A General Equilibrium Investigation of the American Dust Bowl

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Abstract

Economic adjustments through trade and migration can mitigate environmental shocks but may also propagate them to other parts of the economy. Using a dynamic spatial general equilibrium model, I quantify the transmission of environmental shocks during the 1930s American Dust Bowl. The local agricultural shock was transmitted disproportionately to the nontradable sector, while the tradable sector was less affected. This disparity slowed the region's shift toward services. The Dust Bowl region exported higher prices for subsistence goods, imposing a sizeable welfare loss on the outside region. Trade-share adjustment amplified welfare losses in the affected region, while migration provided modest relief.

Keywords: Dust Bowl, Migration, Natural Disasters, Spatial equilibrium, Trade
JEL: F18; J61; N52; Q54.

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1 Introduction

A growing economics literature examines how shocks spread across sectors and regions and how economic activity adjusts in response (Bustos et al., 2016; Allcott and Keniston, 2018; Burstein et al., 2020; Fan et al., 2023). Understanding how environmental changes affect different places over time is especially important for assessing the uneven effects of climate change. Many studies examine the economic effects of future global warming (Costinot et al., 2016; Rudik et al., 2022; Cruz and Rossi-Hansberg, 2024; Desmet and Rossi-Hansberg, 2024). However, empirical evidence documenting the indirect effects of past environmental shocks is relatively scarce.

This paper studies the general equilibrium effects of the American Dust Bowl, one of the most severe ecological disasters in U.S. history. During the 1930s, three waves of severe dust storms struck the Great Plains, damaging farmland and disrupting people's lives. Previous research documents the economic effects on directly affected regions (Hansen and Libecap, 2004; Hornbeck, 2012)[1] and on people who were directly affected (Long and Siu, 2018; Hornbeck, 2023).[2] However, the contraction in agricultural production and mass internal migration would have also affected other regions in the United States.

I construct, estimate, and simulate a dynamic spatial general equilibrium model with structural change to study Dust Bowl spillovers across regions and industries outside the directly affected area. The model builds on standard economic geography models (Eaton and Kortum, 2002; Artuc et al., 2010; Caliendo et al., 2019), adding the effects of environmental damage and changes in consumption spending across sectors. It covers multiple regions and three sectors: agriculture, tradable non-agricultural goods, and locally provided consumer services.

The central mechanism is that food is a necessity. When incomes fall, consumers devote a larger share of their budgets to food and cut spending on other items, especially local services. Producers serving local customers therefore face a sharp decline in demand, whereas ones that sell to customers elsewhere can continue selling to less-affected markets. Consumers outside the damaged region face higher food prices and have limited scope to substitute away from food.

[1]Hornbeck (2012) documents an immediate, substantial, and persistent decrease in agricultural land values and agricultural revenue in the affected regions and finds limited relative adjustment in agricultural production. Instead, long-run economic adjustments relied on the spatial reallocation of workers.

[2]Long and Siu (2018) and Hornbeck (2023) study the characteristics of Dust Bowl migrants and their economic outcomes after migration.

Building on the empirical strategy of Hornbeck (2012), I use county farm revenues and linked census migration records to estimate losses in agricultural productivity and amenities, the non-monetary value of living in a place. I also calibrate the parameter governing how readily workers move by matching the model's 1940 population changes to those observed across counties with different levels of erosion.

Comparing counties with different levels of erosion shows how economic activity changed in more-damaged places relative to less-damaged ones. But even a county whose farmland escaped severe erosion could be affected through food prices, trade, or migration. Such reduced-form comparisons can therefore miss effects shared by both groups. To account for these effects, I compare two model economies: one exposed to the Dust Bowl as in history and one without its estimated environmental damages. Both scenarios allow consumers to adjust their spending and workers to move across places and industries. The comparison traces how damage to Plains agriculture affects the broader economy and the distribution of losses.

The quantitative model outcome implies a U.S. per-capita welfare loss of 2.60%, evaluated in 1940, with losses of 9.66% in the Dust Bowl region and 1.18% in the region outside of the Dust Bowl.[3] Welfare is measured for each region's current residents as the discounted change in consumption welfare and amenities, expressed as an equivalent proportional change in consumption. Movers count as residents of their destination once they arrive.

Within the Dust Bowl region, the agricultural contraction spilled over more strongly to local services than to tradable production. A 1% decline in agricultural revenue per farmland acre is associated with a 1.44% decline in nontradable output, proxied by retail and wholesale sales. The corresponding estimate for tradable non-agriculture, proxied by manufacturing output, is 0.54% and is not statistically distinguishable from zero. The model reproduces this ordering, though manufacturing is less affected in the model than in the data.

Deteriorating agricultural productivity makes tradable non-agriculture relatively more attractive in the Plains, but its employment share initially expands largely at the expense of local services. Falling incomes and the need to maintain food consumption therefore slow the region's transition toward services. National employment patterns change much less in the long run as workers

[3] I denote counties in the Great Plains as the Dust Bowl region and all other regions in the contiguous U.S. as the non-Dust Bowl region. Figure 1 maps the counties in the Great Plains with levels of erosion and drought.

and production relocate across regions. Food demand also slows the exit from farming: under homothetic demand, where food spending falls in proportion to income, the 1940 decline in the Dust Bowl region's agricultural employment share would more than triple.

Outside the Plains, producers benefit from reduced competition, particularly in the South, and real income rises on average. Yet standard real-income measures do not capture the full welfare cost of higher food prices. Accounting for these costs leaves almost all regions worse off, with the largest losses in the Northeast and Mountain West. Under homothetic demand, by contrast, the national welfare loss falls by roughly half, and the 1.18% loss outside the Plains nearly disappears, suggesting that higher food costs account for most of the model's welfare loss outside the Plains.

In the Dust Bowl region, migration adjustment provided modest relief, whereas trade adjustment amplified the welfare loss. Migration allowed residents to move toward less-affected locations, while changes in trade shares shifted demand away from Plains producers.[4] To understand the latter effect, consider an experiment in which customers continue to devote the same spending shares to Plains outputs as they would without the Dust Bowl. These fixed purchasing shares support regional sales and provide implicit income insurance. Allowing customers to shift toward less-affected suppliers removes part of that support.

This paper contributes to the literature on spillover effects (Bustos et al., 2016; Allcott and Keniston, 2018; Burstein et al., 2020; Colmer, 2021; Zappalà, 2023) and structural change (Matsuyama, 1992; Bustos et al., 2016; Fan et al., 2023; see Gollin and Kaboski (2023) for a review). The Dust Bowl illustrates how a negative agricultural shock can propagate beyond the affected region while also pushing workers out of agriculture within the damaged region, where subsistence food demand slows the shift toward services and limits structural change.

This paper also adds to our understanding of the American Dust Bowl and its impact on economic outcomes and internal migration in the 20th century (Hansen and Libecap, 2004; Cutler et al., 2007; Hornbeck, 2012, 2023; Arthi, 2018; Long and Siu, 2018; Sichko, 2024; Liu, 2026; Moscona, 2024). Here, I document how the disaster impacted the economy and people's lives in regions and industries that were not directly affected.[5] To my knowledge, this is one of the first

[4]Following Rudik et al. (2022), the trade experiment holds allocation shares at their no-Dust Bowl paths, although trade volumes can still change. The estimated magnitude of trade amplification is conditional on trade shares inferred from market access rather than observed flows.

[5]In the context of the Dust Bowl, recent research examines the spillover effects through health and human capital

attempts to assess the consequences of the disaster for the entire United States using an estimated quantitative model. This allows me to uncover new findings about the general equilibrium effects of the Dust Bowl by building on recent developments in the spatial equilibrium literature.

Hence, this paper also contributes to the quantitative climate-change literature by providing historical evidence on how market adjustment redistributes environmental losses (Rudik et al., 2022; Cruz and Rossi-Hansberg, 2024; Nath, 2025; Bilal and Rossi-Hansberg, 2025; see Desmet and Rossi-Hansberg (2024) for a review). Untargeted spillover estimates support the model's prediction that agricultural losses hit local services harder than manufacturing. The model also shows that food demand can dampen labor reallocation, as emphasized by Nath (2025), and that food-supply shocks can have welfare effects larger than their consumption share alone would suggest. Trade and migration are complementary, as in Rudik et al. (2022), yet the results show that trade adjustment can exacerbate welfare losses within deeply integrated regions.

2 Historical Background

The Dust Bowl refers to the series of dust storms (wind erosion) and occasional stormwater runoff (water erosion) that affected the Great Plains region in the United States. The region suffered prolonged drought throughout the 1930s, peaking in 1934 and 1936. The drought and erosion affected large areas across the Great Plains, including adjacent sections of New Mexico to Montana and Texas to Minnesota (Worster, 1979). The prevalence of small farms in the 1930s limited individual owners' effective responses to the disaster and exacerbated the environmental damage (Hansen and Libecap, 2004). In many regions, more than 75% of the topsoil was lost by the end of the 1930s. Land degradation followed.

Aside from the short-term economic ramifications, severe long-term economic consequences ensued (Hornbeck, 2012). By 1940, counties that had experienced the most significant levels of erosion also experienced greater declines in agricultural land values. The per-acre value of farmland declined by 30% in high-erosion counties and by 17% in medium-erosion counties, relative to changes in low-erosion counties. During the Depression and through at least the 1950s, there was

(Cutler et al., 2007; Arthi, 2018), intergenerational occupational persistence (Liu, 2026), or directed technical change (Moscona, 2024).

a limited relative adjustment of farmland to move away from the activities that had become less productive. Instead, economic adjustments relied on the population decline in the affected regions (Hornbeck, 2012, 2023). The ensuing exodus was one of the largest migrations in American history. Between 1930 and 1940, approximately 3.5 million people moved out of the Plains states. About 116,000 families arrived in California in the 1930s (Worster, 1979; Gregory, 1991). Long and Siu (2018) show that by the end of the Dust Bowl, the migrants were generally better off than those who chose to stay behind. Though some farmers had to work as unskilled laborers when they moved, a decision to leave the farming sector commonly led to greater social mobility.

Although states outside of the Great Plains were not directly affected by this particular disaster, they would still have been indirectly affected by economic downturns and the mass migration that took place. This paper examines how such spillover effects affected the outside region.

3 Theoretical Framework

The quantitative framework builds on canonical dynamic spatial general equilibrium models of trade and migration (Eaton and Kortum, 2002; Artuc et al., 2010; Caliendo et al., 2019), extended to include environmental response functions (Rudik et al., 2022; Cruz and Rossi-Hansberg, 2024) and structural change (Boppart, 2014; Fan et al., 2023). Environmental response functions capture the Dust Bowl's impacts on productivity and amenities. The non-homothetic preferences allow structural change on the demand side, and industry switching represents structural change on the supply side.

Environment. Time is discrete and indexed by t. The regional units of analysis are counties and states in the contiguous United States, indexed by n and i. Industries consist of agriculture (indexed by A), tradable non-agriculture (indexed by M), and nontradable non-agriculture (indexed by S). Tradable non-agriculture consists of manufacturing and (tradable) production services, and it can be regarded as a goods-producing sector. By contrast, nontradable non-agriculture can be viewed as consumer services that are locally provided. This distinction is aimed at quantifying potentially different spillover effects due to tradability. Individuals are both workers and consumers in the model. I add non-employment as a separate category; individuals can be employed in one industry or non-employed. Throughout this paper, subscripts denote regions and time, and superscripts indicate industries.

Geographic fundamentals $\{\bar{B}_{n,t}, Z^k_{n,t}, \tau^k_{ni,t}, \delta^{ks}_{ni}\}$ consist of the exogenous component of amenities and productivity, $\bar{B}_{n,t}$ and $Z^k_{n,t}$, and bilateral costs for trade and migration. Trade flows are subject to iceberg-type trade costs between exporter i and importer n, $\tau^k_{ni,t}$, and migration flows are shaped by the migration costs from origin labor market n-k to destination i-s, δ^{ks}_{ni}.

The equilibrium prices and allocations $\{w^k_{n,t}, r_{n,t}, b_{n,t}, L^k_{n,t}, V^k_{n,t}\}$ consist of location-industry-specific wages, $w^k_{n,t}$, agricultural land rent, $r_{n,t}$, the value of home production for non-employed individuals, $b_{n,t}$, the adult male population in each labor market, $L^k_{n,t}$, and discounted lifetime utilities of living in region n and working in industry k, $V^k_{n,t}$.

3.1 Workers

Utility. Forward-looking individuals decide in which region n to live and in which industry k to work in the next period by maximizing their welfare. Welfare is defined as the discounted sum of the infinite path of flow utility. The flow utility in each period is defined over indirect consumption utility and amenities via the log-utility function:

$$U(C^k_{n,t}, B_{n,t}) = \log\left(C(e^k_{n,t}, P_{n,t}) \times B_{n,t}\right). \tag{1}$$

Workers inelastically supply their labor and earn wages at competitive market rates. Non-employed individuals receive the value of home production, which is assumed not to be affected by the Dust Bowl. Agricultural workers also receive redistributed land rents. Individuals spend all their income on consumption in each period.

Following Boppart (2014) and Fan et al. (2023), individuals' consumption preferences are in the non-homothetic Price-Independent Generalized Linear (PIGL) class. Non-homotheticity captures an important feature of food consumption: as income falls, consumers reduce food consumption less than proportionally because food is a necessity. Hence, expenditure does not shift easily away from food even when agricultural productivity declines. This can limit sectoral reallocation and transmit welfare losses through higher food prices.[6] The Dust Bowl provides a historical setting in

[6]This channel is also emphasized by Nath (2025) in the context of climate change. Both the non-homothetic CES specification used by Nath (2025), following Comin et al. (2021), and the PIGL family here (Boppart, 2014) capture this mechanism. I use PIGL because of its convenient aggregation and estimation properties.

which I can compare these sectoral spillovers with observed outcomes and quantify the role of food demand. The indirect utility of consumption for an individual with expenditure e facing the local price index P_n takes the form:

$$C(e,P_n) = \frac{1}{\varepsilon}\left(\frac{e}{(P_n^A)^{\phi^A}(P_n^M)^{\phi^M}(P_n^S)^{\phi^S}}\right)^{\varepsilon} - \sum_{s\in\{A,M,S\}} \nu^s \log P_n^s, \tag{2}$$

over sectoral value-added CES aggregates of varieties from all regions.

As the local price index, I use $P_n \equiv (P_n^A)^{\phi^A}(P_n^M)^{\phi^M}(P_n^S)^{\phi^S}$ with $\sum_{s\in\{A,M,S\}} \phi^s = 1$. If $\nu^s = 0$ for all sectors and $\varepsilon = 1$, the consumption utility reduces to a Cobb-Douglas utility with consumption share ϕ^s allocated to each sector s. The income elasticity parameter, $\varepsilon \in (0,1)$, is interpreted as the Engel elasticity. The larger the Engel elasticity, the stronger the effect of real income on consumer demand. As incomes grow to infinity, the consumption share allocated to each good converges to $\phi^s \in (0,1)$ as a consumption asymptote. The parameters ν^s govern expenditure shares' deviations from their asymptotes: $\nu^s > 0$ denotes a necessity (agriculture), whose share declines toward ϕ^s as income rises, and $\nu^s < 0$ a luxury. They are unrestricted in sign but sum to zero, so expenditure shares sum to one at every income level. Note that price enters the consumption utility through both real income and non-homothetic price adjustment terms. Only the former is reflected in the homothetic model.

By applying Roy's identity to the indirect utility function, the consumption share allocated to sector s is:

$$\varphi^s(e,P_n) = \phi^s + \nu^s\left(\frac{e}{P_n}\right)^{-\varepsilon}. \tag{3}$$

An individual's consumption shares depend on the price index in the region and her income. Given the parameter restriction ($\varepsilon > 0$), the consumption share allocated to a necessity declines as individuals' real income rises. The region-industry level equivalent of equation (3) takes the same form under the assumption that individuals in each region-industry cell have the same earnings.

Local amenity, $B_{n,t}$, depends on an exogenous local fixed factor $\bar{B}_{n,t}$ and an environmental response function $g(\cdot)$:

$$B_{n,t} = \bar{B}_{n,t} \exp\Big(g(D_{n,t}, E_{n,t}; \boldsymbol{\beta}_B)\Big), \tag{4}$$

where the environmental amenities depend on the levels of drought $D_{n,t}$ and erosion $E_{n,t}$. For instance, a region with higher levels of drought could face limited availability of water for daily use. Soil erosion is associated with deteriorating living conditions that stem from adverse health effects, such as dust pneumonia, strep throat, and eye infections. The environmental response function is approximated by an exponential function of the drought index and the county's shares in the high- and medium-erosion classes (Section 4.2). The set of parameters $\boldsymbol{\beta}_B$ governs how the value of living in region n at time t is affected by the level of drought and soil erosion. The term $\bar{B}_{n,t}$ allows for flexible, exogenous amenity offerings not explained by environmental factors. I assume that this term was not affected by the Dust Bowl.

Migration. Individuals make forward-looking decisions given the expected value of future utilities where the expectation is taken over both regions and industries:

$$v^k_{n,t} = U(C^k_{n,t}, B_{n,t}) + \max_{\{i,s\}} \Big\{\beta \mathbb{E}[v^s_{i,t+1}] - \delta^{ks}_{ni} + \eta u^s_{i,t}\Big\}, \tag{5}$$

where $v^k_{n,t}$ denotes the lifetime utility, conditional on current preference shocks, of an individual in region n and industry k at time t, and the idiosyncratic preference shocks, $u^s_{i,t}$, follow the Type I extreme value distribution. The parameter η scales the variance of the shock and $1/\eta$ is interpreted as the migration elasticity.

The solution to the individuals' dynamic problem yields the migration share, $\mu^{ks}_{ni,t}$, defined as the share of individuals in region n and industry k at time t who choose region i and industry s for the next period. This share is proportional to the cost- and elasticity-adjusted utility, compared to that of all other possible destinations:

$$\mu^{ks}_{ni,t} = \frac{\exp\Big(\big(\beta \mathbb{E}_t[V^s_{i,t+1}] - \delta^{ks}_{ni}\big)/\eta\Big)}{\sum_{l=1}^{N} \sum_{h=0}^{K} \exp\Big(\big(\beta \mathbb{E}_t[V^h_{l,t+1}] - \delta^{kh}_{nl}\big)/\eta\Big)}, \tag{6}$$

which, combined with the initial population, yields labor market distributions in the next period:

$$L^k_{n,t+1} = \sum_{i=1}^{N} \sum_{s=0}^{K} \mu^{sk}_{in,t} L^s_{i,t}. \tag{7}$$

Throughout the paper, the labor market denotes the region-industry pair, and the migration share includes both moves between regions and switches between sectors.

3.2 Production

Firms. A continuum of firms in each region n and industry k produces output under perfectly competitive conditions. Agriculture combines agricultural labor, $L^A_{n,t}$, and the fixed supply of agricultural land, T_n, using a Cobb-Douglas production function:

$$q^k_{n,t} = A^k_{n,t} (L^k_{n,t})^{\lambda^k} (A^T_{n,t} T_n)^{1-\lambda^k}, \tag{8}$$

with Hicks-neutral productivity $A^k_{n,t}$ and land-augmenting productivity $A^T_{n,t}$. The difference between the two is purely a matter of accounting and depends on the interpretation of the shock. Agricultural land rents are uniformly redistributed to local agricultural workers.

For non-agricultural sectors, labor is the only factor of production ($\lambda^k = 1$). Henceforth, λ only measures the labor share in agriculture. Such a one-factor model assumes that multiple factors of production are used in the same proportions in all sectors (Costinot and Rodriguez-Clare, 2014). An alternative assumption is that other variable factors of production, such as capital, perfectly adjust to labor between time periods, and factor payments are redistributed to workers. Given decadal intervals between time periods, I abstract from other factors of production as the main focus here is to quantify potentially different spillover effects due to tradability.

As in amenities, the productivity term consists of the exogenous component, $z^k_{n,t}$, and the environmental response function $f(\cdot)$:

$$A^k_{n,t} = z^k_{n,t} \exp\Big(f(D_{n,t}, E_{n,t}; \boldsymbol{\beta}^k_A) \Big). \tag{9}$$

The exogenous component $z^k_{n,t}$ follows the Fréchet distribution with the scale parameter $Z^k_{n,t}$ and the shape parameter θ^k. The time-varying base productivity, $Z^k_{n,t}$, captures the level of absolute advantages unrelated to environmental factors. The industry-specific parameter θ^k regulates the magnitudes of heterogeneity across regions' relative efficiencies. The environmental response function captures the impacts of drought and soil erosion on local productivity.

Trade and market clearing. The price of each industry k in importer n is determined as the minimum unit cost across all regions:

$$p^k_{n,t} = \min_{1 \leq i \leq N} \left\{ \frac{c^k_{i,t} \tau^k_{ni,t}}{A^k_{i,t}} \right\}, \tag{10}$$

where $c^A_{i,t} = (\tilde{w}^A_{i,t})^{\lambda} (r_{i,t})^{1-\lambda}$ for agriculture and $c^k_{i,t} = w^k_{i,t}$ for non-agriculture. I use the term $\tilde{w}^A_{i,t}$ to denote the agricultural wage when highlighting multiple factors in agriculture. However, I also use $w^A_{i,t}$ to denote the wage inclusive of redistributed rents as income per worker. The term inside equation (10) is the factory-gate price of one unit of goods multiplied by the trade costs.

With the distributional assumption on productivity, the bilateral expenditure share, defined as the share of market n's sectoral expenditure allocated to goods from region i, is given by:

$$\pi^k_{ni,t} = \frac{X^k_{ni,t}}{X^k_{n,t}} = \frac{\left(c^k_{i,t} \tau^k_{ni,t} / A^k_{i,t} \right)^{-\theta^k}}{\sum_{j=1}^{N} \left(c^k_{j,t} \tau^k_{nj,t} / A^k_{j,t} \right)^{-\theta^k}}, \tag{11}$$

where the denominator can be interpreted as inward market access of region n, capturing its proximity to exporters. It also represents the sectoral price index up to a constant. Finally, the region-industry-level price indices are aggregated by consumption share asymptotes to yield the regional price index.

Goods market clearing implies that regional total expenditure, X_n, equals regional total income, I_n, where income consists solely of labor payments in non-agriculture but includes land payments in agriculture. Market clearing conditions for the factor market are then given by $I^k_{i,t} = \sum_{n=1}^{N} \pi^k_{ni,t} X^k_{n,t}$.

4 Taking the Model to the Data

4.1 Data

I combine three sets of data to discipline the model. First, I use IPUMS Full Count census records, linked across census years by the IPUMS Multigenerational Longitudinal Panel (MLP) between 1910 and 1950 (Ruggles et al., 2024, 2025), to construct county-industry-level transition matrices across the contiguous United States. Second, I use the Census of Agriculture and the Historical, Demographic, Economic, and Social Data: The United States, 1790–2002 (Haines et al., 2010; ICPSR 2896), which contains county- and state-level descriptive data. I use this data for estimation and as the basis for the simulation. Finally, I utilize environmental data about drought severity (Cook et al., 2010; Sichko, 2024) and soil-erosion rates (SCS, 1935; Hornbeck, 2012). Drought intensity is defined as the sum of the drought severity index during the 1930s, and erosion intensity is constructed as a weighted share of land in the high- and medium-erosion classes. Further details on the data are described in Online Appendix Section A.

4.2 Estimation

I recover the environmental response functions for productivity and amenities. Productivity estimation replicates Hornbeck (2012) on agricultural revenue, extended to take into account spatial

Table 1: Structural Parameters.

Definition	Parameter	Comment
Panel A. Utility parameters		
Environmental response function	Table 3, Column 1	Estimation
Inverse migration elasticity	$\hat{\eta} = 0.220$	Simulated Method of Moments
Engel elasticity	$\varepsilon = 0.39$	Estimation (Table OA1)
Asymptotic consumption share	$\boldsymbol{\phi} = (0.01, 0.33, 0.66)$	Moment condition
Preference elasticity	$\boldsymbol{\nu} = (1.27, -0.27, -1.0)$	Moment condition
Discount factor	$\beta = 0.60$	Assumption
Panel B. Productivity parameters		
Environmental response function	Table 2, Column 4, Panels A–C	Estimation
Fréchet distribution	$\boldsymbol{\theta} = (12, 6.5, \infty)$	Nigai (2016)
Labor share in agriculture	$\lambda = 0.66$	Calibration (USDA)
Distance elasticity of trade	$\kappa = 1.30$	Estimation (Table OA2)

linkages across regions (Allen and Arkolakis, 2023). Amenity estimation capitalizes on the dyadic structure of migration flows across counties constructed from the IPUMS MLP-linked census records (Ruggles et al., 2024, 2025). The identification relies on the parallel-trends assumption: counties with different levels of erosion and drought would have followed the same trends in the absence of the Dust Bowl.

Parameters at a glance. Table 1 summarizes the parameters. Dust Bowl-era outcomes identify the productivity response (equation (12), Section 4.2.1), amenity response (equation (13), Section 4.2.2), and inverse migration elasticity η (within-model SMM, Section 4.2.2). Independent sources identify the remaining parameters: the 1935–36 consumer-purchases survey for the Engel elasticity ε; aggregate moment conditions for the other PIGL consumption parameters; Nigai (2016) for trade elasticities θ^k; the Commodity Flow Survey for distance elasticity κ; and an assumed 5% annual discount rate for β (Section 4.2.3).

4.2.1 Productivity Parameters

Productivity estimation replicates and extends Hornbeck (2012) by adding the 1930s drought measure, New Deal spending controls, and a spatial-linkage control. The estimates enter the model's environmental component of agricultural land productivity. I estimate the following equation (12) for agriculture as a reduced-form representation of the underlying agricultural land productivity.[7]

$$\log Y_{i,t} - \log Y_{i,1930} = \beta_{1,t} M_i + \beta_{2,t} H_i + \beta_{3,t} D_i + \beta_\Pi \log \Pi_{i,t} + \alpha_{s,t} + \gamma_t X_i + \varepsilon_{i,t}. \tag{12}$$

The outcome is log land-and-building value or agricultural revenue per farmland acre, measured as the change from 1930 in each agricultural-census year from 1940 to 1992. Exposures are fixed: M_i and H_i are the medium- and high-erosion land fractions in the 1934–35 Soil Conservation Service survey, relative to omitted low erosion; D_i is standardized cumulative 1930s drought severity (Sichko, 2024). Year-interacted coefficients $\beta_{1,t}$, $\beta_{2,t}$, and $\beta_{3,t}$ trace the short- and long-run effects of these cross-sectional exposures.[8] For the ranges reported in Table 2 (e.g., 1978–1992), the

[7] I assume that non-agricultural productivity was not directly affected by the Dust Bowl; Section 6.2.1 compares the implied non-agricultural responses with the data.

[8] Contemporaneous county population is excluded because it is an equilibrium response to the shock. Table OA10, Columns 2 and 6, add log county population as a robustness check; the 1940 high-erosion land-value coefficient changes only from -0.276 (Table 2, Column 2) to -0.269.

coefficients are constrained to be equal across the census years within the range.

Outward market access ($\Pi_{i,t}$) measures farmers' accessible demand as the distance-discounted purchasing power of all other counties (Online Appendix D.1). Even undamaged counties may face lower demand if trading partners are affected. I include outward market access to control for demand changes in trading partners when estimating erosion and drought effects (Allen and Arkolakis, 2023). I do not interpret its coefficient as a structural elasticity.[9]

The identifying assumption is that, absent the Dust Bowl, counties with different levels of erosion and drought would have changed similarly. State-by-year fixed effects and year-interacted county characteristics restrict the comparison to counties within the same state with similar pre-Dust Bowl conditions. Land-use controls are (1) acres of land in farms per county acre and (2) acres of cropland per acre in farms. Population and farm characteristics are (3) population per 100 county acres, (4) the fraction of the population in rural areas, (5) the fraction of the population on farms, (6) farms per 100 county acres, and (7) average farm size in acres. Agricultural-production controls are the cropland fractions in (8) corn, (9) wheat, (10) hay, (11) cotton, and (12) oats, barley, and rye, as well as (13) cattle, (14) swine, and (15) chickens per county acre. The specification includes available 1910, 1920, and 1925 values of these characteristics and the 1910–1930 values of the dependent variables, all interacted with year. Columns 2 and 4 additionally control for (16) per-capita 1933–1939 Agricultural Adjustment Act payments, (17) public-works wages, and (18) relief spending, each interacted with year (Fishback et al., 2003).

Columns 1 and 3 replicate Table 2 of Hornbeck (2012), while Columns 2 and 4 jointly add drought, outward market access, and New Deal controls. Column 4 reports the preferred damage estimates used in the quantitative analysis.[10] The erosion estimates remain similar: in 1940, the high-erosion coefficient changes from -0.300 to -0.276 for land value and from -0.267 to -0.236 for agricultural revenue. The land-value estimates confirm immediate and persistent losses with limited relative adjustment. In agricultural revenue, the high-erosion effect remains negative through

[9]Because outward market access is also endogenous, Table OA10, Columns 3, 4, 7, and 8, instrument it with hypothetical market access (Allen and Arkolakis, 2023), constructed from other counties' predetermined 1930 crop values or population and Jaworski–Kitchens decade-varying travel times (Online Appendix A.4).

[10]Let $d_{i,t} = \beta_{1,t}M_i + \beta_{2,t}H_i + \beta_{3,t}D_i$ denote the fitted environmental component in log revenue per farmland acre. In the production function in Section 3.2, I assign this component to the effective-land term: $(1-\lambda)\Delta \log A^T_{i,t} = d_{i,t}$, or $\widehat{A}^T_{i,t} = \exp\{d_{i,t}/(1-\lambda)\}$. With $\lambda = 0.66$, the conversion uses the land share of 0.34. This is a maintained mapping from reduced-form revenue responses to land quality, rather than an identity that follows from fixed acreage alone.

Table 2: Estimation Results for Productivity.

	Log land value		Log agricultural revenue	
	(1)	(2)	(3)	(4)
	Replication	Extension	Replication	Extension
Panel A. High erosion vs. low erosion				
1940	-0.300***	-0.276***	-0.267***	-0.236***
	(0.038)	(0.039)	(0.055)	(0.053)
1945	-0.223***	-0.208***	-0.107**	-0.102**
	(0.036)	(0.037)	(0.038)	(0.039)
1950-1954	-0.289***	-0.257***	-0.240***	-0.215***
	(0.041)	(0.041)	(0.049)	(0.048)
1959-1969	-0.340***	-0.300***	-0.257***	-0.236***
	(0.044)	(0.043)	(0.058)	(0.059)
1978-1992	-0.286***	-0.235***	-0.297***	-0.306***
	(0.049)	(0.049)	(0.080)	(0.080)
Panel B. Medium erosion vs. low erosion				
1940	-0.166***	-0.167***	-0.155***	-0.155***
	(0.030)	(0.033)	(0.040)	(0.041)
1945	-0.080**	-0.082**	-0.100***	-0.099**
	(0.027)	(0.029)	(0.030)	(0.031)
1950-1954	-0.144***	-0.135***	-0.187***	-0.176***
	(0.032)	(0.032)	(0.037)	(0.037)
1959-1969	-0.183***	-0.175***	-0.118**	-0.111**
	(0.036)	(0.035)	(0.042)	(0.041)
1978-1992	-0.110**	-0.099*	-0.034	-0.034
	(0.041)	(0.040)	(0.060)	(0.059)
Panel C. Drought				
1940		-0.093***		-0.153***
		(0.022)		(0.032)
1945		-0.053*		-0.003
		(0.021)		(0.022)
1950-1954		-0.050**		-0.026
		(0.019)		(0.026)
1959-1969		-0.080***		-0.020
		(0.022)		(0.030)
1978-1992		-0.096***		0.106*
		(0.022)		(0.045)
Panel D. Spatial linkages				
Outward access		0.356**		0.042
		(0.115)		(0.141)
R-squared	0.972	0.975	0.921	0.923
Observations	8,569	8,536	8,569	8,536
Clusters (counties)	779	776	779	776

Note: The table reports changes from 1930 in log agricultural land-and-building value and log agricultural revenue, both per farmland acre. Columns 1 and 3 replicate Hornbeck (2012), Table 2, Columns 1 and 2, using 779 Plains counties; Columns 2 and 4 estimate equation (12) with drought, outward market access, and New Deal controls, using 776 counties. All columns include state-by-year fixed effects and year interactions with the 1930 values of farmland per county acre; cropland per farmland acre; population per 100 county acres; rural and farm population shares; farms per 100 county acres; average farm size; cropland shares in corn, wheat, hay, cotton, and oats, barley, and rye; and cattle, swine, and chickens per county acre. They also include available 1910, 1920, and 1925 values of a subset of these characteristics and the 1910–1930 log land-and-building value and agricultural revenue per farmland acre. Columns 2 and 4 additionally interact year with per-capita 1933–1939 Agricultural Adjustment Act payments, public-works wages, and relief (Fishback et al., 2003). Regressions are weighted by 1930 farmland acres. County-clustered standard errors are in parentheses. * Significant at the 5% level. ** Significant at the 1% level. *** Significant at the 0.1% level.

1978–1992, whereas the medium-erosion effect becomes small and insignificant in the final period. The drought coefficient is sharply negative in 1940, near zero from 1945 through 1969, and positive in 1978–1992, indicating that its initial negative association did not persist.

The coefficients here capture changes in more-eroded counties relative to less-eroded comparison counties, rather than the total effects of the Dust Bowl. Trade and migration may also affect the comparison counties: effects common across erosion groups are differenced out, while differential spillovers may attenuate or amplify the estimated damage. The reduced-form estimates therefore do not directly measure total welfare losses. Quantifying those losses and separating the underlying channels requires the model and its no-shock counterfactual. I report sensitivity to the size of the estimated damage in Section 6.3, and Section 6.2.3 provides separate reduced-form checks on potential spillovers.

4.2.2 Amenity Parameters

Amenities are not observed directly, so I infer their response to environmental conditions from migration choices. The estimating equation is the Euler condition implied by the migration problem (Artuc et al., 2010), derived in Online Appendix B.1:

$$\begin{aligned}
&\log\left(\frac{\mu^{ks}_{ni,t}}{\mu^{kk}_{nn,t}}\right) - \beta\log\left(\frac{\mu^{ks}_{ni,t+1}}{\mu^{ss}_{ii,t+1}}\right) - \frac{\beta}{\eta}\log\left(\frac{w^{s}_{i,t+1}}{w^{k}_{n,t+1}}\right) \\
&= \frac{\beta}{\eta}\left[g\Big(D_{i,t+1}-D_{n,t+1}, E_{i,t+1}-E_{n,t+1}; \boldsymbol{\beta}_B\Big)\right] \\
&\quad + \underbrace{\frac{\beta}{\eta}\log\left(\frac{\bar{B}_{i,t+1}}{\bar{B}_{n,t+1}}\right)}_{=\alpha_i+\alpha_n+\alpha_t} + \underbrace{\frac{\beta-1}{\eta}\delta^{ks}_{ni}}_{=\gamma\,\mathrm{dist}_{ni}+\alpha_n+\alpha_i} + u^{ks}_{ni,t}.
\end{aligned} \tag{13}$$

The left-hand side is the log odds of moving from origin n-k to destination i-s, relative to staying, net of the discounted forward migration odds and wage difference. The forward migration term captures the destination's continuation value and the wage term its pecuniary component; the residual therefore reflects amenity differences and migration costs. The right-hand side relates this residual to destination-minus-origin differences in high- and medium-erosion shares and drought, as in the productivity equation.

I estimate the equation in a single OLS step using county-to-county flows of men aged 18–

Table 3: Amenity Estimation Results.

	(1) Both-county FE	(2) Both-county FE, industry flows	(3) County-state FE	(4) State FE
High erosion (dest − origin)	-0.171***	-0.163***	-0.144**	-0.061
	(0.043)	(0.048)	(0.045)	(0.047)
Medium erosion (dest − origin)	-0.086**	-0.089*	-0.064	-0.006
	(0.032)	(0.043)	(0.038)	(0.037)
Drought (dest − origin)	-0.003	0.001	-0.011	-0.028
	(0.013)	(0.015)	(0.014)	(0.019)
Forward migration share	0.599***	0.688***	0.569***	0.627***
	(0.009)	(0.010)	(0.021)	(0.021)
Forward wage (OccScore)	0.620***	-0.753***	0.931***	0.514***
	(0.111)	(0.011)	(0.067)	(0.052)
Log distance	-0.455***	-0.252***	-0.438***	-0.344***
	(0.011)	(0.010)	(0.024)	(0.024)
Implied η	0.966	-0.913	0.611	1.219
(s.e.)	0.172	0.020	0.059	0.150
R-squared	0.808	0.808	0.775	0.677
Observations	301,162	611,844	301,167	301,169
Clusters (origin/destination counties)	2,918/2,916	2,921/2,921	2,918/2,921	2,920/2,921

Note: The table estimates equation (13) using county-to-county flows of men aged 18–65, pooled over 1910–20, 1920–30, and 1930–40. Data are from IPUMS Full Count records linked by the MLP (Ruggles et al., 2024, 2025). Columns 1, 3, and 4 use flows aggregated over industries; Column 2 uses flows disaggregated by industry, between county-industry cells (agriculture; mining, construction, and manufacturing; and services). Except for distance, all independent variables are destination-minus-origin differences. All columns include year fixed effects. Columns 1 and 2 also include origin- and destination-county fixed effects; Column 3 includes origin-county and destination-state fixed effects; and Column 4 includes origin- and destination-state fixed effects. Robust standard errors are two-way clustered at the origin- and destination-county levels and reported in parentheses. The implied η is the ratio of the forward-migration-share coefficient to the forward-wage coefficient. The baseline simulation uses the SMM estimate $\hat{\eta} = 0.220$ (Table 1). * Significant at the 5% level. ** Significant at the 1% level. *** Significant at the 0.1% level.

65 from the IPUMS MLP-linked full-count census records, pooled over 1910–20, 1920–30, and 1930–40. For transparency, the future migration term and the forward-wage term are moved to the right-hand side.[11] Wages are occupational income scores based on a fixed national income vector because comparable local wages are unavailable for the pre-1940 cohorts. Origin-county, destination-county, and year fixed effects and log distance are assumed to absorb residual amenities, migration costs, and common shocks.

Table 3, Column 1 is the preferred specification, with origin- and destination-county fixed effects and standard errors clustered two-way by origin and destination county. The high- and medium-erosion coefficients are -0.171 and -0.086 relative to low erosion, while the drought

[11] The coefficients on the two forward terms are unrestricted, and their ratio yields a reduced-form inverse migration elasticity η.

coefficient is small and insignificant (-0.003). Column 2 estimates the same specification on flows disaggregated by industry, that is, moves between county-industry cells rather than between counties. The erosion coefficients are similar (-0.163 and -0.089). While the pattern becomes weaker with coarser fixed effects (Columns 3 and 4), the results still point to a negative effect of erosion on the value of living in areas affected by the Dust Bowl.

Interpreting the erosion coefficients as amenity responses requires residual changes in local purchasing power and other time-varying shocks to be unrelated to erosion and drought, after conditioning on the controls. The fixed effects and wage proxy cannot fully absorb such changes, so the preferred estimates discipline the amenity response conditional on this rather strong assumption.[12]

The linked migration flows used for estimation inform the amenity response in 1940 but do not establish its duration. Estimating a 1950 response with the same Euler equation would require linked 1950–60 county-to-county flows, which are not publicly available. I therefore adopt the more conservative baseline in which the dust-related disamenity applies in 1940 and reverses in 1950, rather than assuming a permanent decline. A robustness check in Section 6.3 assesses the quantitative implications of making the erosion-related amenity response permanent.

The above regression yields a reduced-form inverse migration elasticity of $\hat{\eta} = 0.966$, with estimates ranging from 0.61 to 1.22 across fixed-effects structures. Because occupational income scores omit local wage and price variation, I instead estimate the baseline η within the model by simulated method of moments (SMM) for the counterfactual analysis. Holding the other parameters fixed, I choose η to match Hornbeck (2012)'s 1940 high- and medium-erosion population coefficients (-11.6% and -8.8%), using simulated population responses across 875 Dust Bowl counties. The equally weighted fit yields $\hat{\eta} = 0.220$, with fitted moments of -13.4% and -6.6%. The reduced-form value, rounded to 1.00, serves as a robustness check. Online Appendix B.2 reports the SMM estimation process.

[12] Origin- and destination-county fixed effects absorb persistent local wage and price differences, and year fixed effects absorb common shocks, but they do not absorb county-specific changes over time. Occupational income scores exclude amenity-driven local wage variation but omit within-occupation local wage changes and local prices, including the non-homothetic price terms in equation (2). The baseline also assumes no productivity or amenity externalities from population, while Online Appendix C.1 examines these externalities.

4.2.3 Elasticities

Table 1 summarizes the parameters used in the simulation, while details on estimation procedures are described in Online Appendix B. Section 6.3 discusses robustness in terms of parameter values. The reduced-form estimate in Section 4.2.2 ($\hat{\eta} = 0.966$) implies a more responsive migration margin over 10 years than the corresponding annual parameter of 1.88 (Artuc et al., 2010) and quarterly parameter of 5.34 (Caliendo et al., 2019), because a smaller η implies a stronger migration response. The benchmarks also cover different periods: migration responded strongly to local conditions during the Depression (Boustan et al., 2010) and has since declined (Dao et al., 2017).

Next, the Engel elasticity measures how much the expenditure share on food changes when expenditure changes. The estimates using the Study of Consumer Purchases in the United States, 1935–1936, range between 0.34 and 0.45 (Table OA1). I use 0.39, the rounded estimate from the specification that instruments household expenditure with occupation categories. I also document quantification results using 0.34 and 0.45, the bounds used in the sensitivity analysis. I set the discount factor β for the decennial interval to be 0.60, assuming an annual discount rate of 5%. The value is also consistent with the estimated coefficient on the forward migration share, which corresponds to β in equation (13): 0.599 in Table 3, Column 1.

Six parameters governing asymptotic consumption shares and PIGL preference elasticities, ($\{\phi^A, \phi^M, \phi^S, \nu^A, \nu^M, \nu^S\}$), are jointly estimated by two moment conditions for 1940 and 1990, with two normalizations ($\phi^A = 0.01$ and $\nu^S = -1.0$) and two restrictions ($\sum \phi^s = 1$ and $\sum \nu^s = 0$). The time periods correspond to the start and end of the study period, while I pick 1940 to use information on real income in the 1940 population census.

I first normalize the value of $\nu^S = -1.0$ and set the asymptotic consumption share on agriculture equal to the value-added share of U.S. agriculture in 2022, $\phi^A = 0.01$. Jointly matching two moments for aggregate market-clearing conditions for 1940 and 1990 yields $\phi^S = 0.66$ and $\nu^A = 1.27$. The homogeneity restrictions leave the values of two remaining parameters as $\phi^M = 0.33$ and $\nu^M = -0.27$ for tradable non-agriculture.

Note that tradable non-agriculture includes manufacturing and (tradable) production services. Preference elasticities confirm that agriculture is a necessity and the two non-agricultural sectors are luxuries; nontradable non-agriculture has the highest income elasticity. Within non-agriculture, the tradable sector is closer to unit income elasticity.[13] Overall, the values of PIGL parameters are closely aligned with estimates in Fan et al. (2023).[14] Trade flows are governed by the productivity dispersion parameter, θ^k. An obstacle to estimation is that detailed data on inter-regional trade flows do not exist for this period. Nonetheless, the trade literature has extensively documented the values of trade elasticity. Specifically, I use $\theta^A = 12$ for agriculture and $\theta^M = 6.5$ for tradable non-agriculture following Nigai (2016).[15] The nontradable sector is set to $\theta^S = \infty$.

The labor share in agriculture is calculated as the long-run average share of factor payments accruing to labor, using USDA Farm Income and Wealth Statistics. I use the estimate of the distance elasticity of trade,[16] $\kappa = 1.3$, from the 2012 and 2017 Commodity Flow Surveys (Table OA2), which aligns with the value in Allen and Donaldson (2022). An alternative estimate based on U.S. internal railroad commodity trade in 1949 (the earliest available internal trade data), $\kappa = 1.03$ (Klein and Crafts, 2012), is close to this value.

5 Calculating Counterfactuals

Counterfactual experiments quantify the impacts of the Dust Bowl on population, economic activity, and welfare. I first simulate the model with fully calibrated parameters to obtain the baseline economy without removing the impacts of the Dust Bowl. In other words, I run the baseline model with the Dust Bowl. Then, I obtain a counterfactual economy stripped of any environmental shocks to simulate a counterfactual history that would have occurred had the Dust Bowl not occurred. The comparison between the two economies reveals how the Dust Bowl affected the magnitudes and distributions of economic activity and welfare across the United States. I use the dynamic hat algebra approach to calculate counterfactuals (Caliendo et al., 2019).

Before performing the counterfactual analysis, I first construct bilateral trade flows between all

[13]The consumption spending elasticity is not a deep parameter of the model and its exact value depends on the PIGL parameters and consumption shares in each labor market. Specifically, it is given as $1 - \varepsilon(\varphi^s - \phi^s)/\varphi^s$. It equals income elasticity as individuals live hand-to-mouth.

[14]In the context of India, between 1987 and 2011, Fan et al. (2023) estimate $\{\varepsilon, \phi^A, \phi^M, \phi^S, \nu^A, \nu^M, \nu^S\}$ to be $\{0.395, 0.01, 0.298, 0.692, 1.276, -0.276, -1.0\}$, where $\phi^A = 0.01$ and $\nu^S = -1.0$ are normalized, as in this paper.

[15]A lower value of θ^k translates to larger heterogeneity in productivity across regions, and hence, to the greater importance of the productivity difference in trade.

[16]In the initial equilibrium of the counterfactual analysis, κ governs trade costs and is applied to the decennial (1920–1990) panel of county-pair routed distances from the Jaworski–Kitchens highway network, allowing trade costs to evolve with the transportation network.

regional pairs in the contiguous United States using the market access term approach (Donaldson and Hornbeck, 2016; Allen and Donaldson, 2022). I use the constructed initial equilibrium and migration shares from the linked full-count census records as initial conditions for the simulation.

5.1 Dynamic Hat Algebra

The dynamic hat algebra approach calculates the impacts of the Dust Bowl (Caliendo et al., 2019). Related details are further explained in Online Appendix Section D.2. Here, I explain the measure of welfare. Welfare effects for region r are calculated using the following resident-based consumption-equivalent measure:

$$\hat{W}_{r,t} = (1-\beta)\sum_{s=t}^{\infty}\beta^{s-t}\sum_{n\in r}\sum_{k}\omega_{n,s}^{k}\log\left(\hat{C}_{n,s}^{k}\cdot\hat{B}_{n,s}\right), \tag{14}$$

where $\omega_{n,s}^{k}$ is the share of region r's residents in labor market n-k at date s in the Dust Bowl economy. Equation (14) discounts changes in consumption utility and amenities, weighting each resident equally and assigning them to their current region. Consumption utility includes real income and the non-homothetic price adjustments in equation (2). The measure is expressed as an equivalent permanent proportional change in consumption. The environmental response function reported in Table 3, Column 1 directly determines the changes in amenities.

5.2 Counterfactual Environment

The baseline economy takes the historical changes between 1910 and 1930 as given. For the economy after 1940, I iterate the changes in the indirect utility and solve for equilibrium changes in economic allocations while holding non-environmental productivity fundamentals fixed. Agricultural land damage is permanent, whereas the direct environmental amenity shock is temporary, applying in 1940 and reversing in 1950. Subsequent migration and welfare can nevertheless respond to the permanent land damage and earlier reallocation.

The no-Dust Bowl counterfactual holds the policy environment fixed. Thus, the comparison is conditional on policies such as New Deal spending during the 1930s and does not estimate how policy would have responded in the absence of the Dust Bowl. Differences between the baseline and counterfactual economies measure the model-implied effects of the disaster. Effects outside the Dust Bowl region and in non-agricultural sectors arise solely through indirect general-equilibrium responses to shocks originating in the directly affected region and its agricultural sector. Section 6.3 relaxes the fixed-productivity assumption by allowing annual productivity growth of 1–2%.

The geographic units for simulation are 875 counties in the Great Plains located throughout twelve states (Texas, New Mexico, Oklahoma, Kansas, Colorado, Nebraska, Montana, Wyoming, North Dakota, South Dakota, Minnesota, and Iowa) and 44 aggregate non-Dust Bowl regions, including the 36 remaining contiguous states plus the non-Plains remainders of eight sample states. The terms Great Plains and the Dust Bowl region are used interchangeably. The Dust Bowl region matches the sample counties analyzed in Hornbeck (2012). Counties are based on 1990 boundaries (Eckert et al., 2020). Agents' expectations are a key determinant of migration decisions. I assume that individuals learn the entire future counterfactual paths of productivity and amenities between 1930 and 1940. Unless otherwise noted, the effects of the Dust Bowl refer to 1940 outcomes.

6 Quantitative Results

6.1 The Dust Bowl and its Impact on the Great Plains

This section first demonstrates the relationship between the observed changes in environmental variables and model-simulated outcomes. It discusses how simulation results are linked to the literature and assesses the validity of the quantification exercise.

Figure 1 shows an overview of the changes in environmental fundamentals and outcome variables in the Great Plains. Panels A and B present the geographical distributions of erosion and drought. Red represents more severe erosion and drought, relative to yellow. Panel C plots the changes in log land values between 1930 and 1940, with red representing larger declines in land value. Visually comparing the changes in environmental factors and land values shows that higher levels of erosion and drought are associated with larger declines in land values. Hornbeck (2012) documents immediate, substantial, and persistent decreases in agricultural land values in more-eroded counties relative to less-eroded counties. Panel D adds simulation-generated welfare effects in 1940. Red means larger declines in welfare. Simulated welfare losses are larger in counties with more severe erosion and drought. Furthermore, the similarity between log land value changes (Panel C) and welfare effects suggests that the losses to agricultural production contributed to patterns in Panel D. This paper examines the determinants of Panel D in detail and how these losses spilled over into other regions not shown in the figure.

Targeted and non-targeted evidence. The quantitative model embodies the Dust Bowl as the changes in agricultural land productivity and location amenities, while changes in other outcomes are generated as a response to the shock. Hence, I compare the simulation-generated outcomes with empirical patterns in history to examine the validity of the quantification exercise. First, I use empirical results in Hornbeck (2012) as a benchmark.

Figure 2, Panel A shows a regional population gap that widens from 2.03% in 1940 to 2.43% in 1990. The permanent gap in Panel B accords qualitatively with Hornbeck (2012)'s persistent relative population declines.[17] Post-1950 annual productivity growth of all regions of 2% (1%) reduces the 1990 gap to 0.83% (1.58%), even without land recovery. Still, regardless of the scenario,

[17] Empirical losses are 11.6% (high erosion) and 8.8% (medium) in 1940, rising to 22.7% and 22.3% in 1990. Simulated losses are 13.4% and 6.6% in 1940, falling to 6.4% and 2.7% in 1990. The model targets the initial gradient but does not reproduce its long-run deepening, suggesting that additional mechanisms could have contributed to the long-run decline.

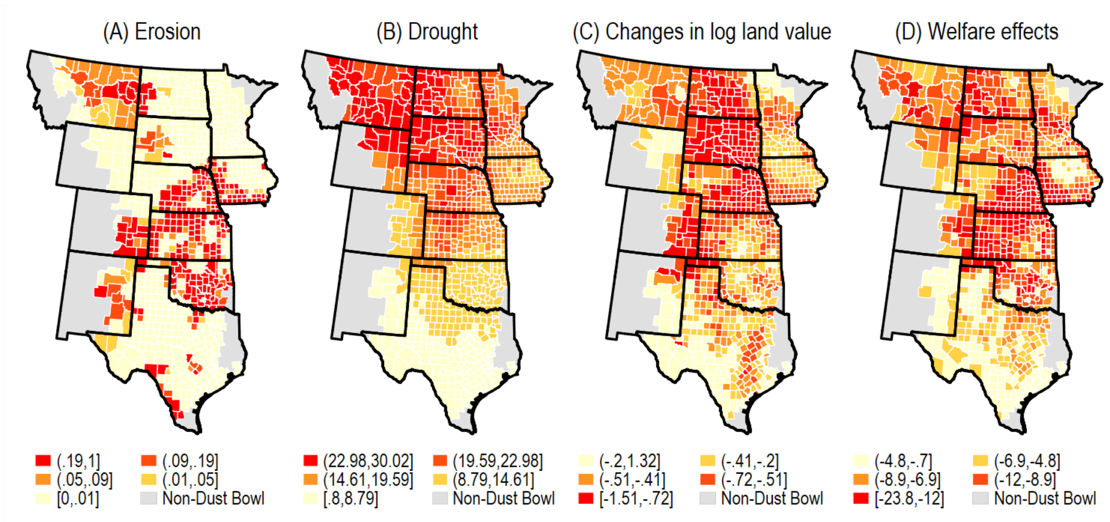

Figure 1: Map of Environmental and Outcome Variables.

Note: The figure shows the geographic distributions of environmental and outcome variables in the Great Plains. Panels A and B plot the maps of erosion and drought that occurred during the 1930s. Panel C shows the actual changes in log land value between 1930 and 1940. Panel D shows welfare effects in 1940, calculated by equation (14). In all panels, red represents more severe erosion and drought, or larger declines in log land value and welfare, relative to yellow. Data are from Haines et al. (2010), Cook et al. (2010), and Hornbeck (2012).

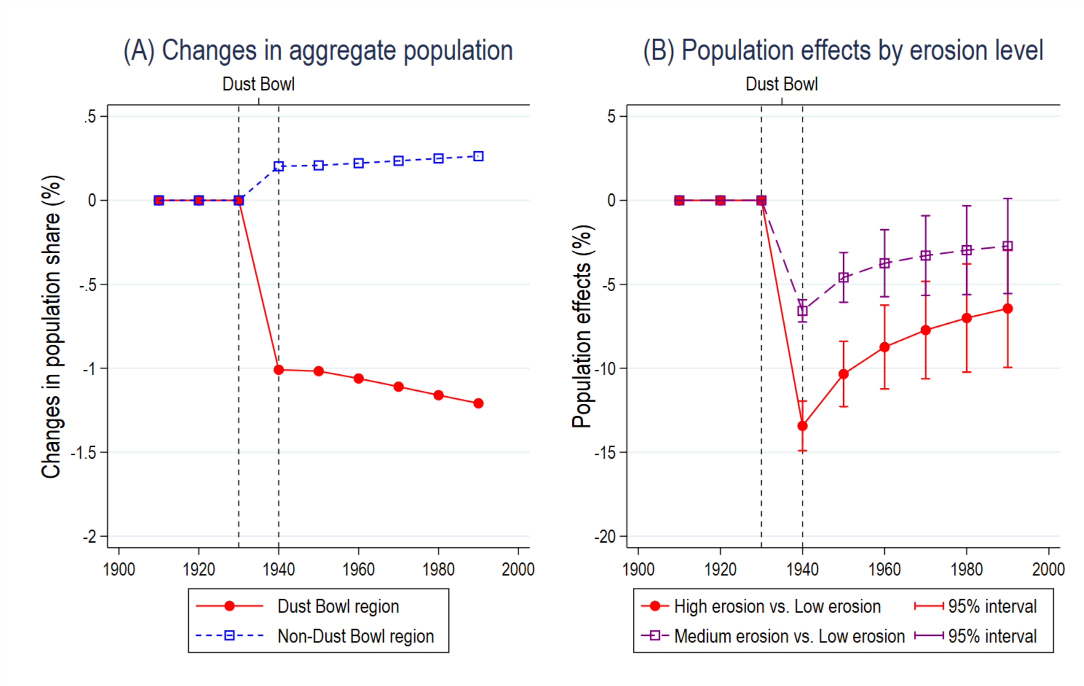

Figure 2: Changes in Simulated Population, 1910–1990.

Note: The figure shows the time trends in aggregate (Panel A) and relative population by erosion level (Panel B), using simulation-generated population. Panel B compares outcomes in more-eroded counties with less-eroded counties in the same state. In Panel B, the regression is weighted by 1930 county population. Robust standard errors are clustered at the state level, and the 95% confidence intervals are plotted. Both panels report model outcomes, but they measure distinct objects and vertical scales differ tenfold. Online Appendix Figure OA1 compares Panel B with the corresponding empirical estimates of Hornbeck (2012) on a common axis.

the gap persists as long as fundamentals do not recover.

Tables OA4 and OA5 provide a broad comparison between the empirical and simulated non-agricultural outcomes, although the available measures do not align one-for-one. In more-eroded counties, lower retail sales and the rise in the 1940 unemployment rate among high-erosion counties accord with the simulated decline in nontradable activity and increase in non-employment. The manufacturing evidence is more mixed across margins. Manufacturing establishments decline, while manufacturing employment per capita is roughly unchanged in 1940 and becomes modestly positive in later decades. Thus, the employment margin is the one most consistent with the model's predicted reallocation toward tradable non-agriculture. The next subsections probe the underlying economic forces that drove these results.

6.2 Transmission of the Shock

6.2.1 Output and Employment Effects

In the Dust Bowl region, non-agricultural sectors were indirectly affected by the local demand shock and employment reallocation from agriculture. As a first-order effect, the Dust Bowl reduced simulated agricultural production in the directly affected region by 13.4% in 1940. Agricultural employment in the region decreased by 2.6%, while the U.S. aggregate agricultural employment was essentially unchanged (+0.2%) as production relocated to unaffected regions. These changes generated two distinct second-order effects in terms of output and employment.

Figure 3 displays scatter plots of changes in non-agricultural output and employment in 1940 with corresponding changes in agriculture. Panels 1A and 1B indicate sizable output spillover effects within the affected counties. The shock was especially strongly transmitted to the nontradable sector, demonstrated by a stronger association with agricultural output changes. On the other hand, tradable non-agriculture was able to mitigate the shock since producers selling to other regions can still capitalize on demand elsewhere.

Such a disparity between the two industries is consistent with evidence on the importance of tradability in shaping local responses to natural resource booms (Allcott and Keniston, 2018) and immigration (Burstein et al., 2020). The responses to the Dust Bowl similarly highlight the importance of trade as an adjustment channel for local production. The cushioning of tradable output, however, does not imply that trade adjustment necessarily insures local welfare: trade shares shifted away from the region, amplifying welfare losses in the Dust Bowl (Section 6.2.4).

Panels 2A and 2B report employment effects in 1940. Within the Dust Bowl region, employment in tradable non-agriculture modestly increased by 2.7% on average despite the local agricultural collapse. Such changes can be rationalized by the Ricardian model of trade. Agricultural productivity fell in the Dust Bowl region while the productivity in tradable non-agriculture had not been directly affected. As a result, the comparative advantage of tradable non-agriculture relatively increased, and the labor allocation followed the altered regional comparative advantage. Nontradable employment falls by 3.5%, compared with 2.6% in agriculture. Some displaced workers switch industries or migrate, while others leave employment. The non-employment share rises by 0.13%p.

Figure A1 plots the empirical relationships corresponding to Figure 3. Manufacturing proxies for

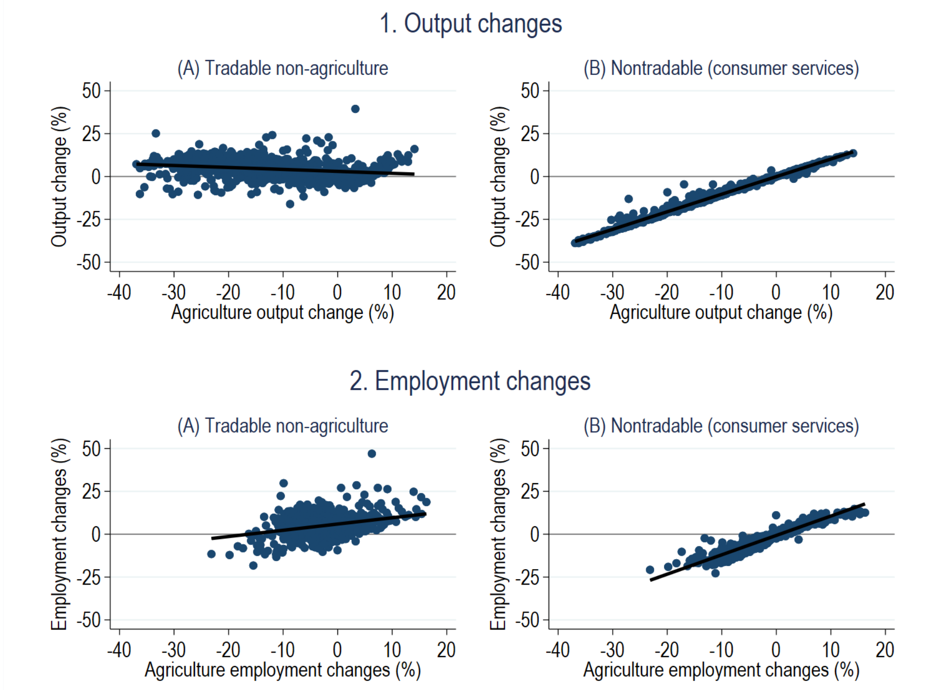

Figure 3: Simulated Output and Employment Effects in the Dust Bowl Region, 1940.

Note: The figure shows scatter plots of output and employment changes in non-agriculture with agricultural output and employment changes in 1940. The x-axis in all panels represents the effects for agriculture. The y-axis of each panel displays the effects for either tradable non-agriculture or nontradable.

tradable non-agriculture, while retail and wholesale proxy for local nontradables. In employment, the contrast between the two non-agricultural sectors is even starker: manufacturing employment tended to increase overall in the Dust Bowl region, while the negative agricultural shock was strongly transmitted to nontradable employment, highlighting the role of trade.

Table 4 quantifies how agricultural losses were associated with output changes in the two non-agricultural sectors, providing a check on the model's transmission mechanism. The regressions relate county-level changes in manufacturing output or retail and wholesale sales to changes in agricultural revenue per farmland acre, the outcome of Table 2, over 1930–1940. Alongside OLS, the IV specifications use high- and medium-erosion land shares to isolate variation in agricultural revenue associated with erosion.

Both OLS and IV estimates show that retail and wholesale sales are more strongly linked to agricultural revenue than manufacturing activity. The IV point estimates imply that a one-percent decline in agricultural revenue is associated with a 1.44% decline in retail and wholesale sales,

Table 4: Shock Transfer Elasticities.

	Manufacturing (tradable) log output		Retail and wholesale (nontradable) log output	
	(1) OLS	(2) 2SLS	(3) OLS	(4) 2SLS
Shock transfer elasticity	0.242**	0.535	0.391***	1.442***
	(0.089)	(0.567)	(0.068)	(0.404)
First stage (dependent variable: Δ log agricultural revenue per farmland acre)				
High-erosion share		-0.225**		-0.225**
		(0.070)		(0.070)
Medium-erosion share		-0.141*		-0.141*
		(0.055)		(0.055)
Kleibergen–Paap F		5.730		5.730
R-squared	0.168		0.553	
Observations	434	434	434	434
Simulated (model)	-0.126		1.027	
	(0.017)		(0.004)	

Note: The table reports estimates relating 1930–1940 changes in log non-agricultural output (Haines et al., 2010) to changes in log agricultural revenue per farmland acre, the outcome of Table 2, among Dust Bowl counties. The sample includes the 434 Dust Bowl counties with both non-agricultural outcomes observed in 1930 and 1940. All columns include state fixed effects and the pre-1930 characteristics listed in Table 2. Columns 1 and 3 use OLS; Columns 2 and 4 use high- and medium-erosion land shares as instruments. Robust standard errors are clustered at the county level, as in Table 2, and reported in parentheses. First-stage coefficients and the Kleibergen–Paap F statistic are shown. Simulated slopes in the last row are model comparisons and carry no significance stars. * Significant at the 5% level. ** Significant at the 1% level. *** Significant at the 0.1% level.

compared with 0.54% in manufacturing, whose estimate is imprecise.[18] The model reproduces this untargeted sectoral contrast: simulated nontradable output declines nearly one-for-one with agricultural revenue,[19] whereas tradable non-agricultural output is largely insulated. As a potential limitation, the model predicts a slightly negative tradable slope, whereas the empirical estimate is positive, though imprecise. This discrepancy suggests that the model may overstate the extent to which access to outside markets insulates tradable production from local agricultural shocks.

6.2.2 Structural Change

Local agricultural productivity growth in an open economy could slow structural change out of agriculture (Matsuyama, 1992; Bustos et al., 2016). Conversely, the Dust Bowl might have facilitated structural change by hampering agricultural productivity. Figure 4 shows simulated

[18]The first stage is not strong (Kleibergen–Paap $F = 5.7$), and erosion can affect local demand through amenities and migration as well as agricultural revenue. I therefore emphasize the sectoral pattern over the exact estimates.

[19]Re-solving the model with homothetic demand (Section 6.2.2) lowers the simulated nontradable slope from 1.03 to 0.88, while the ordering of the two sectors is unchanged. The consumption-share adjustment under subsistence food demand thus makes the simulated transmission to nontradables about 16% larger than under homothetic demand.

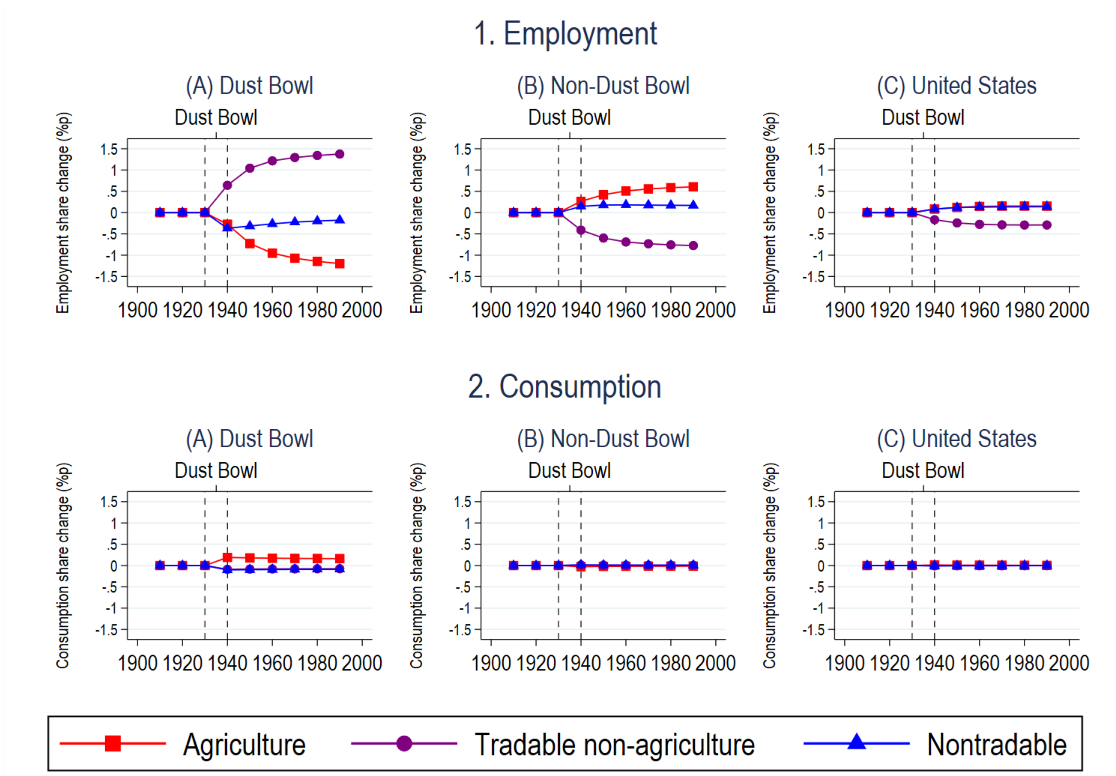

Figure 4: Simulated Changes in Employment and Consumption Shares by Region, 1910–1990.

Note: The figure shows the time trends in employment and consumption shares by region and decennial intervals between 1910 and 1990. Effect sizes are changes in percentage points (%p) in each region.

trends in structural change in terms of employment and consumption shares by region and year. Trade enables observed disparities in employment and consumption.

Panel 1A shows that the employment reallocation, as described in the previous subsection, continued until 1990. In 1940, the employment share in tradable non-agriculture is 0.6%p higher, while the agricultural share is 0.3%p lower. By 1990, these gaps widen to 1.4%p and 1.2%p. This finding that a negative local agricultural productivity shock encouraged the development of the local tradable sector is consistent with the reverse case of improvements in land-augmenting technology (Bustos et al., 2016).[20]

The responses in the outside region display the opposite pattern in both dimensions, albeit with smaller magnitudes (Panels 1B and 2B). The non-Dust Bowl region picked up the slack in agriculture at the expense of tradable non-agricultural employment.

[20] Bustos et al. (2016) examine and contrast the role of labor-saving (soybean) and land-augmenting productivity development (maize), where the improvements in land-augmenting technology reduced industry employment.

However, although the Dust Bowl induced structural change out of agriculture, the magnitude was relatively small, and the tradable sector initially expanded mainly at the expense of local nontradables. Hence, although the Dust Bowl would have mildly boosted structural change out of agriculture, the disaster eventually slowed the structural change within non-agriculture. Empirical patterns confirm this mechanism. While more-eroded counties experienced small gains in terms of manufacturing workers per capita (Table OA4, Column 3), retail sales per capita were depressed at least until 1990 (Column 5). Rather, the relative adjustments primarily relied on the spatial reallocation of population (Column 1).

Food demand helps explain the limited reallocation of agricultural labor. As real income falls and food prices rise, consumers shift spending toward food, sustaining agricultural demand in the Plains. Holding non-preference parameters fixed, replacing PIGL with homothetic demand with fixed consumption share increases the Dust Bowl-induced decline in the region's agricultural employment share from 0.3%p to 0.9%p in 1940 and from 1.2%p to 2.2%p in 1990, with correspondingly larger gains in agricultural employment outside the region. In 1940, under homothetic demand, the tradable non-agriculture share rises by 1.2%p, while the nontradable share falls by only 0.2%p. Under PIGL, by contrast, the nontradable share falls by more than the agricultural share (Figure 4, Panel 1A; 0.4%p vs. 0.3%p).

Aggregate regional agricultural employment provides a separate check on the two specifications. Between 1930 and 1940, agricultural employment fell 3.8% more in the Dust Bowl region than outside it. The corresponding 1940 model comparison is 3.8% under PIGL and 6.7% under homothetic demand. The smaller agricultural reallocation under PIGL is consistent with the competing forces emphasized by Nath (2025): food needs sustain agricultural demand, while trade allows production to shift toward less-affected suppliers.

Panels 1C and 2C document the response at the national level. In terms of employment, the effect on the agricultural share remained small through 1990. This muted national response contrasts with the diverging employment patterns in the two regions. It implies that the country as a whole adjusted through reallocation across regions rather than within. The national-level adjustments took a long time as spatial reallocation is subject to heavy friction.

6.2.3 Welfare Effects

The Dust Bowl reduced aggregate U.S. welfare by 2.60%. The welfare impact was sizable even at the national level, especially considering that the Dust Bowl region constituted less than 15% of the U.S. population during the 1930s. Consumption welfare contributes 2.15%p of the decline and amenities 0.45%p (Table 5, Panel A); the 1940 real-income flow falls by 0.16% (Column 4). The Dust Bowl region accounted for the lion's share of the welfare decrease, experiencing a decrease of 9.66%. However, the outside region also experienced a non-negligible 1.18% reduction in welfare. This section examines the determinants of welfare spillovers.

Figure 5 presents histograms of regional-level welfare effects by industry. In 1940, residents' flow-utility losses were largest in agriculture (14.7%), followed by nontradable non-agriculture (13.4%) and tradable non-agriculture (10.2%). As expected from the output and employment changes (Figure 3), the impact is relatively smaller for the tradable sector. However, the nontradable nature and higher income elasticity of the nontradable sector forced it to absorb most of the local

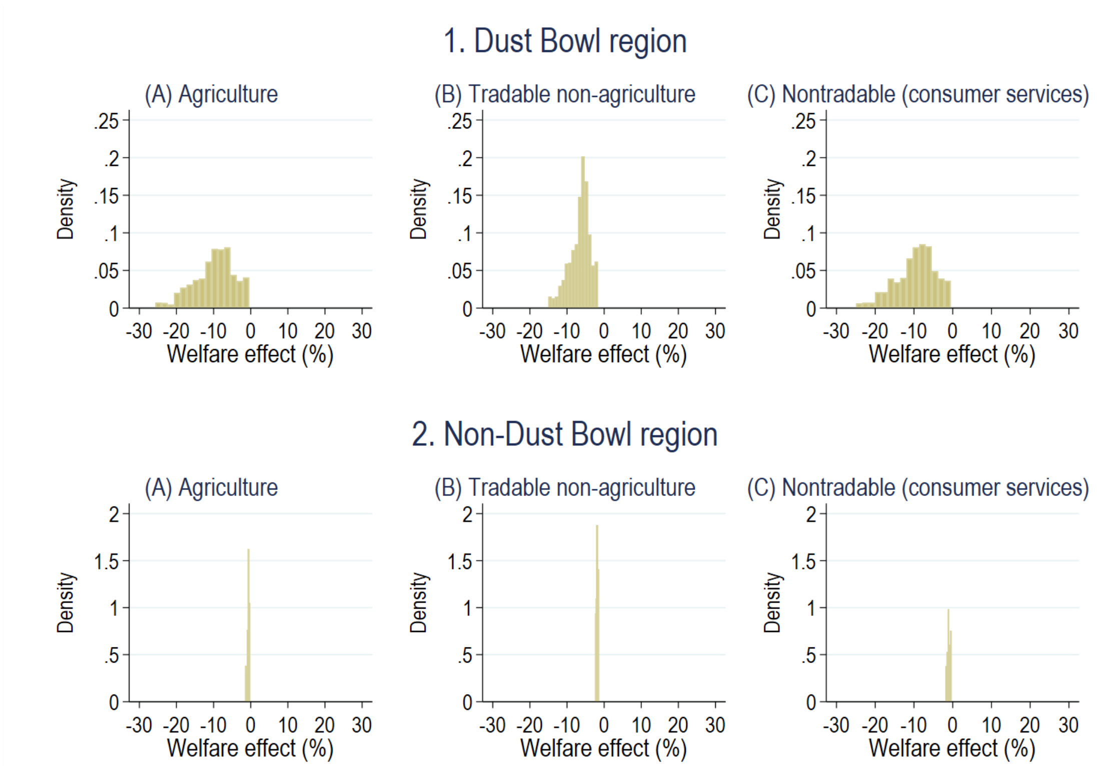

Figure 5: Simulated Welfare Effects by Region and Industry, 1940.

Note: The figure plots the distribution of per-capita flow-utility effects of the Dust Bowl in 1940, by region-industry.

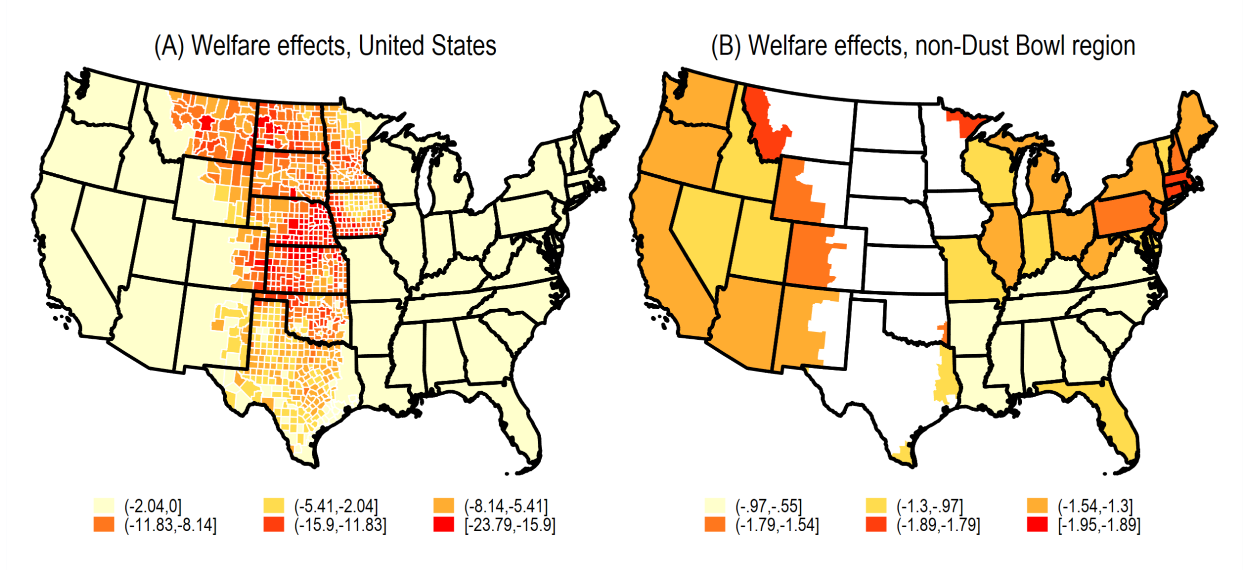

Figure 6: Map of Simulated Welfare Effects, 1940.

Note: The figure maps the per-capita welfare effects of the Dust Bowl, evaluated by equation (14), by counties and states. Panel A shows welfare effects simultaneously for the entire geographical unit, while Panel B drops the Dust Bowl region for visibility. Red represents higher welfare loss relative to yellow.

shocks.

However, the impact of the Dust Bowl did not end in the Great Plains. Figure 5, Panels 2A to 2C show flow-utility losses among workers outside the Dust Bowl. The region's discounted resident welfare loss is 1.18% on average (Table 5, Panel A, Row 3, Column 1). Here, a comparison between consumption welfare and real income reveals contrasting forces at play. First, the non-Dust Bowl region gained real income from the shock (Column 4). This outside region benefited from the deterioration of its competitors in agriculture, filling the gap left by the disaster. Nonetheless, the overall increases in food prices overshadowed the rises in real income, leading to an overall negative impact in terms of consumption utility.[21]

Figure 6 further maps the geographical distribution of welfare effects. Panel A simultaneously shows welfare effects at the same scale for the contiguous United States, while Panel B only plots welfare effects for the states outside the Dust Bowl region. Red indicates greater welfare losses than yellow; each panel has its own scale.

Panel B shows that the Northeast and Mountain West experienced the largest negative spillover

[21]The sign and size of the price-adjustment term depend on the preference elasticities in Table 1 and the consumption utility in equation (2); at the estimated values, increases in the price of subsistence goods are especially costly.

effects, operating through the consumption channel. Two factors contributed to the geographical distribution of the spillovers: distance and initial industry composition. First, regions closer to the affected counties tended to have stronger trade linkages and were therefore more exposed to the resulting price increases. Second, regions that relied more heavily on agricultural imports were more adversely affected by the negative agricultural shock in the Great Plains.

The South, however, was a major producer of agricultural goods and was therefore less exposed to the downturn in the Plains. Figure OA2 shows that initial industry composition helps explain the distribution of consumption welfare effects: exposure depended on whether a state imported agricultural goods from, or competed with, directly affected producers. The response of local nontradables then depended on whether its tradable sector specialized in agriculture or non-agricultural goods.

Migration response. In the simulation, the migrants were more likely to move to closer locations and the Pacific states, the major migration destination around the Dust Bowl era. Table OA6 replicates Hornbeck (2023), Table 1, and shows that simulated flows reproduce the direction, destinations, and erosion gradient of historical migration: out-migration increases with origin erosion, while in-migration decreases with destination erosion (Online Appendix C.2). Figure OA3 maps the state-level population effects for the years 1940 and 1990, relative to the initial 1930 population. For instance, California gained Dust Bowl migrants equivalent to 1.6% of its 1930 population by 1940, with the gain growing to 1.7% by 1990. Notably, the Northeastern states that were most negatively affected by the spillover effects through trade also lost population.

Role of agglomeration externalities. Population shifts induced by the shock may themselves affect productivity and amenities at both origins and destinations. A larger local market can improve matching, facilitate knowledge spillovers, and support local facilities, while pressure on limited land can generate congestion. These forces feed the effects of migration back into local welfare and may either reinforce or dampen the initial response. Because population is an equilibrium outcome, inferring these elasticities from correlations between population and local outcomes is difficult. I therefore assume no agglomeration in the baseline rather than estimating the associated elasticities directly. Online Appendix C.1 instead examines a grid of productivity and amenity feedbacks.

Figure OA4 reports the same welfare measure as Table 5 across alternative values of the productivity and amenity feedback parameters. In 1940, the welfare loss of Dust Bowl-region residents remains between 8.66% and 9.96%, relative to a baseline of 9.66%. Direct environmental damage therefore dominates the potential role of agglomeration forces in the short run. Effects outside the region are more sensitive to these parameters and widen over time. By 1990, they range from a 6.57% loss under productivity congestion to a 0.33% gain under modest agglomeration. Congestion at migrant destinations weakens the insurance provided by migration and spreads the losses, whereas agglomeration helps receiving regions absorb the inflow. Across the parameter grid, population feedback could determine the long-run distribution of welfare outside the Plains, while its role in the 1940 welfare loss within the directly affected region remains limited.

Reduced-form evidence on spillovers. Motivated by evidence in Zappalà (2023) that weather shocks propagate through economic linkages across sectors and countries, I examine spillovers to less-eroded Plains counties as a reduced-form check on the general-equilibrium channels. Table OA8 shows that counties closer to the Dust Bowl experienced larger declines in land values: the three nearest quintiles lost 14–15% relative to the farthest quintile (Column 2).

Table OA9 then examines whether counties facing larger Dust Bowl-induced declines in market access experienced different outcomes. Larger losses in outward market access are associated with higher agricultural revenue (Column 4), consistent with a terms-of-trade spillover benefiting producers in less-eroded counties. These results show that interactions among general-equilibrium channels may attenuate or amplify the reduced-form estimates. Hence, the model complements this evidence by tracing the interaction of these general-equilibrium channels and quantifying their combined welfare effects.

6.2.4 The Value of Trade and Migration Adjustment

Migration and trade are central adaptation margins because they allow workers and goods to move away from damaged places (Rudik et al., 2022; Cruz and Rossi-Hansberg, 2024; Desmet and Rossi-Hansberg, 2024; Nath, 2025). Table 5 examines how migration and trade change the incidence of the Dust Bowl shock. Following Rudik et al. (2022), I re-solve the economy holding bilateral migration shares, trade shares, or both at their no-Dust Bowl paths. Fixing these shares preserves the allocation of workers across destinations or spending shares across suppliers without closing either market. Note that total flows can still change with population and expenditure.

Migration provides insurance by allowing residents to move toward less-affected labor markets. Comparing Panels A and B shows that migration-share changes themselves lower the loss of Dust

Table 5: Welfare Effects - Counterfactual Scenarios and Robustness.

	(1) Welfare effects	(2) Consumption welfare	(3) Amenities	(4) Real income
Panel A. Baseline				
Total	-2.600	-2.150	-0.449	-0.159
Dust Bowl region	-9.664	-6.943	-2.721	-2.777
Non-Dust Bowl region	-1.180	-1.180	0.000	0.359
Panel B. Fixed migration shares				
Total	-2.748	-2.280	-0.468	-0.154
Dust Bowl region	-10.788	-8.012	-2.777	-2.411
Non-Dust Bowl region	-1.089	-1.089	0.000	0.304
Panel C. Fixed trade shares				
Total	-1.764	-1.281	-0.482	-0.015
Dust Bowl region	-5.037	-2.239	-2.799	-0.242
Non-Dust Bowl region	-1.069	-1.069	0.000	0.032
Panel D. Fixed trade and migration shares				
Total	-1.771	-1.303	-0.468	-0.019
Dust Bowl region	-4.484	-1.707	-2.777	-0.025
Non-Dust Bowl region	-1.219	-1.219	0.000	-0.018
Panel E. Cobb-Douglas demand (homothetic demand)				
Total	-1.350	-0.903	-0.446	-0.813
Dust Bowl region	-8.249	-5.524	-2.725	-5.607
Non-Dust Bowl region	0.019	0.019	0.000	0.126
Panel F. Migration elasticity ($\eta = 1$)				
Total	-2.648	-2.198	-0.450	-0.138
Dust Bowl region	-10.196	-7.477	-2.720	-2.451
Non-Dust Bowl region	-1.126	-1.126	0.000	0.320
Panel G. Productivity growth (2%/yr)				
Total	-2.483	-2.035	-0.447	-0.159
Dust Bowl region	-9.275	-6.553	-2.722	-2.774
Non-Dust Bowl region	-1.131	-1.131	0.000	0.356
Panel H. Permanent erosion amenity shock				
Total	-3.317	-2.190	-1.126	-0.161
Dust Bowl region	-13.216	-6.526	-6.690	-2.736
Non-Dust Bowl region	-1.314	-1.314	0.000	0.348

Note: The table reports the per-capita welfare effects in 1940 by region and subcomponent. The welfare effects in Column 1 are the sum of Columns 2 and 3. Welfare effects are evaluated using equation (14) and reported in percentage terms. For comparison, the changes in real income in 1940 are reported in Column 4.

Bowl-region residents by 1.12%p relative to the case with migration shares fixed, about one-tenth of the loss that residents would otherwise bear. Nationally, migration lowers the loss by 0.15%p, while it raises the loss outside the Plains by 0.09%p. Migration insurance is useful here since the shock creates a large spatial difference in earning opportunities.

Trade has a different distributional effect.[22] Allowing trade shares to adjust raises the loss

[22]The magnitude is conditional on bilateral trade shares inferred from routed-distance market access rather than observed flows.

of Dust Bowl-region residents by 4.63%p relative to the hypothetical case where trade shares are fixed (Panel A vs. Panel C). Fixed purchasing shares keep customers' spending allocated to Plains suppliers and support the damaged region's production. When sourcing adjusts, customers substitute toward less-affected suppliers, protecting outside consumers from some price increases but removing part of the demand supporting Plains income. As a result, trade adjustment raises the national loss by 0.84%p in the baseline (Panel A vs. Panel C) and by 0.98%p when migration is also fixed (Panel B vs. Panel D). The loss outside the Plains changes by about 0.1%p because consumer gains from substitution are offset by weaker demand from the Plains.

6.3 Robustness

The remaining panels of Table 5 examine homothetic demand (Panel E), the reduced-form migration elasticity (Panel F), post-1950 productivity growth (Panel G), and permanent erosion-related amenity damage (Panel H). Table OA7 reports additional robustness checks on shock construction, structural parameters, and model elements.

In Panel E, replacing PIGL with homothetic demand roughly halves the national welfare loss and essentially eliminates the 1.18% outside-region loss. Holding non-preference parameters fixed, this comparison shows that the transmission of welfare costs beyond the damaged region depends strongly on the demand specification.

In Panel F, replacing the SMM baseline $\hat{\eta} = 0.22$ with the rounded reduced-form estimate $\eta = 1.00$ changes the national welfare loss from 2.60% to 2.65%, the Dust Bowl-region loss from 9.66% to 10.20%, and the outside-region loss from 1.18% to 1.13%. The welfare effects change little. However, real allocations are substantially more sensitive: the magnitude of the regional population response falls roughly fourfold, from 2.03% to 0.48% in 1940 and from 2.43% to 0.66% in 1990, and the real-wage effect changes from −0.43% to +0.09%. Because η materially affects real allocations, I use the SMM estimate that matches the actual 1940 population responses as the baseline.

In Panel G, post-1950 annual productivity growth of 2% modestly reduces 1940 welfare losses to 2.48% nationally and 9.28% regionally, from 2.60% and 9.66%. Growth narrows the long-run population gap (Section 6.1), but permanent land damage still drives much of the 1940 welfare loss.

In Panel H, I examine the implications of specifying direct amenity damage as permanent, leaving the other parameters unchanged. The national welfare loss rises from 2.60% to 3.32%, and the Dust Bowl-region loss from 9.66% to 13.22%. Within the Dust Bowl region, the additional loss comes from the direct amenity component (+3.97%p), while the consumption-welfare loss becomes slightly smaller. The welfare loss outside the region remains similar (1.18% to 1.31%), suggesting that indirect spillover does not depend on permanent direct amenities.

Online Appendix Table OA7, Panel C, shows that halving (doubling) the estimated log land shock changes the U.S. welfare loss to 1.50% (4.94%) and the Dust Bowl-region loss to 6.24% (16.31%). The shock estimates compare more- and less-eroded counties within the same state and with similar pre-1930 characteristics. They may therefore be biased if the comparison counties follow different trends. For example, spillovers that raise agricultural revenue in less-eroded counties would overstate the estimated damage, whereas spillovers that depress revenue in those counties would understate it. Overestimating the damage would in turn overstate welfare losses, and underestimating it would understate them, although the magnitude of the response in each region depends on the model structure. Still, the estimated shocks and resulting baseline welfare effects could serve as a benchmark.

Online Appendix C.3 also reports additional counterfactual exercises motivated by the historical context of the Dust Bowl. Appendix C.4 reports robustness to the PIGL consumption parameters, trade elasticity, and spatial aggregation. Changes in spatial aggregation and the trade elasticity leave the welfare results largely unchanged, while the consumption-related parameters lead to somewhat larger changes. The main conclusions about welfare spillovers nevertheless remain robust across this broader set of exercises.

7 Conclusion

In this paper, I draw three lessons from the American Dust Bowl by focusing on spillover effects and the role played by adjustment channels. First, the Dust Bowl imposed substantial damage on the entire United States, not just on the directly affected Plains region. Although the Dust Bowl received considerable attention as a cautionary tale of a local disaster, its national repercussions, beyond the large migration to the West, may still have been obscured by the Great Depression. In his description of the Dust Bowl, Worster (1979) writes: “The thirties began in economic depression and in drought. The first of those disasters usually gets all the attention, ..." and "That the thirties were a time of great crisis in American, ... The Dust Bowl, I believe, was part of that same crisis."

Second, consumption adjustments can have substantial local and aggregate effects, especially when a shock affects subsistence goods, whose welfare importance exceeds their consumption share. This is the food problem emphasized by Nath (2025) in climate-change adaptation. Locally, consumption adjustments generate more than proportional spillovers when a sector with a high expenditure elasticity cannot draw on outside demand. This increase in subsistence food demand can also lower agricultural labor reallocation out of the affected region.

Finally, market adjustment need not insure a damaged region. In the deeply integrated Plains, trade shares shifted away, removing implicit income insurance and amplifying welfare losses. Migration provided modest relief at a decadal frequency. The Dust Bowl's large, permanent, and geographically concentrated shock permits historical evaluation of spatial general-equilibrium models using observed patterns of production, migration, and reallocation. The findings in this paper broadly support the use of spatial general-equilibrium models to evaluate the effects of future environmental shocks.

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Appendix

Figure A1: Empirical Changes in Output and Employment in the Dust Bowl Region.

Note: The figure plots empirical changes in county-level industrial activity between 1930 and 1940 in the Dust Bowl region. Data are from Haines et al. (2010). In all panels, the x-axis plots the changes in log agricultural outcomes. The y-axes in Panels 1A and 2A show the changes in log manufacturing outcomes as proxies for tradable non-agriculture. Y-axes in Panels 1B and 2B represent the changes in the log of retail and wholesale outcomes as proxies for nontradable non-agriculture.