PORTAGE AND PATH DEPENDENCE*

HOYT BLEAKLEY AND JEFFREY LIN

Many cities in North America formed at obstacles to water navigation, where continued transport required overland hauling or *portage*. Portage sites attracted commerce and supporting services, and places where the falls provided water power attracted manufacturing during early industrialization. We examine portage sites in the U.S. South, Mid-Atlantic, and Midwest, including those on the *fall line*, a geomorphological feature in the southeastern United States marking the final rapids on rivers before the ocean. Although their original advantages have long since become obsolete, we document the continuing importance of historical portage sites. We interpret these results as path dependence and contrast explanations based on sunk costs interacting with decreasing versus increasing returns to scale. *JEL* Codes: R12, N91, N92, O18, F12.

I. INTRODUCTION

Why is economic activity distributed unevenly across space? Is the distribution of population determined uniquely by natural endowments, or does path dependence have a role even in the long run? Separating these two effects can be challenging, in part because the features that first brought people to an area (such as topography, resources, climate, etc.) are usually persistent, thus confounding attempts to attribute the spatial distribution of activity to path dependence. Put another way, it is difficult to disentangle the effects of state dependence (the presence of factors of production) versus serial correlation (the advantages that first attracted other factors). In this study, we consider natural features that were valued historically—by a coincidence of transportation technology and trade patterns—but that were made obsolete some time ago, thus breaking the link between natural advantage and scale.

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Our approach to this question starts with *portage*—the carrying of a boat or its cargo, over land, between navigable waterways, or to avoid a navigational obstacle such as rapids or falls. (Portage also refers to the place where this act is performed.) During the settlement of North America, when the long-distance movement of goods was mostly waterborne, portages were a focal point for commerce. Traders were obliged to stop because of the natural obstacle to navigation; in turn, these sites offered easy opportunities for exchange and commerce. Although these opportunities were valued historically, they became obsolete long ago: thanks to changes in transportation technology, traders no longer walk canoes around rapids. Similarly, although some falls were sources of water power during early industrialization, these advantages also declined with the advent of other, cheaper power sources. Notably, despite the obsolescence of canoe transport and water wheels, concentrations of economic activity continue to exist and thrive at many of these sites. In this article, we examine this persistence of population centers near obsolete portage advantages.

A typical example occurs at the falls of the James River. During colonial times, an important cash crop in Virginia was tobacco. Tobacco plantations located downriver of the falls of the James had their own wharves and were visited directly by ocean-going ships. On the other hand, these ships could not navigate through the falls, and tobacco growers further inland sent their merchandise downriver on canoe-like bateaux. But these bateaux were slow and cumbersome, and their pilots sought to offload their goods as far upriver as the ocean-capable ships could meet them. This meant that the falls became a place of exchange. In time, this exchange grew into broader sorts of commerce, and commercial activity in turn gave rise to financial services. In the early and mid-nineteenth century, locks and canals bypassed the falls, and rail lines made the bateaux commerce obsolete, nullifying the area's original natural advantage. In spite of the disappearance of its original advantage, the falls of the James persists as a population center—it is the site of present-day Richmond.

We examine early portage sites like the falls of the James throughout the U.S. South, Mid-Atlantic, and Midwest. In the southeastern and Mid-Atlantic United States, we pay particular attention to river basins that intersect the *fall line*, a geomorphological feature dividing the Piedmont and the coastal plain. (The solid lines in Figures II and IV show the approximate location of the fall line.) The fall line usually describes the last set of falls or rapids experienced along a river before it empties into the Atlantic Ocean or the Gulf of Mexico. An advantage of examining fall-line portages is that other natural sources of variation are reduced; on land, the transition from coastal plain to Piedmont is quite gradual. This smoothness allows us to use comparison areas—places within the same river basins—that, except for an initial portage advantage, share features similar to these historical portage sites. This similarity also helps rule out the existence of features co-located with portage that might be valuable. (If flatness is important for road-building, for example, Richmond is essentially as flat as nearby areas along the James River.) In addition to the fall-line portages, we examine portage sites on routes used by French fur trappers in the eighteenth-century Midwest between the Great Lakes and the Mississippi River system.[1] We also consider portages on the three main tributaries of the lower Mississippi River. In Section III, we describe further the historical importance of portage, give quantitative evidence of its decline, and provide some narratives for selected sites. We discuss our sample and data on historical portages, population, and economic activity in Section IV and the Data appendix.

The footprint of portage is evident today, as we show in Section V with both maps and statistical tests. First, in the southeastern United States, an urban area of some size is found nearly every place a river crosses the fall line (as seen in Figures II and IV). Many of these sites are the current locations of substantial metropolitan areas: for example, Washington, Philadelphia, and Richmond, as well as smaller cities such as Augusta and Macon in Georgia and Petersburg and Fredericksburg in Virginia. Moreover, among these portage sites, an area is more densely populated today if it has a larger watershed upstream, which is associated with greater *historical* demand for commerce. Our results are not sensitive to a variety of different controls for spatial, climatic, or geological features (which might have value today), nor to how we measure the concentration of economic activity, at various levels of aggregation. Portage also predicts density today when controlling for water-power measures, suggesting the greater importance of commerce rather than mills. In Section VI, we show similar

1. Indeed, the use of *portage* to mean carrying a canoe around an obstacle entered North American English in colonial times from the experiences of French fur trappers. The word is not conventionally used to describe the fall-line sites in the South, but we do so here to emphasize the commonality of their first-nature advantages.

present-day agglomerations at portages between the Great Lakes and the Mississippi River (such as Chicago, Illinois, and South Bend, Indiana) and along the Mississippi, Ohio, and Missouri rivers (such as Louisville, Kentucky, and the Quad cities of Iowa and Illinois).

In Section VII, we show that portages did not shrink compared to either the average location or locations that were similarly dense historically. Rather, these sites reached their equilibrium (relative) density in the early tweentieth century, after the obsolescence of portage. Thus, historical population density is crucial to explaining present-day populations at portages. Nevertheless, in Section VIII.A, we do not find evidence that any single, specific historical capital stock (such as infrastructure, sectoral composition, or literacy) stands out as a central (statistical) explanation of persistence at portages.

Why, then, did portage cities persist after losing their initial natural advantage? Our findings contrast with the predictions of models featuring locally decreasing returns to scale, which imply that long-run density differences across space will be driven by natural advantages. If congestion costs are high or there are weak economies of density, such models predict that cities should diminish in size as households and other factors of production relocate over time to places where natural advantages did not become obsolete. Instead, we find no evidence that portages, having lost their natural advantages, are in decline.

Historically sunk investments are important to explaining persistence at portages, but the mechanism by which these sunk costs affect density today depends on the strength of local returns to scale, as we discuss in Section VIII.B. If economies of density are strong, there might be multiple equilibria in overall factor density at a given site. This creates a coordination problem: people prefer to co-locate to form a city but might be indifferent as to where that city is. Investments sunk historically, even an array of small ones that have now depreciated completely, might serve as a mechanism to coordinate contemporary investment.[2] In contrast, if returns to scale are decreasing everywhere, small and depreciated (sunk) investments would not affect the long-run distribution of population and capital. But historical investments *could* result

2. The logic of path dependence from small sunk investments solving a coordination problem under increasing returns is similar to David's (1985), example of the QWERTY keyboard, in that historically sunk investments, perhaps even ones that are very small but coordinated, lock us into a certain keyboard layout today.

in highly persistent changes in the distribution of economic activity if the sunk asset were both extremely durable and large enough to affect the marginal investment decision at the city level.

With this in mind, in Section VIII.C, we examine factor densities and prices in recent decades. The case of housing is illustrative. Perhaps there was historical overbuilding at portage sites that continues to benefit residents. We find little evidence for this hypothesis, however. First, only a small fraction of the current housing stock was built before portage became obsolete. (Indeed, with a growing population, nineteenth-century housing assets are almost certainly inframarginal investments.) Second, this fraction today is smaller at portages than it is in the rest of our sample. Finally, if portage cities have persisted only because of historical sunk costs in a particular durable or large asset, we find little evidence that housing is that asset: housing densities and prices at portages are not significantly different from those in comparably dense areas. We show similar results for other kinds of sunk assets, including proxies of transportation infrastructure and social ties. Although we cannot rule out that a particular omitted (and large) sunk asset explains the persistent density at portages, we do not find such evidence across an important set of assets. Instead, our results suggest that the persistence of portage cities can be explained by initial natural advantages that help solve a coordination problem about where to locate cities today, among many similar potential sites. In Section VIII.D, we also find suggestive evidence that portage sites with more literate populations and a more diverse sectoral base adapted better to the obsolescence of the portage advantage. Section IX concludes the study.

II. Related Literature

We follow a century-old literature on commerce near navigational obstacles. Semple (1903) and Phillips (1905) discuss settlements at the fall line, although neither offers a systematic exploration of spatial data or of alternative hypotheses. Furthermore, they analyze a period in which portage still may have been directly valuable; however, they do not analyze whether such sites were in decline. The interpretation of our results depends on the century that has passed since the obsolescence of portage and those studies. More recently, Cain (1985) and Cronon (1991) interpret the specific case of the Chicago portage as a “first nature” advantage that helped resolve the indeterminacy associated with the existence of multiple equilibria.

A wider empirical literature studies locational advantages: Chandler (1972), Kim (1999), Ellison and Glaeser (1999), Rappaport and Sachs (2003), Ellison, Glaeser, and Kerr (2010), and Holmes and Lee (2012) consider natural endowments. Our study suggests that economic activity can be spatially correlated with the location of *obsolete* endowments. Therefore, Rybczynski-like regression coefficients may conflate the effects of both agglomeration economies (with path dependence) and natural features on productivity. Our results therefore address aspects of the inference problem when the distribution of underlying natural features is unknown.[3]

In contrast, Ciccone and Hall (1996), Rosenthal and Strange (2008), and Combes et al. (2010) use historical and geological features as instrumental variables (IV) for contemporary density, with the aim of estimating the causal effect of density to productivity. We report some IV estimates, but our principal concern is the implication of the correlation between density and now-obsolete advantages for models that predict (or are inconsistent with) path dependence. Our work is also distinct from the IV literature in that the U.S. historical data allow us to examine how these places responded when their original advantage became obsolete.

Our findings relate to earlier studies of shocks to economic geography. Davis and Weinstein (2002) find that Japanese cities reverted quickly to prewar population trends, despite widespread destruction by Allied bombings during World War II. Their findings suggest little path dependence in the locations and sizes of cities.[4] One important difference between our study and this literature is that we examine the obsolescence of a natural advantage

3. Many more papers examine “second nature” factors—advantages not from natural endowments but from man-made features, whether railroads, manufacturing, or institutions—on productivity and density differences across locations (e.g., Rosen 1986; Redfearn 2008; Atack et al. 2010). We provide suggestive results related to this literature in Section VIII, although ultimately the precise identification of all secondary factors contributing to the persistence of portage cities lies outside the scope of this study.

4. Brakman, Garretsen and, Schramm (2004) and Miguel and Roland (2011) find similar evidence following wars in Germany and Vietnam. Beeson and Troesken (2006) find that eighteenth century U.S. cities reverted to trend following yellow fever and cholera epidemics. Their sample includes portage sites, although the epidemics took place a century before the obsolescence of portage-related advantages. Paskoff (2008) finds that property destruction during the U.S. Civil War predicts little difference in the postwar capital stock. In Bleakley and Lin

instead of the destruction of factors of production. Differences between these results and ours might be attributed to the greater heterogeneity in natural endowments in Japan versus the relative flatness of the U.S. Midwest and coastal South. Consistent with our results, Redding, Sturm, and Wolf (2011) find evidence of history dependence in airport hub location, an industry featuring sunk costs and increasing returns, following German division.

Theoretical work in economic geography has long included the presence of increasing returns to scale in local economic activity as well as heterogeneity in initial endowments. As in Krugman (1991), one implication of many models featuring increasing returns is the possibility of multiple equilibria,[5] with equilibrium selection potentially determined by history. Arthur (1994) surveys an older literature that grapples with this point.[6] One interpretation of our results is that portage's historical role in completing trade routes helped resolve some indeterminacy between locations that are otherwise similar in natural endowments today.

These predictions contrast with the standard, neoclassical model that features locally decreasing returns to scale. Such a model implies that the steady-state population distribution is uniquely determined by natural advantages. To the extent that there is persistence in such a model, it is only in the medium run, while the state variables (capital stocks, etc.) are still adjusting to their unique, long-run equilibrium. This logic points to an alternative interpretation of our results, namely, that population persists at portages today because of large sunk costs, incurred historically and not yet depreciated away. In Section VIII, we focus on some reduced-form implications of models with sunk costs and varying assumptions about local returns to scale.

(2010), we found no correlation between Paskoff's measure and persistence at portages.

5. Throughout the study, we use "multiple equilibria" to refer to the possibility of more than one equilibrium outcome in *overall factor density* at a particular site. Some readers might prefer the term "multiplicity of steady states." To be clear, even if there are a multiplicity of equilibria, we might expect a unique equilibrium when considering the density of a single factor, such as labor, because the capital stock might be sunk and immobile.

6. Rauch (1993) considers the problem of transitions between equilibria. There is also some parallel in the work integrating monopolistic competition into the Heckscher-Ohlin model of international trade in the 1980s (e.g., Helpman and Krugman 1985). Because of increasing returns, in both trade and geography the location of production might be indeterminate depending on the (initial) distribution of factor endowments.

III. Portage: History and Background

III.A. Historical Discussion

In this section, we discuss the rise and fall of portage and its effects on activity at portage sites. Throughout the study, we use the term *portage* somewhat metaphorically. Rather than just referring to the act of carrying a boat around an obstacle, we mean to conjure the broader set of activities that arose because of the obstacle to navigation. These activities included cartage and other sorts of transshipment, entrepôt trade, water power (if present), and whatever other service sectors that were required locally.

The historical advantage of portage sites derived from their role in completing trade routes. In an early article in the *Quarterly Journal of Economics*, Phillips (1905) notes that:

> In the interior [South] the principal group of trade centers ... were those located at the head of navigation, or "fall line," on the larger rivers. To these points the planters and farmers brought their output for shipment, and there they procured their varied supplies. ... It was a great convenience to the producer to be able to sell his crop and buy his goods in the same market. Thus the towns at the heads of navigation grew into marked importance as collecting points for produce and distributing points for supplies of all sorts.

Early observers saw that the fall line would be a focal point for commerce: "The truth of it is, these two places being the uppermost landing of the James and Appamattuck Rivers, are naturally intended for Marts where the traffick of the outer inhabitants must center" (William Evelyn Byrd 1733, quoted in Henry 1900). These sites became Richmond and Petersburg. Circa 1710, "Indians in canoes brought cargoes of animal skins, which the colonists in turn sent downstream to Savannah," to the site where the Savannah River crosses the fall line (Federal Writers' Project 1938). By 1800, this site—Augusta, Georgia—became a center of cotton trade, with pole boats (and later steamboats) carrying cotton exports to Savannah. Finally, Columbus, Georgia, at the falls of the Chattahoochee River, had water power, which was applied to processing cotton.

These advantages became obsolete some time ago. In the early to mid-1800s, these sites saw two large changes in transportation infrastructure: (i) canals and locks and (ii) railroads.

The initial railroad through Richmond paralleled the James River. This meant that Richmond could be effectively bypassed as a transshipment point.[7] At Augusta and Columbus, locks allowed steamboats to bypass the falls, although there was essentially no commercial river traffic just a few decades after the railroads arrived (circa 1855). At sites where water power was less abundant, the grading for the canals was used to construct mill races, decoupling the location of water power from the location of the falls. Decades later, water power was replaced with more cost-effective forms of power.

Apart from the fall line, portaging also occurred along Mississippi River tributaries and at the watershed boundary between the Mississippi and the Great Lakes. Chicago was the site of a relatively easy portage between Lake Michigan and the Mississippi River system. Native Americans and French voyageurs used this portage, and it became a transshipment hub by 1800. Chicago's advantage was made obsolete by the construction of canals, which obviated the need for transshipment, and railroads, which removed the need for a break-in-bulk specifically at the portage. Another example is at the Falls of the Ohio, where Louisville, Kentucky, grew because of the need to cart goods around the falls. The construction of locks eliminated this demand, but these cities had already become regional centers of commerce and transportation.

We examine these portages in the present study, although these are hardly the only examples of highly persistent settlements at obstacles to navigation. For example, within the Americas, the present-day cities of Sacramento (California), Montréal (Québec), Albany (New York), and Honda (Tolima, Colombia) formed at the heads of navigation of their respective rivers. Further, mill towns arose at water power sites across New England and the Piedmont of the South. Outside of the Americas, there are examples of cities that formed at convenient portages between water systems, such as Corinth (Greece) and a number of places in Russia with the prefix *Volok*, which derives from the verb "to haul." Apropos of place-names in Europe, the *-ford* suffix (or *-furt* in German or *-voorde* in Dutch) refers to a convenient place to ford a river, which would coordinate commerce to that site.

7. For example, before the railroad, coal mined in the interior came down by boat to Richmond and was off-loaded onto ships there for export. Later, coal was loaded onto trains and brought straight to collier ships at the seaport in Hampton Roads. In contrast, tobacco was still brought to Richmond, which had already established itself as a center of tobacco exchange and processing.

Though the systematic study of such sites might be possible, we restrict ourselves to the three sets of portages—the fall-line/river intersections, falls on the three main tributaries of the lower Mississippi, and portages favored by voyageurs between the Great Lakes and the Mississippi River system—for two main reasons. First, it was possible to identify a reasonably complete set of such portages in U.S. historical documents. Second, the flat terrain of surrounding areas (in the Midwest and coastal South) gives us plausible comparison areas nearby. The first reason precludes us from analyzing obstacles farther upstream of the fall line or on minor tributaries of the Mississippi, where such features are perhaps incompletely (and selectively) documented. The second reason precludes us from examining New England or the Pacific Coast, where river valleys tend to be deeper and where there is no broad coastal plain.

III.B. Quantitative Evidence on the Decline of Portage

Employment data from late nineteenth- and early twentieth-century censuses suggest that portaging activities were relatively important at fall-line portage sites, reached a peak sometime before 1880, and declined thereafter. We calculate employment in water transportation at and near fall-line portage sites, using census microdata from 1850 to 1930 (Ruggles et al. 2010).[8] Panel A of Figure I shows, by decade, the share of a river's total water-transportation employment located in fall-line counties, averaged across 51 rivers.[9] At the peak in 1880, the average fall-line county contained 13.1% of total water-transportation employment along an entire river (including at any seaports located near river mouths). By 1930, that figure had dropped to 2.6%; the relative size of portaging activities at fall-line counties fell dramatically in the late nineteenth century.

Alternatively, consider Panel B. Here we display water-transportation employment as a share of total employment[10]

8. Census microdata are unavailable before 1850 and in 1890.

9. The Raritan and Schuylkill rivers are excluded from this figure, since we are unable to distinguish portage-related employment from seaport-related employment.

10. A limitation of this exercise is that the industry classifications are not precise, since the census does not consistently report industries and occupations until well into the twentieth century. The "water transportation" classification is instead assigned by the IPUMS and captures only a small group of workers—this may account for the low employment shares observed in Panel B. This category includes stevedores, but it likely excludes related occupations like laborers and

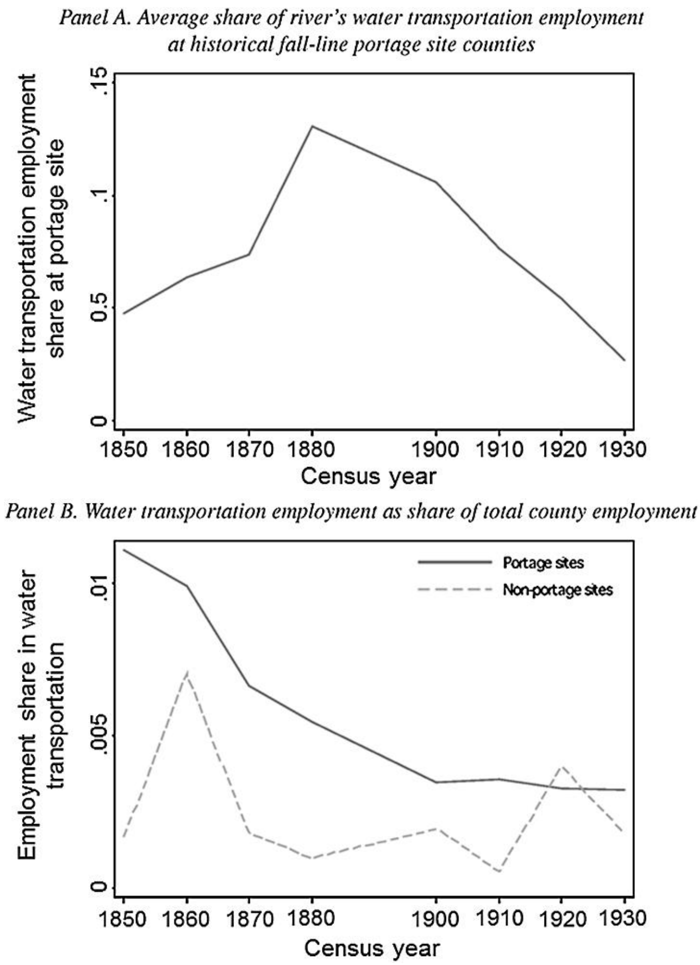


FIGURE I

Water-Transportation Employment across Fall-Line-Area Counties, 1850–1930

This figure displays employment in water transportation (e.g., stevedoring occupations) across 51 historical portage sites between 1850 and 1930. We aggregate microdata from eight IPUMS extracts based on county of residence and water transportation employment in the IPUMS-recoded variable *ind1950*=546. Two historical portage sites, on the Schuylkill and the Raritan rivers, are excluded due to their continued use as seaports. Panel A shows the average share of water-transportation employment at historical portage sites, out of total water-transportation employment along each river. Panel B shows the average share of water-transportation employment out of total employment, in both portage (solid) and nonportage (dashed) counties adjacent to rivers.

for two categories of counties: fall-line portage counties and all other river-adjacent counties. In 1850, the first year for which data are available, water-transportation employment is already low relative to total employment, accounting for 1.5% of total employment, on average, at fall-line portage sites. Portage was already shrinking in importance for local economies as early as 1850. In the same year, the average share of employment in water transportation in nonportage river counties was less: about 0.3%. The difference in water transportation employment shares then declined from 1.2% in 1850 to 0.3% in 1930. By the early twentieth century, both fall-line and non-fall-line counties had similar (and small) employment shares in water transportation.

Finally, note that, except for the Mississippi, fall-line rivers today are no longer used for significant commercial shipping. Indeed, many of these rivers were not used commercially as early as 1890 (Fogel 1964, Figure 3.4).

IV. Data

Our broadest study area includes all locations in river basins that intersect the fall line—a wide swath of the southern and central United States that includes locations near the headwaters of the Raritan, in New Jersey, as well as places along the Rio Grande, in Colorado, New Mexico, and Texas. (See Figure A.1 for the full extent of the fall line.[11]) This includes over two-thirds of the present-day counties in the United States with the excluded areas being mostly New England (the fall line, as a geomorphological feature, goes underwater near New York harbor), around the Great Lakes, most of Florida, and west of the Rockies. Thus, our sample contains both a large number of historical portages (defined as the intersections between the fall line and major rivers) and, to the extent that locations along the same river are similar to each other, a large number of suitable comparison areas.[12] The fall line itself is digitized from

warehousing. On the other hand, it includes nonportage occupations, like sailors and navigators. This imprecision could account for differences in the timing of occupational shifts between interior portages and seaports.

11. In Texas, this line is close to the Balcones Escarpment.

12. Note that our main results are not sensitive to narrower definitions of our sample. In particular, we verify that our results are similar if we restrict our comparison areas to only places that are adjacent to rivers, or places that are relatively close to the fall line. In addition, our main results are qualitatively similar if we limit our study area to the oldest and longest-settled areas east of

Physical Divisions of the United States, produced by the U.S. Geological Survey. We intersect this spatial layer with major rivers in the "Streams and Waterbodies" map layer, from NationalAtlas.gov, to identify points that were likely historical portage sites.

We use historical documents to identify portage sites in the Midwest and Upper South. Portage paths used by fur traders between the Great Lakes and the Mississippi River system are described by Semple (1903, plate following p. 23). For falls and rapids along the Mississippi, Ohio, and Missouri rivers, we process data collected from a number of early nineteenth-century river surveys performed by the U.S. Army Corps of Engineers, available as part of the Serial Set. More details on these portages and those along the fall line can be found in the Data appendix.

To measure the geographic distribution of economic activity, we use population density. Such data are available over a very long period of time: we use county population data at decennial frequency from the U.S. Censuses, 1790–2000, obtained from the Haines (2010) census compilations. County locations, boundaries, and areas for each census are then drawn from the National Historical Geographic Information System (NHGIS, Minnesota Population Center 2004) and spatially matched to our portage sites. One drawback of county-level population density is its relatively low spatial frequency. For subcounty areas that are the most densely populated, measurement at the county level will understate the true level of density experienced by households and other factors. For this reason, we also use census 2000 tract population to measure the contemporary distribution of activity at a very high spatial frequency. The tract data (also from NHGIS) afford greater power for contemporary, cross-sectional comparisons, although tracts (or minor civil divisions) have poor historical coverage of our sample area.

We also use nighttime light intensity, as measured from satellite photos in 2003. These data serve as a high-resolution measure of the distribution of contemporary economic activity (National Geophysical Data Center 2003). The satellite data are both extremely sensitive to variation in visible radiance and available at very high (and regular) spatial frequencies. In addition, they do not rely on the boundaries of census tracts, which are

the Appalachians, where and when initial conditions in transport technology and trade patterns are likely to have valued portage the most.

related mechanically to population density. Needless to say, these satellite data are also unavailable historically.

In addition to data on population and historical portage sites, we use data on other features that may vary over space. For example, we spatially match counties in each decade to data on climate, elevation, aquifers, and more from NationalAtlas.gov and the *Climate Atlas of the United States*. Also, we use spatial data on the locations of potential water-power sources (U.S. Department of the Interior 1885), eighteenth-century seaports (Phillips 1905), the navigability of rivers in 1890 (Fogel 1964), and 19th-century railroads (Atack et al. 2010). Further details on data sources and the GIS work can be found in the Data appendix.

V. The Fall Line

V.A. *Maps*

Today, contemporary agglomerations are found at many fall-line/river intersections that were likely to have had rapids or falls. Starting from the northeast, examples include New Brunswick (on the Raritan River), Trenton (Delaware), Philadelphia (Schuylkill), Washington/Alexandria (Potomac), Richmond (James), Augusta (Savannah), Columbia (Congaree), and Tuscaloosa (Black Warrior). West of the Mississippi River, the fall line passes through Little Rock, Fort Worth, Austin, and San Antonio.[13] This spatial correlation appears along at least two dimensions: both along the fall line, where present-day cities are likely to appear at rivers, and along rivers, where present-day cities are likely to appear at the fall line. We review this pattern here.

Figure II displays a detailed map of the fall line as it passes through Alabama, Georgia, and South Carolina. For reference, on the bottom of the figure, we provide a map with state boundaries, major rivers, and points labeling notable places. A few features are evident in the map. First, there tend to be population centers today at the points where rivers cross the fall line. Second, there tend not to be population centers along the fall line, if a river is not present. Take, for example, Augusta, Georgia, which is along the Savannah River, compared to similar but unpopulated locations to the northeast or southwest along the fall line.

13. In Texas, the Balcones Escarpment coincides with some well-known springs. Since the nature of initial advantage is somewhat different here, we have verified that our results are not sensitive to the exclusion of sites west of the Mississippi. See Figure A.1 for a map of this area.

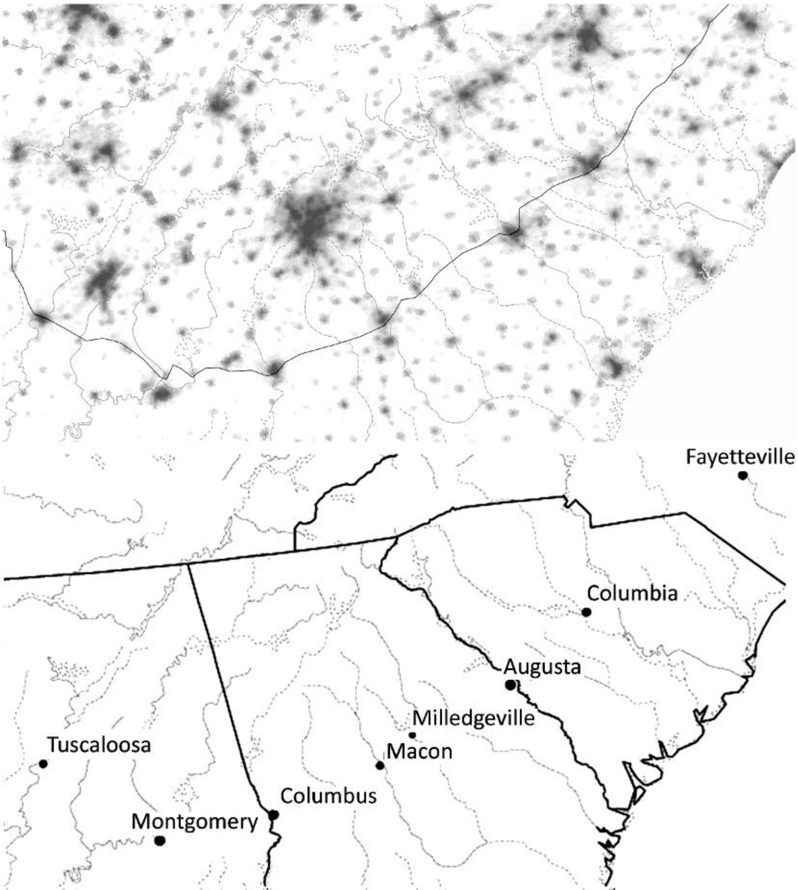


FIGURE II
Fall-Line Cities from Alabama to North Carolina

The map in the upper panel shows the contemporary distribution of economic activity across the southeastern United States, measured by the 2003 nighttime lights layer from NationalAtlas.gov. The nighttime lights are used to present a nearly continuous measure of present-day economic activity at a high spatial frequency. The fall line (solid) is digitized from *Physical Divisions of the United States*, produced by the U.S. Geological Survey. Major rivers (dashed gray) are from NationalAtlas.gov, based on data produced by the United States Geological Survey. Contemporary fall-line cities are labeled in the lower panel.

We can see the importance of fall-line/river intersections by looking *along the paths of rivers*. Along a given river, there is typically a populated place at the point where the river crosses the

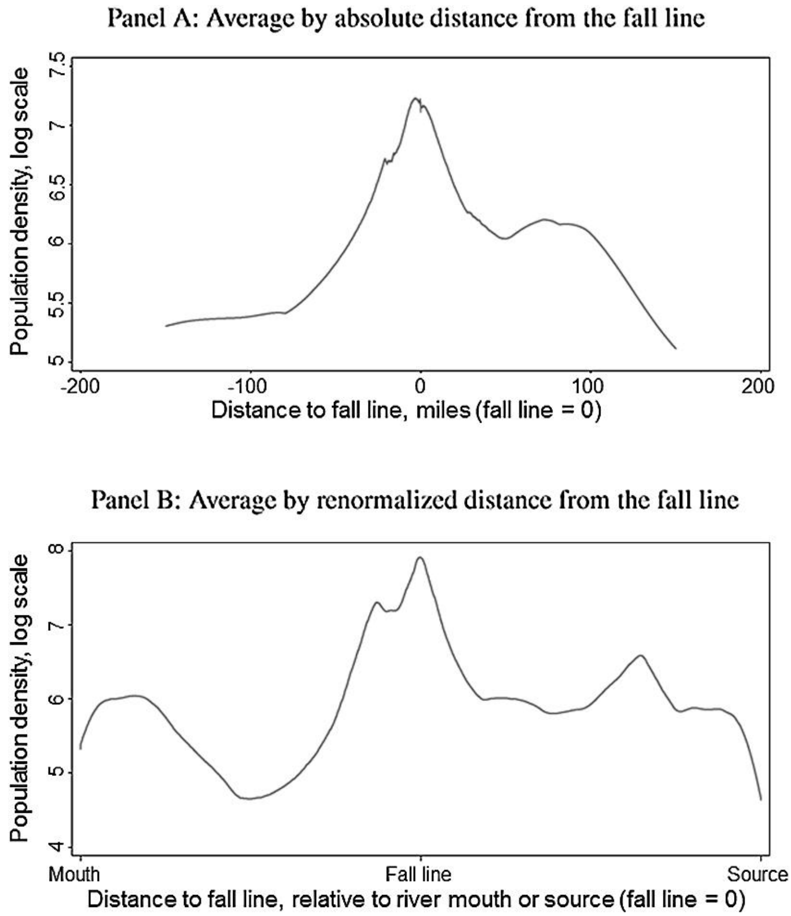


FIGURE III

Population Density in 2000 along Fall-Line Rivers

These graphs display contemporary population density along fall-line rivers. We select census 2000 tracts whose centroids lie within 50 miles along fall-line rivers; the horizontal axis measures distance to the fall line, where the fall line is normalized to zero, and the Atlantic Ocean lies to the left. In Panel A, these distances are calculated in miles. In Panel B, these distances are normalized for each river relative to the river mouth or the river source. The raw population data are then smoothed via Stata's lowess procedure, with bandwidths of 0.3 (Panel A) or 0.1 (Panel B).

fall line. This comparison is useful in the following sense: today, all of the sites along the river have the advantage of being along the river, but only at the fall line was there an initial portage advantage. Figure III shows average tract population density along rivers, for a given distance from the fall line. In Panel A, relative location is measured using absolute distance from the fall line. In Panel B, relative locations are normalized so that each river mouth, at the Atlantic Ocean, is measured at the left axis, and each river source is measured at the right axis. A peak in population density is seen near where rivers cross the fall line.

Another feature is that many of these portage sites have echoes at the coast. That is, many fall-line cities have a sister city downriver that serves as a seaport. For example, in Georgia, downriver from Augusta lies Savannah, and, in Virginia, Norfolk lies downriver from Richmond. This fact highlights that the persistence of population at these portage sites is not about participation in ocean-borne trade today. Indeed, almost none of these rivers were used for commercial navigation by 1890. Some fall-line cities attempted to revive steam travel on their respective rivers as late as the 1910s, but these efforts failed because steamboats were not competitive with rail.

The present-day distribution of population among fall-line portages is also consistent with our narrative. Recall that the presence of rapids along the river acted as a kind of coordination device that selected the location where trade between settlers in the interior and ships would take place. But rapids were not a sufficient condition: if there were no settlers upstream, there would be no commerce to coordinate. Because portage's initial value was in completing trade routes, the upstream watershed is a reasonable proxy for demand for commerce (historically) at the portage site.[14]

The case of Georgia is again illustrative. The Savannah River has a fairly large watershed upstream of the fall line, and this watershed supported a substantial population in the early days of the republic. This ensured that the falls of the Savannah would become an important trading center. Contrast that with the next river to the southwest, the Ogeechee. Upstream of the fall line, the watershed that feeds this river is comparatively small. Louisville, Georgia, the town at the falls of the Ogeechee, was a trading center and was briefly the capital of Georgia around 1800. But today, this town is about an order of magnitude smaller than its neighbor, Augusta. Moving southwest, the next major river

14. According to Phillips (1905), little if any trade occurred between river basins in the South—population was widely scattered, and overland transport costs were high. "No traffic of volume ··· might therefore be expected" (p. 440).

is the Oconee, and the city at the fall line is Milledgeville. The upstream watershed at that site has an area somewhere between the previous two rivers, and, accordingly, Milledgeville today is larger than Louisville (Georgia) but smaller than Augusta.

Farther west, intersections of the fall line and major rivers are also seen in contemporary population density. Still in Georgia, both Macon and Columbus lie at fall-line/river intersections. Montgomery, Alabama, lies just south of the fall line on the Alabama River. (The case of Montgomery is slightly more complicated because the Alabama River bends and bifurcates into two slower moving pieces just south of the fall line. This implies that the effective head of navigation was somewhat south of the rapids.) Tuscaloosa, Alabama, lies at the falls of the Black Warrior River.

The next major river that crosses the fall line is the Mississippi, but there is no population center at that point. Despite the Mississippi's vast watershed, this fact is not a challenge to our hypothesis in that the flow of water is so great that no rapids form at that intersection. Continuing west, there are minor settlements at the intersection of the fall line with minor rivers, and larger cities at intersections with larger rivers. Noteworthy are the cases of Little Rock (on the Arkansas River) and, in Texas, Fort Worth, Waco, Austin, and San Antonio. Curiously, settlements at fall-line/river intersections are absent in Oklahoma, which may be due to the peculiar manner and relatively late date at which that area was settled.

Further north, there are settlements at the intersection of the fall line and rivers, and, indeed, major cities at many of the sites with large upstream watersheds. Figure IV shows detail for the fall line from North Carolina to New Jersey. The case of Richmond was mentioned earlier; it lies at the falls of the James River, whose watershed extends into western Virginia and covers much of the tobacco-growing interior of that state. The first rapids on the Potomac River (not to be confused with the "Great Falls of the Potomac" somewhat farther upstream) lay at the present site of Alexandria, Virginia, and Georgetown, in the District of Columbia. The watershed of the Potomac upstream from that point is large and includes the Shenandoah Valley, which was an important breadbasket region historically. Other major cities at fall-line portage sites include Baltimore, Philadelphia, Wilmington, and Trenton. Furthermore, a few medium-sized cities are found where the fall line intersects

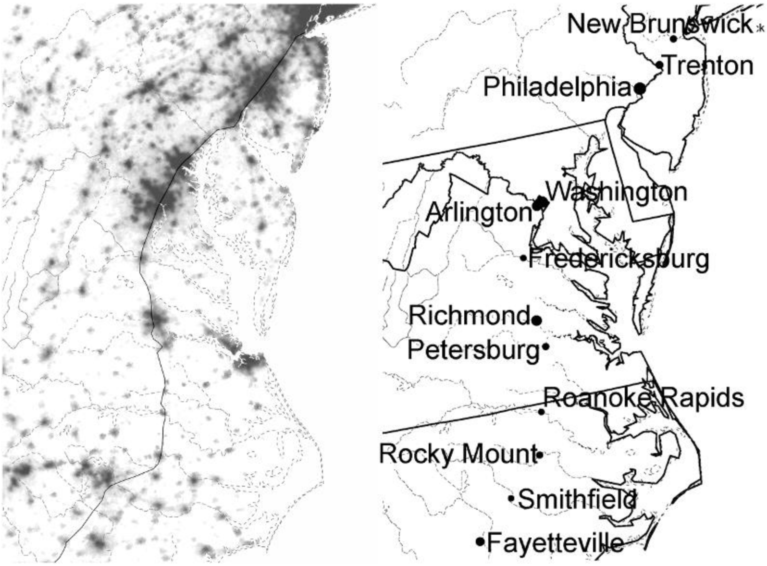


FIGURE IV

Fall-Line Cities from North Carolina to New Jersey

The map in the left panel shows the contemporary distribution of economic activity across the southeastern United States measured by the 2003 nighttime lights layer from NationalAtlas.gov. The nighttime lights are used to present a nearly continuous measure of present-day economic activity at a high spatial frequency. The fall line (solid) is digitized from *Physical Divisions of the United States*, produced by the U.S. Geological Survey. Major rivers (dashed gray) are from NationalAtlas.gov, based on data produced by the U.S. Geological Survey. Contemporary fall-line cities are labeled in the right panel.

rivers with smaller upstream watersheds such as Fredericksburg on the Rappahannock and Petersburg on the Appomattox, both in Virginia. Minor settlements are also found on fall-line portage sites in North Carolina, but the relationship across sites between watershed and population is less evident. These rivers empty into the Albemarle and Pamlico sounds, which were isolated in colonial times from ocean-going commerce by the treacherous navigation near and through the barrier islands. (Indeed, the area offshore was the “Graveyard of the Atlantic.”)

V.B. Statistical Comparisons

Statistical tests confirm the features shown in the maps. We focus on two measures of initial portage advantage: (i) proximity to historical portage sites, and (ii) watershed area upstream of the fall line. We consider three outcome variables: (a) population density in census 2000 tracts, (b) the average intensity of night-time lights in 2003, and (c) population density in census 2000 counties. All three of these variables are transformed into natural logarithms so that coefficients can be interpreted as percentage differences.

We first investigate whether proximity to a fall-line/river intersection predicts population density in recent data. Note that we treat any fall-line/river intersection as a historical portage site, whether or not we can verify that it was an early trading site. This strikes us as the correct choice in that it eliminates the endogeneity of these sites having become historical trading centers and further having survived long enough for their history to have been recorded for us to find it. For brevity, we refer throughout to such sites of potential historical portage simply as portages or portage sites.

We estimate the following equation:

$$\ln density_{gr} = \beta \cdot portage_g + \alpha_1 D_g^{FL} + \alpha_2 D_g^{R} + \mathbf{Z_g}\xi + \delta_r + \epsilon_{gr}, \tag{1}$$

where $density_{gr}$ is the population density of geographic area g (either a county, tract, or night-light observation) lying in river watershed r. The variable $portage_g$ indicates if the area is close to a portage site. The main measure of proximity used is a dummy equal to 1 if the centroid of the area is within 15 miles of the portage site.[15] The variables D_g^{FL} and D_g^{R} are binary variables equal to one if the area's centroid is within 15 miles of the fall river or river, respectively. (These are the first-order terms corresponding to the portage variable, which is an interaction of the fall line and the river.) The other measure is the natural logarithm of distance to the closest portage. Being closer to a historical portage site was valuable, so we expect the coefficient on the proximity dummy to be positive, but negative on the log-distance measure. The other variables in equation (1) are δ_r, a fixed effect across all areas in the watershed of each river r, and $\mathbf{Z_g}$, which includes a number of area-specific characteristics, such as a fourth-order polynomial in (miles) latitude and longitude. We

15. We have experimented with a variety of dummy variables for proximity. The alternative dummy variable that we examined is a condition based on adjacency: whether any part of the area is within four miles of the portage site. In the working-paper version (Bleakley and Lin 2010), we present similar estimates using the centroid, adjacency, either, or both conditions.

cluster the standard errors at the major-river level to account for spatial correlation[16] across counties within each watershed.

Proximity to portage predicts greater population density today, as shown in Table I. The basic specification, which again controls for river/watershed fixed effects and a fourth-order polynomial in latitude, longitude, and their various interactions is shown in column (1). Being 10% farther away from a portage site predicts 6% lower population density in the tract data and 2% lower density in the lights and county data. The dummy variable for proximity predicts 50% to 110% increases in density, depending on the outcome variable used.

These results are not sensitive to controlling for a variety of spatial variables, as seen in columns (2)–(6) of Table I. Results in column (2) include a full set of state fixed effects, which might be needed if there are differences in state-level policies affecting density. Column (3) presents results controlling for the log distance to the fall line, to the ocean, to the closest river, and to the closest circa-1890 seaport. Column (4) controls for climate variables: the average fraction of days with sunshine and the natural logs of heating degree days, cooling degree days, and precipitation. Columns (5) and (6) include controls for, respectively, the share of the area over a known aquifer and the mean elevation of the area. Coefficient estimates in these specifications are similar to the baseline.

Next, we find broadly similar estimates in a few different subsamples. In column (7), we restrict the sample to include only watersheds whose rivers flow into the Atlantic Ocean. In column (8), we restrict the sample to be only those areas whose

16. We explored several alternative strategies for managing the spatial serial correlation in the data. First, we constructed standard errors by clustering instead on state and on a series of 60-square-mile grid squares that we defined to completely cover the sampled areas, the latter approach following Bester, Conley, and Hansen (2011). We also estimated standard errors by bootstrapping on the river/watershed rather than clustering. Next, we used Conley's (1999) estimator, which allows for serial correlation within a given radius around each geocoded observation. The statistical inferences that we make using these alternative standard errors are broadly similar to those from the baseline results. In contrast, standard errors estimated using the Gauss-Markov or Huber-White assumptions are much smaller than our baseline estimates, which is to be expected if the data are spatially autocorrelated. Finally, we constructed a series of placebo portage sites by choosing places that are both on principal rivers but farther inland from the fall line. The estimates using these placebo sites were smaller than for portages and insignificantly different from zero. All of these results were presented in the working-paper version of this study (Bleakley and Lin 2010).

TABLE I

PROXIMITY TO HISTORICAL PORTAGE SITE AND CONTEMPORARY POPULATION DENSITY

	(1) Basic	(2) Other spatial controls	(3)	(4) Additional fixed factors	(5)	(6)	(7) Other samples	(8)
Specifications:		State fixed effects	Distance from various features	Climate variables	Aquifer Share	Mean elevation	Atlantic Rivers only	Within 100mi of the fall line
Explanatory variables:								
Panel A: Census Tracts, 2000, $N = 21452$								
Dummy for proximity	1.113	1.009	1.118	1.041	0.979	1.077	0.838	1.039
to portage site	(0.340)***	(0.321)***	(0.243)***	(0.316)***	(0.330)***	(0.316)***	(0.401)**	(0.319)***
Distance to portage	−0.617	−0.653	−0.721	−0.460	−0.562	−0.577	−0.572	−0.764
site, natural logs	(0.134)***	(0.128)***	(0.118)***	(0.121)***	(0.123)***	(0.118)***	(0.177)***	(0.142)***
Panel B: Nighttime Lights, 1996–97, $N = 65000$								
Dummy for proximity	0.504	0.445	0.490	0.500	0.506	0.522	0.495	0.391
to portage site	(0.144)***	(0.127)***	(0.161)***	(0.144)***	(0.147)***	(0.155)***	(0.151)***	(0.100)***
Distance to portage	−0.188	−0.159	−0.151	−0.186	−0.196	−0.138	−0.130	−0.212
site, natural logs	(0.065)***	(0.065)**	(0.090)	(0.061)***	(0.065)***	(0.059)**	(0.101)	(0.060)***

TABLE I

(CONTINUED)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Basic	Other spatial controls		Additional fixed factors			Other samples	
Specifications:		State fixed effects	Distance from various features	Climate variables	Aquifer Share	Mean elevation	Atlantic Rivers only	Within 100mi of the fall line
Panel C: Counties, 2000, $N = 3480$								
Dummy for proximity to portage site	0.912	0.850	0.770	0.939	0.912	0.884	1.074	0.915
	(0.236)***	(0.206)***	(0.253)***	(0.225)***	(0.236)***	(0.216)***	(0.288)***	(0.227)***
Distance to portage site, natural logs	−0.217	−0.215	−0.202	−0.195	−0.222	−0.192	−0.487	−0.201
	(0.081)***	(0.083)**	(0.090)**	(0.067)***	(0.082)***	(0.076)**	(0.194)**	(0.120)*

Notes. This table displays estimates of equation (1) in the text. Each cell presents estimates from a separate regression. The baseline sample consists of all areas that are within the watersheds of rivers that cross the fall line. The estimator used is OLS, with standard errors clustered on watershed. There are 53 watershed clusters, except for column (7), which uses 22. The outcome variables are, for Panel A, population density by census tracts from 2000; for Panel B, the intensity of nighttime lights; and, for Panel C, population data for counties from 2000. The basic specification includes dummies for proximity to the fall line and rivers, a fourth-order polynomial in latitude and longitude, set of fixed effects for watersheds of each river that crosses the fall line, and dummies for proximity to the fall line and to a river. Two measures of proximity to historical portage sites are employed. The first is a binary indicator for proximity to the river/fall-line intersection. The second is the natural log of distance from the nearest river/fall-line intersection to the centroid of the area. Column (3) controls for the natural log of distance to the fall line, to the ocean, to the closest river, and to the closest circa-1890 seaport. Column (4) controls for the average fraction of days with sunshine, natural log of heating degree days, cooling degree days, and precipitation. Column (5) includes a control for the fraction of that area that sits on top of an aquifer, and column (6) includes a control for the average elevation of the area. Results for columns (7–8) are estimated with specifications denoted in the column headings. Reporting of additional coefficients is suppressed. Data sources and additional variable and sample definitions are found in the text and the appendices. Coefficients that are statistically significant at the 90% level of confidence are marked with a*; at the 95% level, a**; and at the 99% level, a***.

centroids are within 100 miles of the fall line. Thus, this specification compares counties within the same watershed that are comparatively similar along many dimensions, except that some lie on a river and others do not. Estimates from these last two samples are quite similar to those from the basic specification.

Among fall-line/river intersections, the watershed upstream from the fall line predicts having higher population density today. This measure is based on the land area drained by the river of each portage site and is determined by aggregating hydrologic units, from NationalAtlas.gov, upstream of the fall line. As discussed earlier, a larger watershed upstream should have been correlated with greater demand (historically) for commerce at the portage site. In Table II, we estimate:

$$\begin{aligned} \ln density_{gr} &= \zeta \cdot portage_g + \gamma \cdot portage_g \cdot (\ln watershed_r - \mu) \\ &\quad + \tilde{\alpha}_1 D_g^{FL} + \tilde{\alpha}_2 D_g^{R} + \mathbf{Z_g}\nu + \delta_r + \varepsilon_{gr}, \end{aligned} \tag{2}$$

where $portage_g$ is the binary indicator for the portage site described above, $\ln watershed_r$ is the natural logarithm of the watershed area upstream of fall line drained by each river r, μ is the mean of $\ln watershed$ areas across portages, and the other variables are as in equation (1). As before, we cluster the standard errors on river/watershed to account for spatial correlation. The default specification again includes fixed effects for each river/watershed, fixed effects for proximity to a river and to the fall line, as well as a fourth-order polynomial in miles latitude and longitude. Column (1) displays these estimates. A 10% larger upstream watershed is associated with approximately a 4% higher density at the portage site. By construction, the coefficient of the portage dummy measures the density at a portage site with average watershed size. These coefficients are similar to those in Table II. If we instead evaluate the portage dummy for a watershed equal to the minimum in our sample (approximately 80 square miles), the coefficient would be 90% lower and insignificantly different from zero. This is consistent with our hypothesis in that there should be no benefit of being at the head of navigation when there is no upstream commerce to coordinate. Next, we find results similar to the baseline if we estimate these models with some additional spatial controls, such as state fixed effects (column (2)) or distances to the ocean, to the fall line, to the closest river, and to the closest early seaport (column (3)).

TABLE II

UPSTREAM WATERSHED AND CONTEMPORARY POPULATION DENSITY

	(1) Basic	(2) Other spatial controls	(3)	(4) Water power	(5)
Specifications:		State fixed effects	Distance from various features		
Explanatory variables:					
Panel A: Census Tracts, 2000, N = 21452					
Portage site times upstream watershed	0.467 (0.175)**	0.467 (0.164)***	0.500 (0.114)***	0.496 (0.173)***	0.452 (0.177)**
Binary indicator for portage site	1.096 (0.348)***	1.000 (0.326)***	1.111 (0.219)***	1.099 (0.350)***	1.056 (0.364)***
Portage site times horsepower/100k				−1.812 (1.235)	
Portage site times I(horsepower > 2000)					0.110 (0.311)
Panel B: Nighttime Lights, 1996–97, N = 65000					
Portage site times upstream watershed	0.418 (0.115)***	0.352 (0.102)***	0.456 (0.113)***	0.415 (0.116)***	0.393 (0.111)***
Binary indicator for portage site	0.463 (0.116)***	0.424 (0.111)***	0.421 (0.121)***	0.462 (0.116)***	0.368 (0.132)***
Portage site times horsepower/100k				0.098 (0.433)	
Portage site times I(horsepower > 2000)					0.318 (0.232)
Panel C: Counties, 2000, N = 3480					
Portage site times upstream watershed	0.443 (0.209)**	0.372 (0.185)**	0.423 (0.207)**	0.462 (0.215)**	0.328 (0.154)**
Binary indicator for portage site	0.890 (0.211)***	0.834 (0.194)***	0.742 (0.232)***	0.889 (0.211)***	0.587 (0.210)***
Portage site times horsepower/100k				−0.460 (0.771)	
Portage site times I(horsepower > 2000)					0.991 (0.442)**

Notes. This table displays estimates of equation (2) in the text. Each column/panel presents estimates from a separate regression. The baseline sample consists of all areas that are within the watersheds of rivers that cross the fall line. The estimator used is OLS, with standard errors clustered on the 53 watersheds. The outcome variables are, for Panel A, population density by census tracts from 2000; for Panel B, the intensity of nighttime lights; and, for Panel C, population data for counties from 2000. The basic specification includes a fourth-order polynomial in latitude and longitude, a set of fixed effects by the watershed of each river that crosses the fall line, dummies for proximity to the fall line and to a river, and the interaction of these latter dummies with ln watershed area. The first portage-related variable in this table is the interaction of the portage site with the (demeaned) log of land area in the watershed upstream of the fall line, a variable that proxies for historical demand for commerce at the portage site. The second portage-related variable is a binary indicator for proximity to the river/fall-line intersection. Column (3) controls for the natural log of distances to the fall line, to the ocean, to the closest river, and to the closest circa-1890 seaport. Columns (4) and (5) include controls for potential water-power at the fall line. Reporting of additional coefficients is suppressed. Data sources and additional variable and sample definitions are found in the text and the appendixes.

Next, we consider the specific mechanism of having the potential of water power at these sites, versus other portage-related effects. These results are seen in columns (4) and (5) of Table II. We use data from the census (1885) that reports engineering estimates of the total potential water power that could be extracted from a census of major water power sites across the United States.[17] The first specification includes the interaction of potential horsepower with portage site. (We renormalize water power into units of 100,000 horsepower, which is approximately the maximum in our sample.) As seen in the table, results for water power are mixed, and the coefficient on the watershed/portage interaction are essentially unchanged from column (1). The second specification, seen in column (5), interacts portage site with a binary indicator for having horsepower greater than 2,000 (approximately 1.5 MW). Results for water power are generally insignificantly different from zero, although at least in this case all of their coefficients are of the expected (positive) sign. Nevertheless, the estimates for the portage-site dummy are quite similar to the baseline in column (1). The main exception is for the county-level results, in which the portage and watershed/portage coefficients drop about 15% on inclusion of the water power dummy in column (5). Nevertheless, the vast majority of the portage effects seem to be working through something other than water power.[18]

VI. Portages in the Midwest

The correlation between historical portage and the current distribution of economic activity is not unique to the fall line: present-day agglomerations occur at many Midwestern portage sites as well. The most well-known Midwestern example is Chicago, as detailed in Cronon (1991). But various portage routes between the Great Lakes and the Mississippi River system were used, and many of those routes today have portage-descended

17. This census volume also contains information on the vertical drop and horizontal length of the falls. Using either of these other variables instead does not affect the results here. See also Online Appendix H, which shows that these results are not qualitatively affected by controlling for upstream coal extraction in the pre-portage-obsolescence period.

18. We obtain similar results using the other water power sites in the sample to get more precise estimates of the coefficients. Further, we do not find evidence of complementarity between these two factors. These results are found in Bleakley and Lin (2010).

cities. (The locations of such portages are shown in Online Appendix C.) These routes connected rivers flowing into the Great Lakes with small tributaries of the Mississippi or Ohio rivers. In the case of Chicago, the portage occurred relatively close to Lake Michigan. Along the continental divide that separates the Mississippi watershed from the Great Lakes watershed, contemporary cities located near early portage routes include (from the northwest) Portage (Wisconsin), Chicago, South Bend, Fort Wayne, Akron, and Erie.

There were also a number of obstacles to navigation along Mississippi River tributaries that required portage. We cataloged the nineteenth-century locations of falls, rapids, or heads of navigation along three major tributaries of the lower Mississippi River: the Ohio, the Missouri, and the upper Mississippi. Populated areas are seen near each set of (historical) falls. The number of examples is so small that it is convenient to discuss them individually. (Maps of population density with the falls denoted are found in Online Appendix D.) The Falls of the Ohio are located at the site of present-day Louisville, Kentucky. Next, falls and rapids along the upper Mississippi were located near Minneapolis (the Falls of Saint Anthony), at the Quad cities in Iowa and Illinois, and near the Iowa/Missouri border, in Keokuk, Iowa. Finally, two navigational heads of the Missouri River existed at Sioux City, Iowa, and Great Falls, Montana.[19]

VII. Responses Following Portage Obsolescence

In this section, we examine changes to the pattern of concentration near portages during 1790–2000. This period includes decades when portage had direct value and later decades when the direct portage advantage was going and then had become obsolete. We show that portage sites have *not* been in decline relative to comparison areas. Instead, there is evidence that activity has become increasingly concentrated at historical portages, a century or more after portage obsolescence. This finding is common to fall-line portages, portage routes between the Great Lakes

19. In addition, river confluences—the joining of two rivers—were another potential cause of transshipment because many of these confluences coincided with changes in river depths and the need for different kinds of craft on different river sections. Examples of cities at confluences are Kansas City, Paducah, Cincinnati, and several others. These are not part of our main argument, however, because there might be persistent advantages of confluences if the tributary is still used for shipping.

and the Mississippi River, and portages along major Mississippi tributaries.

To show this, we use county-year data on population density, normalized to consistent county boundaries.[20] Then, we estimate repeated fixed-effects regressions. Each regression uses county-year observations from a reference year, 1850, and another year, which varies from 1790 to 2000. The outcome variable is the natural logarithm of population density. The explanatory variables include a fixed county effect, an indicator variable for the observation year, and its interactions with a spatial trend, a river watershed indicator, and a portage proximity variable. In other words, we group (consistent) counties from 1850 and another decade and estimate

$$(3) \qquad \ln density_{grt} = \delta_g + \delta_{rt} + \delta_t + \zeta_t \cdot proximity_g + \mathbf{Z}_g \cdot \omega_t + \epsilon_{grt},$$

where δ_g, δ_{rt}, and δ_t are fixed effects for county, watershed-year, and year. (By including county fixed effects, we control for characteristics whose value is time-invariant.) We also allow for a time-varying spatial trend in $\mathbf{Z_g}$. The variable $proximity_g$ is a binary indicator for portage site, as before, and we allow for a time-varying effect on population density. Thus, for each decade τ we can obtain estimates of the effect of portage proximity *relative to 1850*—that is, $\hat{\zeta}_\tau - \hat{\zeta}_{1850}$. (To identify the model, we normalize ζ_{1850} to zero.)

Estimates by year are seen in Figure V, and the solid line displays the coefficient for fall-line/river intersections. The elasticity between population density and portage proximity is greater today than in 1850 or earlier, the period during which there was still direct value from portaging activities. We interpret this result as showing that economic activity has become increasingly

20. The results presented here use boundaries from 2000, but we have also verified that they are robust to using 1850 county boundaries. We constructed population density for consistently defined county boundaries using the NHGIS shapefiles (for county boundaries and areas) and ICPSR study #2869 (Haines 2010). For each decade, we used ArcGIS to create a raster file, using pixels that were approximately 1 km^2, that coded the population density within each (historically defined) county on the raster grid. (Because we did not have information on population densities at the subcounty level consistently across the decades, we are implicitly assuming that the population is uniformly distributed within the county.) We then took the electronic boundary files for a base year (either 1850 or 2000) and overlaid them on the raster file from each alternate year. We imputed the population density over the extent of the base-year county boundaries by summing the rastered population densities and dividing by the count of pixels.

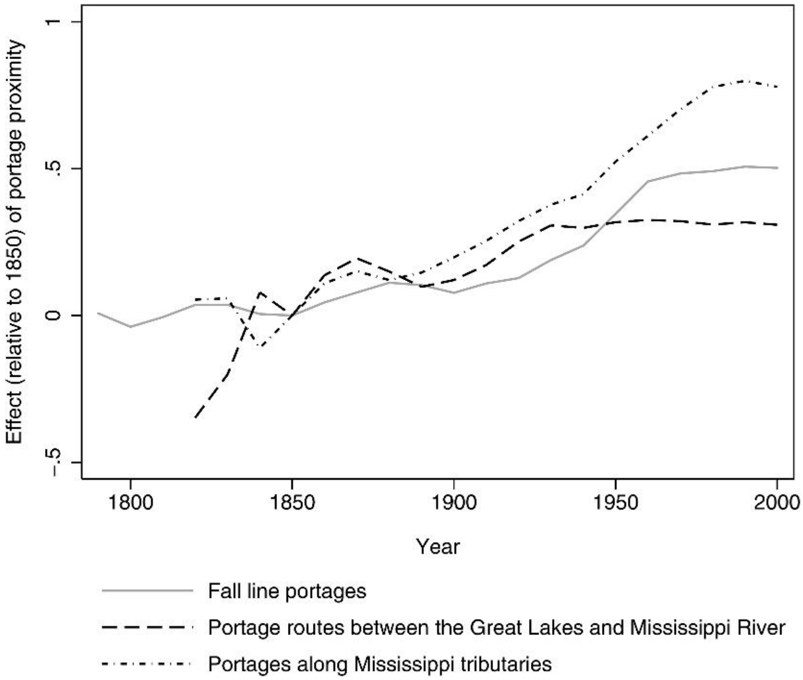


FIGURE V

Portage and Population Density, 1790–2000

This graph displays estimates of equation (3) from repeated fixed-effects regressions estimated separately by decade. Each regression uses county-year observations from the year indicated on the horizontal axis and 1850, the reference year. The outcome variable is the natural log of population density, normalized to year 2000 county boundaries. The explanatory variables include a fixed county effect, an indicator variable for observation year and its interactions with a spatial trend, and portage proximity. Each line shows, for a different sample, the estimated coefficients, by year, on the interaction between the year indicator and the portage proximity variable, which can be interpreted as the effect, relative to 1850, of portage proximity on population density. For fall line portages, the sample includes counties in fall-line river watersheds, and the county group variable is river watershed. For portage routes between the Great Lakes and Mississippi River, the sample includes counties along the watershed boundary between the Great Lakes and the Mississippi River. For portages along Mississippi tributaries, the sample includes counties along the Upper Mississippi, Ohio, and Missouri Rivers. The final two samples omit regressions before 1820, due to the lack of county data in these years.

concentrated at historical portages—rather than at comparable locations nearby. The dashed and dash-dot lines of Figure V show similar patterns for, respectively, portage routes between the Great Lakes and the Mississippi and portages on the Ohio, Missouri, and upper Mississippi rivers.

To test formally whether portages are in relative decline, we also pool the sample of fall-line counties across decades to perform a difference-in-differences estimation. The first difference is counties having portage advantage or not, measured by the portage proximity variable. The second difference is the nineteenth versus the late twentieth century, that is, during and after portage relevance. We exclude decades around 1900 because they likely include the decline of portage-related activities. We again estimate equation (3) but t takes on two values: $t = 1$ for county observations from 1790–1870 and $t = 2$ for county observations from 1950–2000 (i.e., during and after portage relevance). We correct the inference for spatial autocorrelation by clustering at the watershed level. Using county observations from 1790–1870 and 1950–2000, we estimate a difference of 0.456 (with a cluster-robust standard error of 0.092) between the late twentieth and nineteenth-century effect of portage proximity on log population density.

An alternative approach to test for the relative decline of portages would be to compare them with places that were similarly dense historically. Previously we used all nonportage locations as a comparison group (conditioned on various spatial controls). This assumes that all of these areas were on essentially the same trajectory for population growth, which might not be the case. The period that we study saw considerable urbanization as well as depopulation from some rural areas. Instead, we may want to compare portages to sites that were of similar densities historically. We present evidence on this point in Figure VI, which shows estimates from repeated regressions of year 2000 population density on portage proximity and lagged population density. This figure plots estimates of portage from equation (1), modified to include controls for population density[21] from a particular

21. Specifically, we control for a sixth-order polynomial in lagged density. The flexibility of this functional form accounts for possible nonlinearities in the expected growth rates as a function of initial density over time. The general shape of the curve in Figure VI is similar if we use a matching estimator with lagged density as a match variable (see Online Appendix E), or if we simply condition on linear lagged density rather than the polynomial, or indeed if we fixed the coefficient on the linear lagged density control to be unity (which is close to the estimated value for most of the sample). It bears mentioning that we do not have an instrument for historical density, and we do not claim to estimate the causal effect of lagged population. The motivating assumption is simply that, following portage

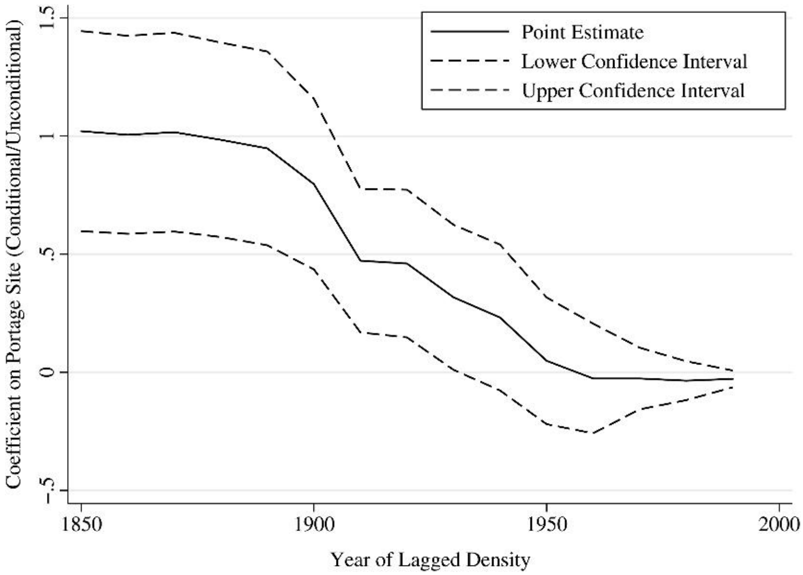


FIGURE VI

Portage and Population Density in 2000, Controlling for Historical Population Density

This graph displays coefficient estimates from equation (1) in the text, with the exception that controls for the historical population density in each county are also included. The historical decade from which the density controls are drawn is indicated by the horizontal axis of the graph. Dashed lines indicate 95% confidence intervals.

decade. The horizontal axis displays the decade in which the historical density is measured. The coefficients are normalized by the unconditional estimate, so a value of 1 indicates no difference from the baseline specification. Note that this estimator, because of inclusion of the lagged dependent variable, has the flavor of a partial-adjustment model.[22]

Using this approach, we find no evidence that portage sites are in decline relative to comparably populated areas. First, note that the portage coefficient is essentially unchanged when

obsolescence, the expected value of natural advantages drops *more* at portages than at areas with similar density historically.

22. We could alternatively specify this model as a decade-by-decade panel AR(1) model or use decadal growth rates as the dependent variable (as seen in Online Appendixes F and G, respectively). Neither of these changes to the specification affects the interpretation.

controlling for densities in 1850–1890. Despite the obsolescence of the original portage advantage, portage cities today are still *more dense* than comparable nearby cities with similar late nineteenth-century population densities. Second, note that the coefficient on portage declines continuously as we condition on more recent measures of density in the middle range of decades, and the estimate becomes statistically insignificant starting in 1930. Finally, the coefficient on portage aymptotes to zero as we condition on more recent decades of lagged density, which indicates that portage sites experience growth similar to comparably dense areas for the latter two-thirds of the twentieth century.

In the late nineteenth and early twentieth century, as portage's value declined, one might have expected portage sites to have become less attractive relative to other, similar locations. In fact, boosters in many portage cities of this era worried about new technologies that would displace older portaging activities. For example, in Louisville, Kentucky, local observers, worried about the profound impact on labor demand of the newly constructed Louisville and Portland Canal, said that the canal was "precisely one of those improvements for the private interests, at the expense of the public good, which is obnoxious to the good of the whole community" (Louisville Business Directory, 1844, quoted in Trescott 1958). A plausible hypothesis is that the obsolescence of portage should have encouraged people and factors to disperse from dense, congested portage locations, to either other locations nearby or to other cities with more advantages. In contrast, we see no evidence that portage cities became less concentrated as original portaging activities became obsolete.

VIII. Discussion

In this section, we examine potential explanations for the persistence of population at portages. We compare the historical densities of specific factors in portage and nonportage locations. These results suggest the importance of specific factors as a partial explanation. However, if we condition on present-day population density, we find few differences between portage and nonportage sites in the density of *contemporary* factors. We interpret these results using standard economic geography models that can feature path dependence in the location of cities. Finally, we show that some historical factors are important in explaining growth among portage sites.

VIII.A. Historical Factors

We first consider evidence on nineteenth-century factor densities in portage and nonportage sites. Because portage-related advantages have long since disappeared, higher population densities today seem not to be directly related to pulling canoes out of the water but are likely instead functions of these initial conditions having attracted economic activity in the past. We already saw that conditioning on population density as early as 1900 halved the portage coefficient, but here we investigate if specific capital stocks can explain (in a statistical sense) persistence at portages. We assemble historical county-level information on factors for selected years. Then, for each factor and decade, we estimate historical factor density as a function of proximity to portage. This specification is similar to equation (1), except that $density_{gr}$ is the local density of a particular nineteenth-century factor, instead of population density.

We show many of these estimates in Table III, Panel A. Each column is a separate regression that varies the observed factor as the dependent variable. For example, the first two columns use railroads in 1850 (from Atack et al. 2010) as the left-hand-side variable. This regression allows us to examine whether portage and nonportage sites differed in terms of early railroad development. In 1850, portage counties were on more extensive railroad networks (column (1)) and closer to railroad hubs (column (2)) than similar counties in the same river watershed.[23] However, in the case of railroads, these differences in early railroad development attenuate once we control for contemporaneous (i.e., 1850) population density, which we do for the estimates shown in Panel B.

A similar pattern can be seen in the next three columns, which use county-level measures of educated worker stocks in 1850. The density of literate white men in 1850 (that is, the natural logarithm of people per unit area) is higher in portage cities than in other locations, as one might expect given the greater population densities at these sites. However, these differences evaporate once we control for these population density differences in Panel B. If, instead, we examine per capita measures of lit-

23. The working-paper version of this study used a less precise measure of historical railroad locations, but the results for portage estimates were not greatly affected. See Online Appendix I for a comparison of results. That table also shows results for a dummy for railroad access.

TABLE III

PROXIMITY TO HISTORICAL PORTAGE SITE AND HISTORICAL FACTORS

	Baseline	(1) Railroad network length, 1850	(2) Distance to RR hub, 1850	(3) Literate white men, 1850	(4) Literacy rate white men, 1850	(5) College teachers per capita, 1850	(6) Manuf. / agric., 1880	(7) Non-agr. share, 1880	(8) Industrial diversity (1-digit), 1880	(9) Industrial diversity (3-digit), 1880	(10) Water power in use 1885, dummy
Explanatory variables:											
Panel A. Portage and historical factors											
Dummy for proximity		1.451	−0.656	0.557	0.013	0.240	0.065	0.073	0.143	0.927	0.164
to portage site		(0.304)***	(0.254)**	(0.222)**	(0.014)	(0.179)	(0.024)***	(0.025)***	(0.078)*	(0.339)***	(0.053)***
Panel B. Portage and historical factors, conditioned on historical density											
Dummy for proximity		1.023	−0.451	0.021	−0.003	0.213	0.022	0.019	0.033	−0.091	0.169
to portage site		(0.297)***	(0.270)	(0.035)	(0.014)	(0.162)	(0.019)	(0.019)	(0.074)	(0.262)	(0.054)***
Panel C. Portage and contemporary density, conditioned on historical factors											
Dummy for proximity	0.912	0.774	0.751	0.729	0.940	0.883	0.833	0.784	0.847	0.691	0.872
to portage site	(0.236)***	(0.236)***	(0.258)***	(0.187)***	(0.237)***	(0.229)***	(0.227)***	(0.222)***	(0.251)***	(0.221)***	(0.233)***
Historical factor		0.118	−0.098	0.439	0.666	1.349	1.989	2.390	0.838	0.310	0.331
		(0.024)***	(0.022)***	(0.069)***	(0.389)*	(0.164)***	(0.165)***	(0.315)***	(0.055)***	(0.015)***	(0.152)**

Notes. This table displays estimates of equation 1, with the below noted modifications. In Panels A and B, the outcome variables are historical factor densities, as noted in the column headings. The main explanatory variable is a dummy for proximity to a historical portage. Panel B also controls for historical population density. In Panel C, the outcome variable is 2000 population density, measured in natural logarithms, and the explanatory variables are portage proximity and the historical factor density noted in the column heading. Each panel/column presents estimates from a separate regression. The sample consists of all U.S. counties, in each historical year, that are within the watersheds of rivers that cross the fall line. The estimator used is OLS, with standard errors clustered on the 53 watersheds. The basic specification includes a polynomial in latitude and longitude, a set of fixed effects by the watershed of each river that crosses the fall line, and dummies for proximity to the fall line and to a river. Reporting of additional coefficients is suppressed. Data sources and additional variable and sample definitions are found in the text and appendixes.

eracy and college teachers (columns (4)–(5)), we find no significant difference between portage and nonportage sites in 1850 either.

We consider a third set of measures based on sectoral employment from historical U.S. censuses. There is evidence of some historical differences in sector composition, but this attenuates when controlling for population density. For example, in 1880, portages had smaller agricultural employment shares compared to nonportage sites, as seen in column (7).[24] One intriguing hypothesis is that the persistence of portage cities was not because of any a specific activity but rather the diversity of activities. We examine this hypothesis by constructing measures of industrial diversity in 1880 using historical sectoral employment from the census. For each of these decades we calculate a Herfindahl-Hirschman index of employment concentration for each county, at both one-digit and three-digit industry levels. Then we take the inverse of this index so that larger values indicate greater diversity of employment. As expected given their larger populations, portage sites have greater levels of historical diversity (columns (8)–(9)), but these differences are insignificant when controlling for historical population density.

Finally, we consider measures, from 1885, of water power that had already been harnessed at that time. (We think of this as a reproducible factor rather than a natural endowment insofar as there were many sites with the potential for water power, but only some where water power was developed and installed.) Portage cities were more likely than comparison sites to use water power in 1885 (column (10)). When we condition on 1890 population density, these differences persist (Panel B). In contrast to the earlier factors that we examine in this table, the strength of the results conditioned on contemporary population density is perhaps to be expected: In many of our sample watersheds, only at the intersection between the fall line and the river was there immediate access to *both* rivers and falls. Thus, portage cities were more likely to install water power because they were more likely to have access to potential water power.

Another way we try to separate the direct versus indirect effects of portage is to see how, in a regression of present-day population density on portage (as in Section VII), the coefficient on

24. We obtain similar results, albeit attenuated, using 1850 sectoral data. Online Appendix J repeats specifications from Table III, Panel C for a broader set of historical shares for both 1880 and 1850.

portage changes as we control for the presence of historical factors. (For these regressions, we recalculate the location of factors based on 2000 county boundaries.) These results are seen in Table III, Panel C. We replicate the specification used earlier, displaying the coefficients on portage and on the historical factor noted in the column heading as an additional regressor. The baseline portage coefficient estimate, without additional regressors, is redisplayed in the column labeled Baseline.

For example, controlling for the density of literate white men in 1850 (Panel C, column (3)) reduces the portage coefficient by 10–25%. One interpretation of these regressions is that historical factor densities are able to at least partially explain present-day differences in population density, in a way that weakens the partial correlation between portage and present-day population density. As a thought experiment, suppose we were able to identify a historical factor whose location in the nineteenth century (nearly) perfectly explains present-day population density. A regression of present-day population density on this factor and portage would project onto the historical factor and leave the portage coefficient insignificant. While nothing so extreme is the case for any of our historical factors, there are modest declines in the magnitude of the portage coefficient when controlling for railroads, literacy, or nonagricultural sector.

VIII.B. Interpreting Persistence as Path Dependence

We interpret our evidence in the context of recent theoretical models in economic geography that can feature path dependence. As a starting point, consider an economy with many locations and with variation in fixed amenities across these locations. There are also congestion costs that prevent locations from becoming too crowded. In such an environment, with mobile households and firms, what determines the location of economic activity and hence density across places?

We first discuss a case that features a unique long-run equilibrium (case A) versus a case that possibly has multiple long-run equilibria (case B). Then we describe the influence of historical sunk assets on the equilibrium density at various time horizons. Finally, we consider a few observable implications of each case.

Long-Run Equilibria. One convenient way to describe long-run equilibrium in many economic geography models is shown in

Figure VII, Panel A. This graph, showing indirect value V for a marginal mobile agent[25] as a function of the density, X, of factors in a particular location, is similar to the equilibrium analysis in the economic geography model by Helpman (1998). For discussion, it is useful to call V indirect household utility. Thus, there is some level of utility V^* that a household can receive in some other location in the economy, and the long-run equilibrium density of a particular location can be seen where the indirect utility curve $V(X)$ intersects the line V^*.[26]

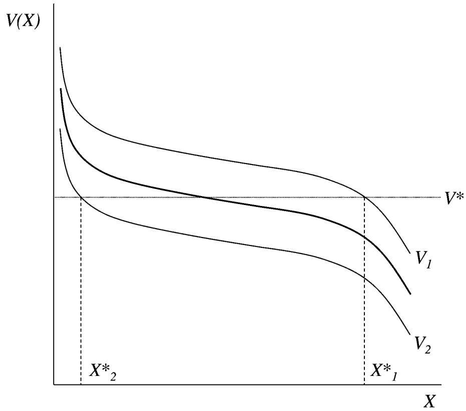
Compare two locations that are distinguished only by the presence of some fixed natural feature (such as portage) in location 1. Thus location 2 (situated nearby along the same river) is essentially the same as location 1 except for the portage-related advantage. With congestion costs, households are worse off as locations become more crowded; this is seen in the downward-sloping utility curves V_1 and V_2. The vertical difference between these two locations is the value of portage, and this difference implies a long-run equilibrium in which factor density is higher in location 1 than in location 2. In this framework, an interpretation of early (pre-1800) differences in density across portage and nonportage locations is that households and other factors exploited the initial value of portage and tolerated the congestion associated with the higher density. However, if the specific natural advantage at location 1 becomes obsolete, the two locations will have the same V curve in the long run and, therefore, converge to the same population density. Put another way, obsolete natural advantages will not affect the long-run equilibrium for factor density in this case.

In an alternate scenario, there are strong local economies of scale, so that increasing returns dominate congestion costs over some range of density. If so, indirect utility may increase with density. As illustrated in Panel B of Figure VII, strong aggregate increasing returns generate a hump shape in the indirect utility

25. Think of the agent as bringing not just his labor but also his optimal stock of capital that he will work with at the location. In this exercise, we are contemplating the equilibrium for the total factor density rather than the equilibrium density of population holding the capital stock fixed.

26. To see this, consider the case if location 1 is slightly less dense than the point X_1^*. Then, utility in location 1 is higher than in other locations; the marginal mobile household would choose to relocate to location 1, increasing its density until equilibrium utility is the same across locations.

Panel A: Differences in density with natural advantages and strong congestion costs



Panel B: Differences in density with strong increasing returns

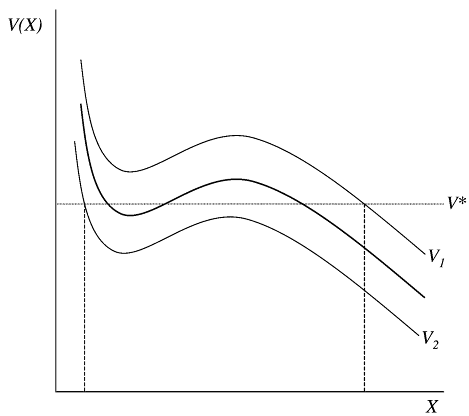


FIGURE VII

Equilibrium Density in a Model with Natural Advantages and Increasing Returns

These graphs show indirect utility V as a function of factor density X in a particular location g. The horizontal (dotted) line shows the equilibrium utility level V^* achieved in other locations in the economy. Equilibrium at location g obtains when indirect utility equals V^*, i.e., when the V_g curve intersects the dotted line. Panels A and B correspond to cases A and B discussed in the text, respectively.

curves.[27] As drawn, the range over which $V(X)$ increases is the range where increasing returns overpower congestion costs. As before, early differences in portage advantages can explain density differences. But, in this case, as portage-related advantages become obsolete, differences in density can be persistent. Historical portage advantages can act as a coordination device that selects the high-density equilibrium in the later period.[28]

In the discussion that follows, we refer to the previous two cases as case A and case B, corresponding to Panels A and B of Figure VII, respectively.

Portage Obsolesence and the Role of Sunk Costs. Where do households and firms decide to locate in subsequent periods, as portage's value fades? Take the existing distribution of economic activity as determined by history. Some of these previous location decisions involved durable or sunk investments—factors such as housing, railroad tracks, or land surveying and platting. Moving may be less costly for other factors, such as households or machines. Furthermore, new investments might be made even after obsolescence if their marginal product is higher because of the continuing presence of the sunk factors.

First consider case A, in which the long-run equilibrium is uniquely determined by natural advantages. Sunk investments in a particular location would not affect the long-run equilibrium, as long as the legacy assets eventually depreciate. Along the transition path to the new long-run equilibrium, however, the

27. This feature is general to many models featuring agglomeration economies. Imagine instead that the degree of increasing returns is greater than the degree of congestion costs for all density levels. The resulting equilibrium is that a single location receives all households, and all economic activity concentrates in a single, black-hole location—a result for which it is easy to provide a counterfactual. Alternatively, the relevant ranges over which increasing returns outpace congestion costs could be different, as might be the case if agglomeration economies came from multiple different sources. The visual implication of such a parameterization might be multiple large and small "bumps" in the utility curves, followed by a flat or declining curve. This case would imply possibly many more equilibria. There exists a knife-edge case, too, in which indirect utility is flat over some range(s) of X. This could imply a continuum of equilibria, but note that economies of scale are (just) large enough to compensate for congestion costs.

28. It bears mentioning that our results do not constitute direct evidence of multiple equilibria, in that we cannot observe a site to be simultaneously in both equilibria for density. In any case, we believe that the *historical* equilibrium density at a portage and its watershed is likely to be unique. This would have been determined by the agricultural productivity of the region, the watershed extent, and the location of the falls along the river.

sticky factors (and whatever later investments they induced) will tend to be over-supplied (i.e., the marginal product is less than the national price). This slows the eventual convergence in density between portages and sites with similar natural advantages. In Figure VII, Panel A, the decline in portage's value might appear as a narrowing of the vertical gap between V_1 and V_2, first because of the obsolescence of portage-related advantages and later because of the depreciation of sunk capital. Note that depreciation here should be broadly construed as not just physical dilapidation of the assets but also because the optimal stock of capital might be rising. The past two centuries have seen population growth in the region. Even if the sunk assets are still around today, it is quite likely that they are inframarginal.

In contrast, sunk costs can solve the coordination problem for the location of factors in case B. After losing the natural advantage, it might still make sense in this case to subsequently locate factors in locations where there are already concentrations of economic activity—for example, with fixed costs to constructing new houses or new railroad tracks, new factors will be attracted to existing population centers or existing railroad hubs. Indeed, investments sunk historically, even an array of small ones that have now depreciated completely, might serve as a mechanism to coordinate contemporary investment. This mechanism is similar in spirit to ones discussed by David (1985) and Redding, Sturm, and Wolf (2011). Consider the obsolesence of portage in Figure VII, Panel B: the vertical distance between V_1 and V_2 shrinks, which might allow for multiple equilibria in density at a site. If the legacy of sunk capital leaves the site at a point to the right of the unstable equilibrium in Panel B, then the site would naturally tend toward the equilibrium with higher density. Differences in density may therefore persist for a long time even as the original advantages from portage or durable sunk factors decline.

Finally, it is useful to consider constant returns to scale with no congestion costs, a special instance of case B. Recall that there is a possibility of multiple equilibria in the constant returns case. Any equilibrium is only saddlepath stable: factor ratios are determined by relative prices, but the overall scale is not. Geometrically, we can think of the set of equilibria as lying along a ray from the origin, where the direction of the ray is determined by optimal factor ratios. In this special case, sunk capital, before it depreciates away, places a lower bound on the scale of the city. In factor space, the sunk capital simply chops off the part of that ray that is below the level of the sunk capital stock. All sites with the same level of activity and/or population would have the same factor ratios. Therefore, even if one site has a stronger legacy of sunk investments, its factor ratios today could be the same as those of similarly populated sites. This would not happen in case A because the higher factor density depresses the average return to reproducible factors, which would motivate disinvestment in at least some of the factors.

Reduced-Form Implications. Finally, we discuss some of the implications of the model under cases A and B as a guide for interpreting our results. In both cases, we expect population density to persist at the portage site, although at different time horizons. In case A, population can persist at a portage because of durable sunk assets only over the medium run but not in the long run. In contrast, in case B, density could persist indefinitely at that site, provided that the historical sunk investments acted as a coordination device in selecting the high-density equilibrium. The question that remains is whether portages today reflect the medium-run of case A or the equilibrium selection of case B.

These two cases have different implications about population growth following obsolescence. Portage sites should be in decline if the case-A assumptions are correct. In case B, however, there is no need for portages to be systematically growing or shrinking relative to other sites. But note that in Section VII we found no long-run tendency for portage and nonportage locations, similar in other natural advantages, to converge in population density. This finding was not changed if we compared portages to places that had similar historical populations, which would control for shocks that were common to urban-specific capital over the intervening century.[29]

A final difference between these two cases concerns factor ratios and prices. In case A, cities can persist in the medium run because of the legacy of higher investment before the city lost its natural advantage. This legacy starts with specific, durable assets that were sunk before the obsolescence of portage but could also include investments subsequent to obsolescence. The key

29. Shocks to production technology or preferences favoring urban density that outpace the depreciation of sunk assets could delay convergence in case A. Nonportage sites that were dense would have had similar high-density capital stocks historically, but did not lose as much natural advantage as portages. Thus the similarity of growth rates over the past century at portages and historically dense nonportages suggests that this mechanism was not quantitatively important.

implication is that if portages remained dense in the medium run because of this legacy capital stock, then portage cities should have abnormally high levels of this type of capital. In contrast, a portage would not need a historical oversupply of capital to persist in case B, if the legacy of investments at the site had shifted the site into a higher-density equilibrium. Once in the denser equilibrium, returns to factors would be high enough to maintain density at the site without the reliance on portage-era sunk assets.

Additionally, in the medium run of case A, the oversupplied factors will also tend to be underpriced in the sites that lost their natural advantages,[30] whereas all factors will have homogeneous prices across similarly dense sites in the long run of either case. We investigate these implications next.

VIII.C. Present-Day Factors and Prices

We now consider whether agglomerations at portage sites exhibit significant observable differences from other nonportage agglomerations. This is meant as another test of the idea that historically sunk capital currently sustains density at portages as a medium-run outcome in case A. Our null hypothesis is that portage cities are statistically indistinguishable *today* from comparably sized nonportage cities. Nevertheless, because homotheticity is a restrictive assumption, we would not wish to compare portage and nonportage sites without conditioning on scale. Instead, we prefer to compare a portage to a site of similar density that is already in its long-run equilibrium (and thus determined only by natural advantages). We could see if a portage site looks unusual relative to this benchmark, for example by having an unusually high density of transport infrastructure relative to its population density. Although we cannot be sure that populations at nonportage sites are determined only by natural advantages, it seems likely that natural advantage plays a stronger continuing role in sustaining populations there than at historical portages. In other words, we know that direct portage advantages became obsolete, whereas it seems unlikely that other natural advantages at nearby sites also simultaneously lost their value.

We perform regressions similar to those in Table III: for each factor and decade, we estimate current (either 1990 or 2000) factor

30. The implication that the price of the oversupplied asset will be lower follows if the local aggregate production function is decreasing returns to scale and with quasiconcave isoquants. If factor ratios did not change, however, the average factor payment would nevertheless decline with scale in case A. See Online Appendix M.

density as a function of proximity to portage. These results are shown in Table IV. To parallel with the treatment of population density throughout, factor densities here are measured as the natural logarithm of quantities normalized by area.[31] In Panel A, each column is a separate regression that varies the observed factor. Again, we continue to include a spatial trend and a fixed effect for the watershed of each river. In Panel B, we display results for a regression in which we also control for present-day population density. Needless to say, current population density is endogenous and influenced by durable factors. We emphasize that we are not estimating a causal effect of density here, but rather comparing sites using a reduced-form relationship between factors and population.

In columns (1)–(3), we use measures related to housing in 1990. According to our estimates, portage sites have higher density of housing units (Panel A, column (1)) and somewhat more expensive housing (Panel A, columns (2) and (3)). Note, however, that the coefficients on house price and rent are of similar magnitude, which implies that the price-to-rental ratio is similar at portages versus elsewhere. This suggests that portages have an expected growth rate of housing prices that is similar to the rest of the sample. In any event, these estimated differences are almost entirely accounted for by differences in population density. When we control for population density (Panel B), we find little significant difference in the housing stocks of portage and nonportage cities. Note that given the depreciation of housing over time, we actually find it an unlikely reason to explain the persistence of portage cities. In fact, in our fall-line sample in 1990, fewer than 15% of houses in portage counties were more than 50 years old, compared to 20% of houses in other counties in our sample area. In any event, the United States grew rapidly in population after portage obsolescence, suggesting that century-old housing is an inframarginal investment today.

We find a similar pattern for transportation infrastructure (columns (4)–(6)). In 2000, portage sites have higher infrastructure density than comparison sites, as measured by (length of)

31. Some readers might prefer to measure these quantities as per capita rather than per area. These results can be found in Online Appendix K. The conclusions below about portage conditional on population are similar whether factors are measured in per-capita or per-area terms. Without conditioning on population, we find little evidence that per-capita measures shift in a way that favors higher density at portages.

TABLE IV

PROXIMITY TO HISTORICAL PORTAGE SITE AND CONTEMPORARY FACTORS

	(1) Housing units, 1990	(2) Median rents, 1990	(3) Median values, 1990	(4) Interstates, 2000	(5) Major roads, 2000	(6) Rail, 2000	(7) Travel time to work, 1990	(8) Crime, 1995	(9) Born in state, 1990	(10) Water use, 1995	(11) Federal expend., 1997	(12) Gov't. empl., 1997
Explanatory variables:												
Panel A. Portage and contemporary factors												
Dummy for proximity	0.910	0.110	0.108	0.602	0.187	0.858	−0.554	1.224	0.832	0.549	1.063	1.001
to portage site	(0.243)***	(0.040)***	(0.053)**	(0.228)**	(0.071)**	(0.177)***	(0.492)	(0.318)***	(0.186)***	(0.197)***	(0.343)***	(0.283)***
Panel B. Portage and contemporary factors, conditioned on contemporary density												
Dummy for proximity	0.005	0.014	−0.001	0.159	−0.064	0.182	−0.447	−0.007	−0.025	−0.153	0.032	0.114
to portage site	(0.015)	(0.020)	(0.038)	(0.108)	(0.054)	(0.110)	(0.513)	(0.058)	(0.046)	(0.145)	(0.091)	(0.077)

Notes. This table displays estimates of equation (1), with exceptions noted here. In Panels A and B, the outcome variables are current factor densities (natural log of the ratio of quantity per square mile), as noted in the column headings. (The exceptions are house rent and value, which are in logs but not normalized by area, and travel times, which are in minutes.) The coefficient reported is for proximity to historical portage sites. Panel B also controls for current population density. Each cell presents estimates from a separate regression. The sample consists of all US counties, from the indicated year, that are within the watersheds of rivers that cross the fall line. The estimator used is OLS, with standard errors clustered on the 53 watersheds. The specification includes a polynomial in latitude and longitude, a set of fixed effects by the watershed of each river that crosses the fall line, and dummies for proximity to the fall line and to a river. Reporting of additional coefficients is suppressed. Data sources and additional variable and sample definitions are found in the text and appendixes.

interstate highways, major roads, or railroads.[32] But conditioned on population density, there is little difference between portage and nonportage cities in the presence of interstate highways, major roads, or railroads. Average commuting times in portage and nonportage cities are likewise similar; in portage cities commutes are on average less than a minute shorter.

In the next three columns, we examine other measures of present-day amenities and find little difference between portage and nonportage cities when we account for the relationship between these variables and population. In column (8), we examine crime in 1995[33] and find that this disamenity is higher at portages, but in proportion with their higher population. Additionally, we turn to the density of people born in same state (i.e., those who did not migrate from some other state or country to live in that county) as a proxy for social ties. Social and family networks might be a sunk, location-specific asset that would keep people in declining areas, and declining areas might therefore have a higher local-born population. Nevertheless, we do not see a significant relationship between this variable and portage when we condition on population density. Next, we consider water use in column (10). Portage sites are more likely to be on rivers by construction, and this might allow for greater water consumption. There is greater water consumption at portages, but slightly (and insignificantly) less when population is controlled for.

Finally, we analyze the role of government. Essentially every one of the portage sites is at or near an administrative center of some sort (a capital, county seat, circuit court, etc.), but this does not mean that the presence of government "explains" the persistence of population at portages. Denser areas inevitably become centers of government to some degree because that is where the services would be in more demand.[34] In any

32. These data were constructed from the ESRI DVDs that accompany ArcGIS v9.

33. Specifically, we use the "Number of serious crimes known to police (crime index) 1995" reported in the 1998 *County Data Book* via Haines (2010).

34. It was a common occurrence for county seats to move historically, and new county seats were created (often at existing population centers) when new counties were formed. State capitals also moved with certain frequency. In our data, three of the portage sites in Georgia were state capitals (Milledgeville, Louisville, and Macon), before the capital of Georgia eventually moved to Atlanta. Further, several of the portage sites (besides Washington) were national capitals for a time (Philadelphia and Trenton for the United States, and Montgomery and Richmond for the Confederate States).

event, we obtain similar results using samples that exclude river watersheds where the fall-line occurs at present-day capitals. Compared to the baseline estimate of 0.912 (with cluster-robust std. err. 0.236) on a dummy for proximity to portage, the estimate is 0.839 (0.272) when we drop those river watersheds. Next, we consider differences in government demand at portages using two continuous measures: federal spending and government employment (at all levels). These results are seen in columns (11) and (12) of Table IV. Portage does indeed predict greater government density unconditionally, but this predictive power goes away if we condition on population density. A related issue is that government centers might shift out the local demand for (or supply of) infrastructure. But when we examined various measures of infrastructure density, we found that portage sites have comparable levels of infrastructure to areas of similar population density.

Workers at portage sites are paid more, consistent with (or perhaps slightly higher than) the observed "density premium" that workers earn elsewhere. To better match the literature, we estimate a wage-on-density equation and use portage variables as instruments for population density, as seen in Table V. The data, drawn from the 2000 IPUMS, are for workers living in metropolitan areas intersecting fall-line river watersheds. The dependent variable is the natural logarithm of the worker's hourly wage, and the reported coefficient of interest is for the natural logarithm of population density of the workers' area of residence.[35] The ordinarly least squares (OLS) estimate in column (1) gives an elasticity of about 5%, in line with previous estimates from the literature. If the history of portage had no direct effect on prices today (except through density), then portage variables are excludable instruments. In columns (2)–(4), we report estimates using two-stage least squares (2SLS) with portage instruments. These coefficients are about 80% higher than the OLS, but the confidence intervals on the 2SLS estimates are large enough that we can reject neither the OLS nor the overidentification restriction. As

35. We allocate portage-related advantages based on workers' identified CONSPUMA code, which is a consistent public-use microdata area defined by the IPUMS. CONSPUMAs are county-based and typically follow metropolitan area boundaries, but large metropolitan areas typically contain multiple CONSPUMAs. The sample is restricted to workers aged 25–65. Other regressors include flexible controls for gender, race, ethnicity, nativity, educational attainment, marital status, and age, as well as the spatial controls in equation (1). See Online Appendix L for estimates with occupation and industry dummies as well.

TABLE V
ESTIMATES OF THE EFFECT OF DENSITY ON WAGES USING PORTAGE AS AN INSTRUMENTAL VARIABLE

Log hourly wage	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS
Log population density	0.049	0.085	0.089	0.091
	(0.003)**	(0.032)**	(0.030)**	(0.028)**
Instruments				
Portage-site dummy	–	X	–	X
Log watershed size interaction	–	–	X	X
First-stage statistics				
F	–	8.69	10.7	8.93
p (overidentification)	–	–	–	0.888

Notes. This table displays estimates of regressions of wages on population density. The outcome variable is hourly wage, measured in natural logarithms. Each column presents estimates from a separate regression. The sample consists of all workers in the 2000 IPUMS, age 25–65, that are observed in metropolitan areas in the watersheds of rivers that cross the fall line. In column (1), the estimator used is OLS, with standard errors clustered on the 53 watersheds. In columns (2–4), the estimator used is 2SLS, with standard errors clustered on the 53 watersheds. The basic specification includes, at the worker level, controls for sex, race, ethnicity, nativity, educational attainment, marital status, and age, and, at the area level, a polynomial in latitude and longitude, set of fixed effects for the watershed of each river that crosses the fall line, and dummies for proximity to river and fall line. Two portage-related variables are used as instruments for log population density in this table. The first is a binary indicator for proximity to the river/fall-line intersection. The second is the interaction of portage site with the log of land area in the watershed upstream of the fall line, a variable which proxies for demand for commerce at the portage site. First-stage robust F and p (from a NR^2 Sargan-Hausman overidentification test adjusting for clustering at CONSPUMA level) statistics are also reported in each column. Reporting of additional coefficients is suppressed. Data sources and additional variable and sample definitions are found in the text and appendixes.

a point of comparison, note that the earlier estimates imply an elasticity of housing price to population density of 0.12, so wages more than compensate for the higher housing cost (if housing has roughly a one-third budget share). This suggests that the other costs of density (including disutility of congestion) outweigh any amenities arising with density, at least for the marginal migrant.

In conclusion, we find few observable differences in factors or amenities between portage and nonportage cities today. Although we cannot discard the influence of some unmeasured legacy capital, the evidence suggests that the persistence of population at portages relates to forces common to other present-day cities. The evidence is less consistent with a view that some large, historical sunk costs incurred for particular types of capital are causing excess medium-run agglomeration at portages compared to other nonportage cities. This evidence instead seems to favor an explanation that is more general to the centripetal forces holding all cities together today.

VIII.D. Interactions with Other Factors

A wide literature in urban economics tries to identify factors that can explain U.S. city growth. For example, Glaeser and Saiz (2004) identify human capital and climate as important factors. Jacobs (1969) suggests that industrial diversity can promote city growth through faster technological adaptation (see Lin 2011 for evidence). In this section, we provide suggestive evidence relevant to this literature.

We examine whether certain historical factors were associated with stronger persistence of population density among portage sites. To do so, we use the same county-year data, with consistent county boundaries, that we used in Section VII. With these data, we perform a similar difference-in-differences estimation described earlier (equation (3)), with the addition of another interaction term between portage proximity and various historical factors. Overall, we find that portage cities that were historically skilled and diverse grew faster.

These results are reported in Table VI. We report the coefficients on the interaction of post with the following variables: portage proximity, the historical factor noted in the column heading, and portage proximity times historical factor. For ease of interpretation, each of the historical factors has been normalized to zero mean. Standard deviations of the historical factors are displayed in the first row. Column (1) reports the original difference-in-differences estimate from Section VII.

The second column reports results for specifications that include an interaction with the natural logarithm of heating-degree days, a measure of climate. A greater number of heating-degree days is associated with a colder climate. The results suggest that portage sites in colder climates grew faster than portage sites in warmer climates. This result is not entirely unexpected, given that many of the northern fall-line portage sites in our sample are today large agglomerations—Washington and Philadelphia, for example. Still, because we are already controlling for a time-varying, flexible spatial trend, the estimates suggest that colder places grew faster, even conditioned on latitude.

In the next two columns, we add interactions using historical measures of education and skills. Column (3) displays a regression that includes college teachers per capita in 1850, and column (4) includes the literacy rate among white men in 1850. In both cases, portage sites with greater densities of these factors in 1850

TABLE VI

INTERACTION OF HISTORICAL FACTORS WITH GROWTH AT PORTAGES

	(1) Baseline estimate	(2) Warm climate	(3) College teachers, 1850	(4) Literacy rate, 1850	(5) Industry diversity, 1850	(6) Manuf. / agr., 1880	(7) Regional pop. (donut), 2000
Explanatory variables:							
Dummy for proximity to	0.456	0.727	0.417	0.440	0.346	0.274	0.451
portage site × 20th century	(0.092)***	(0.174)***	(0.092)***	(0.094)***	(0.085)***	(0.085)***	(0.090)***
Additional factor (column		0.124	0.475	−0.731	0.202	0.349	2.843
heading) × 20th century		(0.130)	(0.162)***	(0.218)***	(0.033)***	(0.055)***	(1.626)*
Dummy for portage × add'l		−0.402	1.080	1.083	0.275	0.044	0.034
factor × 20th century		(0.196)**	(0.419)***	(0.472)**	(0.095)***	(0.061)	(0.078)

Notes. This table displays estimates of equation (3) in the text. Each column presents estimates from a separate regression. Each regression uses county-year observations for years 1790–1870 and 1950–2000 and all counties that lie in river watersheds that intersect the fall line. The estimator used is OLS, with standard errors clustered on the 53 watersheds. The outcome variable for each county-year is the natural logarithm of population density, normalized to year 2000 county boundaries. The explanatory variables include a fixed county effect, an indicator variable for the observation year being 1950 or later and its interactions with a spatial trend, a county group indicator, and a portage proximity variable. An additional regressor, noted in column headings, that is interacted with portage proximity and year is also included. These additional variables are transformed to have mean zero with standard deviations displayed in brackets. Reporting of additional coefficients is suppressed. Data sources and additional variable and sample definitions are found in the text and the appendixes.

experienced greater population growth. Based on these results, historical measures of skill appear to be associated with greater persistence.

Columns (5) and (6) include measures based on historical sectoral composition. One intriguing hypothesis is that a diversity of activities might allow for better adaptation. The estimates presented in column (5) suggest that portage cities with more industrial diversity in 1850 did see greater population growth. However, in column (6), a measure of structural change, the ratio of manufacturing to agricultural employment in 1880, does not seem to be related to greater portage persistence.

Finally, in column (7), we include an interaction based on population growth in the surrounding area, excluding the portage site itself. (We use counties in a "donut" of 120 miles radius around the portage site. This donut excludes portage counties.) According to the estimates, portage sites that experienced less population growth in their corresponding donut saw greater population growth during 1850–2000. Although it seems counterintuitive that a city grows more if its hinterland grows less, it may be that more productive cities drained population away from their environs.

IX. Conclusion

We study the evolution of economic activity at pre-nineteenth-century portage sites across the U.S. South, Mid-Atlantic, and Midwest. Many of these sites became centers of commerce and manufacturing before 1900, although their natural advantage was made obsolete a century (or more) ago by changes in technology. Nevertheless, these portage sites are likely to be population centers even today. Furthermore, we do not find evidence that these areas have declined since the obsolescence of their portage-related advantages. Nor do these sites seem to be oversupplied with various sunk assets relative to comparably populated non-portage cities today. Taken together, these results stand in contrast with the predictions of a neoclassical model with decreasing returns to scale locally or even a model where increasing returns are too weak to overcome congestion costs.

Our preferred interpretation for these results is seen in a model with strong increasing returns to scale in local economic activity. Such a model predicts the possibility of multiple long-run equilibria in overall factor density at a given site. We argue that historical portage acts as a coordination device, selecting equilibrium density at a given site. Portage shifted out the demand for labor at these sites, and the historical presence of reproducible factors contributes to high relative population densities at portages today. This is the sense in which our results exhibit path dependence. Some readers might have a preferred reproducible factor that they would propose as a parsimonious explanation for these results, where the key factor might be railroads, housing, or some other long-lived asset. But a direct, nonnegligible effect today of some specific early factor seems unlikely, for a variety of reasons. Instead, we suggest early factor density had an indirect effect via more than a century of overlapping generations of location decisions for various reproducible factors, perhaps combined with increasing returns to scale locally. In a standard economic geography model, path dependence can emerge if (i) historical advantages coordinate activity to a particular location and (ii) returns to scale rise enough to sustain density there. Nevertheless, we cannot completely rule out some particular sunk factor that is both persistent and important enough to explain the enduring growth at portage sites.

Our findings contrast with the work of Davis and Weinstein (2002, 2008) who show that bombing during World War II failed to change the equilibrium location of economic activity across Japanese cities. Although their evidence suggests that path dependence may not be empirically relevant for city sizes, we believe that standard models of economic geography help us understand the difference between these results. As noted earlier, heterogeneity in natural features can suppress alternative potential equilibria (see Figure VII, Panel B). Japan's varied topography highlights the large variation in the natural productivity value of locations, perhaps enough to preclude the existence of multiple spatial equilibria. As a parallel thought experiment that might be more familiar to the North American reader, consider California, another Ring-of-Fire area with varied topography. Within California, there is large variation in natural features: mountains, deserts, fertile valleys, oil and mineral deposits, natural harbors, temperate weather, and views of the Pacific. If we were to resettle California starting from a tabula rasa, it seems likely that population would concentrate near the very same fixed factors and in the same locations we see today: in the sunny valleys of Southern California, near the port of San Francisco, in the Sacramento River delta,[36] and in the fertile Central Valley. In contrast, this need not be the case in a more homogeneous landscape, such as the coastal South or Midwestern United States.

We have intentionally said little about the welfare implications of these results, although understanding the optimal size and distribution of cities is of paramount interest. A perennial concern in models with path dependence is that we might get locked into a choice that is somehow sub-optimal in the future. However, we have chosen comparison sites that were similar to portages to facilitate the analysis. Thus, it is unlikely that, for example, if we were to magically move Richmond up or down the James River it would result in substantial welfare gains.[37] Nevertheless, having a city on a river brings its own set of problems. River cities are more vulnerable to flooding in extreme times and require extensive interventions around the riverbanks to prevent changes in the course of the river, even in normal times. Furthermore, even if the river continues to be navigable nowadays, river cities are at a disadvantage in land-based transport because bridges are needed to cross-connect parts of the metro area. Bridges over water are more expensive to build and to maintain than are roads and railroads on land. While historically this was compensated by access to water transport, almost all of these cities lie on rivers that are no longer used for commercial navigation.

Central to the persistence of cities at historical portage sites has been that these areas have been able to adapt and respecialize into other activities. But not every historical agglomeration has persisted after losing its initial reason for being. In future work, it would be useful to better understand the size and quality of natural endowments or institutions that are necessary to have made this transformation possible.

Data Appendix

A. The Fall Line

We use data on counties in fall-line river watersheds. The base data are county shapefiles, 1790–2000, from the National

36. Nevertheless, Sacramento's place at the head of navigation on the Sacramento River, as well as its role in transshipment during the California Gold Rush, is noteworthy as a parallel to our results.

37. One possible exception is Chicago, which would seem to be located 30+ miles to the northwest of an optimally sited transshipment hub. That said, Chicago's economy is no longer as centered on transshipment, and therefore the percentage cost of its mislocation might be small.

Historical Geographic Information System (NHGIS), matched to county populations (and other data) from the Haines (2010) extracts of the decennial U.S. censuses.

First, we select counties based on their location within river watersheds that intersect the fall line. The fall line itself, from Texas to New Jersey, is digitized from the map Physical Divisions of the United States. (Figure A.1 shows the digitized fall line, in solid black, superimposed over both the rivers layer and the nighttime lights layer.) We select the 51 large rivers between the Rio Grande and the Delaware rivers, inclusive, from the North American Atlas-Hydrography map layer available on NationalAtlas.gov, that intersect the fall line. Two smaller rivers, the Raritan River in New Jersey and the Appomattox River in Virginia, are added from the Streams and Waterbodies layer. Hydrologic units from the Hydrologic Units (Watersheds) layer are then aggregated to entire river watersheds and matched to each of the 53 rivers. In addition, we identify the locations of likely historical portage sites by intersecting the fall-line layer with the rivers map layer. These steps form a basic "sampling" layer, which is then used to select counties in each decennial NHGIS map layer. Counties that lie on the boundary of multiple watersheds are assigned to the watershed of the closest river, when we perform our across-watershed analyses.

Second, we intersect each decade's sampled county layer with various map layers containing geographic information. These layers include information on spatial relationships (county distances to the fall line, seaports, or the Atlantic coast, county position upstream or downstream of the fall line, county adjacency to fall-line portage sites), fixed characteristics of counties (climate, elevation, the presence of aquifers, and potential water power), and mobile factors (the locations of nineteenth-century railroads, state capitals). The major nineteenth-century seaports (Baltimore, Norfolk, Wilmington, Charleston, Savannah, Mobile, New Orleans, and Galveston) are taken from Phillips (1905). Climate data are from the *Climate Atlas of the United States*, which reports (categorical) 30-year averages, over 1961–1990, for most of the climate variables. Data on the locations of aquifers and other geological features are from NationalAtlas.gov.

Potential water power is from the *Reports on the Water-Power of the United States* (1885), published as part of the Tenth Census. The tables beginning on pages xxx and xxxiii summarize by river and "locality" the total water power available and the total water power then used in service. We geo-code this information, and in some cases we rely on textual descriptions in the accompanying survey to identify localities.

The locations of railroads in 1850 were provided by Jeremy Atack, based on data constructed for Atack et al. (2010). We defined a buffer of 10 miles in width around the digitized rail routes. Rail length is then determined by counties that intersect this buffer, divided by 10.

Finally, we merge each decade's spatial data with census data from the Haines extracts. In addition to data on population, the Haines extracts also include, for some years, information on the age distribution of the housing stock. We then pool the decennial county data into a single data set.

The construction of the census 2000 tract data is identical to the procedure just described. For the nighttime lights, we first sample one out of every 100 raster-resolution pixels, creating a grid of sample points, then apply the procedure described above.

B. The Great Lakes

The basic data sets (NHGIS and the Haines extracts) are the same for our Great Lakes sample. We first use the Hydrologic Units (Watersheds) to define the divide between the Great Lakes and the Mississippi River watersheds. Then, we select counties that intersect a buffer of 12.5 miles in either direction from the divide. We identify 12 portage routes based on the map "Portages Between the Great Lakes and the Mississippi" (Semple, 1903, facing p. 28) and the two river layers from NationalAtlas.gov described earlier. Counties are assigned to portage-route groups based on distance to the nearest portage route. The remaining procedures are identical to those described in the fall-line section.

C. The Mississippi River Basin

We select counties within 12.5 miles in either direction of each of the three major upstream branches of the Mississippi River. Major confluences with other rivers are identified from the river layers from NationalAtlas.gov described earlier. We identify early portage sites along these rivers using early nineteenth-century surveys from the U.S. Army Corps of Engineers, found in the Serial Set. For example, the "Survey of the Ohio and Mississippi Rivers" (17th Congress, 2nd session, H. No. 260, January 22, 1823) notes navigation obstacles at the Falls of the Ohio and other sites

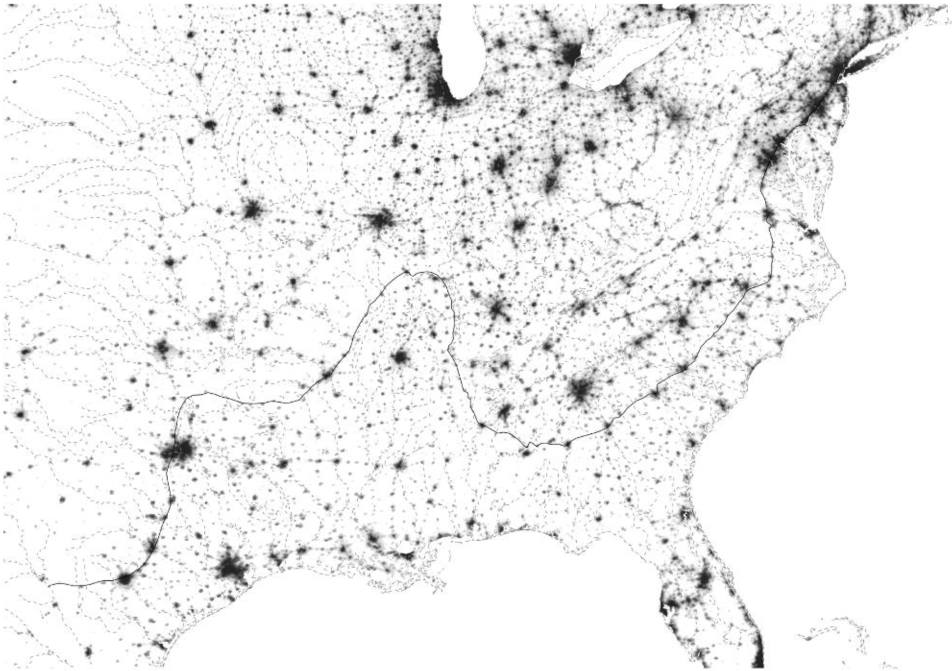


FIGURE A.1
The Density Near Fall-Line/River Intersections

This map shows the contemporary distribution of economic activity across the southeastern United States measured by the 2003 nighttime lights layer. For information on sources, see notes for Figures II and IV.

along the Ohio River. The report "Improvement of Missouri River" (46th Congress, 3rd session, H. Ex. Doc. No. 92, February 17, 1881) and Part II of the *Reports on the Water-Power of the United States*, in the section called "The Mississippi River and Some of its Tributaries" (U.S. Department of Interior 1885) note seasonal navigation obstacles along the Missouri River near Sioux City, Iowa; Council Bluffs, Iowa (across from Omaha, Nebraska); and Kansas City, Missouri. Part II of the *Reports on the Water-Power of the United States* also notes rapids near Keokuk, Iowa; Rock Island, Illinois; and the Falls of St. Anthony, near Minneapolis. These observations are similar to those in "Report Intended to Illustrate a Map of the Hydrographical Basin of the Upper Mississippi River" (26th Congress, 2nd session, S. Doc. 237, February 16, 1841). In addition, many of these surveys (and others not cited) include notes of minor navigation obstacles at regular intervals along all these rivers and other major U.S. waterways, which, because of their large number, we do not use in this article. We noted several examples of present-day cities at the sites of these minor navigation obstacles. Finally, we exclude portages along smaller tributaries of the Mississippi River.

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Supplementary Material

An Online Appendix for this article can be found at QJE online (qje.oxfordjournals.org).

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