RESEARCH BRIEF

Railroads, Reallocation, and the Rise of American Manufacturing

Based on BFI Working Paper No. 2019-146, "Railroads, Reallocation, and the Rise of American Manufacturing" by Richard Hornbeck, V. Duane Rath Professor of Economics and Neubauer Family Faculty Fellow, UChicago's Booth School of Business; and Martin Rotemberg, assistant professor, New York University

KEY TAKEAWAYS

- ✓ Economists have long noted the economic benefits derived from the expanding rail network in the second half of the 19th century in the United States
- ✓ However, those benefits have traditionally been described as relatively small compared to the pace of general economic growth
- ✓ New research incorporates the indirect benefits derived from an expanded rail network to reveal broader and deeper gains
- ✓ By connecting domestic markets and allowing for a more efficient use of inputs—including materials, capital, and labor—railroads had a substantial impact on US economic growth

Of these two workers, who is more productive? Amy works for one minute every afternoon and produces 11 minutes' worth of goods, for a net gain of 10 minutes' worth of goods for her employer. Sally works for five hours and produces six hours' worth of goods, for a net gain of 60 minutes.

Whom would you hire? Amy is clearly the most productive on a per unit, or ratio, basis: Her employer only has to pay for one minute's work for 10 minutes of net production. But Sally, in an aggregate sense, is more productive: She nets her employer 60 net units every afternoon, six times more than Amy produces. It would be great to hire Amy if she could maintain the same per-unit productivity and work for 5 hours, but perhaps she is not willing to work 5 hours or her productivity plummets after working 1 minute.

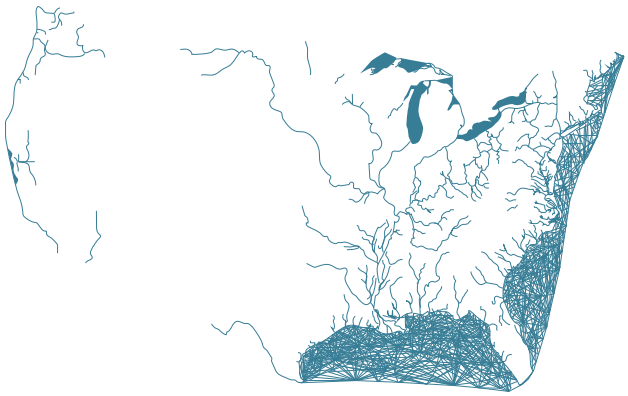
Richard Hornbeck of UChicago's Booth School of Business uses that simple story with his students to describe alternative ways of thinking about productivity. This distinction—between ratio productivity and aggregate productivity—helps in thinking about the central findings of a recent paper he coauthored with New York University's Martin Rotemberg, "Railroads, Reallocation, and the Rise of American Manufacturing." Hornbeck and Rotemberg show that many US counties were held back from expanding by market

Becker Friedman Institute
FOR ECONOMICS AT UCHICAGO

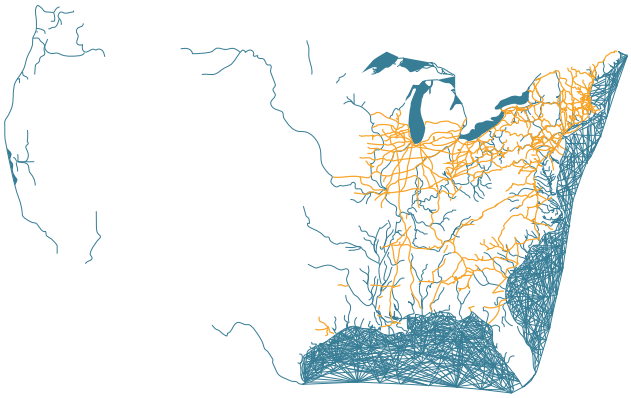
5757 S. University Ave.
Chicago, IL 60637
Main: 773.702.5599
bfi.uchicago.edu

Figure 1 · Waterways and Railroads, by Decade

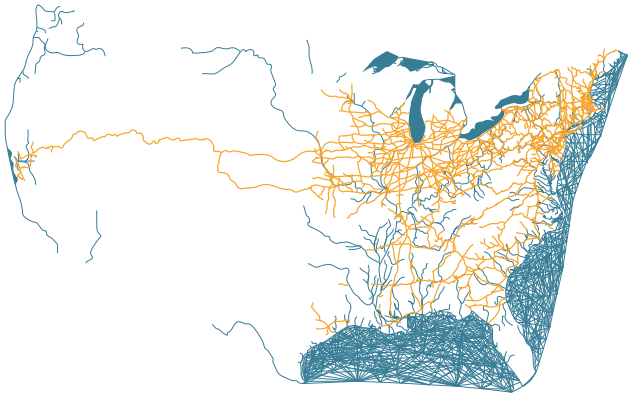
A. Waterways



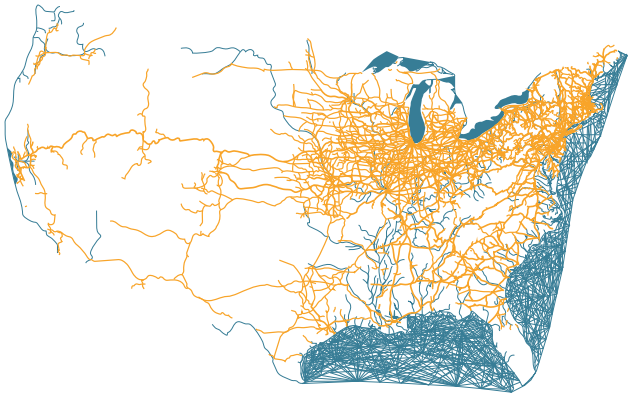
B. Waterways and 1860 Railroads



C. Waterways and 1870 Railroads



D. Waterways and 1880 Railroads



Notes: Panel A shows the waterway network: natural waterways (including navigable rivers, lakes, and oceans) and constructed canals. Panel B adds railroads constructed by 1860, Panel C adds railroads constructed between 1860 and 1870, and Panel D adds railroads constructed beween 1870 and 1880.

inefficiencies, and when these counties were encouraged to grow by the expanding railroad network, there were substantial gains in aggregate productivity that have been missed in previous analyses.

Efficiency unbound

The manufacturing sector in the United States expanded substantially in the latter half of the 19th century. This increase occurred alongside the expansion of the railroad network, as coast-to-coast and regional rail lines opened large domestic markets to new areas and to new commodity resources. How important was rail in the development of US manufacturing and other sectors? While railroads were a clear technological improvement in the transportation sector, and while they brought competition to water-based transportation, previous research has revealed only a relatively modest contribution from rail lines. The direct benefits of improved transportation were clear from reducing resources spent on transportation itself, but—in the aggregate—they were small compared to the general rate of economic growth.

This new research upends this conventional wisdom by incorporating the indirect benefits of rail transportation through the expansion in manufacturing and other sectors that were inefficiently small. In effect, railroads induced increased manufacturing activity in places that were previously held back by expensive modes of transportation. Many of these new places—whether from the existence of untapped natural endowments, commodities, or labor supply—proved particularly efficient at production.

Before describing the authors' findings in more detail, it is useful to revisit the above description of ratio vs. aggregate productivity. In the first

The authors estimate that absent an expanded rail network, US aggregate productivity would have been 25 percent lower in 1890, equaling about $3 billion or a 25 percent reduction in gross domestic product (GDP). Previous estimates put this loss at 3.2 or 2.7 percent of GDP.

case, economists refer to ratio productivity as technical efficiency (or total factor productivity), which is the amount of output you would expect to produce given increased inputs; in other words, the amount that is produced beyond expectations. For example, if a firm begins using more labor, capital, or land, you would expect output to increase. However, you may be surprised on the upside: that difference between expected and actual output is technical efficiency growth.

Now imagine that this same firm, which has increased its inputs, experiences an increase in the value of its output that is greater than the increase in the costs of its inputs – but its technical efficiency was unchanged. How could this be? This reflects increases in reallocative efficiency, which stems from inefficiencies in resource allocation in the economy. When markets are efficient, and technical efficiency is unchanged, increases in input usage lead to increases in the value of output that are equal to the increases in the cost of inputs (or marginal output equals marginal cost). When there are market inefficiencies, due to firms' inability to access enough capital or firms being able to price above marginal cost, then the value of the increased output can exceed the value of the increased inputs (marginal output is greater than marginal cost). In this case, increases in firm production contribute to an overall increase in aggregate productivity. The authors investigate how the expansion of the railroad network impacted both these forms of productivity – technical efficiency and reallocative efficiency – and find substantial impacts of the railroads through increases in reallocative efficiency.

To conduct their analysis, the authors employed US Census of Manufacturers' data from 1860, 1870, and 1880. This 20-year period was the primary focus of their research, though they extend some of their analyses to 1890 and 1900. At the time, census takers were charged to include information from all manufacturers with more than $500 in sales, including smaller operations run, for example, out of semi-permanent structures like sheds or other outbuildings. Further, these manufacturing data included the annual value of output, the annual cost of materials, the annual cost of labor, and the value of invested capital.

To determine the contributions of an expanded rail network, the authors measure how changes in the network affected market access for various counties. This market access reflects the degree to which a county's manufacturers had improved access to workers, consumers, and material inputs from the introduction of rail service. The authors' findings were clear: relative increases in county market access resulted in substantial increases in manufacturing productivity (roughly 13 percent for every one standard deviation increase in county market access from 1860 to 1880). These gains were driven by the increases in market access in marginally productive areas, in other words, from increases in reallocative efficiency. Imagine, for example, a particular county that was endowed with abundant natural resources, but productive firms could not get enough capital or were pricing substantially above their costs – the overall economy benefits when those firms expand production.

With such gains at a county level, what was the impact on aggregate productivity? The authors estimate that absent an expanded rail network, US aggregate productivity would have been 25 percent lower in 1890, equaling about $3 billion or a 25 percent reduction in gross domestic product (GDP). Previous estimates put this loss at 3.2 or 2.7 percent of GDP. Further, the authors' estimate a 43 percent annual social rate of return[1] on the $8 billion of capital invested in railroads in 1890. Only 8 percent of that social rate of return was captured by the railroads.

Much of this increase in aggregate productivity growth extends from an increase in national population. Absent railroads, had US aggregate population remained fixed in 1890, the real wages

[1]The social rate of return not only considers all direct benefits associated with the railroads, such as railroad profits and decreased resources spent on transportation, but also considers indirect benefits through increases in input usage (materials, labor, capital) whose marginal product was greater than their marginal cost.

CLOSING TAKEAWAY

Railroads allowed for increasing production in counties that were otherwise underutilizing inputs, or where the value marginal product of inputs (be they materials, capital, or labor) was greater than their marginal cost. In other words, counties that were inefficiently small experienced large gains after the arrival of rail lines. These potential gains from infrastructure are indeed largest when the economy is most inefficient, to which the authors cheekily note: "With great problems come great possibilities."

of workers would have declined by 34 percent. In addition, the gains from reallocating workers across counties would have been lost, amounting to lower aggregate productivity of about 5.3 percent.

Conclusion

The contribution of railroads to the economic growth of the United States, especially in the latter half of the 19th century, has long been debated by researchers. For many decades, due in part to the Nobel prize winning research by Robert Fogel, conventional wisdom held that while railroads delivered clear direct benefits to the economy, the aggregate effect of extending rail lines to new counties was relatively small compared with the general pace of economic growth.

This research, though, reveals how railroad lines linked domestic markets throughout the United States (as the accompanying maps reveal). Railroads allowed for increasing production in counties that were otherwise underutilizing inputs, or where the value marginal product of inputs (be they labor, capital, or materials) was greater than their marginal cost. In other words, counties that were inefficiently small experienced large gains after the arrival of rail lines.

The indirect benefits derived from the expanded economic activities that were generated by the expanded railroad network were much larger than the direct benefits derived from lower transportation costs, which is how researchers have traditionally measured the impact of railroads on the US economy in the second half of the 19th century. As noted above, US aggregate productivity would have been 25 percent lower in 1890 absent railroads, much higher than previous estimates of around 3 percent.

While the authors do not offer specific policy prescriptions based on their work, their results suggest that, at a minimum, policymakers—especially those in developing countries—should pay attention to all benefits derived (both direct and indirect) from improved transportation networks. These potential gains are indeed largest when the economy is most inefficient, to which the authors cheekily note: "With great problems come great possibilities."

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bfi.uchicago.edu/working-paper/2019146

ABOUT OUR SCHOLARS

Richard Hornbeck

V. Duane Rath Professor of Economics and Neubauer Family Faculty Fellow, Booth School of Business, University of Chicago

chicagobooth.edu/faculty/directory/h/richard-hornbeck

Written by David Fettig, BFI Senior Writer and Editor