# Impact of Railroad Access on Land Value in Nineteenth Century America.

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## Abstract

This research studies whether the benefits of rail transport over water transport were large enough to influence agricultural land value in nineteenth century America. Two time periods are identified where one mode of transportation was more dominant than the other. Monte Carlo techniques are employed to test the difference between the annual growth rate of land value in the two periods. Results of the study reveal that rail transport did not significantly influence land value.

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# 1 Introduction

Access to transportation brings appreciable gains to land value. This observation is true even in modern times, when there are substantially more factors affecting land valuation. Following the similar argument, a more efficient mode of transportation would bring even greater appreciation in land value.

The impact of transportation was particularly great in nineteenth century America. The nineteenth century transportation revolution made it possible for the West to sell its agricultural surplus in the higher priced markets of the East. This revolution started with building of canal systems, and then was taken over by railroad building.

Railroads have several advantages over water transport; it is more flexible, reliable and fast. Moreover, rail is available during the winter season, unlike water transport, which could come to standstill due to freezing conditions. The superiority of railroads is evident from the observation that railroads were built parallel to water routes in the nineteenth century and ultimately the railway triumphed over water transport.

But are the advantages of railroads big enough to be reflected in land prices? Did the transportation revolution brought about by railroads lead to the greater appreciation of land value compared to canal transport? In other words, does the particular mode of transportation matter for the valuation of agricultural land? The objective of this research is to assess whether the annual growth of the value of agricultural land during the railroad era was significantly greater than the water transport era.

Until 1860, canal and railroad construction were undertaken simultaneously. However, after 1860 the nation essentially focused on railroad expansion. In 1860, the miles served by railways was around 30,000; by 1890 it had grown to 200,000. Before 1860 only water transport had national character, while railroad had local/regional character due to several track gauges used by the railroads. By 1890, the track gauge was standardized, giving railways a national character as a mode of transportation, *Figure* (1). *Figure (*2*) to (*5*)* provide a visual illustration of the transport situation in the antebellum economy. Fishlow (1965) finds that before 1860, railroad was in its infancy and concludes that future generations enjoyed more by the development of railways than the antebellum economy. Literature also argues that by 1890 the US railroad system was quite well developed. Therefore, I will call the period before 1860 as water transport era and period after 1860 as railroad transport era.

To verify the effect of the railroads on land value, it is important to quantitatively isolate the effects of important interrelated economic variables. However, the paucity of data makes multivariate approach infeasible. Therefore, I propose to test whether the annual rate of growth of agricultural land value was significantly greater during the railroad era (1860 to 1890) compared to water transport era (1850 to 1860). If it is found to be significantly greater then, to some extent, the railroad contributed to such an outcome. Thus the hypothesis to test is the following,

$$H_O : g_{rail} - g_{water} = 0 \tag{1}$$

$$H_A : g_{rail} - g_{water} \neq 0 \tag{2}$$

where $g_{rail}$ is per year growth rate of the value of land from 1860 to 1890 and $g_{water}$ is per year growth rate of the value of land from 1850 to 1860.

However, we can only observe a few data points that are not enough to compute standard error of the test statistic for the above hypothesis. Therefore, we cannot test the above hypothesis empirically. Hence, to test whether the annual growth rates were significantly different during the two periods, I employed Monte Carlo analysis. I undertook this exercise at the state and county level, for which the data is available.

## 2 Literature Review

The railroad system is of considerable interest to economists. Fogel (1964) started the debate, *whether railroads were indispensable for American economic development in the nineteenth century*, and even after forty years this debate is unsettled. He measured the social savings by railroad, i.e., savings by shipping goods via railroad as opposed to next best alternative. Fishlow (1965) measured antebellum expansion of the railroad focusing on whether railroad was build ahead of demand and on total factor productivity growth. Both these studies find that economic gains produced by railroad were significant, but railroad do not deserve the label *indispensable*, as Fogel puts it.

Another way to look at railroad influence on a region is by measuring railroad impact on land value. Fogel (1960) find approximate increase of $15,630,000 in the value of land of 80 miles due to the Union Pacific Railroad construction in 1880. Coffman and Gregson (1998) find that Knox County in Illinois reaped large capital gains, in terms of appreciation of land value, due to the development of the railroad. Craig, et. al (1998) undertake county level estimation and find that in 1850 average farm values in counties with water access were $2.68 per acre greater than counties without such access and $1.80 greater with rail access. In 1860 the respective figures were $3.75 and $1.35. They conclude that transportation access yielded substantial gains to land valuation and water transportation had a *larger* impact on land value than railroad. Haines and Margo (2006) use a pooled sample of counties from 1850 and 1860 to investigate the impact of gaining access to railroad. They find that rail access increased urbanization, reduced share of improved acreage in total land area, had a positive effect on value of land and a negative effect on the ratio of farm wages to land prices. The present study tries to compare appreciation of land valuation over a period of time, which was marked by the expansion of different modes of transportation.

# 3 Methodology

To model value of land, I first compute annual growth rate of land value using the method of difference of logs, and then introduce uncertainty in its valuation, i.e., land value has stochastic growth. Since uncertainty is not observable I assume it to be IID normal. In this setup I employ Monte Carlo analysis to test whether there is significant difference in appreciation of land value during the two period.

## 3.1 Model

In the data we can observe land value in the initial year $V_t$ and in the final year $V_{t+k}$, where k is time difference in years between the two observations. Using these two observations annual growth rate is computed as

$$g = \frac{1}{k}\left(\ln(V_{t+k}) - \ln(V_t)\right) \tag{3}$$

where ln is natural log, $V_{t+k}$ is value of land at the end of the period, $V_t$ is the value of land at the beginning of the period and $g$ is per year growth rate of land value.

Rearranging and taking antilog, we obtain

$$\begin{aligned} gk &= (\ln(V_{t+k}) - \ln(V_t)) && (4) \\ V_{t+k} &= e^{gk}V_t && (5) \end{aligned}$$

However, we live in an uncertain world, every year there is a random shock affecting land value, i.e., time heterogeneity. I assume random shock is IID normal with mean of 0 and standard deviation of 0.5, this means that land value has stochastic growth. That is, land value can be written as the an autoregressive process of order one, as follows

$$V_{t+1} = e^{g} V_t + \epsilon_t \tag{6}$$

where $\epsilon$ is error term, it is IID Normal with mean 0, and standard deviation 0.5.

## 3.2 Monte Carlo Analysis

In Monte Carlo analysis, a run consists of N trial, where N is 10,000 for a state and 1000 for a county. Each trial will compute an estimate of exponential of the annual growth rate of land value (i.e. coefficient of $V_t$ in equation (6)) during the period under consideration.

For the period 1850 to 1860, in each trial[1]:

1. Given $V_{1860}$ and $V_{1850}$, calculate per year growth rate, $g_{water} = \frac{1}{10}(\ln(V_{1860}) - \ln(V_{1850}))$
2. Draw a sequence of $\epsilon_i$ (for i=1 to 10) from IID Normal distribution with mean of 0 and standard deviation of 0.5.
3. Compute a sequence of land values $V_j$ (for j=1851 to 1860) using the growth rate from step (1) and $\epsilon_i$'s from step (2), as follows, $V_{1850+i} = e^{g_{water}} V_{1850+i-1} + \epsilon_i$ (for i=1 to 10).
4. Regress value of land (obtained in step (3)) on its lagged value (i.e., regress $V_j$ on $V_{j-1}$ (for j=1851 to 1860)) to obtain OLS[2] estimate $e^{\hat{g_{water}}}$.

Repeat the above steps N times to obtain a sequence $e^{\hat{g_{water}}^{r}}$ for r=1 to N. The Monte

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[1] where $V_{1850}$,$V_{1860}$ and $V_{1890}$ are the values of land observed in the data for the respective year.

[2] Ordinary Least Square.

Carlo estimate of exponential of growth rate of land value is

$$e^{\hat{\hat{g}}_{water}} = \frac{\sum\limits_{r=1}^{N} e^{\hat{g}_{water}^{\,r}}}{N} \tag{7}$$

For the period 1860 to 1890, in each trial:

1. Given $V_{1890}$ and $V_{1860}$, calculate per year growth rate, $g_{rail} = \frac{1}{30}(\ln(V_{1890}) - \ln(V_{1860}))$
2. Draw a sequence of $\epsilon_i$ (for i=1 to 30) from IID Normal distribution with mean of 0 and standard deviation of 0.5.
3. Compute a sequence of land values $V_j$ (for j=1861 to 1890) using the growth rate from step (1) and $\epsilon_i$'s from step (2), as follows, $V_{1860+i} = e^{g_{rail}} V_{1860+i-1} + \epsilon_i$ (for i=1 to 30).
4. Regress value of land (obtained in step (3)) on its lagged value (i.e., regress $V_j$ on $V_{j-1}$ (for j=1861 to 1890)) to obtain OLS estimate $e^{\hat{g}_{rail}}$.

Repeat the above steps N times to obtain a sequence $e^{\hat{g}_{rail}^{\,r}}$ for r=1 to N. The Monte Carlo estimate of exponential of growth rate of land value is

$$e^{\hat{\hat{g}}_{rail}} = \frac{\sum\limits_{r=1}^{N} e^{\hat{g}_{rail}^{\,r}}}{N} \tag{8}$$

Given the sequence of $e^{\hat{g}_{rail}^{\,r}}$ and $e^{\hat{g}_{water}^{\,r}}$, I can test the following hypothesis[3]

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[3] Note that testing

$$H_O : e^{g_{rail}} - e^{g_{water}} = 0$$
$$H_A : e^{g_{rail}} - e^{g_{water}} \neq 0$$

is equivalent to testing

$$H_O : g_{rail} - g_{water} = 0$$
$$H_A : g_{rail} - g_{water} \neq 0$$

Because exponential is continuous and monotonic function.

$$H_O : e^{g_{rail}} - e^{g_{water}} = 0 \tag{9}$$

$$H_A : e^{g_{rail}} - e^{g_{water}} \neq 0 \tag{10}$$

The test statistic for the above hypothesis is

$$zstat = \frac{mean(e^{g_{rail}} - e^{g_{water}})}{std(e^{g_{rail}} - e^{g_{water}})} \tag{11}$$

which is distributed standard Normal[4].

# 4 Data

Pressley and Scofield provide county level data for the value of agricultural land from 1850 to 1959. Using price of wheat per bushel from *Historical Statistics*, I measure value of agricultural land in terms of bushels of wheat. The *Statistical Abstract of the United States (1891)* reports data for a number of railroad miles in operation in each state. *Table*(1) reproduces this data for the reader's convenience.

# 5 Results

Railroad miles in operation for each state during 1860 and 1890 is presented in *Figure* (6). It is evident that railroad milage increased quite substantially for most states, for example Arkansas railroad miles increased over 59 times by 1890 compared to 1860. In California, it increased over 187 time during the same period. Texas, Iowa, Michigan and Wisconsin also registered impressive increase, over 28, 12, 9 and 6 times respectively, during the same

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[4] mean() is a mean operator and std() is an operator for standard deviation.

period of thirty years. To better understand railroad expansion, in *Figure* (7) I report the increase in railroad miles from 1890 to 1860. Some of the big gainers of railroad are Texas and Iowa, among others.

By observing *Figure* (6) and (7) we can agree that railroad expansion increased impressively for some states. Therefore, if railroad can bring substantial gains to land value then land value should significantly increase during post-1860 compared pre-1860 for these states. To verify this, I compute zstat as described in equation (11), and plot it in *Figure* (8) for each state. The annual rate of growth of agricultural land value in post-1860 is significantly greater than the annual rate of growth of agricultural land value in pre-1860 at five percent confidence level if zstat is greater than 1.95.

It is evident from *Figure* (8) that only a few states experienced significantly greater increase in land value during post-1860 compared to pre-1860, namely Connecticut, Massachusetts and Rhode Island, all other states did not share this experience; as the difference in annual growth rate of land value during post-1860 and pre-1860, for the states other than the above three, is not significantly greater at 5 percent level of confidence (i.e. zstat is less than 1.95).

Railroad milage increased in Connecticut, Massachusetts and Rhode Island by 409.79, 833.25 and 116.43 miles respectively, during 1860 to 1890, *Table* (1). This does not compare well with the increase registered by some other states, for example Illinois, Iowa and Texas experienced an increase of 10114.78, 8436.02 and 8754.31 railroad miles respectively, in the same period. If the effect of railroad was strong enough to significantly influence land value, then it is expected that states that experienced large railroad expansion in post-1860 would have had a significantly greater appreciation in land value in post-1860 relative to pre-1860. That is, for such states, the difference in per year growth rate of land value in post-1860 will be significantly greater than per year growth rate of land value in pre-1860. But this difference is not significantly greater for the states that experienced large railroad expansion. Consider, for example, Michigan and Missouri, these two states (among others) experienced large increase in railroad milage from 1860 to 1890, 6325.96 and 5336.18 respectively; however, their per year rate of growth of land value in post-1860 is not significantly greater from the appreciation they registered in pre-1860, their respective zstats are 0.38 and 0.07, *Table* (2).

The significant appreciation in land value for Connecticut, Massachusetts and Rhode Island in post-1860 as compared to pre-1860, their respective zstats are 3.5, 5, and 2.4; with a relatively moderate increase in railroad from 1860 to 1890, implies that their must be *other* factors positively affecting land price in these three states.

There are some states that experienced large increase in railroads but actually saw a decline in land value, although insignificant. For example Illinois and Indiana had large increase in railroad milage from 1860 to 1890, but experienced a decline in land value in post-1860 compared to pre-1860, although insignificant at 5 percent level of confidence, zstat is -1.5 and 1.4 respectively. Louisiana is the only state in the sample that experienced a significant decline in per year growth rate of land value in post-1860 compared to pre-1860, its zstat is -2.1; it had increase in railroad milage of 1461.5 miles in the same period. However, the decline in land value cannot be attributed to railroad development, it must be due to *other* factors.

As a robustness check, the appreciation of land value in post-1860 relative to pre-1860 (that is zstat, as described in equation (11)), is computed at county level to make sure no *outlier county*[5] is affecting the result for the state. No such evidence is found[6]. Therefore, as far as the appreciation of land value is concerned railroad did not bring impressive gains over water transport.

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[5] Outlier county would be the one that had a huge decline in land value (while other counties had significant increase in land value) so that the state level statistic (zstat) would be dominated by such a county. Producing insignificant increase in post-1860 compared to pre-1860 in agricultural land value at state level.

[6] County level estimates are available upon request.

# 6 Conclusion

Using a Monte Carlo method, this research studies the contribution of railroads compared to water transport towards the appreciation of land value; by examining the annual growth rate of land value during post-1860 (railroad era) compared to pre-1860 (water transport era), for the selected American states. The railroad, considered as a distinct innovation from the pre-existing modes of transportation, did not provide significant appreciation in agricultural land value relative to water transport, for the group of states examined in this study. However, it is not to say that transportation is not important for land value. In fact transportation, in general, greatly influences land value, as previous literature has found. But particular mode of transportation and subsequent increase in access would not bring substantial gains to land value.

# References

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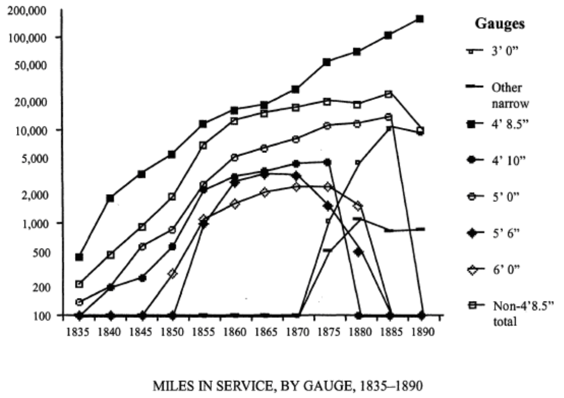
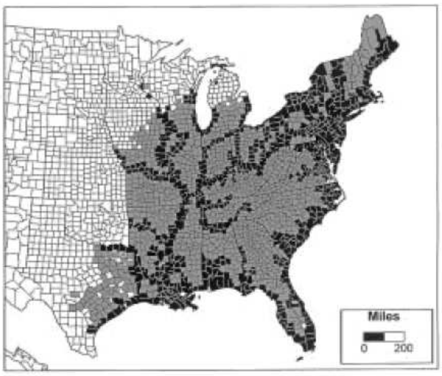
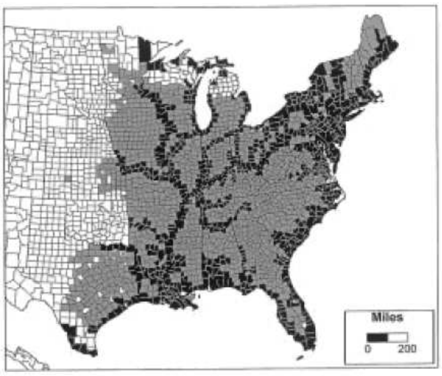


Figure 1: Source: Douglas (2000)



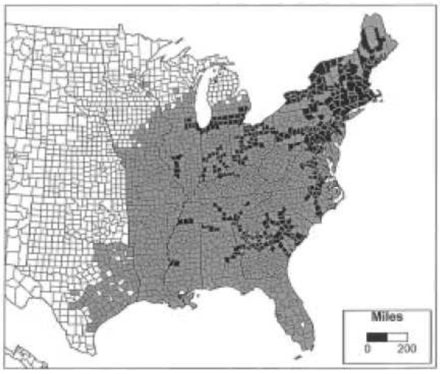
Counties with water access in 1850.

Figure 2: Counties with water access in 1850. Source: Craig, et al. (1998)



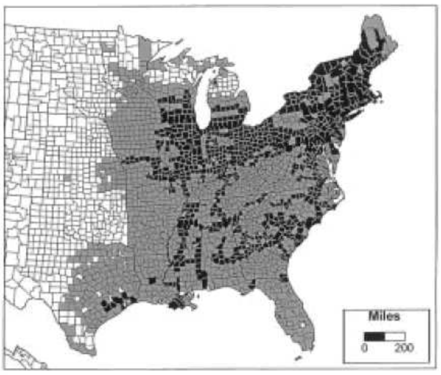
Counties with water access in 1860.

Figure 3: Counties with water access in 1860. Source: Craig, et al. (1998)



Counties with rail access in 1850.

Figure 4: Counties with rail access in 1850. Source: Craig, et al. (1998)



Counties with rail access in 1860.

Figure 5: Counties with rail access in 1860. Source: Craig, et al. (1998)

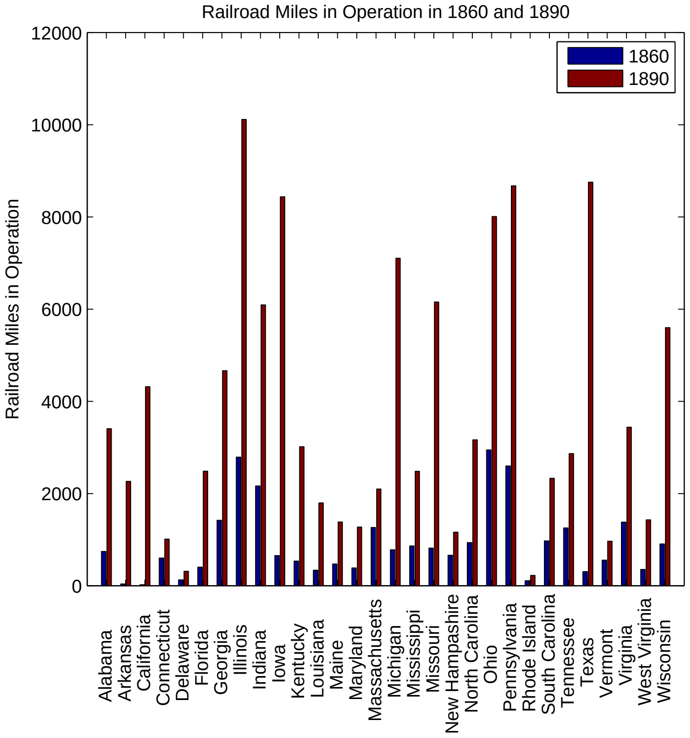


Figure 6: Number of Miles of Railroad in Operation.

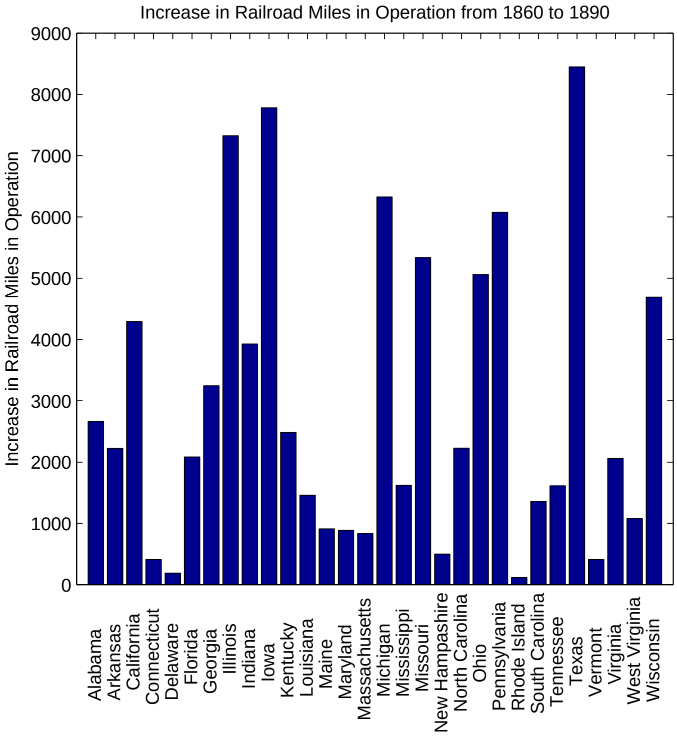


Figure 7: Increase in Number of Miles of Railroad in Operation From 1860 to 1890.

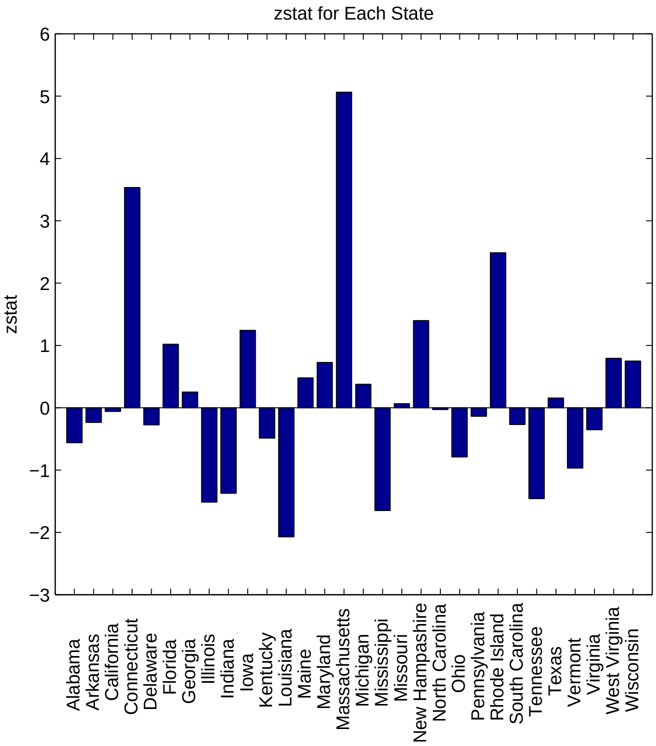


Figure 8: zstat (as described in equation (11)) for Each State.

| State | miles1860 | miles1890 | Increase in miles (= miles1890-miles1860) |
|---|---|---|---|
| Alabama | 743 | 3406.49 | 2663.49 |
| Arkansas | 38 | 2262.3 | 2224.3 |
| California | 23 | 4315.21 | 4292.21 |
| Connecticut | 601 | 1010.79 | 409.79 |
| Delaware | 127 | 314.54 | 187.54 |
| Florida | 402 | 2485.85 | 2083.85 |
| Georgia | 1420 | 4663.86 | 3243.86 |
| Illinois | 2790 | 10114.78 | 7324.78 |
| Indiana | 2163 | 6090.66 | 3927.66 |
| Iowa | 655 | 8436.02 | 7781.02 |
| Kentucky | 534 | 3015.98 | 2481.98 |
| Louisiana | 335 | 1796.5 | 1461.5 |
| Maine | 472 | 1381.41 | 909.41 |
| Maryland | 386 | 1272.19 | 886.19 |
| Massachusetts | 1264 | 2097.25 | 833.25 |
| Michigan | 779 | 7104.96 | 6325.96 |
| Mississippi | 862 | 2482.28 | 1620.28 |
| Missouri | 817 | 6153.18 | 5336.18 |
| New Hampshire | 661 | 1161.01 | 500.01 |
| North Carolina | 937 | 3165.44 | 2228.44 |
| Ohio | 2946 | 8007.54 | 5061.54 |
| Pennsylvania | 2598 | 8674.04 | 6076.04 |
| Rhode Island | 108 | 224.43 | 116.43 |
| South Carolina | 973 | 2328.37 | 1355.37 |
| Tennessee | 1253 | 2866.7 | 1613.7 |
| Texas | 307 | 8754.31 | 8447.31 |
| Vermont | 554 | 964.59 | 410.59 |
| Virginia | 1379 | 3438.24 | 2059.24 |
| West Virginia | 352 | 1429.39 | 1077.39 |
| Wisconsin | 905 | 5596.13 | 4691.13 |

Table 1: Number of Miles of Railroad in Operation, Source: US Statistical Abstract (1891).

Table-2 shows land value in various years, exponent of growth rate and Monte Carlo estimates for various states[7]

1. landvalue1850 is average value (in bushels of wheat) of farmland and buildings per acre in 1850.
2. landvalue1860 is average value (in bushels of wheat) of farmland and buildings per acre in 1860.
3. landvalue1890 is average value (in bushels of wheat) of farmland and buildings per acre in 1890.
4. $e^{g_{canal}} = exp(\frac{1}{10}\,(ln(landvalue1860) - ln(landvalue1850)))$
5. $e^{g_{rail}} = exp(\frac{1}{30}\,(ln(landvalue1890) - ln(landvalue1860)))$
6. $e^{\hat{\hat{g}}_{canal}}$ is Monte Carlo estimate as described in equation (7).
7. $e^{\hat{\hat{g}}_{rail}}$ is Monte Carlo estimate as described in equation (8).
8. zstat is Monte Carlo estimate as described in equation (11).

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[7] Analogous data and estimates at county level are available on request.

| State | landvalue1850 | landvalue1860 | landvalue1890 | $e^{g}canal$ | $e^{g}rail$ | $e^{g}\hat{\hat{canal}}$ | $e^{g}\hat{\hat{rail}}$ | zstat |
|---|---|---|---|---|---|---|---|---|
| Alabama | 3.936947328 | 5.565722219 | 6.401518419 | 1.015149805 | 1.002027435 | 1.0229 | 0.9967 | -0.563 |
| Arkansas | 4.720965309 | 6.079789775 | 9.111651962 | 1.011046341 | 1.005874137 | 1.0172 | 1.0081 | -0.2364 |
| California | 2.156862745 | 5.868044998 | 47.52729608 | 1.044425624 | 1.030744808 | 1.0761 | 1.0714 | -0.0611 |
| Connecticut | 23.87799564 | 23.56001486 | 48.42646114 | 0.999417939 | 1.010484824 | 0.9983 | 1.024 | 3.5338 |
| Delaware | 18.43137255 | 23.91304348 | 48.55491329 | 1.011371891 | 1.010306023 | 1.0259 | 1.0236 | -0.2754 |
| Florida | 5.490196078 | 6.688963211 | 25.45865795 | 1.008613984 | 1.019537633 | 1.0129 | 1.0439 | 1.0179 |
| Georgia | 3.617963314 | 4.095075187 | 7.824411494 | 1.005394269 | 1.009417057 | 0.996 | 1.0107 | 0.2505 |
| Illinois | 5.701960784 | 12.19599312 | 44.22245917 | 1.033570481 | 1.018822475 | 1.075 | 1.0433 | -1.5168 |
| Indiana | 7.851662404 | 14.24101845 | 42.46379514 | 1.02619516 | 1.015941659 | 1.059 | 1.0366 | -1.3726 |
| Iowa | 5.490196078 | 6.771713271 | 31.88439306 | 1.009152703 | 1.022682748 | 1.0144 | 1.0517 | 1.2423 |
| Kentucky | 7.975150456 | 10.98814229 | 20.79961464 | 1.014015853 | 1.0092805 | 1.0296 | 1.0201 | -0.4901 |
| Louisiana | 11.79808093 | 14.94837865 | 12.62042389 | 1.010331275 | 0.997552329 | 1.0226 | 0.9932 | -2.0728 |
| Maine | 8.347338936 | 9.679323234 | 19.24515471 | 1.006450409 | 1.009998872 | 1.0119 | 1.0214 | 0.4794 |
| Maryland | 14.15499533 | 19.61082396 | 63.35260116 | 1.014259319 | 1.017120525 | 1.0324 | 1.0396 | 0.726 |
| Massachusetts | 31.05882353 | 32.5083612 | 81.23314066 | 1.001982971 | 1.013346215 | 1.0043 | 1.0309 | 5.0629 |
| Michigan | 8.235294118 | 11.27027198 | 32.9688697 | 1.013718779 | 1.015660347 | 1.0287 | 1.0356 | 0.3756 |
| Mississippi | 4.091503268 | 7.819167339 | 8.53361728 | 1.028527081 | 1.001266557 | 1.0583 | 0.9989 | -1.65 |
| Missouri | 4.447058824 | 6.847386024 | 21.93515959 | 1.018921988 | 1.016996694 | 1.0353 | 1.0376 | 0.0658 |
| New Hampshire | 12.76292335 | 12.76983886 | 22.70099842 | 1.000023526 | 1.008363431 | 0.9989 | 1.0184 | 1.399 |
| North Carolina | 2.833333333 | 4.351670319 | 9.582265658 | 1.018810562 | 1.011492612 | 1.0198 | 1.0177 | -0.0298 |
| Ohio | 14.17052214 | 20.90113111 | 52.80249399 | 1.017021639 | 1.013506555 | 1.0388 | 1.0311 | -0.7906 |
| Pennsylvania | 21.17647059 | 28.02270194 | 62.56375383 | 1.012239945 | 1.01169495 | 1.028 | 1.027 | -0.1378 |
| Rhode Island | 28.62745098 | 32.55295429 | 71.48362235 | 1.005596374 | 1.011452286 | 1.0126 | 1.0264 | 2.4859 |
| South Carolina | 4.209150327 | 5.890603086 | 9.858702633 | 1.014703582 | 1.007483194 | 1.0234 | 1.012 | -0.2719 |
| Tennessee | 3.794117647 | 7.995278379 | 13.34296724 | 1.032901962 | 1.007441512 | 1.0685 | 1.0145 | -1.4594 |
| Texas | 1.97167756 | 3.086792039 | 8.152188662 | 1.019657868 | 1.014158186 | 1.0007 | 1.0173 | 0.1551 |
| Vermont | 11.76470588 | 15.20624303 | 22.19653179 | 1.011206412 | 1.005490457 | 1.0247 | 1.0118 | -0.9702 |
| Virginia | 7.356037152 | 9.68534571 | 16.60115607 | 1.012018773 | 1.007831279 | 1.0241 | 1.0165 | -0.3532 |
| West Virgin | 8.011204482 | 8.988294314 | 19.75827641 | 1.005010457 | 1.011467647 | 1.0084 | 1.0249 | 0.7926 |
| Wisconsin | 6.896551724 | 9.03618121 | 30.62746084 | 1.011804422 | 1.017827922 | 1.0239 | 1.0404 | 0.7494 |

Table 2: State Data and Estimates