructure alters the location of economic activity in the context of a developed country. Evaluating these effects over time requires a new empirical approach that addresses the endogenous placement and timing of highway construction. Results from reduced form analysis indicate that, counties traversed by interstates experienced early and persistent employment growth relative to unconnected regions. Spatial spillovers in employment growth were concentrated among counties adjacent to metropolitan areas, with small, negative spillovers to adjacent, non-metropolitan areas.

These spatial distinctions are important when considering the specific agglomeration economies affected by this type of infrastructure. Interstates induced larger changes in employment growth in non-traded sectors, like retail sales, services, and transportation and utilities, in both highway counties and in the metropolitan periphery. The industry mix, the timing of the employment gains, and the spatial scale of the spillovers are consistent with interstates supporting agglomeration through lower transit costs within labor markets.

References

Aggarwal, S. (2018). Do rural roads create pathways out of poverty? evidence from india. *Journal of Development Economics 133*, 375–395.

Agrawal, A., A. Galasso, and A. Oettl (2017). Roads and innovation. *Review of Economics and Statistics 99*(3), 417–434.

Ahlfeldt, G. M. and A. Feddersen (2018). From periphery to core: measuring agglomeration effects using high-speed rail. *Journal of Economic Geography 18*(2), 355–390.

Alder, S. (2019). Chinese roads in india: The effect of transport infrastructure on economic development.

Alder, S., M. Roberts, and M. Tewari (2017). The effect of transport infrastructure on india?s urban and rural development. *Unpublished manuscript, University of North Carolina, Chapel Hill*.

Allen, T. and C. Arkolakis (2014). Trade and the Topography of the Spatial Economy. *The Quarterly Journal of Economics 129*(3), 1085–1140.

Allen, T. and C. Arkolakis (2019). The welfare effects of transportation infrastructure improvements. Working Paper 25487, National Bureau of Economic Research.

Atack, J. (2016). *Historical Geographic Information Systems (GIS) database of U.S. Railroads for 1916*.

Atack, J., F. Bateman, M. Haines, and R. A. Margo (2010). Did Railroads Induce or Follow Economic Growth?: Urbanization and Population Growth in the American Midwest, 1850-1860. *Social Science History 34*(2), 171–197.

Atack, J. and R. A. Margo (2012). The Impact of Access to Rail Transportation on Agricultural Improvement: The American Midwest as a Test Case, 1850-1860. *Journal of Transport and Land Use 4*(2).

Autor, D. H., D. Dorn, and G. H. Hanson (2013). The china syndrome: Local labor market effects of import competition in the united states. *The American Economic Review 103*(6), 2121–2168.

Banerjee, A., E. Duflo, and N. Qian (2020). On the road: Access to transportation infrastructure and economic growth in china. *Journal of Development Economics*, 102442.

Bartelme, D. (2018). Trade costs and economic geography: evidence from the us. *Work. Pap., Univ. Calif., Berkeley*.

Bartik, T. J. (2020). Using place-based jobs policies to help distressed communities. *Journal of Economic Perspectives 34*(3), 99–127.

Baum-Snow, N. (2007). Did highways cause suburbanization? *The Quarterly Journal of Economics 122*(2), 775–805.

Baum-Snow, N. (2020). Urban transport expansions and changes in the spatial structure of us cities: Implications for productivity and welfare. *Review of Economics and Statistics 102*(5), 929–945.

Baum-Snow, N., L. Brandt, J. V. Henderson, M. A. Turner, and Q. Zhang (2017). Roads, railroads, and decentralization of chinese cities. *Review of Economics and Statistics 99*(3), 435–448.

Baum-Snow, N., J. V. Henderson, M. A. Turner, Q. Zhang, and L. Brandt (2020). Does investment in national highways help or hurt hinterland city growth? *Journal of Urban Economics 115*, 103124.

Baum-Snow, N., M. E. Kahn, and R. Voith (2005). Effects of urban rail transit expansions: Evidence from sixteen cities, 1970-2000 [with comment]. *Brookings-Wharton papers on urban affairs*, 147–206.

Berger, T. (2019). Railroads and rural industrialization: Evidence from a historical policy experiment. *Explorations in Economic History 74*, 101277.

Berger, T. and K. Enflo (2017). Locomotives of local growth: The short-and long-term impact of railroads in sweden. *Journal of Urban Economics 98*, 124–138.

Blonigen, B. A. and A. D. Cristea (2015). Air service and urban growth: Evidence from a quasi-natural policy experiment. *Journal of Urban Economics 86*, 128–146.

Boarnet, M. G. (2014). National transportation planning: Lessons from the us interstate highways. *Transport Policy 31*, 73–82.

Bogart, D., X. You, E. Alvarez, M. Satchell, and L. Shaw-Taylor (2018). Railways, growth, and spatial reorganization: Evidence from nineteenth century england and wales. Technical report, Technical report.

Brinkman, J. and J. Lin (2019). Freeway revolts!

Brooks, L. and Z. D. Liscow (2019). Infrastructure costs. *Available at SSRN 3428675*.

Chandra, A. and E. Thompson (2000). Does public infrastructure affect economic activity?: Evidence from the rural interstate highway system. *Regional Science and Urban Economics*.

Conley, T. G. (1999). Gmm estimation with cross sectional dependence. *Journal of econometrics 92*(1), 1–45.

Conley, T. G. (2010). Spatial econometrics. In *Microeconometrics*, pp. 303–313. Springer.

Donaldson, D. (2018). Railroads of the raj: Estimating the impact of transportation infrastructure. *American Economic Review 108*(4-5), 899–934.

Donaldson, D. and R. Hornbeck (2016). Railroads and american economic growth: A "market access" approach. *The Quarterly Journal of Economics 131*(2), 799–858.

Duranton, G., P. M. Morrow, and M. A. Turner (2014). Roads and Trade: Evidence from the US. *The Review of Economic Studies 81*(2), 681–724.

Duranton, G. and M. A. Turner (2011). The fundamental law of road congestion: Evidence from us cities. *American Economic Review 101*(6), 2616–52.

Duranton, G. and M. A. Turner (2012). Urban Growth and Transportation. *The Review of Economic Studies 79*(4), 1407–1440.

Eckert, F., T. C. Fort, P. K. Schott, and N. J. Yang (2020). Imputing missing values in the us census bureau's county business patterns. Technical report, National Bureau of Economic Research.

Economic Research Service (2019). *Commuting Zones and Labor Market Areas*. U.S. Department of Agriculture.

Faber, B. (2014). Trade integration, market size, and industrialization: Evidence from china's national trunk highway system*. *The Review of Economic Studies*, rdu010.

Fajgelbaum, P. D. and E. Schaal (2020). Optimal transport networks in spatial equilibrium. *Econometrica 88*(4), 1411–1452.

Garcia-López, M.-À., A. Holl, and E. Viladecans-Marsal (2015). Suburbanization and highways in spain when the romans and the bourbons still shape its cities. *Journal of Urban Economics 85*, 52–67.

Garin, A. (2019). Putting america to work, where? evidence on the effectiveness of infrastructure construction as a locally targeted employment policy. *Journal of Urban Economics 111*, 108–131.

Ghani, E., A. G. Goswami, and W. R. Kerr (2016). Highway to success: The impact of the golden quadrilateral project for the location and performance of indian manufacturing. *The Economic Journal 126*(591), 317–357.

Ghani, E., A. G. Goswami, and W. R. Kerr (2017). Highways and spatial location within cities: Evidence from india. *The World Bank Economic Review 30*(Supplement_1), S97–S108.

Gibbons, S. and W. Wu (2020). Airports, access and local economic performance: evidence from china. *Journal of Economic Geography 20*(4), 903–937.

Girvan, M. and M. E. J. Newman (2002). Community structure in social and biological networks. In *Proceedings of the National Academy of Science*, pp. 7821–7826.

Gonzalez-Navarro, M. and M. A. Turner (2018). Subways and urban growth: Evidence from earth. *Journal of Urban Economics 108*, 85–106.

Haines, M. R. et al. (2010). Historical, demographic, economic, and social data: the united states, 1790–2002. *Ann Arbor, MI: Inter-university Consortium for Political and Social Research*.

Heblich, S., S. J. Redding, and D. M. Sturm (2020). The making of the modern metropolis: evidence from london. *The Quarterly Journal of Economics 135*(4), 2059–2133.

Herzog, I. (2020). National transportation networks, market access, and regional economic growth.

Heuermann, D. F. and J. F. Schmieder (2019). The effect of infrastructure on worker mobility: evidence from high-speed rail expansion in germany. *Journal of economic geography 19*(2), 335–372.

Hines, F. K., D. L. Brown, and J. M. Zimmer (1975). *Social and Economic Characteristics of the Population in Metro and Nonmetro Counties, 1970*. Agricultural economic report. Economic Research Service, U.S. Department of Agriculture.

Hodgson, C. (2018). The effect of transport infrastructure on the location of economic activity: Railroads and post offices in the american west. *Journal of Urban Economics 104*, 59–76.

Holl, A. (2004a). Manufacturing location and impacts of road transport infrastructure: empirical evidence from Spain. *Regional Science and Urban Economics 34*(3), 341–363.

Holl, A. (2004b). Transport Infrastructure, Agglomeration Economies, and Firm Birth: Empirical Evidence from Portugal*. *Journal of Regional Science 44*(4), 693–712.

Holl, A. (2016). Highways and productivity in manufacturing firms. *Journal of Urban Economics 93*, 131–151.

Hornbeck, R. (2010). Barbed wire: Property rights and agricultural development. *The Quarterly Journal of Economics 125*(2), 767–810.

Hornbeck, R. and M. Rotemberg (2019). Railroads, reallocation, and the rise of american manufacturing. Technical report, National Bureau of Economic Research.

Hsiang, S. M. (2010). Temperatures and cyclones strongly associated with economic production in the caribbean and central america. *Proceedings of the National Academy of sciences 107*(35), 15367–15372.

Jaworski, T. and C. T. Kitchens (2019). National policy for regional development: Historical evidence from appalachian highways. *Review of Economics and Statistics 101*(5), 777–790.

Jaworski, T., C. T. Kitchens, and S. Nigai (2020). Highways and globalization. *NBER Working Paper 27938*.

Jedwab, R., E. Kerby, and A. Moradi (2017). History, path dependence and development: Evidence from colonial railways, settlers and cities in kenya. *The Economic Journal 127*(603), 1467–1494.

Jedwab, R. and A. Moradi (2016). The permanent effects of transportation revolutions in poor countries: evidence from africa. *Review of economics and statistics 98*(2), 268–284.

Jedwab, R. and A. Storeygard (2020). The average and heterogeneous effects of transportation investments: Evidence from sub-saharan africa 1960-2010. Technical report, National Bureau of Economic Research.

Karnes, T. (2009). *Asphalt and Politics: A History of the American Highway System*. McFarland.

Kaszynski, W. (2000). *The American Highway: The History and Culture of Roads in the United States*. McFarland.

Kelly, M. (2019). The standard errors of persistence.

Kelly, M. (2020). Understanding persistence.

Kline, P. and E. Moretti (2014). Local Economic Development, Agglomeration Economies, and the Big Push: 100 Years of Evidence from the Tennessee Valley Authority. *Quarterly Journal of Economics 129*(1), 275–331.

Long, J. H. (1995). Atlas of historical county boundaries. *The Journal of American History 81*(4), 1859–1863.

McGraw, M. J. (2020). The role of airports in city employment growth, 1950–2010. *Journal of Urban Economics 116*, 103240.

Michaels, G. (2008). The effect of trade on the demand for skill: evidence from the Interstate Highway System. *The Review of Economics and Statistics 90*(4), 683–701.

Michaels, G., F. Rauch, and S. J. Redding (2019). Task specialization in us cities from 1880 to 2000. *Journal of the European Economic Association 17*(3), 754–798.

Möller, J. and M. Zierer (2018). Autobahns and jobs: A regional study using historical instrumental variables. *Journal of Urban Economics 103*, 18–33.

Morten, M. and J. Oliveira (2018). The effects of roads on trade and migration: Evidence from a planned capital city. *NBER Working Paper 22158*, 43.

National Historical Geographic Information System (2011). *"National Historical Geographic Information System: Version 2.0"*. Minneapolis, MN: University of Minnesota.

Newman, M. E. (2001). Scientific collaboration networks. II. Shortest paths, weighted networks, and centrality. *Physical Review E 64*(1), 016132.

Newman, M. E. and M. Girvan (2004). Finding and evaluating community structure in networks. *Physical Review E 69*(2), 26113.

Newman, M. E. J. (2004). Analysis of weighted networks. *Physical Review E 70*(5), 56131.

Ody, C. J. and T. N. Hubbard (2011). County Business Patterns, 1962, 1964-1970: U.S. Summary, State, and County Data. Inter-university Consortium for Political and Social Research [distributor].

OECD (2021). Infrastructure Investment (indicator. Technical report.

Qin, Y. (2017). ?no county left behind??the distributional impact of high-speed rail upgrades in china. *Journal of Economic Geography 17*(3), 489–520.

Redding, S. J. and M. A. Turner (2015). Transportation costs and the spatial organization of economic activity. In *Handbook of regional and urban economics*, Volume 5, pp. 1339–1398. Elsevier.

Rose, M. (1990). *Interstate: Express Highway Politics, 1939-1989*. Gaia future series. University of Tennessee Press.

Rothenberg, A. D. (2013). Transport infrastructure and firm location choice in equilibrium: evidence from indonesia?s highways. *Unpublished Manuscript, Department of Economics, University of California, Berkeley*.

Sheard, N. (2014). Airports and urban sectoral employment. *Journal of Urban Economics 80*, 133–152.

Sheard, N. (2019). Airport size and urban growth. *Economica 86*(342), 300–335.

Stock, J. H. and M. Yogo (2005). Testing for weak instruments in linear iv regression. *Identification and inference for econometric models: Essays in honor of Thomas Rothenberg 1*.

Storeygard, A. (2016). Farther on down the road: transport costs, trade and urban growth in sub-saharan africa. *The Review of economic studies 83*(3), 1263–1295.

Swift, E. (2011). *The Big Roads: The Untold Story of the Engineers, Visionaries, and Trailblazers Who Created the American Superhighway*. Houghton Mifflin Harcourt.

Turner, M., G. Duranton, and G. Nagpal (2020). Transportation infrastructure in the us. Technical report, National Bureau of Economic Research.

U.S. Census Bureau (1958). *Statistical Abstract of the United States*. Number 79. U.S. Government Printing Office.

U.S. Department of Transportation Statistics (1960). *Highway Statistics*. Federal Highway Administration.

U.S. Department of Transportation Statistics (1970). *Highway Statistics*. Federal Highway Administration.

U.S. Department of Transportation Statistics (2017). *Highway Statistics*. Federal Highway Administration.

U.S. Dept of Transportation (1977). *America's highways, 1776-1976: a history of the Federal-aid program*. U.S. Governmant Printing Office.

U.S. Federal Works Agency (1947). Public Roads Administration, press release.

Appendix

to

"Transportation Networks and the Geographic Concentration of Employment"

Appendix A Table and Figure Appendix

Appendix A.1 Summary Statistics and Descriptive Tables

Table A.1.1: Summary Statistics by Eventual Highway Status and Spatial Geography

	Counties			Commuting Zones		
	(1)	(2)	(3)	(4)	(5)	(6)
	Non-Hwy	Hwy	Difference	Non-Hwy	Hwy	Difference
Total Employment	5,876.785	55,015.117	49,138.332***	14,329.710	170,271.609	155,941.906***
	[11,638.321]	[165,745.891]	(4,310.156)	[22,392.162]	[449,250.812]	(19,800.160)
∆ Ln(Employment)	0.017	0.022	0.005***	0.017	0.020	0.002***
	[0.127]	[0.089]	(0.001)	[0.086]	[0.057]	(0.001)
Highway (0/1)	0.000	0.894	0.894***	0.000	0.920	0.920***
	[0.000]	[0.307]	(0.004)	[0.000]	[0.271]	(0.006)
Pershing IV 25yr (0/1)	0.230	0.532	0.302***	0.315	0.686	0.371***
	[0.421]	[0.499]	(0.015)	[0.465]	[0.464]	(0.030)
1947 Plan IV 25yr (0/1)	0.050	0.694	0.643***	0.044	0.800	0.755***
	[0.219]	[0.461]	(0.011)	[0.205]	[0.400]	(0.017)
Highway Dist. Per Sq KM	0.000	0.026	0.026***	0.000	0.013	0.013***
	[0.000]	[0.027]	(0.001)	[0.000]	[0.010]	(0.000)
Pershing IV Dist. Per Sq KM	0.005	0.014	0.009***	0.004	0.009	0.005***
	[0.011]	[0.019]	(0.001)	[0.008]	[0.009]	(0.001)
1947 Plan Dist. Per Sq KM	0.001	0.017	0.017***	0.000	0.010	0.010***
	[0.004]	[0.017]	(0.000)	[0.001]	[0.008]	(0.000)
Observations	95,872	76,272	172,144	16,072	26,600	42,672

Notes: Employment data from 1953–2016 County Business Patterns annual reports. Columns (1), (2), (4), and (5) report means and standard deviations in brackets. Columns (3) and (6) present the difference in means, with standard errors in parentheses. The standard errors are clustered by the geographic unit. *** p<0.01, ** p<0.05, * p<0.1.

Table A.1.2: Summary Statistics of Covariates by Spatial Geography

	County Sample			Commuting Zone Sample		
	(1)	(2)	(3)	(4)	(5)	(6)
	Non-Hwy	Hwy	Difference	Non-Hwy	Hwy	Difference
Ln(Employment in 1953)	7.052	8.478	1.425***	7.938	9.825	1.887***
	[1.296]	[1.717]	(0.056)	[1.420]	[1.699]	(0.114)
Ln(1950 Population)	9.476	10.433	0.957***	10.245	11.660	1.415***
	[0.878]	[1.224]	(0.039)	[1.130]	[1.321]	(0.090)
Ln(1940 Population)	9.502	10.340	0.837***	10.245	11.572	1.328***
	[0.842]	[1.143]	(0.037)	[1.134]	[1.268]	(0.089)
Ln(1930 Population)	9.472	10.267	0.796***	10.228	11.506	1.278***
	[0.823]	[1.130]	(0.037)	[1.118]	[1.251]	(0.087)
Ln(1920 Population)	9.427	10.161	0.734***	10.156	11.399	1.243***
	[0.874]	[1.095]	(0.036)	[1.155]	[1.229]	(0.088)
Ln(1910 Population)	9.366	10.052	0.686***	10.057	11.266	1.209***
	[0.876]	[1.063]	(0.036)	[1.187]	[1.249]	(0.091)
Pct of Pop in Urban Area in 1950	0.193	0.391	0.197***	0.185	0.304	0.119***
	[0.218]	[0.280]	(0.009)	[0.165]	[0.160]	(0.012)
Market Potential with 1950 Pop	167.223	198.112	30.889***	140.922	173.803	32.881***
	[56.718]	[107.254]	(3.213)	[49.668]	[75.956]	(4.554)
MSA County	0.009	0.191	0.182***	0.010	0.293	0.282***
	[0.093]	[0.393]	(0.011)	[0.102]	[0.455]	(0.022)
Metro County	0.062	0.383	0.320***	0.007	0.080	0.073***
	[0.242]	[0.486]	(0.014)	[0.083]	[0.272]	(0.013)
Rural County	0.682	0.298	-0.384***	0.791	0.341	-0.450***
	[0.466]	[0.458]	(0.017)	[0.407]	[0.475]	(0.032)
Area in sq mi	933.262	1,034.421	101.160**	3,081.251	4,468.015	1,386.764***
	[1,114.182]	[1,549.751]	(49.884)	[2,407.356]	[4,198.723]	(239.393)
1911 Railroad KMs per sq mi	0.148	0.235	0.087***	0.117	0.178	0.062***
	[0.107]	[0.178]	(0.005)	[0.089]	[0.109]	(0.007)
KM to 1911 RR	5,489.628	1,562.504	-3,927.124***	14.592	8.340	-6.252***
	[13,804.614]	[5,688.747]	(367.530)	[21.158]	[11.725]	(1.359)
KM to Nearest 1955 Port	436.631	350.103	-86.528***	552.114	412.081	-140.033***
	[294.908]	[294.113]	(10.692)	[323.950]	[314.237]	(23.944)
KM to Nearest 1955 Airport	59.800	39.612	-20.188***	73.155	48.729	-24.426***
	[34.274]	[31.122]	(1.182)	[41.151]	[33.382]	(2.871)
KM to Nearest 1918 National Highway	48.430	27.463	-20.966***	61.198	33.900	-27.298***
	[40.616]	[33.377]	(1.335)	[47.385]	[34.490]	(3.213)
KM to Nearest 1950 MSA Centroid	141.813	95.448	-46.365***	199.519	123.684	-75.835***
	[117.135]	[104.468]	(4.003)	[149.205]	[120.164]	(10.388)
Latitude	38.349	38.210	-0.138	39.616	38.396	-1.219***
	[4.989]	[4.682]	(0.175)	[5.279]	[4.964]	(0.386)
Longitude	-92.811	-90.529	2.282***	-97.296	-93.048	4.248***
	[10.730]	[12.225]	(0.421)	[10.733]	[12.536]	(0.856)
Latitude Sq	1,495.508	1,481.943	-13.565	1,597.172	1,498.854	-98.318***
	[385.351]	[355.130]	(13.392)	[416.801]	[379.303]	(30.130)
Longitude Sq	8,728.927	8,344.860	-384.067***	9,581.298	8,814.717	-766.581***
	[2,074.673]	[2,347.685]	(80.998)	[2,127.178]	[2,428.020]	(167.840)
Ln(State Hwy Spending)	12.305	12.381	0.076***			
	[0.638]	[0.682]	(0.024)			
Ln(State Hwy Spending over 5 Years)	13.642	13.722	0.080***			
	[0.643]	[0.701]	(0.025)			
Observations	1,712	1,362	3,074	287	475	762

Notes: Detailed source and measurement information in Appendix C.2. Columns (1), (2), (4), and (5) report means and standard deviations in brackets. Columns (3) and (6) present the difference in means, with standard errors in parentheses. The standard errors are clustered by the geographic unit. *** p<0.01, ** p<0.05, * p<0.1.

Table A.1.3: Overlap Between Interstate Highway Assignment and Proposed Highway Maps

	Interstate Highway Counties		
	No	Yes	Total
Panel A: 1947 Highway Plan			
No	91,998	15,219	107,217
	94.28%	*19.60%*	*61.19%*
Yes	5,586	62,415	68,001
	5.72%	*80.40%*	*38.81%*
Total	97,584	77,634	175,218
Panel B: Military Plan			
No	71,079	30,324	101,403
	72.84%	*39.06%*	*57.87%*
Yes	26,505	47,310	73,815
	27.16%	*60.94%*	*42.13%*
Total	97,584	77,634	175,218

Notes: Pershing routes digitized from original map housed at the U.S. National Archives. Interregional Highway Committee routes digitized from Public Roads Administration map. Interstate locations from Department of Transportation.

Table A.1.4: Differences in Highway Counties by Era of Construction

	Actual Highway Counties			Predicted Pershing Counties		
	(1)	(2)	(3)	(4)	(5)	(6)
	Constructed: 1956 - 1965	Constructed: 1966 - 1975	Difference	Constructed: 1956 - 1965	Constructed: 1966 - 1975	Difference
Employment	35,494.988	10,431.561	-25,063.426***	25,724.498	38,804.035	13,079.538
	[128,863.766]	[35,389.285]	(3,777.028)	[102,971.211]	[143,451.891]	(9,659.899)
Ln(1950 Population)	10.639	10.030	-0.609***	10.319	10.611	0.292*
	[1.297]	[1.062]	(0.075)	[1.271]	[1.401]	(0.160)
Ln(1940 Population)	10.521	9.986	-0.535***	10.255	10.490	0.235
	[1.220]	[0.984]	(0.070)	[1.195]	[1.299]	(0.149)
Ln(1930 Population)	10.444	9.920	-0.524***	10.202	10.415	0.213
	[1.210]	[0.970]	(0.071)	[1.181]	[1.270]	(0.145)
Ln(1920 Population)	10.310	9.859	-0.452***	10.120	10.307	0.188
	[1.184]	[0.926]	(0.068)	[1.144]	[1.174]	(0.138)
Ln(1910 Population)	10.191	9.769	-0.422***	10.033	10.165	0.132
	[1.136]	[0.922]	(0.073)	[1.113]	[1.152]	(0.144)
Pct of Pop in Urban Area in 1950	0.439	0.300	-0.139***	0.377	0.429	0.053**
	[0.278]	[0.268]	(0.016)	[0.284]	[0.298]	(0.023)
Market Potential with 1950 Pop	197.698	188.823	-8.875	197.974	183.071	-14.903
	[104.634]	[83.658]	(8.205)	[103.987]	[110.141]	(11.226)
MSA County	0.247	0.102	-0.145***	0.200	0.254	0.054
	[0.432]	[0.303]	(0.024)	[0.400]	[0.436]	(0.038)
Metro County	0.456	0.265	-0.190***	0.353	0.451	0.098**
	[0.498]	[0.442]	(0.036)	[0.478]	[0.498]	(0.044)
Rural County	0.234	0.426	0.192***	0.361	0.276	-0.085
	[0.424]	[0.495]	(0.040)	[0.481]	[0.447]	(0.052)
Area in sq mi	1,223.577	775.212	-448.365***	1,269.011	1,167.707	-101.304
	[1,879.231]	[776.075]	(159.995)	[2,111.006]	[1,344.354]	(193.131)
1911 Railroad KMs per sq mi	0.250	0.203	-0.047***	0.243	0.232	-0.011
	[0.197]	[0.143]	(0.012)	[0.206]	[0.182]	(0.020)
KM to 1911 RR	1,357.878	2,144.456	786.578	1,878.371	1,118.773	-759.597
	[5,319.771]	[6,971.619]	(556.777)	[7,341.075]	[3,646.803]	(672.146)
KM to Nearest 1955 Port	361.298	357.453	-3.845	429.368	295.922	-133.446**
	[317.265]	[270.970]	(29.349)	[316.997]	[302.042]	(55.096)
KM to Nearest 1955 Airport	37.163	45.723	8.559***	43.501	33.098	-10.402***
	[31.519]	[31.069]	(1.991)	[36.549]	[28.035]	(2.589)
KM to Nearest 1918 National Highway	25.381	28.742	3.362	26.149	26.087	-0.061
	[33.116]	[33.092]	(2.630)	[32.730]	[38.850]	(3.828)
KM to Nearest 1950 MSA Centroid	91.610	107.741	16.132*	96.665	115.897	19.232
	[108.195]	[109.618]	(8.819)	[90.503]	[145.736]	(27.763)
Latitude	38.627	37.465	-1.162**	38.752	38.933	0.181
	[4.611]	[4.788]	(0.437)	[3.722]	[5.732]	(0.969)
Longitude	-91.288	-90.591	0.697	-91.945	-92.849	-0.904
	[13.223]	[10.802]	(1.305)	[12.739]	[14.629]	(1.963)
Latitude Sq	1,513.304	1,426.522	-86.782**	1,515.528	1,548.564	33.036
	[351.544]	[361.342]	(33.888)	[285.290]	[438.786]	(74.564)
Longitude Sq	8,508.067	8,323.076	-184.992	8,615.832	8,834.503	218.671
	[2,544.001]	[2,080.345]	(253.347)	[2,439.329]	[2,840.793]	(383.840)
Ln(State Hwy Spending)	12.370	12.373	0.003	12.345	12.279	-0.067
	[0.709]	[0.674]	(0.062)	[0.752]	[0.748]	(0.115)
Ln(State Hwy Spending over 5 Years)	13.705	13.723	0.018	13.675	13.616	-0.059
	[0.730]	[0.686]	(0.062)	[0.777]	[0.769]	(0.100)
Observations	834	392	1226	535	417	952

Notes: Detailed source and measurement information in Appendix C.2. Columns (1), (2), (4), and (5) report means and standard deviations in brackets for each specific construction era. Columns (3) and (6) present the difference in means, with standard errors in parentheses. The standard errors are clustered by the geographic unit. *** p<0.01, ** p<0.05, * p<0.1.

Table A.1.5: Summary Statistics of Industry Employment by Spatial Geography

	County Sample			Commuting Zone Sample		
	(1)	(2)	(3)	(4)	(5)	(6)
	Non-Hwy	Hwy	Difference	Non-Hwy	Hwy	Difference
Agric Emp	46.933	297.363	250.430***	115.801	951.839	836.037***
	[135.287]	[1,001.235]	(22.631)	[222.791]	[2,760.705]	(108.225)
Construct Emp	327.219	2,999.323	2,672.104***	800.287	9,295.989	8,495.702***
	[751.555]	[8,155.828]	(208.567)	[1,391.550]	[22,397.809]	(981.571)
Finance Emp	293.316	4,473.358	4,180.042***	702.134	13,459.704	12,757.570***
	[914.652]	[18,090.482]	(468.325)	[1,163.707]	[44,036.332]	(1,926.473)
Mining Emp	126.195	287.467	161.272***	384.672	1,046.687	662.015***
	[460.552]	[1,432.466]	(36.357)	[1,310.295]	[3,177.487]	(150.551)
Manuf Emp	1,510.672	10,709.112	9,198.441***	3,327.558	34,141.203	30,813.646***
	[2,610.417]	[33,316.570]	(842.943)	[5,149.257]	[87,481.805]	(3,802.765)
Retail Emp	1,320.411	10,593.984	9,273.573***	3,366.394	33,101.883	29,735.490***
	[2,691.534]	[27,466.691]	(719.056)	[5,480.428]	[77,338.617]	(3,448.397)
Services Emp	1,706.837	18,905.188	17,198.350***	4,193.883	57,825.949	53,632.066***
	[4,494.238]	[63,924.047]	(1,550.592)	[8,590.031]	[174,242.859]	(7,085.929)
Trans & Util Emp	337.024	3,897.278	3,560.254***	861.849	11,868.898	11,007.049***
	[735.506]	[13,073.895]	(330.883)	[1,519.696]	[34,291.816]	(1,478.931)
Wholesale Emp	306.040	3,708.223	3,402.183***	810.537	11,246.142	10,435.605***
	[680.410]	[12,778.542]	(332.156)	[1,219.073]	[33,529.367]	(1,495.949)
Observations	95,872	76,272	172,144	16,072	26,600	42,672

Notes: Employment data from 1953–2016 County Business Patterns annual reports. Columns (1), (2), (4), and (5) report means and standard deviations in brackets. Columns (3) and (6) present the difference in means, with standard errors in parentheses. The standard errors are clustered by the geographic unit. *** p<0.01, ** p<0.05, * p<0.1.

Appendix A.2 Extensions and Robustness

Table A.2.1: Estimates With Varying Spatial Fixed-Effects

	Main Specification		Flexible Controls		Commuting Zone FEs		State X Year FEs	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	Pershing IV	OLS	Pershing IV	OLS	Pershing IV	OLS	Pershing IV
Highway (0/1)	0.0044***	0.0048*	0.0046***	0.0065**	0.0041***	0.0074**	0.0046***	0.0071***
	(0.0005)	(0.0026)	(0.0007)	(0.0027)	(0.0008)	(0.0035)	(0.0008)	(0.0027)
Observations	171,999	171,999	171,999	171,999	171,999	171,999	171,943	171,943
Counties	3,072	3,072	3,072	3,072	3,072	3,072	3,071	3,071
Region X Years	2,744	2,744	2,744	2,744	2,744	2,744	2,688	2,688
Pershing First-Stage		0.202		0.201		0.155		0.202
		(0.016)		(0.017)		(0.017)		(0.017)
KP F-Statistic		150.943		144.374		80.438		144.974

Notes: Every specification reports results from estimating equation 1, where the outcome of interest is average year over year changes in the log of employment and the highway treatment is the binary interstate highway indicator. Columns (1)–(2) report results with the baseline set of controls and fixed-effects. Columns (3)–(4) replace time invariant covariates with time dummy interacted covariates. Columns (5)–(6) replace state fixed effects with commuting zone fixed effects. Columns (7)–(8) replace both state and census region × year fixed effects with state × year fixed effects. Employment data from 1956–2016 County Business Patterns annual reports at the county-level. Standard errors are two-way clustered by county and state × year. *** p<0.01, ** p<0.05, * p<0.1.

Table A.2.2: Effects of Highways with Spatially Adjusted Standard Errors

	Baseline	Spatial HAC	Spatial HAC	Spatial HAC
	(1)	(2)	(3)	(4)
Highway (0/1)	0.0044***	0.0044***	0.0044***	0.0044***
	(0.0007)	(0.0006)	(0.0006)	(0.0006)
Observations	171,999	171,999	171,999	171,999
Distance (KMs)		100	500	1000
Time Periods		25	25	25

Notes: Every specification reports results from estimating equation 1, where the outcome of interest is average year over year changes in the log of employment and the highway treatment is the binary interstate highway indicator and includes the baseline set of controls and fixed-effects. Employment data from 1956–2016 County Business Patterns annual reports at the county-level. Standard errors in Column (1) are two-way clustered by county and state × year. Columns (2)–(4) report standard errors following Conley (1999, 2010) and Hsiang (2010) under varying distances. *** p<0.01, ** p<0.05, * p<0.1.

Table A.2.3: Interstate Highways and Employment: Constructed Distance Treatment

	County-Level		Commuting Zone-Level	
	(1)	(2)	(3)	(4)
	OLS	Pershing IV	OLS	Pershing IV
Highway Dist. Per Sq KM	0.0700***	0.0489	0.1486***	0.2379*
	(0.0157)	(0.0421)	(0.0355)	(0.1442)
Observations	171,999	171,999	42,672	42,672
Counties	3,072	3,072	762	762
Region X Years	2,744	2,744	504	504
KP F-Statistic		51.538		40.788

Notes: Every specification reports results from estimating equation 1, where the outcome of interest is average year over year changes in the log of employment and the highway treatment is the measure of interstate highway density. Columns (1)–(2) report results with the full set of counties. Columns (3)–(4) report results at the commuting zone level. Every specification includes state and census region × year fixed effects, along with the full set of controls outlined in Appendix C.2. Employment data from 1956–2016 County Business Patterns annual reports. Standard errors are two-way clustered by county and state × year. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A.2.4: Effects of Highways with 35 Year IV Construction Timeline

	Binary Treatment		Distance Treatment	
	(1)	(2)	(3)	(4)
	OLS	Pershing IV	OLS	Pershing IV
Highway (0/1)	0.0044***	0.0074***	0.0040***	0.0083***
	(0.0005)	(0.0026)	(0.0006)	(0.0030)
Highway Dist. Per Sq KM			0.0137	-0.0322
			(0.0154)	(0.0425)
Observations	171,999	171,999	171,999	171,999
Counties	3,072	3,072	3,072	3,072
Region X Years	2,744	2,744	2,744	2,744
KP F-Statistic		150.893		73.025

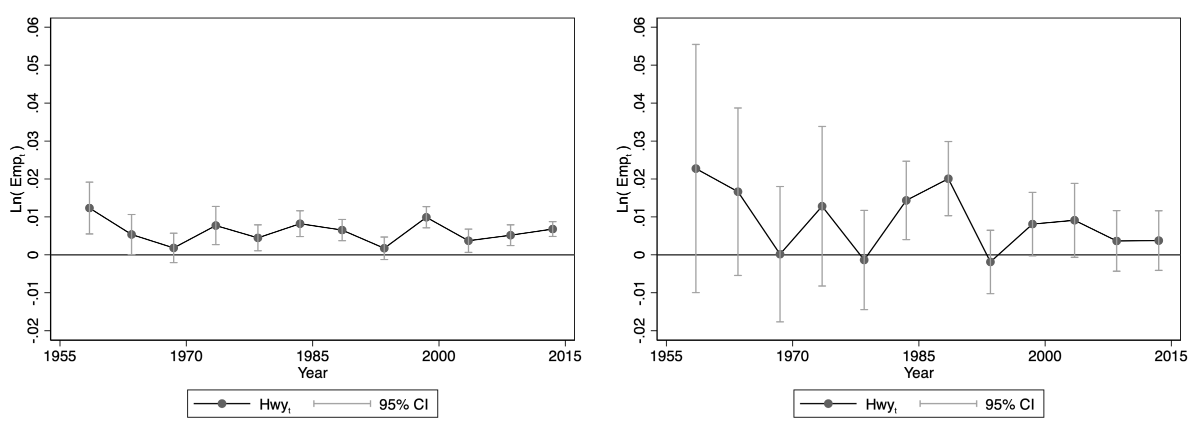
Notes: Table replicates results from Panel A of Table 2 using a 35 year construction timeline. Every specification reports results from estimating equation 1, where the outcome of interest is average year over year changes in the log of employment and the highway treatment is the binary interstate highway indicator. Columns (3) and (4) include the measure of interstate highway density. Every specification includes state and census region × year fixed effects, along with the full set of controls outlined in Appendix C.2. Employment data from 1956–2016 County Business Patterns annual reports. Standard errors are two-way clustered by county and state × year. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A.2.5: Highway Interactions by Multiple Adjacency Levels

	(1) OLS	(2) Pershing IV	(3) OLS	(4) Pershing IV	(5) OLS	(6) Pershing IV	(7) OLS	(8) Pershing IV
Highway (0/1)	0.0040***	0.0047	0.0042***	0.0039	0.0041***	0.0049*	0.0041***	0.0039
	(0.0007)	(0.0031)	(0.0007)	(0.0031)	(0.0006)	(0.0026)	(0.0007)	(0.0031)
Adjacent to Hwy	-0.0000	-0.0020	-0.0003	-0.0020			0.0000	-0.0020
	(0.0007)	(0.0035)	(0.0007)	(0.0034)			(0.0007)	(0.0035)
Adjacent CZ	-0.0006	0.0028			-0.0009	-0.0008	-0.0009	0.0000
	(0.0007)	(0.0020)			(0.0007)	(0.0023)	(0.0007)	(0.0022)
Adjacent CZ with MSA			0.0005	0.0052***	0.0010	0.0053**	0.0010	0.0052**
			(0.0008)	(0.0019)	(0.0009)	(0.0021)	(0.0009)	(0.0022)
Observations	171,999	171,999	171,999	171,999	171,999	171,999	171,999	171,999
Counties	3,072	3,072	3,072	3,072	3,072	3,072	3,072	3,072
Region X Years	2,744	2,744	2,744	2,744	2,744	2,744	2,744	2,744
KP F-Statistic		36.509		36.638		39.125		27.229

Notes: Every specification reports results from estimating equation 1 with different adjacent county interactions, where the outcome of interest is average year over year changes in the log of employment. Results are an extension of Table 3, but include multiple spatial interactions. Every specification includes state and census region × year fixed effects, along with the full set of controls outlined in Appendix C.2. Employment data from 1956–2016 County Business Patterns annual reports. Standard errors are two-way clustered by county and state × year. *** p<0.01, ** p<0.05, * p<0.1.

Figure A.2.1: Estimating Effects of Interstate Highways Every Five Years



(a) OLS: Employment

(b) Pershing IV: Employment

Notes: Figure presents coefficient estimates replicating the results in Table 4 using five year intervals. Every specification includes state and census region × year fixed effects, along with the full set of controls outlined in Appendix C.2. Standard errors are two-way clustered by county and state × year. *** p<0.01, ** p<0.05, * p<0.1.

Table A.2.6: Highway Effects During Three Construction Phases for Traded Sectors

	Agriculture		Mining		Manufacturing		Wholesale Trade	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Highway X I(56-75)	0.0139**	-0.0028	0.0038	0.0104	0.0037*	0.0101	0.0004	-0.0028
	(0.0067)	(0.0165)	(0.0057)	(0.0209)	(0.0020)	(0.0113)	(0.0027)	(0.0102)
Adj CZ with MSA X I(56-75)	-0.0043	0.0184	-0.0008	0.0251	-0.0037	-0.0218***	-0.0021	0.0179
	(0.0088)	(0.0189)	(0.0091)	(0.0250)	(0.0032)	(0.0059)	(0.0048)	(0.0114)
Highway X I(76-95)	0.0123***	0.0053	0.0061	-0.0075	-0.0006	-0.0010	0.0069***	0.0099*
	(0.0027)	(0.0109)	(0.0046)	(0.0141)	(0.0014)	(0.0058)	(0.0016)	(0.0051)
Adj CZ with MSA X I(76-95)	0.0050	0.0235**	0.0027	0.0197*	-0.0023	0.0028	-0.0002	0.0002
	(0.0068)	(0.0109)	(0.0059)	(0.0109)	(0.0025)	(0.0057)	(0.0033)	(0.0067)
Highway X I(96-16)	-0.0059**	-0.0049	0.0095**	0.0221	0.0096***	-0.0020	0.0058***	0.0069
	(0.0026)	(0.0086)	(0.0044)	(0.0156)	(0.0015)	(0.0051)	(0.0013)	(0.0052)
Adj CZ with MSA X I(96-16)	-0.0030	-0.0034	0.0138**	0.0118	0.0007	-0.0031	0.0016	0.0082
	(0.0036)	(0.0072)	(0.0064)	(0.0129)	(0.0019)	(0.0049)	(0.0024)	(0.0050)
Observations	125,024	125,024	105,534	105,534	162,446	162,446	160,575	160,575
Counties	2,378	2,378	2,124	2,124	3,022	3,022	2,985	2,985
Region X Years	2,646	2,646	2,646	2,646	2,646	2,646	2,646	2,646
KP F-Statistic		14.124		12.115		19.695		20.097

Notes: Results are an extension of Columns (3) and (4) of Table 4 for each industry. Every specification reports results from estimating equation 1 with adjacent metropolitan commuting zone interactions, where the outcome of interest is average year over year changes in the log of employment for the specific industry. Every specification includes state and census region $\times$ year fixed effects, along with the full set of controls outlined in Appendix C.2. Employment data for traditionally traded sectors from 1956–2016 County Business Patterns annual reports at the county-level. Standard errors are two-way clustered by county and state $\times$ year. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A.2.7: Highway Effects During Three Construction Phases Non-Traded Sectors

	Construction		FIRE		Retail		Services		Transp/Util	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Highway X I(56-75)	-0.0007	-0.0108	0.0010	0.0005	0.0102***	0.0157***	0.0052***	0.0203**	0.0131***	0.0246**
	(0.0028)	(0.0144)	(0.0018)	(0.0071)	(0.0013)	(0.0047)	(0.0018)	(0.0080)	(0.0029)	(0.0103)
Adj CZ with MSA X I(56-75)	-0.0019	0.0164	0.0024	0.0120*	0.0036**	0.0068*	0.0053**	0.0093*	0.0013	0.0133*
	(0.0066)	(0.0130)	(0.0025)	(0.0063)	(0.0014)	(0.0040)	(0.0026)	(0.0050)	(0.0026)	(0.0078)
Highway X I(76-95)	0.0062***	0.0018	0.0019*	0.0017	0.0048***	0.0033	0.0032**	0.0027	-0.0000	-0.0008
	(0.0018)	(0.0051)	(0.0011)	(0.0041)	(0.0008)	(0.0032)	(0.0013)	(0.0034)	(0.0013)	(0.0054)
Adj CZ with MSA X I(76-95)	0.0079**	0.0204***	-0.0010	0.0073*	0.0018	0.0096***	0.0018	0.0126***	-0.0018	-0.0059
	(0.0033)	(0.0060)	(0.0020)	(0.0042)	(0.0014)	(0.0029)	(0.0022)	(0.0040)	(0.0025)	(0.0060)
Highway X I(96-16)	0.0038***	0.0039	0.0076***	0.0086**	0.0020**	0.0030	0.0040***	0.0049	0.0103***	0.0039
	(0.0014)	(0.0045)	(0.0011)	(0.0035)	(0.0008)	(0.0027)	(0.0009)	(0.0031)	(0.0018)	(0.0053)
Adj CZ with MSA X I(96-16)	-0.0008	-0.0002	-0.0006	0.0029	0.0001	0.0011	-0.0007	0.0007	-0.0011	0.0042
	(0.0021)	(0.0037)	(0.0014)	(0.0038)	(0.0014)	(0.0027)	(0.0016)	(0.0031)	(0.0024)	(0.0048)
Observations	160,938	160,938	162,965	162,965	165,664	165,664	164,760	164,760	159,108	159,108
Counties	2,994	2,994	3,022	3,022	3,069	3,069	3,055	3,055	2,966	2,966
Region X Years	2,646	2,646	2,646	2,646	2,646	2,646	2,646	2,646	2,646	2,646
KP F-Statistic		20.240		20.838		20.939		20.938		20.375

Notes: Results are an extension of Columns (3) and (4) of Table 4 for each industry. Every specification reports results from estimating equation 1 with adjacent metropolitan commuting zone interactions, where the outcome of interest is average year over year changes in the log of employment for the specific industry. Every specification includes state and census region $\times$ year fixed effects, along with the full set of controls outlined in Appendix C.2. Employment data for traditionally non-traded sectors from 1956–2016 County Business Patterns annual reports at the county-level. Standard errors are two-way clustered by county and state $\times$ year. *** p<0.01, ** p<0.05, * p<0.1.

Table A.2.8: Effect of Proposed Priority Three Military Plan

	Total
	(1)
Unbuilt Pershing (0/1)	-0.0002
	(0.0015)
Observations	69,687
Counties	1,245
Region X Years	2,352

Notes: The specification estimates the effect of unbuilt Pershing priority three segments on year over year employment growth. The sample is restricted to non-interstate counties, where the Unbuilt Pershing counties are the subset with proposed, but never built segments from original Pershing Map. Regression includes state and census region × year fixed effects, along with the full set of controls outlined in Appendix C.2. Employment data from 1956–2016 County Business Patterns annual reports. Standard errors are two-way clustered by county and state × year. *** p<0.01, ** p<0.05, * p<0.1.

Table A.2.9: Highway Interactions by Metro/Rural Classification

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	IV	OLS	IV	OLS	IV
Highway (0/1)	0.0043***	0.0048*	0.0045***	0.0053*	0.0045***	0.0056**
	(0.0006)	(0.0025)	(0.0006)	(0.0031)	(0.0006)	(0.0026)
Highway X I(Metro)	0.0003	-0.0004			0.0001	-0.0011
	(0.0013)	(0.0065)			(0.0013)	(0.0064)
Highway X I(Rural)			-0.0004	-0.0010	-0.0004	-0.0013
			(0.0010)	(0.0039)	(0.0010)	(0.0035)
Observations	171,999	171,999	171,999	171,999	171,999	171,999
Counties	3,072	3,072	3,072	3,072	3,072	3,072
Region X Years	2,744	2,744	2,744	2,744	2,744	2,744
KP F-Statistic		22.394		55.680		14.936

Notes: Every specification reports results from estimating equation 1 with market size interaction terms, where the outcome of interest is average year over year changes in the log of employment. Each specification includes the binary interstate highway indicator and the baseline set of controls and fixed-effects. Metro and rural status is designated in Hines et al. (1975). Columns (1)–(2) include a binary interaction term for metro status. Columns (3)–(4) include a binary interaction term for rural status. and Columns (5)–(6) include both terms. Employment data from 1956–2016 County Business Patterns annual reports at the county-level. Standard errors are two-way clustered by county and state × year. *** p<0.01, ** p<0.05, * p<0.1.

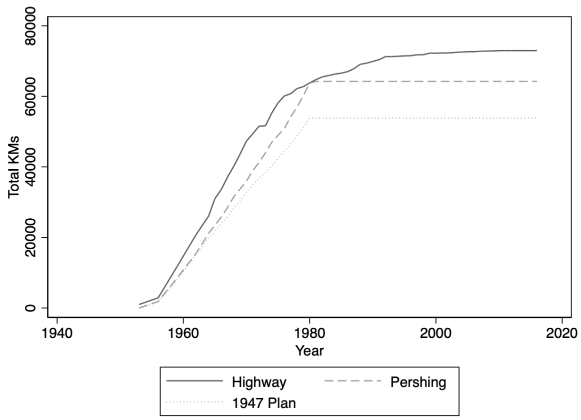
Table A.2.10: Alternative Measures of Employment

	First-Difference Ln(Employment)		Long-Difference Ln(Employment)		Ln(Employment)		Employment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Unweighted	OLS	Pershing IV	OLS	Pershing IV	OLS	Pershing IV	OLS	Pershing IV
Highway (0/1)	0.0044***	0.0048*	0.1303***	0.3376***	0.1538***	0.1835**	3207.4733***	14479.0659**
	(0.0005)	(0.0026)	(0.0204)	(0.1021)	(0.0188)	(0.0899)	(1067.0246)	(6279.5337)
Observations	171,999	171,999	172,007	172,007	172,007	172,007	172,144	172,144
Counties	3,072	3,072	3,072	3,072	3,072	3,072	3,074	3,074
Region X Years	2,744	2,744	2,744	2,744	2,744	2,744	2,744	2,744
Pershing First-Stage		0.202		0.198		0.202		0.198
		(0.016)		(0.016)		(0.016)		(0.016)
KP F-Statistic		150.943		146.137		150.957		145.742
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel B: Weight by 1950 Pop	OLS	Pershing IV	OLS	Pershing IV	OLS	Pershing IV	OLS	Pershing IV
Highway (0/1)	0.0033***	0.0128*	0.0921***	0.6995***	0.1204***	0.4228**	5585.1034	65208.2201
	(0.0005)	(0.0068)	(0.0222)	(0.2557)	(0.0202)	(0.2058)	(9085.9784)	(108275.6106)
Observations	171,999	171,999	172,007	172,007	172,007	172,007	172,144	172,144
CZs	3,072	3,072	3,072	3,072	3,072	3,072	3,074	3,074
Years	2,744	2,744	2,744	2,744	2,744	2,744	2,744	2,744
Pershing First-Stage		0.110		0.106		0.110		0.105
		(0.016)		(0.016)		(0.016)		(0.016)
KP F-Statistic		47.954		44.177		47.954		42.795

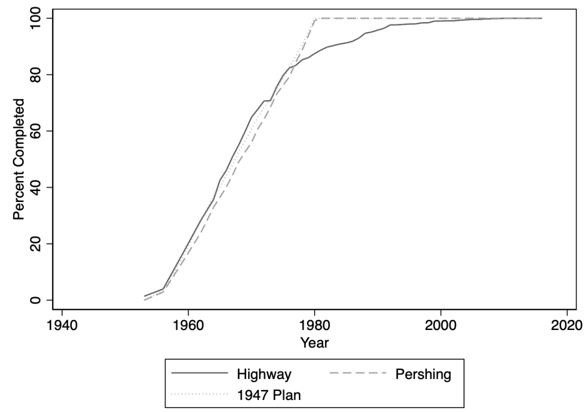
Notes: Panel A reports unweighted regressions from estimating equation 1, with each pair of columns specifying a different measure of county-level employment. Panel B reports weighted regressions, with weights based on 1950 population. Each specification uses a binary interstate highway treatment. Every specification includes state and census region $\times$ year fixed effects, along with the full set of controls outlined in Appendix C.2. Employment data from 1956–2016 County Business Patterns annual reports. Standard errors are two-way clustered by county and state $\times$ year. *** p<0.01, ** p<0.05, * p<0.1.

Appendix A.3 Highway Construction and Illustrating the Instrument

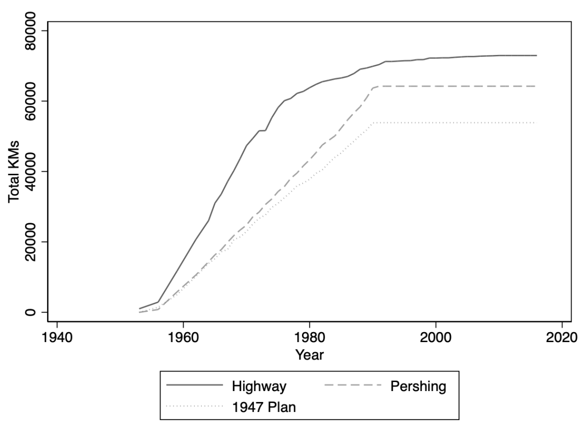
Figure A.3.1: Timing of Highway Construction and Predicted Construction



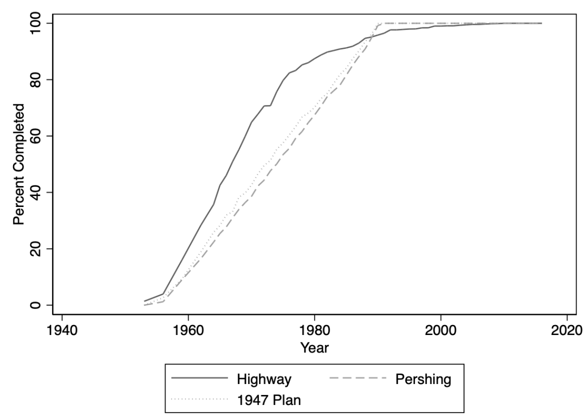
(a) Construction in KMs over 25 years



(b) Construction as a Share Completed over 25 years



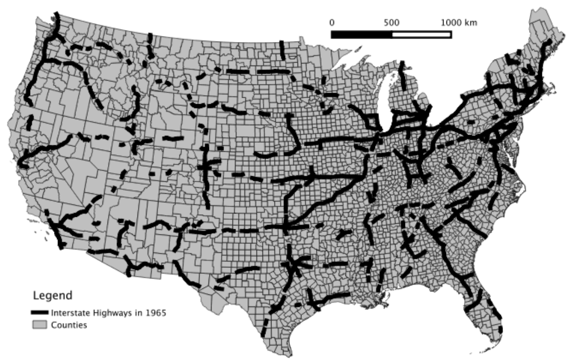
(c) Construction in KMs over 35 years



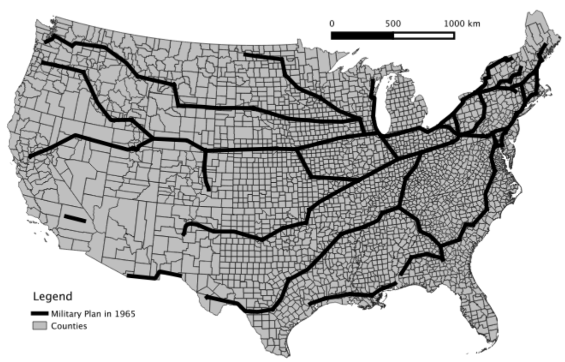
(d) Construction as a Share Completed over 35 years

Notes: Figure plots the expansion of interstate highways over time (solid line) with the left column presenting mileage and the right column presenting the share completed. Sub-figures (a) and (b) plot the Pershing Map and sub-figures (c) and (d) plot the 1947 Plan, both as dashed lines.

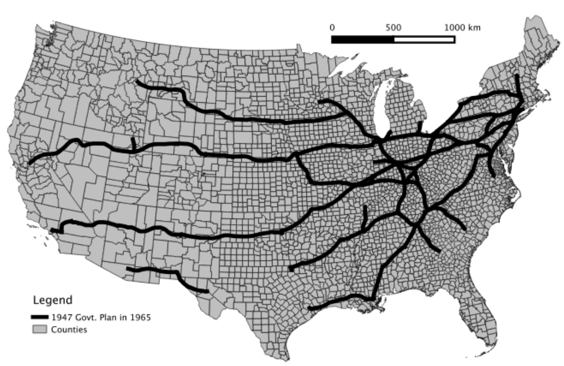
Figure A.3.2: Highway Construction in 1965



(a) Interstate Highway Construction in 1965



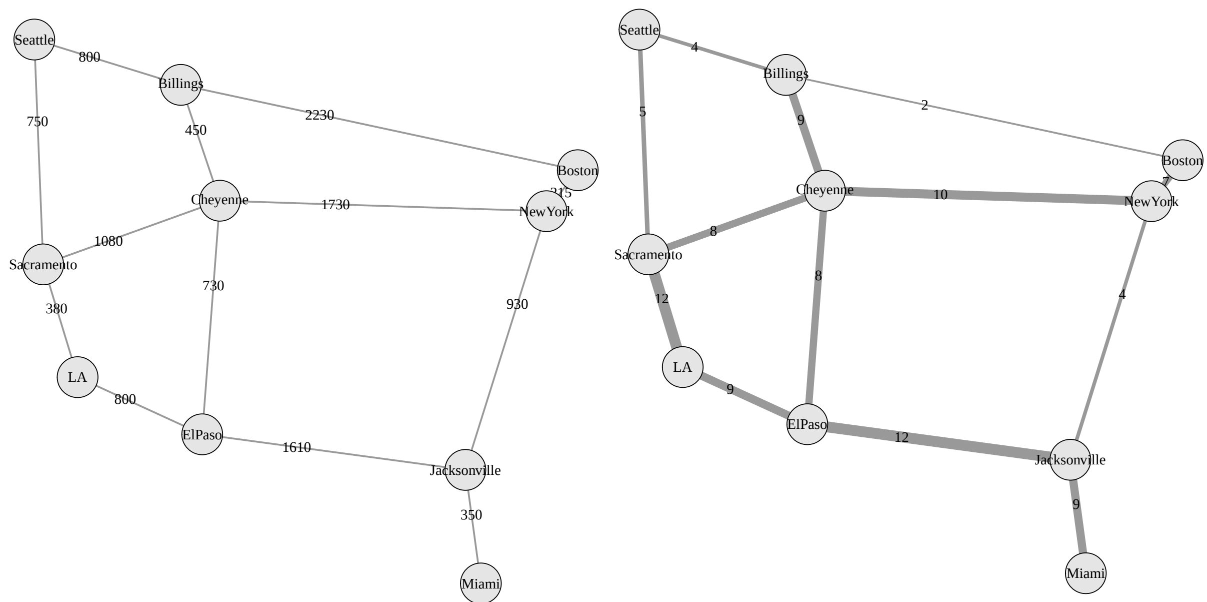
(b) Predicted Pershing Construction in 1965



(c) Predicted 1947 Plan Construction in 1965

Notes: Figure maps completed and predicted segments of the Interstate Highway system in 1965. Sub-figures (a) plots the completed segments, sub-figure (b) plots the predicted Pershing segments, and sub-figure (c) plots the predicted 1947 Plan segments.

Figure A.3.3: Illustrating Edge Betweenness

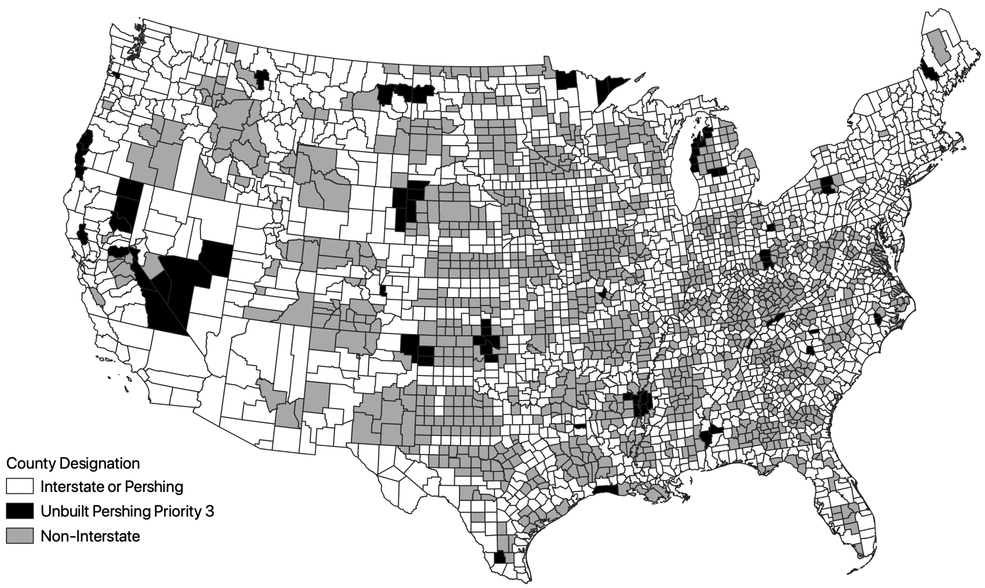


(a) Simple Highway Network with Distances

(b) Highway Network with Edge Betweenness Values

Notes: Figure presents stylized highway map illustrating the edge betweenness in a small network. A.3.3a presents the ten cities with approximate distances between cities listed along each edge. A.3.3b presents the edge betweenness calculation along each edge and adjusts the line width to reflect higher betweenness values.

Figure A.3.4: Plotting Unbuilt Pershing Counties

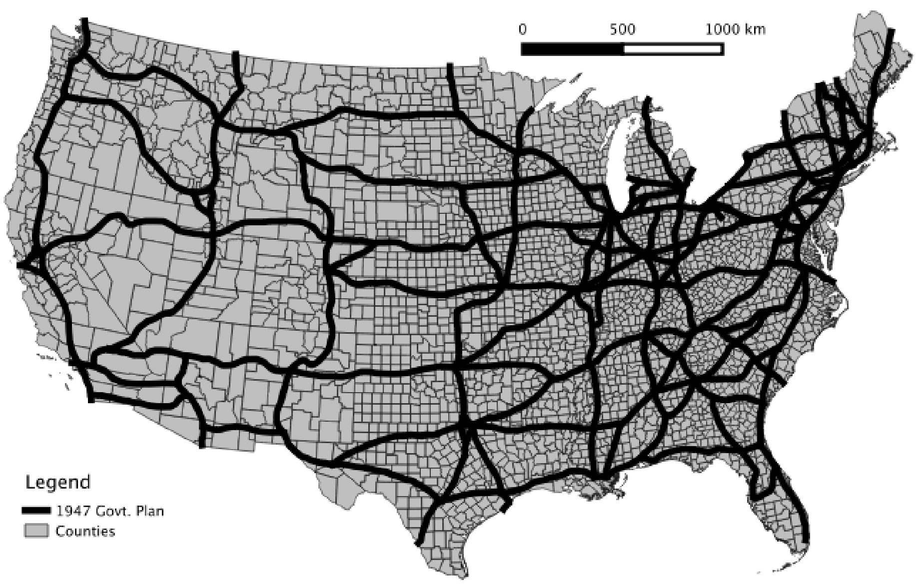


Notes: Map shades three types of counties based on Interstate or Pershing designation. White counties either constructed interstate or were designated to receive a Pershing route in the two highest priority rankings. Black counties were designated to receive a priority three Pershing route, which were never constructed. Gray counties are the non-interstate and non-Pershing counties.

Appendix B 1947 Interregional Highway Committee Plan

Section 2 introduces an alternative proposed map from the National Interregional Highway Committee published in a 1947 report. The primary objective of the 1947 plan was to *"connect by routes as direct as practicable the principal metropolitan areas, cities, and industrial centers, to serve the national defense and to connect suitable border points with routes of continental importance in the Dominion of Canada and the Republic of Mexico"* (U.S. Federal Works Agency, 1947). Figure B.1.1 shows the 1947 Interregional Highway Committee plan. This map is visually very similar to the map of eventual highway locations. Appendix Table A.1.3 confirms this result; 80 percent of highway counties were designated to receive a highway by the 1947 Plan compared to 61 percent for the Pershing Map.

Figure B.1.1: 1947 Plan from Interregional Highway Committee



Notes: Interregional Highway Committee routes digitized from Public Roads Administration map.

The 1947 Plan is the most commonly used location instrument in the U.S. interstate literature. Prior work has focused on measuring urban rays (Agrawal et al., 2017; Baum-Snow, 2007, 2020) or urban mileage (Duranton and Turner, 2011, 2012; Duranton et al., 2014), or has used focused on rural settings, mostly relying on the plan as an extension of the inconsequential units approach (Herzog, 2020; Michaels, 2008). This particular plan has not been used to evaluate a national setting with both urban and rural counties, where interstate treatment is measured at the extensive margin. As a test for the validity of the instrument in that setting, I replicate the falsification exercise in Table 1, replacing the Pershing plan with the 1947 plan. Appendix Table B.1.1 reports the results. The second column of each outcome reports coefficient estimates using the 1947 Plan and results indicate that both employment and bank deposits grew prior to highway construction. This raises concerns that the 1947 Plan does not sufficiently address the endogeneity concerns when considering a national set of counties and measuring highway treatment at the extensive margin.

Table B.1.1: Comparing the Effects of Highways Prior to Construction Using the 1947 Plan

	Employment		Bank Deposits		Farms	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: General	OLS	1947 Plan IV	OLS	1947 Plan IV	OLS	1947 Plan IV
Highway (0/1)	0.0021***	0.0023***	0.0019***	0.0018**	0.0002	-0.0001
	(0.0006)	(0.0006)	(0.0007)	(0.0008)	(0.0005)	(0.0008)
Observations	9,303	9,303	14,613	14,613	15,352	15,352
Counties	3,101	3,101	2,962	2,962	3,092	3,092
Region X Years	147	147	235	235	243	243
KP F-Statistic		921.183		1154.525		1207.474
	Manufacturing Estab.		Retail Trade Estab.		Wholesale Trade Estab.	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel B: Establishments	OLS	1947 Plan IV	OLS	1947 Plan IV	OLS	1947 Plan IV
Highway (0/1)	0.0008	-0.0005	0.0017***	0.0015	0.0020***	0.0013
	(0.0008)	(0.0013)	(0.0006)	(0.0009)	(0.0006)	(0.0011)
Observations	12,676	12,676	12,393	12,393	11,891	11,891
Counties	2,559	2,559	3,099	3,099	3,014	3,014
Region X Years	245	245	196	196	196	196
KP F-Statistic		1004.358		1072.824		1046.526

Notes: Every specification reports results from estimating a modified equation 1, which regresses a time invariant binary interstate highway indicator on average year over year changes in the log outcome. Every specification includes state and census region $\times$ year fixed effects, along with the full set of controls outlined in Appendix C.2. Outcome data from 1930–1960 decadal censuses and 1954 County Business Patterns reported at the county-level. Employment reflects the total county employment; Bank Deposits is the total inflation adjusted value of deposits; Farms, Manufacturing, Retail Trade, and Wholesale Trade all the reflect the number of establishments. Each measure is used to calculate the average log change from the prior period. Standard errors are two-way clustered by county and state $\times$ year. *** p<0.01, ** p<0.05, * p<0.1.

Appendix C Data Appendix

Appendix C.1 County Business Pattern

County Business Patterns (CBP) data was collected from three sources: Archival CBP reports for 1953 - 1962, ICPSR 25894 for 1964 - 1970, and US Census Bureau for 1970 - 2015. The data contain information for total employment, the total number of establishments, and the number of establishments in different sized employment bins. Bin sizes vary across CBP reports. From 1953-1973, there were 8 bins: 0-3, 4-7, 8-19, 20-49, 50-99, 100-249, 250-499, 500+. From 1974-1997, there were 13 bins: 1-4, 5-9, 10-19, 20-49, 50-99, 100-249, 250-499, 500-999, 1000+, 1000-1499, 1500-2499, 2500-4999, 5000+. From 1998-2016, there were 13 bins, similar to those above. I aggregated the bins to the largest consistent bin size to be consistent across every wave of the CBP. Prior to 1997, CBPs were arranged according to the SIC classification system. From 1998 to the present, industries are classified by NAICS codes. I follow Autor et al. (2013) in unifying broad industry codes over time.

Due to confidentiality and reporting restrictions, some employment totals were redacted from the final CBP reports. I impute the missing redacted employment values similar to Duranton and Turner (2012). In cases where there were missing establishment counts. I impute those based on the information in the prior and following periods. Prior to 1964, some counties were reported as county groups. This occurs in Georgia, Illinois, Kansas, Kentucky, Missouri, New Mexico, New York, North Carolina, South Dakota, Texas, and Virginia. It is most common in Georgia, Texas, and Virginia (ICs). There were fewer cases in the other states. To address this issue, I split the combined data by the employment shares in 1964 (the first year I observe split counties). For Yellowstone NP in MT, I use the share of 1950 employment from the US Census.

I adjust for county boundary changes using 1950 boundary definitions following Hornbeck (2010). County boundary locations from 1950 to 1990 are defined from Long (1995). For changes after 1990, I rely on the reported boundary changes from the US Census Bureau. I also aggregate independent cities, typically in Virginia, into their surrounding or neighboring counties similar to Jaworski and Kitchens (2019).

Appendix C.2 Covariate Descriptions

I compile county-level covariate information from several sources to account for pre-interstate differences in market size, geography, and access to transportation infrastructure.

1. I compile county-level population and urbanization data from 1910 to 1950 are available from National Historical Geographic Information System (2011). Using the 1950 population data, I construct a measure of market potential for each county based on the euclidean distance between every pair of county seats. For several constructed measures I rely on 1950 county seats instead of county centroids because in large rural counties they provide more information regarding the most economically relevant location in the county.

2. I include three controls for county type, by designating each county to either overlap with a 1950 MSA boundary (National Historical Geographic Information System, 2011) or be classified as either rural or metropolitan using the definitions from Hines et al. (1975). In this case the excluded category is the set of non-MSA, non-rural, and non-metropolitan counties. As an additional spatial control, I control for the distance from the nearest MSA centroid to each county seat.

3. Every specification includes constructed geographic controls for the total area of the county, to account for the fact that geographically large counties are more likely to be traversed

by the interstate system or the proposed IVs and are more likely to be located in growing western states. I also control for both latitude and longitude and their squares for each county seat.

4. I control for several measures of existing transportation infrastructure and in some cases the proximity from each county seat to the infrastructure.
   (a) I construct two measures of access to railroads from the records provided by Atack (2016). The first measures railroad density as the total kilometers of track within the county. The second measures distance from the nearest railroad to the county seat.
   (b) I measure access to major historic highway networks using a 1918 map, which pre-dates the Pershing Map, using distance from nearest route to county seat.
   (c) To account for access to airports and ports, I determined the coordinates of each type of location from (U.S. Census Bureau, 1958) and measure the geographic distance to county seats.
5. To account for changes in other forms of road development, I construct to annual measures of spending on state highways from the Annual Survey of State and Local Government Finances from 1943 to 2016. The first measure is the most recent years capital outlay and the second accumulates the prior five years.