Railroads and the Rise of the Factory: Evidence for the United States, 1850-1870

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1. Introduction

In the early years of the nineteenth century, manufacturing production in the United States took place in artisan shops where a highly skilled worker – the artisan – crafted a good from start to finish perhaps with the help of an assistant or two. Artisans used comparatively little in the way of physical capital – a building, general purpose hand tools, and not much else—and their operations were to be found everywhere in the country. By mid-century while artisan shops still constituted the majority of manufacturing establishments a new organizational form – the factory – had emerged. Compared with the artisan shop the typical factory employed more but less skilled workers who specialized in specific production tasks, often with the aid of machinery driven by inanimate sources of power such as water or steam (Atack, Bateman, and Margo 2008). A fundamental consequence of these differences in organization and technology is that factories had higher labor productivity than artisan shops

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(Sokoloff 1984). Over the balance of the nineteenth century resources in manufacturing production continued to shift towards the factory and away from the artisan shop. Overall, the manufacturing sector grew rapidly and country became the dominant player in many industries worldwide by the end of the century (Wright 1990; Broadberry and Irwin 2006).

What were the causes of the shift towards factory production? One classic answer invokes the role played by the "transportation revolution" (Clark 1916; Taylor 1951). Before the transportation revolution the market for manufactured goods was limited to the immediate surrounding area because transport costs were very high relative to the value of the good at the point of production. Falling transport costs expanded the size of markets, eroding monopoly power and compelling firms to raise productivity through division of labor-*cum*-mechanization. In addition, improved transportation reduces the cost of raw materials and if these are complementary to capital goods that raise the productivity of unskilled labor, optimal firm size will increase. Improved transportation also lowers the likelihood of production downtime due to input supply disruptions. This allows firms to shift capital invested in inventories (of raw materials) towards capital (for example, steam power) that is complementary to division of labor (Atack, Bateman, and Margo 2008). Less downtime also means that the firm can expand employment because workers will accept a lower wage since their unemployment risk is reduced (Atack, Bateman, and Margo 2002).

Although the transportation revolution is a plausible causal factor in the rise of the factory, it is far from the only plausible cause. Improvement in steam technology is another; recent work has shown that steam power was adopted more quickly by larger-scale enterprises arguably because the positive impact of steam on labor productivity (relative to water or hand power) was increasing in establishment size (see Atack, Bateman and Margo 2008). All else equal, factories would be more profitable if the wage of unskilled labor was low relative to skilled labor. Early factories in the Northeast, for example, made extensive use of the labor of young women and children whose productivity in agriculture relative to the adult males was low due to the region's crop mix (Goldin and Sokoloff 1982). As the century progressed waves of immigration from Europe expanded the relative supply of unskilled labor, arguably fueling the growth of factories (Rosenbloom 2002).[2]

Assessing the relative importance of the transportation revolution as a causal factor in the diffusion of the factory has been hampered by a lack of suitable data connecting the two along with a defensible identification strategy for establishing causality. In this paper we report on our preliminary efforts to bridge this gap using repeated cross-sections of establishments drawn from the 1850, 1860 and 1870 federal censuses of manufacturing that are linked to county-level information on transportation access derived from contemporary maps. Both the timing and nature of the linked sample causes us to focus attention in this paper on the diffusion of the railroad rather than other forms of man-made transportation such as canals, which was largely complete by 1850.

Following previous work (Craig, Palmquist, Weiss 1996; Haines and Margo 2008) we measure rail access as a dummy variable indicating whether a railroad passed through the boundaries of a particular county in a given census year. Some counties already had rail access

[2] Other factors include the development of financial markets (Rousseau and Sylla 2005) and legal changes in business organization (Lamoreaux 2006; Hilt 2008).

in this sense in 1850 while others did not. Among the counties that did not have access in 1850, a subset gained access in the 1850s or in the 1860s. We adopt two identification strategies to assess causality. Our first strategy is to use a difference-in-differences (DD) estimator. This estimator measures whether factory status increased on average in counties that gained rail access over the course of the 1850s or 1860s – the "treatment" sample – as compared with a control sample (counties that did not gain access or already had access at the start of the decade).

By design, the difference-in-differences estimator eliminates any fixed factors at the county level that, in a cross section, would have been correlated with rail access. However, the legitimacy of DD rests on the presumption that gaining access occurred through the equivalent of random assignment. Consequently, as a check we implement a second estimation using instrumental variables applied to a cross-section of establishments in 1850.

We use two instruments in our analysis. One instrumental variable derives from "straight lines" drawn between urban areas as of 1820 and the closest major coastal port; this instrument is used for counties located in the South and the Northeast. The second instrument, also derived from straight lines, uses information on the starting and endpoints of a series of railroad engineering surveys authorized by Congress from the mid-1820s to the late 1830s. This instrument is used for counties in the Midwest. The presumption is that a county would have been more likely to gain rail access by 1850 if it lay along one of the straight lines than if it did not. Judging by our first stage regressions, this logic is correct: both instruments do a good job of predicting 1850 rail access in their respective sub-samples.

Our empirical findings suggest that that the coming of the railroad was a causal factor in the rise of factories. Our preferred DD estimate implies, for example, that the diffusion of the railroad after 1850 can account for about a third of the increase in the proportion of establishments that were factories between 1850 and 1870 in our sample.

2. Data

Our empirical analysis uses repeated cross-sections of manufacturing establishments for the 1850-70 census years. These have been linked to a newly created database of transportation infrastructure for the nineteenth century United States. Our data description is very brief; for further details readers are directed to the working paper version of this paper (Atack, Haines, and Margo, 2008; see also Atack and Bateman, 1999; and Atack, Bateman, Haines, and Margo 2009).

To create our transportation database we used digitized versions of nineteenth century maps that contain information on transportation infrastructure and which have been matched electronically to geographic information system (GIS) files showing county boundaries. GIS software is then used to create various measures of transportation access. In particular, the database records water transportation access as of 1850 by four variables: CANAL (=1 if there was a canal within or passing through the county); RIVER (=1 if there was a navigable river within or passing through the county); GREAT LAKES (=1 if the county bordered on a Great Lake); and OCEAN (=1 if the county bordered on the Atlantic or Pacific oceans, or the Gulf of Mexico). The database also contains a similar measure of rail access (RAIL = 1 if a railroad within or passing through the county) at census year frequencies (1850-70). Thus, by construction, while our water transportation access variables do not change over time for any given county, our rail access variables will change if the county gained rail access at some point between 1850 and 1870.

We have linked the transportation database to the so-called "national" samples of manufacturing establishments that were drawn from the 1850-70 manuscript censuses of manufacturing by Bateman and Weiss and modified and extended by Atack and Bateman.[3] Along with inputs, outputs, and other firm level characteristics, the Atack-Bateman samples record the location of the establishment, including the county. For additional details on the manufacturing data, see Atack and Bateman (1999).

The linkage between the transportation and manufacturing databases is accomplished through the variable common to both – namely, the county. However, the Atack-Bateman samples are not stratified random samples by county – they are, by intention, nationally representative. As such, there are many counties in our transportation database for which no establishment level observations exist in the Atack-Bateman samples for one or more of the relevant census years. We impose two constraints on the linkage. First, for any specific county in the transportation database to be included in the linked sample there had to be observations in the Atack-Bateman samples in all three census years. This ensures that the linked sample is balanced – that is, there are 3 x N county-level observations on our transportation variables where N = number of counties. Second, we require that the counties have fixed county

[3] Although sample data for 1880 are also available, these are not used here because by 1880 rail coverage was essentially perfect in the counties included in the 1880 sample.

boundaries over the sample period (1850-70). We also impose a number of other screens on the manufacturing sample that are similar to those used in other studies using the Atack-Bateman samples (see the notes to Table 1).

Our final sample contains 8,597 establishments located in 368 counties. Panel A of Table 1 shows the distribution of the sample establishments by region. Reflecting the regional character of early industrial development in the United States, the overwhelming majority of establishments were located in the Northeast or Midwestern states. Panel B shows the sample means of an indicator for factory status and our rail access variable. The unit of observation is the establishment. For the purposes of this paper we have chosen to follow the previous literature (Sokoloff 1984) and have defined a "factory" as an establishment with 16 or more workers.[4] Small variations around the factory cutoff (for example, 15 or 17 workers as opposed to 16) do not affect our substantive findings. We do not separately identify mechanized

[4] In 1850 and 1860, the number of workers is the sum of male and female employees. In 1870, the number of workers is the sum of adult males, adult females, and child employees. We have experimented with the adjustment of entrepreneurial labor suggested by Sokoloff (1984) which involves adding one person to the count of workers but as our substantive findings were not affected, we only report results using the unmodified census counts. Similarly, no adjustment has been made to render the number of employees comparable across establishments in terms of adult-male equivalents because at least some of the process of division of labor involved the substitution of women and children for adult men (Goldin and Sokoloff 1982).

establishments because mechanization was a complement to the division of labor (Atack, Bateman, and Margo 2008).

Panel B reveals that, although factories were not very common in any of census years, a majority of workers, even in 1850, were employed in factories. The proportion of factories rose between 1850 and 1870 by 2.1 percentage points whereas the proportion of workers employed in factories also increased from 68 to 77 percent. The panel also shows that over three-quarters of the sample establishments and 88 percent of the workers employed in them were located in counties that already had rail access by 1850. Even so, rail access increased over the sample period – by 20 percentage points, weighting establishments equally, a substantial rise.

3. Estimation

We use our linked database to assess whether the coming of the railroad had an impact on mean factory status in manufacturing. For this purpose we adopt as our base specification a standard difference-in-difference (DD) specification:

$$F_{ijt} = \alpha_j + \delta_t + \gamma RAIL_{jt} + X_{ijt}\beta + \varepsilon_{ijt}$$

Here, F =1 if the establishment was a factory according to our definition; i indexes the establishment, j the county, and t the year; α is the county fixed effect; the δ's are year effects; and the X's are establishment level variables (for example, industry or urban location). The including the county fixed effect, our specification differences away all (fixed) factors that are associated with the presence of a railroad.[5] Hence, we are identifying γ from changes in rail access – that is, counties which gained rail access over time (the "treatment") compared with counties that did not or else had access as of 1850 (the "control").

The hypothesis of interest is $\gamma > 0$. There are two economic channels through which a transportation improvement might generate an increase in factories. The first channel occurs on the demand side. To understand the demand side channel, imagine that firms have access to a technology that uses division of labor as more workers are hired up to some level of output. Division of labor raised productivity and reduces average costs up to this level of minimum average cost.

If markets are local relative to minimum average cost, the number of firms serving the market will be small, possibly only a single firm. Each firm is likely to have some monopoly power, facing a downward sloping demand curve – that is, a scenario of monopolistic competition. Because demand slopes downward, the optimal size of the firm will be smaller than minimum average cost a division of labor limited. However, ss transport costs fall the output market no longer is local, and the number of firms that compete in the market effectively increases. Because there will be more competition than in the initial equilibrium, the demand curve facing each firm flattens causing the firm to produce more output. Given a

[5] Among the fixed factors differenced away are the level effects of the water access dummies. However, interaction effects between the water access dummies and time are identified (see the text).

standard U-shaped average cost curve, this will be achieved through an increase in division of labor and, therefore, by an increase in firm size.[6]

The second channel operates on the supply side. We think the primary mechanism here is the impact of falling transport costs on the geographic extent of the market for raw materials. Certain raw materials are complementary to the growth of the factory system in the sense that a fall in their price makes it more likely that firms will adopt production methods that utilize division of labor. In our context, arguably the best example of a raw material that was complementary to capital and unskilled labor was coal. Expensive coal limited the diffusion of steam engines, whereas cheap coal made steam more profitable, relative to water or hand power. Atack, Bateman, and Margo (2008a) show that the productivity effects of steam were increasing in establishment size, most likely because firms that utilized steam could employ a more intricate division of labor.[7] The most plausible explanation of this relative decline is

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[6] See Bresnahan and Reiss (1991) for a formal argument similar to the text.

[7] Atack, Bateman, and Margo (2003) estimate output and capital good price indices for manufacturing over the period 1850 to 1880. Using these as the base, the price of coal in Northeastern cities clearly fell over the same period, and in all likelihood this relative decline began before 1850. According to our indices, capital goods prices in manufacturing declined by 24 percent relative to output prices between 1850 and 1880; the corresponding decline in the relative price of coal was 31 percent. In this case the coal price pertains to prices in Philadelphia (computed from series Cc237 in Carter, et. al. (2006, Volume 3, pp. 213-214). Using the same source coal prices in Philadelphia declined by 35 percent from 1836-40 to 1846-

improvement in internal transportation that made it cheaper to transport coal from comparatively remote places to urban areas where manufacturing production took place.

A reduction in the delivered price of inputs is not the only supply-side way that a transportation revolution may have promoted factory growth. Improved transportation not only lowers the delivered price of raw materials but also smoothes fluctuations in raw materials prices. As a result, firms hold less of their capital in the form of inventories of raw materials, freeing capital for other uses – such as a steam engine. A corollary of input price smoothing is that firms are less likely to experience disruptions in input supply. If such disruptions are common, firms will shut down from time to time – production will be “part-year” as opposed to “full-year”. To the extent that improvements in transportation lessened the likelihood of plant shutdowns this would also make year-round production more likely and lead to larger firm sizes. Atack, Bateman, and Margo (2002) show that full year operation in American manufacturing increased over the course of the nineteenth century and that larger establishments were, as hypothesized, more likely to engage in year-round production than smaller establishments.

The coincidence of the increases in factory status and rail access suggest a temporal link between the two but the time series correlation, of course, is not evidence of a causal relationship. Table 2 shows the difference-in-difference estimates of γ for various specifications of the regression equation and over different sample periods. The unit of observation is the

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40. This strongly suggests that the post 1850 trend in the relative price of coal began before 1850.

establishment and the establishments are equally weighted, except in the last column where observations are weighted by employment.

In general, we find a positive effect of rail access on factory status. The effect however is not statistically significant unless we include controls for urban status and industry, and year interactions between the water transportation dummies and the state in which the establishment was located. When the regression covers all three census years with the full specification just alluded to, rail access adds 3.8 percentage points to the probability that an establishment was a factory, or about 28 percent (= 0.038/0.137) of the average of the sample means (1850-70) shown in Panel A of Table 1. If the data are weighted by employment, the effect is larger in absolute terms (0.087, using all three years), but smaller (12 percent = 0.087/0.725) expressed relative to the average of sample means (1850-1870) of the shares of workers employed in factories.

As a robustness check we perform an estimation using instrumental variables (IVs). For this purpose, we focus on the 1850 cross section since there was more variation in rail access in this year, and we seek one or more instruments to predict rail access in 1850. The idea behind the IV approach is to find a variable that predicts rail access in 1850 but which otherwise does not have a direct effect the probability that an establishment was a factory.

Our first instrument is a “Port” variable. To construct this instrument we identify all towns and cities of population 2,500 or more in the 1820 census. Next we identified nine “major” ports in 1820 from customs information. These ports were Baltimore, Boston, Charleston, New Orleans, New York, Norfolk, Philadelphia, Portland (ME), and Savannah. We then drew straight lines between each interior city/town and the nearest port. If a county lay along a straight line as drawn, our instrument takes the value one and zero otherwise.

Our second instrument is a “Congressional Survey” variable. Beginning in 1824 with the passage of the General Survey Bill, the President was granted authority to survey routes for “such roads and canals as he may deem of national importance, in a commercial or military point of view, or necessary for the transportation of the public mail.” Although the act contains no mention of railroads, beginning in 1825 with a survey to “ascertain the practicability of uniting the headwaters of the Kenawha [sic] with the James river and Roanoke river, by Canals or Railways” (Haney 1908, p. 277) railroads quickly came to the fore. This law remained in effect until it was repealed by the Jackson administration, effective in 1838. According to Haney (1908, p. 283), information on 59 surveys was reported in official Congressional documents (such as *American State Papers*, see below).

We construct our “Congressional Survey” instrumental variable (IV) as follows. First, we identified the pair of counties that constitute the starting and endpoint of all railroad surveys listed in *American State Papers* over the period 1824 to 1838. We then draw a straight line between the geographic centers of the “start” and “end” counties. Counties that lay along this straight line received a value of one, while those that did not were coded as zero.

The idea behind both of these instruments is that costs mattered in the construction of a railroad. Specifically, all other factors held constant, (i) a lower cost rail network is preferable to a higher cost network (ii) a shorter line is less costly to build than a longer line and (iii) the shortest distance between two points is a straight line. Connecting interior places that had already established some level of economic activity in 1820 to the wider world (*via* ports in existence in 1820) clearly would make economic sense – if the transportation infrastructure were economically feasible. In the case of the Congressional surveys, the idea is that existence of such a survey raised the likelihood that a railroad would eventually be built because these surveys provided valuable information about topography and other factors that clearly affected potential construction costs. As Taylor (1951, p. 95) notes "[a]s trained engineers were still very scarce … the government rendered a uniquely valuable service by making its experts available for such surveys."[8] In sum, counties that happened to be on the straight lines as described would be at greater risk of gaining rail access earlier rather than later.

Given the location of urban areas in 1820 our "port" IV is capable of predicting rail access in the Northeast and the South but not the Midwest. Similarly, given where the bulk of the surveys were taken the survey IV has potential for predicting rail access in the Midwest (but not the other regions). Accordingly we split the sample into two groups – Midwestern counties, and counties in the Northeast and South – and we also deleted observations in the West (for which we have no instrument). In addition to rail access, we control for industry (3-digit SIC code), urban status, the water transportation dummies, and the state in which the establishment was located.

[8] See also Haney (1908, p. 284) who remarks "[i]t is of some significance that in most cases the routes of these government surveys were early taken by railways … in the great majority of cases these early surveys have been closely followed."

Table 3 shows the IV results. The first stage coefficients are both positive and highly significant, indicating that the IVs do, in fact, predict rail access in 1850.[9] The second stage or two-stage least-squares (2SLS) coefficients are also positive. The magnitudes of the 2SLS coefficients exceed the DD coefficient (0.038) in the full specification; however, the standard errors are also fairly large, and we cannot reject the hypothesis that the IV and DID coefficients are (statistically speaking) the same.

Finally in Table 4, we use the DD coefficient from the full specification (columns 4 and 5, row, Table 2) to predict the change in factory status from 1850 to 1870 given the change in rail access. If the data are equally weighted the change in predicted factory status can account for a third of the actual change in factory status. If the data are weighted by employment counts, the percent explained is still positive (9 percent) but much smaller. Our results suggest, therefore, that the diffusion of the railroad after 1850 was certainly a factor in the rise of the factory system. It is plausible, therefore, that other components of the transportation revolution (such as canals and harbor improvements) also contributed to the rise of the factory

[9] We also conducted a placebo test of the Congressional survey instrument. Specifically we randomly drew 30 pairs of counties using the full universe of US counties in 1840. We then drew straight lines between the pairs; if a county was on such a straight line, it received a value of one, zero otherwise. We estimate a regression of 1850 rail access in our Midwest sample on the placebo IV; the first stage coefficient is slightly negative and statistically insignificant. The results of our placebo test suggest that the strong first stage with our Congressional Survey IV is not accidental.

but measuring the treatment effects will require extending our analysis prior to 1850, when many of the relevant improvements occurred.

4. Concluding Remarks

In the nineteenth century the United States experienced both a transportation revolution and an industrial revolution. In this paper we report on a preliminary investigation of a particular link between these two revolutions – whether improved access to transportation networks increased the proportion of manufacturing establishments that were factories. The idea here, a very old one in economics, is that establishments that operated in larger markets were more likely to engage in division of labor.

Our empirical analysis derives from a newly created and linked sample of county level data on transportation access and establishment level data from the 1850-70 censuses of manufacturing. The transportation database has been created from digitized nineteenth century transportation maps that have been overlaid on maps showing county boundaries, enabling us to measure whether or not, in particular, a railroad operated in a county in a given census year.

Using two separate identification strategies, we showed that rail access was positively and significantly associated with the probability that an establishment was a factory, which we identify to be establishments with sixteen or more workers. The first identification strategy is a difference-in-difference analysis applied to repeated cross sections of establishments, while the second is an instrumental variable estimation applied to the 1850 sample of firms. The DD estimate suggest that gaining rail access did increase the proportion of establishments that met our definition of factory status, as well as the proportion of workers employed in factories. The IV estimation, a robustness check, also finds a positive impact of gaining rail access on factory status, and we cannot reject the hypothesis that the two types of coefficients are statistically indistinguishable.

It is important not to overstate the significance of the results. Our measure of rail access, in particular, is crude and it would be worthwhile to refine it, for example, by measuring the actual number of rail miles in each county. It would also be a worthwhile extension to develop additional instrumental variables, which would enable us to compute an over-identification test. That said, our results do provide a prima-facie case that a central feature of the American transportation revolution – the diffusion of the railroad -- was a causal factor behind the rise of the factory.

Table 1: Sample Statistics

Panel A: Distribution of Establishments by Region Linked Manufacturing-Transportation Database, 1850-1870

State	Number of Establishments	Percent of Total Sample (Establishments)
Northeast	6,123	71.2%
Midwest	1,874	21.8
South	600	7.0
Total	8,597	100.0

Source: see text, Atack and Bateman (1999) and Atack, Haines, and Margo (2008). Sample is a repeated cross-section of manufacturing establishments from 1850-70 manuscript censuses of manufacturing linked to county level data on transportation infrastructure. Counties included are those that existed in the census years 1850-70 and which had no or very minimal changes in county boundaries over the period, and which were not in the far West. To be included in the sample, establishments had to have positive values of employment, capital invested, raw materials, value of output, and value added (value of outputs – value of raw materials) > $500.00 and total employment <=1,000, and be located in one of the sample counties (N = 368 counties).

Panel B: Sample Establishment Means, Factory Status and Railroad Access

	1850	1850	1860	1860	1870	1870
Weight	Equal	Workers	Equal	Workers	Equal	Workers
Factory = 1	0.124	0.675	0.142	0.727	0.145	0.772
Rail Access = 1	0.781	0.883	0.925	0.948	0.978	0.992
N (establishments)	2,874	31,446	2,897	37,602	2,826	40,018

Unit of observation is the manufacturing establishment. Factory = 1 if number of employees ≥ 16. Rail Access = 1 if railroad passed through county boundary as of year shown. Equal: each establishment counts equally. Workers: establishments are weighted by reported employment. In 1850 and 1860, reported employment is the sum of male and female employees; in 1870 reported employment is the sum of children, female, and adult male employees.

Table 2: Differences-in-Differences Regression Estimates of the Effect of Rail Access on Factory Status

Sample	County and Year Fixed Effects	Add Establishment Urban Status and Industry	Add State and Water Transportation Year Interactions	Column 4, Weighted by Employment
1850, 1860	0.021 (0.018)	0.015 (0.018)	0.046* (0.021)	0.092** (0.053)
1860, 1870	0.020 (0.027)	0.024 (0.025)	0.039 (0.027)	
1850, 1870	0.023 (0.020)	0.017 (0.019)	0.035 (0.021)	
1850, 1860, 1870	0.022 (0.015)	0.019 (0.014)	0.038* (0.015)	0.087* (0.041)

Source: see notes to Table 1. Figures shown are coefficients of rail access dummy variable (=1 if railroad line passes through county boundary, 0 otherwise) on factory status (=1 if number of workers ≥ 16). Standard errors, shown in parentheses, are clustered by county. Industry: dummy variables for 3-digit SIC codes. Urban = 1 if establishment located in incorporated village, town, or city of population 2,500 or more. State: dummy variables for state; West Virginia observations are recoded as Virginia for consistent classification over time. Great Lakes = 1 if county bordered on one of the Great Lakes. Canal = 1 if a canal passed through the county as of 1850. River = 1 if a navigable river passed through the county boundary as of 1850. Ocean =1 if county bordered on ocean as of 1850. All regressions include year dummies. In columns 4 and 5, state and water transportation dummies interacted with row-appropriate time dummies are included. Standard errors are clustered by county. *: significant at the 5 percent level. **: significant at 10 percent level.

Table 3: Instrument Variables Estimation of the Effects of Rail Access on Factory Status in 1850

	Congressional Survey IV	Port IV
Sample	Midwest	Northeast, South
First Stage	0.472* (0.092)	0.248* (0.072)
2SLS	0.076 (0.064)	0.158 (0.124)
Significance Level, 2SLS – DID (β = 0.038)	0.541	0.334
Number of establishments	427	2,435

Congressional Survey IV = 1 if county lies on a straight line connecting beginning and endpoints (counties) of a congressional railroad survey; see text and Atack, Haines, and Margo (2008). Port IV = 1 if county lies on a straight line between urban area of population 2,500 or more in 1820 and nearest major port; see Atack, Haines, and Margo (2008). The congressional survey IV estimation is restricted to sample counties located in the Midwest. The Port IV estimation is restricted to sample counties located in the Northeast and South. First Stage: coefficient of rail access in 1850 on instrument. 2SLS: coefficient of factory status on predicted rail access using first stage regression. Column #1 (Midwest) specification includes dummies for urban status, 3-digit SIC industry code, canal, river, Great Lakes, and state. Column #2 (Northeast, South) specification includes the same dummies plus a dummy for ocean counties. Significance level: significance level of test of the difference between the 2SLS coefficient and DID coefficient (β = 0.038) from Table 2, row 5, column 4.

Table 4: Explaining the Change in Factory Status, 1850-1870: The Role of Rail Access

Weights:	Equal	Workers
Actual Change in Rail Access, 1850-70	0.197	0.109
Predicted Change in Factory Status, 1850-70	0.007	0.009
Actual Change in Factory Status	0.021	0.097
Percent Explained (1 – Row 2/Row 3) x 100%	33.3%	9.3%

Change in Rail Access: see Panel B, Table 1. Predicted Change in Factory Status: Actual Change in Rail Access x regression coefficient, column 4 or 5, row 5, Table 2. Actual Change in Factory Status: see Panel B, Table 1. Equal: establishments weighted equally. Workers: establishments weighted by number of employees.

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