

Economic Adaptation to the Environment:
Lessons from the Dust Bowl
and the Ogallala Aquifer

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April 3, 2014

Figure 1A. Share of Land in Farms on the US Plains

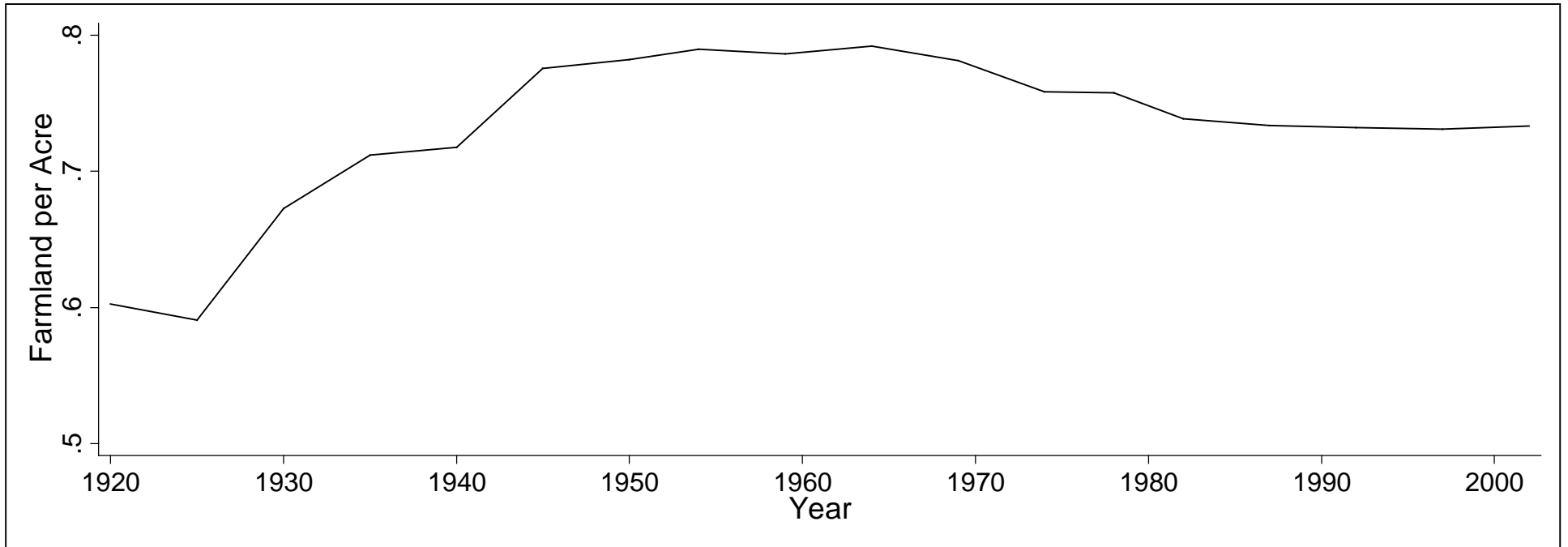
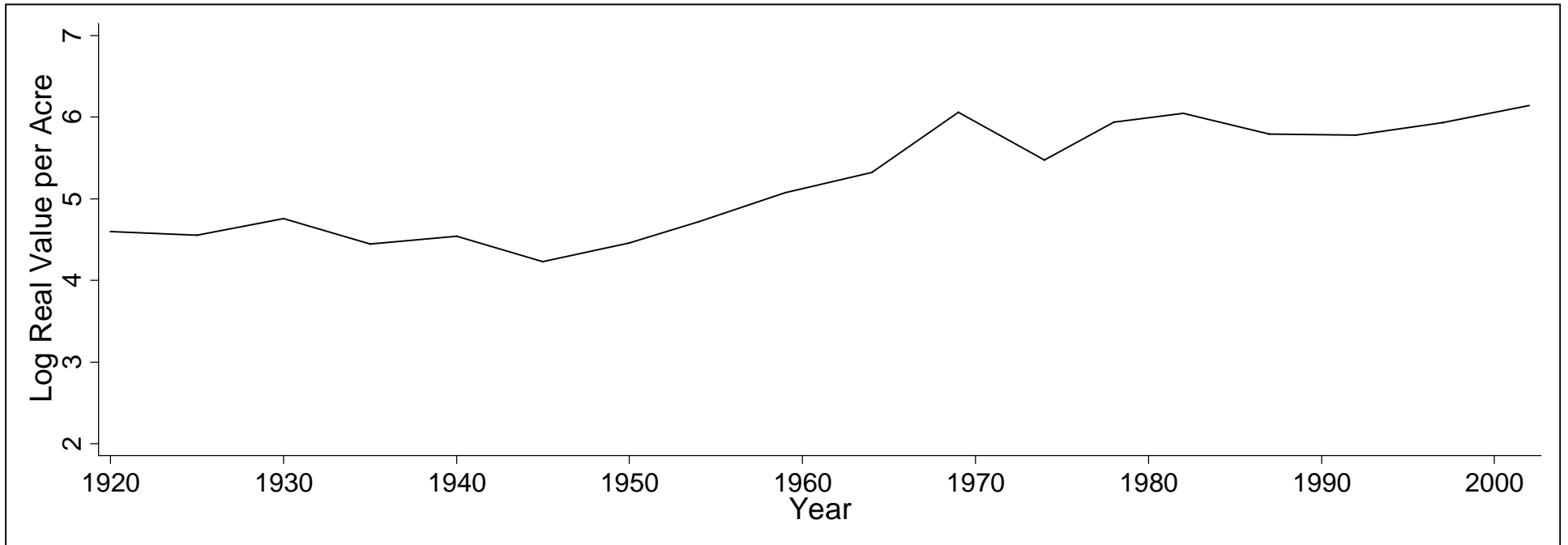


Figure 1B. Real Agricultural Value of Land on the US Plains



Land Values and Environmental Endowments

Does a change in technology preserve environmental advantages?

Definition 1. A change in technology from A_1 to A_2 preserves environmental rank of $(i, j) \in G$ if

$V_{i1}(A_1, E_i) \geq V_{j1}(A_1, E_j)$ implies that
 $V_{i2}(A_2, E_i) \geq V_{j2}(A_2, E_j)$.

Does technological change affect the dispersion of environmental advantages or disadvantages?

Definition 2. A change in technology from A_1 to A_2 is **environment-neutral** if the standard deviation of land values over environmental characteristics is constant:

$$\sqrt{\frac{\sum_{i=1}^G (V_{i2} - \bar{V}_2)^2}{G - 1}} - \sqrt{\frac{\sum_{i=1}^G (V_{i1} - \bar{V}_1)^2}{G - 1}} = 0.$$

By contrast, a change in technology from A_1 to A_2 leads to **environmental convergence** if < 0 and **environmental divergence** if > 0 .

Estimation Method

Two Step Procedure:

1. Estimate Within-Group Values, weighted by county area

$$\text{LogValue}_{ct} = \sum_{i=1}^G \theta_{it} \text{LandShare}_c^i + \epsilon_{ct}$$

2. Estimate Cross-Group Std Deviation, weighted by group area

$$\sigma_t = \sqrt{\frac{\sum_{i=1}^G (\theta_{it} - \bar{\theta}_t)^2}{G - 1}}$$

Figure 2A. Value of Land by Major Soil Group

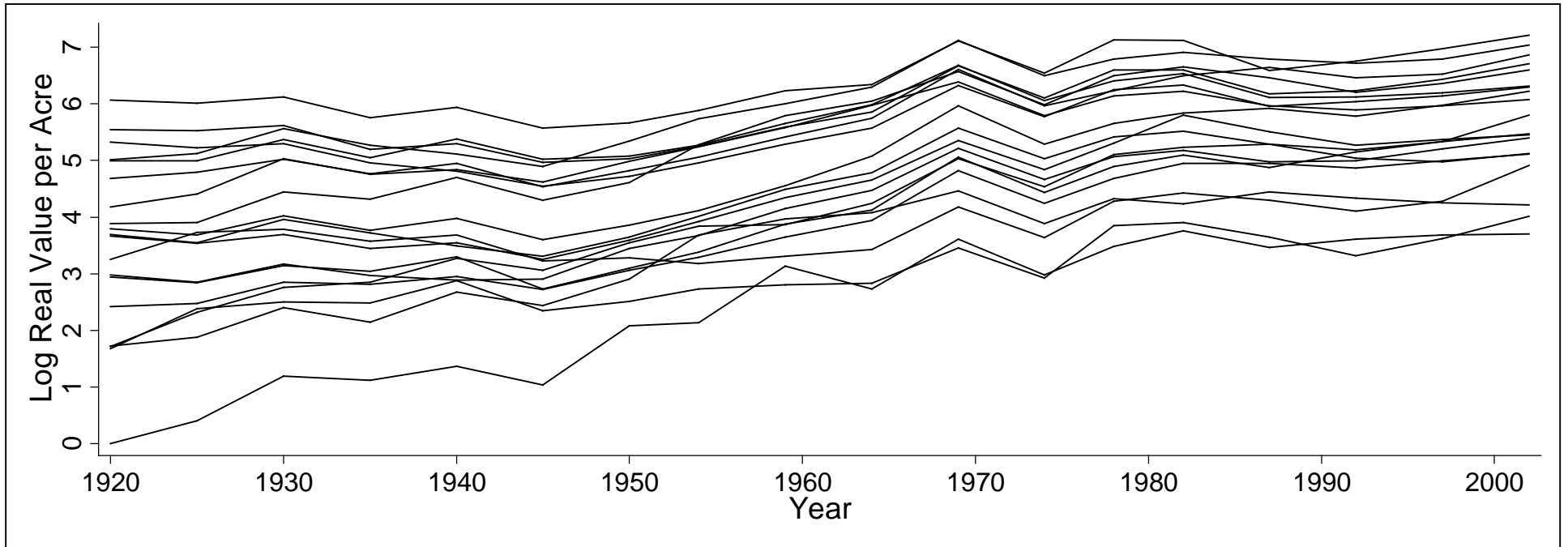


Figure 2B. Standard Deviation in Land Values, Across Soil Groups

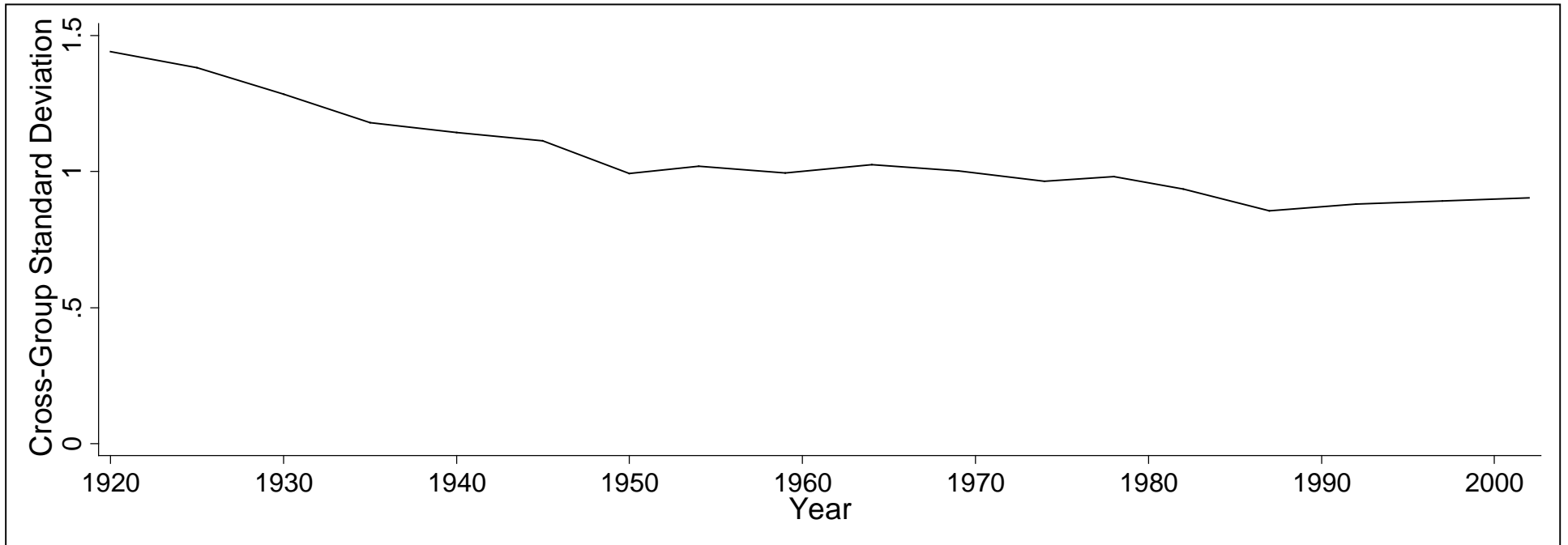


Figure 3A. Value of Land by Mean Annual Temperature Group (20 Groups)

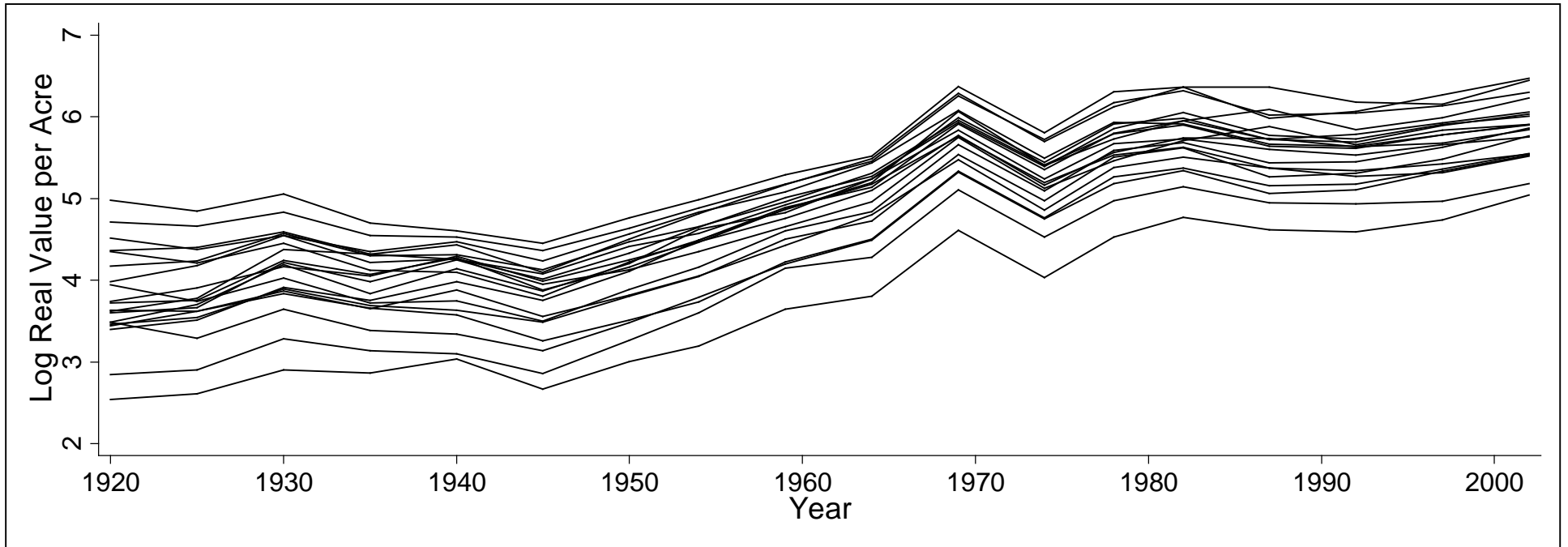


Figure 3B. Standard Deviation in Land Values, Across Temperature Groups

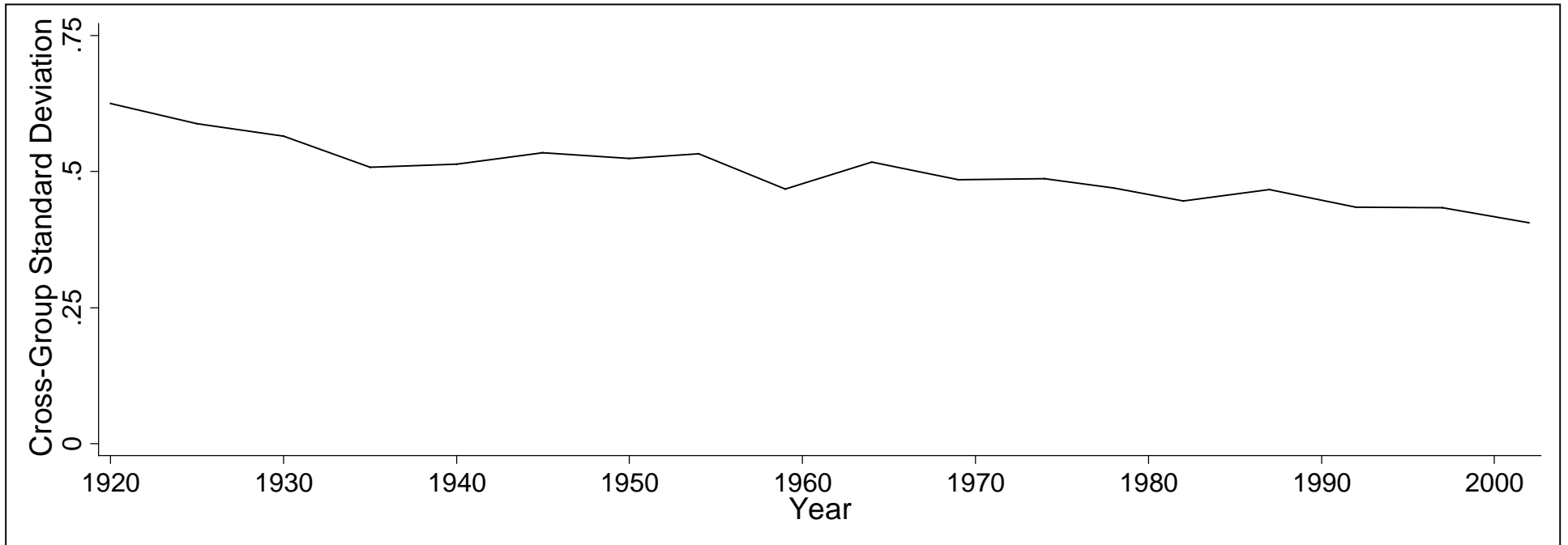


Figure 4A. Value of Land by Mean Annual Precipitation Group (20 Groups)

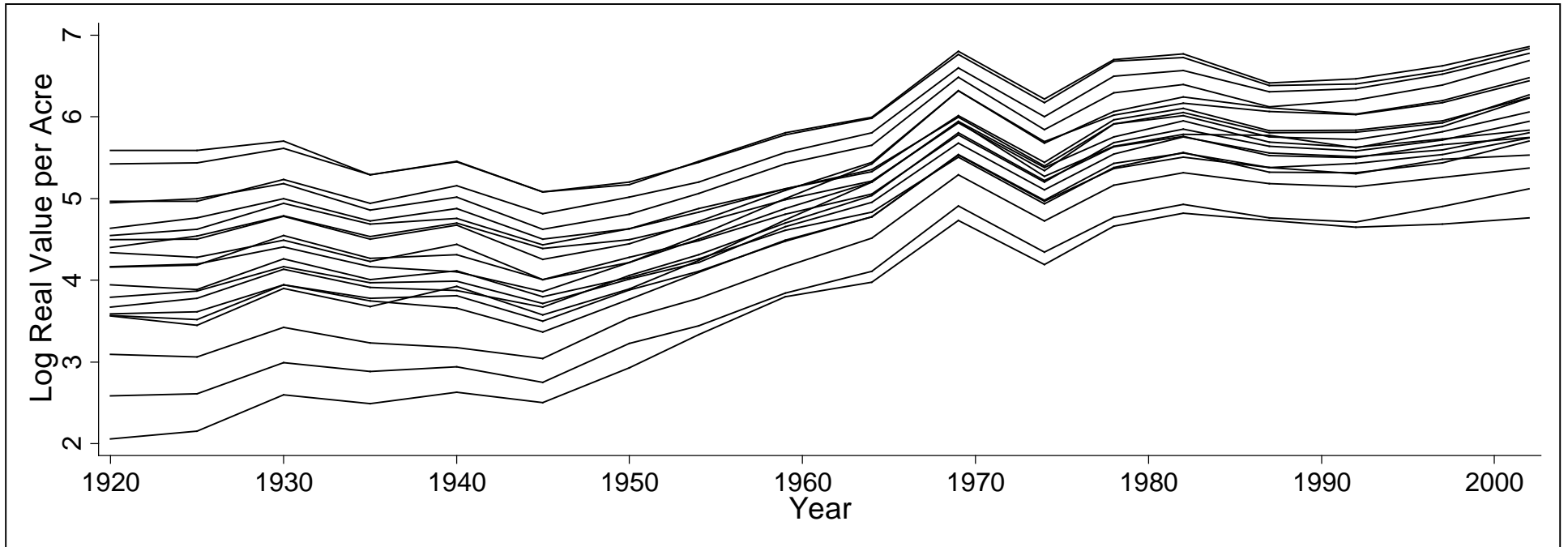
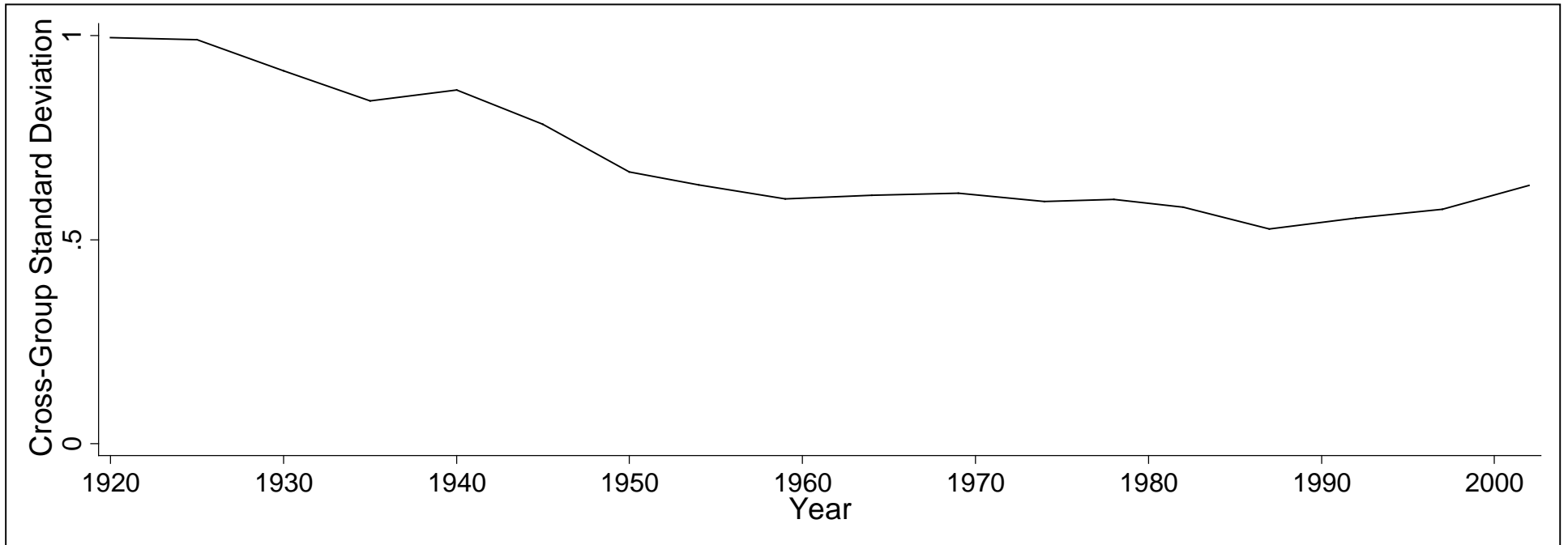


Figure 4B. Standard Deviation in Land Values, Across Precipitation Groups

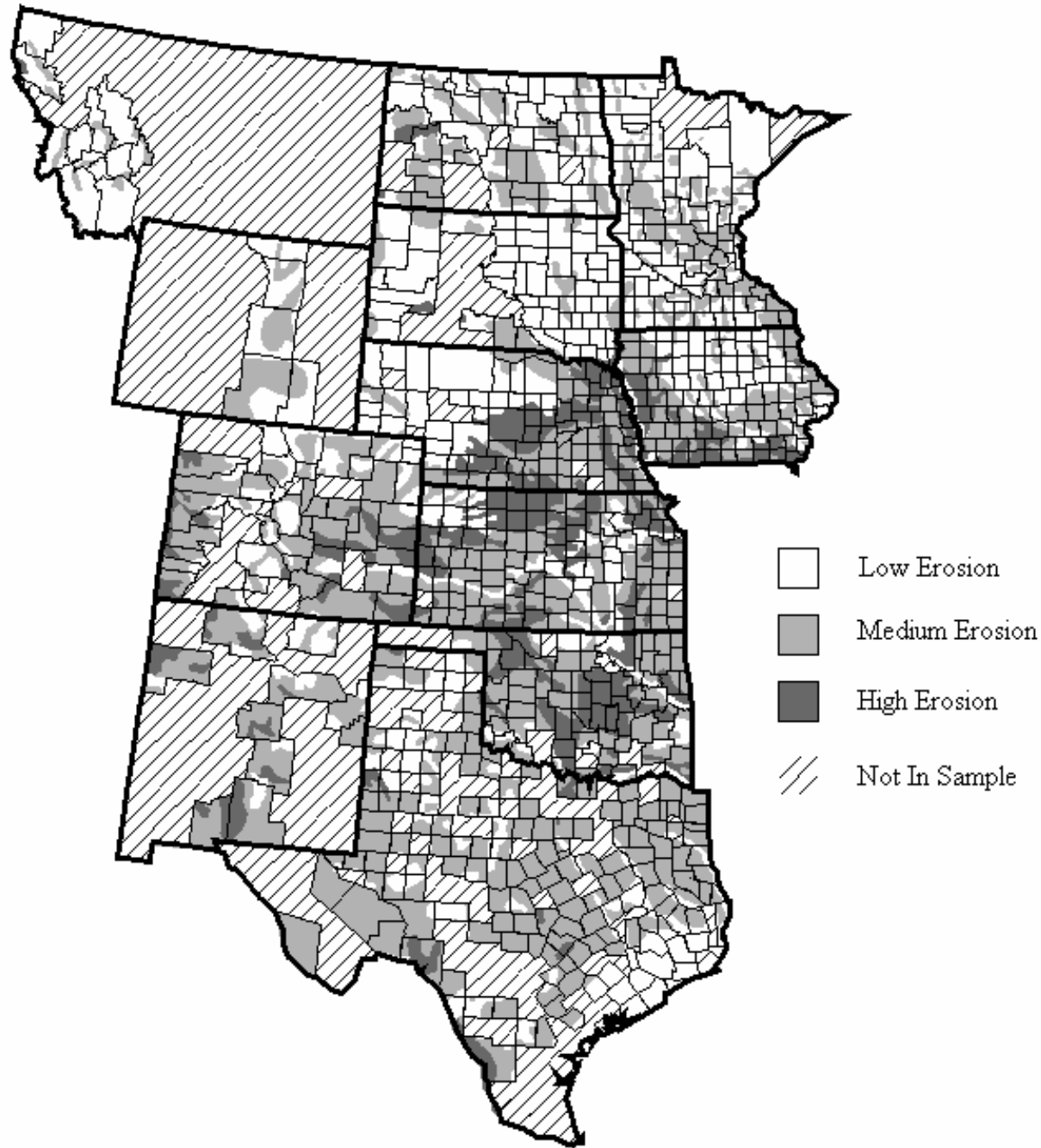






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2. Sample Counties, by Erosion Level

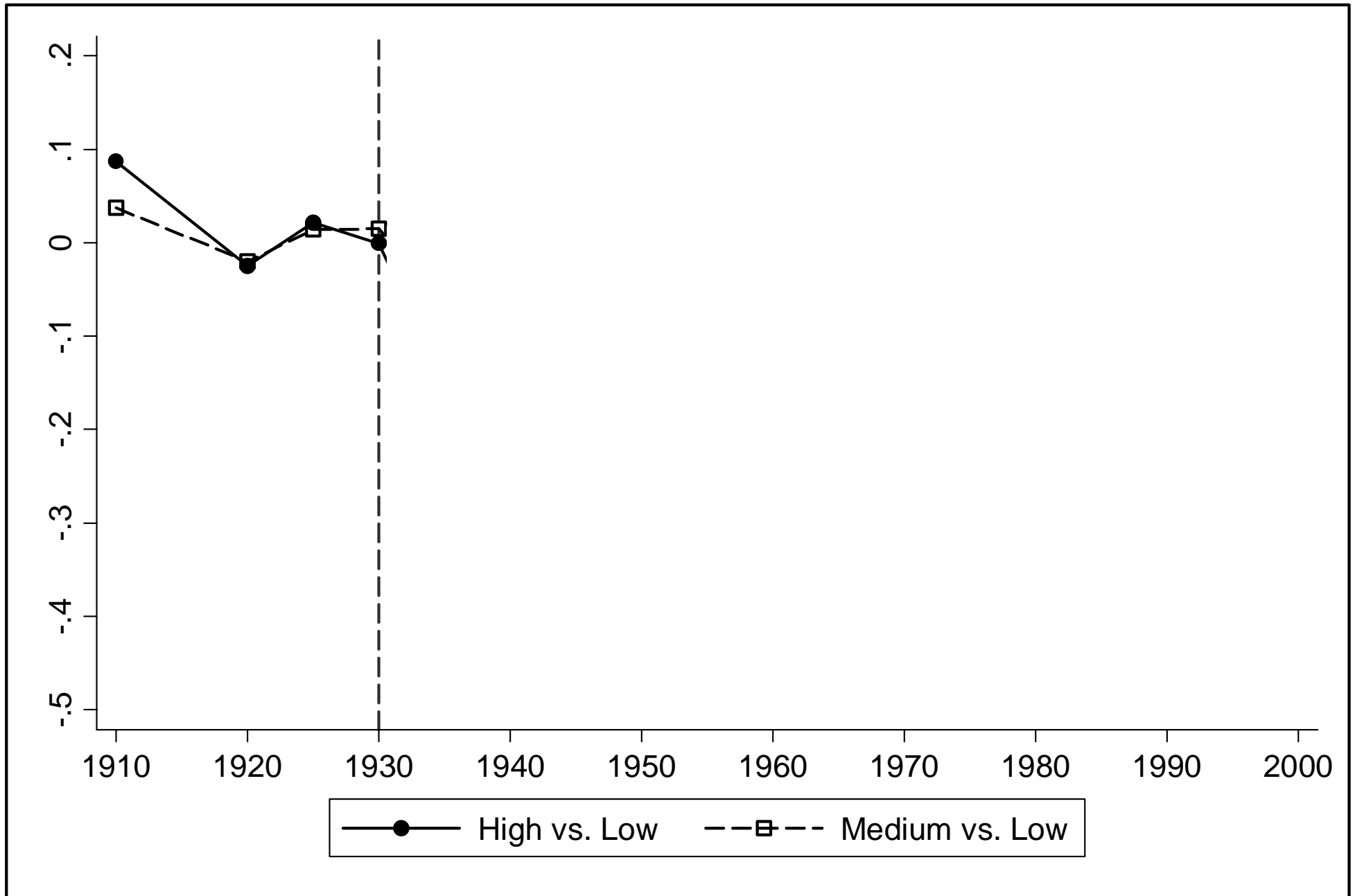


Estimating Equations

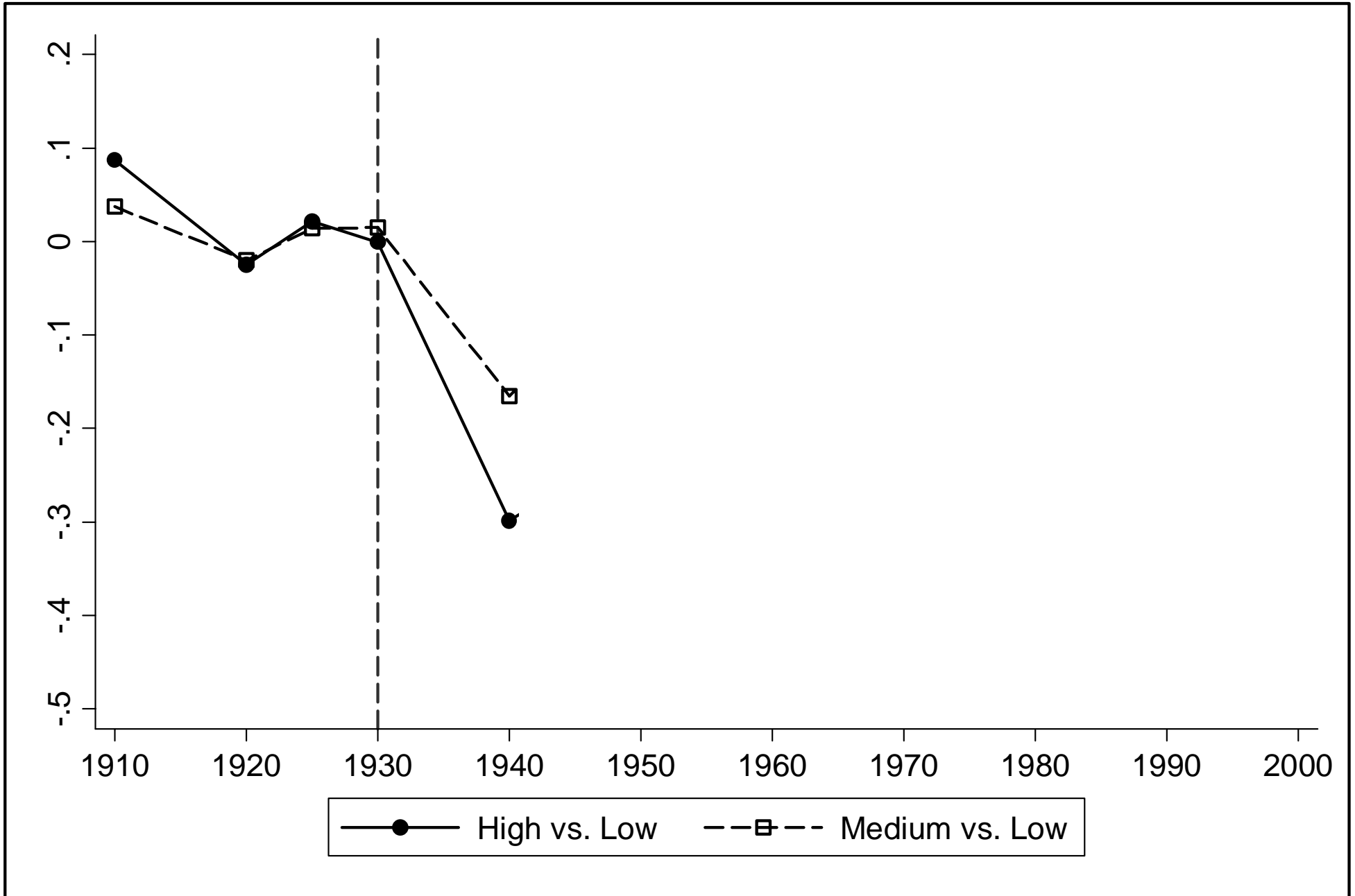
Figures:

$$Y_{ct} = \beta_{1t}M_c + \beta_{2t}H_c + \alpha_{st} + \theta_t X_c + \epsilon_{ct} \quad (1)$$

3. Land Value, per acre of farmland



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3. Land Value, per acre of farmland



Estimating Equations

Figures:

$$Y_{ct} = \beta_{1t}M_c + \beta_{2t}H_c + \alpha_{st} + \theta_t X_c + \epsilon_{ct} \quad (1)$$

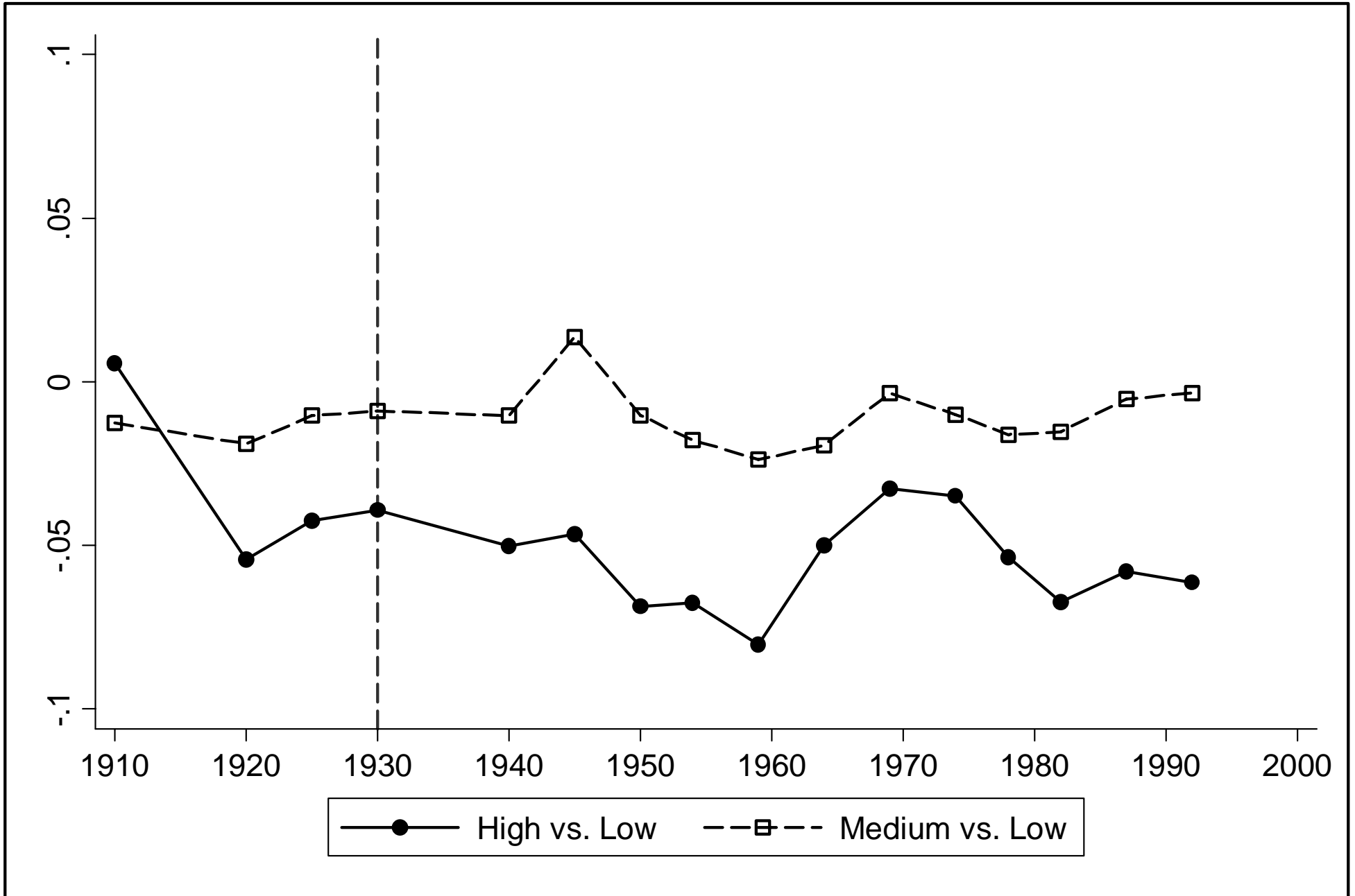
Tables:

$$Y_{ct} - Y_{c1930} = \beta_{1t}M_c + \beta_{2t}H_c + \alpha_{st} + \theta_t X_c + \gamma_t L_c + \epsilon_{ct} \quad (2)$$

2. Changes in Agricultural Land Value and Revenue

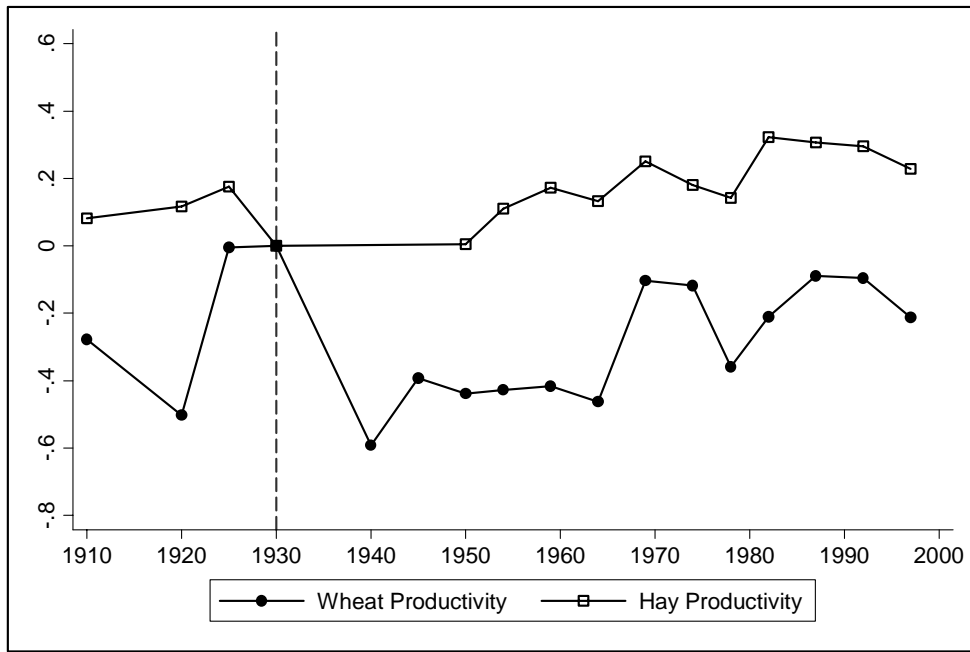
| | Land Value | | Revenue | | Ratio (1) / (3) |
|-----------------|------------|------------|------------|------------|-----------------|
| | Change | % Persist | Change | % Persist | |
| | After 1930 | After 1940 | After 1930 | After 1940 | |
| | (1) | (2) | (3) | (4) | (5) |
| 1940 | | | | | |
| High - Low | -0.278 | | -0.316 | | 0.881 |
| | (0.041) | | (0.055) | | (0.120) |
| Medium - Low | -0.167 | | -0.202 | | 0.824 |
| | (0.029) | | (0.039) | | (0.136) |
| High - Medium | -0.111 | | -0.114 | | 0.981 |
| (calculated) | (0.032) | | (0.048) | | (0.313) |
| Averaged Value | | | | | 0.861 |
| (GLS) | | | | | (0.112) |
| R-squared | 0.9496 | | 0.8925 | | |
| Sample Counties | 769 | | 769 | | |

6. Farmland, per acre of County

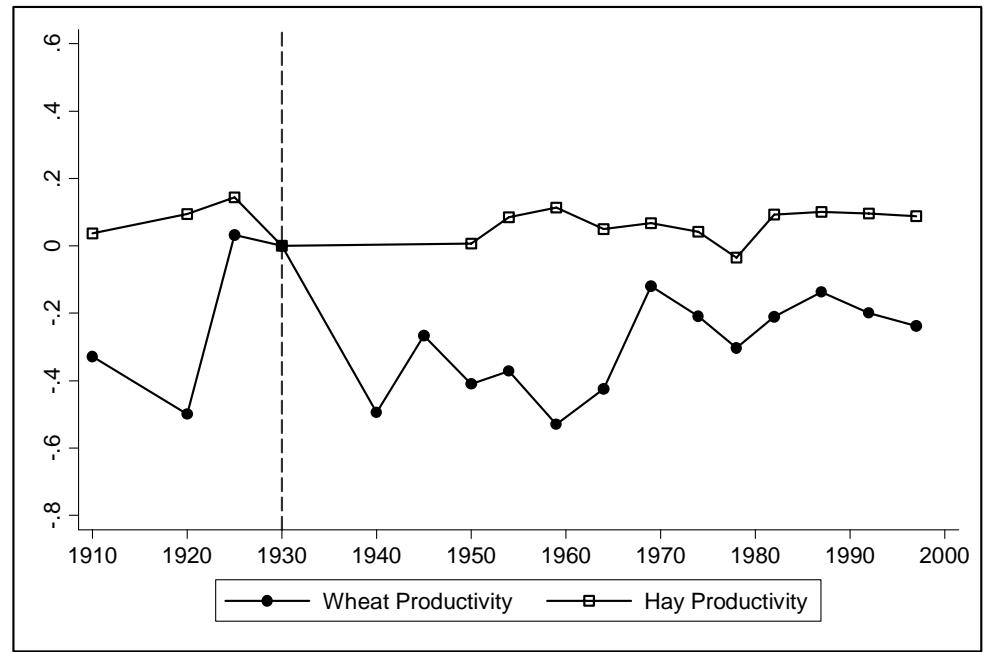


8. Wheat & Hay Productivity, and Land Allocated to Wheat

A. Productivity: High – Low Erosion

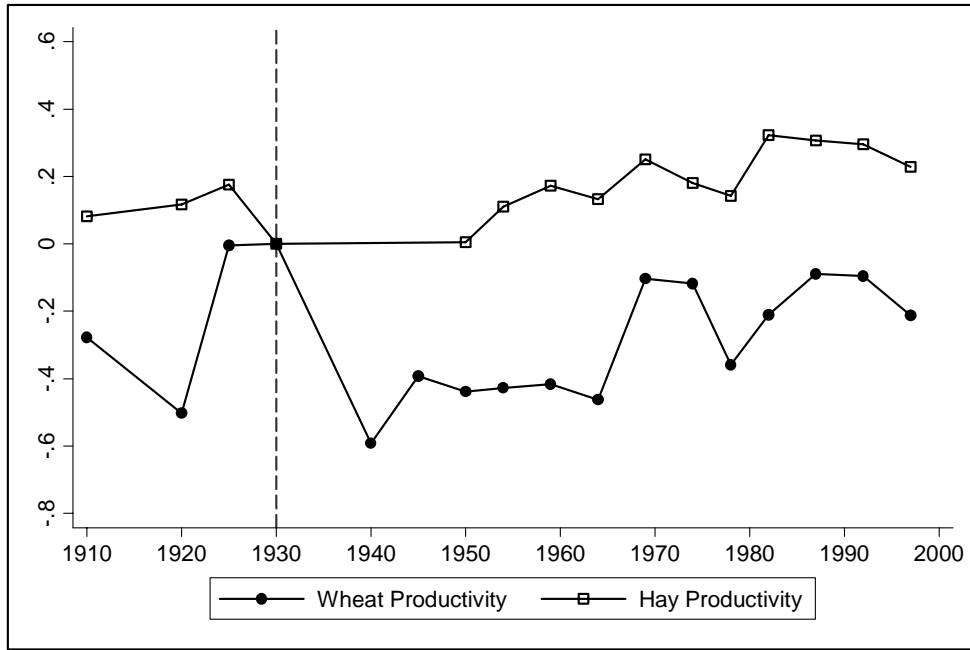


B. Productivity: Medium – Low Erosion

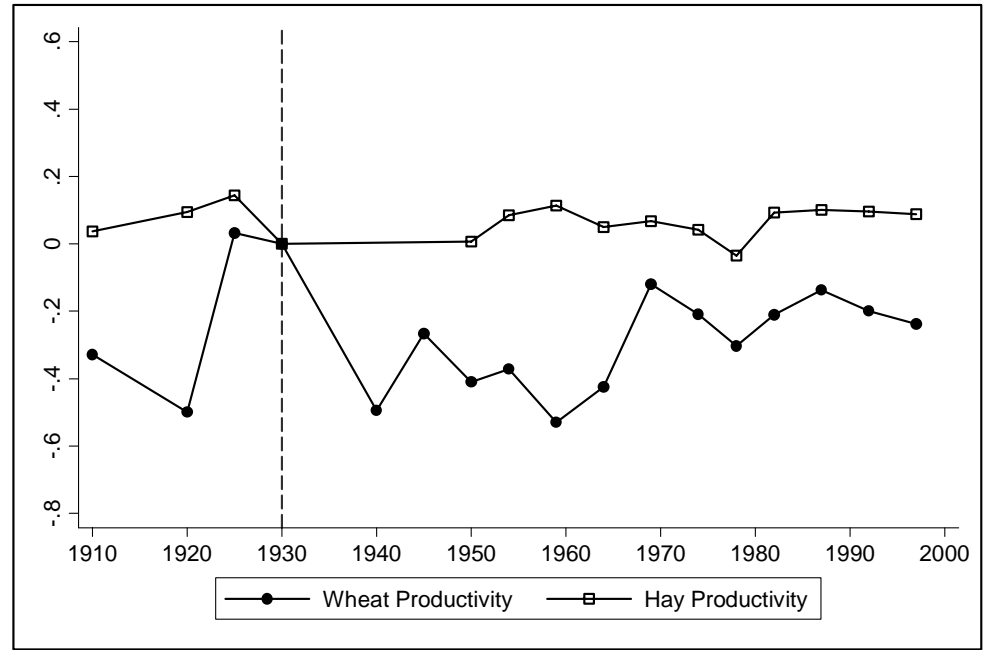


8. Wheat & Hay Productivity, and Land Allocated to Wheat

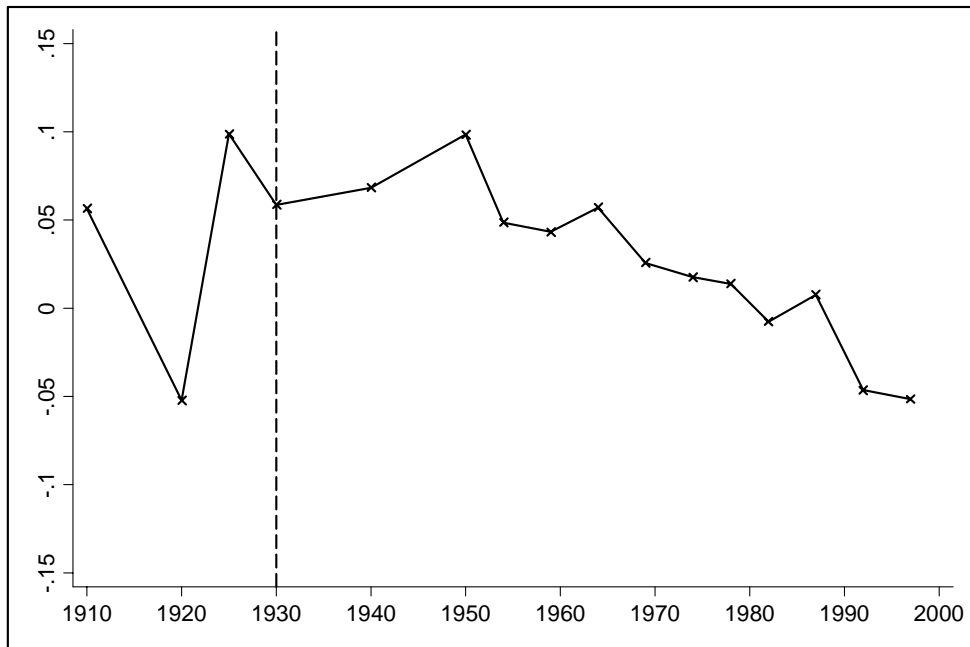
A. Productivity: High – Low Erosion



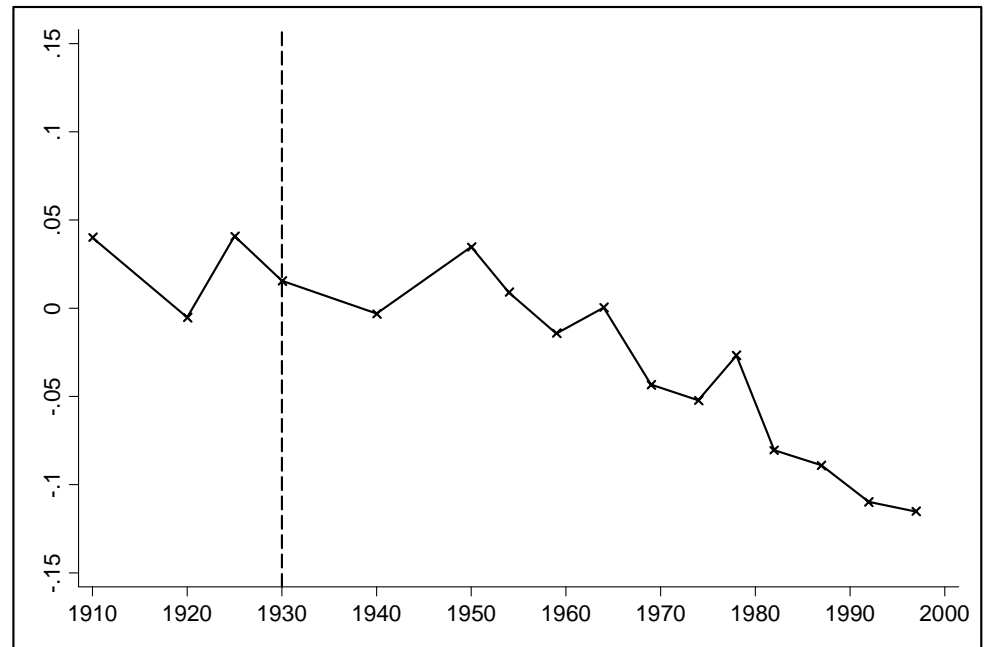
B. Productivity: Medium – Low Erosion



C. Land in Crops: High – Low Erosion

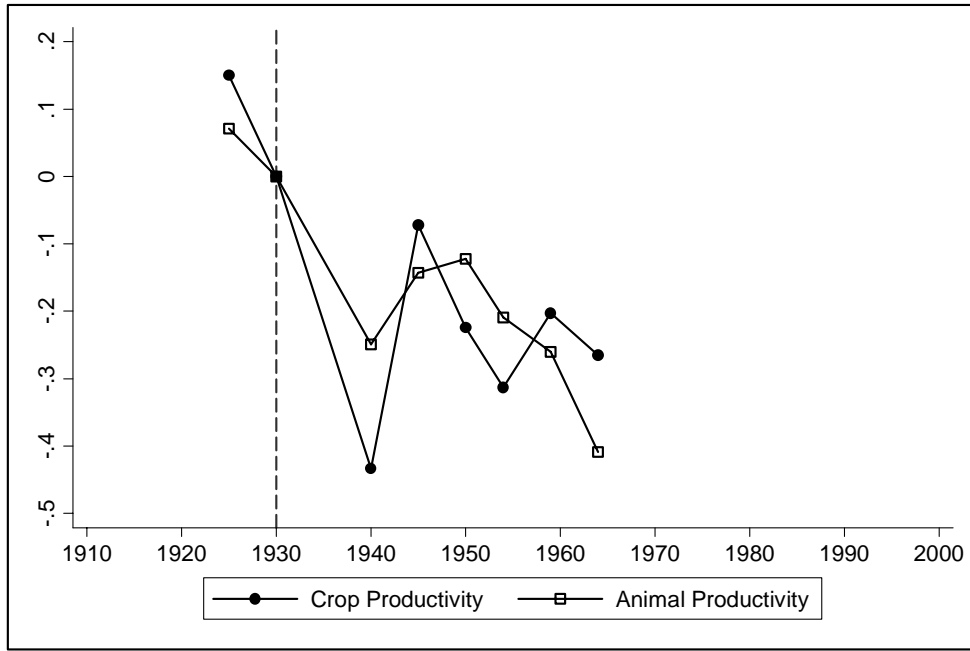


D. Land in Crops: Medium – Low Erosion

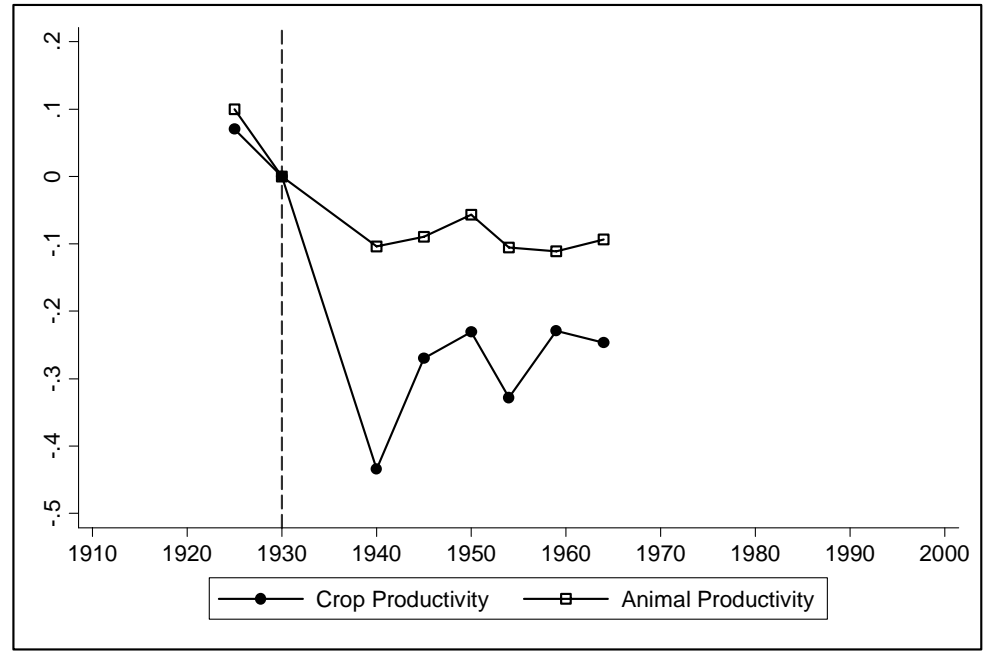


7. Crop & Animal Productivity, and Land Allocated to Crops

A. Productivity: High – Low Erosion

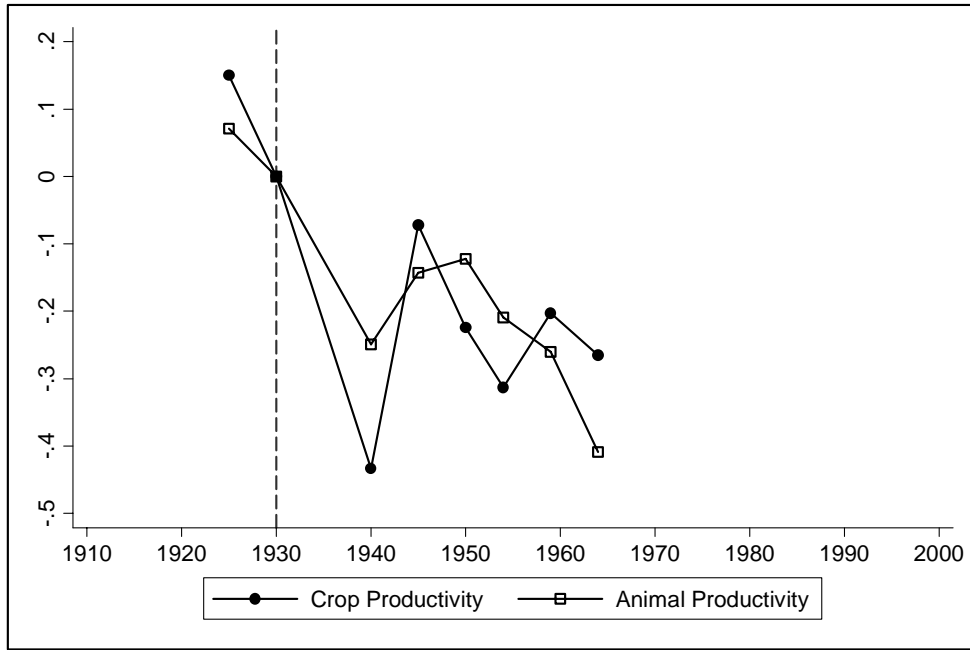


B. Productivity: Medium – Low Erosion

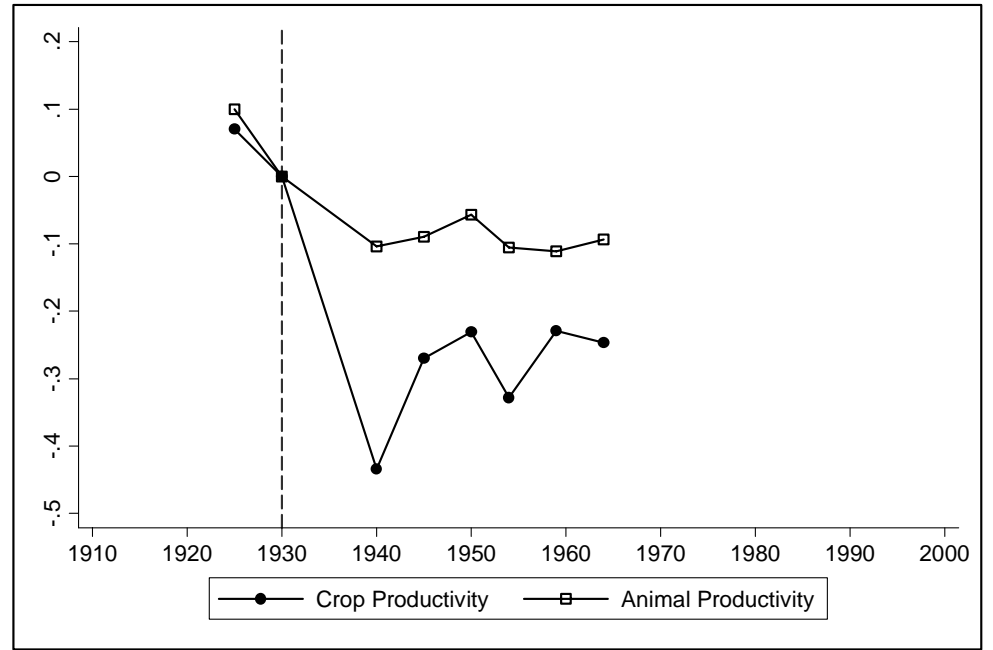


7. Crop & Animal Productivity, and Land Allocated to Crops

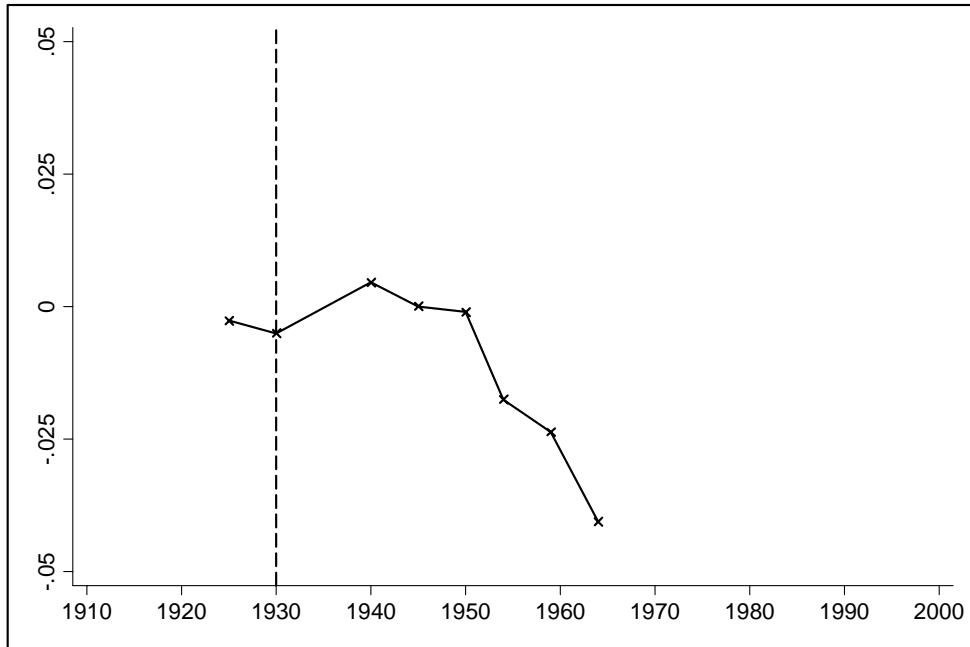
A. Productivity: High – Low Erosion



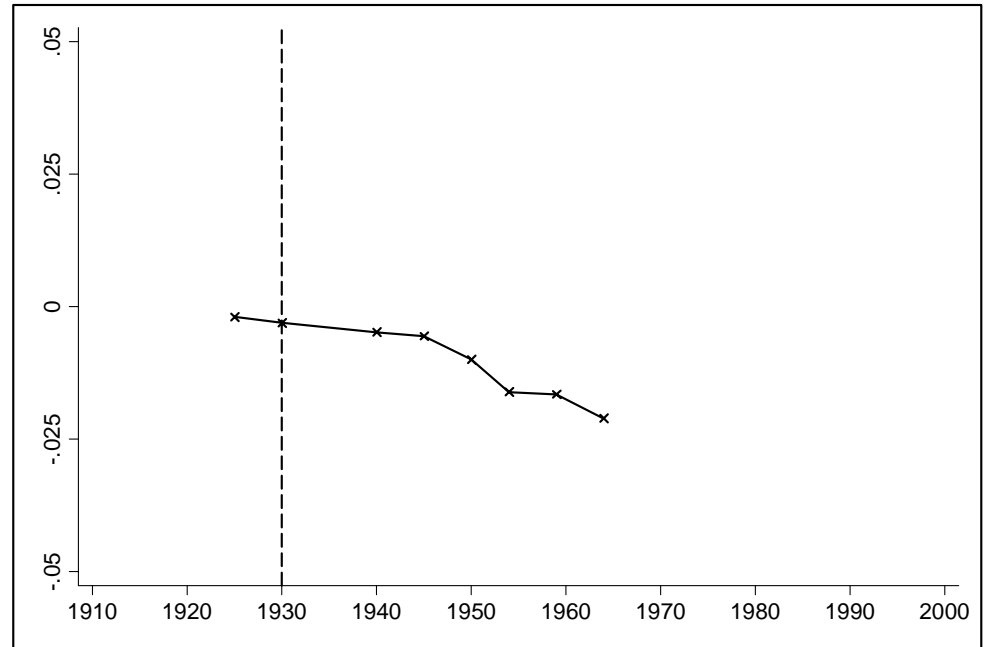
B. Productivity: Medium – Low Erosion



C. Land in Crops: High – Low Erosion



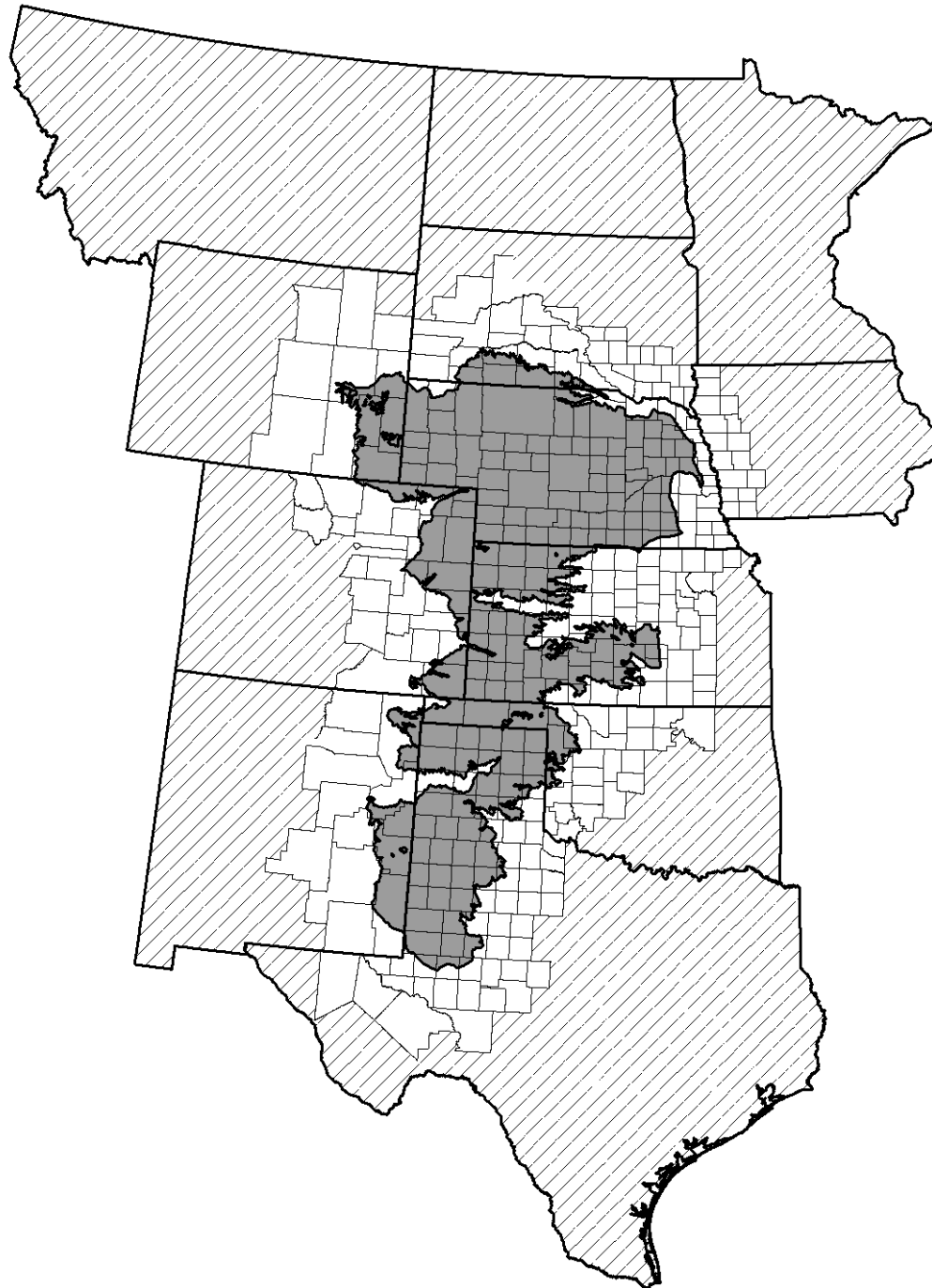
D. Land in Crops: Medium – Low Erosion



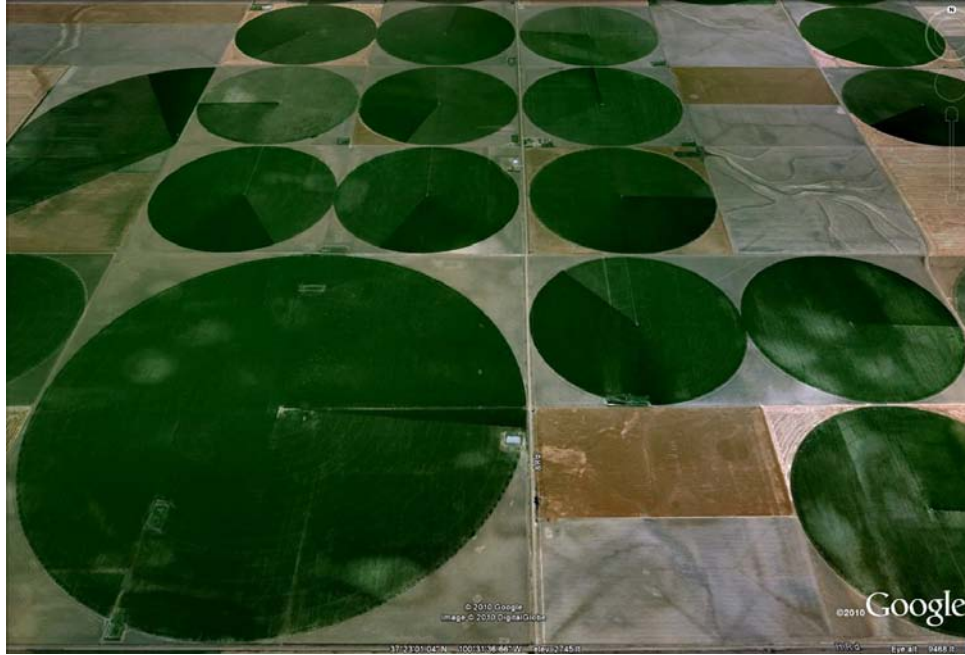
7. Population Outcomes

| | Log Population | Fraction Rural | Fraction on Farm |
|--------------|---------------------|---------------------|----------------------|
| High - Low | | | |
| 1940 | -0.081** (0.021) | -0.0118 (0.0090) | 0.0159 (0.0095) |
| 1950 | -0.108** (0.041) | -0.0115 (0.0157) | 0.0204* (0.0095) |
| 1960 | -0.148* (0.064) | -0.0165 (0.0199) | |
| 1970 | -0.157 (0.080) | 0.0084 (0.0225) | 0.0334** (0.0121) |
| 1990 | -0.127 (0.109) | | 0.0120 (0.0081) |
| Medium - Low | | | |
| 1940 | -0.065** (0.020) | -0.0102 (0.0075) | 0.0000 (0.0049) |
| 1950 | -0.108** (0.035) | -0.0065 (0.0126) | 0.0077 (0.0070) |
| 1960 | -0.170** (0.055) | -0.0144 (0.0157) | |
| 1970 | -0.180* (0.072) | -0.0094 (0.0181) | -0.0027 (0.0096) |
| 1990 | -0.160 (0.103) | | 0.0004 (0.0065) |

Figure 1. Ogallala Region and Counties Within 100km



Appendix Figure 1a. Kansas Farmland over Ogallala

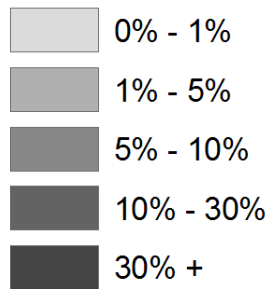
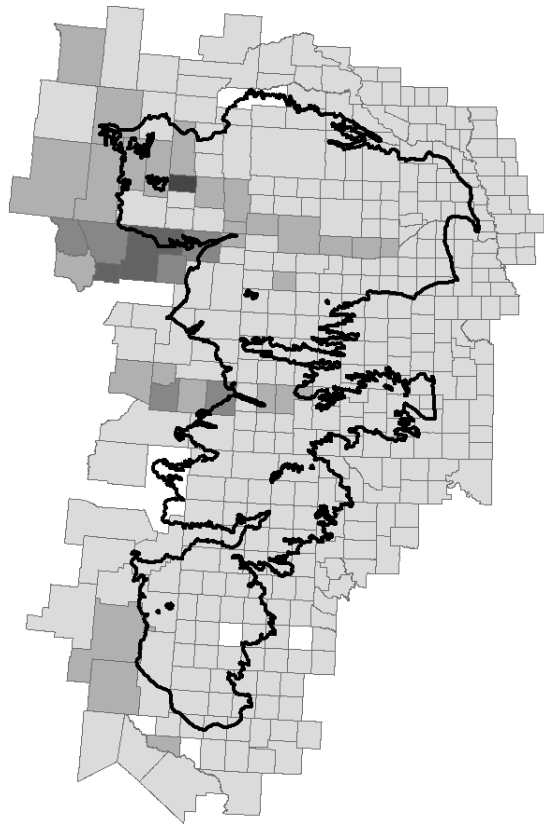


Appendix Figure 1b. Kansas Farmland outside Ogallala



Figure 3. Irrigated Percent of County Area in 1935 and 1974

A. Irrigation in 1935



B. Irrigation in 1974

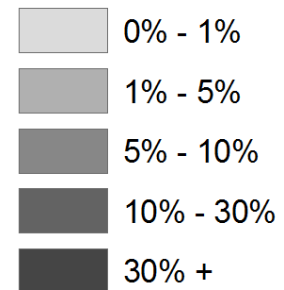
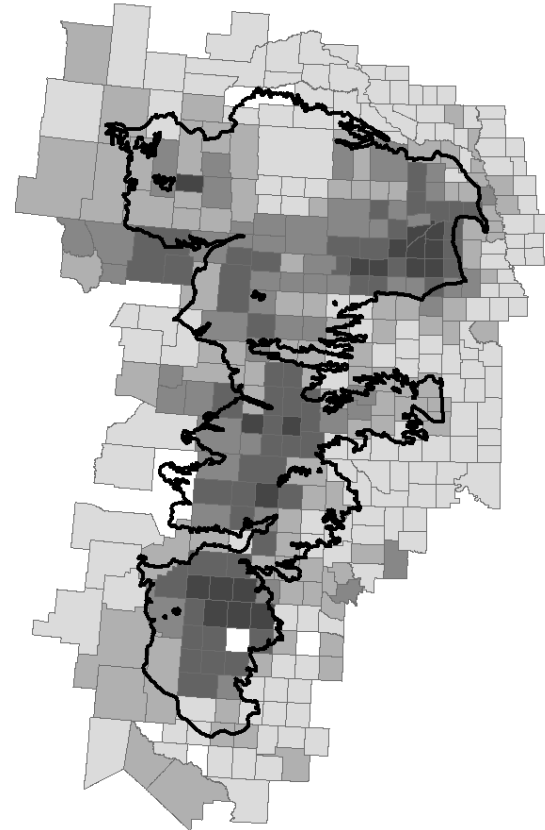
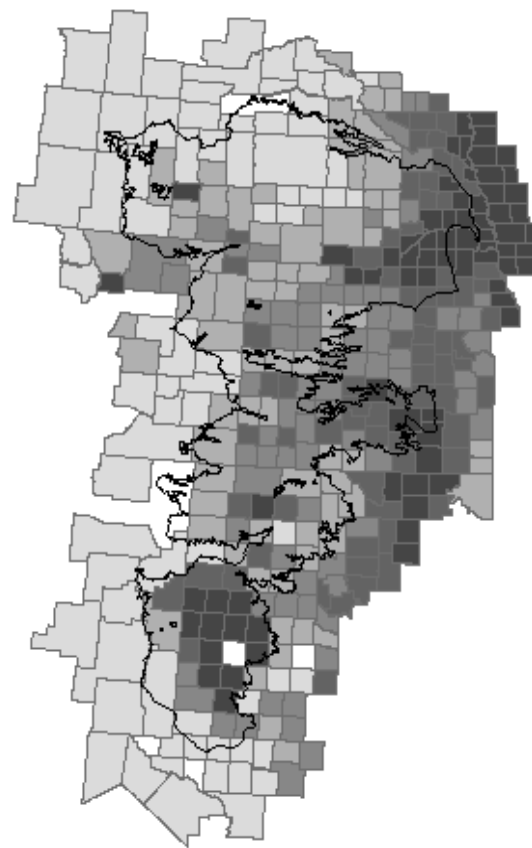
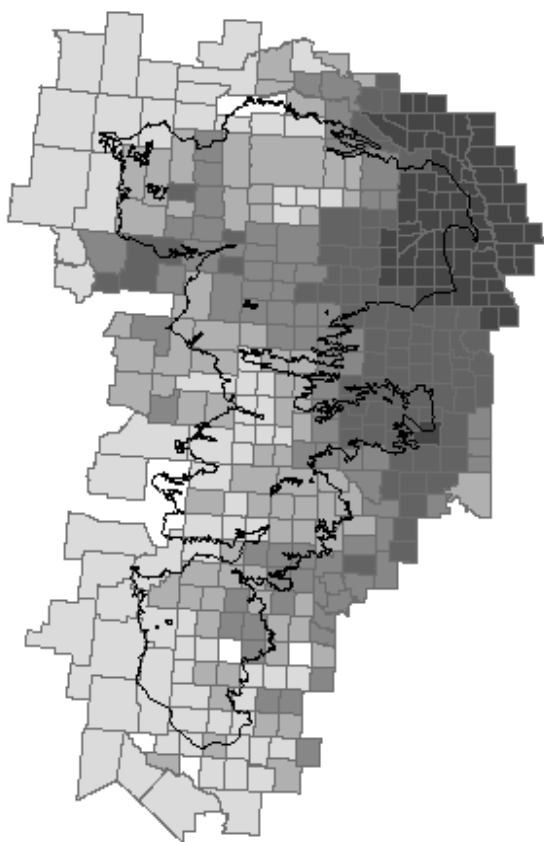


Figure 4. Farmland Value, Shaded by Quintile in Each Year

A. Farmland Value in 1920

B. Farmland Value in 1964



Main Estimating Equation

Cross-sectional differences by Ogallala availability:

$$Y_{ct} = \beta_t \text{OgallalaShare}_c + \alpha_{st} + \gamma_{gt} + \theta_t^x \text{Longitude}_c + \theta_t^y \text{Latitude}_c + \epsilon_{ct}$$

Notes on the estimation:

- ▶ Restricted to counties within 100km of Ogallala
- ▶ Balanced panel of counties
- ▶ Regression weighted by county area
- ▶ Standard errors clustered by county

1. Average County Characteristics in 1920 and Differences by Ogallala Share

| | County Averages: |
|---|---------------------|
| Per county acre: | (1) |
| Farmland | 0.706 [0.249] |
| Irrigated Farmland (1935) | 0.007 [0.020] |
| Log Value of Farmland and Farm Buildings | 2.868 [1.303] |
| Log Value of Farm Revenue | 1.750 [1.179] |
| Corn Acres | 0.054 [0.088] |
| Irrigated Corn Acres | 0.0003 [0.0011] |
| Wheat Acres | 0.077 [0.113] |
| Irrigated Wheat Acres | 0.001 [0.003] |

1. Average County Characteristics in 1920 and Differences by Ogallala Share

Coefficient on Ogallala Share:

| | County Averages: | No Controls |
|---|---------------------|----------------------|
| Per county acre: | (1) | (2) |
| Farmland | 0.706 [0.249] | 0.140** (0.039) |
| Irrigated Farmland (1935) | 0.007 [0.020] | - 0.001 (0.002) |
| Log Value of Farmland and Farm Buildings | 2.868 [1.303] | 0.432* (0.194) |
| Log Value of Farm Revenue | 1.750 [1.179] | 0.306 (0.177) |
| Corn Acres | 0.054 [0.088] | 0.007 (0.010) |
| Irrigated Corn Acres | 0.0003 [0.0011] | 0.0001 (0.0002) |
| Wheat Acres | 0.077 [0.113] | 0.017 (0.013) |
| Irrigated Wheat Acres | 0.001 [0.003] | - 0.0002 (0.0003) |

1. Average County Characteristics in 1920 and Differences by Ogallala Share

| | County Averages: | Coefficient on Ogallala Share: | |
|---|---------------------|--------------------------------|----------------------|
| | | No Controls | State FE |
| Per county acre: | (1) | (2) | (3) |
| Farmland | 0.706 [0.249] | 0.140** (0.039) | 0.020 (0.032) |
| Irrigated Farmland (1935) | 0.007 [0.020] | - 0.001 (0.002) | - 0.001 (0.002) |
| Log Value of Farmland and Farm Buildings | 2.868 [1.303] | 0.432* (0.194) | - 0.203 (0.155) |
| Log Value of Farm Revenue | 1.750 [1.179] | 0.306 (0.177) | - 0.224 (0.147) |
| Corn Acres | 0.054 [0.088] | 0.007 (0.010) | - 0.035** (0.007) |
| Irrigated Corn Acres | 0.0003 [0.0011] | 0.0001 (0.0002) | - 0.0001 (0.0001) |
| Wheat Acres | 0.077 [0.113] | 0.017 (0.013) | - 0.008 (0.011) |
| Irrigated Wheat Acres | 0.001 [0.003] | - 0.0002 (0.0003) | - 0.0001 (0.0003) |

1. Average County Characteristics in 1920 and Differences by Ogallala Share

| | County Averages: | Coefficient on Ogallala Share: | | |
|---|---------------------|--------------------------------|----------------------|-------------------------------|
| | | No Controls | State FE | State FE and Soil Group FE |
| Per county acre: | (1) | (2) | (3) | (4) |
| Farmland | 0.706 [0.249] | 0.140** (0.039) | 0.020 (0.032) | - 0.001 (0.034) |
| Irrigated Farmland (1935) | 0.007 [0.020] | - 0.001 (0.002) | - 0.001 (0.002) | - 0.003 (0.003) |
| Log Value of Farmland and Farm Buildings | 2.868 [1.303] | 0.432* (0.194) | - 0.203 (0.155) | - 0.057 (0.120) |
| Log Value of Farm Revenue | 1.750 [1.179] | 0.306 (0.177) | - 0.224 (0.147) | - 0.102 (0.117) |
| Corn Acres | 0.054 [0.088] | 0.007 (0.010) | - 0.035** (0.007) | 0.001 (0.007) |
| Irrigated Corn Acres | 0.0003 [0.0011] | 0.0001 (0.0002) | - 0.0001 (0.0001) | - 0.0002 (0.0002) |
| Wheat Acres | 0.077 [0.113] | 0.017 (0.013) | - 0.008 (0.011) | - 0.003 (0.011) |
| Irrigated Wheat Acres | 0.001 [0.003] | - 0.0002 (0.0003) | - 0.0001 (0.0003) | - 0.001 (0.001) |

1. Average County Characteristics in 1920 and Differences by Ogallala Share

| | County Averages: | Coefficient on Ogallala Share: | | | |
|---|---------------------|--------------------------------|----------------------|-------------------------------|---------------------------------|
| | | No Controls | State FE | State FE and Soil Group FE | State & Soil FE X-Y controls |
| Per county acre: | (1) | (2) | (3) | (4) | (5) |
| Farmland | 0.706 [0.249] | 0.140** (0.039) | 0.020 (0.032) | - 0.001 (0.034) | 0.017 (0.035) |
| Irrigated Farmland (1935) | 0.007 [0.020] | - 0.001 (0.002) | - 0.001 (0.002) | - 0.003 (0.003) | - 0.005 (0.003) |
| Log Value of Farmland and Farm Buildings | 2.868 [1.303] | 0.432* (0.194) | - 0.203 (0.155) | - 0.057 (0.120) | 0.015 (0.127) |
| Log Value of Farm Revenue | 1.750 [1.179] | 0.306 (0.177) | - 0.224 (0.147) | - 0.102 (0.117) | - 0.025 (0.121) |
| Corn Acres | 0.054 [0.088] | 0.007 (0.010) | - 0.035** (0.007) | 0.001 (0.007) | 0.007 (0.007) |
| Irrigated Corn Acres | 0.0003 [0.0011] | 0.0001 (0.0002) | - 0.0001 (0.0001) | - 0.0002 (0.0002) | - 0.0003 (0.0002) |
| Wheat Acres | 0.077 [0.113] | 0.017 (0.013) | - 0.008 (0.011) | - 0.003 (0.011) | 0.001 (0.011) |
| Irrigated Wheat Acres | 0.001 [0.003] | - 0.0002 (0.0003) | - 0.0001 (0.0003) | - 0.001 (0.001) | - 0.001 (0.001) |

2. Estimated Differences Between Ogallala and Non-Ogallala Counties (368 Counties)

| Coefficient in year | Irrigated Farmland Acres per county acre (1) |
|---------------------|--|
| 1920 | |
| 1935 | - 0.005 (0.003) |
| 1945 | |
| 1950 | 0.015* (0.007) |
| 1954 | 0.034** (0.009) |
| 1959 | 0.058** (0.011) |
| 1964 | 0.068** (0.011) |
| 1969 | 0.089** (0.011) |
| 1974 | 0.107** (0.012) |
| 1982 | 0.114** (0.013) |
| 1992 | 0.113** (0.013) |
| 2002 | |

2. Estimated Differences Between Ogallala and Non-Ogallala Counties (368 Counties)

| Coefficient in year | Irrigated Farmland Acres | Log Value Land & Bldgs |
|---------------------|--------------------------|------------------------|
| | per county acre | per county acre |
| | (1) | (2) |
| 1920 | | 0.015 (0.127) |
| 1935 | - 0.005 (0.003) | 0.154 (0.085) |
| 1945 | | 0.079 (0.081) |
| 1950 | 0.015* (0.007) | 0.305** (0.077) |
| 1954 | 0.034** (0.009) | 0.390** (0.081) |
| 1959 | 0.058** (0.011) | 0.363** (0.088) |
| 1964 | 0.068** (0.011) | 0.440** (0.077) |
| 1969 | 0.089** (0.011) | 0.424** (0.069) |
| 1974 | 0.107** (0.012) | 0.409** (0.067) |
| 1982 | 0.114** (0.013) | 0.242** (0.070) |
| 1992 | 0.113** (0.013) | 0.272** (0.075) |
| 2002 | | 0.240** (0.078) |

2. Estimated Differences Between Ogallala and Non-Ogallala Counties (368 Counties)

| Coefficient in year | Irrigated Farmland Acres per county acre (1) | Log Value Land & Bldgs per county acre (2) | Implied Ogallala Value in millions: \$ (3) |
|---------------------|--|--|--|
| 1920 | | 0.015 (0.127) | 59 |
| 1935 | - 0.005 (0.003) | 0.154 (0.085) | 296 |
| 1945 | | 0.079 (0.081) | 200 |
| 1950 | 0.015* (0.007) | 0.305** (0.077) | 1,310 |
| 1954 | 0.034** (0.009) | 0.390** (0.081) | 2,117 |
| 1959 | 0.058** (0.011) | 0.363** (0.088) | 2,566 |
| 1964 | 0.068** (0.011) | 0.440** (0.077) | 4,091 |
| 1969 | 0.089** (0.011) | 0.424** (0.069) | 4,807 |
| 1974 | 0.107** (0.012) | 0.409** (0.067) | 7,885 |
| 1982 | 0.114** (0.013) | 0.242** (0.070) | 11,097 |
| 1992 | 0.113** (0.013) | 0.272** (0.075) | 9,134 |
| 2002 | | 0.240** (0.078) | 11,751 |

2. Estimated Differences Between Ogallala and Non-Ogallala Counties (368 Counties)

| Coefficient in year | Irrigated Farmland Acres | Log Value Land & Bldgs | Implied Ogallala Value in millions: | |
|---------------------|--------------------------|------------------------|-------------------------------------|--------------|
| | per county acre (1) | per county acre (2) | \$ (3) | \$CPI (4) |
| 1920 | | 0.015 (0.127) | 59 | 531 |
| 1935 | - 0.005 (0.003) | 0.154 (0.085) | 296 | 3,883 |
| 1945 | | 0.079 (0.081) | 200 | 2,001 |
| 1950 | 0.015* (0.007) | 0.305** (0.077) | 1,310 | 9,791 |
| 1954 | 0.034** (0.009) | 0.390** (0.081) | 2,117 | 14,167 |
| 1959 | 0.058** (0.011) | 0.363** (0.088) | 2,566 | 15,840 |
| 1964 | 0.068** (0.011) | 0.440** (0.077) | 4,091 | 23,728 |
| 1969 | 0.089** (0.011) | 0.424** (0.069) | 4,807 | 23,587 |
| 1974 | 0.107** (0.012) | 0.409** (0.067) | 7,885 | 28,765 |
| 1982 | 0.114** (0.013) | 0.242** (0.070) | 11,097 | 20,682 |
| 1992 | 0.113** (0.013) | 0.272** (0.075) | 9,134 | 11,709 |
| 2002 | | 0.240** (0.078) | 11,751 | 11,751 |

2. Estimated Differences Between Ogallala and Non-Ogallala Counties (368 Counties)

| Coefficient in year | Irrigated Farmland Acres | Log Value Land & Bldgs | Implied Ogallala Value in millions: | | |
|---------------------|--------------------------|------------------------|-------------------------------------|--------------|-------------|
| | per county acre (1) | per county acre (2) | \$ (3) | \$CPI (4) | \$LV (5) |
| 1920 | | 0.015 (0.127) | 59 | 531 | 598 |
| 1935 | - 0.005 (0.003) | 0.154 (0.085) | 296 | 3,883 | 7,091 |
| 1945 | | 0.079 (0.081) | 200 | 2,001 | 3,651 |
| 1950 | 0.015* (0.007) | 0.305** (0.077) | 1,310 | 9,791 | 14,565 |
| 1954 | 0.034** (0.009) | 0.390** (0.081) | 2,117 | 14,167 | 19,165 |
| 1959 | 0.058** (0.011) | 0.363** (0.088) | 2,566 | 15,840 | 18,523 |
| 1964 | 0.068** (0.011) | 0.440** (0.077) | 4,091 | 23,728 | 23,802 |
| 1969 | 0.089** (0.011) | 0.424** (0.069) | 4,807 | 23,587 | 21,372 |
| 1974 | 0.107** (0.012) | 0.409** (0.067) | 7,885 | 28,765 | 20,777 |
| 1982 | 0.114** (0.013) | 0.242** (0.070) | 11,097 | 20,682 | 13,253 |
| 1992 | 0.113** (0.013) | 0.272** (0.075) | 9,134 | 11,709 | 14,039 |
| 2002 | | 0.240** (0.078) | 11,751 | 11,751 | 11,751 |

3. Estimated Differences Between Ogallala and Non-Ogallala Counties

Farmland
per county acre

| Coefficient: | (1) |
|--------------|--------------------|
| 1920 | 0.017 (0.035) |
| 1930 | 0.040 (0.031) |
| 1940 | 0.009 (0.027) |
| 1950 | 0.019 (0.026) |
| 1954 | 0.042 (0.029) |
| 1959 | 0.012 (0.028) |
| 1964 | 0.048* (0.024) |
| 1969 | 0.059** (0.021) |
| 1978 | 0.067** (0.018) |
| 1987 | 0.064** (0.019) |
| 1997 | 0.066** (0.020) |

3. Estimated Differences Between Ogallala and Non-Ogallala Counties

| Coefficient: | Farmland per county acre | Corn Harvested per county acre | |
|--------------|-----------------------------|-----------------------------------|-----------------------|
| | (1) | All Corn (2) | Irrigated Corn (3) |
| 1920 | 0.017 (0.035) | 0.0090 (0.0068) | - 0.0003 (0.0002) |
| 1930 | 0.040 (0.031) | 0.0233** (0.0088) | |
| 1940 | 0.009 (0.027) | 0.0011 (0.0065) | |
| 1950 | 0.019 (0.026) | 0.0138 (0.0083) | 0.0020* (0.0010) |
| 1954 | 0.042 (0.029) | 0.0121 (0.0073) | 0.0030* (0.0012) |
| 1959 | 0.012 (0.028) | 0.0137 (0.0079) | 0.0095** (0.0026) |
| 1964 | 0.048* (0.024) | 0.0043 (0.0053) | 0.0120** (0.0028) |
| 1969 | 0.059** (0.021) | | |
| 1978 | 0.067** (0.018) | 0.0528** (0.0106) | 0.0665** (0.0101) |
| 1987 | 0.064** (0.019) | 0.0449** (0.0090) | 0.0562** (0.0089) |
| 1997 | 0.066** (0.020) | 0.0730** (0.0121) | 0.0778** (0.0111) |

3. Estimated Differences Between Ogallala and Non-Ogallala Counties

| Coefficient: | Farmland | Corn Harvested | | Wheat Harvested | |
|--------------|--------------------|----------------------|----------------------|----------------------|----------------------|
| | per county acre | All Corn | Irrigated Corn | All Wheat | Irrigated Wheat |
| | (1) | (2) | (3) | (4) | (5) |
| 1920 | 0.017 (0.035) | 0.0090 (0.0068) | - 0.0003 (0.0002) | - 0.0002 (0.0113) | - 0.0010 (0.0007) |
| 1930 | 0.040 (0.031) | 0.0233** (0.0088) | | 0.0690** (0.0148) | |
| 1940 | 0.009 (0.027) | 0.0011 (0.0065) | | 0.0259* (0.0102) | |
| 1950 | 0.019 (0.026) | 0.0138 (0.0083) | 0.0020* (0.0010) | 0.0742** (0.0138) | 0.0016* (0.0007) |
| 1954 | 0.042 (0.029) | 0.0121 (0.0073) | 0.0030* (0.0012) | 0.0295** (0.0100) | 0.0022** (0.0007) |
| 1959 | 0.012 (0.028) | 0.0137 (0.0079) | 0.0095** (0.0026) | 0.0532** (0.0097) | 0.0048** (0.0014) |
| 1964 | 0.048* (0.024) | 0.0043 (0.0053) | 0.0120** (0.0028) | 0.0218* (0.0093) | 0.0090** (0.0019) |
| 1969 | 0.059** (0.021) | | | 0.0235** (0.0089) | |
| 1978 | 0.067** (0.018) | 0.0528** (0.0106) | 0.0665** (0.0101) | 0.0225* (0.0103) | 0.0162** (0.0021) |
| 1987 | 0.064** (0.019) | 0.0449** (0.0090) | 0.0562** (0.0089) | 0.0285** (0.0102) | 0.0193** (0.0026) |
| 1997 | 0.066** (0.020) | 0.0730** (0.0121) | 0.0778** (0.0111) | 0.0139 (0.0116) | 0.0166** (0.0022) |

Ogallala and Drought: Estimating Equation

Preliminary specification:

$$Y_{ct} = \beta_e^1 \text{OgallalaShare}_c + \alpha_c + \gamma_e \\ + \beta_e^2 \text{OgallalaShare}_c \times \text{Drought}_{ct} + \delta_e \text{Drought} + \epsilon_{ct}$$

Full specification:

$$Y_{ct} = \beta_e^1 \text{OgallalaShare}_c + \alpha_c \\ + \gamma_{se}^1 + \gamma_{ge}^2 + \gamma_e^3 \text{Long}_c + \gamma_e^4 \text{Lat}_c \\ + \beta_e^2 \text{OgallalaShare}_c \times \text{Drought}_{ct} \\ + \delta_{se}^1 \text{Drought} + \delta_{ge}^2 \text{Drought} \\ + \delta_e^3 \text{Long}_c \times \text{Drought} + \delta_e^4 \text{Lat}_c \times \text{Drought} + \epsilon_{ct}$$

Notes on the estimation:

- ▶ Balanced panel of counties (restricted sample)
- ▶ Regression weighted by county area
- ▶ Standard errors clustered by county

4. Estimated Impacts of Drought and Ogallala on Crop Yields

| | Log Corn Yield 1940 - 1993 (1) |
|------------------------------------|--------------------------------------|
| (1958 - 1971) | 0.162 [0.089] |
| (1972 - 1993) | 0.705** [0.080] |
| Ogallala * (1958 - 1971) | 0.439** [0.110] |
| Ogallala * (1972 - 1993) | 0.716** [0.090] |
| Drought * (1940 - 1957) | - 0.197** [0.018] |
| Drought * (1958 - 1971) | - 0.449** [0.090] |
| Drought * (1972 - 1993) | - 0.163** [0.036] |
| Ogallala * Drought * (1940 - 1957) | 0.0570* [0.023] |
| Ogallala * Drought * (1958 - 1971) | 0.371** [0.101] |
| Ogallala * Drought * (1972 - 1993) | 0.169** [0.046] |
| # of Sample Counties | 134 |
| State-Coordinate-Soil Controls | No |

4. Estimated Impacts of Drought and Ogallala on Crop Yields

| | Log Corn Yield | |
|------------------------------------|----------------|----------|
| | 1940 - 1993 | |
| | (1) | (2) |
| (1958 - 1971) | 0.162 | |
| | [0.089] | |
| (1972 - 1993) | 0.705** | |
| | [0.080] | |
| Ogallala * (1958 - 1971) | 0.439** | - 0.148 |
| | [0.110] | [0.143] |
| Ogallala * (1972 - 1993) | 0.716** | 0.126 |
| | [0.090] | [0.165] |
| Drought * (1940 - 1957) | - 0.197** | |
| | [0.018] | |
| Drought * (1958 - 1971) | - 0.449** | |
| | [0.090] | |
| Drought * (1972 - 1993) | - 0.163** | |
| | [0.036] | |
| Ogallala * Drought * (1940 - 1957) | 0.0570* | - 0.071* |
| | [0.023] | [0.032] |
| Ogallala * Drought * (1958 - 1971) | 0.371** | 0.287* |
| | [0.101] | [0.118] |
| Ogallala * Drought * (1972 - 1993) | 0.169** | - 0.177* |
| | [0.046] | [0.076] |
| # of Sample Counties | 134 | 134 |
| State-Coordinate-Soil Controls | No | Yes |

4. Estimated Impacts of Drought and Ogallala on Crop Yields

| | Log Corn Yield | | |
|------------------------------------|----------------------|---------------------|----------------------|
| | 1940 - 1993 | | 1958-1993 |
| | (1) | (2) | (3) |
| (1958 - 1971) | 0.162 [0.089] | | |
| (1972 - 1993) | 0.705** [0.080] | | |
| Ogallala * (1958 - 1971) | 0.439** [0.110] | - 0.148 [0.143] | |
| Ogallala * (1972 - 1993) | 0.716** [0.090] | 0.126 [0.165] | 0.264* [0.113] |
| Drought * (1940 - 1957) | - 0.197** [0.018] | | |
| Drought * (1958 - 1971) | - 0.449** [0.090] | | |
| Drought * (1972 - 1993) | - 0.163** [0.036] | | |
| Ogallala * Drought * (1940 - 1957) | 0.0570* [0.023] | - 0.071* [0.032] | |
| Ogallala * Drought * (1958 - 1971) | 0.371** [0.101] | 0.287* [0.118] | 0.145* [0.062] |
| Ogallala * Drought * (1972 - 1993) | 0.169** [0.046] | - 0.177* [0.076] | - 0.119* [0.0535] |
| # of Sample Counties | 134 | 134 | 200 |
| State-Coordinate-Soil Controls | No | Yes | Yes |

4. Estimated Impacts of Drought and Ogallala on Crop Yields

| | Log Corn Yield | | | Log Wheat Yield | | |
|------------------------------------|----------------|----------|-----------|-----------------|---------|-----------|
| | 1940 - 1993 | | 1958-1993 | 1940 - 1993 | | 1958-1993 |
| | (1) | (2) | (3) | (1) | (2) | (3) |
| (1958 - 1971) | 0.162 | | | 0.447** | | |
| | [0.089] | | | [0.038] | | |
| (1972 - 1993) | 0.705** | | | 0.619** | | |
| | [0.080] | | | [0.033] | | |
| Ogallala * (1958 - 1971) | 0.439** | - 0.148 | | 0.040 | - 0.022 | |
| | [0.110] | [0.143] | | [0.065] | [0.041] | |
| Ogallala * (1972 - 1993) | 0.716** | 0.126 | 0.264* | 0.206** | 0.104* | 0.041 |
| | [0.090] | [0.165] | [0.113] | [0.058] | [0.052] | [0.040] |
| Drought * (1940 - 1957) | - 0.197** | | | - 0.124** | | |
| | [0.018] | | | [0.021] | | |
| Drought * (1958 - 1971) | - 0.449** | | | - 0.163** | | |
| | [0.090] | | | [0.015] | | |
| Drought * (1972 - 1993) | - 0.163** | | | - 0.145** | | |
| | [0.036] | | | [0.023] | | |
| Ogallala * Drought * (1940 - 1957) | 0.0570* | - 0.071* | | - 0.108** | - 0.064 | |
| | [0.023] | [0.032] | | [0.037] | [0.035] | |
| Ogallala * Drought * (1958 - 1971) | 0.371** | 0.287* | 0.145* | - 0.085* | 0.003 | - 0.044 |
| | [0.101] | [0.118] | [0.062] | [0.042] | [0.037] | [0.038] |
| Ogallala * Drought * (1972 - 1993) | 0.169** | - 0.177* | - 0.119* | - 0.036 | - 0.027 | 0.001 |
| | [0.046] | [0.076] | [0.0535] | [0.034] | [0.027] | [0.020] |
| # of Sample Counties | 134 | 134 | 200 | 165 | 165 | 243 |
| State-Coordinate-Soil Controls | No | Yes | Yes | No | Yes | Yes |

Lessons from the Great Plains: Drought and Adaptation

Persistent Importance of the Environment

- ▶ Technology and the environment
- ▶ Environmental neutrality

Environmental Impacts Endure

- ▶ Dust Bowl
- ▶ Enduring economic costs
- ▶ Limited and delayed agricultural adaptation
- ▶ Out-migration

Environmental Impacts Shaped by Economic Decisions

- ▶ Ogallala
- ▶ Short-run decrease in drought sensitivity
- ▶ Long-run return of drought sensitivity