# The Development of Agricultural Drainage in the United States 1850-1969

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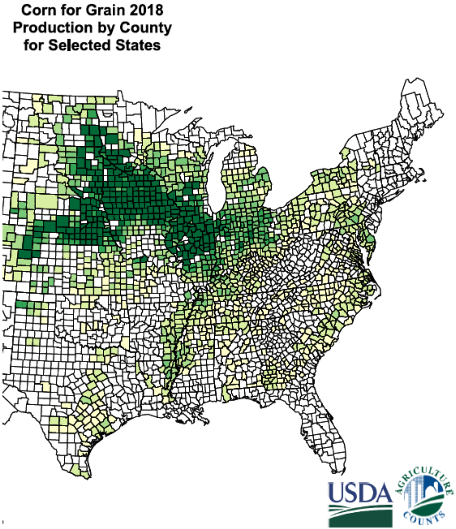
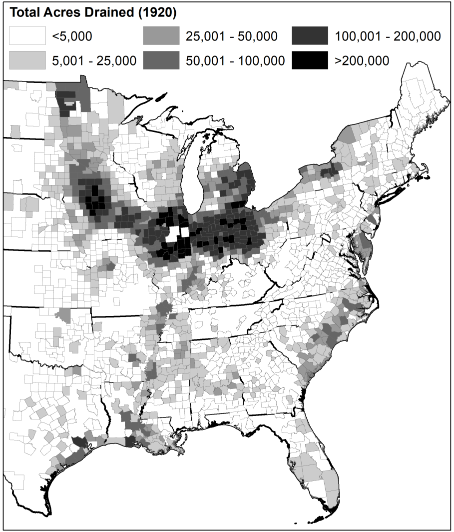
# Motivation: The Corn Belt



# Motivation: The Drainage Belt



# This Paper

- What was the impact of agricultural drainage on farmland and farmland value in the eastern U.S.?
  - Key physical problems faced (e.g. soils, engineering, technology)
  - Role of institutional factors (e.g. coordination, land ownership, district /legislation)

- Construct measure of “need” for drainage using soil drainage index and use drainage law passage as treatment in a diff-in-diff framework

- Drainage problem faced on Coastal Plain raised transaction costs relative to Upper Midwest

# What is Agricultural Drainage

- Water in root zone reduces yields or kills crops
- Flat topography leads to water logging
- Ditches and drain tile provide pathway for water
- Usually 4-6 feet deep parallels on field
- Larger drains and ditches as outlets

# Drainage and Swamp Land Acts

- First tile drainage in US: 1835
- A series of Swamp Land Acts turned surplus swamp lands over to states for reclamation
- Huge swaths of land granted to states (65$M$ acres by early 1910s)
- Initial efforts by state governments to drain were unsuccessful
- Some large farms experiment with drainage

| Year | State | Acres |
|---|---|---:|
| 1849 | Louisiana | 9,493,456 |
| 1850 | Alabama | 441,289 |
| | Arkansas | 7,686,575 |
| | California | 2,192,875 |
| | Florida | 20,325,013 |
| | Illinois | 1,460,184 |
| | Indiana | 1,259,231 |
| | Iowa | 1,196,392 |
| | Michigan | 5,680,310 |
| | Mississippi | 3,347,860 |
| | Missouri | 3,432,481 |
| | Ohio | 26,372 |
| | Wisconsin | 3,360,786 |
| 1860 | Minnesota | 4,706,503 |
| | Oregon | 286,108 |
| TOTAL | | 84,895,415 |

**Source: Fretwell (1996)**

# Drain Tile: Benefits and Costs

- Prior to 1880, unimproved wetland in Upper Midwest sold for \$7 (\$2-\$12)
- Various estimates of cost of tiling range from \$20-\$35 per acre
- After 1880 unimproved land price increases to around \$25/acre (\$15-\$40)
- Drained land sold for \$60-\$70 per acre
- Implies some change in market expectations
  - $P_{unimproved\ land} + C_{tiling} = P_{improved\ land}$
  - $\$25 + \$35 = \$60$

# The Drainage Coordination Problem

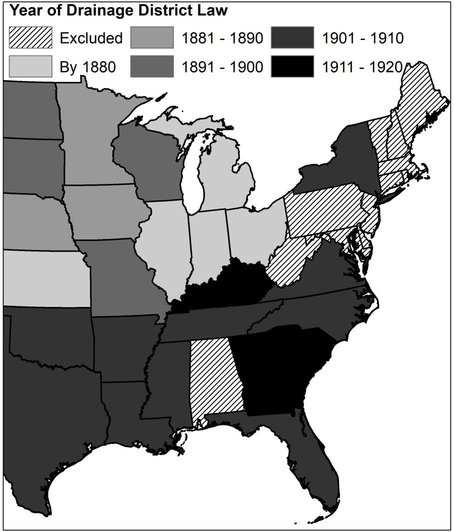
- Common law and legislation defined rights to drain among neighboring farms
- A system of integrated outlet channels was often a prerequisite to success
- Voluntary provision is hindered by collective action issues (Olson, 1989)
- Ostrom (1990) provides guidance to the settings where local groups can successfully cooperate in managing natural resource problems:
  - Rights to organize locally recognized by the central or local government
  - Decisions nested in local organizations
- Bretsen and Hill (2006) for irrigation districts and Edwards (2016) for groundwater districts show the success of state laws empowering local management
- **Special districts**: landowners retains rights to operate as economic factors dictate, while ceding one property right "stick" to a local elected body

# The Drainage Coordination Problem

> *In order to secure the necessary cooperation for efficient work...some legal method of compulsion has been found necessary, and drainage statutes have been enacted by many of the States...when it comes to deciding what lands shall be embraced in the project, where the ditches shall be located, how the work shall be done, and particularly, what each individual landowner shall pay, differences of opinion are sure to arise. To overcome this diversified sentiment and enable the owners of swamp and overflowed lands to reclaim the same in an efficient and equitable manner, drainage laws have been found necessary.*

1907 report to the U.S. Senate on the status of *Swamp and Overflowed Lands in the United States* (Wright, 1907)

# Drainage District Legislation



# Drainage Districts: Upper Midwest

**Blue Earth County, MN**

- 92 districts form 1898-1952
- Around 100,000 acres
- 320-7,202 acres per district
- Average 1,161 acres and about 20 farms per district

**Story County, IA**

- 95 districts by 1920
- 60% of county in a district
- 2,080 acres and about 20 farms per district

# Drainage Districts: Coastal Plain

**Cypress Creek, AR**

- 285,000 acres
- Several decades of litigation

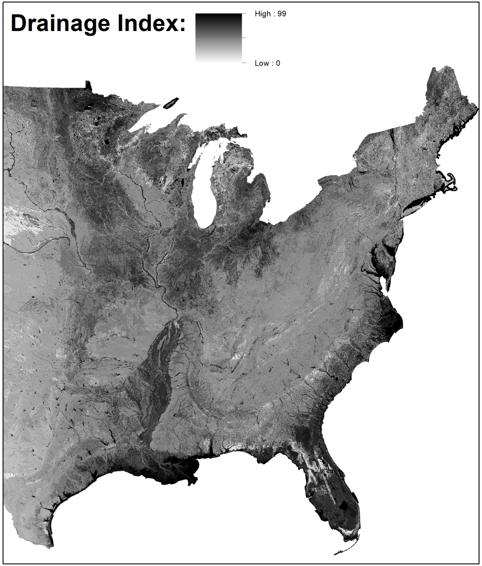
**Ross Drain District, AR**

- 40,000 acres

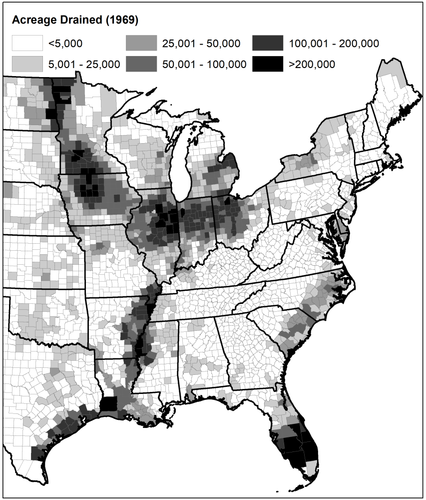
**North Carolina**

- 81 districts total by 1920
- 543,000 acres drained $\rightarrow$ 6,700 acres per district
- Acreage drained had increased to 5.4M acres by 1985
- Number of districts had decreased to 53 $\rightarrow$ 100,000 acres per district

# Poorly Drained Soils



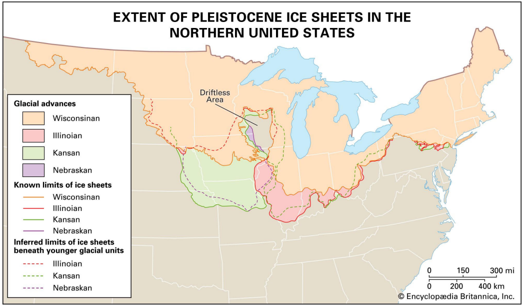
# Soils Drained by 1969



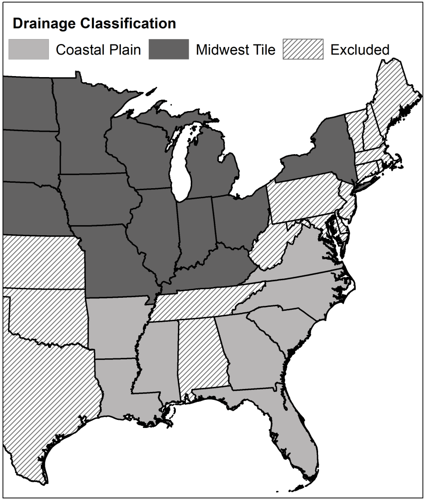
# Two Types of Drainage

Atlantic Coastal Plain

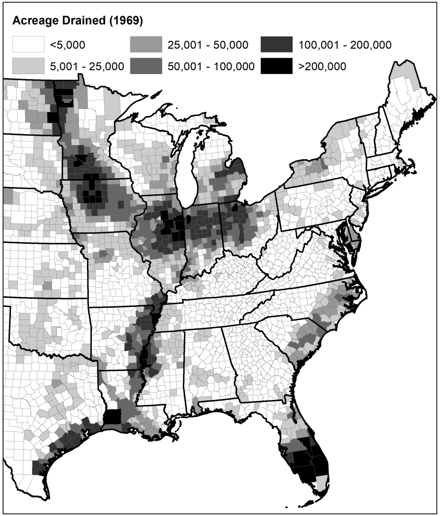
Midwest Glaciated Prairie

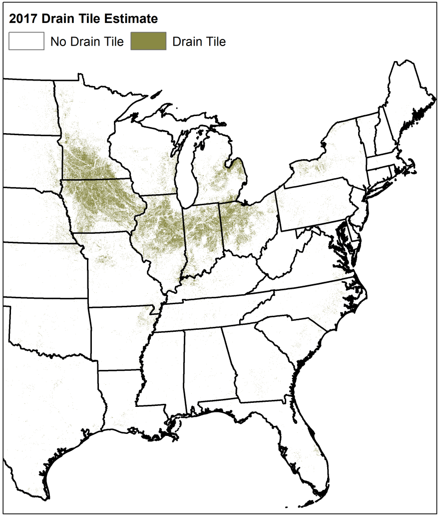


# Drainage Categories



# Drainage Outcomes

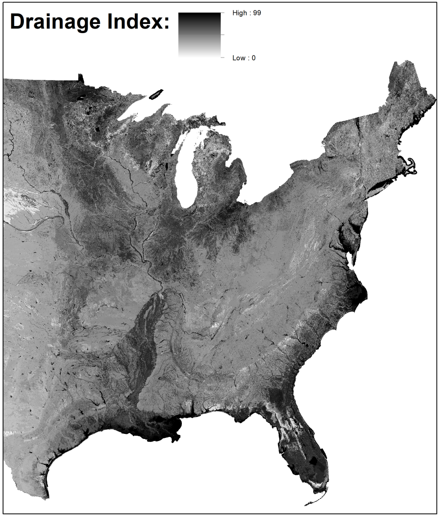


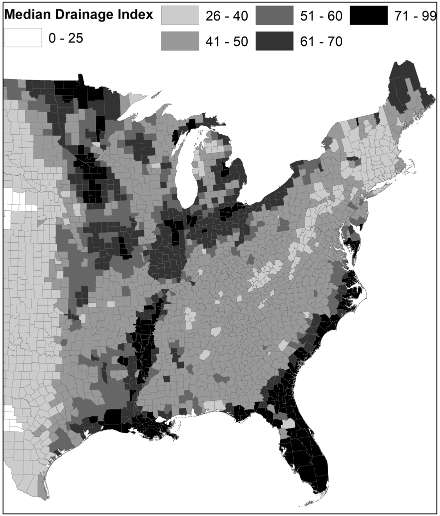
# Variables

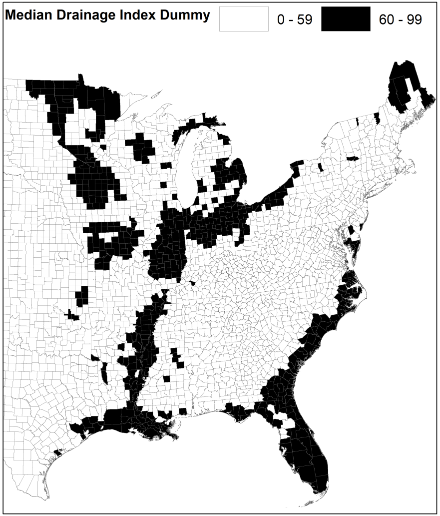
- Outcome variables: **Improved acres** and **value per acre**
- **Soil drainage index (DI)** - ordinal measure of long-term soil wetness (0-99); DI of around 60 are termed “somewhat poorly drained”
- **Drained acres** available in 1920, 1930, 1969
- **Soil Productivity Index (PI)** - ordinal measure of soil quality for crop production (0-19)
- **Year of first drainage district legislation** - collect by authors; legislation should provide for local petition, election, eminent domain, and taxation

# Drainage and Productivity

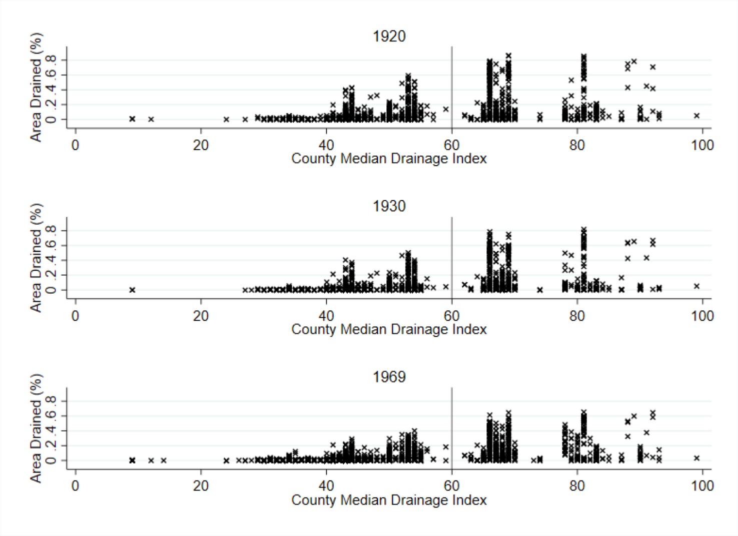



# Measures of Poorly Drained Soil



# Drainage Index and Observed Drainage

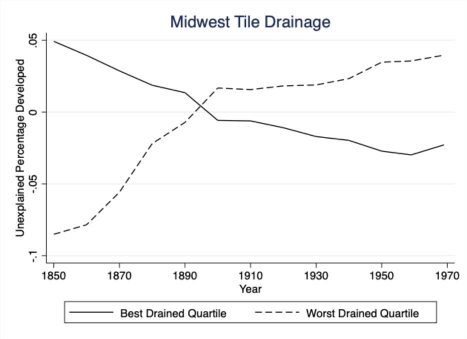


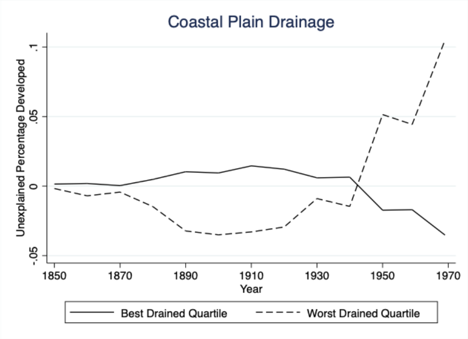
# Conditional Summary Statistics

| Variable | Drainage Index $< 60$ Pre | Drainage Index $< 60$ Post | Drainage Index $> 60$ Pre | Drainage Index $> 60$ Post |
|---|---|---|---|---|
| Total Value in Farms (2020$ millions) | 118.92 | 273.98 | 76.46 | 414.74 |
| | (165.59) | (254.58) | (117.49) | (398.31) |
| Pct. of County Improved | 0.27 | 0.39 | 0.18 | 0.49 |
| | (0.20) | (0.24) | (0.20) | (0.28) |
| Total Farms | 1,538 | 1,854 | 1,116 | 2,048 |
| | (1,317) | (1,151) | (1,210) | (1,349) |
| Total Acres in Farms | 193,255 | 283,391 | 151,427 | 273,265 |
| | (135,533) | (185,360) | (130,312) | (165,209) |
| Per Acre Farm Value | 862.95 | 1,300.12 | 461.47 | 1,540.88 |
| | (3,393.03) | (9,162.02) | (556.02) | (2,334.91) |
| Median Drainage Index | 43.84 | | 72.47 | |
| | (6.24) | | (7.83) | |
| Median Productivity Index | 8.09 | | 10.16 | |
| | (3.93) | | (3.42) | |

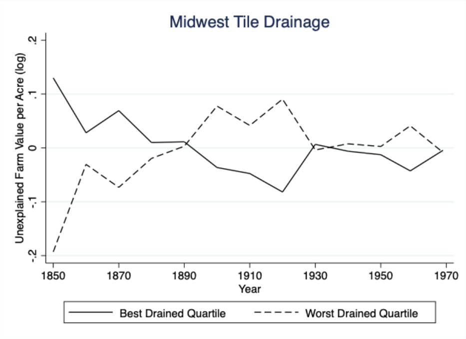
**Notes:** Summary statistics conditional on treatment status: high drainage counties $DI > 60$ and pre/post drainage district laws. All values are the mean value of all the counties in that treatment status for the variable described on the left and for all years in that status. Standard deviations are reported in parentheses.

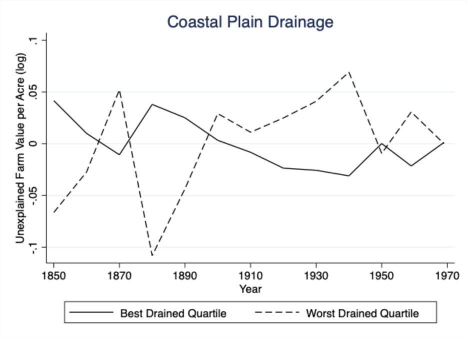
# Drainage Quartile Residuals: Percentage Improved



# Drainage Quartile Residuals: Ag Land Value per Acre



# Empirical Strategy

- The typical approach for recovering difference-in-difference estimates of average treatment effects (ATT) would be to use a two-way fixed effects estimator (TWFE) of the form:

$$Y_{ist} = \beta_{TWFE} PostLaw_{st} \times HighDI_i + \lambda_i + \tau_t + \varepsilon_{ist}$$

  - $Y_{ist}$ is the outcome for county $i$ in state $s$ in year $t$
  - $\lambda_i$ and $\tau_t$ are county and year FE
  - *PostLaw* d- state as passed a drainage law
  - and *HighDI* - county is designated as having a high DI, respectively.
- Identification: Comparison group is counties within a state that become treated, but which differ in their need for drainage
- de Chaisemartin and d'Haultfoeuille (2020) and Callaway and Sant'Anna (2020) both propose alternative DiD estimators that are robust to heterogeneous treatment effects across time and/or cohorts

# Diff-in-Diff with TWFE and Heterogeneous Treatment

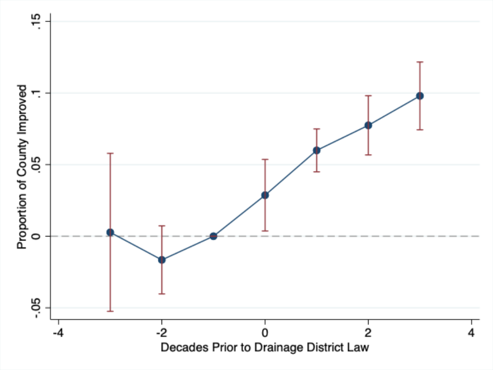
- $\beta_{TWFE}$ potentially provides biased estimates of the ATT when states are treated at different times and there is substantial heterogeneity in the treatment effects over time or between states
- $\beta_{TWFE}$ is a weighted average of all comparisons of "switchers" to "non-switchers":
  1. switchers to never-treated counties
  2. early switchers to non-yet-treated counties
  3. late switchers to already-treated counties
- The third comparison can lead to negative weights

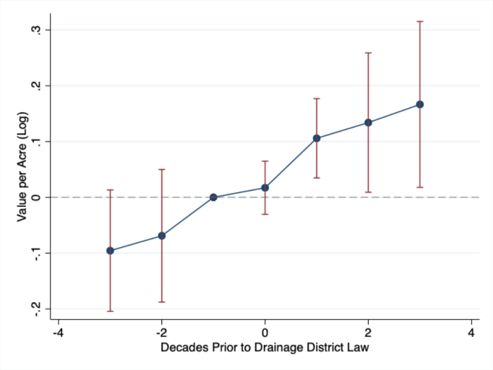
# Treatment: Drainage District Legislation

Table: Year of Drainage District Legislation

| State | Year | State | Year |
|---|---|---|---|
| Michigan | 1869 | Kentucky | 1912 |
| Ohio | 1859 | Arkansas | 1904 |
| Iowa | 1884 | Louisiana | 1907 |
| Illinois | 1879 | South Carolina | 1912 |
| Missouri | 1899 | Virginia | 1906 |
| Nebraska | 1881 | Georgia | 1911 |
| Minnesota | 1887 | Florida | 1907 |
| Indiana | 1863 | North Carolina | 1909 |
| Wisconsin | 1899 | Mississippi | 1906 |
| South Dakota | 1907 | Texas | 1905 |
| North Dakota | 1895 | Tennessee | 1909 |
| Kansas | 1879 | Oklahoma | 1908 |
| New York | 1909 | | |

# Event Studies: Midwest Tile

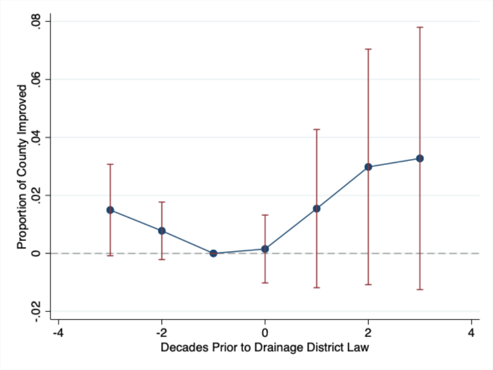


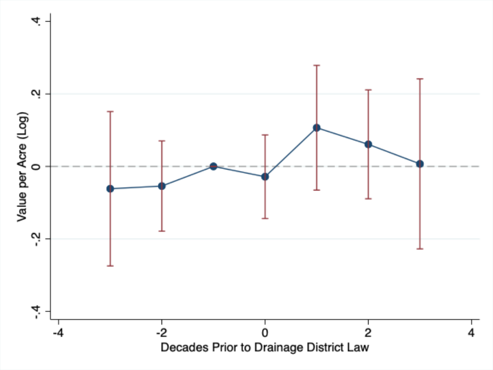



# Failed Drainage: Wisconsin

- Beginning around 1900 Wisconsin marsh lands were organized into drainage districts
- Followed by several decades the successful efforts in Iowa and Illinois
- By the 1930s, drained lands largely reverted to public ownership and became recreational havens

# Event Studies: Coastal Plain



# Failed Drainage: North Carolina

- Lake Mattamuskeet: largest lake in NC near coast
- Partial draining of the lake took place as early as 1837
- Private investors fully drained the lake in 1916 by dredging 130 miles of canals and building water control dams and a large coal-fired pumping station
- Firm failed due in part to low commodity prices and pumping station abandoned.
- Twice more between 1916 and 1926, the lake was drained but then abandoned and allowed to refill
- Sold to the federal government in 1934 to become wildlife refuge.

# Estimates of Ag Development after Drainage District Laws

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | All States in Sample | | Midwest Tile | | Coastal Plain | |
| | Pct. Impr. | \$/ac (log) | Pct. Impr. | \$/ac (log) | Pct. Impr. | \$/ac (log) |
| *Panel A:* | | | | | | |
| | *de Chaisemartin & D'Haultfoeuille (2020)* | | | | | |
| Post Drainage District Law | 0.049*** | 0.081*** | 0.066*** | 0.106*** | 0.02 | 0.058 |
| | (0.012) | (0.036) | (0.007) | (0.048) | (0.015) | (0.091) |
| *Panel B:* | | | | | | |
| | *Callaway & Sant'Anna (2020)* | | | | | |
| Post Drainage District Law | 0.043* | 0.109** | 0.043 | 0.092 | 0.040** | 0.142 |
| | (0.022) | (0.051) | (0.032) | (0.066) | (0.016) | (0.091) |
| *Panel C:* | | | | | | |
| | *Two-Way Fixed Effects* | | | | | |
| Post Drainage District Law | 0.055*** | 0.134*** | 0.070*** | 0.125** | 0.032* | 0.132 |
| | (0.012) | (0.040) | (0.015) | (0.042) | (0.016) | (0.129) |
| Number of Counties | 1788 | 1788 | 1122 | 1122 | 666 | 666 |
| $R^2$ (TWFE) | 0.926 | 0.909 | 0.914 | 0.912 | 0.895 | 0.925 |

**Notes:** Standard errors are clustered by county and reported in parentheses; statistical significance is indicated by $*(p < 0.1), **(p < 0.05), ***(p < 0.01)$.

# Results Summary

- Drainage has two effects:
  - Brings more land is swampy counties into production
  - Increases productivity of land
- The coefficient estimates are fairly consistent and robust for improved acres for the Midwest Tile group
  - A poorly drained county (DI>60) will see a 4.3 to 7.0 percentage point increase in the area of the county with improved agricultural land
  - 9.6-13.3% increase in land value per acre
- Coastal Plain coefficient magnitudes are lower for improved acres and generally not statistically significant
- Back of envelope calculation:
  - Average high-DI county has 151,427 acres improved, which increases by 4.3-5.5pp
  - The average per acre land value in a high-DI county was $461 pre-treatment, which increases 8.4-14.3%
  - The total increase in value due was $7.3-13M per high-DI county
  - There are 503 counties in the high-DI category, suggesting that drainage added $3.67-6.54B

# Thank you!

# References

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