Economic Consequences of US Federal Land Disposal

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Outline of Presentation

1. Land patent data set
2. Model of frontier settlement
3. Agricultural Adjustment
   ▶ Land consolidation frictions within railroad grant boundaries
By 1850, the federal government acquired vast territories spanning the current contiguous states.

By 1940, nearly half of this land had been directly transferred to private owners.

Contentious congressional debates regarding land disposal:
- Revenue motives
- Equity concerns
- Survey design

Later research echoes themes of earlier debates:
- Gates (1936, 1968); Anderson and Hill (1975)
- Fogel and Rutner (1972); Allen (1991)
Disposal of Federal Land

Current Federal Domain
Private or State Owned
Current Indian Reservation
Never Federal Land

Dippel, O'Grady & Whalley (email: trevorogrady@fas.harvard.edu)
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Land patents were issued whenever federal land was sold or granted. Patents represent the original deed transferring land ownership from the federal government to an individual, corporation, or state. Each patent contains information regarding:

- legal description of the plot
- plot size
- patentee name
- date issued
- act of authorization
The United States of America,

TO ALL TO WHOM THESE PRESENTS SHALL COME, GREETING:

Whereas there has been deposited in the General Land Office of the
United States a certificate of the Register of the Land Office at Alliance
Nebraska, certifying that pursuant to the Act of Congress approved
March 3, 1854. To-wit: "In pursuance to which Act, the same
was laid off and surveyed in the manner therein provided for by the
Executive officer and duly enumerated and registered to be for the
North Part

Quarta of Section eight in Township
Twenty, Seven North Of Range forty and
West of the North West Quadrant
in Nebraska containing one hundred
and sixty acres.

according to the Official Plat of the Survey of the said Land returned to the General Land Office
by the Surveyor General.

Now have I, the undersigned, authorized by the United States under the
said

Joseph Turck

where described to have and to hold the said Land, with the appurtenances thereof, with
the said

Joseph Turck

and all trees and minerals thereon.

In the name and stead of Benjamin Harrison
President of the United States of America, have caused these letters to be made
Patent, and the Seal of the General Land Office to be hereunto affixed.

Given under my hand at the City of Washington, the

day of

July

in the year of our Lord one

hundred and eighty-four, and of the
Independence of the United States the one hundred and thirty-second.

By the President

Benjamin Harrison

By Ellen Macfarlane, Sig.

J. B. Cornell, Register of the General Land Office.

ad interim.
Homestead Act (1862)
Legal description of tract
Size: 160 Acres
Patentee: Josef Turek
Issue Date: July 27, 1891
Data Set: Land Patents

- 5.5 million patents
- Recorded by General Land Office
- Digitized by Bureau of Land Management
- Dominant allocation methods observed
  - cash sales
  - military warrants
  - homestead grants
  - railroad grants
Land Disposal over Time

![Graph showing land disposal over time with labels for Acres Patented (10,000), Issue Year, and various types of land sales and patents including Cash Sales, Homestead, Enlarged Homestead, and Stock Raising Homestead.]
Locating patented land

- Nearly all of the federal land disposal was administered through the Public Land Survey System (PLSS)
- We use the systematic legal descriptions to connect patents to various ground-truthed shapefiles of PLSS townships
  - 6x6 mile grid cells
Patented Land: 1840

Cash Sales

Homesteads
Patented Land: 1870

Cash Sales

Homesteads
Patented Land: 1880

Cash Sales

Homesteads
Patented Land: 1900

Cash Sales

Homesteads
Patented Land: 1920

Cash Sales

Homesteads
Patented Land: 1940

Cash Sales

Homesteads
Difficulties we face with estimating reduced form causal effects in variation in land granting rules on outcomes:

1. Many sources of variation: Homestead Act, Kincaid Act, Enlarged Homestead Act, Graduation Act, Railways
2. Acts endogenous to geography, esp. in large spatial units
3. Sharp date of acts but no sharp spatial breaks in acts used
4. Land settlement data at grant level but county-outcomes

Alternative approach: take settler decision as the outcome, and model these structurally. Advantages:

- Can use the many sources of exogenous variation in acts and settlement incentives
- Unit of observation is township
- Answer counterfactual questions, e.g. “how would frontier have evolved if there had been no homestead act”

This is joint work with Connan Snider at UCLA
Discrete/Continuous choice: Each potential farmer decides jointly on (a) optimal farm size given settlement location (township) and (b) preferred settlement location, with non-settlement the outside option.

Model individual decisions but estimate in data at the market-level, i.e. the township.

Some guidance provided by stylized facts in the data:
1. Almost all homesteaders also bought some cash sale land.
2. Farms with a homestead in the mix were smaller.
Why should a subsidy reduce optimal farm size?

Answer likely to be selection: Cash-strapped farmers, who choose a constrained-optimal smaller farm size, but would not settle at all without homestead.

Consistent with the history that Homestead Act attracted immigrants, urban poor and broke farmers from behind frontier
The country is populated with some number of potential settlers $N$.

There are $J$ possible townships to locate a farm in.

- Data on when a township is surveyed and “offered”

Each potential settler chooses a township $j \in 0, 1, \ldots, J$ (0 = no farm, the outside option) and, given $j$, a farm size $L_{ij}^*$

Each township is described by characteristics, split in

- location/land quality ($Z_{jt}$) determines productivity: Soil Quality, climate, Native hostility
- market access ($X_{jt}$): Distance from frontier, Railroads/Waterways proximity

Some of ($Z_{jt}$) and ($X_{jt}$) are endogenous to the model, but not to the individual.
Farm output depends on farm size and exogenous characteristics (not on individual farmers)

\[ Y_{ijt} = \theta(Z_{jt})L_{ij}^0 - c(Z_{jt})L_{ij} \]

Farmer’s (quasi-linear) utility depends on how much farm output he eats himself and how much he sells:

\[ Y_{ijt} = y_{e,ijt} + y_{s,ijt} \]

\[ u(y_{e,ijt}, y_{s,ijt}) = y_{e,ijt}^\gamma + p(X_{jt})y_{s,ijt} \]

\( p \) are ”net” price of output, which depends on market access (evolves endogenously in the model but exogenous to farmers)
Model - Step 1, Continuous Choice

- Optimal eat/sell split yields indirect utility of a farm as a function of farm size and state variables

\[ u^* = p(X_{jt})^{\frac{\gamma}{1-\gamma}} \left( \left( \frac{1}{\gamma} \right)^{\frac{1}{1-\gamma}} - \left( \frac{1}{\gamma} \right)^{\frac{1}{1-\gamma}} \right) + p(X_{jt}) Y_{ijt}(L_{ij}, X_{jt}, Z_{jt}) \]

- Once a farmer makes settles on a farm of a given size utility accrues each period forever

- Value of a farm of size \( L_{ij} \) in township \( j \) is then:

\[ V_j(L_{ij}, X_{jt}, Z_{jt}) = E[\sum_{\tau=t}^{\infty} \beta^{\tau-t} u^*(X_{j\tau}, Z_{j\tau}, L_{ij})|X_{jt}, Z_{jt}] \]
Optimal size farm solves:

\[
\max_{L_{ij}} - f(L_{ij} - 160) - \kappa(L_{ij}, \sum_i L_{ij}, \bar{L}_j) + V_j(L_{ij}, X_{jt}, Z_{jt}) \\
\text{s.t. } - f(L_{ij} - 160) \leq W_i
\]

- $\bar{L}_j$ is the average size of farm possibly capturing difficulty of consolidating widely held land.
- $\kappa$ is a "congestion" cost capturing the fact that it may be harder to put together a contiguous farm on good land the later you arrive.
- $f$ is the unit land price not subsidized by Homestead Act.
  - Before 1863, the "160" subsidy drops out.
  - With data on Graduation Act, $f = 1.25\$$ becomes $f_{jt}$.
- Budget constraint introduces selection through $W_i$. 
Model - Step 1, Continuous Choice

- Optimal farm size: **either** most you can afford **or** solves FOC:

  
  \[-f\{L > 160\} - \frac{\partial \kappa}{\partial L_{ij}} + \rho L_{ij}^{1-\rho} E\left[\sum_{t=\tau}^{\infty} p(X_{tj})\theta(Z_{tj}) - \sum_{t=\tau}^{\infty} c(Z_{tj})\right] = 0\]

- linear dependence: $L_{ij}$ not in the infinite sum

- Over time (within a township), farm sizes will vary because of wealth constraints and date of arrival (through congestion costs and through $X_{tj}, Z_{tj}$)

- Modeling future prices, $p_{tj} = \beta_0 + \beta_1 X_{tj}, \theta_{tj} = \beta_2 + \beta_3 Z_{tj}$

- We can measure these states and model their evolution (and thus model beliefs about their evolution)
Given $L^*_jt$, calculate discrete settlement choice $j$

Utility of settler $i$ choosing farm in township $j$ is

$$U_{ij} = \bar{V}(X_{jt}, Z_{jt}, W_i) + \epsilon_{ij}$$

Outside option is

$$U_{i0} = g(W_i) + .5772 + \beta E[log \sum(\bar{V}(X_{jt+1}, Z_{jt+1}, W_i))]$$

i.e. depends on initial wealth plus continuation value (the logit "social surplus function" assuming logit errors)

Individual settlement probabilities:

$$P_{ijt} = \frac{exp(U_{ijt})}{exp(U_{i0t}) + \sum_k exp(U_{ikt})}$$
For estimation, individual choices \( \{L_{ijt}, j_t\} \) aggregate up to township-level \( \{\bar{L}_{jt}, \text{share-settled}_{jt}\} \)

The vector \( \{\bar{L}_{jt}, \text{share-settled}_{jt}\} \) describes the American frontier at time \( t \)

Goodness of Fit: Evolution of estimated vs. actual frontier

Ask counterfactual questions:
- Did immigration waves push the frontier faster?
- How would the frontier have evolved with no homestead act or different rules
- How important was Native hostility?
- How important was European demand for agricultural imports
Farm Size and Crop Yields in the US

- **In 1900**
  - Average Farm Size = 147 Acres
  - Corn Production per Corn Acre = 28.1
  - Wheat Production per Wheat Acre = 12.2

- **In 1997**
  - Farm Size = 487 Acres
  - Corn Production per Corn Acre = 126.7
  - Wheat Production per Wheat Acre = 39.5
Farm Size and Crop Yields in the US

- Wheat Yield x 10
- Corn Yield x 5
- Average Farm Size

Graph showing trends in crop yields and farm size from 1900 to 1997.
Farm Size and GDP Per Capita

Figure 1. Average Farm Size across Countries
(Some) Recent Work

- Land allocation: farm size
  - Bleakley and Ferrie (2014)
- Land allocation: mechanisms
  - Libecap and Lueck (2011)
- Farm Size and Tractor Diffusion
  - Olmstead and Rhode (2001)
- Farm Size and External Effects
What We Do

- US railroad land grants
  - Special rules
    - Homestead maximum: 80 Acres
    - Minimum price doubled
  - Checkerboarding
    - Potential for strategic holdout in land consolidation
- We ask:
  - Did checkerboard affect farm size and land value growth?
  - How do farms adjust?

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Checkerboard Example

Railroad Land Grant Checkerboard
10 one-square mile blocks on both sides of the tracks in a checkerboard pattern.
- One-square mile land grant block
- Railroad tracks
1. Agricultural Census: 1900-1997
   - Farm size, Farm Value per Acre, Wheat Yield, Corn Yield, Acres planted, etc.

2. Railroad Land Grant Map
   - Share county land checkerboarded

   Counties:
   - Public land states only
   - First patents issued before 1890
   - Share county land checkerboarded $> 0$ (1,021 counties)
## Cross-Sectional Comparison, 1900

<table>
<thead>
<tr>
<th>Checkerboarded Land:</th>
<th>None</th>
<th>Any</th>
<th>High</th>
<th>Low</th>
<th>p-value (3)-(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td></td>
</tr>
<tr>
<td>Average Farm Size</td>
<td>194</td>
<td>227</td>
<td>194</td>
<td>259</td>
<td>0.003</td>
</tr>
<tr>
<td>Farm Value Per Acre</td>
<td>20.87</td>
<td>18.59</td>
<td>20.83</td>
<td>16.36</td>
<td>0.000</td>
</tr>
<tr>
<td>Equipment Per Acre</td>
<td>1.00</td>
<td>1.13</td>
<td>1.24</td>
<td>1.03</td>
<td>0.046</td>
</tr>
<tr>
<td>Wheat Yield</td>
<td>12.78</td>
<td>12.60</td>
<td>12.97</td>
<td>12.19</td>
<td>0.024</td>
</tr>
<tr>
<td>Corn Yield</td>
<td>27.18</td>
<td>25.89</td>
<td>27.54</td>
<td>24.23</td>
<td>0.000</td>
</tr>
<tr>
<td>Fraction Cropland Wheat</td>
<td>0.12</td>
<td>0.12</td>
<td>0.13</td>
<td>0.10</td>
<td>0.000</td>
</tr>
<tr>
<td>Fraction Cropland Corn</td>
<td>0.21</td>
<td>0.22</td>
<td>0.22</td>
<td>0.21</td>
<td>0.298</td>
</tr>
<tr>
<td>Soil Quality (2000)</td>
<td>10.11</td>
<td>10.35</td>
<td>10.86</td>
<td>9.84</td>
<td>0.000</td>
</tr>
<tr>
<td>Distance to Rail (2000)</td>
<td>19.87</td>
<td>14.05</td>
<td>11.74</td>
<td>16.37</td>
<td>0.000</td>
</tr>
<tr>
<td>Counties</td>
<td>531</td>
<td>1021</td>
<td>510</td>
<td>511</td>
<td></td>
</tr>
</tbody>
</table>
\[ Y_{it} = \alpha_i + \alpha_{st} + \beta_t ShareCheckerboard_i + \gamma_t X_i + \epsilon_{it} \] (1)

- **\( Y_{it} \):** Agricultural outcome in county \( i \) in year \( t \)
- **\( \alpha_i \):** county fixed effect
- **\( \alpha_{st} \):** state-by-year fixed effect
- **\( ShareCheckerboard_i \):** fraction of county area within RR grant boundaries interacted with year fixed effect.
  - Omitted category: \( t = 1900 \)
- **\( X_i \):** soil characteristics, latitude, longitude, (distance to current railroads)
  - Excluded in baseline estimates
logged Farm Size

![Graph showing logged farm size over time with data points from 1900 to 2000. The graph indicates a significant decrease in logged farm size from the early 1900s to the mid-1930s, followed by a gradual increase towards the 2000s. The x-axis represents years from 1900 to 2000, while the y-axis shows the logged farm size in increments of 0.05.](image-url)
logged Farm Value Farm per Acre
Agricultural Adjustments

- Mechanization
  - Checkerboarding may reduce intensity of lumpy capital
    - Equipment and tractors per acre

- Crop mix
  - Checkerboarding may reduce productivity and share of crops with larger efficient scale
    - Wheat vs Corn yield and share
logged Farm Equipment Value per Farm Acre
Corn Yield: logged Corn Output per Corn Acre

![Graph showing corn yield trends from 1900 to 2000](image-url)
Fraction of Cropland in Corn

[Graph showing the fraction of cropland in corn over time from 1900 to 2000.]