The effect of transport infrastructure on the location of economic activity: Railroads and post offices in the American West

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ABSTRACT

This paper uses data on the locations of historical US Post Offices to study the effect of railroad construction between 1868 and 1889 on the geographical distribution of towns in the American West. I estimate the probability of survival and expected lifetime of a post office as flexible functions of the distance to the railroad. Existing post offices that were bypassed by the railroad at between 5 and 10 km were 20 to 50 percentage points less likely to remain in operation until 2010 than control post offices over 50 km from the railroad. Given the historically close correspondence between the location of post offices and the location of towns, these results provide evidence that the railroads generated an agglomeration shadow - towns that were “almost” connected to the railroad were more likely to decline than those that remained isolated. I show that the short distances over which the forces of agglomeration act in this setting mean that it is difficult to detect the agglomerative effects of railroad construction using alternative methodologies based on census population data.

1. Introduction

How does transport infrastructure impact the geographical distribution of economic activity? Economic theory suggests that reduced trade costs and greater market access should increase economic activity at locations close to transport hubs. However, some of this growth in local economic activity might be the result of agglomeration economies that relocate activity from areas further away from the transport network. The magnitude and direction of the net effect depends on the distance of the location in question from the transport network - locations very close to the network are likely to grow at the expense of locations that fall within the “agglomeration shadow”, while locations sufficiently far away will be unaffected (see Fujita et al., 1999; Fujita and Krugman, 1995; Krugman, 1991). The actual distances at which these different effects dominate depend sensitively on the context, but existing literature suggests that agglomeration effects die out quickly with distance. For example, using modern data on the location of plants in the United States, (Rosenthal and Strange., 2003) find that agglomeration economies are strongest within the first mile, and attenuate rapidly between 2 and 5 miles.1

In this paper, I study the agglomerative effects of railroad construction in the 19th Century American West on the distribution of settlement and economic activity over space. In particular, I measure the change in the geographic distribution of towns in seven western states caused by the construction of the railroad between 1868 and 1889. To measure these effects, I use data on the location, opening, and closing dates of post offices. I argue that, in this historical context, the existence of a post office is a good proxy for the existence of a town, and the discontinuation of a post office indicates the dispersal of economic activity and population associated with that town. This data source is new to the economics literature, and allows me to measure the effect of the railroad on the location of settlements at a higher level of spatial and temporal precision than existing census data. The relocation of economic activity due to agglomeration is likely to operate at especially short distances in historical contexts where the cost of overland transportation is high, and such effects are therefore particularly difficult to measure using census data.

The results provide evidence of the heterogeneous effects of transport infrastructure on the location of settlement and economic activity. The spatial distribution of towns in the West was disrupted by the arrival of the railroad, with towns that were “almost” connected to the railroad less likely to survive than those that were connected and those that remained isolated. I measure these effects by estimating two functions: the probability that a post office (possibly established before the railroad was built) survives to some end date as a function of distance from the railroad, and the expected year a post office closes as a function of the year established and distance from the railroad. The post office data allows me to adopt a non-parametric approach such that the relationship between distance and the probability of survival need not be monotonic.
Indeed, the baseline estimates suggest a non-monotonic effect. Being directly connected to the railroad (located within 5 km) increases the probability that a post office survives to 2010 by between 7 and 12 percentage points relative to “control” post offices located further than 50 km from the railroad. However, railroad construction between 5 and 10 km of an existing post office decreases the probability that post office survives to 2010 by between 25 and 50 percentage points relative to the control post offices. Thus, locations directly connected to the railroad appear to benefit at the expense of locations slightly further away. After this dip between 5 and 10 km the survival probability increases with distance from the railroad. A similar pattern is found for the expected lifetime of a post office.

I interpret these results as demonstrating the effect of railroad construction on the “agglomeration shadow” predicted by Fujita et al. (1999) model of city location. In this model, agglomeration economies lead manufacturers to locate in cities - point masses separated by an agricultural hinterland. One implication of this model is that if the “market potential” of a city increases, for example if it is connected to new markets by a railroad, manufacturers will relocate to that city from the surrounding area and the city’s hinterland will expand. In the new equilibrium, other cities that fall within this “agglomeration shadow” are dispersed. The post office data speaks directly to these dynamics of town survival. The negative effect of railroad construction on post office survival extends approximately 10 km from the railroad network, after which it becomes insignificant in many specifications, suggesting that the “agglomeration shadow” created by the railroad was approximately 10 km wide. These findings of large effects at short distances suggest that the growth and decline of frontier towns, and the long run distribution of settlement, was particularly sensitive to local competition between neighboring towns. Towns that were “almost” connected to the railroad network in the 1870s and 1880s were more likely to decline than those that remained isolated. To provide further evidence for this interpretation, I exploit the high temporal resolution of the post office data to show that the positive effect of the railroad on survival at 0–5 km is largest for those post offices established while the railroad was being built, and the negative effect at 5–10 km is largest for post offices established before the railroad was built. The results indicate that existing towns bypassed by the railroad were likely to decline, with population relocating to newly founded railroad towns.

In addition to these empirical findings, this paper contributes to the literature by demonstrating that the lack of spatial precision in census data can be overcome using data on the locations of US Post Offices. Existing studies of the effects of transportation on economic activity in 19th century America have typically used census population data at the county level. Counties in the 19th Century west were large - the average county in Kansas in 1870 was 883 km², approximately the area of a 30 × 30 km square. This lack of spatial precision makes the measurement of any effects that take place at less than 30 km difficult. Indeed, I show that the main finding of an agglomeration shadow at 10 km cannot be replicated precisely using county level data and that this result is identified mostly by within-county variation in post office survival. More precise census data is limited for this era, and sub-county units are difficult to link over time. As far as I know, the only geo-coded sub-county data for this era was assembled by Michaels et al. (2012), who map the population of minor civil divisions in 1880 to the nearest MCD centroid in 2000. I use this data to corroborate my interpretation of the findings on post office survival. Among rural MCDs, population growth between 1880 and 2000 is lowest in those centered between 5 and 10 km from the railroad. These results do not hold for MCDs near major cities, for which long term trends in population such as the growth of suburbs likely obscure the short run effects of railroad construction. This highlights the relative utility of the post office data as a measure of the survival of independent towns during the 19th and early 20th centuries.

The economic effects of railroad construction in 19th Century America have been studied extensively in the economic history literature, starting with Fogel (1964) and Fishlow (1965) who quantified the impact of the railroads on American economic growth. More recently, the creation of GIS databases on the precise location of railroads and canals in the 19th century (Atack, 2013, 2015) has encouraged economists to revisit these questions. For example, Donaldson and Hornbeck (2015) use a “market access” approach based on general equilibrium trade theory to quantify the contribution of the rail network to agricultural land values. The results in this paper are most closely related to the findings of Atack et al. (2010), who compare levels of urbanization in railroad and non-railroad counties in the American Midwest during the 1850s. They find that connection to a railroad has a significant positive effect on a county’s urbanization, measured by the share of residents living in incorporated cities of more than 2500 inhabitants, but does not have a significant impact on county-level population density. These results suggest that the construction of the railroads relocated settlement and economic activity towards urban centers at small distances within railroad counties, consistent with the findings of this paper.

More broadly, this paper is related to previous empirical studies of the effects of transport investments on the distribution of economic growth. In line with this paper’s findings on railroads, Chandra and Thompson (2000) find that interstate highways in the US increase economic activity in counties that they pass through partly by relocating activity away from adjacent counties. Jedwab and Moradi (2016) examine the effect of the construction of railroads in colonial Ghana on cocoa output and population in rural locations. Using data on output and population aggregated to grid cells of 0.1 × 0.1 degrees (approximately 121 Sq. km), the authors find that output and population increased in grid cells through which the railroad passed. Furthermore, they find a positive effect on output for adjacent grid cells that diminished with distance from the railroad, and, unlike Chandra and Thompson, find no evidence of relocation of activity or population from adjacent cells to railroad cells. Contrary to these results, Faber (2014) study of China’s National Trunk Highway System finds that peripheral (non-metropolitan) counties through which the highways pass experience a reduction in GDP growth. He also finds that the effect is diminished for counties further away from the highways. This is suggestive of agglomeration at the level of metropolitan locations - economic activity appears relocated away from connected rural counties towards connected urban counties. Faber finds no evidence of the relocation of activity from unconnected to connected rural counties.

These studies all use a difference in differences approach in which the levels of some measure of economic activity before and after the transport improvement are compared between connected (treated) and non-connected (control) counties or grid cells. One downside of this approach is that the geographical units, usually counties, are of an arbitrary size. There is no reason to expect, for example, highway construction to have a uniform treatment effect across areas the size of Chinese counties - there is likely within county variation in the treatment effect which is not picked up by measures of total county output. Data aggregated to differently sized geographic units can therefore lead to different conclusions about the effect of transportation on the distribution of economic activity. I avoid this problem by measuring how the spatial distribution of points of urbanization and concentration of economic activity changes with railroad construction, allowing me to estimate how the effect of railway construction on economic activity varies over arbitrarily small distances.

Finally, note that Acemoglu et al. (2016) provide an alternative interpretation of the geographic distribution of post offices. They...
emphasize the importance of the post office as an indicator of state capacity, and use the density of post offices in a region as a measure of the “infrastructural power” of the state. The authors show that, controlling for county population, variation in the number of post offices in a county is a good predictor of patenting rates. Their interpretation in not incompatible with the interpretation of post offices as a measure of the number of towns in a county. Indeed, a region with more established settlements is more likely to have the government and commercial infrastructure necessary to support innovation and patenting.\footnote{Furthermore, Acemoglu, Moscon, and Robinson use data from 13 snapshot years in the 19th century, 8 of which are before the Civil War, and study the United States as a whole. Much of the variation in their data is therefore likely to represent the initial expansion of the Post Office in the East in the early 1800s. This paper focuses on the post-Civil War West, an era in which the ubiquity of the Post Office makes it is much less likely that an established town or village would lack an office. Finally, note that the main results below are related to the timing of post office closures, which would not seem to reflect diminishing state capacity in the late 19th century.}

The remainder of this paper proceeds as follows. Section 2 provides background on the history of 19th century American railways and post offices, and on the economic history literature that has dealt with the period. Section 3 describes the data used in the analysis. Section 4 describes the empirical strategy and Section 5 presents the main results and several robustness tests. Section 6 concludes.

2. Historical background

2.1. The railroad

The settlement and economic development of the United States in the 19th century went hand in hand with the expansion of the railroad. Between 1830 and 1860, over 30,000 miles of railroad track were laid in the United States (Fishlow, 1965; Fishlow, 2000). At the same time the population of what was then the Northwestern frontier was rapidly expanding - the population of Illinois, Indiana, and Ohio grew by 270% between 1830 and 1860. This period of expansion of the settlement frontier and the railroad network has been characterized by Fishlow (1965) as a dynamic system of railroad construction following settlement, and “anticipatory settlement” ahead of the railroads. The growth of the antebellum railroad network was decentralized and driven almost entirely by entrepreneurial investors taking advantage of westward settlement with little government assistance (White, 2011).

The Civil War stopped this organic process of railroad expansion in its tracks. In 1861, the network crossed the Midwest from Ohio to Illinois, but had reached no further west than Missouri. The end of hostilities saw a second wave of railroad construction with a considerably different character. The passage of the Pacific Railroad Acts of 1862 and 1864 committed the federal government to the construction of a railroad connecting California to the existing network (White, 2011, p. 17). To overcome the limited commercial interest in building such a railroad, the Federal government instituted a system of generous loans and land grants. The “transcontinental” railroads received blocks of formerly public land along their proposed routes. Railroad companies were thus incentivized to construct unprofitable routes by the prospect of future land value increases. Although settlement in the plains states of Missouri, Nebraska, and Kansas would have likely provided commercial incentives for railroad expansion similar to those that existed before the War, the Pacific Railroad Acts introduced incentives for construction to leap ahead of these regions of commercially viable settlement. This regime precipitated what White terms the “railroad war” of the 1870s and 1880s in which, for example, as many as five railroad companies were built parallel “transcontinental” railroads across Kansas, each seeking to reach new Western territory and secure land rights before its competitors (White, 2011, p.210). Between 1860 and 1880, over 100,000 miles of railroad track were laid (Fishlow, 1965; Fishlow, 2000), and by 1890 an extensive network covered the Western states.

Much of the territory into which the rail network expanded after the Civil War was already settled, especially in Missouri, Kansas, Nebraska, and Utah.\footnote{Populations in the 1870 census are approximately: Missouri 1.7 million, Kansas 370 thousand, Nebraska 122 thousand, Utah 86 thousand.} The wave of construction driven by the federally supported Pacific railroads therefore not only brought settlement and economic activity into sparsely settled areas, but disrupted the equilibrium of settlement in areas that had already been populated. I focus on railroad construction between 1868 and 1889 in seven states, Missouri, Kansas, Nebraska, Colorado, Wyoming, Utah, and Nevada, where the railroad network was dominated by east-west land grant railroads, including the Union Pacific, Central Pacific, Kansas Pacific, and Atlantic & Pacific, whose construction was driven by political and speculative, rather than purely commercial, objectives. The apparent independence of railroad building from short term commercial incentives, in particular the independence of route choice from local economic conditions, makes this a suitable setting for measuring the causal effects of railroad construction on the distribution of economic activity.

2.2. Post offices

In order to measure the distribution of settlement at a high spatial and temporal resolution, I use data on the location of United States Post Offices for each year of the 19th century. Mail was the primary system of long distance communication in 19th century America, and almost all settlements of any consequence had a post office (John, 1995, p. 112). The US Post Office was, at the time, “one of the largest and most geographically far flung organizations in the world” (Walker Howe, 2007, p.225) and the largest federal agency by far. New post offices were requested by settlers through petitions to Congress. Petitions were granted on the basis of need rather than expected revenue, and, in practice, Congress rarely denied requests for new routes and offices (Henkin, 2006, p. 50). Indeed, in 1850 Michigan congressman Charles E. Stuart “ventured” that there “had never been an application denied” in the last 25 years (Congressional Globe, 1852, p.1664). There was broad political support for the expansion of the postal service, both as “a service to the public and to national unification”, and as a means of consolidating political coalitions and reaching out to voters (Walker Howe, 2007, p.226). The service was not run for profit, and, for most of the 19th Century, there was no minimum revenue required for a post office to remain in operation (Walker Howe, 2007). Post offices would continue to operate in remote villages until those villages ceased to exist. In general, Congress would allow post offices to continue operating as long as a postmaster willing to file quarterly reports could be found and at least some mail continued to be delivered to the office (Blevins, 2015). This situation persisted until the adoption of Rural Free Delivery in the first decade of the 20th century, when Congress sought to close post offices in smaller towns that were now served by delivery routes. In Section 5.4, I discuss the relevance of the delivery reforms and the resulting wave of post office closures to this paper’s main results in detail.

As a result of the particular ubiquity of the post office in 19th Century America, the geographic distribution of post offices at a particular date serves as a spatially and temporally precise measure of the distribution of towns and villages - locations of concentrated settlement and economic activity. Indeed, the Postmaster-General’s Annual Report of 1902 makes the case that the number of “presidential” post offices (those with annual gross receipts of $1,900 or more) in a state “may safely be regarded as an index of the industry and commercial activity of its people” (Annual Report of the Postmaster-General, 1902). I provide empirical evidence supporting this interpretation in Section 3 below.\footnote{In order to measure the distribution of settlement at a high spatial and temporal resolution, I use data on the location of United States Post Offices for each year of the 19th century. Mail was the primary system of long distance communication in 19th century America, and almost all settlements of any consequence had a post office (John, 1995, p. 112). The US Post Office was, at the time, “one of the largest and most geographically far flung organizations in the world” (Walker Howe, 2007, p.225) and the largest federal agency by far. New post offices were requested by settlers through petitions to Congress. Petitions were granted on the basis of need rather than expected revenue, and, in practice, Congress rarely denied requests for new routes and offices (Henkin, 2006, p. 50). Indeed, in 1850 Michigan congressman Charles E. Stuart “ventured” that there “had never been an application denied” in the last 25 years (Congressional Globe, 1852, p.1664). There was broad political support for the expansion of the postal service, both as “a service to the public and to national unification”, and as a means of consolidating political coalitions and reaching out to voters (Walker Howe, 2007, p.226). The service was not run for profit, and, for most of the 19th Century, there was no minimum revenue required for a post office to remain in operation (Walker Howe, 2007). Post offices would continue to operate in remote villages until those villages ceased to exist. In general, Congress would allow post offices to continue operating as long as a postmaster willing to file quarterly reports could be found and at least some mail continued to be delivered to the office (Blevins, 2015). This situation persisted until the adoption of Rural Free Delivery in the first decade of the 20th century, when Congress sought to close post offices in smaller towns that were now served by delivery routes. In Section 5.4, I discuss the relevance of the delivery reforms and the resulting wave of post office closures to this paper’s main results in detail. As a result of the particular ubiquity of the post office in 19th Century America, the geographic distribution of post offices at a particular date serves as a spatially and temporally precise measure of the distribution of towns and villages - locations of concentrated settlement and economic activity. Indeed, the Postmaster-General’s Annual Report of 1902 makes the case that the number of “presidential” post offices (those with annual gross receipts of $1,900 or more) in a state “may safely be regarded as an index of the industry and commercial activity of its people” (Annual Report of the Postmaster-General, 1902). I provide empirical evidence supporting this interpretation in Section 3 below. The interpretation of the distribution of post offices as reflecting the}
location of towns has two important limitations. First, as highlighted by Fishlow (1965), settlement in the post-Civil War west was often speculative, anticipating the arrival of the railroad and future land value increases. Indeed, it was common for speculative and entrepreneurial settlers to establish a store and a post office in an unsettled location in the hope of attracting other settlers (John, 1995, p. 124). This means that the opening and closure of post offices in different locations may reflect changing beliefs about future economic activity and settlement, rather than the relocation of actual settlement. A second, related, limitation of post office location as a proxy for town location is that the presence of a post office tells us nothing about the size of the town it represents. I discuss these concerns more in my description of the data in Section 3 and my interpretation of the results in Section 5.4.

The case of West Point, Missouri, a town which is not separately listed in any census, demonstrates how data on post offices can be used to measure the effect of the railroad on the distribution of settlement and the location of towns. Missouri congressman W. O. Atkeson, in his 1918 History of Bates County Missouri, describes the town after the Civil War as “a small business house and a post office... with a few scattered residences.” According to Atkeson:

“The village had a precarious existence until the Kansas City Southern railroad crept stealthily by under the hill to the east, and the new town of Amsterdam was established a couple of miles south. Then the historic town of West Point gave up the ghost, and only debris remain to speak its former glory. It is a pitiful story, but one not uncommon in this western country.” Atkeson (1918, p.267)

The West Point post office, established 1838, was discontinued in 1881, 9 years after the railroad arrived in Bates County in 1872.

3. Data description

The data on historical post offices was published in United States Post Offices Vol. 1–8 (Helbock, 2010). These books contain data on every post office that has operated in United States territory from 1776 to 2010. Each entry contains the name of the post office, its county and state, the year it was established and the year it was discontinued (if not currently operating), and a “stamp rarity factor”. The states and counties recorded correspond to present day boundaries.

The data I use in the analysis also includes latitude and longitude coordinates for each post office established before 1900. The mapping from post office names to coordinates was carried out by Cameron Blevins for his dissertation, The Postal West (Blevins, 2015). Post office name, county and state were matched with historical place names in the USGS Geographic Names Information System (GNIS) using a string matching algorithm. The geographic features whose coordinates are matched to historical post offices are often existing or historical towns ("populated places" in the GNIS database), but post offices are also matched to other features. For example, in Kansas, 50% of matched post offices are matched to a “populated place”, 30% are matched to a “locale”, and 16% are matched to a “school”. Not all historical post offices are successfully matched to a feature in the GNIS database - only 64% of the post offices in the raw data are assigned a latitude and longitude. The implications of the imperfect match rate are discussed further in Appendix B.4, where I present evidence that selection into the sample on GNIS match does not bias the results.

As discussed in Section 2, I focus on post offices in the territory of 7 modern-day States: Missouri, Kansas, Nebraska, Colorado, Wyoming, Utah, and Nevada. Panel 1 of Fig. 2 maps each post office in the data and Table 1 records summary statistics. There are a total of 15070 Post Offices in the data established between 1800 and 1900, with an average year established of 1876, an average year discontinued of 1916, and an average lifespan of around 40 years. Note that Post Offices that were still operating in 2010 are coded as having been discontinued in 2010. There are 2509 of these “operational in 2010” post offices, about 17% of all post offices in the data. Row 11 of Table 1 indicates that around 50% of the post offices were discontinued before 1900. The number of discontinuations before 1900 suggests a large amount of churn in the locations of urban centers over the second half of the 19th century. Significantly, this was not only a period of migration to the West and Midwest, but also of continual reorganization of patterns of settlement.

To verify that the location of a post office is a reasonable proxy for the presence of population and economic activity, I use data on county populations from the 6 US Censuses between 1860 and 1910. In columns 1 to 3 of Table 2, I present regressions of the number of active post offices in a county in the census years on county population. Column 1 reports a statistically significant positive correlation between county post offices and population, although the magnitude of the correlation is small - an increase in population of 1000 is associated with an additional 0.076 post offices. Column 2 restricts the sample to county-years with population of less than 50,000, dropping the most highly populated county-years which represent less than 2% of the sample and mostly correspond to large cities such as St. Louis, Salt Lake City, Denver, and Kansas City. On this restricted sample the effect is larger by an order of magnitude: an increase in population of 1000 is associated with an additional 0.721 post offices. That is, using variation both within and across counties, one additional post office is associated with an increase in county population of approximately 1400. Adding county and year fixed effects to the regression decreases the magnitude of the coefficient somewhat but does not change the statistical significance of the result, as reported in column 3.

The results indicate that the number of post offices in a county is a good measure of variation in county population both across counties and within counties over time. However, this correlation does not hold for the most populous urban counties. This finding is consistent with the interpretation of the existence of a post office as a proxy for the existence of a town or village. As discussed in Section 2 above, it is reasonable to assume that during this era virtually all towns and villages had a post office, but larger towns and cities did not have significantly more post offices than smaller towns or villages. Post offices are therefore a good measure of the spatial distribution of towns, centers of population and economic activity, but not a good measure of the intensive margin of the level of population or economic activity within a town. The extent to which the number of post offices in a county correlates with population depends on to the extent to which increases in county population reflect the growth of new towns rather than population growth within existing towns.

To further illustrate this point, column 4 of Table 2 presents the results of a regression of the number of post offices in a county-year on total population and urban population, where urban population includes towns with populations greater than 2500. The results are consistent with the interpretation of post office count as a measure of the number of towns or villages in a county. Holding urban population fixed, an increase in county population of 1000 is associated with an additional 0.961 post offices. Controlling for urban population therefore increases the magnitude of the coefficient on total population. An increase in county population that is not associated with an increase in the population of existing larger towns is likely to be associated with the growth of new towns, which should result in an increased number of post offices. On the other hand, the coefficient on urban population is significant and negative. Holding county population fixed, an increase in urban population of 1000 is associated with a loss of 0.816 post offices. The negative effect likely reflects the presence of fewer rural villages in counties with a higher urban population share. These results suggest that as rural areas become more sparsely populated, existing

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7 See Blevins (2015) for details.
Table 1
Post office data: Summary statistics.

<table>
<thead>
<tr>
<th>State</th>
<th>CO</th>
<th>KS</th>
<th>MO</th>
<th>NE</th>
<th>NV</th>
<th>UT</th>
<th>WY</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>1675</td>
<td>4001</td>
<td>5517</td>
<td>2369</td>
<td>411</td>
<td>552</td>
<td>545</td>
<td>15070</td>
</tr>
<tr>
<td>Min</td>
<td>1858</td>
<td>1800</td>
<td>1804</td>
<td>1853</td>
<td>1852</td>
<td>1849</td>
<td>1850</td>
<td>1800</td>
</tr>
<tr>
<td>Year established Mean</td>
<td>1884</td>
<td>1878</td>
<td>1871</td>
<td>1880</td>
<td>1879</td>
<td>1878</td>
<td>1887</td>
<td>1876</td>
</tr>
<tr>
<td>Max</td>
<td>1900</td>
<td>1900</td>
<td>1900</td>
<td>1900</td>
<td>1900</td>
<td>1900</td>
<td>1900</td>
<td>1900</td>
</tr>
<tr>
<td>Min</td>
<td>1859</td>
<td>1841</td>
<td>1811</td>
<td>1855</td>
<td>1858</td>
<td>1851</td>
<td>1854</td>
<td>1811</td>
</tr>
<tr>
<td>Year discontinued Mean</td>
<td>1919</td>
<td>1913</td>
<td>1913</td>
<td>1920</td>
<td>1912</td>
<td>1914</td>
<td>1925</td>
<td>1916</td>
</tr>
<tr>
<td>Mean rarity</td>
<td>5.01</td>
<td>5.08</td>
<td>4.219</td>
<td>4.637</td>
<td>5.883</td>
<td>4.053</td>
<td>4.528</td>
<td>4.652</td>
</tr>
<tr>
<td>Matched to GNIS</td>
<td>0.555</td>
<td>0.659</td>
<td>0.667</td>
<td>0.566</td>
<td>0.968</td>
<td>0.768</td>
<td>0.514</td>
<td>0.643</td>
</tr>
<tr>
<td>Mean lifespan</td>
<td>35.211</td>
<td>35.446</td>
<td>42.435</td>
<td>40.055</td>
<td>32.579</td>
<td>56.413</td>
<td>37.549</td>
<td>39.469</td>
</tr>
<tr>
<td>Discontinued before 1900</td>
<td>0.494</td>
<td>0.564</td>
<td>0.438</td>
<td>0.529</td>
<td>0.479</td>
<td>0.332</td>
<td>0.361</td>
<td>0.486</td>
</tr>
</tbody>
</table>

Notes: Row 1 records the total number of post offices established before 1900 in the data, including those that are not matched to the GNIS database and for which latitude and longitude is therefore not available. The statistics in Rows 2 to 7 are also computed for all post offices in the state(s) indicated, including those not matched to GNIS. Row 8 records the mean stamp rarity factor for post offices in the state(s) indicated. Row 9 indicates the share of these post offices that is matched to the GNIS place names database. Row 10 records the mean lifetime (in years) of all post offices located in the state(s) indicated, including those post offices that survived until at least 2010. Lifetime for those post offices which were still open in 2010 is recorded as the number of years the post office had been open as of 2010. Row 11 records the share of all post offices that were discontinued before 1900.

Table 2
Post offices and population.

<table>
<thead>
<tr>
<th>Dependent variable: Number of post offices</th>
</tr>
</thead>
<tbody>
<tr>
<td>County population</td>
</tr>
<tr>
<td>(0.008)</td>
</tr>
<tr>
<td>Urban population</td>
</tr>
<tr>
<td>.</td>
</tr>
<tr>
<td>R²</td>
</tr>
<tr>
<td>N</td>
</tr>
<tr>
<td>County fixed effects</td>
</tr>
<tr>
<td>Year fixed effects</td>
</tr>
<tr>
<td>Population &lt; 50,000</td>
</tr>
</tbody>
</table>

Notes: Robust standard errors in parentheses. *** indicates significance at the 1% level. * indicates significance at the 5% level. An observation is a county-year for counties in the in the 7 states in years 1860, 1870, 1880, 1890, 1900, and 1910. County population and urban population measured in thousands. Urban population is population in towns with a population of over 2,500. For each county-year the dependent variable is the number of post offices in the data that saw the greatest increase in track length: 1868–1872, 1872–1877, 1877–1881, and 1881–1889. The growth of the railroad network over this period is mapped in Panels 2, 3 and 4 of Fig. 3. The combined data allow me to examine the distribution of distance to the railroad network among active post offices at each of the snapshot years in the railroad data. For instance, let distance,1872 be the length (in km) of the shortest line from post office i to the 1872 railroad network. The left panel of Fig. 1 illustrates the distribution of distance,1872 among all post offices for which latitude and longitude are available. Post offices are massed around the railroad network, with 86% of post offices less than 100 km from the nearest railroad line. The right panel of Fig. 1, which shows the distribution conditional on distance,1872 < 100, illustrates the mass of post offices very close to the railroad - 18% of all post offices are within 5 km of the railroad. The distribution of distance from the railroad for other years is presented in Appendix Table A.3.

The main analysis examines how this distribution changes over time. In particular, I ask how the expected lifetime of a post office and the probability that it survives to the present day changes when a railroad is built nearby. Under the assumption that post offices are proxies for towns, and that post offices that no longer exist or whose post offices close, but as larger towns become more populous, additional post offices are unlikely to open.

In addition to recording the location and dates of operation of each post office, the data includes a coarse measure of post office size, the "stamp rarity factor". This measure indicates, on a 0–9 scale, the rarity of a stamp or letter bearing the cancellation mark of each post office. Rarity factors for cancellation stamps are used by philatelists to value stamp collections, and the measure included in this data, sometimes known as the "Helbock Scarcity Index," is widely used. In Appendix Section A.2, I show that the term "Helbock Scarcity Index" is frequently included as part of the item description in online stamp auctions, and that there is a significant positive correlation between stated rarity factor and auction prices. Under the assumption that the survival of pieces of mail to the present day is random, stamp rarity can be interpreted as a measure of the total volume of mail ever sent from a given post office, which in turn is a proxy for the level of population and economic activity in the area served by the post office. This table records mean stamp rarity for each state.

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10 See: https://my.vanderbilt.edu/jeremyatack/data-downloads/.

11 See Appendix Table A.1 and Appendix Figure A.1 for details on the length of track constructed between each snapshot year. For the sake of brevity, I present some results only for 1868–1872 and 1872–1877. Results for other years are available in the Appendix.
population has declined below some threshold, this analysis illustrates how the construction of transportation infrastructure changes the spatial distribution of settlements. Fig. 4 illustrates the patterns in the data that drive the main results. Let $l_{ife_i}$ be the lifetime in years of a post office $i$, and let $exist_{i,2010}$ be an indicator for whether post office $i$ remains open in 2010. The left panel of Fig. 3 illustrates the relationship between $l_{ife_i}$ and $distance_{i,1872}$ among post offices founded before 1868 (the prior snapshot year) for which $distance_{i,1872} < 50$. The solid line is a local polynomial estimate of $E[l_{ife_i}|distance_{i,1872}]$, and the shaded region is the 95% confidence interval. The right panel is an analogous estimate of $E[exist_{i,2010}|distance_{i,1872}]$. Both panels show that post offices located within 5 km of the railroad survive longer on average than more distant post offices. However, expected lifetime and probability of survival are not monotonically decreasing in distance. Post offices between 5 km and 10 km of the railroad are less likely to survive than post offices located further away. The existence of this non-monotonicity highlights the advantages of using post office data, which can be used to measure the heterogeneous effects of railroad building at short distances, over more aggregated census data. The remainder of the paper focuses on identifying, measuring, and interpreting these effects.

4. Empirical strategy

4.1. Baseline specifications

I use two main econometric specifications to measure the effect of the railroad construction on the geographic distribution of economic
activity. The first regresses an indicator, \( \text{exist}_{i,2010} \), for whether a post office \( i \) survived until 2010 on its distance from the railroad network at different years. The second regresses the year a post office was discontinued, \( \text{closed}_i \), on its distance from the railroad, controlling for year established (opened). The specifications attempt to replicate the following ideal experiment. Consider a set of post offices that are equidistant from the existing railroad network in 1868 and otherwise identical (established in the same year etc.). Suppose that, between 1868 and 1872, the railroad network is extended in a random direction. In 1872, some post offices are now closer to the railroad than others. Differences in the survival rate or lifetime of post offices at different distances from the 1872 railroad can then be used to measure the causal effect of railroad construction at different distances.

The first regression specification is a linear probability model of the form:

\[
\text{exist}_{i,2010} = \alpha + \sum_{k=0}^{4} \beta_k \text{band}_{ki} + g(\text{distance}_{i,1872}) + X_i \gamma + \epsilon_i \tag{1}
\]

Where, for each snapshot year \( y_n \), the variables \( \text{band}_{ki} \) are defined as follows:

- \( \text{band}_{0,ki} = 1 \) if \( \text{distance}_{i,1872} < 5 \)
- \( \text{band}_{1,ki} = 1 \) if \( 5 \leq \text{distance}_{i,1872} < 10 \)
- \( \text{band}_{2,ki} = 1 \) if \( 10 \leq \text{distance}_{i,1872} < 15 \)
- \( \text{band}_{3,ki} = 1 \) if \( 15 \leq \text{distance}_{i,1872} < 25 \)
- \( \text{band}_{4,ki} = 1 \) if \( 25 \leq \text{distance}_{i,1872} < 50 \)
- \( \text{band}_{5,ki} = 1 \) if \( 50 \leq \text{distance}_{i,1872} \)

\( \text{band}_{5,ki} \) is the omitted category and \( g(\text{distance}_{i,1872}) \) is a quartic polynomial. Control variables in \( X_i \) are dummies for year established and state fixed effects.\(^\text{12}\) I run this specification separately for each of the four snapshot years, \( y_n \), in the railroad data between 1872 and 1889. Note that the subscript \( y_{n-1} \) indicates the previous snapshot year at which railroad data is available not the previous calendar year. That is, if \( y_n = 1872 \) then \( y_{n-1} = 1868 \), if \( y_n = 1877 \) then \( y_{n-1} = 1872 \), if \( y_n = 1881 \) then \( y_{n-1} = 1877 \), and if \( y_n = 1889 \) then \( y_{n-1} = 1881 \).

The use of dummy variables indicating whether or not a post office falls in each of several distance “bands” is flexible enough to measure different treatment effects at different distances while providing a small set of estimated coefficients with clear interpretations, and allowing the straightforward application of linear instrumental variables methods. The coefficients of interest are the elements of the vector \( \beta = (\beta_1, \ldots, \beta_5) \). \( \beta_0 \), for example, measures the difference in expected probability of survival to 2010 between a post office less than 5 km from the railroad and a post office further than 50 km from the railroad in year \( y_n \), controlling for railroad distance in year \( y_{n-1} \).

Why use these particular distance bands? Post offices in the omitted category are assumed to be “controls” - locations sufficiently distant from the railroad such that it has no effect on the probability of post office survival. Since the survival of a post office is taken to be a proxy for the continued existence of a town, the required assumption is that the effects of the railroad on town survival are insignificant beyond some threshold distance, taken to be 50 km in the main specifications.

In the American West during the later 19th century, 50 km represented approximately one day’s journey from the railroad. A person can travel roughly 35 km on foot or 64 km on horseback in a day. Wagons and coaches could travel between 20 km (heavily laden wagons) and 170 km (mail stagecoaches on the fastest roads) in a day, depending on load and road conditions.\(^\text{13}\) Since the location of farmland and natural resources is fixed, it is reasonable to assume that the effect of railroad construction on the location of towns and villages is diminishing in distance from the railroad. One day’s journey serves as a convenient cutoff that might also represent a point of discontinuity in the time cost of travel. In particular, settlements within a day’s journey of the railroad might be relocated to the railroad while still supporting agriculture and natural resource extraction in a fixed hinterland, while agriculture at more distant locations would be unsustainable without the presence of a local town or village.\(^\text{14}\)

\( ^{12} \) In Appendix Table A.20 I present results which include county fixed effects. I discuss these more in Section 5.5 below.

\( ^{13} \) Walking distance calculated based on 8 hours of travel a day using the human preferred walking speed of 5.1 km/hr measured by Browning et al. (2006). Horse distance based on a speed of 8 km/hr from Rodrigue et al. (2009). Distance for a one ton wagon pulled by four horses on ordinary roads from Rodrigue et al. (2009). Mail stagecoach speed based on 25 day completion of the 2795 mile Butterfield overland mail route (Williams (1957)).

\( ^{14} \) The idea that farmland and natural resources are fixed is a simplification that ignores changes in agricultural technology (Olmstead and Rhode. (2008)) and the discovery of natural resources (David and Wright (1997)). The importance of this assumption is that the location of pre-existing natural resource extraction and agriculture cannot be relocated towards the railroad, and resources that are sufficiently distant from the railroad cannot fall the hinterland of an on-railroad town. This is true even if the productivity of land is increasing. This relates to the model of a two sector spatial economy of Fujita et al. (1999) which I discuss in Section 5.3.
The remainder of the distance bands within the 50 km cutoff are chosen to measure the heterogeneous effects of railroad construction at different distances. Fig. 3 suggests that the effect of the railroad on post office survival varies in magnitude and sign within 15 km. The 5 km, 5–10 km, and 10–15 km distance bands measure the heterogeneous effects at these short distances. Further from the railroad, the density of post offices declines, as illustrated in Fig. 1. I therefore choose the wider bands of 15–25 km and 25–50 km to ensure sufficient power at these distances.

The second specification, given by equation 2 below, has closed, the year a post office is closed, as the dependent variable, and is otherwise identical to equation 1.

\[
closed_i = \alpha + \sum_{k=0}^{4} \beta \text{band}_{ik} + g(\text{distance}_{ik}) + X_i + \epsilon_i
\]  

(2)

As in equation 2, \(X_i\) includes dummy variables for year established. The coefficients \(\beta\) are identified by variation across post offices established the same year, and therefore measure the effects of railroad construction within each of the distance bands on the expected lifetime of a post office. As with the first specification, I estimate equation 3 separately for each of the four snapshot years, \(y_n\), between 1872 and 1889.

A possible source of bias in estimating equation 2 by OLS is the censoring of the year discontinued for post offices which survived until 2010 or beyond. 17% of all post offices in the sample survive until 2010. Estimates of equation 3 that do not correct for the censoring could therefore result in estimates of \(\beta\) that are biased and inconsistent. To correct for this, I also estimate a Type I Tobit model.

The main sample used for year \(y_n\) estimation includes all post offices discontinued after previous snapshot year \(y_{n-1}\). That is, all post offices whose survival is potentially affected by the railroad constructed between years \(y_{n-1}\) and \(y_n\), including those post offices that are opened after the railroad is built. These estimates combine the effect of railroad construction on pre-existing post offices and the effect of the presence of the railroad on post offices that are established later. To separate these effects, I estimate equations 2 and 3 on the sub-sample that includes only post offices established before \(y_{n-1}\) and the sub-sample that includes only post offices established after \(y_n\).

### 4.2. Endogeneity

The chief empirical concern in most studies of the effect of transport infrastructure on local economic outcomes is the potential endogeneity of the placement of infrastructure. The ideal experiment outlined above assumes random placement of railroad lines. If railroads were placed close to towns or regions that were expected to grow, then the causal effect of distance from the railroad on the distribution of towns that the regressions outlined above attempt to measure is contaminated by the endogeneity of railroad placement.

Previous literature has addressed this problem either by arguing for the exogeneity of infrastructure placement for the regions being studied or by using an appropriate instrumental variable. Chandra and Thompson (2000) argue that rural counties receive new highways because they “happen to fall between” cities that the government wishes to connect. A similar argument could be made for the placement of railroad lines in the seven states in the data during the post-Civil War era. As discussed in Section 2, the expansion of the railroad into these states after the Civil War was driven by the government’s objective of constructing transcontinental lines. The routes laid were therefore likely to be exogenous with respect to local economic conditions in the rural communities they passed through. Endogeneity of route placement is therefore less of a concern in interpreting the OLS estimates of equations 2 and 3 than it would be in other contexts such as railroad expansion before the Civil War.

However, the first transcontinental lines were followed by local railroads and branch lines that served to connect towns and fill in the gaps in the network, and whose placement was likely driven by local economic factors. Although these lines are unlikely to drive the qualitative patterns in the main OLS results, their presence means it is not possible to interpret the OLS point estimates as causal. To deal with this potential endogeneity, I construct an instrumental variable and argue that it affects the survival of post offices only through its correlation with the location of the railroad. For each of the four snapshot years, \(y_n\), between 1872 and 1889, I connect major towns on the year \(y_n\) railway network that were established before year \(y_{n-1}\) (the previous snapshot year) with straight lines. Distance of a post office from this straight line network is closely correlated with distance from the railroad. Proximity to a straight line between two towns plausibly has no direct effect on the likelihood that a post office survives. In contrast, proximity to the railway line between these two towns, which typically deviates from a straight line, may be due to the pre-railway size or rate of growth of the post office’s town.\(^{15}\)

I identify the “major” towns which act as the nodes of this network using the data on stamp rarity. I select all post offices with a stamp rarity of 0 that were established before \(y_{n-1}\) and are within 1 km of the year \(y_n\) railroad. I then construct a minimum spanning tree that connects all of these points. The minimum spanning tree is the set of edges that connects all points in the network at the minimum cost. Cost is defined for each potential edge, and different assignments of costs to potential edges will result in different minimum spanning trees. Faber (2015) uses the “euclidean distance minimum spanning tree”, which uses euclidean distance of each potential edge as the cost. I use a similar cost function, but allow north-south and east-west distance to be weighted differently. In particular, I let the cost of connecting two points, \(i\) and \(j\) be:

\[
\text{cost}_{ij} = \sqrt{(\text{latitude}_i - \text{latitude}_j)^2 + ((1 - \lambda) \text{longitude}_i - (1 - \lambda) \text{longitude}_j)^2}
\]

Where \(\lambda \in [0, 1]\) is the relative weight placed on north-south distance. When \(\lambda = 1\), east-west connections with no change in latitude between the endpoints are costless. Likewise when \(\lambda = 0\), connections that run directly north-south are costless. For each value of \(\lambda\) for a given set of points, there is potentially a different minimum spanning tree. When \(\lambda > 0.5\), the minimum spanning tree will tend to have more east-west connections than the euclidean distance minimum spanning tree, etc. I use this more flexible cost specification because the objective of several major Western railroads during this era was to build east-west transcontinental lines, rather than connect all towns in the region at the least cost. One might therefore suspect that a minimum spanning tree that places less cost on east-west connections than on north-south connections would be more likely to replicate this pattern of railroad building.

The selection of \(\lambda\) is equivalent to the choice an appropriate instrument for the railroad network.\(^{16}\) For each year \(y_n\), I generate a spanning tree for each value of \(\lambda\) in the set \([0.1, 0.2, ... , 0.9]\). For each spanning tree, I generate the set of variables \([\text{band}_{ij} = 0, 1, 2, ..., 15]\), which are defined analogously to \([\text{band}_{ij} = 0, 1, 2, ..., 15]\), but use distance from the minimum spanning tree for year \(y_n\) and weight \(\lambda\) instead of distance from the railroad. I then run the following “first stage” regressions for each \(y_n\), \(\lambda\), and distance band \(k\):

\[
\text{band}_{ijk} = \alpha + \sum_{l=0}^{4} \beta \text{band}_{i,k} + g(\text{distance}_{ijk}) + X_i + \epsilon_i
\]
Appendix Figure A.2 records the $R^2$ from each of these regressions. The $R^2$ for most bands and snapshot years is maximized at $\lambda = 0.7$. Based on these results, I set $\lambda = 0.7$ for the remainder of the analysis. For this value of $\lambda$, the minimum spanning trees generated for each year $y_n$ tend to have more east-west connections, closely matching the historical pattern of railroad building.

I use $\{IVband_{n,0,0.7}\}_{n=0}^{n}$ to instrument for $\{band_{n,0,0.7}\}$ in 2SLS regressions of equations 2 and 3. Note that the post offices used as nodes must be omitted from the regression since these post offices were selected because they represent major towns on the railroad network. Distance to the minimum spanning tree is therefore directly related to the times these post offices were opened or on the probability of survival to 2010. This strategy is similar to the results of these regressions are recorded in Appendix Table A.22. I discuss these issues further in my interpretation of the results in Section 5.

Because of these concerns with the selection of post office nodes, I run an alternative IV specification in which the instrument is constructed by generating minimum spanning trees that connect all towns with a population of at least 1000 recorded in the 1870 and 1880 censuses, where town coordinates were obtained from Google Maps. These specifications are discussed further in Appendix Section B.1. The results generated are qualitatively similar to those presented in the main results below, but the census town instruments are relatively weak, with low first stage F statistics.

In addition to the concerns regarding the construction of the instrument, any straight line network that connects major nodes (whether post offices or census towns) may be correlated with the location of pre-existing transport routes, such as roads and trails, as well as with the railroad. To provide evidence that the results described below are not driven by the prior existence of roads and trails, I run alternative OLS specifications using distance from existing roads, explorer routes, and planned routes for the Pacific railroads. I use the proposed routes in the "Map of Routes for a Pacific Railroad", published by the Office of Pacific Railroad Surveys in 1857, based on the surveys of potential westward routes were carried out by the War Department between 1853 and 1855. I supplement this with the locations of overland postal roads, trails, and survey routes from the 1859 "General Map of the United States & Their Territory Between the Mississippi and the Pacific Ocean," compiled by the Missouri Surveyor-General. The results of these regressions are recorded in Appendix Table A.22. I find that proximity of post offices to planned routes, survey routes, post roads, and overland trails has no significant effect on expected lifetime or on the probability of survival to 2010. This strategy is similar to the placebo regressions run by Donaldson (2012), who shows that planned railroads which were never built had no significant effect on agricultural income in 19th Century India.

5. Results

5.1. OLS Results

Table 3 presents the baseline OLS results. Columns 1 to 4 record the estimated parameters $\beta$ from equation 1, the regression of $exist_{2010}$ on distance bands, for each of the 4 snapshot years between 1872 and 1889. Recall that the estimation sample for year $y_n$ includes all post offices that are active at any date after the previous snapshot year, $y_{n-1}$. The coefficients in the first column are representative of the broad pattern of results. Post offices within 5 km of the railroad are 9.1 percentage points more likely to survive to 2010 than post offices greater than 50 km form the railroad. Post offices slightly further than 5 km from the railroad are, on the other hand, significantly less likely to survive until 2010 than post offices greater than 50 km from the railroad. Post offices 5–10 km from the railroad are 10.7 percentage points less likely to survive than distant post offices. Moving further away from the railroad, the magnitude of the negative effect decreases monotonically towards 0. Post offices between 10 and 15 km from the railroad are only 5.4 percentage points less likely to survive than post offices beyond 50 km. At 15–25 km and 25–50 km, the effect is not statistically significant. The effects for railroad construction in 1872–1877, 1877–1881, and 1881–1889, recorded in columns 2, 3, and 4, display a similar pattern to those in column 1.

Columns 5 to 8 present the analogous coefficient estimates for equation 2, the regression of $closed$, on distance bands. Recall that the control variable include dummies for year established, so the coefficient for a given distance band measures the expected lifetime of post offices within that distance of the railroad built between snapshot years $y_{n-1}$ and $y_n$ relative to “control” post offices further than 50 km from the railroad in year $y_n$. Again, the estimation sample for year $y_n$ includes all post offices that are active at any date after the previous snapshot year, $y_{n-1}$.

The estimated coefficients follow a similar pattern to those in columns 1 to 4. Post offices less than 5 km from the railroad survive for significantly longer, between 7 and 12 years, than control post offices further than 50 km from the railroad. Post offices slightly further from the railroad, between 5 and 10 km, have lifetimes between 17 and 28 years shorter than control post offices. This negative effect is significant and persists at further distances although it becomes smaller in magnitude, and for post offices between 25 and 50 km the effect is insignificant for each of the four snapshot years. Appendix Table A.8 presents equivalent estimates for the Tobit regression of $closed$, on distance bands, which corrects for the fact that $closed = 2010$ for post offices that may have survived beyond 2010. The estimated effects have the same pattern as those recorded in Table 5, but the magnitudes are larger.

Note that these results measure both the effect of railroad construction on pre-existing post offices and the effect of proximity to the railroad constructed between years $y_{n-1}$ and $y_n$ on post offices that were established later, since the estimation sample includes all post offices active at any point after $y_{n-1}$. That is, it includes both the effect of railroad construction on existing post offices, and the effect of being located near an existing railroad on new post offices. To differentiate between these effects, I estimate equations 1 and 2 separately for three subsamples: The sample of post offices established before year $y_{n-1}$, the sample of post offices established at the same time as the railway was being built, between $y_{n-1}$ and $y_n$, and the sample of post offices established after $y_n$.

The top left panel of Fig. 4 records the estimated parameters, $\beta$, from OLS regressions of equation 1 on these three subsamples for $y_n = 1877$. The solid red circles record the estimated effects of railroad construction at each distance band on the probability of post office survival for the sample of pre-existing post offices established before the previous snapshot year, 1872. The solid green triangles record equivalent point estimated for post offices established between 1872 and 1877. The solid blue squares record equivalent point estimates for the sample of post offices that were established after 1877. The error bars around each point estimate record a 95% confidence interval.

A similar pattern of results holds for each subsample. For each set of post offices, being located between 5 and 10 km of the year $y_n$ railroad has a negative effect on the probability of survival. The negative effects at this distance are on the same order of magnitude as those from the pooled regression recorded in Table 3. Note that the negative effect is...
Table 3
OLS results.

<table>
<thead>
<tr>
<th>Dependent variable: Exists 2010</th>
<th>Year discontinued</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year of RR construction ($y_n$):</td>
<td>1872</td>
</tr>
<tr>
<td>0–5 km from RR</td>
<td>0.091***</td>
</tr>
<tr>
<td></td>
<td>(0.018)</td>
</tr>
<tr>
<td>5–10 km from RR</td>
<td>−0.107***</td>
</tr>
<tr>
<td></td>
<td>(0.017)</td>
</tr>
<tr>
<td>10–15 km from RR</td>
<td>−0.054***</td>
</tr>
<tr>
<td></td>
<td>(0.016)</td>
</tr>
<tr>
<td>15–25 km from RR</td>
<td>−0.017</td>
</tr>
<tr>
<td></td>
<td>(0.014)</td>
</tr>
<tr>
<td>25–50 km from RR</td>
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<tr>
<td></td>
<td>(0.015)</td>
</tr>
<tr>
<td>N</td>
<td>9230</td>
</tr>
</tbody>
</table>

Notes: Robust standard errors in parentheses. *** indicates significance at the 1% level. ** Indicates significance at the 5% level. * indicates significance at the 10% level. Columns 1–4 present OLS parameter estimates of the coefficients $\beta$ on $|\text{band}_{k,yn}|$ in equation 2 for snapshot years $y_n = 1872, 1877, 1881, and 1889$. The dependent variable is $\text{exists}_{2010}$, and control variables are a quartic in $-d_{yn}$, where $y_{n-1}$ is the previous snapshot year, and fixed effects for year established and state. Columns 5–8 present OLS parameter estimates of the coefficients $\beta$ on $|\text{band}_{k,yn}|$ in equation 3 for snapshot years $y_n = 1872, 1877, 1881, and 1889$. The dependent variable is $\text{closed}_{2010}$, which is set to 2010 for post offices that are still active, and the control variables are the same as in columns 1–4. For each regression, the sample includes all post offices that are discontinued after $y_{n-1}$. That is, all post offices active at some point after the previous snapshot year.

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**Fig. 4. Heterogeneity by Year Established.**

Notes: The top two panels record OLS estimates of the coefficients $\beta$ from equations 1 (left panels) and 2 (right panels) for snapshot year $y_n = 1877$, and different samples. In each panel, the red circles plot estimated coefficients, $\beta$, on 5 distance bands and 95% confidence intervals using the sample of post offices established before the previous snapshot year, $y_{n-1}$. The green triangles plot estimated coefficients on the sample of post offices established between $y_{n-1}$ and $y_n$ inclusive. The blue squares plot estimated coefficients on the sample of post offices established after $y_n$. The bottom two panels record analogous IV estimates, where distance bands are instrumented for using distance from the minimum spanning tree, as described in Section 4.2. The samples used are the same as in the OLS results, except for the sample of post offices established before $y_{n-1}$, which also excludes post offices within 1 km of the year $y_n$ railroad in the IV results. Estimates where post offices within 1 km of the railroad are dropped are plotted using hollow red circles. All confidence intervals are constructed using robust standard errors. Control variables for which estimated parameters are not plotted are a quartic in $-d_{yn}$, state fixed effects, and, in the right panels, fixed effects for year established. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)
largest and most significant for the set of pre-existing post offices (the red circles). Railroad construction between 1872 and 1877 that bypasses an existing post office by between 5 and 10 km reduces that post office’s probability of survival to 2010 by about 30 percentage points. The effect of a post office established after 1877 being located between 5 and 10 km from the 1872–1877 railroad is a reduction in survival probability of only 10 percentage points.

The subsample regression also indicate that the positive effect of being located within 5 km of a railroad on a post office’s probability of survival and expected lifetime, documented in the first row of Table 3, appears to be driven mostly by post offices established at the same time as the railway was being built. Post offices established between 1872 and 1877 within 5 km of a railroad that was also built between 1872 and 1877 are about 30 percentage points more likely to survive until 2010 than control post office. For post offices established before 1872 or after 1877 the effect is close to 0 and not significant.

The top right panels of Fig. 4 records analogous OLS estimates of equation 2, the effect of railroad distance on post office lifetime for the three subsamples with \( y_0 = 1877 \). The overall pattern of results matches that of the pooled regressions in Table 3. The negative effect of the railroad construction at 5 - 10 km on post office lifetime is larger for those post offices that were established before the railroad was extended between 1872 and 1877 than for those post offices that were established after 1877. The positive effect at less than 5 km is largest for post offices established at the same time as the railroad is being built, and is close to 0 for the post offices established before 1872 and after \( y_0 = 1877 \).

The top panels of Appendix Figures A.4, A.5, and A.6 record similar patterns for snapshot years 1872, 1881, and 1889.

5.2. IV Results

To correct for the potential endogeneity of railroad placement with respect to post office outcomes, I estimate equations 2 and 3 using the instrumental variable strategy described in Section 4.2. Table 4 presents the results of the baseline IV regressions for each of the four snapshot years. The results in columns 1 to 4 indicate that the presence of a railroad between 5 and 10 km of a post office has a significant negative effect on that post office’s probability of survival. Across the four snapshot years, the survival rate among post offices at this distance is between 14 and 34 percentage points lower than the survival rate of control post offices. Note that these effects are larger than those measured by the OLS regressions in Table 3. At further distances the effects are not statistically significant for the years 1872, 1877, and 1881. For the year 1889, the negative effect persists at further distances, but declines in magnitude. Columns 5 to 8 of Table 4 show a similar pattern in the IV estimates of equation 3. The presence of a railroad between 5 and 10 km of a post office reduces the expected lifetime of that post office by between 22 and 40 years, relative to control post offices. Again, these effects are larger in magnitude than the OLS estimates in Table 3.

The first row of Table 4 records the effect of the railroad on post office survival and lifetime at between 1 and 5 km. Note that the coefficients in this row are all negative and most are not statistically significant. The contrast between these results and the positive results in the first row of Table 3 suggests that the apparent positive effect of railroad construction on the survival of post offices close than 5 km from the OLS regressions is mostly driven by post offices less than 1 km from the railroad, which are omitted from the sample in the IV regressions.

As with the OLS regressions, I run the IV regressions separately on three subsamples of post offices: those established before \( y_{-1} \), those established between \( y_{-1} \) and \( y_0 \), and those established after \( y_0 \) for each snapshot year \( y_0 \). Parameter estimates and 95% confidence intervals for the main parameters, \( \beta \), of equations 1 and 2 for \( y_0 = 1877 \) are plotted in the lower panels of Fig. 4.21 Note that the endogeneity problem that motivates the use of an IV strategy is less of a concern for the subsample regressions which include only post offices established after year 1872, since these post offices were either established while the railroad was being built, or after it was completed, and the locations of the towns these post offices represent were unlikely to have directed the placement of the railroad. I include IV results for these subsamples for completeness.

Focusing first on the red circles in the lower left panel of Fig. 4, which plot the effect of distance to the railroad constructed in 1872–1877 on the set of post offices established before 1872, note that railroad construction between 5 and 10 km of a pre-existing post office reduces the probability of survival of that post office to 2010 by around 50 percentage points. This effect is larger in magnitude than that measured by the OLS regression, and is also larger in magnitude than the pooled IV estimate in the first column of Table 4. These results

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21 Notice that the subsample of post offices established before 1872, the previous snapshot year, omits post offices less than 1 km from the year 1877 railroad since these post offices are used to construct the instrument. The subsamples of post offices established after 1872 do not drop post offices less than 1 km from the railroad, since none of these post offices are used to define the instrumental variable.
support the observation that the negative effect of the railroad on the survival of nearby post offices was larger for pre-existing post offices than for post offices established after the railroad was constructed.

For post offices established between 1872 and 1877, plotted as green triangles, the significant positive effect of being located within 5 km of the railroad documented in the OLS results is also present in the IV results, and the estimates are of roughly the same magnitude. That is, post offices located within 5 km of the railroad which are established while the railroad is being built are around 30 percentage points more likely to survive to 2010 than control post offices established at the same time.

The results plotted in the lower right panel of Fig. 4 show analogous IV estimates of equation 2, which measures the effect of railroad distance of post office lifetime, for the three subsamples. The results follow similar patterns to the estimates of equation 1. For example, in 1877, Railroad construction at 5 to 10 km reduces the expected lifetime of a pre-existing post office by around 75 years. For post offices established after 1877, being located within 5 to 10 km of the 1872–1877 railroad decreases expected lifetime by approximately 25 years. For post offices established between 1872 and 1877, the effect of being located between 5 and 10 km of the railroad is much smaller, but being located within 5 km of the railroad increases expected lifetime by around 40 years.

The IV regressions for other snapshot years display similar patterns, and are presented in the bottom panels of Appendix Figures A.4, A.5, and A.6.

5.3. Interpretation and potential mechanisms

The results suggest that the spatial distribution of settlement and economic activity in these seven Western states was disrupted by the arrival of the railroads. Pre-existing post offices that were bypassed but that fell within a few hours to a day’s walk of the railroad (those post offices between 5 and 50 km in the main specifications) were more likely to close than those post offices which were connected to the railroad (those less than 5 km from the railroad) and those that were more remote (those greater than 50 km from the railroad). Post offices established on the railroad (those less than 5 km from the railroad) while it was being built were significantly less likely to close than distant post offices established at the same time. This pattern suggests that settlement and economic activity was redirected towards the railroad from the surrounding area. Towns that were bypassed by the railroad were likely to shrink as businesses and settlers opted to locate at nearby railroad towns that could serve the same farming hinterland. New towns that were established on the railroad were likely to benefit from this redirection of settlement and economic activity. The negative effect of railroad construction on town survival was largest between 5 and 10 km of the railroads, with post offices in this distance band being between 14 and 33 percentage points less likely to survive to 2010 than post offices distant from the railroad. The construction of the railroad therefore had very local effects on the distribution of settlement: new railroad towns succeeded at the expense of neighboring towns that were bypassed.

This mapping of the closure of post offices to the decline of rural villages that were bypassed by the railroads is supported by historical accounts such as those in Atkeson (1918). The town of West Point, Missouri, discussed in Section 2 above, was abandoned after the railroad “crept by” a few miles south (Atkeson, 1918, p.267). The nearby town of Hudson suffered a similar fate. An “ambitious little village” with “visions of greatness,” Hudson declined and was abandoned after “the Missouri, Kansas & Texas railroad... went by and Appleton City was started three and one half miles east.” (Atkeson, 1918, p.282). The post office at Hudson was active from 1867 to 1890.

5.3.1. Agglomeration Shadows and the Equilibrium Distribution of Towns

Under this interpretation, the results measure the extent of the theoretical “agglomeration shadow” discussed by Fujita et al. (1999, henceforth FKV). FKV present a model of a spatial economy with two sectors, farming and manufacturing. Farmland is fixed, and distributed uniformly along a line, while manufacturing firms can freely choose where to locate. FKV show that agglomeration economies can lead all manufacturing to locate at the same point, a “city”, in equilibrium. FKV illustrate this equilibrium using a device they call the “market potential” for manufacturing, the marginal return to employment in manufacturing relative to the marginal return to employment in agriculture. In equilibrium the economy will resemble a point mass of manufacturing, where “market potential” for manufacturing is high (in equilibrium, market potential in the city is 1), and a hinterland of agricultural production, where market potential is low (less than 1).

The model of FKV admits equilibria with multiple cities because at a sufficient distance from an existing city, market potential rises again. Beyond some “critical distance” from the city, the return to manufacturing can rise above the return to agriculture since manufacturing firms located far from the existing city can serve previously unserved customers located far from that city. The area between a city and this “critical distance” is the city’s “agglomeration shadow”. No manufacturer would choose to locate here because these locations lack the agglomeration economies of the city, and are not sufficiently distant from the city to grant the firm market power over some population of consumers not served by the existing city. FKV illustrate how different critical distances, which are determined, for example, by the cost of overland transport, can generate different equilibria with multiple cities separated by hinterlands where market potential is too low for manufacturing.

The presence of transportation infrastructure changes the relative market potential of different locations, and can alter the equilibrium distribution of cities (Fujita et al., 1999, pp. 227–236). Railroads increase market access, exposing businesses to more customers and reducing the transportation cost of inputs, and hence the construction of a railroad raises the “market potential” of locations on the network. It is possible that a railroad would raise market potential sufficiently that firms and workers would relocate to a point on the railroad from existing cities off the railroad. The new on-railroad city could therefore cast an agglomeration shadow over the locations of pre-existing cities, which would disappear in the new spatial equilibrium. Equally, if an existing city was connected to the railroad, its agglomeration shadow would expand, potentially swallowing up other nearby cities that were bypassed by the railroad.

Although manufacturing activity was limited in the Western states, the model of FKV applies equally to the location of general stores, outfitters, blacksmiths, and other businesses that might have been found in rural Western towns. There are clearly agglomeration economies that drive the co-location of these businesses.22 As in the model, the location of farmland and other natural resource activities were fixed. In Missouri, Kansas, and Nebraska especially, the construction of the railroads can be thought of as an experiment that changed the equilibrium distribution of cities on a uniform plain of farmland. The estimated parameters of equations 1 and 2 then measure the agglomeration shadow cast by the railroad, and the measurements of Tables 3 and 4 are tests of whether different distances fall within the agglomeration shadow.23 The IV results indicate that the “critical distance” which formed the boundary of the agglomeration shadow cast by the railroad was located at approximately 10 km. The significant negative effect of

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22 The key assumptions about the “manufacturing” sector are that producers can freely choose their location - they are not tied to the location of natural resources - and that there are productivity benefits or cost savings from co-location with other producers. In FKV, these agglomeration economies are driven by the fact that manufacturing workers are also customers. In more recent work, Kerr and Kominers (2015) show how individual firm location choice can generate regional industry clusters, even when agglomeration spillovers take place at very short distances.

23 In fact, Fig. 2 is strikingly similar to FKV’s figure 9.4 which illustrates the idea of the agglomeration shadow of a city.
the railroad within this distance indicates that towns in this band were likely to have fallen within the agglomeration shadow of some on-railroad town. Beyond this distance, the construction of the railroad has no significant effect on town survival.

Note that this interpretation suggests not only that cities near the railroad should decline, but that new cities should appear on the railroad. This idea is supported by the results in Fig. 4, which show that post offices established between years \( y_a \) and \( y_{a+1} \) within 5 km of railroads constructed between those same years were around 20 percentage points more likely to survive to 2010 than control post offices. This contrasts with the results for post offices within 5 km but established before \( y_a \) or after \( y_{a+1} \), which are not significantly more likely to survive to 2010 than control post offices. These results suggest that the increase in market access and “market potential” induced by the railroads mainly benefited new towns that were established along the line as it was built. Those towns within the 5–10 km band that declined and whose post offices did not survive were likely victim of the success of new, on-railroad towns.

For example, Atkeson (1918) blames the demise of West Point, MO on the founding of the railroad town Amsterdam, and the demise of Hudson, MO on the railroad town of Appleton City.

5.3.2. The Timing of Post Office Closures

Over what time frame did this shift in the distribution of settlements take place? To answer this, I repeat the estimation of equation 1, replacing \( \text{exist}_{t,2000} \) with \( \text{exist}_{t,e} \), an indicator for whether a post office survived until year \( e \), for each end year, \( e \), at five year intervals between 1880 and 2010. Fig. 5. Figure 5 records the IV estimates of the parameter on the 5–10 km distance band and a 95% confidence interval for each end year and for each railroad snapshot year. The coefficients for each of the four snapshot years are consistently negative, increasing in magnitude sharply after 1900, and are not all statistically significant at the 5% level until 1905. This pattern indicates that the rate of closures of post offices between 5 and 10 km of the railroad relative to those over 50 km from the railroad increased sharply during the first decade of the 20th century. Between end dates 1910 and 1930 the coefficients for each of the four railroad snapshot years either remain approximately constant or decline further, at a slower rate. After 1930, the coefficients shrink towards 0 indicating a diminishing effect of proximity to the railroad on closure rates for the remaining post offices.

These findings are supported by the results in Appendix Figure A.13, which record the 5–10 km coefficient of regressions of \( \text{exist}_{t,2010} \) on distance bands defined using the railroad network in 1889, restricting the sample to those post offices that survived until a specific threshold year. Each coefficient measures the effect of being located between 5 and 10 km of the 1889 railroad on the probability a post office survives until 2010, conditional on that post office surviving to the given threshold year. These effects are negative and significant in both the OLS and IV regressions for every threshold year up to and including 1930, and tend towards 0 thereafter. These results suggest that the railroads constructed between 1868 and 1889 had a significant effect on the survival of post offices until at least 1930. The magnitude and significance of this effect increases sharply between 1900 and 1910, coinciding with the wave of post office closures in small towns that accompanied the introduction of Rural Free Delivery. This finding is discussed further in Section 5.4 below.

Why might the effect of railroad proximity on post office closures die off in the 1930s? One possible explanation is that the twenty years between 1910 and 1930 saw rapid adoption of the automobile. During this era, the rail network was relatively stable and the state highway system was rapidly expanding.24 The adoption of the automobile

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24 From 1923 to 1933 the mileage state highway systems increased by 13,106 from 20,311 to 33,417 miles, while national main line railroad mileage declined by 1343 from 258,084 miles to 256,741 miles (Carter et al., 2006). These two decades also correspond roughly with the production run of the Ford Model T, from 1908 to 1927.

5.4. Robustness to alternative interpretations

5.4.1. Rural free delivery

The sharp increase in post office closure between 1900 and 1910 documented in Fig. 5 suggests a potential threat to the interpretation of the results as documenting an agglomeration shadow. It is possible that the closure of post offices was not driven by the relocation of settlement and economic activity, but by the reorganization of the postal service through the introduction of Rural Free Delivery. Free delivery meant that farmers no longer had to travel to their local post office to pick up or send mail, and that a single post office could serve a larger area, eliminating the need for a small Post Office in every village. A large number of post offices in smaller towns closed as a result of the reforms.

Rural free delivery was implemented gradually. 44 trial routes were established in 1896 after the program was approved by Congress. In December 1899, the Post Office Department expanded the experimental program nationwide, and in 1902 it became a permanent service (USPS, 2012). Roll out of the service continued over the following decade. In Missouri, for example, only 5 post offices had RFD routes in January...

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1900, with 559 more being established between 1900 and 1904. The expansion of RFD significantly reduced the cost of long distance communication for rural Americans. Studies in economic history have highlighted the effects of RFD on the growth of the manufacturing sector (Feigenbaum and Rotemberg, 2015) and its importance to rural delivery programs considerably. As the network of delivery routes expanded over the first decade of the 20th Century, the number of active post offices fell from a peak of 76,945 in 1901 to 58,729 in 1912 (Pope, 2011).

This wave of post office closures does not necessarily invalidate the interpretation of the results discussed above. If post offices were closed because they were in towns with smaller populations and lower economic activity, the results would tell us that, among post offices established before or after 1902 in each county where RFD had been implemented, although this was rarely achieved, and many larger fourth class post offices continued to operate in tandem with RFD (Fuller, 1972).

Post office closures were often controversial and could inspire fierce opposition from local business people and, naturally, postmasters themselves. Debates over which post offices in a county should be closed tended to emphasize the small size and economic insignificance of the villages where post offices were lined up to be discontinued. Fuller (1972) discusses the account of a Post Office agent tasked with laying out delivery routes in Hardin County, Iowa in 1901. The settlements were deemed superfluous were described variously as “a store, an elevator, a post office and not much else” and “nothing except an elevator with a post office inside the elevator office” (Fuller (1972)). Note that post offices on the railroad, even those with stations and grain elevators, were not immune from closure if they represented very small communities. Protests over post office closures, which were often successful, tended to focus on the size of the communities the post offices represented. The people of Cleves, Iowa, successfully protested the planned closure of their post office by writing to the Post Office Department “giving the impression that Cleves was a thriving metropolis”, and including “a map designating all the houses in the neighborhood in order to show the exact size of the community” (Fuller, 1972).

These accounts suggest that the closures which accompanied RFD focused largely on eliminating the smallest and most underused post offices, and that the main results therefore reflect the effect of railroad building in the 1870s and 1880s on the size of towns at different distances from the railroad. Patterns in the data support this interpretation. The results presented in Fig. 4 indicate that the effect of railroad construction in a particular year on pre-existing post offices is larger than the effect on post offices established after that year. If rural free delivery removed a large number of post offices within 5 to 10 km of the railroad for logistical reasons unrelated to the level of economic activity, then we should expect to see an effect on all post offices founded before 1900, regardless of whether they were established before or after a particular stretch of railroad.

Furthermore, if the results were driven by purely logistical effects...
related to the distribution of mail by railroad in the 1900s, then the expected survival probability of two post offices that are the same distance from the railroad in the 1900s should be the same, regardless of how far each post office was from the railroad in the 1870s and 1880s. To test this, I estimate versions of the main specifications, equations 2 and 3, that also control for a quartic polynomial in distance, \(d_{1898} \), distance from the railroad in 1898, just before the roll out of RFD. The results, presented in Appendix Table A.18, indicate that a post office between 5 and 10 km from the railroad in 1872 is 11 percentage points less likely to survive than a control post office that is the same distance from the railroad in 1889. The magnitude of this effect is close to that recorded in the main OLS results in Table 3. As with the baseline results, the negative effect declines in magnitude for further distance bands. Similar patterns prevail for the other snapshot years.

Finally, note that if the main pattern of results were driven by the roll out of rural free delivery between 1900 and 1910, we would see no effect of proximity to the railways on survival until 1900. To test this, I define \( \text{exist}_{1890} \) as an indicator for whether a post office survived until at least 1900. I then run OLS and IV regression analogous to equation 2 replacing \( \text{exist}_{1900} \) with \( \text{exist}_{1890} \). The results of these regressions are reported in Table A.19. The IV results have large negative coefficients at 5–10 km, all of which are statistically significant at least the 10% level. The results indicate that railroad construction between 5 and 10 km of an existing post office significantly reduced the probability that post office survived to 1900, two years before rural free delivery was permanently implemented in 1902.

5.4.2. Speculative settlement

A second important caveat to this interpretation of the results is the idea advanced by Fishlow (1965) that patterns of settlement in the West, especially before the arrival of the railroads, were driven by expectations about future economic activity. In particular, Fishlow argues that settlers expected that the future arrival of the railroad would drive up land values. This speculative settlement would seem to complicate the interpretation of the results. If a post office represents a location without significant settlement or real economic activity, perhaps a store set up by a land speculator in the hopes of attracting other settlers, then the closure of that post office upon the arrival of the railroad likely represents the collapse of speculative beliefs.

Changes in expectations about the future growth were certainly important in determining the location of settlements, but this effect does not mean that the closure of post offices does not reflect relocation of real economic activity. Indeed, one could imagine a richer model of location choice along the lines of FKV in which settlers are forward looking, and choose location based on expected future returns. If settlers have symmetric information, then the same agglomeration forces are likely to apply (see for example Mossay (2013) and Baldwin (2001)). The construction of a railroad would then represent both a change in market potential at on-network locations and a resolution of uncertainty about future settlement which would give two reasons for economic activity to relocate away from towns bypassed by the railroad. The results in Fig. 4 indicate that the negative effect of railroads on post office survival are larger for post offices established before the railroad was constructed (before \( \text{exist}_{1875} \)). These towns were originally settled under uncertainty about where the railroad would be located, and the additional effect on these towns might be attributed to changes in expectations.26

More clearly estimating the separate effects of expectations and current market potential in determining the spatial distribution of towns would be a valuable exercise, but would likely require additional information, for example data on the dates that planned railway routes were announced. Whatever the relative importance of these effects, the historical and empirical evidence suggests that the closure of post offices was unlikely to have been driven by land speculators abandoning their projects. Recall that the post office closures that drive the main results occur mostly from 1900 to 1930, long after any uncertainty about the path of the railroad had been resolved, and that closures were imposed by the federal government on the smallest towns and villages.

5.5. County and minor civil division level results

The main results suggest that the arrival of the railroad changed the geographic distribution of towns, with settlements between 5 and 10 km from the railroad declining relative to towns on the railroad and those further from the railroad that remained isolated. If this interpretation of post office survival is correct, then changes in settlement patterns should be observable in movement of the underlying population. However, as discussed in Section 1, one of the benefits of using the post office data rather than census population data is that it is difficult to measure changes in the geographical distribution of population in this era with high spatial precision. The most complete population data for this era is at the county level. Measures of county level population and economic activity from historical censuses, digitized by Haines (2005), are widely used in studies of the effect of transportation on population and economic activity in the United States. For example, Atack et al. (2010), Atack (2011), and Donaldson and Horbeck (2015) all use this data. Chandra and Thompson (2000) use industry earnings data at the county level. Note however, that the average area of an 1880 county in the seven states being studied is 1902 km², the area of a 43 × 43 km square. In Missouri, the most densely populated state, the average 1880 county was 674 km², or the area of a 26 × 26 km square. County level data is therefore may not to have sufficient spatial precision to measure the “agglomeration shadow” within 10 km of the railroad.

To test whether county level census data can be used to measure the agglomeration shadow picked up by the main results, I regress county level urban population growth on county distance bands. I run two specifications using different distance measures. The first specification is analogous to equations 1 and 2, and uses dummies for whether the county centroid falls within each distance band. The second specification replaces these distance dummies with variables recording the share of each county’s area that falls in each distance band. The dependent variable for each county-year is the change in urban population (defined in the census as population in towns with more than 2500 inhabitants) from the previous census year. I use 1880 county boundaries and link counties across census years from 1970 to 1940 using Horbeck (2010) method as implemented by Perlman (2014). In particular, if 1880 county A is split into counties B and C in 1890, I reconstruct the 1890 population for county A by adding the populations of B and C.27 The regressions also include state fixed effects and lagged railroad distance.

OLS estimates of the distance band coefficients from these regressions for each of the four railroad snapshot years are plotted in Fig. 6. For all four years the county area specifications, displayed in the left panel, have positive coefficients on the 0–5 km distance bands and negative coefficients on the 5–10 km or 10–15 km distance band, with coefficients close to 0 for greater distances. Although not statistically significant, this pattern is suggestive of the agglomeration shadow observed in the post office results. Likewise, the coefficients of the centroid distance specification, presented in the right panel, display a u-

26 Another interpretation of these differences could be that those post offices established after the railroad is built are located in places where a town can be sustained for idiosyncratic reasons despite the presence of the railroad nearby, and that therefore the negative effect of the railroad on the survival of these towns should be expected to be small.

27 If the match is not perfect, that is if 1880 county A corresponds to part of 1890 county B and part of 1890 county C, then I weight the 1890 population of B and C by the share of those counties falling inside 1880 county A as in Horbeck (2010). I drop county-years for which the 1880 county cannot be reconstructed using only counties with weights above 0.8.
shape for each snapshot year. The pattern of results for the 1877 and 1881 railroads in particular are close to that of the main results - the magnitude of the estimated coefficient goes from positive to negative moving from 0 to 5 km to 5–10 km, and then rises as distance from the railroad increases. Again, the coefficients are not significantly different from 0. The results are suggestive, but hardly as striking as those in the main analysis. Assuming that the measured effect on post office survival reflects a real effect on the distribution of population, these results suggest that aggregating up to the county level “smooths out” the survival rate as a function of distance - post offices in the 5–10 km band are likely in the same county as those in the 0–5 km band.

To further test that the weak county population results are explained by low spatial precision, I aggregate the post office data up to the county level using 1880 county boundaries and regress the share of post offices in a county that survive to 2010 on railroad distance bands. OLS estimates of the distance band coefficients for each snapshot year are plotted in Appendix Figure A.10. For each snapshot year, none of the distance band coefficients are significant at the 5% level. Furthermore, the pattern of the coefficients’ signs and magnitudes found in the main results is not present in these county level results. These insignificant results are not an artifact of the particular bands used. Appendix Figure A.11 plots local polynomial regressions of county survival rate on centroid distance from the railroads for each snapshot year. These figures are the county-level analogues of the right panel of Fig. 3. Fig. 3 showed a significant “dip” in survival probability from 0.45 at 0 km to 0.1 between 5 and 10 km, and back up to 0.2 at 15 km. Appendix Figure A.11 shows no such pattern.

Since there is no significant difference in post office survival rates across counties at different distances from the railroad, these results suggest that the effects of railroad construction at short distances measured in the main results are identified by within-county variation in post office survival rates. To confirm this, I estimate the main specifications, equations 1 and 2, including fixed effects for modern day counties instead of state fixed effects. OLS results analogous to those in Table 3 are presented in Appendix Table A.20. The distance band coefficients in these regressions are identified by within county variation in railroad distance and survival. The estimated coefficients are very close, in terms of sign, magnitude, and statistical significance, to those in Table 3.

Although census data at the county level is likely too aggregated to detect the local agglomeration effects of the railroad, individual records from the US census contain location information at the level of minor civil divisions smaller than counties, for instance city wards and rural townships. Population data at the minor civil division level has been digitized and linked across time for the years 1880 and 2000 by Michaels et al. (2012). Since minor civil division boundaries have changed significantly over time, the authors match 1880 MCDs with 2000 MCDs by using historical maps to find the approximate population center of each 1880 MCD, mapping that point to the 2000 MCD in which it falls. The resulting data is at the level of 2000 MCDs (or groups of MCDs) and records population in 2000 and approximate population in 1880. Note that for three of the seven states studied in this paper, 1880 MCD data is missing. The other states, Missouri, Kansas, Nebraska and Utah, have a poor match rate between 1880 and 2000 and are omitted from Michaels et al. (2012) main analysis.

To test whether the agglomeration shadow suggested by the post office results can be observed using MCD level population data, I regress the change in population from 1880 to 2000 in each MCD on railroad distance bands defined using MCD centroids. I instrument distance from the railroad with distance from the minimum spanning tree as discussed in Section 4.2. The results of IV regressions using distance from the 1872 and 1877 railroad are presented in Fig. 7. The left panel presents estimates of the distance band coefficients using the full sample of MCDs. For both railroad years, long run population growth for MCDs in the 10–15 km and 15–25 km bands is lower than population growth for control MCDs further than 50 km from the railroad, indicating that intermediate proximity to the railroad lowers long run population growth. However, at 5–10 km, the distance at which the negative effect on post office survival is largest, the effect on MCD population growth is positive.

The deviation of the MCD results from results on post office closings should not be surprising, since population growth over 120 years includes additional changes to the distribution of population that obscure those captured by the closure of post offices. For example, the area occupied by an independent town which declined in the late 19th...
century could be swallowed up by the geographic expansion of a larger railroad town in the 20th century. Such an effect could generate a positive coefficient on the 5–10 km distance band of the MCD regressions, despite the fact that pre-existing towns in this band declined after the expansion of the railroad. To illustrate this, the right panel of Fig. 7 records the distance coefficients from a subsample of MCDs that are not in any Metropolitan Statistical Area in 2000. When restricted to these “rural” MCDs, the effect of railroad distance on long run population growth closely resembles the effect on post office survival. The population of MCDs 5–10 km from the railroad growing by approximately 1500 less than MCDs further than 50 km from the railroad and the coefficients decline in magnitude at greater distances. Away from larger cities, the change in the distribution of towns recorded in the post office data is mirrored by a long run shift in population away from areas bypassed by the railroad.

The rural MCD results corroborate the main findings but lack the statistical precision of the post office results. For example, in the rural MCD regression using the 1872 railroad, the coefficient on the 5–10 km distance band is not statistically different from zero. Although the results at the MCD level are clearer than those at the county level, “smoothing” of the survival rate as a function of distance is likely to still be a problem. In the most densely populated state, Missouri, the average area of matched civil divisions is 163 Km². This corresponds roughly to a 13 × 13 km square, which could cover more than one of the distance bands. Furthermore, there are 3,678 mapped post offices in Missouri and only 1095 MCDs, indicating that the post office data has significantly greater spatial precision than this detailed census data. The heterogeneity of the MCD results between rural and urban location highlights the relative contribution of the post office data, which can be used to detect detailed short run patterns in the establishment and decline of towns during an era of substantial population churn, for example heterogeneity in town survival by date established, that are obscured in census data.

6. Conclusion

This paper uses data on the locations and dates established and discontinued of US Post Offices to study the effect of railroad construction on the geographical distribution of settlement in the 19th Century American West. I argue that the location of US Post Offices during this period is a good measure of the location of settlements. By studying how the distribution of Post Offices changed with the arrival of railroads, I examine how this major transport infrastructure disrupted the existing spatial distribution of towns. In particular, I ask whether the construction of the railroads changed the distribution of settlements my redirecting population and economic activity towards the rail network from the surrounding areas.

I estimate the probability of survival and expected lifetime of a post office as a flexible function of the distance to the railroad. I find that being directly connected to the railroad increases the expected lifetime of a post office by between 7 and 12 years and the probability that that post office survives to 2010 by between 7 and 12 percentage points, but that railroad construction between 5 and 10 km of an existing post office decreases the probability that post office survives to 2010 by between 25 and 50 percentage points. For locations greater than 10 km from the railroad, the survival probability and expected lifetime increase with distance. I interpret this finding as evidence of the “agglomerative shadow” predicted by Fujita et al. (1999) model of equilibrium city location. The construction of the railroad increased the market access of directly connected locations, relocating population and economic activity towards the rail network from surrounding areas. Towns that were connected to the railroad and new towns established on railroad lines were likely to prosper at the expense of nearby towns that were bypassed. Towns that were bypassed were also more likely to decline than those that lay sufficiently far from the railroad to resist its agglomerative pull. These findings provide empirical support for accounts of “ambitious little town[s]” that declined after the railroad passed them by (Atkeson, 1918). The finding of an agglomeration shadow within 10 km of the railroad is robust to alternative specifications and identification challenges.

This is the first paper in the economics literature to use data on post office locations to measure the geographical distribution of settlement in the 19th century United States. This data has the advantage of spatial and temporal precision relative to census population data. I show that alternative methodologies based on county-level data are unable to detect the effects of railroad construction and might lead to incorrect or incomplete conclusions because of the short distances over which the forces of agglomeration act in this setting. More detailed census data at
the minor civil division level supports the interpretation of the results as documenting an agglomeration shadow, suggesting that long run population growth was lower in areas bypassed by the railroad, but lacks the precision of the post office results. Future literature might combine the post office data, which measure the geographical extent of settlement and economic activity, with data on the intensity of economic activity, for example data on postmaster salaries, post office class or mail volume.

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Supplementary material

Supplementary material associated with this article can be found, in the online version, at 10.1016/j.jue.2018.01.005.

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