“Axiom of Indispensability”

- The railroads were essential to the economic development of the United States.

“Escape from the confines of the past is never easy; it has been particularly difficult in this case. The evidence that must be re-examined is vast, and the economic significance of railroads is intricately intertwined with a host of social and political issues. … However, the required revisions are much more extensive than has been generally recognized.” (Fogel, p. 1)

Fogel’s Hypothesis To Be Tested:

Rail connections between the primary and secondary markets of the nation were a necessary condition for the system of agricultural production and distribution that characterized the American economy of the last half of the nineteenth century. Moreover, the absence of such rail connections would have forced a regional pattern of agricultural production that would have significantly restricted the development of the American economy.

Social Saving of the Railroads

- The difference between what it cost using railroads to ship the actual bundle of goods from primary to secondary markets, and what it would have cost using the next best alternative.

- Crucial idea of the "counterfactual."

Is it legitimate for the historian to consider alternative possibilities to events which have happened? . . . To say that a thing happened the way it did is not at all illuminating. We can understand the significance of what did happen only if we contrast it with what might have happened.

MORRIS RAPHAEL COHEN

How Does Fogel Simplify His Analysis?

- Uses only one year—1890.
- Considers only 4 commodities: corn, wheat, beef, and pork (accounted for 42% of income originating in agriculture in 1889).
- Compares distance only on a sample of routes.

A Key Technique

- Try to convince readers that any simplifications bias the results away from what you want to show.
- Examples from Fogel:
  - Using same routes and bundles of goods ignores the possibilities for re-optimization.
  - Using 1890 likely results in a larger estimate than in previous years.
- Were you convinced?

Fogel's Bottom Line

- Social saving of the railroad in the interregional transportation of agricultural goods was about 6/10 of 1% of GDP.

- The rest of the book goes on to consider social saving related to intraregional trade (including in the counterfactual the construction of additional canals). These effects are larger (but still not very large, in Fogel's view).

Relation between Social Saving and Economic Growth

- Fogel's calculation is fundamentally about levels.
- Could a small social saving nevertheless be important for growth?

Railroads and American Economic Growth: A "Market Access" Approach

Dave Donaldson and Rick Hornbeck
MIT and Harvard

Overview

Railroads spread throughout the US in the 19th century

- Became dominant form of freight transportation
- Enabled geographic shift in economic activity

What aggregate economic gains did railroads generate by decreasing transportation costs?

- That is: what is the economic impact of market integration?

This Paper

1. Propose a method to estimate aggregate impacts in the presence of cross-spatial spillover effects
   - Workhorse gravity model with (or without) factor mobility suggests counties value "market access", not "railroad access"
   - Construct network database with possibilities to trade via railroads, waterways, wagons; use this to construct lowest-cost routes and hence market access
2. Regress county land values on county market access
   - Changes from 1870 to 1890
   - Identifying variation not local railroad density (not even local market access, necessarily)
3. Calculate losses under Fogel's counterfactual scenarios
   - No railroads in 1890
   - Replace railroads in 1890 with extended canal network

Model Introduction

Model of trade among many counties

- How do changes in the railroad network affect each county?

In general equilibrium, (pecuniary) spillovers among counties:

- Competition in goods markets
- Competition in factor markets

We use a gravity model (with factor mobility) to guide micro-level empirical work:

- Estimate relative impacts, in the presence of spatial spillovers
- Estimate aggregate impacts

Theory

Donaldson and Hornbeck (2016) derive market access from an Eaton and Kortum (2002) supply-side model with one immobile factor (land). Let's start directly with two key results.

The consumer price in destination (d) is

$$(P_d)^{-\theta} = \kappa_1 \sum_o \left(A_0 (q_o^\alpha w_o^\gamma)^{-\theta} \right) \tau_{od}^{-\theta} \equiv CMA_d \tag{1}$$

which is a weighted-sum of productivity adjusted costs in each supplying origin, weighted by the trade costs τ_{od}.

The value of exports from o to d follow the gravity equation

$$X_{od} = \kappa_1 A_0 (q_o^\alpha w_o^\gamma)^{-\theta} \tau_{od}^{-\theta} CMA_d^{-1} Y_d. \tag{2}$$

Trade depends on o's supply costs and d's CMA and income. Note that $Y_o = \sum_d X_{od}$ when goods markets clear.

An approximation

Firm market access at the origin o is related to CMA at d

$$FMA_o \equiv \sum_d \tau_{od}^{-\theta} CMA_d^{-1} Y_d \tag{3}$$

In fact, both are the same up to a multiplicative constant (they are proportional).

Hence they speak of "market access" in general and write

$$MA_o = \kappa_3 \sum_d \tau_{od}^{-\theta} MA_d^{-\frac{-(1+\theta)}{\theta}} N_d \approx \sum_{d \neq o} \tau_{od}^{-\theta} N_d \tag{4}$$

All the GIS work in the paper is about correctly proxying for $\tau_{od}^{-\theta}$.

Model to empirics

Using the full structure, they derive an equation for land prices q_0

$$\ln q_o = \kappa_4 + \left(\frac{1}{1+\alpha\theta}\right)\ln\left(\frac{A_0}{L_0}\right) + \left(\frac{1+\gamma}{1+\alpha\theta}\right)\ln MA_o. \tag{5}$$

Note L_o is land, not labor. All endogenous characteristics are summarized by MA_o and only A_o is unobserved. With labor mobility, population at o is also endogenous to MA_o.

Immobile land in o is more valuable if county o has access to large noncompetitive markets and/or cheap labor which wants to migrate.

They translate this into the following empirical equation

$$\ln V_{ot} = \beta \ln MA_{ot} + \delta_o + \delta_{st} + f(x_o, y_o)\delta_t + e_{ot} \tag{6}$$

where δ_o are county FEs, δ_{st} are state-year FEs and $f(x_o, y_o)$ is a cubic polynomial in latitude and longitude.

$$MA(\mathbf{N})_c = \sum_{d \neq c} (\tau_{cd})^{-\theta} N_d$$

Empirical Definition of "Market Access"

For value of θ:

- Baseline: $\theta = 3.8$, as in Donaldson (2014)
- Explore robustness in range $\theta = [1, 12.86]$

Similar to Harris (1954) concept of "market potential":

$$MA_c = \sum_{d \neq c} (\text{distance}_{cd})^{-1} N_d$$

Trade Cost Estimates (τ_{cdt} to feed into MA_{ct})

Build network database of all transportation modes (rail, river, canal, ocean/lake, wagon).

- Navigable water routes from Fogel (1964)
- Railroad maps in 1870 and 1890
- Transshipment points (rail-wagon, rail-water, harbors, etc)
- County-to-network: average over 200 random points in county

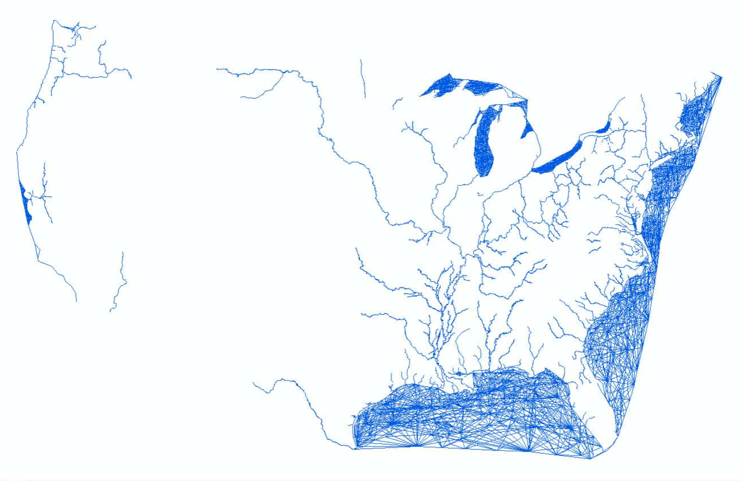
Transportation rates per ton mile (Fogel 1964)

- 0.63 cents for railroads
- 0.49 cents for rivers (including insurance and time costs)
- 23.1 cents for wagons
- 50 cents for transshipment

Solve for lowest-cost route between every county c and d in every t

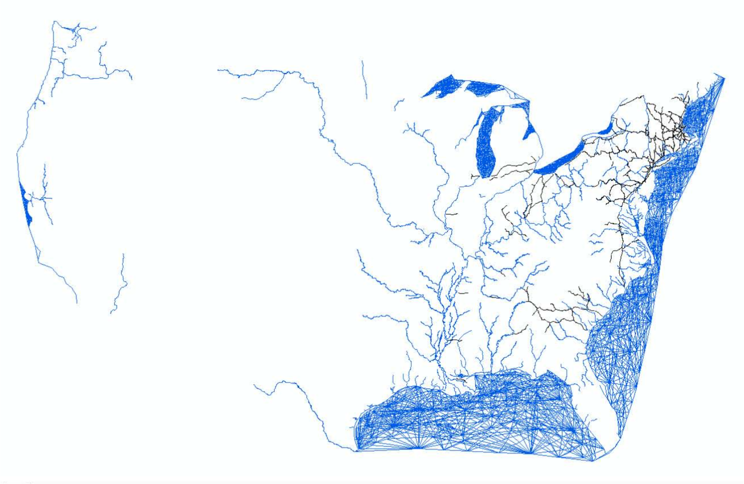
Change in Transportation Network

Waterways and No Railroads



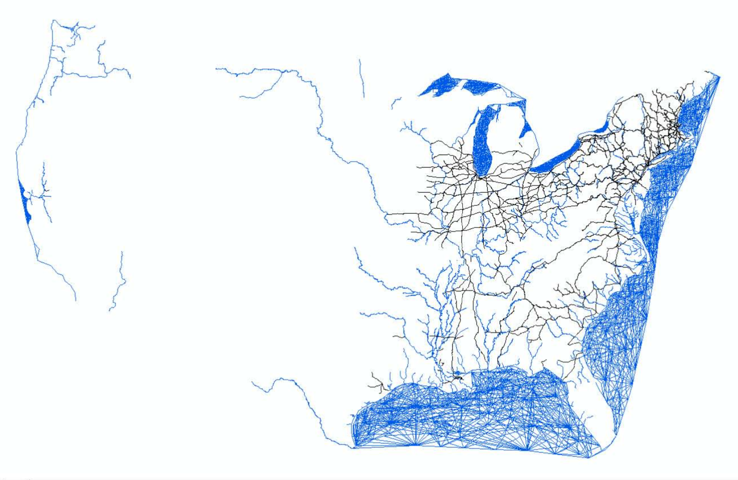
Change in Transportation Network

Waterways and 1850 Railroads



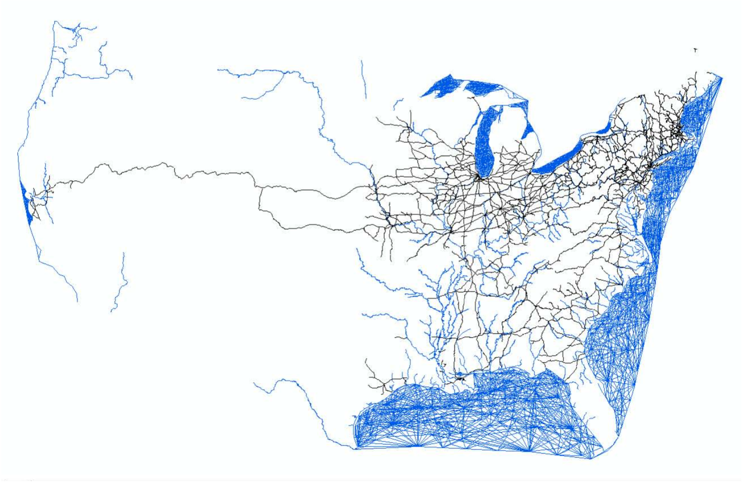
Change in Transportation Network

Waterways and 1860 Railroads



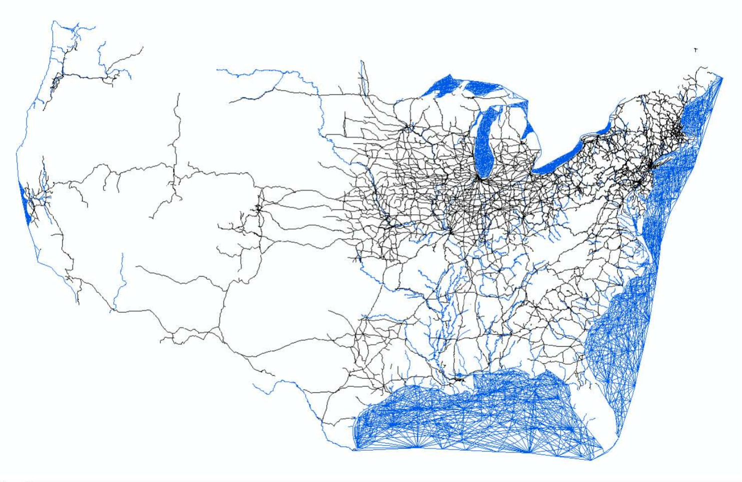
Change in Transportation Network

Waterways and 1870 Railroads



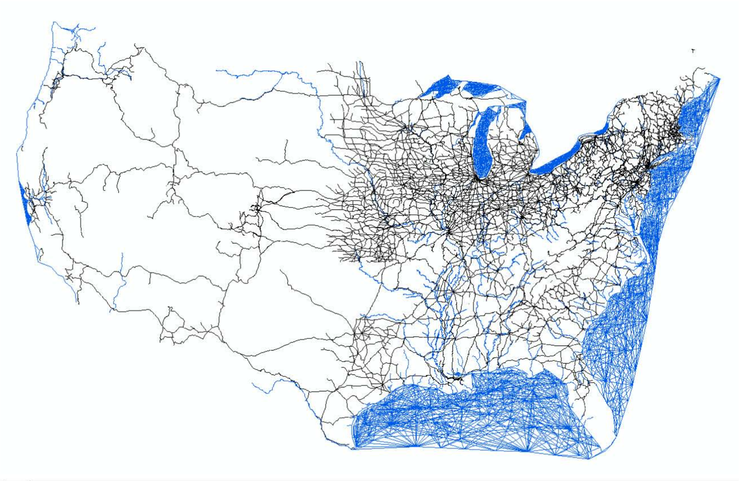
Change in Transportation Network

Waterways and 1880 Railroads



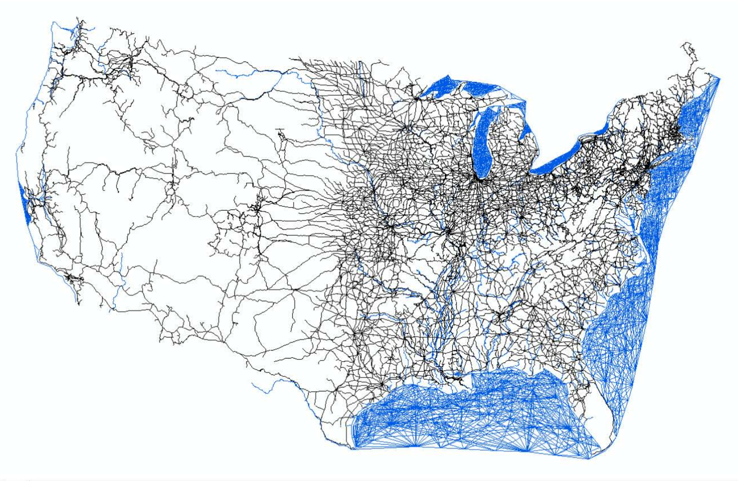
Change in Transportation Network

Waterways and 1887 Railroads



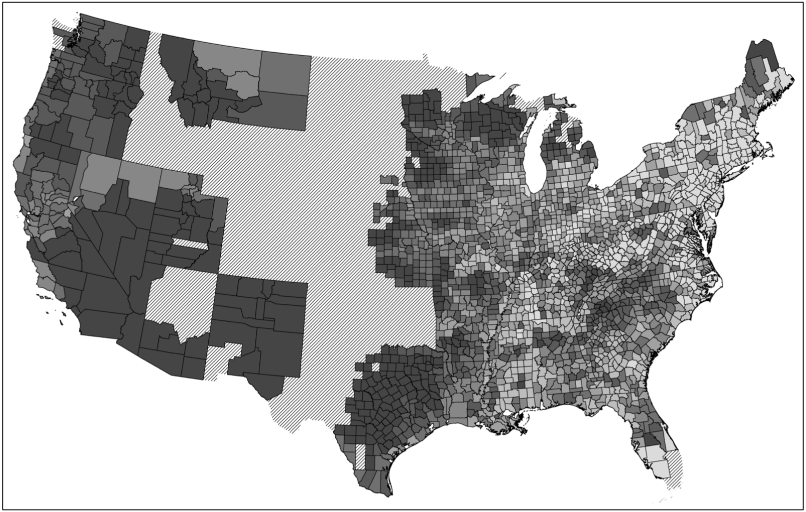
Change in Transportation Network

Waterways and 1911 Railroads



Market Access Variation

Figure 3. Calculated Changes in Market Access from 1870 to 1890, by County



Notes: This map shows the 2,327 sample counties, shaded according to their calculated change in market access from 1870 to 1890. Counties are divided into seven groups (with an equal number of counties per group) and darker shades denote larger changes in market access.

Estimating Equation

Estimating the elasticity of land value to market access:

$$\ln V_{ct} = \beta \ln(MA_{ct}) + \alpha_c + \lambda_{s(c)t} + \gamma_t f(x_c, y_c) + \varepsilon_{ct}$$

Estimation details:

- Balanced panel of 2,327 counties (1890 borders)
- Standard errors clustered by state
- Regression weighted by value of agricultural land in 1870

Market Access Results

$$\ln V_{ct} = \beta \ln(MA_{ct}) + \alpha_c + \lambda_{s(c)t} + \gamma_t f(x_c, y_c) + \varepsilon_{ct}$$

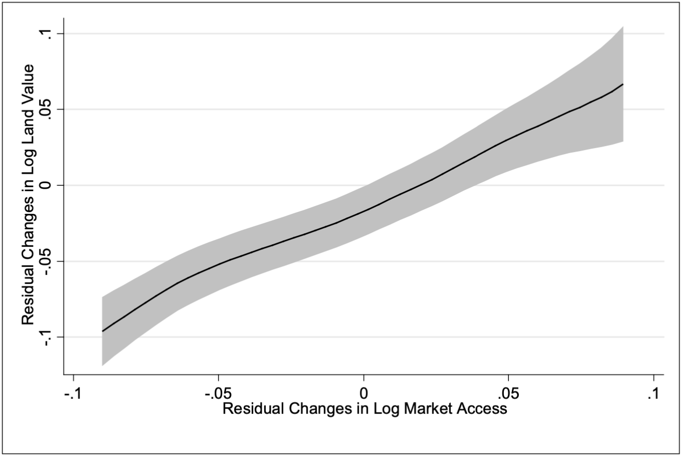
Table 1. Estimated Elasticity of Land Value to Market Access

	Log Value of Agricultural Land				
	Baseline Specification	MA calibrated using model	MA with fixed (1870) population	MA with 100-mile Buffer Only	Unweighted
	(1)	(2)	(3)	(4)	(5)
Log Market Access	1.11	1.17	1.11	1.04	1.07
	(0.14)	(0.15)	(0.14)	(0.14)	(0.27)
Number of Counties	2,327	2,327	2,327	2,327	2,327
R-squared	0.62	0.63	0.62	0.62	0.61

Market Access Results: Nonparametric

$\ln V_{ct} = f(\ln(MA_{ct})) + \alpha_c + \lambda_{s(c)t} + \gamma_t f(x_c, y_c) + \varepsilon_{ct}$

Figure 4. Local Polynomial Relationship Between Changes in Log Land Value and Log Market Access, 1870 to 1890



Notes: Residual changes in sample counties are calculated by regressing changes in the indicated variable on state fixed effects and county longitude and latitude, as in equation (12). This figure then plots the local polynomial relationship between changes in log land value and changes in log market access, based on an Epanechnikov kernel function with bandwidth 0.04. The shaded region reflects the 95% confidence interval.

Counterfactuals: Aggregate Impact of Railroads

Implied cost of losing railroads:

- \$5.2 billion (64% of agricultural land value)
- \$408 million annually (3.4% of GNP)

Replacing railroads with canal network proposed by Fogel (1964):

- Still loss of 56% of ag. land value
- Canal benefits greater than costs, without railroads

Conclusion

Goal has been to estimate the aggregate impact of US railroads from relative spatial comparisons.

Key to approach:

- Workhorse gravity model, with factor mobility $\Rightarrow$ counties value market access, not railroad access
- Market access amalgamates all spatial spillovers into a single index. Attractive for spatial research designs.
- Estimate stable effect of changes in market access (driven by railroads) on changes in price of immobile factor (land).

Findings:

- Estimated cost of removing railroads is moderately larger than Fogel's estimate: 64 % of ag. land value
- Large impacts on worker utility and total population
- Little ability to mitigate losses through extended canals or improved roads