The Railroad's Impact on Land Values in the Upper Great Plains at the Closing of the Frontier

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Abstract

We show that the impact of transportation improvements on land values is complex with a direct, positive relationship on the price of land and also a positive relationship with the ratio of improved acres to total acres, another important influence on the per acre price of land. We construct a two step estimation that removes the impact of transportation outlets on the ratio of improved to total acres before including the transportation variables and the adjusted ratio variable as independent variables in a regression on price per acre. This estimation gives us the expected positive impact of railroads on land price. We also use Box-Cox regressions to show the semi-log form, a common model specification, may be inappropriate for our data and possibly then for other land price research.

I. Introduction

The economic history of the American "east" in the nineteenth century is characterized by rapid industrialization, the creation of giant corporations, conflicts with organized labor and market regulation. By contrast, the economic history of the American "west" is largely a story of public land disposal, westward migration, and the establishment and enforcement of private property rights (Anderson and Hill, 1975, 1990; Anderson & Leal 1991). An integral aspect of the "story of the west" is the role that (improvements in) transportation infrastructure played in the development of the west. Indeed, transportation construction, particularly the railroad in the Post Civil War ear (1870-1900), opened the west, allowing settlers access to previously isolated regions, and making agriculture a profitable venture by providing farmers the necessary access to markets.

While many studies have investigated the development of the American west and volumes have been written analyzing the impact of the railroad on American development, few studies concentrate specifically on the local impact that transportation infrastructure has had on western economic development. In this paper we attempt to shed light on this relationship by focusing particular attention on one sector of the western economy: agriculture. Specifically, we investigate the impact of transportation outlets, primarily the railroad, on the per acre value of agricultural land at the closing of the frontier in 1900 for four states in the upper Plains area of the United States: Kansas, Nebraska, North Dakota, and South Dakota.

A few historical studies exist that specifically look at agricultural land values and rail access. Lindert (1993) found that land values in the East North Central region (Indiana, Illinois, Michigan Ohio, and Wisconsin) experienced real capital gains of about 3.72 percent per year during the 1850s, a period of rapid expansion of the region's railroad infrastructure. Coffman and Gregson (1998) showed that land owners located close to an accessible railroad in rural Illinois experienced significant capital gains, approximately 9 percent of the land values, during the late 1840 and early 1850s. Craig, Palmquist, and Weiss (1998) construct a county-level hedonic model of agricultural land values for the United States' eastern region (roughly those counties located east of the Missouri River) for the years 1850 and 1860. They found that in both census years, land values in counties with access to canals or rivers as well as counties with access to railroads were higher. Interestingly, they also found that access to canals or river transport had a larger impact on land values than access to rail: river or canal access increased land values 22% in 1850 and 19% in 1860 while railroad access increased land values by 15% in 1850 and by 7% in 1860.[1] Moreover, they found no statistical support for the notion that the growth in land values between 1850 and 1860 did increased any faster for those counties that gained access to a railroad in that decade.

These studies look exclusively at the pre-civil war eastern United States. As such, the results above conform well to expectation. In the east, railroad lines followed existing settlements were a canal or road network linking settlement to canal access likely existed already. The rail lines, then, served to largely augment these existing networks. Hence, the fact that the marginal effect of railroad access on land values in these regions was not as large as that for canal access seems quite reasonable. Moreover, the finding that rail construction between 1850 and 1860 had not statistical impact on land value growth makes sense in this region as well sense, because the railroad followed settlement, rail lines would have been constructed in those areas that would have benefited the most. Such lines would have been constructed prior to 1850.

[1] There may be some issues here in situations where more marginal land is brought into production increasing the per acre cost of production and lowering the positive impact somewhat.

Our study extends these works by focusing attention on the plains region west of the Missouri River during the last two decades of the nineteenth century, when most of the transcontinental rail lines were built and for all practical purposes the nation's rail infrastructure was nearing completion (Atack and Passell, 1994). As such our results do contrast (in largely intuitive ways) from existing research. There are several reasons why this region may be of interest. As stated above, most eastern railroads linked pre-existing settlements. Hence, railroad private returns on investment were nearly immediate. The fact that in the east railroad infrastructure followed population makes statistical inference regarding the railroad's causal impact of regional growth difficult to quantify. In western regions like the upper plains, construction preceded population. In a sense, the railroad pulled the economy west (Atack and Passell, 1994; Webb, 1981). With no immediate return on investment, it has been argued that subsidization of railroad construction was necessary to facilitate economic growth in the west. While regional data is difficult to come by, Webb (1981) presents evidence that rates of return on railroad construction and operation over the plains region in the 1870s was about 2.25 percent and over the mountain and upper Pacific Northwest region 2.00%.[2] Indeed, many historians have suggested that the direction of massive amounts of public monies to finance rail construction, combined with such low rates of return on investment, led to excessive over-construction and was the principle cause of the financial panic of 1873 (Webb, 1981, Atack and Passell, 1994).

Since private rates of return are inappropriate measures for ascertaining whether or not over-construction, or premature construction, did indeed occur, a measure of the social rate of

[2] There is some debate as the need to support railroad development with public funds. Mercer (1974) for instance presents evidence that for a number of railroad companies involved in transcontinental construction such as the Union Pacific and the Great Northern, private returns on investment were more than sufficient to warrant construction.

return, i.e. some measure quantifying the benefits of rail access, is necessary. The debate regarding the social rate of return regarding railroad construction seems far from settled as estimates vary significantly. Fishlow (1965) estimates a return on the order of 15 percent, while Fogel (1964) for instance finds social rates of return to be substantially lower. In fact, Fogel's work has largely led to the notion that the railroads impact on national growth in the nineteenth century was rather small, suggesting that railroads were not indispensable to growth. The measure of social savings (social benefits to railroads) commonly used are based on price differentials between railroad passenger and shipping rates and the next best alternative transport vehicle, typically water or overland wagon transport. However, these measures are predicated on the assumption of marginal cost pricing, which may be difficult to justify since the railroad industry tended to be more oligopolistic in nature.

An alternative means of measuring the railroad's overall impact is to look at forward linkages, the impact on industries using railroad services such as farmers and industrialists shipping output to markets, and backward linkages, the impact on industries supplying the rail industry such as iron and steel, lumber and machine tools. According to Fogel (1964), derived demand in 1860 for products used by the railroad industry represent about 2.8 percent of all manufacturing, suggesting the railroad industry had little impact on such markets. The forward linkages are more difficult to quantify, given the reach of the industry. It does seem to be universally accepted though that land owner located on the railroad's right-of-way would have realized some benefit perhaps in the form of increased land values. To date, no effort has been made to quantify these benefits for the plains region. Doing so, however, should add to our understanding of the forward linkages the railroad brought to certain markets and could, as part of a larger calculus, further refine measures of the social benefits of railroad construction.

As a hypothesis, we expect that transportation improvements would add value to land, particularly land devoted to agricultural production, although to what magnitude we do not know.[3] Our investigation adopts an approach similar to that of Craig, Palmquist and Weiss (1998), hereafter referred to as CPW.

As stated above, CPW use county level data to examine of the impact of the railroad on land values. While their results are compelling, there is a lack of regional dis-aggregation in their model. While using county level data is a sufficiently small unit, it does not account for the distinct political, economic, demographic or other social characteristics of the larger regions, such as states, that impact financial variables such as land prices. The regional impact on land prices would differ depending on the type of goods produced, its weight or bulk to price ratio, the distance to the final market and the other transportation alternatives available. It also seems likely that there would be a differential impact on counties depending on the length of time rail service was available.

From our analysis we obtain some results qualitatively similar to the existing empirical literature on this subject. However we find the variable relationships and model structure much more complicated and intricate. Moreover, we obtain a number of results that differ from the existing work. For instance, we find that for this region, access to rail lines was at least as important a determinant of land values as was proximity to river resources. Moreover, contrary to existing results, we find that gaining access to a railroad line did indeed contribute to the growth of land values in this region.

Our paper is organized as follows. In Section II we discuss the model variables and data sources. In Section III we discuss model estimation and results for our cross-sectional analysis.

[3] We do not address causality issues such as whether railroads dictated which land was brought into production, as suggested by Murray (1957 p.59), or whether land was the determining factor in the location of the railroad in this paper.

In section IV we discuss model estimation and results for our growth equations. In Section V we conclude.

II. Model Variables and Data Sources

The dependent variable in our analysis, VALACR, measures the ratio of total farm values to total acres in farms in 1900 for each county. As shown below, we model this as a function of several variables believed to impact land values. The variable ACIMPACR, measures the ratio of total "improved" acres to total acres in farms in 1900 and is expected to impact VALACR positively. DENSITY is the ratio of county population to county land area and, again should impact land values in a positive way. YLD measures for each county the ratio of bushels of agricultural crops produced to total acres planted (see Table 1 for details). We include this data as an indication of productive capability of land and as such we expect land values to increase with higher productive yields. To avoid potential co-linearity and simultaneity issues, YLD data was collected for the year 1890. URBAN is a dummy variable equaling one if the county has a population in excess of 20,000 residents while NEARURB is a dummy variable equaling one if the county is directly adjacent to a county with a population in excess of 20,000. Closer proximity to a larger market is expected to drive land values higher and therefore we expect a positive coefficient on both of these variables.

The variable RR represents a dummy variable equal to one if the county in question contained at least one city, town, or village that had a railroad passing through it. This definition increases the likelihood that 1) the train would make a scheduled stop and 2) there would be a location within the town (county) where sufficient infrastructure existed to facilitate freight transfers from wagon to train. This data comes from an analysis of several detailed state and county maps for the year 1895 and can be found at http://www.ivgenmi.com/1895. The variable

RIVER represents a dummy variable equal to one if the county in question had a river passing through it. This variable was constructed by the authors from the same maps supplied by the above web page.[4]

Following CPW, we also empirically evaluate the potential impact of railroad service has on land values, we collected data for the year 1880.[5] VALACR1880, ACIMPACR1880, YLD1880, and DENSITY1880 are constructed for the year 1880 in the same manner as the corresponding concepts for 1900. URCH is a dummy variable equal to one if a county had less than 20,000 residents in 1880 and then realized an increase to 20,000 or more residents by 1900. NURBCH is a dummy variable equal to one if a county was not adjacent to a county with 20,000 or more residents in 1880 but was adjacent to such a county by 1900. The variable RRCH is a dummy variable equal to one if the county in question did not possess a rail line in 1876 but gained a road by 1895. The 1876 rail line data was compiled by the authors using a series of maps published by Rand McNally & Company (1969) (see Table 1 for details).

The agricultural and population data for 1900 come from the *Twelfth Decennial Census of the United States, 1900*.[6] The 1890 YLD data came from the *Eleventh Decennial Census of the*

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[4] The variable is problematic in that there was no reasonable means of ensuring the waterway as navigable. Therefore, as a substitute for rail service (as assumed by CPW), our RIVER dummy may be inadequate to the task. However, it is still a useful variable to include in our analysis of land values even if the river isn't navigable in that the proximity to a river may represent a source of fresh drinking water as well as increasing the potential for irrigation to take place. Particularly in those areas west of the 98th meridian, where the land is very arid, water would be of significant value.

[5] The reason for comparing 1900 data with 1880 data and not 1890 data is largely because obtaining time series data on county level railroad development in this region is very difficult. As we discuss below, we had reliable information on completed railroads for the year 1876 and 1895. Hence, we had no record for railroad lines constructive between the late 1870s and late 1880s.

[6] The county population data comes from *Volume I: Population of States and Territories 1906*, Table 92, and the agricultural data comes from *Volume V: Agriculture of the United States 1908*, Table 19.

United states, 1890.[7] Finally the 1880 agricultural and population data came from the *Tenth Decennial Census of the United States, 1880*.[8]

Additional control variables are included in our model. For instance, we include state dummy variables to control for potential state-level policies or idiosyncrasies that may impact land values. Finally, we include DMY98, a dummy variable equal to one if a county (or any part of a county) is located east of the 98th meridian. Many authors (Anderson and Hill 1991, Webb, 1981) delineate the "true west" as beginning west of this point since generally speaking the area experiences significantly less amount of rainfall, making it much more arid and thus less productive as farm land, at least for smaller farm establishments, a hallmark characteristic of western North America. Hence, with our focus on land valuation specifically devoted to farming, we should expect to see generally higher values for those areas where the land is more fertile and rainfall more appreciable. Summary statistics are presented in Table 1.

III. Regression Models and Results

The general model we estimate is as follows:

$$\begin{aligned} &VALUEF = f(ACIMPACR, DENSITY, YLDURBAN, NEARURB, \\ &RR, RIVER, DMY98, DMYNE, DMYND, DMYSD, \varepsilon) \end{aligned} \tag{1}$$

In most hedonic models, such as CPW's, equation (1) is estimated assuming a semi-log functional form. We do this as well and these results are presented in Table 2. However, there is no *a priori* reason to expect the semi-log functional form to provide the most efficient estimates for our parameters.[9] Therefore, we test for the appropriateness of this form by applying a Box-

[7] The production and acres planted data comes from *Volume V: Report on the Statistics of Agriculture 1895*, Table 4.
[8] The county population data comes from *Volume I: Statistics of Population 1883*, Table 23, and the agricultural data comes from *Volume III: Report on the Production of Agriculture 1883*: Table 7.
[9] Heckelman and Wallis (1997) use a cubic relationship in their investigation of railroads and property taxes.

Cox (1964) transformation to our historical data.[10] We model two different Box-Cox transformations and report the results in Table 2. Model 1 transforms only VALUEF by θ and Model 2 transforms VALUEF by θ and ACIMPADJ, DENSITY and YIELD by λ. If the data suggest a semi-log form for Model 1 then we expect θ = 0. This would be the case for Model 2 if θ = 0 and λ = 1

In general our results do not favor a semi-log form. Indeed, following a relatively standard technique illustrated in Greene (1993, p. 334 and applied to Model 1) we reject the null hypothesis that θ = 0 and so reject the semi-log form as appropriate for our case. Model 2 is the most general form and both λ and θ are statistically significant. The data suggest a more complicated relationship than either Model 1 of the semi-log form allow and so we report Model 2 results in most of what follows.

Focusing then on Model 2, our transformed independent variables all bear the expected positive relationship to the per acre price of land and are statistically significant. Moreover, our state and geographic dummy variables are also all positive and significant. URBAN and NEARURB fail to achieve statistical significance and in the case of URBAN, the sign is incorrect.

The most troubling aspect of our results so far is that the regression indicates the relationship between the price per acre and the presence of a railroad is negative, that is, railroads reduce the value of land, even after correcting for the possible regional differences that may exist between our states. RIVER, while not negative, disappoints because it fails to achieve statistical significance. One probable source of difficulty is that there may exist an endogenous

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[10] The transformation involves the following functional form: $\frac{y^{\theta}-1}{\theta} = \alpha + \sum_{i=1}^{k} \beta_i \frac{x_i^{\lambda}-1}{\lambda} + \sum_{j=1}^{q} \beta_j x_j$, where θ and λ are additional parameters to be estimated.

relationship between the ratio of improved acres to total acres (ACIMPACR) and our transportation dummy variables for railroad (RR) and river (RIVER), essentially that we encounter a collinearity problem. In essence, the presence of a railroad or water transport would impact the improvement of acres. Indeed, as Scheiber, Vatter and Faulkner (1976) write:

> "Just as the railroads carried the West's surplus crops to coastal markets, they brought into the frontier or near-frontier areas the farm machinery, lumber, consumer goods, and other needs of commercial farmers and rural towns." (p. 138)

To address this issue we run the following OLS regression:

$$\ln(ACIMPACR) = \alpha + \beta_1 RR + \beta_2 RIVER \qquad (2)$$

The results of equation (2) showed both RR and RIVER have strong positive impact on ACIMPACR.[11] Based on these results, we construct a measure (ACIMPADJ) that represents the amount of improved acreage *not* attributable due to access to rail or river transport. To do so, we capture the resulting residuals from equation (2), exponentiate them and substitute the resulting series for ACIMPACR in our original regression model. These results are presented in Table 3.

With the above adjustment to acres improved introduced, we still find the semi-log form to be ill-suited for the data and the more general Box-Cox Model 2 to be preferable. That said, the results follow closely to expectation. In all three model specifications all explanatory variables are highly significant and have the expected sign. Only URBAN disappoints.

In addition to statistical significance, one of the benefits to hedonic studies is that we can interpret the marginal effects of each independent variable as the implicit or marginal price of a

[11] This is an issue that CPW seem not to have considered, perhaps due to the fact that the eastern farms were not as far removed from sources of productive inputs. Our region at this time was certainly characterized as having farms located in more remote locations where the need to bring productive inputs necessitated the transport of such equipment via rail and/or water. Moreover, our analysis takes places fifty years later than does CPW. Over this time, it's reasonable to presume that farm production became more capital intensive. At any rate, our results do suggest a strong link between transportation and land improvements. These results are not reported here but are available from the authors upon request.

particular attribute. However, our model specifications, the estimated coefficients themselves are not these marginal effects and must be adjusted. For all three models, we include in Table 3 a column indicating the marginal impact of each variable on VALUEF. These effects are constructed so that we can interpret them as elasticities for ACIMPADJ, DENSITY, and YLD. For our dummy variables, the marginal effects measure the percentage impact on VALUEF as each variable changes discretely from 0 to 1.[12] For instance, focusing on Model 2, we find that a ten percent increase in improved acres relative to total acres in farms not attributable to rail or river access increases per acre land values by 4.87 percent, or \$0.62 per acre (relative to its mean).

Focusing attention on the RR and RIVER variables, from Model 2 we see that farmlands located in counties with access to a railroad realize a 22 percent increase in land value, or about \$2.84 per acre (evaluated at its mean). This percentage is substantially larger than the 15 percent estimate CPW found for their 1850 data (although the dollar estimate is fairly close to ours at about \$1.80 per acre). Farmlands located with access to river resources realize also a 22 percent increase in land values and this estimate is very much in line with CPW's results. These results highlight a telling difference between these two studies. CPW found that proximity or canals or rivers had a significantly higher impact on land values than did the railroad in the mid-nineteenth

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[12]For the semi-log form, the elasticity is calculated as $\beta_i \bar{x}_i$ where $\bar{x}_i$ is the sample mean for each variable x_i = ACIMPADJ, DENSITY, and YLD. For the dummy variables the percent change in VALUEF as a dummy variable x_i moves from 0 to 1 is $\exp(\beta_i)-1$. For Model 1, the elasticity is $\beta_i \frac{\bar{x}_i}{\bar{y}_i^{\theta}}$ where $\bar{x}_i$ is the sample mean for each variable x_i = ACIMPADJ, DENSITY, and YLD, and $\bar{y}_i$ is the sample mean for VALUEF. For Model 2, the elasticity is $\beta_i \frac{\bar{x}_i^{\lambda}}{\bar{y}_i^{\theta}}$ where $\bar{x}_i$ is the sample mean for each variable x_i = ACIMPADJ, DENSITY, and YLD, and $\bar{y}_i$ is the sample mean for VALUEF. Finally, it can be shown that for the dummy variables for Models 1 and 2 the percent change in VALUEF as a dummy variable x_i moves from 0 to 1 is $\exp\left(\frac{\ln(\theta\beta_i+1)}{\theta}\right)-1$.

century eastern United States. We find, by contrast, that the railroad's impact on land values was on par with that of river access. In this region, then, access to rail seems to have been worth more than in the east. Again, since rail access tended to precede substantial settlement and little existing transportation infrastructure existed in this region, this contrasting result seems reasonable.

IV. Land Value Growth and Railroad Construction

Thus far we have not addressed the potential impact railroad construction and access has on the growth of land values in this region. To address this issue, we construct a Barro (1991)-type model of land value growth were we identify potential determinants of such growth over the twenty-year period between 1880 and 1900. Since North and South Dakota were not states in 1880, county-level data is somewhat difficult to define. Hence, we restrict our sample to consider only land value growth over this period for just Kansas and Nebraska. The estimated model is

$$\begin{aligned} &\ln(VALUEF / VALUEF1880) = \alpha + \beta_1 * VALACR1880 + \\ &\beta_2 * ACIMPACR / ACIMPACR1880 + \beta_3 * YLD / YLD1880 + \\ &\beta_4 * DENSITY / DENSITY1880 + \beta_5 * URBCH + \beta_6 * NURBCH + \\ &\beta_7 * RRCH + \beta_8 * DMY98 + \beta_9 * DMYNE + \beta_{10} * RIVER + \varepsilon \end{aligned} \tag{3}$$

With the exception of VALACR1880, we expect all the estimated coefficients to be positive. If land values are to some degree converging in value over this region, we should see the estimated coefficient on VALACR1880 as negative.[13] Of course, the issue of collinearity between RRCH and increases in improved acres over this period is still an issue. Hence, we adopt a similar procedure as done earlier to account for this and construct a new variable

[13]Our model is similar to CPW's growth model although they did not investigate the potential for land value convergence. Specifically, we consider β convergence here – where the value of land in counties with lower land values to begin with grow faster than land values in other counties. We do not consider σ convergence – where the dispersion in land values over time declines. This issue we leave for future research.

ACIMPACRADJ_CH.[14] Both results with and without this adjustment to improve acreage are presented in Table 4.

These results indicate a number of interesting patterns regarding farm land value growth. First, there does seem to be evidence of value convergence as the effect that VALACR1880 has on growth is negative. More highly valued land in 1880 appeared to have realized increases in value at a slower rate than did less valued land in 1880. Not too surprisingly, both measures of increased improved acres seemed to stimulate land value growth. We also find some potentially contradictory results. First land values seem to have grown more quickly in those counties where population was increasing (as evidenced by the positive and significant impact URBCH seems to have on growth). However, increased population density seemed to depress growth over this period.

The variable of key interest here thought is RRCH and our results do stand in contrast to those of CPW's. They find that changes in railroad access was statistically insignificant, explaining this as an indication that railroads were presumably built first where their contribution was greatest. Hence additional access during the decade of the 1850 would have increased land values but not by as much as earlier building. Our results, by contrast, show that farmland located in counties gaining rail access between 1876 and 1895 realized a nearly twenty percent increase in value between 1880 and 1900 once the acres improved impact is isolated. This may be indicative of the fact that the major transcontinental railroads were constructed between 1880 and 1900. For instance the Northern Pacific Railroad Company completed its line in 1883 and the Great Northern Railway completed its line in 1893 (Veenendaal, 2003). Hence, many of the various branch lines built off from these main rails would have been constructed between 1880

[14]In this case, however, our intermediate regression is $\ln(ACIMPACR / ACIMPACR1880) = \alpha + \beta_i * RRCH$. RRCH proved to have a strongly significant positive impact upon the growth in improved acres. Again, the exponentiated residual values were captured and included in equation (4). The results of this equation are available upon request.

and 1900. Indeed, our data indicates that the number of counties with access to rail lines in Kansas and Nebraska in 1880 represented 47 percent of all counties. By 1880, this percentage reached 90 percent. Moreover, as Webb (1981) pointed out, these transcontinental lines were built for the express purpose of linking the east and west coast at least cost. Hence, construction did not necessarily come first to those areas where the local contribution was greatest.

V. Conclusions

Our paper demonstrates two major points. First, transportation outlets impacted land values in complex ways. While providing a direct boost to land values by lowering transport costs for agricultural products the railroad and water transport also influenced the decision to improve acreage, another factor influencing land prices. This may require researchers to undertake slightly more complicated regression specifications when examining historical data on land prices. Second, our inability to replicate the CPW results suggests that further research into the precise functional relationship between land value and other variables in a historical context may be fruitful and that Box-Cox transformations may be an appropriate test for model specification.

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Table 1. Summary Statistics

Variable	Definition	Mean	Standard Deviation
1900 data, Kansas, Nebraska, North Dakota, and South Dakota counties, N = 284			
VALACR	Ratio of farm values to acres (1)	12.931	10.824
ACIMPACR	Ratio of improved acres to total acres (1)	0.578	0.241
DENSITY	Ratio of county population to county area (sq. miles) (2)	18.149	39.310
YLD*	Ratio of the number of bushels produced of agricultural products to total acres planted (3)	21.400	13.002
URBAN	dummy variable = 1 if county population exceeded 20,000, 0 otherwise (1)	0.134	0.343
NEARURB	dummy variable = 1 if county is adjacent to URBAN, 0 otherwise (1)	0.264	0.443
RR	dummy variable = 1 if county had a railroad present as of 1895, 0 otherwise (6)	0.894	0.305
RIVER	dummy variable = 1 if county had a river, 0 otherwise (6)	0.775	0.420
DMY98	dummy variable = 1 if county was east of the 98 meridian, 0 otherwise	0.479	0.500
DMYNE	dummy variable = 1 if county is located in Nebraska	0.313	0.466
DMYND	dummy variable = 1 if county is located in North Dakota	0.134	0.343
DMYSD	dummy variable = 1 if county is located in South Dakota	0.183	0.380
1880 data, Kansas and Nebraska counties only, N=154			
VALACR1880	Ratio of farm values to acres (4)	11.578	17.739
ACIMPACR1880	Ratio of improved acres to total acres (4)	0.478	0.230
YLD1880*	Ratio of the number of bushels produced of agricultural products to total acres planted (4)	13.347	7.735
DENSITY1880	Ratio of county population to county area (sq. miles) (5)	15.628	16.831
URBCH	dummy variable = 1 if county pop. was less than 20,000 in 1880 and greater than 20,000 in 1900, 0 otherwise (2), (5)	0.158	0.366
NURBCH	dummy variable = 1 if county was not adjacent to URBAN in 1880 but adjacent to URBAN in 1900, 0 otherwise (2), (5)	0.250	0.434
RRCH	dummy variable = 1 if county did not have a railroad in 1876 but did have a railroad by 1895 (6), (7)	0.454	0.500

*Note: the agricultural products were barley, buckwheat, corn, oats, rye, and wheat.

(1) Twelfth Decennial Census of the United States 1900: Volume V: Agriculture of the United States, Table 19.

(2) Twelfth Decennial Census of the United States 1900: Volume I: Population of States and Territories, Table 92.

(3) Eleventh Decennial Census of the United States, 1890: Volume V: Report on Statistics of Agriculture, Table 4.

(4) Tenth Decennial Census of the United States 1880: Volume III: Report on the Production of Agriculture, Table 7.

(5) Tenth Decennial Census of the United States 1880: Volume I: Statistics of Population, Table 3.

(6) Data can be found at http://www.livgenmi.com/1895/

(7) Rand McNally's Pioneer Atlas of the American West, 1969 Edition, Rand McNally & Company

Table 2. Hedonic model of land values, 1900
Dependent variable: VALUEF

	Semi-log		Box-Cox Model 1		Box-Cox Model 2[1]	
	coeff.	sig.	coeff.	sig.	coeff.	sig.
INTERCEPT	0.238	***	0.011		1.649	
	(3.196)					
ACIMPACR	2.155	***	2.882	***	1.048	***
	(18.004)		(210.041)		(61.537)	
DENSITY	0.003	***	0.006	***	0.140	***
	(6.566)		(53.242)		(44.167)	
YLD	0.021	***	0.028	***	0.104	***
	(7.616)		(54.621)		(21.766)	
URBAN	0.012		0.037		-0.057	
	(0.204)		(0.213)		(0.546)	
NEARURB	0.052		0.097		0.119	
	(1.011)		(1.968)		-(5.351)	
RR	-0.012		-0.022		-0.064	
	-(0.207)		(0.080)		-(6.691)	
RIVER	0.034		0.032		0.066	
	(0.815)		(0.318)		-(6.715)	
DMY98	0.155	***	0.226	***	0.245	
	(3.000)		(10.380)		(0.987)	
DMYNE	0.141	***	0.240	***	0.312	**
	(2.980)		(13.476)		(3.866)	
DMYND	0.358	***	0.473	***	0.516	***
	(5.010)		(23.380)		(15.130)	
DMYSD	0.197	***	0.276	***	0.281	***
	(3.104)		(10.381)		(2.940)	
θ			0.151	***	0.110	**
			(3.45)		(2.33)	
λ					0.383	***
					(4.79)	
Adj. R^2	0.892					
F (11, 272 df)	213.61	***				
LR stat (11 df)			653.24	***	650.30	***
No. of obs	284		284		284	

t-statistics are in parentheses for the semi-log results. χ^2 statistics are reported for Box-Cox results.

[1]Note that in Model 2, only ACIMPJ, DENSITY, and YLD were transformed independent variables.

* - significant at 10% level.

** - significant at 5% level.

*** - significant at 1% level.

Table 3. Hedonic model of land values, 1900 with adjustment to acres improved
Dependent variable: VALUEF

	Semi-log			Box-Cox Model 1			Box-Cox Model 2[1]		
	coeff.	sig.	Marginal effect[2]	coeff.	sig.	Marginal effect[2]	coeff.	sig.	Marginal effect[2]
INTERCEPT	-0.230	***		-0.582			0.671		
	-(2.740)								
ACIMPADJ	1.030	***	0.595	1.346	***	0.542	0.782	***	0.487
	(17.550)			(200.479)			(60.174)		
DENSITY	0.003	***	0.060	0.005	***	0.069	0.144	***	0.325
	(6.490)			(50.663)			(55.495)		
YLD	0.021	***	0.452	0.028	***	0.422	0.105	***	0.250
	(7.750)			(56.500)			(21.246)		
URBAN	0.004		0.004	0.025		0.025	-0.059		-0.057
	(0.060)			(0.095)			(0.603)		
NEARURB	0.087	*	0.091	0.140	***	0.149	0.127	***	0.134
	(1.690)			(4.161)			(4.174)		
RR	0.367	***	0.444	0.475	***	0.584	0.200	***	0.219
	(6.120)			(33.848)			(4.984)		
RIVER	0.246	***	0.279	0.309	***	0.354	0.203	***	0.223
	(5.530)			(26.092)			(13.430)		
DMY98	0.176	***	0.192	0.249	***	0.277	0.247	***	0.276
	(3.380)			(12.870)			(15.428)		
DMYNE	0.163	***	0.177	0.262	***	0.293	0.314	***	0.362
	(3.420)			(16.252)			(21.443)		
DMYND	0.390	***	0.476	0.509	***	0.634	0.513	***	0.649
	(5.430)			(27.582)			(29.667)		
DMYSD	0.224	***	0.251	0.308	***	0.351	0.279	***	0.317
	(3.520)			(13.199)			(12.639)		
θ				0.141	***		0.105	**	
				(3.16)			(2.23)		
λ							0.372	***	
							(4.98)		
Adj. R^2	0.889								
F (11, 272 df)	207.20	***							
LR stat (11 df)				643.68	***		648.94	***	
No. of obs	284			284			284		

t-statistics are in parentheses for the semi-log results. χ^2 statistics are reported for Box-Cox results.

[1]Note that in Model 2, only ACIMPJ, DENSITY, and YLD were transformed independent variables.
[2]For each dummy variable, the marginal effect measures the proportional change in VALUEF as the dummy variable increases from 0 to 1. The marginal effects for ACIMPADJ, DENSITY, and YLD, respectively can be interpreted an elasticity (evaluated at the mean levels of each variable. See text for details.

* - significant at 10% level.
** - significant at 5% level.
*** - significant at 1% level.

Table 4. Change in land values between 1880 and 1900 for Kansas and Nebraska counties. Dependent variable: ln(VALUEF/VALUEF1880)

	Without adj. to acres improved		With adj. to acres improved	
INTERCEPT	0.2339	*	0.1500	
	(1.8413)		(1.0383)	
VALACR1880	-0.0216	***	-0.0215	***
	(-7.8197)		(-7.7553)	
ACIMPACR/ACIMPACR1880	0.1233	***	---------	
	(3.8480)		---------	
ACIMPACRADJ CH	---------		0.2353	***
	---------		(3.8828)	
YLD/YLD1880	-0.0001		-0.0001	
	-(1.2273)		-(1.2216)	
DENSITY/DENSITY1880	-0.0303	***	-0.0303	***
	-(11.2405)		-(11.1921)	
URBCH	0.1397	**	0.1442	**
	(2.1260)		(2.1754)	
NURBCH	0.0218		0.0205	
	(0.3775)		(0.3536)	
RRCH	0.0213		0.1069	*
	(0.4039)		(1.8943)	
DMY98	0.3002	***	0.3089	***
	(-0.3895)		(-0.4092)	
DMYNE	0.5546	***	0.5522	***
	(10.1978)		(10.2313)	
RIVER	-0.1154		-0.1204	
	(-0.8711)		(-0.8860)	
Adj. R^2	0.7726		0.7752	
F statistic (11, 142 df)	52.2928	***	53.0632	***
No. of obs.	154		154	

Estimated using White's heteroscedasticity-consistant standard errors.
t-statistics are in parentheses
* - significant at 10% level.
** - significant at 5% level.
*** - significant at 1% level.