Online Appendices (Not for Publication)

A Data Appendix

A.1 Complete-Count Census

I use IPUMS Full Count data (Ruggles et al., 2024) as my primary census source. The census data contain individual-level microdata, including the place of residence, occupation, and labor market status. The linked records are drawn from Version 2.0 of the IPUMS Multigenerational Longitudinal Panel (MLP), which assigns a consistent Historical Identification Key (HIK) to individuals across censuses (Ruggles et al., 2025). I restrict the analysis to men aged 18–65 in the base census, consistent with the model's labor-force population.

A.2 Historical, Demographic, Economic, and Social Data

Historical, Demographic, Economic, and Social Data: The United States, 1790–2002 (Haines et al., 2010; ICPSR 2896) combines the information from the Census of Manufactures, Census of Agriculture, and other detailed county-, city-, and state-level descriptive data from 1790 to 2002. I mainly utilize information related to county-level wages and industrial activities, such as manufacturing output and retail sales throughout the 20th century. County-level wages used as an initial condition for simulation come from Haines et al. (2010) for every decade, including those before 1940. Manufacturing wages equal the wage bill divided by average wage earners (Census of Manufactures); retail and wholesale payrolls come from the Census of Business. Agricultural wages are unavailable before 1950. Instead, the model assumes that workers receive agricultural revenue as wages and uniformly redistributed rents, so income per worker equals revenue per worker. Census of Agriculture revenues identify damage in main-text equation (12). Migration and amenity estimation use occupational income scores from the complete-count Census.

A.3 Environmental Variables

I use soil erosion rates and drought intensity as environmental variables. The cumulative erosion damage at the county level was first measured by specialists during the 1934–35 field survey (SCS, 1935) and digitized by Hornbeck (2012). The cumulative damage proxies for differences in erosion during the 1930s. The data contain the fraction of a county's land in one of three tiers of erosion rates: low erosion (less than 25% of topsoil lost), medium erosion (25% to 75% of topsoil lost), and high erosion (more than 75% of topsoil lost). I also use this measure to construct erosion intensity as a weighted share of land in the high- and medium-erosion classes.

Data measuring yearly drought intensity are from the U.S. National Oceanic and Atmospheric Administration: The Living Blended Drought Atlas (LBDA; Cook et al., 2010). The LBDA reconstructs 2,000 years of annual drought severity across roughly 11,000 North American grid points using tree-ring chronologies calibrated to 1928–1978 instrumental moisture measurements. County severity averages points assigned using 1990 boundaries (Sichko, 2024). The regressor is standardized cumulative 1930s severity.

A.4 Additional Data Sources

To construct trade costs for simulation, I utilize a decennial panel of county-pair routed distances between 1920 and 1990. Taylor Jaworski and Carl Kitchens constructed this decennial twentieth-century highway network, with routed distances and travel times for every U.S. county pair. The network is unpublished but is also used for market access in Jaworski and Yang (2025). Simulation periods use the nearest available decade, with 1920 assigned to the initial year, 1910. Trade costs thus reflect transportation changes, including highway expansion. I use the geographic crosswalk of Eckert et al. (2020) to harmonize the spatial units to 1990 county boundaries.

Sectoral consumption shares are built from U.S. Bureau of Labor Statistics (2006), which compiles national consumer expenditure surveys for 1901, 1918–19, 1934–36, 1950, 1960–61, 1972–73, 1984–85, 1996–97, and 2002–03. I interpolate the national expenditure shares to decades from 1910 to 1990 and map food to agriculture, apparel to tradable non-agriculture, and housing and all remaining categories to nontradable services. The resulting shares for agriculture, tradable non-agriculture, and nontradable services are 40%, 15%, and 45% in 1910; 31%, 12%, and 57% in 1940; and 14%, 6%, and 80% in 1990.

B Estimation Appendix

B.1 Amenity Estimating Equation

I follow Artuc et al. (2010) and Rudik et al. (2022) to derive the amenity estimating equation. First, the individual's problem can be written as a dynamic programming problem of maximizing instantaneous flow utility and the discounted expected future-value function:

$$v_{n,t}^{k} = U(C_{n,t}^{k}, B_{n,t}) + \max_{\{i,s\}} \Big\{ \underbrace{\beta \mathbb{E}[v_{i,t+1}^{s}]}_{\substack{\text{expectation over} \\ \text{region} \times \text{industry pair}}} - \underbrace{\delta_{ni}^{ks}}_{\substack{\text{migration} \\ \text{costs}}} + \underbrace{\eta u_{i,t}^{s}}_{\substack{\text{inverse migration elasticity} \\ \times \text{preference shocks}}} \Big\}, \tag{A1}$$

where individuals choose where to live and what industry they will work in the next period.

Taking the expectation over preference shocks, the expected lifetime utility consists of instantaneous utility, the base value of staying, and the option value of moving between labor markets. The option value depends on the difference between the base value of staying and the expected lifetime utility of the most desirable destination:

$$\underbrace{V_{n,t}^{k}}_{=E_u[v_{n,t}^{k}]} = \underbrace{U(C_{n,t}^{k}, B_{n,t})}_{\substack{\text{instantaneous} \\ \text{utility}}} + \underbrace{\beta E_t[v_{n,t+1}^{k}]}_{\substack{\text{base value} \\ \text{of staying}}} + \underbrace{E_u[\max_{i,s}\{\eta u_{i,t}^{s} + \eta \bar{u}_{ni,t}^{ks}\}]}_{\text{option value of moving}}, \tag{A2}$$

where $\bar{u}_{ni,t}^{ks} \equiv u_{n,t}^{k} - u_{i,t}^{s}$. The term $\bar{u}_{ni,t}^{ks}$ denotes the difference in idiosyncratic shocks between the two pairs in equilibrium.

The solution to the above dynamic problem yields the Euler equation as:

$$\begin{aligned} \eta \bar{u}_{ni,t}^{ks} + \delta_{ni}^{ks} &= \beta E_t \Big(v_{i,t+1}^{s} - v_{n,t+1}^{k} \Big) \\ &= \beta E_t \Big[U(C_{i,t+1}^{s}, B_{i,t+1}) - U(C_{n,t+1}^{k}, B_{n,t+1}) \\ &\qquad + \eta \bar{u}_{ni,t+1}^{ks} + \delta_{ni}^{ks} + \Omega(\bar{u}_{i,t+1}^{s}) - \Omega(\bar{u}_{n,t+1}^{k}) \Big]. \end{aligned} \tag{A3}$$

In equilibrium, the difference in idiosyncratic shocks between origin *n*-*k* and destination *i*-*s*, subject to migration costs, equals the difference in expected lifetime utility between the two regions in the next period. Migration flows between the pair continue until the surplus from migration is exhausted. The last equality follows from designating the option value of moving between labor markets as the $\Omega(\cdot)$ term (Artuc et al., 2010, eq. 7). The key intuition is that the migration flows are a sufficient statistic of the option value of moving. Under the extreme-value assumption, the option-value expression $\Omega(\cdot)$ is the negative logarithm of the share of stayers. Substituting this expression into the Euler equation and rearranging, following the steps from equation (5), through (6)–(7), to moment condition (8) in Artuc et al. (2010), yields:

$$E_t\left[\frac{\beta}{\eta}\log\left(\frac{B_{i,t+1}}{B_{n,t+1}}\cdot\frac{C^s_{i,t+1}}{C^k_{n,t+1}}\right)+\beta\log\left(\frac{\mu^{ks}_{ni,t+1}}{\mu^{ss}_{ii,t+1}}\right)-\log\left(\frac{\mu^{ks}_{ni,t}}{\mu^{kk}_{nn,t}}\right)+\frac{\beta-1}{\eta}\delta^{ks}_{ni}\right]=0. \tag{A4}$$

I then substitute the structure of amenities and rearrange the future relative migration share and future relative wage to obtain the following estimating equation:

$$\begin{aligned}
&\log\left(\frac{\mu^{ks}_{ni,t}}{\mu^{kk}_{nn,t}}\right)-\beta\log\left(\frac{\mu^{ks}_{ni,t+1}}{\mu^{ss}_{ii,t+1}}\right)-\frac{\beta}{\eta}\log\left(\frac{w^s_{i,t+1}}{w^k_{n,t+1}}\right)\\
&\quad=\frac{\beta}{\eta}\left[g\left(D_{i,t+1}-D_{n,t+1},E_{i,t+1}-E_{n,t+1};\boldsymbol{\beta}_B\right)\right]\\
&\qquad+\underbrace{\frac{\beta}{\eta}\log\left(\frac{\bar{B}_{i,t+1}}{\bar{B}_{n,t+1}}\right)}_{=\alpha_i+\alpha_n+\alpha_t}+\underbrace{\frac{\beta-1}{\eta}\delta^{ks}_{ni}}_{=\gamma\,\mathrm{dist}_{ni}+\alpha_n+\alpha_i}+u^{ks}_{ni,t}.
\end{aligned} \tag{A5}$$

Equation (A5) regresses current migration-share odds on forward relative migration shares and wages, with unrestricted coefficients β and β/η; their ratio identifies the reduced-form estimate $\hat{\eta}$. Destination-minus-origin differences identify amenity changes associated with Dust Bowl environmental shocks, while distance and fixed effects absorb exogenous amenity differences and migration costs. The estimation uses occupational income scores because individual-level wage measures are not available before 1940. Main-text Table 3 reports single-step OLS estimates across alternative fixed-effects specifications. The estimates range from 0.61 to 1.22, with $\hat{\eta}=0.966$ (s.e. 0.172) in the preferred specification with origin- and destination-county fixed effects.

B.2 Elasticity Estimation

Consumption parameters. Table OA1 shows estimation results for the Engel elasticity. I use the Study of Consumer Purchases in the United States, 1935–1936 (ICPSR 8908), which provides household-level consumption data during the Dust Bowl period. The specified PIGL preferences share the same parameters for the value-added and final expenditure demand systems, and also admit aggregation (Fan et al., 2023). Hence, the estimates using the household-level consumption data can be used as structural parameters in the regional value-added demand system.

Approximating the small agricultural asymptote by zero, the log-linear estimating equation regresses the log food expenditure share (φ_h^A) on log expenditure (e_h) for household h. The negative slope identifies ε:

$$\log(\varphi_h^A) = -\varepsilon \log(e_h) + \alpha_s + \alpha_c + \gamma X_h + u_h, \tag{A6}$$

where α_s and α_c denote state and city fixed effects and X_h is a set of household characteristics. The controls include the ages of the husband and wife, the amount of rent, and their squared values. I also include demographic fixed effects for (1) dwelling categories, (2) race, and (3) work status of household members. Columns 1 to 3 progressively add household characteristic controls, geographic fixed effects, and demographic fixed effects. The next two columns instrument household expenditure using household income (Column 4) and occupation fixed effects (Column 5).

Next, PIGL preference parameters ($\{\phi^A, \phi^M, \phi^S, \nu^A, \nu^M, \nu^S\}$) are jointly estimated by moment conditions for 1940 and 1990, corresponding to the beginning and end of the study period.

The market-clearing condition for the nontradable sector in region i is given as:

$$w_{i,t}^S L_{i,t}^S = \left(\phi^S + \nu^S \left(\frac{e_{i,t}}{P_{i,t}}\right)^{-\varepsilon}\right) e_{i,t} L_{i,t}, \tag{A7}$$

where $e_{i,t}$ is the per-capita expenditure. The market-clearing condition for agriculture is:

$$\tilde{w}_{i,t}^A L_{i,t}^A + r_{i,t} T_i = \sum_{n=1}^{N} \pi_{ni,t}^A \left(\phi^A + \nu^A \left(\frac{e_{n,t}}{P_{n,t}}\right)^{-\varepsilon}\right) e_{n,t} L_{n,t}, \tag{A8}$$

where the presence of trade shares highlights the tradability of agriculture. The market-clearing condition for tradable non-agriculture is given similarly, with the left-hand side consisting solely of labor payments. Combining equations (A7) and (A8) gives:

$$\sum_{i=1}^{N} \left(\tilde{w}_{i,t}^A L_{i,t}^A + r_{i,t} T_i\right) = \phi^A \sum_{i=1}^{N} w_{i,t} L_{i,t} - \frac{\nu^A}{\nu^S} \sum_{i=1}^{N} \left(\phi^S - \frac{L_{i,t}^S}{L_{i,t}}\right) w_{i,t} L_{i,t}, \tag{A9}$$

for years 1940 and 1990. Hence, equation (A9) yields two moment conditions for six parameters. As in Fan et al. (2023), I proceed with two normalizations ($\phi^A = 0.01$ and $\nu^S = -1.0$) and two restrictions ($\sum \phi^s = 1$ and $\sum \nu^s = 0$), identifying the two remaining parameters.

Distance elasticity of trade. Table OA2 reports distance elasticity estimates using the Commodity Flow Survey (CFS) for 2012 and 2017. I use modern trade flow data as detailed regional-level trade flow information did not exist during the Dust Bowl period.

Here, I regress log trade value on log routed distance between the origin and destination, with origin- and destination-state fixed effects. Each column reports an estimate for a different survey year or level of aggregation. I use the absolute value of the estimated coefficient, $\kappa = 1.3$, consistent with the estimate in Allen and Donaldson (2022), who use the 1997 CFS. I assume that the distance elasticity of trade is constant throughout time. The routed distance between counties, on the other hand, changed during the 20th century. The decade-varying Jaworski–Kitchens network data is described in Appendix A.4.

Migration elasticity. I estimate the inverse elasticity of migration, η, using a simulated method of moments (SMM) procedure by fitting the Dust Bowl population response with all other parameters fixed. The SMM-estimated baseline is $\hat{\eta} = 0.220$ (main-text Section 4.2.2), while the reduced-form dyadic estimate ($\eta \approx 1.00$) provides a robustness check (Section 6.3).

Targeted moments are Hornbeck's (2012) high- and medium-erosion county-population coefficients: -11.6% and -8.8% in 1940. Model moments regress $\log(L_n^{\text{DB}}/L_n^{\text{no-DB}})$ on the two erosion shares (low erosion omitted) across 875 Dust Bowl counties. The primary objective equally weights squared deviations of the two 1940 moments, identifying responsiveness at the shock.

I minimize the objective over $[0.05, 1.50]$ using successive quadratic interpolation in $\log \eta$, stopping when the proposed step is below 0.005. Six full-model evaluations use $\eta = 0.10$, 0.15, 0.22, 0.25, 0.30, and 1.00; the boundary 0.05 diverges because $1/\eta = 20$ destabilizes the value-function update. The objective has one minimum, and the convergence gives $\hat{\eta} = 0.220$.

C Additional Results

C.1 Adding Agglomeration Externalities

The main purpose of this paper is to quantify how natural disasters propagate throughout the economy and to examine the role of adjustment mechanisms. Thus, in the baseline simulation, I proceed without agglomeration externalities. However, large labor reallocation could have generated potential second-order effects stemming from changed labor market sizes and local population. Hence, this subsection adds agglomeration forces in both amenities and productivity terms. These variants impose agglomeration on inputs estimated without it (main-text Section 4.2.2), providing sensitivity analysis rather than internally consistent re-estimation. Section C.1.2 reports resident-welfare results over the computed agglomeration grid.

C.1.1 Model Extension

In the extended model, regional amenities also depend on the endogenous component from the size of the local population per square mile, $(L_{n,t}/M_n)^{\rho_B}$:

$$B_{n,t} = \bar{B}_{n,t}(L_{n,t}/M_n)^{\rho_B} \exp\left(g(D_{n,t}, E_{n,t}; \boldsymbol{\beta}_B)\right). \tag{A10}$$

The agglomeration parameter ρ_B captures the potential influence of the number of local residents on amenities. For instance, the current population $L_{n,t}$ might affect amenities through congestion effects if local factors, such as housing and land, are in fixed supply. Conversely, a larger population might support amenity-enhancing facilities, such as parks and libraries. I model the regional agglomeration in a reduced-form way, and the directions of the effects are determined by the sign of ρ_B.[1] I assume that each individual worker takes these terms as given. For quantification exercises, note that the dynamic hat algebra approach only uses the changes in labor allocation (Section D.2) as the time-invariant denominator (land in square miles) cancels out.

Similarly, the productivity term consists of an exogenous component, $z^k_{n,t}$, agglomeration

[1] Imposing a specific microfoundation requires taking an a priori stance on the sign of ρ_B. As the main goal of this paper is to quantify the Dust Bowl's general equilibrium impacts, I take a more flexible approach to agglomeration, and the direction of the spillover effect is not restricted. Allen and Donaldson (2022) and Allen and Arkolakis (2023) provide microfoundations for the above formulation of amenity externalities.

externalities, $(L^k_{n,t}/M_n)^{\rho^k_A}$, and the environmental response function, $f(\cdot)$:

$$A^k_{n,t} = z^k_{n,t}(L^k_{n,t}/M_n)^{\rho^k_A} \exp\left(f(D_{n,t}, E_{n,t}; \boldsymbol{\beta}^k_A)\right). \tag{A11}$$

The agglomeration parameter, ρ^k_A, governs the strength of externalities working through the size of the local labor market in each industry. I assume that firms take the labor allocation as given. The microfoundation for positive externalities can be rationalized by external economies of scale, generated by knowledge transfers and learning (Glaeser et al., 1992) or thick market effects in output or input markets (Moretti, 2011). Conversely, negative spillover effects could be present due to production congestion.

C.1.2 Quantification Results with Agglomeration Forces

Figure OA4 shows how population feedback through productivity externalities (ρ_A) and amenity externalities (ρ_B) changes the welfare implication in the baseline simulation. Each elasticity ranges from -0.2 to 0.2 in steps of 0.05 at $\hat{\eta} = 0.220$. Panels A and B report the Dust Bowl region in 1940 and 1990, and Panels C and D report the non-Dust Bowl region. The figure reports welfare results for 24 parameter combinations. The remaining 57 combinations are left blank because the solver did not converge in the earlier grid calculations. Note that numerical failure alone does not establish nonexistence or multiplicity of equilibrium.

The no-agglomeration cell ($\rho_A = \rho_B = 0$) reproduces the 1940 losses in Table 5. Across the reported grid, the Dust Bowl-region loss remains between 8.66% and 9.96%, close to the 9.66% baseline. Productivity congestion ($\rho_A < 0$) deepens the loss, whereas modest productivity agglomeration ($\rho_A > 0$) cushions it. Effects outside the region are more responsive and, by 1990, range from a 6.57% loss to a 0.33% gain. The reason is that permanent land damage directly depresses the origin, whereas outcomes elsewhere depend on how receiving economies absorb migrants. Agglomeration helps destinations accommodate the inflow, while congestion weakens this adjustment and spreads the losses. Overall, within the computed range, the direct welfare costs of the Dust Bowl in the Plains remain large at similar levels. However, population feedback could materially alter whether indirectly affected regions experience losses or gains, as well as how persistent these effects are.

C.2 Simulation-generated Migration Effects

Table OA6 replicates Table 1 of Hornbeck (2023) using the simulation-generated migration effects in this paper. The effects are percentage changes in migration flows between 1930 and 1940 due to the Dust Bowl. Panel A reports out-migration by destination group, and Panel B reports in-migration by origin. The intercept is the predicted change for a county with no high- or medium-erosion land, and adding an erosion coefficient gives the predicted change for a county entirely in that erosion class. For example, the California column shows that migration to California increased throughout the Plains and rose with origin erosion: flows from high- and medium-erosion counties increased by about 48% and 25%, respectively, relative to the counterfactual without the Dust Bowl (Panel A, Column 4).

Out-migration increased relatively for counties with higher levels of erosion, and migrants tended to move to unaffected non-Dust Bowl regions, reaching as far as California and the Pacific Northwest. Overall, the out-migration from more-eroded counties increased for every destination and most for these western destinations. Consistent with Long and Siu (2018), migration flows into the more-eroded Dust Bowl counties also decreased regardless of the origins, especially for counties with higher levels of erosion.

C.3 Additional Counterfactual Results

Table OA7 reports welfare effects under alternative scenarios and parameters. For readability, I mainly discuss aggregate U.S. and Dust Bowl regional effects in this subsection. Table OA7, Panel A, Rows 2 and 3 decompose the baseline into productivity and amenity shocks, summing almost exactly to the total. Permanent land damage accounts for about seven-tenths of the regional loss (-6.94 of -9.66), versus -2.73 for amenities. Productivity also dominates nationally (-2.15 of -2.60, versus -0.45). By environmental driver, Panel A, Rows 4 and 5 show national and regional losses of 1.91% and 7.44% from erosion alone, versus 0.93% and 3.11% from drought alone. Offsetting interaction effects make the full effect slightly smaller than their sum.

Table OA7, Panel B reports welfare effects from alternative policy experiments. Specifically, Rows 1–3 study the potential value of land allocation and land-use adjustment. During the Dust Bowl era, the SCS encouraged farmers to convert cropland into pastureland because the productivity of the latter was less affected by erosion. However, the process of shifting land use was slow and limited (Hornbeck, 2012). Cropland can be interpreted as production technology that is more susceptible to environmental shocks, while pastureland is more resistant to erosion and drought. I examine how technology adoption in terms of land use would have affected the implications of the Dust Bowl.

I first reestimate equation (12) separately for cropland and pastureland. Table OA3, Columns 2 and 3 document the estimation results. Then, I quantify the impacts of converting all cropland to pastureland in either 1930 (Panel B, Row 2) or 1940 (Panel B, Row 3). For simplicity, I assume that shifting land use is costless and the two land uses are identical except for their susceptibility to erosion and drought. Thus, the quantification results only inform the maximum potential benefits.

Applying the cropland-specific response to all land produces welfare effects of -4.98% nationally and -16.53% regionally (Panel B, Row 1), versus -0.88% and -4.13% with the pastureland-specific response (Panel B, Row 2). Converting all cropland to pasture before the shock (Panel B, Row 2), representing perfect preventive technology adoption when permanent damage cannot be avoided, would have reduced welfare losses by 66% for the United States and 57% for the Dust Bowl region. Immediate post-shock conversion (Panel B, Row 3) reduces losses by only about 1%, suggesting that prevention is an order of magnitude more valuable than responding after irreversible damage.

The actual gains would have been much smaller after taking into account the adjustment costs and labor market responses. Still, the large reductions in welfare losses imply potentially huge gains from adopting a more robust technology. However, credit constraints may have inhibited such land-use adjustments (Hornbeck, 2012). Furthermore, innovation after the shock could have further reduced its effects in the long run (Moscona, 2024).[2]

C.4 Additional Robustness Results

Table OA7, Panel C groups the robustness checks conducted with the baseline spatial resolution: Rows 1–3 vary post-1950 productivity growth and the demand specification; Rows 4–5 vary the price index; Rows 6–8 vary the magnitude and persistence of land damage; and Rows 9–12 vary the

[2]Moscona (2024) shows that agricultural technology was redirected toward crops more exposed to the Dust Bowl. Such an adaptive, endogenous technical response further ameliorated the consequences of the immediate productivity decline from the disaster.

Engel and agricultural trade elasticities.

Consumption parameters. Table OA7, Panel C, Rows 9 and 10, reports sensitivity to the Engel elasticity. At $\varepsilon = 0.34$, the losses are 2.31% (U.S.), 8.77% (Dust Bowl region), and 1.01% (outside); at $\varepsilon = 0.45$, they are 2.89%, 10.53%, and 1.35%, respectively. Hence, a higher Engel elasticity magnifies losses in every region. A higher value of ε reduces the income elasticity of agricultural demand while raising it for goods and consumer services, making price increases in subsistence goods especially consequential. In contrast, price increases in luxury goods can be more flexibly mitigated at a higher value of ε. Fan et al. (2023) document that a higher value of ε lowers the welfare gains from local nontradable productivity growth.

Rows 4 and 5 alter only the weights used in the price index, leaving PIGL expenditure shares endogenous as in the baseline. Using fixed 1910 weights raises the losses to 3.71%, 11.26%, and 2.19%, respectively; using time-varying observed weights yields corresponding losses of 3.41%, 10.62%, and 1.96%. Both price-index alternatives place more weight on food than the asymptotic baseline and therefore assign a larger welfare cost to the Dust Bowl-induced rise in food prices. The fixed-1910 index also narrows the welfare–real-income gap because more of the food-price increase enters the real-income deflator. Note that the PIGL indirect utility uses the asymptotic weights; Rows 4–5 are reported only as illustrative sensitivity checks and should be interpreted accordingly.

Trade elasticity. Table OA7, Panel C, Rows 11 and 12 show that counterfactual results with $\theta^A = 8$ and 16 (2/3 and 4/3 of the baseline value) change national losses by less than 0.01%p and regional losses by at most 0.16%p (-9.51% and -9.75%, versus -9.66%). Although not directly applicable, an analogy with the Arkolakis et al. (2012) formula can illustrate the influences of θ. Arkolakis et al. (2012) show that consumption welfare in canonical trade models can be expressed as changes in own consumption share, one minus import share, raised to the power of the negative inverse trade elasticity. A lower value of θ simultaneously raises the changes in own consumption share and the elasticity exponent, which generate the opposite effects. As a result, the overall influence of trade elasticity on welfare is limited.

Full-county aggregation. In Panel D, I disaggregate the 44 outside regions into 2,190 counties, yielding a total of 3,065 spatial units. This exercise leaves the welfare loss of the Dust Bowl region virtually unchanged (-9.66% to -9.70%), while national losses rise from -2.60% to -2.83% and outside losses from -1.18% to -1.38%. In other words, disaggregation modestly increases the losses. This is because state-level aggregation suppresses within-state heterogeneity and therefore tends to understate non-homothetic welfare losses. Panel D, Rows 2 and 3, show that the amenity channel changes little, so the difference across aggregation levels operates primarily through the productivity and trade channels.

D Theoretical Framework Appendix

D.1 Initial Equilibrium

I adopt the market access term approach and first construct bilateral trade flows between all regional pairs in the contiguous United States. The bilateral trade flows between importer n and exporter i in industry k can be expressed as a function of trade costs $\tau^k_{ni,t}$, price index $P^k_{n,t}$, wages $w^k_{n,t}$,[3] labor allocation $L^k_{n,t}$, productivity $A^k_{i,t}$, consumption share φ^k, and productivity dispersion parameter θ^k:

$$\begin{aligned} X^k_{ni,t} &= \left(\tau^k_{ni,t}\frac{w^k_{i,t}}{A^k_{i,t}}\right)^{-\theta^k}(P^k_{n,t})^{\theta^k} \times \varphi^k Y_{n,t} \\ &= T^k_{ni,t} \times \left(\frac{Y^k_{i,t}}{(\Pi^k_{i,t})^{-\theta^k}}\right) \times \left(\frac{X^k_{n,t}}{(P^k_{n,t})^{-\theta^k}}\right), \end{aligned} \tag{A12}$$

where the terms $Y^k_{i,t}$ and $X^k_{n,t}$ each denote output and expenditure on industry k. The second line follows from introducing the outward market access term $\Pi^k_{i,t} \equiv \left(\frac{w^k_{i,t}}{A^k_{i,t}}\right)^{-1}\left(Y^k_{i,t}\right)^{-1/\theta^k}$ and the effective trade costs $T^k_{ni,t} = (\tau^k_{ni,t})^{-\theta^k}$. As outlined in Appendix A.4, I impose a simplifying assumption that $T^k_{ni,t}$ is a function of the routed distance and distance elasticity of trade.

The outward market access term $\Pi^k_{i,t}$ captures how close exporter i is to the potential importers. The price index $P^k_{n,t}$ represents the inward trade market access and captures how close each importer n is to exporters. Using the two market access terms, the following proposition characterizes the initial trade equilibrium as the solution to a system of non-linear equations.

Proposition 1 (Initial Equilibrium; following Donaldson and Hornbeck (2016) and Allen and Donaldson (2022)). Given the allocation of output and labor, $\{Y_t, L_t\}$, trade costs raised to the elasticity exponent, $\{T_t\}$, and consumption share, $\{\varphi^k\}$, the solution to the initial equilibrium at t is the set of market access terms and expenditure shares, $\{P_t, \Pi_t, \pi_t\}$. In particular, it is obtained as

[3] I use wages for non-agricultural sectors and rent-redistributed wages for agriculture.

the solution to the following system of non-linear equations:

Outward and Inward Trade Market Access Terms:

(I1a) $$(\Pi^k_{i,t})^{-\theta^k} = \sum_{j=1}^{N} T^k_{ji,t} \times X^k_{j,t} \times (P^k_{j,t})^{\theta^k},$$

(I1b) $$(P^k_{n,t})^{-\theta^k} = \sum_{j=1}^{N} T^k_{nj,t} \times Y^k_{j,t} \times (\Pi^k_{j,t})^{\theta^k}.$$

Trade Flows:

(I2) $$X^k_{ni,t} = T^k_{ni,t} \times \frac{Y^k_{i,t}}{(\Pi^k_{i,t})^{-\theta^k}} \times \frac{X^k_{n,t}}{(P^k_{n,t})^{-\theta^k}}.$$

Output and Expenditure:

(I3) $$Y^k_{n,t} = w^k_{n,t} L^k_{n,t}, \quad Y_{n,t} = \sum_k Y^k_{n,t}, \quad \text{and} \quad X^k_{n,t} = \varphi^k Y_{n,t}.$$

Wages:

(I4) $$w^k_{n,t} L^k_{n,t} = \sum_{j=1}^{N} X^k_{jn,t}.$$

D.2 Dynamic Hat Algebra

I adopt the dynamic hat algebra approach proposed by Caliendo et al. (2019) for the counterfactual analysis. Dynamic hat algebra calculates how allocations and prices change in a counterfactual economy relative to a baseline economy across space and time. It eliminates the need to recover time-invariant fundamentals and focuses on quantifying the changes in allocations and prices, given a new sequence of fundamentals.

Dot notation expresses a variable in terms of changes over time: $\dot{Y}_{t+1} \equiv Y_{t+1}/Y_t$. Prime denotes the values in the counterfactual economy, and the changes in the counterfactual economy can also be expressed in terms of time changes: $\dot{Y}'_{t+1} \equiv Y'_{t+1}/Y'_t$. Lastly, I define hat variables, $\hat{Y}_t \equiv \dot{Y}'_t/\dot{Y}_t$, as the counterfactual time changes relative to the baseline time changes for any variable Y. Temporary-equilibrium fundamentals $\Theta_t \equiv \{A^k_{i,t}, \tau^k_{ni,t}\}$ comprise time-varying sectoral productivities and bilateral trade costs. Amenities $B_{n,t}$ enter the dynamic problem separately (Proposition 3). The set $\bar{\Theta}_t$ contains exogenous baseline productivities, amenities, and migration costs, whose levels are likewise unnecessary for hat algebra.

Proposition 2 (Temporary Equilibrium; adapting Proposition 1 of Caliendo et al. (2019)). Given the allocation of the temporary equilibrium at t, $\{L_t, \pi_t, Y_t\}$, the solution to the temporary equilibrium at $t+1$ for a given change in $\dot{L}_{t+1}$ and $\dot{\Theta}_{t+1}$ does not require information on the level of fundamentals at t, Θ_t or $\bar{\Theta}_t$. In particular, it is obtained as the solution to the following system of non-linear equations:

$$\text{(T1)} \qquad \dot{P}^k_{n,t+1} = \Big[\sum_{i=1}^{N} \pi^k_{ni,t}\big(\dot{\tau}^k_{ni,t+1}\dot{c}^k_{i,t+1}\big)^{-\theta^k}\big(\dot{A}^k_{i,t+1}\big)^{\theta^k}\Big]^{-1/\theta^k},$$

$$\text{(T2)} \qquad \pi^k_{ni,t+1} = \pi^k_{ni,t}\Big(\frac{\dot{\tau}^k_{ni,t+1}\dot{c}^k_{i,t+1}}{\dot{P}^k_{n,t+1}}\Big)^{-\theta^k}\big(\dot{A}^k_{i,t+1}\big)^{\theta^k},$$

$$\text{(T3)} \qquad Y_{n,t+1} = \sum_{k=1}^{K}\Big(\dot{w}^k_{n,t+1}\dot{L}^k_{n,t+1}w^k_{n,t}L^k_{n,t}\Big),$$

$$\text{(T4)} \qquad (\dot{w}^k_{i,t+1}\dot{L}^k_{i,t+1})w^k_{i,t}L^k_{i,t} = \sum_{n=1}^{N}\pi^k_{ni,t+1}\sum_{s=1}^{K}\varphi^k_{ns,t+1}Y^s_{n,t+1}.$$

$$\text{(T5)} \qquad \varphi^k_{is,t+1} = \phi^k + \big(\varphi^k_{is,t} - \phi^k\big)\Big(\frac{\dot{w}^s_{i,t+1}}{\dot{P}_{i,t+1}}\Big)^{-\varepsilon},$$

where φ^k_{is} represents consumption shares of individuals in labor market i-s on sector k.

The next proposition shows how to calculate a dynamic sequence of the economy. I study how migration flows, μ, vary with the new sequence of temporary equilibria. I define $\mathbb{V}^k_{n,t} \equiv \exp(V^k_{n,t})$.

Proposition 3 (Sequential Equilibrium; adapting Proposition 2 of Caliendo et al. (2019)). Given an initial allocation $(L_0, \pi_0, X_0, \mu_{-1})$ of the economy, and an anticipated convergent sequence of time changes in fundamentals, $\{\dot{\Theta}_t\}_{t=1}^{\infty}$ with $\lim_{t\to\infty}\dot{\Theta}_t = 1$, the solution to the sequential competitive equilibrium in time differences does not require information on the levels of fundamentals, $\{\Theta_t\}_{t=0}^{\infty}$. In particular, the changes in migration shares are obtained as the solution to the following system of non-linear equations:

$$\text{(S1)} \qquad \mu^{ks}_{ni,t+1} = \frac{\mu^{ks}_{ni,t}\Big(\dot{\mathbb{V}}^s_{i,t+2}\Big)^{\beta/\eta}}{\sum_{l=1}^{N}\sum_{h=0}^{K}\mu^{kh}_{nl,t}\Big(\dot{\mathbb{V}}^h_{l,t+2}\Big)^{\beta/\eta}}$$

$$\text{(S2)} \qquad \dot{\mathbb{V}}^k_{n,t+1} = \dot{B}_{n,t+1}\dot{C}^k_n\Big(\dot{L}_{t+1}, \dot{\Theta}_{t+1}\Big)\Big(\sum_{i=1}^{N}\sum_{s=0}^{K}\mu^{ks}_{ni,t}(\dot{\mathbb{V}}^s_{i,t+2})^{\beta/\eta}\Big)^{\eta},$$

$$L^k_{n,t+1} = \sum_{i=1}^{N}\sum_{s=0}^{K} \mu^{sk}_{in,t} L^s_{i,t}. \tag{S3}$$

In equation (S2), the time change in amenities, $\dot{B}_{n,t+1}$, is given by

$$\begin{aligned}\dot{B}_{n,t+1} = (\bar{B}_{n,t+1}/\bar{B}_{n,t}) \times (L_{n,t+1}/L_{n,t})^{\rho_B} \\ \times \exp\Big(g(D_{n,t+1}, E_{n,t+1}; \boldsymbol{\beta}_B) - g(D_{n,t}, E_{n,t}; \boldsymbol{\beta}_B)\Big),\end{aligned}$$

and the consumption indirect utility, $C^k_n(\dot{L}_{t+1}, \dot{\Theta}_{t+1})$, is constructed from the solution of the temporary equilibrium given $\{\dot{L}_t, \dot{\Theta}_t\}_{t=1}^{\infty}$:

$$C^k_{n,t+1} = \frac{1}{\varepsilon}\Big(\frac{\dot{w}^k_{n,t+1}}{\dot{P}_{n,t+1}}\frac{w^k_{n,t}}{P_{n,t}}\Big)^{\varepsilon} - \sum_{s=1}^{K} \nu^s \log(\dot{P}^s_{n,t+1} P^s_{n,t}),$$

where I first recover wages at $t = 1$ consistent with the initial-period economic allocation. The terms are real wages and the non-homothetic price adjustment. This consumption-utility flow enters the value function; main-text Section 5.1 defines its aggregation into consumption-equivalent welfare.

Definition (Stationary Equilibrium). A stationary equilibrium is a sequential competitive equilibrium such that $\{\mathbf{L}_t, \boldsymbol{\mu}_t, \mathbf{V}_t, \mathbf{w}_t\}_{t=0}^{\infty}$ is constant for every t. A stationary equilibrium in this economy is a situation in which no aggregate variables change over time. It requires fundamentals to be constant for all t. In a stationary equilibrium, individuals continually move from one market to another, but inflows and outflows balance. This stationarity is the terminal condition.

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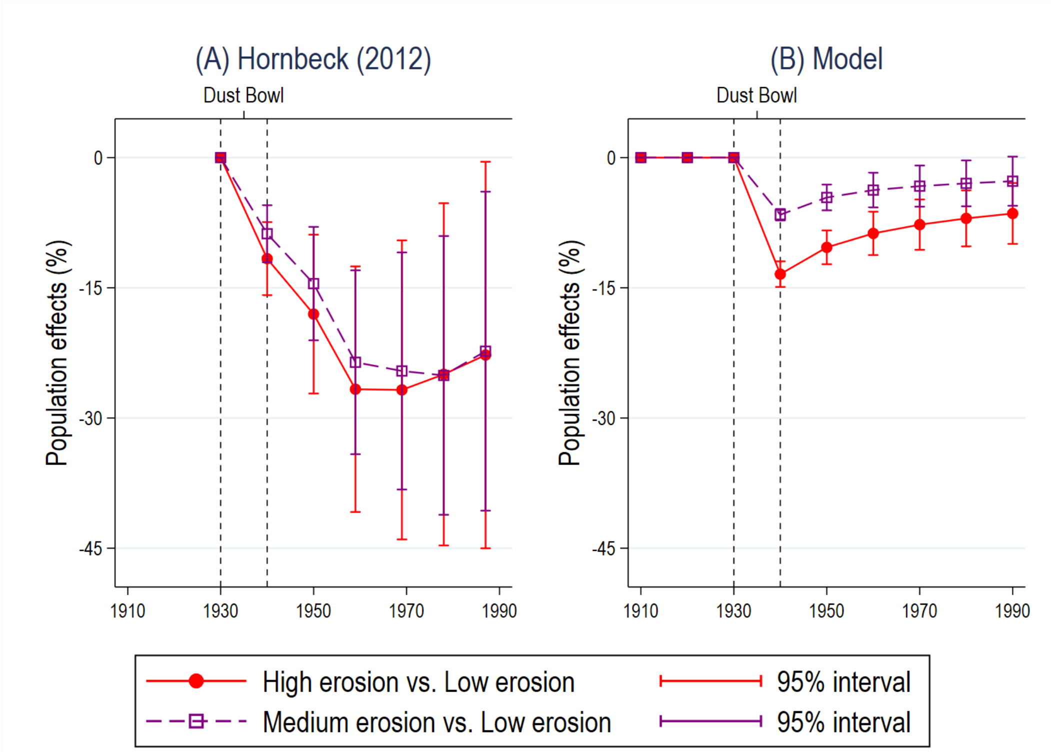
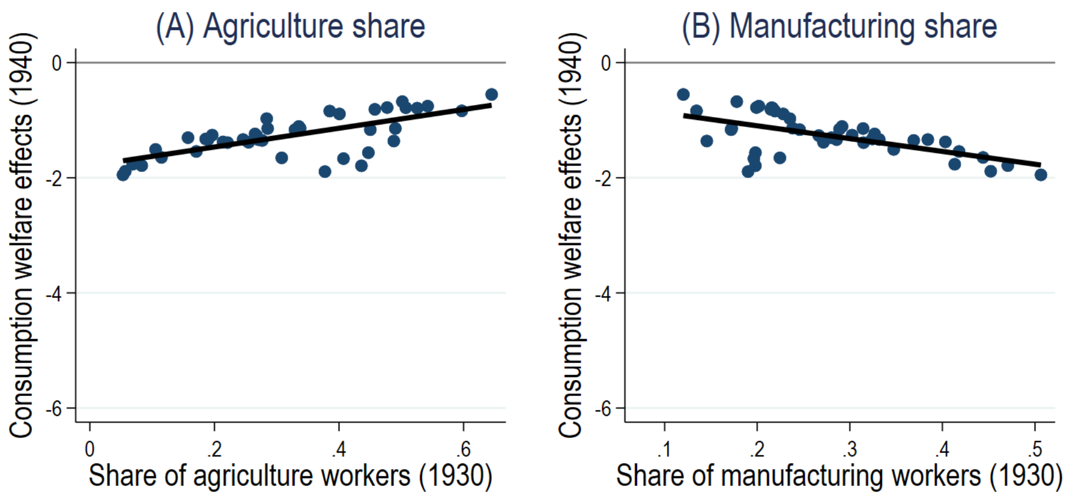
E Additional Tables and Figures

Figure OA1: Empirical and Simulated Population Effects by Erosion Level.



Note: The figure compares the population effects of erosion estimated by Hornbeck (2012) (Panel A) with the corresponding effects generated by the model with permanent land damage (Panel B). Both panels plot high- and medium-erosion counties against low-erosion counties in the same state, in percent, on a shared vertical axis, with 95% confidence intervals.

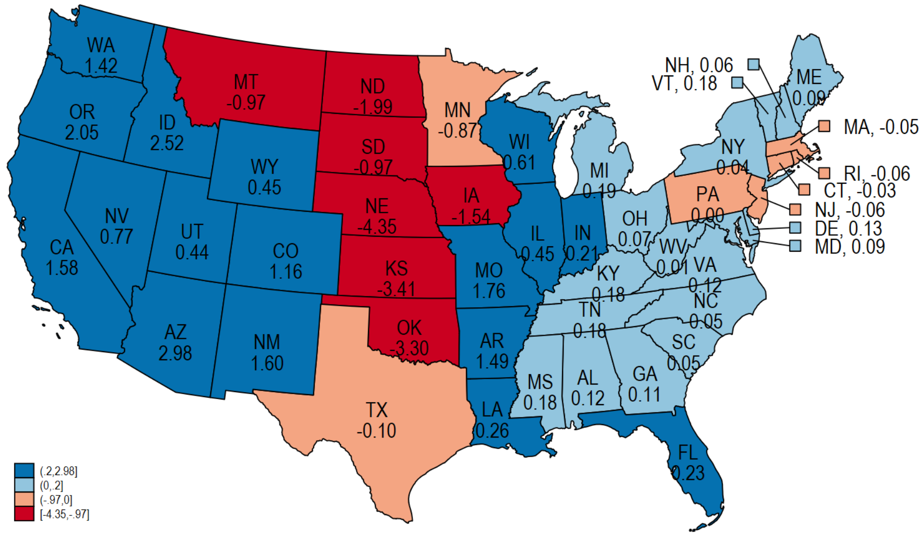
Figure OA2: Determinants of Welfare Effects in the Non-Dust Bowl Region.



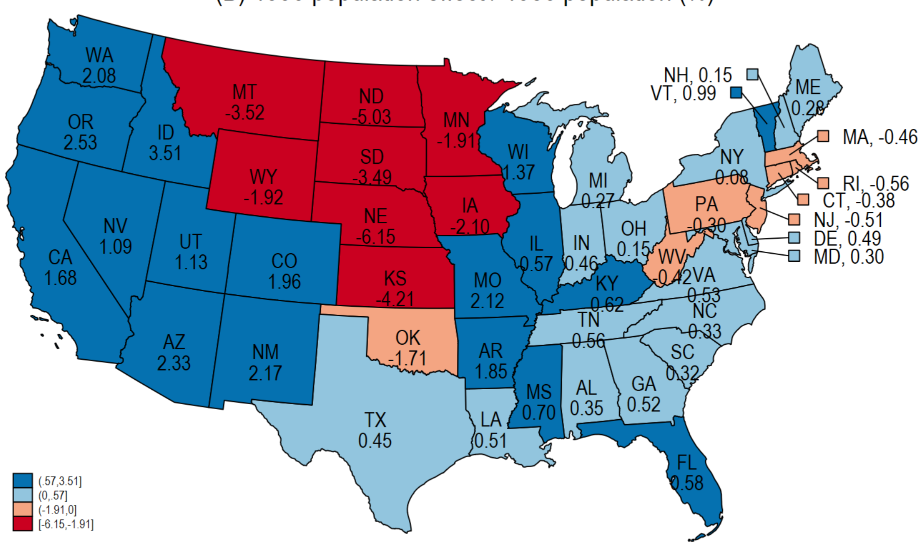
Note: The figure shows the determinants of welfare effects in the non-Dust Bowl region. Panels A and B show the relationship between simulated consumption welfare (y-axis) and empirical shares of workers in agriculture and manufacturing (x-axis) for each state. Shares of workers before the shock (the year 1930) are used.

Figure OA3: Simulated Population Effects by State and Year, 1940 and 1990.

(A) 1940 population effect / 1930 population (%)

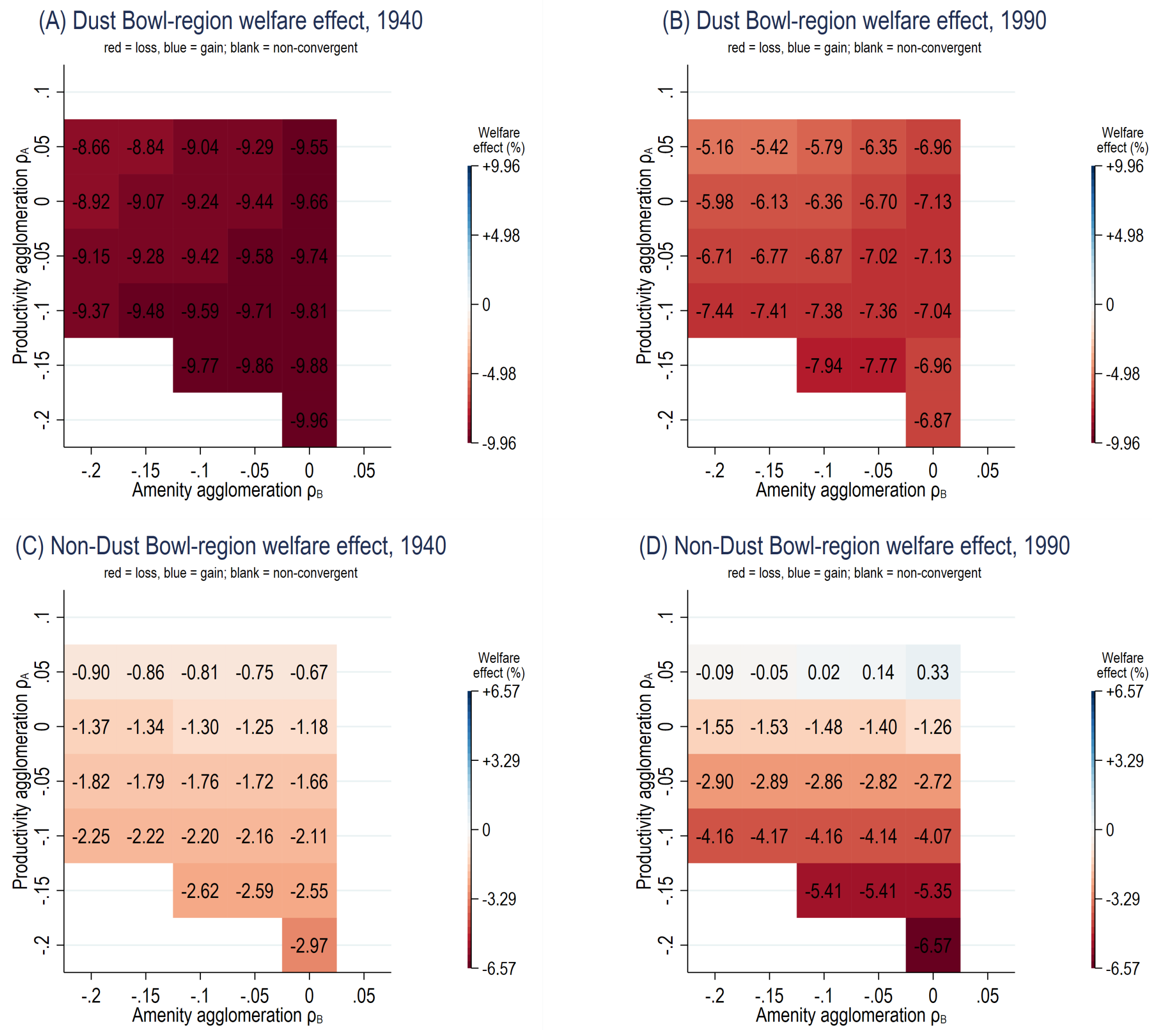


(B) 1990 population effect / 1930 population (%)



Note: The figure maps the number of simulation-generated Dust Bowl migrants in 1940 and 1990, relative to each state's 1930 population before the Dust Bowl. Darker blue represents larger increases in simulation-generated population due to the Dust Bowl, while darker red means larger decreases. Each state's population effects, in percent, are displayed in each panel.

Figure OA4: Resident Welfare Effects over the Agglomeration Grid.



Note: The figure reports the resident-based welfare effects in main-text Table 5, in percent, across combinations of the productivity externality ρ_A (rows) and the amenity externality ρ_B (columns) at $\hat{\eta} = 0.220$. Results are reported for 24 parameter combinations; the remaining cells were non-convergent in the earlier grid calculations and left blank. Panels A and B share one color scale and Panels C and D another, each centered at zero (red = loss, blue = gain). Panels A and C evaluate welfare from 1940 onward and Panels B and D from 1990 onward.

Table OA1: Estimation Results for Engel Elasticity.

	(1)	(2)	(3)	(4)	(5)
	Log food expenditure share				
Log total spending	-0.338***	-0.352***	-0.392***	-0.457***	-0.394***
	(0.030)	(0.034)	(0.023)	(0.029)	(0.039)
Controls	No	Yes	Yes	Yes	Yes
Geographic FE	No	Yes	Yes	Yes	Yes
Demographic FE	No	No	Yes	Yes	Yes
Instruments	No	No	No	Total income	Occupation
R-squared	0.294	0.346	0.371	0.296	0.304
Observations	1,726	1,726	1,726	1,726	619

Note: The table reports estimates for Engel elasticity, ε, using the log household-expenditure coefficient in Engel-curve regression equation (A6). Data are from the Study of Consumer Purchases in the United States, 1935–1936. The sample includes 1,726 households (619 with occupation information in Column 5). Columns 1–3 are estimated by OLS, progressively adding household characteristic controls, geographic fixed effects, and demographic fixed effects. The next two columns instrument household expenditure using household income (Column 4) and occupation fixed effects (Column 5). The controls include the ages of the husband and wife, the amount of rent, and their squared values. Geographic fixed effects consist of state and city fixed effects. Demographic fixed effects include (1) dwelling categories, (2) race, and (3) work status of household members. Robust standard errors are clustered at the state level and reported in parentheses. * Significant at the 5% level. ** Significant at the 1% level. *** Significant at the 0.1% level.

Table OA2: Estimation Results for Distance Elasticity of Trade.

	(1)	(2)	(3)	(4)
	Log trade value			
Log routed distance	-1.316***	-1.242***	-1.309***	-1.222***
	(0.0615)	(0.0691)	(0.0549)	(0.0577)
Data	2012 CFS	2012 CFS	2017 CFS	2017 CFS
Geographic units	State	MSA	State	MSA
R-squared	0.878	0.692	0.877	0.701
Observations	2,393	6,825	2,386	6,815

Note: The table reports estimates for the distance elasticity of U.S. internal trade, κ. The dependent variable is the logged trade value, and the independent variable is the logged routed distance between the origin and destination. All columns include origin- and destination-state fixed effects. Columns 1 and 2 use the 2012 Commodity Flow Survey (CFS), and Columns 3 and 4 use the 2017 CFS. Columns 1 and 3 are estimated using state-level trade flows, while Columns 2 and 4 use MSA-level flows. Robust standard errors are clustered at the origin–destination state-pair level and reported in parentheses. * Significant at the 5% level. ** Significant at the 1% level. *** Significant at the 0.1% level.

Table OA3: Empirical Changes in Agricultural Production, by Erosion Level.

	(1) Farmland share	(2) Log cropland productivity	(3) Log pasture productivity	(4) Land share in cropland	(5) Log wheat productivity	(6) Log hay productivity	(7) Land share in wheat
Panel A. High erosion vs. low erosion							
1940	-0.019	-0.304*	-0.230***	-0.000	-0.129		0.038
	(0.016)	(0.120)	(0.042)	(0.009)	(0.102)		(0.023)
1945	-0.011	-0.139	-0.142*	-0.011	-0.199**		
	(0.016)	(0.075)	(0.055)	(0.011)	(0.070)		
1950-1954	-0.038*	-0.364***	-0.112*	-0.023	-0.228***	-0.003	0.020
	(0.016)	(0.066)	(0.055)	(0.014)	(0.069)	(0.051)	(0.022)
1959-1964	-0.045**	-0.272***	-0.233**	-0.050**	-0.189**	0.087	0.005
	(0.017)	(0.077)	(0.076)	(0.016)	(0.070)	(0.046)	(0.023)
1969-1974	-0.013				0.009	0.138**	-0.028
	(0.015)				(0.058)	(0.043)	(0.026)
1978-1992	-0.047**				-0.008	0.194***	-0.053
	(0.016)				(0.047)	(0.047)	(0.029)
Panel B. Medium erosion vs. low erosion							
1940	-0.015	-0.362***	-0.082*	-0.002	-0.104		0.001
	(0.013)	(0.090)	(0.037)	(0.006)	(0.082)		(0.017)
1945	0.006	-0.267***	-0.071	-0.007	-0.065		
	(0.013)	(0.062)	(0.039)	(0.007)	(0.053)		
1950-1954	-0.009	-0.298***	-0.017	-0.014	-0.166**	0.026	0.006
	(0.013)	(0.055)	(0.040)	(0.009)	(0.062)	(0.047)	(0.019)
1959-1964	-0.026	-0.259***	0.010	-0.023	-0.248***	0.066	-0.019
	(0.014)	(0.065)	(0.054)	(0.012)	(0.055)	(0.046)	(0.021)
1969-1974	-0.010				-0.043	-0.017	-0.064**
	(0.012)				(0.045)	(0.034)	(0.022)
1978-1992	-0.023				-0.051	0.001	-0.106***
	(0.013)				(0.034)	(0.038)	(0.023)
Panel C. Drought							
1940	0.005	-0.233***	-0.071**	0.003	-0.221***		0.014
	(0.011)	(0.059)	(0.026)	(0.004)	(0.040)		(0.008)
1945	-0.000	0.020	0.010	-0.002	0.036		
	(0.011)	(0.032)	(0.027)	(0.005)	(0.025)		
1950-1954	0.003	-0.033	-0.011	-0.005	0.022	0.081***	0.012
	(0.009)	(0.034)	(0.027)	(0.006)	(0.027)	(0.020)	(0.009)
1959-1964		-0.155***	0.042	-0.011	-0.115***	0.061**	0.000
		(0.039)	(0.037)	(0.008)	(0.025)	(0.021)	(0.009)
1959-1969	0.006						
	(0.009)						
1969-1974					-0.032	0.049*	-0.025*
					(0.022)	(0.020)	(0.010)
1978-1992	0.007				0.000	0.066**	-0.036**
	(0.010)				(0.018)	(0.022)	(0.011)
Panel D. Spatial linkages							
Outward access	-0.006	-0.332	0.389**	-0.071**	-0.104	0.261**	-0.119
	(0.038)	(0.179)	(0.139)	(0.027)	(0.121)	(0.093)	(0.085)
R-squared	0.529	0.512	0.402	0.577	0.704	0.548	0.320
Observations	9,312	4,656	4,656	4,656	5,052	4,210	4,631
Clusters (counties)	776	776	776	776	421	421	421

Note: The table replicates Hornbeck (2012), Table 3, using main-text equation (12) with an outward-market-access control, state-by-year fixed effects, and the pre-1930 controls listed in main-text Table 2. The sample includes up to 776 Plains counties, depending on outcome availability. Outcomes by column: (1) farmland/county acres; (2) log crop revenue/cropland acres; (3) log animal revenue/pasture acres; (4) cropland/(cropland plus pasture); (5) log wheat output/wheat acres; (6) log hay output/hay acres; (7) wheat/(wheat plus hay acres). Regressions are weighted by the 1930 acreage in each outcome's denominator. Robust standard errors are clustered at the county level and reported in parentheses. * Significant at the 5% level. ** Significant at the 1% level. *** Significant at the 0.1% level.

Table OA4: Empirical Changes in Population and Non-agriculture, by Erosion Level.

	(1) Log population	(2) Log mfg. establishments	(3) Mfg. workers per capita	(4) Unemployment rate	(5) Log retail sales per capita
Panel A. High erosion vs. low erosion					
1940	-0.116***	-0.015	0.003	0.010***	-0.122***
	(0.021)	(0.069)	(0.002)	(0.003)	(0.029)
1950	-0.180***	-0.183**		-0.004	
	(0.047)	(0.067)		(0.002)	
1960	-0.267***	-0.188*	0.005		-0.066*
	(0.072)	(0.082)	(0.007)		(0.029)
1970	-0.268**	-0.104	0.006		-0.044
	(0.088)	(0.100)	(0.010)		(0.037)
1980	-0.250*	-0.041	0.013		-0.093*
	(0.101)	(0.117)	(0.013)		(0.043)
1990	-0.227*	-0.087	0.010		-0.090
	(0.114)	(0.136)	(0.012)		(0.051)
Panel B. Medium erosion vs. low erosion					
1940	-0.088***	-0.100*	-0.001	0.003	-0.066**
	(0.017)	(0.047)	(0.002)	(0.002)	(0.021)
1950	-0.145***	-0.084		-0.002	
	(0.033)	(0.046)		(0.002)	
1960	-0.236***	-0.139*	0.005		0.023
	(0.054)	(0.062)	(0.005)		(0.021)
1970	-0.246***	-0.116	0.012		0.041
	(0.070)	(0.075)	(0.008)		(0.026)
1980	-0.251**	-0.036	0.018*		-0.021
	(0.082)	(0.092)	(0.009)		(0.032)
1990	-0.223*	-0.026	0.024**		-0.013
	(0.094)	(0.107)	(0.008)		(0.039)
R-squared	0.654	0.637	0.612	0.866	0.998
Observations	4,674	5,676	1,435	1,558	3,790
Clusters (counties)	779	516	287	779	758

Note: The table replicates Hornbeck (2012), Table 4, for changes in population and non-agricultural activities by regressing each outcome on the high- and medium-erosion shares of county land, with low erosion omitted. The sample includes up to 779 Plains counties, depending on outcome availability. All columns include state-by-year fixed effects and the pre-1930 county characteristics of Hornbeck (2012) (listed in the note to main-text Table 2). Regressions are weighted by 1930 county population. Robust standard errors are clustered at the county level and reported in parentheses. * Significant at the 5% level. ** Significant at the 1% level. *** Significant at the 0.1% level.

Table OA5: Simulated Changes in Non-agricultural Activities, by Erosion Level.

	(1) Tradable output	(2) Tradable employment	(3) Nontradable output	(4) Nontradable employment	(5) Non-employment share
Panel A. High erosion vs. low erosion					
1940	4.359***	0.862***	-7.985***	-1.020***	0.133***
	(0.366)	(0.144)	(0.620)	(0.093)	(0.032)
1950	5.937***	1.688***	-8.965***	-0.848***	0.186***
	(0.409)	(0.198)	(0.561)	(0.111)	(0.034)
1960	6.927***	2.078***	-10.037***	-0.850***	0.221***
	(0.461)	(0.238)	(0.530)	(0.111)	(0.034)
1970	7.307***	2.212***	-10.300***	-0.854***	0.235***
	(0.505)	(0.255)	(0.520)	(0.110)	(0.032)
1980	7.426***	2.266***	-10.438***	-0.863***	0.237***
	(0.541)	(0.262)	(0.517)	(0.109)	(0.031)
1990	7.453***	2.289***	-10.546***	-0.872***	0.239***
	(0.570)	(0.264)	(0.516)	(0.108)	(0.032)
Panel B. Medium erosion vs. low erosion					
1940	1.946***	0.460***	-3.511***	-0.482***	0.061**
	(0.303)	(0.063)	(0.555)	(0.053)	(0.020)
1950	2.637***	0.781***	-4.154***	-0.426***	0.103***
	(0.363)	(0.078)	(0.485)	(0.060)	(0.027)
1960	3.050***	0.920***	-4.646***	-0.411***	0.116***
	(0.403)	(0.091)	(0.467)	(0.064)	(0.021)
1970	3.214***	0.966***	-4.750***	-0.407***	0.123***
	(0.424)	(0.098)	(0.455)	(0.067)	(0.018)
1980	3.266***	0.986***	-4.771***	-0.408***	0.124***
	(0.436)	(0.101)	(0.444)	(0.069)	(0.016)
1990	3.287***	0.996***	-4.799***	-0.412***	0.125***
	(0.444)	(0.103)	(0.438)	(0.071)	(0.016)
R-squared	0.904	0.882	0.936	0.844	0.749
Observations	7,875	7,875	7,875	7,875	7,875
Clusters (counties)	875	875	875	875	875

Note: The table reports estimation results from regressing simulated outcomes on the high- and medium-erosion shares of county land, with low erosion omitted. The sample includes the 875 Dust Bowl counties of the model. All columns include state-by-year and county fixed effects. Estimates are changes in percentage points (%p). Each column corresponds to empirical results in Hornbeck (2012). Columns 1 and 2 (tradable output and employment) replicate Table OA4, Columns 2 and 3; Column 3 (nontradable output) reproduces Table OA4, Column 5; and Column 5 (non-employment share) corresponds to Table OA4, Column 4. Column 4 (nontradable employment) has no direct empirical counterpart. Regressions are weighted by 1930 county population. Robust standard errors are clustered at the county level and reported in parentheses. * Significant at the 5% level. ** Significant at the 1% level. *** Significant at the 0.1% level.

Table OA6: Simulated Migration Effects, by Erosion Level.

Panel A. Out-migration from Dust Bowl counties, 1930–1940					
	(1) All destinations	(2) To non-Dust Bowl region	(3) Within Dust Bowl region	(4) To California	(5) To Pacific Northwest
High erosion (origin)	28.54***	36.95***	27.01***	40.93***	39.98***
	(3.369)	(5.187)	(3.024)	(5.691)	(5.736)
Medium erosion (origin)	11.94***	15.45***	11.35***	17.81***	16.33***
	(1.383)	(2.217)	(1.248)	(3.168)	(3.125)
Intercept	-8.63***	6.30**	-11.15***	7.19**	7.82**
	(1.005)	(1.592)	(0.903)	(2.178)	(2.009)
R-squared	0.476	0.789	0.305	0.750	0.742
Observations	287,831	40,324	247,507	3,880	2,492
Clusters (origin states)	12	12	12	12	12

Panel B. In-migration into Dust Bowl counties, 1930–1940					
	(1) All origins	(2) From non-Dust Bowl region	(3) Within Dust Bowl region	(4) From California	(5) From Pacific Northwest
High erosion (destination)	-33.62***	-33.41***	-38.12***	-33.26***	-34.34***
	(1.124)	(1.134)	(1.253)	(0.862)	(1.245)
Medium erosion (destination)	-18.40***	-18.32***	-20.09***	-18.27***	-18.83***
	(1.040)	(1.033)	(1.462)	(0.688)	(0.915)
Intercept	-4.46***	-5.39***	13.06***	-5.23***	-7.67***
	(0.570)	(0.566)	(0.832)	(0.379)	(0.450)
R-squared	0.782	0.781	0.585	0.784	0.724
Observations	318,567	71,060	247,507	9,231	9,791
Clusters (destination states)	12	12	12	12	12

Note: The table replicates Hornbeck (2023), Table 1, in terms of simulation-generated migration effects. The migration effects are defined as percentage changes in migration flows between 1930 and 1940 due to the Dust Bowl. Panel A reports flows out of Dust Bowl counties; Panel B reports flows into them. Columns 1–5 respectively cover all destinations/origins, the non-Dust Bowl region, other Dust Bowl counties, California, and the Pacific Northwest (Washington and Oregon). Cells regress the percentage flow change on high- and medium-erosion shares, measured at the origin in Panel A and destination in Panel B. The intercept reports the predicted flow change for a county with no high- or medium-erosion area. All columns include origin- and destination-state fixed effects. Regressions are weighted by 1930 county population. Robust standard errors are clustered at the origin-state (A) or destination-state (B) level and reported in parentheses. * Significant at the 5% level. ** Significant at the 1% level. *** Significant at the 0.1% level.

Table OA7: Welfare Effects - Additional Counterfactual Scenarios.

	(1) Aggregate effects	(2) Dust Bowl region	(3) Outside region
Panel A. Baseline Results and Decomposition			
(1) Baseline	-2.600	-9.664	-1.180
(2) Productivity (land) shock	-2.151	-6.936	-1.183
(3) Amenity shock	-0.448	-2.727	0.004
(4) Erosion damage only	-1.912	-7.440	-0.803
(5) Drought damage only	-0.928	-3.107	-0.488
Panel B. Land-use and Adaptation			
(1) All farmland to cropland	-4.984	-16.530	-2.657
(2) All farmland to pastureland	-0.878	-4.126	-0.231
(3) Cropland to pastureland in 1940	-2.563	-9.558	-1.158
Panel C. Robustness			
(1) Productivity growth (1%/yr)	-2.538	-9.458	-1.155
(2) Productivity growth (2%/yr)	-2.483	-9.275	-1.131
(3) Cobb-Douglas demand	-1.350	-8.249	0.019
(4) Price index, initial weights	-3.711	-11.264	-2.187
(5) Price index, time-varying	-3.412	-10.618	-1.960
(6) Halved land shock (log $\times 0.5$)	-1.504	-6.235	-0.557
(7) Doubled land shock (log $\times 2$)	-4.939	-16.306	-2.649
(8) Transitory land damage	-2.334	-8.865	-1.024
(9) Engel elasticity 0.34	-2.312	-8.773	-1.013
(10) Engel elasticity 0.45	-2.886	-10.534	-1.349
(11) Trade elasticity $\theta^A = 8$	-2.604	-9.506	-1.216
(12) Trade elasticity $\theta^A = 16$	-2.596	-9.747	-1.160
Panel D. Outside Region at the County Level ($N = 3{,}065$)			
(1) Baseline	-2.828	-9.699	-1.379
(2) Productivity (land) shock	-2.356	-7.036	-1.365
(3) Amenity shock	-0.469	-2.659	-0.010

Note: The table reports the per-capita welfare effects evaluated in 1940 under additional counterfactual scenarios and alternative structural parameter values. Welfare effects are the resident-based consumption-equivalent measure of the main text (discounted flow-utility changes of each region's current residents), evaluated in 1940 for $N = 919$ model units ($N = 3{,}065$ in Panel D, where the 44 outside regions are disaggregated into 2,190 counties), and are reported in percent. For the structural parameters, the baseline simulation uses $\{\beta, \varepsilon, \hat{\eta}, \theta^A, \theta^M, \kappa\} = \{0.60, 0.39, 0.220, 12, 6.5, 1.3\}$.

Table OA8: Spillovers to Less-eroded Plains Counties, by Distance Gradient.

	(1)	(2)	(3)	(4)
	Land value		Revenue	
Q1 (nearest)	-0.199**	-0.138	0.066	0.112
	(0.076)	(0.073)	(0.096)	(0.100)
Q2	-0.159*	-0.141*	0.002	0.010
	(0.065)	(0.062)	(0.084)	(0.084)
Q3	-0.168**	-0.151**	-0.031	-0.024
	(0.054)	(0.052)	(0.066)	(0.067)
Q4 (second farthest)	-0.023	-0.014	0.047	0.044
	(0.039)	(0.039)	(0.047)	(0.048)
Own erosion and drought controls	No	Yes	No	Yes
R-squared	0.986	0.986	0.965	0.966
Observations	3,058	3,058	3,058	3,058
Clusters (counties)	278	278	278	278

Note: The table reports changes from 1930 in log agricultural land value and revenue by remoteness from the Dust Bowl among less-eroded Plains counties, relative to the farthest quintile (Q5). The sample includes Plains counties with no more than half of their land in the medium- or high-erosion shares. All columns include state-by-year fixed effects, Table 2's pre-1930 characteristics and New Deal controls; Columns 2 and 4 also include the county's own year-interacted medium- and high-erosion shares and drought index (the exposure terms of Table 2). Regressions are weighted by 1930 farmland acres. Robust standard errors are clustered at the county level and reported in parentheses. * Significant at the 5% level. ** Significant at the 1% level. *** Significant at the 0.1% level.

Table OA9: Spillovers to Less-eroded Plains Counties, by Remoteness and Market Access.

	Geographic remoteness (reduced-form)		Trade-channel access loss (semi-structural)	
	(1)	(2)	(3)	(4)
	Land value	Revenue	Land value	Revenue
Log remoteness from Dust Bowl	0.429***	-0.101		
	(0.114)	(0.162)		
Dust Bowl market-access loss			-0.315	1.260***
			(0.239)	(0.303)
R-squared	0.986	0.965	0.986	0.965
Observations	3,058	3,058	3,058	3,058
Clusters (counties)	278	278	278	278

Note: The table reports estimates of Dust Bowl spillovers to less-eroded Plains counties. The sample includes Plains counties with no more than half of their land in the medium- or high-erosion shares. Outcomes are changes from 1930 in log agricultural land value and revenue, as in main-text Table 2. Columns 1 and 2 use geographic exposure: the log of the sum of distances to Dust Bowl counties, each weighted by its 1930 population and high-erosion land share. A positive coefficient indicates greater losses nearer the Dust Bowl. Columns 3 and 4 use the Dust Bowl-induced loss in outward market access, a semi-structural measure incorporating model trade structure. All columns include state-by-year fixed effects, Table 2's pre-1930 characteristics and New Deal controls, and the county's own year-interacted medium- and high-erosion shares and drought index (the exposure terms of Table 2). Regressions are weighted by 1930 farmland acres. Robust standard errors are clustered at the county level and reported in parentheses. * Significant at the 5% level. ** Significant at the 1% level. *** Significant at the 0.1% level.

Table OA10: Productivity Estimation Robustness.

	Log land value				Log agricultural revenue			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Baseline	+ log pop.	AAiv1	AAiv2	Baseline	+ log pop.	AAiv1	AAiv2
Panel A. High erosion vs. low erosion								
1940	-0.276***	-0.269***	-0.248***	-0.254***	-0.236***	-0.229***	-0.297***	-0.300***
	(0.039)	(0.037)	(0.042)	(0.042)	(0.053)	(0.053)	(0.076)	(0.078)
1945	-0.208***	-0.200***	-0.184***	-0.189***	-0.102**	-0.095*	-0.155*	-0.158*
	(0.037)	(0.037)	(0.041)	(0.041)	(0.039)	(0.039)	(0.065)	(0.068)
1950-1954	-0.257***	-0.246***	-0.238***	-0.241***	-0.215***	-0.205***	-0.257***	-0.259***
	(0.041)	(0.042)	(0.042)	(0.041)	(0.048)	(0.046)	(0.073)	(0.075)
1959-1969	-0.300***	-0.282***	-0.290***	-0.292***	-0.236***	-0.219***	-0.259***	-0.260***
	(0.043)	(0.041)	(0.045)	(0.044)	(0.059)	(0.055)	(0.077)	(0.078)
1978-1992	-0.235***	-0.217***	-0.234***	-0.234***	-0.306***	-0.289***	-0.309***	-0.309***
	(0.049)	(0.042)	(0.051)	(0.050)	(0.080)	(0.079)	(0.090)	(0.091)
Panel B. Medium erosion vs. low erosion								
1940	-0.167***	-0.161***	-0.139***	-0.145***	-0.155***	-0.149***	-0.217***	-0.220***
	(0.033)	(0.032)	(0.036)	(0.036)	(0.041)	(0.041)	(0.064)	(0.066)
1945	-0.082**	-0.075*	-0.056	-0.062	-0.099**	-0.091**	-0.156**	-0.159**
	(0.029)	(0.029)	(0.032)	(0.032)	(0.031)	(0.031)	(0.055)	(0.057)
1950-1954	-0.135***	-0.123***	-0.112***	-0.117***	-0.176***	-0.165***	-0.227***	-0.229***
	(0.032)	(0.030)	(0.033)	(0.033)	(0.037)	(0.035)	(0.056)	(0.058)
1959-1969	-0.175***	-0.159***	-0.157***	-0.161***	-0.111**	-0.095*	-0.151**	-0.153**
	(0.035)	(0.032)	(0.037)	(0.036)	(0.041)	(0.039)	(0.055)	(0.057)
1978-1992	-0.099*	-0.092**	-0.085	-0.087*	-0.034	-0.027	-0.066	-0.068
	(0.040)	(0.034)	(0.043)	(0.042)	(0.059)	(0.058)	(0.067)	(0.068)
Panel C. Drought								
1940	-0.093***	-0.085***	-0.117***	-0.112***	-0.153***	-0.146***	-0.099	-0.096
	(0.022)	(0.022)	(0.028)	(0.028)	(0.032)	(0.032)	(0.051)	(0.052)
1945	-0.053*	-0.047*	-0.080**	-0.074**	-0.003	0.003	0.056	0.059
	(0.021)	(0.021)	(0.028)	(0.028)	(0.022)	(0.022)	(0.046)	(0.049)
1950-1954	-0.050**	-0.044*	-0.080**	-0.074*	-0.026	-0.020	0.040	0.043
	(0.019)	(0.019)	(0.030)	(0.029)	(0.026)	(0.024)	(0.045)	(0.047)
1959-1969	-0.080***	-0.070***	-0.111***	-0.105**	-0.020	-0.011	0.050	0.053
	(0.022)	(0.020)	(0.033)	(0.032)	(0.030)	(0.027)	(0.048)	(0.051)
1978-1992	-0.096***	-0.086***	-0.136***	-0.128***	0.106*	0.116**	0.194**	0.198**
	(0.022)	(0.019)	(0.038)	(0.038)	(0.045)	(0.044)	(0.064)	(0.066)
Panel D. Labor input and spatial linkages								
Log population		0.145***				0.141***		
		(0.017)				(0.027)		
Outward access	0.356**	0.344**	-0.829	-0.590	0.042	0.030	2.663	2.794
	(0.115)	(0.108)	(0.886)	(0.892)	(0.141)	(0.132)	(1.393)	(1.470)
First-stage coef. on instrument (t-stat.)			0.002 (3.23)	0.002 (3.09)			0.002 (3.23)	0.002 (3.09)
Kleibergen–Paap F			10.5	9.6			10.5	9.6
R-squared	0.975	0.977			0.923	0.925		
Observations	8,536	8,536	8,536	8,536	8,536	8,536	8,536	8,536
Clusters (counties)	776	776	776	776	776	776	776	776

Note: The table reports robustness checks of Dust Bowl effects on log agricultural land value (Columns 1–4) and log agricultural revenue (Columns 5–8). The sample includes 776 Plains counties as in Table 2. Columns 1 and 5 reproduce the extended OLS specifications of main-text Table 2, Columns 2 and 4. Columns 2 and 6 add log county population, linearly interpolated between censuses. Columns 3, 4, 7, and 8 instrument outward market access using Allen and Arkolakis (2023)'s hypothetical access, constructed from other counties' predetermined 1930 crop values (AAiv1) or population (AAiv2), and Jaworski–Kitchens decade-varying travel times (Section A.4). The lower rows report the excluded instrument's coefficient, t-statistic, and Kleibergen–Paap rank Wald F. IV R^2 is omitted because partialled-out fit is not comparable to OLS. Robust standard errors are clustered at the county level and reported in parentheses; other notes follow Table 2. * Significant at the 5% level. ** Significant at the 1% level. *** Significant at the 0.1% level.