Online Appendices (Not for Publication)

A Data Appendix

A.1 Complete-Count Census

I use the complete-count Census data (Ruggles et al., 2021) as my primary dataset. The census data contains individual-level microdata, including the place of residence, occupation, and labor market status. Individuals from both years are matched using ABE standard matching (Abramitzky et al., 2022). The method matches the individuals based on exact or standardized names, birth year, and place of birth. The sample is limited to the male population as women are hard to match between Census because they often change surname at marriage (Abramitzky et al., 2022).

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

Historical, Demographic, Economic, and Social Data: The United States, 1790-2002 (HDES; Haines et al. 2010) 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.

A.3 Environmental Variables

I use soil erosion rates and drought intensity as environmental variables. The cumulative erosion damages at the county level were first measured by specialists during the 1930s (SCS 1935) and digitized by Hornbeck (2012). The cumulative damages proxy for differential erosion occurred 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 high-erosion and medium-erosion rates.

Data measuring yearly drought intensity are from the *U.S. National Atmospheric and Oceanic Administration: The Living Blended Drought Atlas* (LBDA; Cook et al., 2010). The LBDA estimates yearly drought conditions for the past 2000 years based on instrument records of heat, rain, wind, soil, runoff, and evaporation for a grid of 11 thousand points across North America. It computes drought severity relative to conditions measured during the calibration period of 1928 to 1978. I use the drought severity during the 1930s matched to the county border (Sichko, 2020).

A.4 Additional Data Sources

To construct trade costs for simulation, I utilize a panel of county-pair routed distance during the decennial interval between 1920 and 1990 (Jaworski et al., 2023). I use the geographic crosswalk of Eckert et al. (2020) to match the spatial unit of analysis for different data sources into the 1990 county boundaries.

B Estimation Appendix

B.1 Amenity Estimating Equation

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

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

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

By taking expectation of the preference shock, the expected lifetime utility consists of instantaneous utility, the base value of staying, and option value of moving 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 and $\bar{u}_{ni,t}^{ks} \equiv u_{n,t}^{k} - u_{i,t}^{s}$. 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:

$$\begin{aligned}\eta \bar{u}^{ks}_{ni,t} + \delta^{ks}_{ni} &= \beta E_t \left(v^s_{i,t+1} - v^k_{n,t+1} \right) \\ &= \beta E_t \Big[U(C^s_{i,t+1}, B_{i,t+1}) - U(C^k_{n,t+1}, B_{n,t+1}) \\ &\qquad + \eta \bar{u}^{ks}_{ni,t+1} + \delta^{ks}_{ni} + \Omega(\bar{u}^s_{i,t+1}) - \Omega(\bar{u}^k_{n,t+1}) \Big].\end{aligned} \tag{A3}$$

In equilibrium, the difference in idiosyncratic shocks between origin *n*-*k* and destination *i*-*s*, subject to migration costs, equals the difference between the 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 labor markets as the $\Omega(\cdot)$ term (Artuc et al., 2010). The key intuition is that the migration flows are a sufficient statistic of the option value of moving.

By converting the Euler equation, I obtain the following moment condition:

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

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

$$\begin{aligned}&\ln \left(\frac{\mu^{ks}_{ni,t}}{\mu^{kk}_{nn,t}} \right) - \beta \ln \left(\frac{\mu^{ks}_{ni,t+1}}{\mu^{ss}_{ii,t+1}} \right) - \frac{\beta}{\eta} \ln \left(\frac{w^s_{i,t+1}}{w^k_{n,t+1}} \right) \\ &= \frac{\beta}{\eta} \left[g\left(D_{i,t+1} - D_{n,t+1}, E_{i,t+1} - E_{n,t+1}; \boldsymbol{\beta}_B \right) \right] + \frac{\beta}{\eta} \left[\rho_B (\ln L_{i,t+1} - \ln L_{n,t+1}) \right] \\ &\quad + \underbrace{\frac{\beta}{\eta} \ln \left(\frac{\bar{B}_{i,t+1}}{\bar{B}_{n,t+1}} \right)}_{=\alpha_{i,t} + \alpha_{n,t}} + \underbrace{\frac{\beta - 1}{\eta} \delta^{ks}_{ni}}_{=\gamma dist_{ni} + \alpha^k_{state(n)} + \alpha^s_{state(i)} + \alpha_{i,t} + \alpha_{n,t}} + u^{ks}_{ni,t},\end{aligned} \tag{A5}$$

where I also add population sizes as a control for potential congestion forces. Section C.2 discusses a model extension that includes agglomeration externalities stemming from the population size.

The relative wage and future migration shares are known from the data. Before estimating equation (A5), I calibrate the discount rate, β, and estimate migration elasticity, η, ex-ante. The interpretation of each component and estimation results can be found in the main text.

B.2 Elasticity estimation

Migration Elasticity. Table OA1 documents migration elasticity estimates $(1/\hat{\eta})$ from the following estimating equation:

$$\text{(A6)} \qquad \ln\left(\frac{\mu^{ks}_{ni,t}}{\mu^{kk}_{nn,t}}\right) - \beta \ln\left(\frac{\mu^{ks}_{ni,t+1}}{\mu^{ss}_{ii,t+1}}\right) = \frac{\beta}{\eta} \ln\left(\frac{w^{s}_{i,t+1}}{v^{k}_{n,t+1}}\right) + \gamma dist_{ni} + \alpha^{k}_{state(n)} + \alpha^{s}_{state(i)} + \alpha_{i,t} + \alpha_{n,t} + u^{ks}_{ni,t}.$$

The derivation steps are the same as in equation (A5), but equation (A6) focuses on estimating the value of η.

Columns 1 and 2 estimate equation (A6) at face value, while Columns 3 and 4 move the future migration flows term to the RHS control. Columns 1 and 3 employ OLS, while Columns 2 and 4 instrument the migration flows using past differences in occupational income score and past migration flows. The estimates range from 1.189 to 1.426, corresponding to the value of η between 0.70 and 0.84. A lower value of η implies that migration is more responsive to consumption and amenities changes. I adopt the conservative value of 0.84.

Consumption Parameters. Table OA2 shows estimation results for Engel elasticity. I use the *Study of Consumer Purchases in the United States, 1935-1936* (ICPSR 8908), available household-level consumption data during the Dust Bowl period. The specified PIGL preference shares the same parameters for the value-added and final expenditure demand systems, and it also admits aggregation (Fan et al., 2023). Hence, the estimates using the household-level consumption data can be used as structural parameters in value-added demand system at regional-level.

By taking logs of the consumption share in agriculture and rearranging, the estimating equation for Engel elasticity regress log consumption share on agriculture (φ^{A}_{h}) on log expenditure (e_h) of household h:

$$\text{(A7)} \qquad \ln(\varphi^{A}_{h}) = \varepsilon \ln(e_h) + \alpha_s + \alpha_c + \gamma X_h + u_h,$$

where α_s and α_c denotes state and city fixed effects and X_h is a set of household characteristics. The controls include the age of 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).

Nest, 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 periods.

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

$$w^S_{i,t} L^S_{i,t} = \left(\phi^S + \nu^S \left(\frac{e_{i,t}}{P_{i,t}}\right)^{-\varepsilon}\right) e_{i,t} L_{i,t}, \tag{A8}$$

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

$$\tilde{w}^A_{i,t} L^A_{i,t} + r^A_{i,t} T^A_i = \sum_{n=1}^{N} \pi^A_{ni,t} \left(\phi^A + \nu^A \left(\frac{e_{n,t}}{P_{n,t}}\right)^{-\varepsilon}\right) e_{i,t} L_{i,t}, \tag{A9}$$

where the presence of trade share highlights the tradability of agriculture. The market clearing for tradable non-agriculture is given similarly, with LHS solely consisting of labor payment. Combining equations (A8) and (A9) gives:

$$\sum_{i=1}^{N} \left(\tilde{w}^A_{i,t} L^A_{i,t} + r^A_{i,t} T^A_i\right) = \phi^A \sum_{i=1}^{N} w_{n,t} L_{n,t} - \frac{\nu^A}{\nu^S} \sum_{i=1}^{N} \left(\phi^s - \frac{L^S_{n,t}}{L_{n,t}}\right) w_{n,t} L_{n,t}, \tag{A10}$$

for years 1940 and 1990. Hence, equation (A10) 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 two remaining parameters.

Distance Elasticity of Trade. Table OA3 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 the value of trade by the routed distance between the origin and the destination with state-fixed effects. Each column reports an estimate using different data periods and the level of aggregation. I pick a value of -1.3, consistent with the estimate in Allen and Donaldson (2022) who use the 1997 CFS. I assume that trade elasticity is constant throughout time. The routed distance between counties, on the other hand, changed during the 20th century. I use a time-varying routed distance between county pairs from Jaworski et al. (2023).

C Additional Results

C.1 Simulation-generated Migration Effects

Table OA7 replicates Hornbeck (2023), Table 1 in terms of simulation-generated migration effects. The migration effect is defined as the percentage changes in migration flows between 1930 and 1940 due to the Dust Bowl. Column 1 reports the average effects for the entire Dust Bowl counties, weighted by 1930 population. Columns 2 and 3 report the relative effects for high- and medium-eroded counties, compared to less-eroded counties within the same origin state for Panels A to E and within the same destination state for Panels F and G. For instance, Panel D, Column 1 shows that migration flows leaving a Dust Bowl county to California increased by 8.47% on average. Columns 2 and 3 further indicate that migration flows to California relatively increased by 12.90% and 7.62% more for high- and medium-eroded counties, compared to less-eroded counties.

Panels A to E show that out-migration increased relatively for counties with higher levels of erosion, and migrants tended to move to not-directly affected non-Dust Bowl regions, reaching as far as California (Panel D) and the Pacific Northwest (Panel E). The Western states especially experienced increases in in-migration flows even compared to other non-Dust Bowl regions. On the contrary, overall mobility within the Dust Bowl region decreased.

Panels F and G document results on diverted in-migration. Consistent with Long and Siu (2018), migration flows into the Dust Bowl counties decreased regardless of the origins, especially for counties with higher levels of erosion.

C.2 Implications of 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. Then, I evaluate how the quantification results would change by the value of agglomeration parameters.

C.2.1 Model Extension

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

$$B_{n,t} = \bar{B}_{n,t}(L_{n,t}/M_n)^{\rho_B} \exp\left(g(D_{n,t}, E_{n,t}; \boldsymbol{\beta}_B)\right). \tag{A11}$$

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. On the contrary, the higher 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 signs of ρ_B.[1] I assume that 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 exogenous component, $z^k_{n,t}$, agglomeration externalities, $(L^k_{n,t}/M_n)^{\rho^k_A}$, and the environmental response function, $f(\cdot)$:

$$A^k_{n,t} = z^k_{n,t}(L^k_{n,t}/M_n)^{\rho^k_A} \exp\left(f(D_{n,t}, E_{n,t}; \boldsymbol{\beta}^k_A)\right). \tag{A12}$$

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 market (Moretti, 2011). Conversely, negative spillover effects could be present due to production congestion.

[1] Imposing a specific microfoundation requires taking 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.

C.2.2 Quantification Results with Agglomeration Forces

Using the extended model, I examine how the presence of agglomeration externalities might have affected the distribution of the shock. Figure OA3 displays the welfare effects in 1940 for the Dust Bowl region (Panel A) and the non-Dust Bowl region (Panel B) by the values of agglomeration parameters. Panels C and D report the welfare effects in 1990 for each region. The x- and y-axes each denote the parameter values from -0.4 to 0.4 with an interval of 0.2. Darker red represents the greater welfare loss, and the values at the center of each Panel are the baseline welfare effects without agglomeration. The right upper quadrants represent the combination of stronger positive agglomeration forces, while the left lower quadrants mean stronger but negative agglomeration forces (dispersion forces).

By 1940, the overall impacts were not critically dependent on the strength of the agglomeration economies, where overall effect sizes can vary by up to 15% within the parameters listed in Figure OA3. Although such changes are non-negligible, they are relatively small compared to the impacts of the Dust Bowl. Still, notably, the implication of agglomeration is the opposite for the two regions. Panel A shows that stronger positive agglomeration leads to worsened outcomes for the Dust Bowl region, whereas the outside region benefits from stronger agglomeration.

As the shock struck, labor was reallocated from the affected region to the outside region. If the size of the local labor market generates positive externalities in terms of productivity or amenities, the regions that gained population would experience increases in real income and local amenities, leading to increases in welfare. The opposite holds for the directly affected regions that lost population. Thus, the presence of positive agglomeration externalities amplifies the disparity in welfare effects. On the contrary, dispersion forces would diminish the disparity between the two regions in terms of welfare and population.

The importance of agglomeration increases in the long run, as population reallocation continued at least throughout the 1950s. Such long-lived population adjustments made the long-run impacts of the Dust Bowl more dependent on the strength of agglomeration. Figure OA4 suggests that outside regions, except for the Northeast, may have benefited from the Dust Bowl by 1990 with sufficiently strong agglomeration forces ($\rho_A = \rho_B = 0.2$, for instance). However, the strength of the agglomeration economies would have to be very large for the entire non-Dust Bowl region to gain in the long run (Figure OA3, Panel D).

Previous literature reports positive contemporaneous production externalities working through the size of the local labor market,[2] while evidence on the influences of the local population on amenities is mixed. Within a reasonable range of parameter values in the literature listed in Figures OA3 and OA4, the main messages of this paper would be maintained.

C.3 Additional Counterfactuals

Table OA8 summarizes welfare effects from alternative counterfactual scenarios and by values of structural parameters. Panel A, Row 1 reports the baseline welfare effects. Here, I only report regional-level aggregate effects for readability.

First, Panel A, Rows 2 to 5, decompose the drivers of the baseline welfare effect. Summing up productivity and amenity shocks (Panels A, Rows 2 and 3; henceforth A.2 and A.3) results in the baseline results. The decomposition suggests that productivity declines contributed to the majority of the welfare loss. Alternatively, Panels A.4 and A.5 show the results separately for the effects driven by erosion or drought. Among environmental factors, erosion contributed the most, and the interaction between the two generated additional welfare loss.

Panel A.5 can also be interpreted as a scenario where perfectly successful land conservation was implemented before the shock. In 1935, Congress established the Soil Conservation Service (SCS), currently known as the Natural Resources Conservation Service. The SCS developed extensive conservation programs that retained topsoil and prevented irreparable damage to the land. Since then, a consensus has arisen that soil-conservation efforts are of critical importance for preserving agricultural productivity (Hansen and Libecap, 2004).

Compared to the baseline, the perfect soil conservation before 1930 would have reduced overall U.S. welfare losses by 80.7%. Thus, were it not for the excessive soil erosion, the consequences of the severe drought would have been much smaller than those that emerged in this chapter of U.S. history, highlighting the importance of preventing permanent damages from a transient shock.

[2] For instance, Bleakley and Lin (2012) estimate a long-run production agglomeration elasticity of 0.09 by examining the location of early portage sites and persistent clustering around portage sites in the U.S. Kline and Moretti (2014) document a contemporaneous agglomeration elasticity of 0.2 in manufacturing by evaluating the local impacts of the Tennessee Valley Authority investments. In this paper, the estimation using revenue productivity per acre with model-implied instruments suggests a moderate range of agglomeration parameters between 0.019 to 0.169 (Table OA4, Columns 2, 3, 5, and 6).

Consistent with this exercise, Hansen and Libecap (2004) documents that the comparable levels of drought and wind during the 1950s and 1970s did not materialize into erosion as seen during the 1930s. Coordinated erosion control successfully prevented the transient shock from causing persistent side effects and did not result in a similar disaster as in the Dust Bowl.

Panel B reports welfare effects from alternative policy experiments. Specifically, Panels B.1 to B.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. Here, 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 OA4, Columns 2 and 3 document the estimation results. Then, I quantify the impacts of converting all cropland to pastureland in either 1930 (Panel B.2) or 1940 (Panel B.3). For simplicity, I assume that shifting land use is costless and the two lands are identical except for their susceptibility to erosion and drought. Thus, the quantification results only inform the maximum potential benefits.

Panel B.2 shows that preemptively converting all cropland to pasture before the shock would have reduced the negative welfare effects by 77.3%. This scenario represents a perfect preventive technology adoption when avoiding permanent side effects is unattainable. Alternatively, shifting land use immediately after the shock would have still mitigated welfare loss by 31.7% (Panel B.3). These experiments emphasize how different types of technology would shape the consequences of environmental shocks. 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 response after the shock could have additionally relieved the shock in the long run (Moscona, 2024).[3]

[3] Moscona (2024) shows that agricultural technology was redirected toward more Dust Bowl-exposed crop. Such adaptive, endogenous technical response further ameliorated the consequences of immediate productivity decline.

C.4 Additional Robustness Check

Table OA8, Panel C, Rows 6 to 10 show that aggregate welfare effects are insensitive to the values of migration and trade elasticity. Although the levels of elasticity affect the size of migration and trade response, their influences on welfare are determined through migration option value and consumption welfare. Migration option value takes the share of stayer and scales it with minus η (Artuc et al., 2010). Although an increase in η lowers the migration flow response (reducing migration option value), this increase in η also directly raises the option value through the exponent term as the share takes a value between 0 and 1. Thus, two competing forces maintain the influences of η in terms of aggregate welfare outcomes. Nevertheless, the size of aggregate and relative population effects is inversely proportional to η. The comparison between Figure 2 and Table OA5, Column 1, indicates that the magnitude of simulated population effects aligns with the empirical estimates.

Similarly, changing trade elasticity leads to a quantitatively small impact on consumption welfare. Although not directly applicable, an analogy with the ACR 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 by 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.

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 $w^k_{n,t}$,[4] labor

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

allocation $L^k_{n,t}$, productivity $A^k_{i,t}$, consumption share φ^k, and productivity dispersion parameter θ^k:

$$
\begin{aligned}
X^k_{ni,t} &= \left(\tau^k_{ni,t}\frac{w^k_{i,t}}{A^k_{i,t}}\right)^{-\theta^k} (P^k_{n,t})^{\theta^k} \times \varphi^k Y_{n,t} \\
&= T^k_{ni,t} \times \left(\frac{Y^k_{i,t}/Y_W}{(\Pi^k_{i,t})^{-\theta^k}}\right) \times \left(\frac{X^k_{n,t}/Y_W}{(P^k_{n,t})^{-\theta^k}}\right),
\end{aligned}
\tag{A13}
$$

where the terms $Y^k_{i,t}$ and $X^k_{n,t}$ each denote output and expenditure on industry k. World income Y_W normalizes the output and expenditure. The second line follows from introducing the outward market access term $\Pi^k_{i,t} \equiv \left(\frac{w^k_{i,t}}{A^k_{i,t}}\right)^{-1}\left(\frac{Y^k_{i,t}}{Y_W}\right)$ and the effective trade costs $T^k_{ni,t} = (\tau^k_{ni,t})^{-\theta^k}$. As outlined in Section B.2, 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 $\Pi_{i,t}$ captures how close exporter i is to the potential importers. The price index $P_{n,t}$ 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 defines the initial equilibrium for trade.

Proposition 1 (Initial Equilibrium). Given the allocation of output and labor, $\{Y_t, L_t\}$, trade costs raised to elasticity exponent, $\{T_t\}$, and expenditure 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 the solution to the following system of non-linear equations:

Outward and Inward Trade Market Access Terms:

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

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

Trade Flows:

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

Output and Expenditure:

$$Y_{n,t}^k = w_{n,t}^k L_{n,t}^k, \quad Y_{n,t} = \sum_k Y_{n,t}^k, \quad \text{and} \quad X_{n,t}^k = \varphi^k Y_{n,t}. \tag{I3}$$

Wages:

$$w_{n,t}^k L_{n,t}^k = \sum_{j=1}^{N} X_{jn,t}^k. \tag{I4}$$

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 annihilates 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 at 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.

Proposition 2 (Temporary Equilibrium). 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:

$$\dot{P}_{n,t+1}^k = \left[\sum_{i=1}^{N} \pi_{ni,t}^k \left(\dot{\tau}_{ni,t+1}^k \dot{c}_{i,t+1}^k\right)^{-\theta^k} \left(\dot{A}_{i,t+1}^k\right)^{\theta^k}\right]^{-1/\theta^k}, \tag{T1}$$

$$\pi_{ni,t+1}^k = \pi_{ni,t}^k \left(\frac{\dot{\tau}_{ni,t+1}^k \dot{c}_{i,t+1}^k}{\dot{P}_{n,t+1}^k}\right)^{-\theta^k} \left(\dot{A}_{i,t+1}^k\right)^{\theta^k}, \tag{T2}$$

$$Y_{n,t+1} = \sum_{i=1}^{K} \left(\dot{w}_{n,t+1}^k \dot{L}_{n,t+1}^k v_{n,t}^k L_{n,t}^k\right), \tag{T3}$$

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

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

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 by the new sequence of temporary equilibrium. I define $\mathbb{V}^k_{n,t} \equiv \exp(V^k_{n,t})$.

Proposition 3 (Sequential Equilibrium). Given an initial allocation of the economy, $(L_0, \pi_0, X_0, \mu_{-1})$, 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 in the level 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:

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

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

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

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

$$\begin{aligned}\dot{B}_{n,t+1} = {} & (\bar{B}_{n,t+1}/\bar{B}_{n,t}) \times (L_{n,t+1}/L_{n,t})^{\rho_B} \\ & \times \exp(f(D_{n,t+1};\gamma_D) - f(D_{n,t};\gamma_D))\exp(f(E_{n,t+1};\gamma_E) - f(E_{n,t};\gamma_E)),\end{aligned}$$

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 $\{\dot{L}_t, \dot{\Theta}_t\}_{t=1}^{\infty}$:

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

where I first recover wages at $t = 1$ consistent with the initial period economic allocation. The first term in RHS is the real wage component and the second term is the non-homothetic price adjustments.

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.

D.3 Predictions on Structural Change

The aggregate spending share on sector s goods for individuals in region n, sector k is given as:

$$\varphi^s_{nk,t} = \phi^s + \nu^s \left(\frac{w^k_{n,t}}{(P^A_{n,t})^{\phi^A} (P^M_{n,t})^{\phi^M} (P^S_{n,t})^{\phi^S}} \right)^{-\varepsilon}. \tag{A14}$$

Taking derivatives with respect to price and wage yields:

$$\frac{\partial \varphi^s_{nk,t}}{\partial \ln P^l_{n,t}} = \varepsilon \phi^l (\varphi^s_{nk,t} - \phi^s) \quad \text{and} \quad \frac{\partial \varphi^s_{nk,t}}{\partial \ln w^k_{n,t}} = -\varepsilon (\varphi^s_{nk,t} - \phi^s), \tag{A15}$$

where the signs are determined by the value of structural parameters and local baseline consumption share. Given the estimates in this paper, the first expression is positive for agriculture and negative for nontradable in 1940, while the sign for tradable non-agriculture depends on regional consumption share. Hence, the rise in the price of agricultural goods raises its spending share on agriculture, while the opposite holds for nontradable. The decreases in income have the same effects as the price increase.

References

Abramitzky, Ran, Leah Boustan, Katherine Eriksson, Myera Rashid, and Santiago Pérez, "Census Linking Project: 1910-1940 Crosswalk [dataset]," 2022.

Allen, Treb and Costas Arkolakis, "Economic Activity across Space: A Supply and Demand Approach," *Journal of Economic Perspectives*, 2023, *37* (2), 3–28.

— **and Dave Donaldson**, "Persistence and Path Dependence in the Spatial Economy," *Unpublished Manuscript*, 2022.

Arkolakis, Costas, Arnaud Costinot, and Andres Rodriguez-Clare, "New Trade Models, Same Old Gains?," *American Economic Review*, 2012, *102* (1), 94–130.

Artuc, Erhan, Shubham Chaudhuri, and John McLaren, "Trade Shocks and Labor Adjustment: A Structural Empirical Approach," *American Economic Review*, 2010, *100* (3), 1008–1045.

Bleakley, Hoyt and Jeffrey Lin, "Portage and Path Dependence," *The Quarterly Journal of Economics*, 2012, *127* (2), 587–644.

Caliendo, Lorenzo, Maximiliano Dvorkin, and Fernando Parro, "Trade and Labor Market Dynamics: General Equilibrium Analysis of the China Trade Shock," *Econometrica*, 2019, *87* (3), 741–835.

Cook, Edward R., Richard Seager, Richard R. Heim Jr, Russell S. Vose, Celine Herweijer, and Connie Woodhouse, "Megadroughts in North America: placing IPCC projections of hydroclimatic change in a long-term palaeoclimate context," *Journal of Quaternary Science*, 2010, *25* (1), 48–61.

Eckert, Fabian, Andrés Gvirtz, Jack Liang, and Michael Peters, "A Method to Construct Geographical Crosswalks with an Application to Us Counties since 1790," *Unpublished Manuscript*, 2020.

Fan, Tianyu, Michael Peters, and Fabrizio Zilibotti, "Growing Like India—the Unequal Effects of Service-Led Growth," *Econometrica*, 2023, *91* (4), 1457–1494.

Glaeser, Edward L., Hedi D. Kallal, José A. Scheinkman, and Andrei Shleifer, "Growth in Cities," *Journal of Political Economy*, 1992, *100* (6), 1126–1152.

Haines, Michael and Inter-university Consortium for Political and Social Research, "Historical, Demographic, Economic, and Social Data: The United States, 1790-2002 [dataset]," 2010. Inter-university Consortium for Political and Social Research.

Hansen, Zeynep K. and Gary D. Libecap, "Small farms, externalities, and the dust bowl of the 1930s," *Journal of Political Economy*, 2004, *112* (3), 665–694.

Hornbeck, Richard, "The Enduring Impact of the American Dust Bowl: Short- and Long-run Adjustments to Environmental Catastrophe," *American Economic Review*, 2012, *102* (4), 1477–1507.

— , "Dust Bowl Migrants: Environmental Refugees and Economic Adaptation," *The Journal of Economic History*, 2023, *83* (3), 645–675.

Jaworski, Taylor, Carl Kitchens, and Sergey Nigai, "Highways and Globalization," *International Economic Review*, 2023, *64* (4), 1615–1648.

Kline, Patrick and Enrico Moretti, " Local Economic Development, Agglomeration Economies, and the Big Push: 100 Years of Evidence from the Tennessee Valley Authority," *The Quarterly Journal of Economics*, 2014, *129* (1), 275–331.

Long, Jason and Henry Siu, "Refugees from Dust and Shrinking Land: Tracking the Dust Bowl Migrants," *Journal of Economic History*, 2018, *78* (4), 1001–1033.

Moretti, Enrico, "Local labour markets," in David Card and Orley Ashenfelter, eds., *Handbook of Labor Economics*, volume 4b ed., New York: Elsevier, 2011, pp. 1237–1313.

Moscona, Jacob, "Environmental Catastrophe and the Direction of Invention: Evidence from the American Dust Bowl," *Unpublished Manuscript*, 2024.

National Oceanic and Atmospheric Administration (NOAA), "Climate at a Glance County Mapping," 2019.

Rudik, Ivan, Gary Lyn, Weiliang Tan, and Ariel Ortiz-bobea, "The Economic Effects of Climate Change in Dynamic Spatial Equilibrium," *Unpublished Manuscript*, 2022.

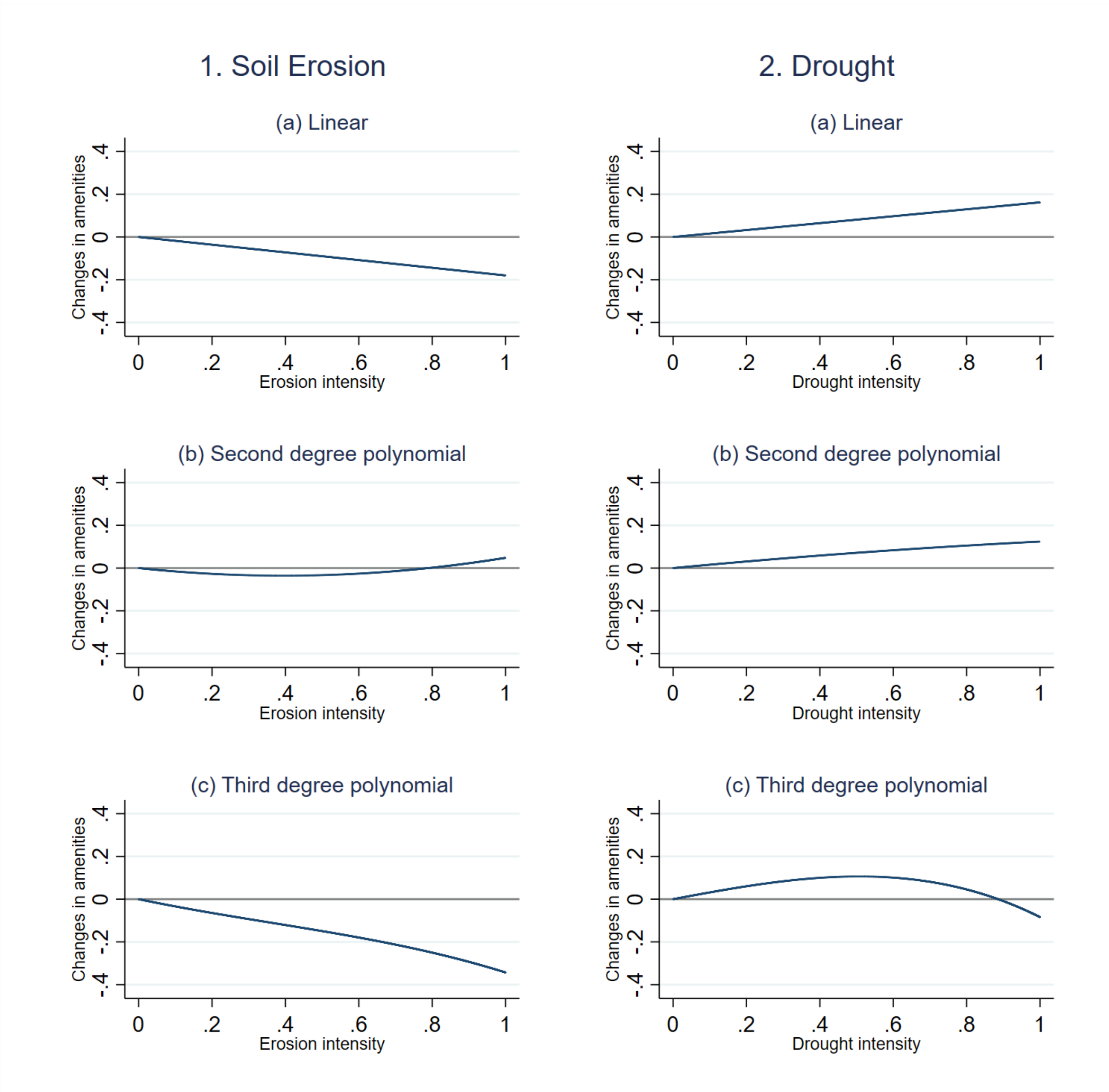
Ruggles, Steven, Catherine A. Fitch, Ronald Goeken, J. David Hacker, Matt A. Nelson, Evan Roberts, Megan Schouweiler, and Matthew Sobek, "IPUMS Ancestry Full Count Data: Version 3.0 [dataset]," 2021. Minneapolis, MN: IPUMS.

Sichko, Christopher, "Migrant Selection and Sorting during the Great American Drought," *Doctoral Dissertation*, 2020.

Soil Conservation Service (SCS), "Soil Erosion: A Critical Problem in American Agriculture," 1935.

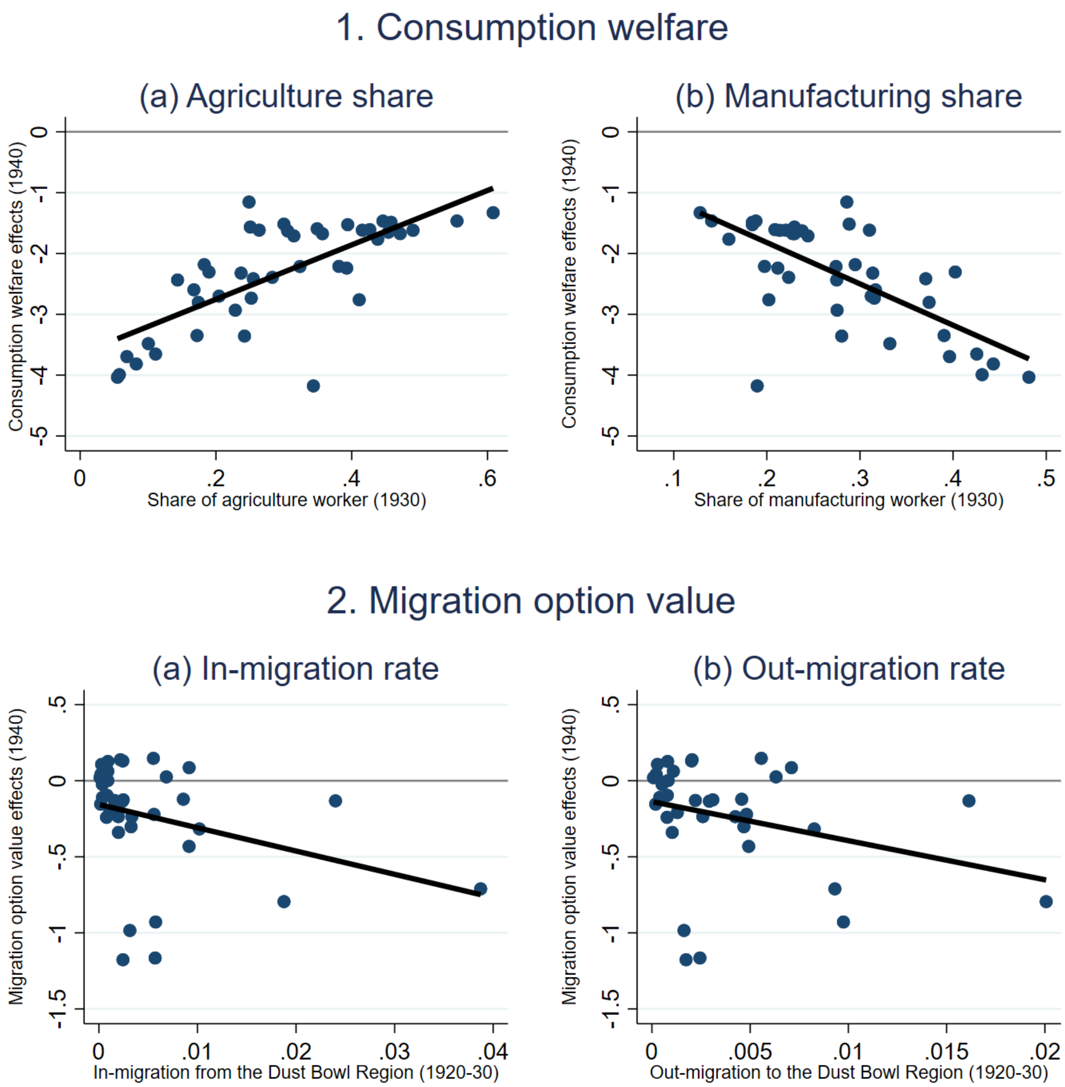
E Additional Tables and Figures.

Figure OA1: Shape of Environmental Response Function on Amenities.



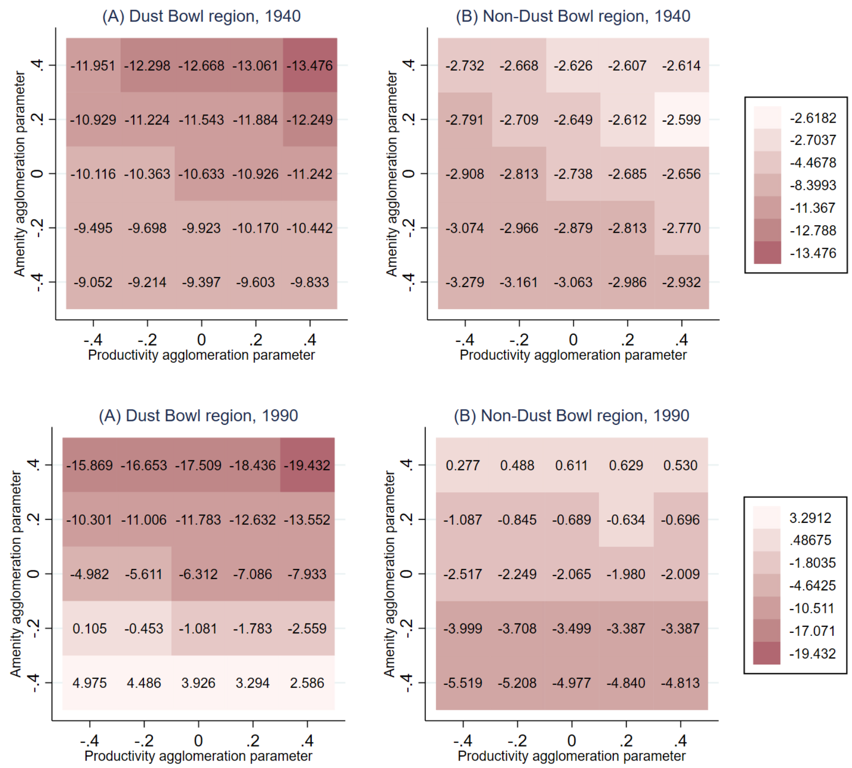
Note: The figure plots the shape of the environmental response function on amenities using the parameter estimates in Table 2, Column A, Panel C. Estimation uses amenity estimating equation (13). Data is from the matched complete-count Census (Ruggles et al., 2021; Abramitzky et al., 2022).

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



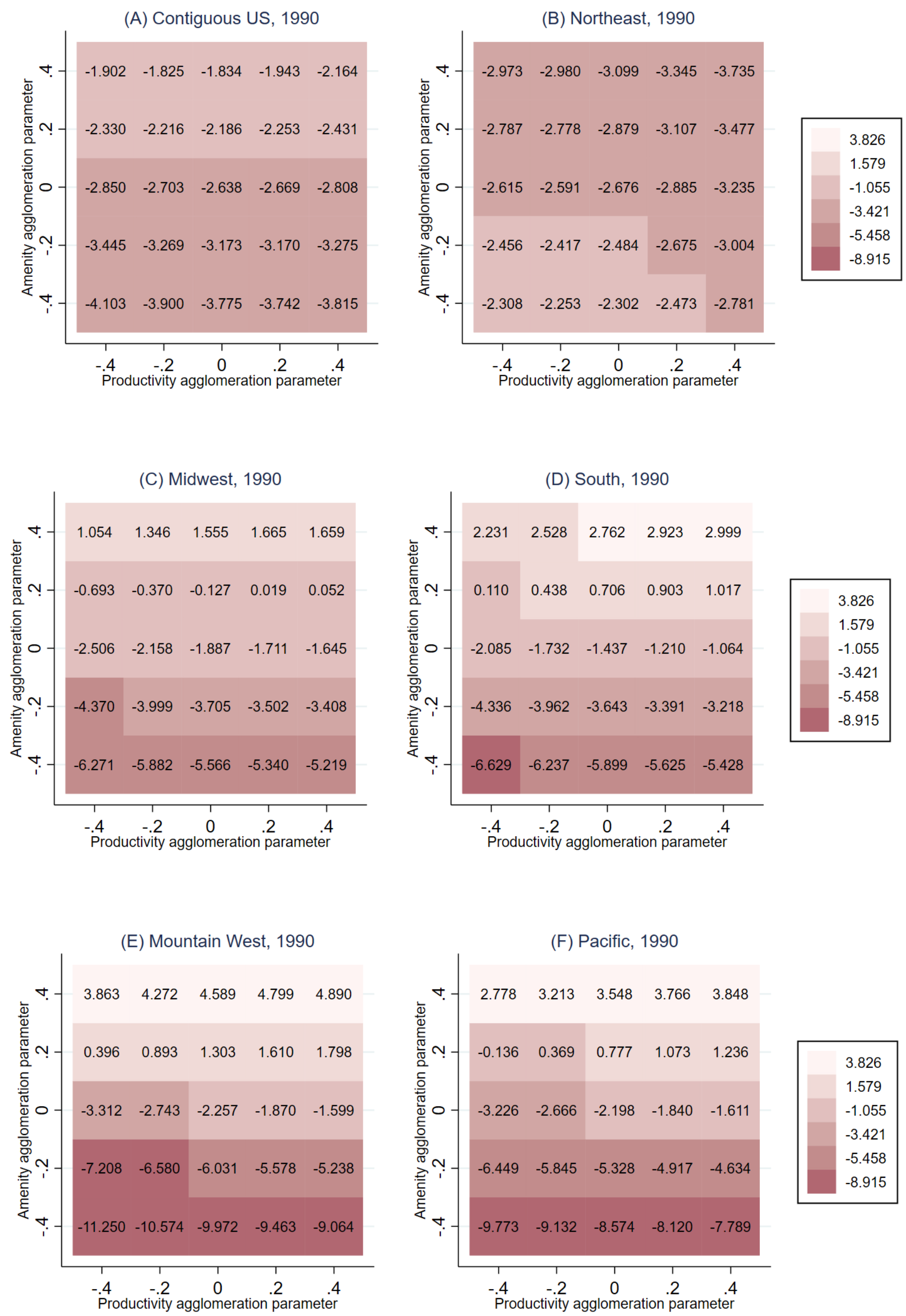
Note: The figure demonstrates the determinant of welfare effects in the non-Dust Bowl region. Panels 1a and 1b show the relationship between simulated consumption welfare (y-axis) and empirical shares of workers in agriculture and manufacturing (x-axis) for each state. Shares of workers before the shock (the year 1930) are used. Panels 2a and 2b display the relationship between simulated migration option value (y-axis) and empirical initial migration shares (x-axis). Migration shares before the shock (between the years 1920 and 1930) are used.

Figure OA3: Simulated Welfare Effects by Agglomeration Parameters, 1940 and 1990.



Note: The figure shows the welfare effects by the values of agglomeration parameters, separately for the Dust Bowl and non-Dust Bowl regions. Welfare effects are reported in percentage terms. The x-axis denotes the values of productivity parameter ρ_A, while the y-axis indexes amenity parameter ρ_B. The value at the center of each panel is the baseline welfare effect without agglomeration. Darker red represents a more severe welfare loss. The Panels for the same year share an identical color scheme.

Figure OA4: Welfare Effects by Agglomeration Parameters, by Census Region (1990).



Note: The figure shows the welfare effects in 1990 by values of agglomeration parameters, by census region. The U.S. aggregate effects are displayed on Panel A. The x-axis denotes the values of productivity parameter ρ_A, while the y-axis indexes amenity parameter ρ_B. The value at the center of each panel is the baseline welfare effect without agglomeration. Darker red represents a more severe welfare loss. All Panels share the same scale for the color scheme.

Table OA1: Estimation Results for Migration Elasticity.

	(1)	(2)	(3)	(4)
Log wage difference	1.189	1.416	1.192	1.426
	(0.022)	(0.032)	(0.022)	(0.032)
Log distance	-0.434	-0.435	-0.440	-0.441
	(0.010)	(0.099)	(0.011)	(0.011)
Lead dependent variable			0.004	0.001
			(0.012)	(0.012)
Geographic FE	O	O	O	O
N	2,876,186	2,723,131	2,798,982	2,655,632
R^2	0.587	0.178	0.589	0.180

Note: The above table reports estimates for inverse migration elasticity, η, using equation (A6). Data is from the matched complete-count Census (Ruggles et al., 2021; Abramitzky et al., 2022) using county-level migration flow between 1930 and 1940 with state-level future migration flow between 1940 and 1950. Columns 1 and 2 estimate equation (A6) at face value, and Columns 3 and 4 move the future migration flows term in LHS as a control. Columns 1 and 3 use OLS, while Columns 2 and 4 instrument the migration flows using past differences in occupational income score and past migration flows. State-by-industry fixed effect and county fixed effect are included for origin and destination. Robust standard errors are clustered by origin-destination state pairs and reported in parentheses.

Table OA2: 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	X	O	O	O	O
Geographic FE	X	O	O	O	O
Demographic FE	X	X	O	O	O
Instruments	-	-	-	Total income	Occupation
N	1,726	1,726	1,726	1,726	619
R^2	0.294	0.346	0.371	0.296	0.304

Standard errors in parentheses

Note: The above table reports estimates for Engel elasticity, ε, using equation (A7). The data is from the *Study of Consumer Purchases in the United States, 1935-1936*. Columns 1 to 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 effect (Column 5). The controls include the age of 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 by state and reported in parentheses.

Table OA3: Estimation Results for Distance Elasticity of Trade.

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

Note: The above 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. State fixed effects for the origin and destination are included. 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 by origin-destination state pairs and reported in parentheses.

Table OA4: 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 versus low erosion							
1940	-0.029	-0.327**	-0.238**	-0.003	-0.108		0.037
	(0.017)	(0.119)	(0.045)	(0.010)	(0.105)		(0.022)
1945	-0.020	-0.158*	-0.134*	-0.013	-0.202**		
	(0.017)	(0.076)	(0.054)	(0.011)	(0.069)		
1950-1954	-0.042*	-0.361**	-0.115*	-0.027	-0.237**	-0.011	0.020
	(0.016)	(0.068)	(0.054)	(0.014)	(0.068)	(0.048)	(0.021)
1959-1964	-0.049**	-0.240**	-0.233**	-0.052**	-0.192*	0.069	0.007
	(0.017)	(0.077)	(0.073)	(0.017)	(0.074)	(0.046)	(0.023)
1969-1974	-0.019				0.022	0.108*	-0.025
	(0.015)				(0.061)	(0.045)	(0.026)
1978-1992	-0.055**				-0.012	0.171**	-0.043
	(0.017)				(0.049)	(0.048)	(0.029)
Panel B. Medium erosion versus low erosion							
1940	-0.020	-0.372**	-0.060	-0.003	-0.084		-0.002
	(0.013)	(0.088)	(0.039)	(0.006)	(0.083)		(0.016)
1945	0.002	-0.287**	-0.058	-0.008	-0.063		
	(0.012)	(0.064)	(0.040)	(0.007)	(0.049)		
1950-1954	-0.010	-0.294**	-0.008	-0.016	-0.177**	0.009	0.003
	(0.013)	(0.055)	(0.041)	(0.010)	(0.064)	(0.046)	(0.019)
1959-1964	-0.028*	-0.249**	0.019	-0.024*	-0.255**	0.033	-0.021
	(0.014)	(0.064)	(0.052)	(0.012)	(0.060)	(0.046)	(0.021)
1969-1974	-0.014				-0.037	-0.037	-0.070**
	(0.012)				(0.044)	(0.035)	(0.022)
1978-1992	-0.029*				-0.069*	-0.024	-0.101**
	(0.013)				(0.034)	(0.038)	(0.023)
Panel C. Drought							
1940	0.006	-0.202**	-0.037	0.006	-0.189**		0.015*
	(0.011)	(0.057)	(0.027)	(0.004)	(0.040)		(0.007)
1945	0.002	0.039	0.014	0.002	0.041		
	(0.012)	(0.033)	(0.026)	(0.005)	(0.025)		
1950-1954	0.008	0.011	-0.007	-0.002	0.042	0.070**	0.013
	(0.010)	(0.038)	(0.024)	(0.006)	(0.030)	(0.020)	(0.008)
1959-1964		-0.097*	0.047	-0.006	-0.085**	0.047*	0.001
		(0.043)	(0.033)	(0.009)	(0.028)	(0.021)	(0.009)
1959-1969	0.008						
	(0.009)						
1978-1992	0.008				0.011	0.057**	-0.036**
	(0.010)				(0.017)	(0.022)	(0.010)
Panel D. Spatial lingkages							
Log employment	-0.004	0.169**	0.085**	0.016**	0.011*	0.019**	-0.002
	(0.002)	(0.030)	(0.022)	(0.004)	(0.005)	(0.005)	(0.003)
Outward access	0.040	0.386*	0.427**	0.027	0.019	0.177**	-0.083*
	(0.023)	(0.163)	(0.129)	(0.026)	(0.059)	(0.055)	(0.033)
Sample counties	779	779	779	779	421	421	421
R^2	0.524	0.521	0.410	0.575	0.682	0.544	0.315
Kleibergen-Paap F	2.216e+06	4.007e+06	4.738e+06	5.260e+06	9.073e+06	773696	1.109e+06

Note: The above table replicates and extends Table 3 of Hornbeck (2012) using the estimating equation (12) with model-implied instruments. The dependent variable in each Column is farmland per county acre (column 1), log crop revenue per cropland acre (column 2), log animal revenue per pasture acre (column 3), cropland per acre of cropland and pasture (column 4), log wheat output per wheat acre (column 5), log hay output per hay acre (column 6), wheat per acre of wheat and hay (column 7). State-by-year fixed effect and pre-1930 county characteristics are added as controls. See footnote 14 for the list of variables. Robust standard errors are clustered at the county level and reported in parentheses.

Table OA5: 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 versus 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 versus 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)
Sample counties	779	516	287	779	758
R^2	0.654	0.637	0.612	0.866	0.998

Note: The above table replicates Hornbeck (2012), Table 4 for changes in population and non-agricultural activities by regressing the fraction of the county in a high-erosion area and the fraction of the county in a medium-erosion area, relative to a low-erosion area. State-by-year fixed effect and pre-1930 county characteristics are included as controls. See footnote 14 for the list of variables. Robust standard errors are clustered at the county level and reported in parentheses.

Table OA6: Simulated Changes in Non-agricultural Activities, by Erosion Level.

	(1) Goods output per capita	(2) Goods workers per capita	(3) CS output per capita	(4) CS workers per capita	(5) Non-employment
Panel A. High erosion versus low erosion					
1940	-4.673	0.298	-11.18	-0.614	0.456
	(0.660)	(0.064)	(1.029)	(0.080)	(0.031)
1950	-7.317	0.914	-18.96	-1.386	0.844
	(0.845)	(0.132)	(1.563)	(0.096)	(0.056)
1960	-10.09	1.510	-26.89	-2.079	1.230
	(1.008)	(0.247)	(1.954)	(0.189)	(0.078)
1970	-6.905	1.785	-23.88	-2.232	1.344
	(0.925)	(0.309)	(1.836)	(0.255)	(0.086)
1980	-12.10	2.428	-35.31	-2.939	1.808
	(1.124)	(0.427)	(2.227)	(0.360)	(0.105)
1990	-11.97	2.602	-35.19	-2.940	1.875
	(1.506)	(0.460)	(2.289)	(0.414)	(0.111)
Panel B. Medium erosion versus low erosion					
1940	-2.067	0.228	-5.990	-0.300	0.271
	(0.324)	(0.037)	(0.730)	(0.054)	(0.041)
1950	-4.056	0.591	-12.23	-0.755	0.544
	(0.562)	(0.065)	(1.168)	(0.104)	(0.048)
1960	-4.583	0.834	-15.23	-1.012	0.721
	(0.737)	(0.100)	(1.498)	(0.163)	(0.063)
1970	-3.312	0.919	-13.98	-1.025	0.768
	(0.641)	(0.110)	(1.399)	(0.187)	(0.070)
1980	-2.860	0.990	-14.53	-1.020	0.829
	(0.819)	(0.142)	(1.698)	(0.228)	(0.086)
1990	-4.093	1.017	-15.51	-0.979	0.843
	(1.552)	(0.149)	(2.165)	(0.237)	(0.091)
Sample counties	875	875	875	875	875
R^2	0.697	0.707	0.862	0.783	0.785

Note: The above table reports estimation results on simulated outcomes by regressing the fraction of the county in a high-erosion area and the fraction of the county in a medium-erosion area, relative to a low-erosion area. State-by-year fixed effect is included. Estimates represent percentage point changes in outcomes. Each column corresponds to empirical results in Hornbeck (2012). Columns 1 and 2 replicate Table OA5, Columns 2 and 3. Columns 3 and 4 reproduce Table OA5, Columns 5 and Columns 3 corresponds to Table OA5, Columns 4. Robust standard errors are clustered at the county level and reported in parentheses.

Table OA7: Simulated Migration Effects, by Erosion Level.

	(1)	(2)	(3)
		Relative to Low-Erosion Counties	
	All Dust Bowl Counties	High-Erosion Counties	Medium-Erosion Counties
Panel A. Migration To All Counties			
Migration Effect	0.427	9.41	5.66
	[7.254]	(0.868)	(0.507)
Panel B. Migration to the Non-Dust Bowl Region			
Migration Effect	7.929	11.24	6.84
	[4.303]	(0.931)	(0.581)
Panel C. Migration Within the Dust Bowl Region			
Migration Effect	-1.764	8.76	5.30
	[6.430]	(0.876)	(0.481)
Panel D. Migration to California			
Migration Effect	8.456	12.90	7.62
	[4.432]	(1.172)	(0.647)
Panel E. Migration to Pacific Northwest			
Migration Effect	8.455	11.96	7.03
	[4.724]	(1.335)	(0.898)
Panel F. Diverted in-Migration from the Non-Dust Bowl Region			
Migration Effect	-8.010	-16.04	-9.57
	[6.030]	(0.387)	(0.252)
Panel G. Diverted in-Migration within the Dust Bowl Region			
Migration Effect	-1.764	-16.50	-10.01
	[6.430]	(0.457)	(0.294)

Note: The above 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. Panels A to E show the results on migration flows out of a Dust Bowl county between 1930 and 1940, and Panels F to G show the results on flows into a Dust Bowl county during the same period. Panel A reports all migration flows leaving a Dust Bowl county. Panel B reports the migration flow leaving a Dust Bowl county to the non-Dust Bowl region. Panel C reports the migration flow within the Dust Bowl counties. Panels D and E each report the corresponding effects for the migration flows to California and the Pacific Northwest (Washington and Oregon). Panel F reports the migration effects for the migrants leaving a non-Dust Bowl state to a Dust Bowl county. Panels G reports the corresponding effects of migration within Dust Bowl counties. Column 1 reports the average effects across all Dust Bowl counties, weighted by 1930 county population, with standard deviations reported in brackets. Columns 2 and 3 report regression results from regressing the fraction of the county in a high-erosion area and the fraction of the county in a medium-erosion area, relative to a low-erosion area. Regressions in Columns 2 and 3 include origin and destination state fixed effects. Robust standard errors are clustered at the origin state for Panels A to E and at the destination state for Panels F and G. They are reported in parentheses.

Table OA8: Welfare Effects - Additional Counterfactual Scenarios.

	(1) Aggregate effects	(2) Dust Bowl region	(3) Outside region
Panel A. Baseline Results and Decomposition			
(1) Baseline	-3.803	-10.633	-2.738
(2) Productivity shock	-3.601	-9.136	-2.738
(3) Amenity shock	-0.202	-1.497	0.000
(4) Erosion shock	-2.999	-8.580	-2.128
(5) Drought shock	-0.733	-2.085	-0.522
Panel B. Additional Counterfacturals			
(1) All farmland to cropland	-6.298	-16.392	-4.724
(2) All farmland to pastureland	-0.862	-3.176	-0.502
(3) Immediate land-use adjustment	-2.596	-7.967	-1.759
(4) Fixed trade share	-3.809	-11.215	-2.654
(5) Fixed migration share	-3.823	-11.923	-2.560
Panel C. Robustness			
(1) Shock sizes by half	-1.902	-6.037	-1.257
(2) Shock sizes by twofold	-8.321	-19.940	-6.508
(3) Cobb-Douglas demand	-1.590	-13.990	0.345
(4) Engel elasticity, $\varepsilon = 0.35$	-3.398	-9.497	-2.447
(5) Engel elasticity, $\varepsilon = 0.45$	-4.294	-12.067	-3.082
(6) Migration elasticity, $\eta = 0.70$	-3.859	-10.573	-2.811
(7) Migration elasticity,$\eta = 2.02$	-3.757	-10.683	-2.677
(8) Trade elasticity, $\theta \times 75\%$	-3.884	-10.478	-2.855
(9) Trade elasticity, $\theta \times 125\%$	-3.916	-10.265	-2.926
(10) Distance elasticity, $\kappa = 1.03$	-3.817	-10.384	-2.792

Note: The table reports the per-capita welfare effects at 1940 for additional counterfactual scenarios and by values of structural parameters. Welfare effects are reported in percentage terms. For the structural parameters, the baseline simulation uses $\{\varepsilon, \eta, \theta^A, \theta^M, \kappa\} = \{0.39, 0.84, 12, 6.5, 1.3\}$.