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ABSTRACT

This paper introduces the concept of “climate matching” as a driver of migration and establishes several new results. First, we show that climate strongly predicts the spatial distribution of immigrants in the US, both historically (1880) and more recently (2015), whereby movers select destinations with climates similar to their place of origin. Second, we analyze historical flows of German, Norwegian, and domestic migrants in the US and document that climate sorting also holds within countries. Third, we exploit variation in the long-run change in average US climate from 1900 to 2019 and find that migration increased more between locations whose climate converged. Fourth, we verify that results are not driven by the persistence of ethnic networks or other confounders, and provide evidence for two complementary mechanisms: climate-specific human capital and climate as amenity. Fifth, we back out the value of climate similarity by: i) exploiting the Homestead Act, a historical policy that changed relative land prices; and, ii) examining the relationship between climate mismatch and mortality. Finally, we project how climate change shapes the geography of US population growth by altering migration patterns, both historically and into the 21st century.

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A data appendix is available at http://www.nber.org/data-appendix/w32035

"What a glorious new Scandinavia might not Minnesota become! The climate...agrees with our people better than that of any other of the American States." – Fredrika Bremer, Swedish immigrant, 1850

1 Introduction

What explains where immigrants settle? Answers to this question include economic opportunities (Borjas, 2001; Cadena and Kovak, 2016), ethnic networks (Altonji and Card, 1991; Stuart and Taylor, 2021), geographic distance (Schwartz, 1973; Steckel, 1982), and political preferences and cultural traits (Bishop and Cushing, 2009; Bazzi et al., 2020). Another potential factor driving the location decisions of migrants is climate similarity. In 1925, US President Calvin Coolidge observed that "the newcomers from Europe commonly sought climatic conditions here [in the US] like those in which they had been raised. So the Scandinavians are found chiefly in the northern parts of this country" (Coolidge, 1926, p. 255). Similar arguments have been made about early English settlement patterns in the colonial US (Fischer, 1989). Despite its intuitive appeal, though, limited evidence exists on the relationship between climate similarity and migration.

Do migrants seek out familiar climates? With climate change increasingly driving migration (Stern, 2007; Missirian and Schlenker, 2017), answering this question is important for several reasons.[1] First, if individuals value climate similarity, this factor might help predict where people move and how much they are willing to pay for a given destination. Second, climate matching might favor the geographic diffusion of climate-specific skills (Bazzi et al., 2016), with important consequences for productivity. Third, even though individuals displaced by weather shocks are often forced to leave their home region (Mahajan and Yang, 2020; Bertoli et al., 2022), their preferences may determine where they move—or, where they would like to move if they were unconstrained. This can inform the design of programs (e.g., resettlement or dispersal policies) to cope with climate change. Finally, since climate change is not happening uniformly across the globe, climate similarity between and within countries will shift dramatically in the decades ahead, with possibly important downstream effects on migration patterns.

We consider US international and internal migration for both the historical and the modern periods. The US is an ideal setting to study the role of climate preferences on migration. First, the US is unique in its inherent climate variability: the continental US spans climates ranging from arid to temperate to tropical. Second, few restrictions on migration from European

[1] Recent work has shown that migration may mitigate the direct effects of climate change (Bosetti et al., 2021; Desmet and Rossi-Hansberg, 2023), but that climate-induced migration may also increase conflict (McGuirk and Nunn, 2023).

countries existed during the Age of Mass Migration (1850-1920), when more than 30 million people moved from Europe to the US.[2] Likewise, there are few formal impediments to domestic migration in the US, both historically and in the present day.[3] The relative lack of internal and international restrictions on mobility and the wide range of climate zones imply that migrants have a large variety of climatic options to choose from. Third, rich datasets allow us to precisely measure the relationship between climate similarity and migration.

Figure 1 summarizes our central result in a scatterplot of the average temperatures where immigrants settled in the US in 1880 against the average temperature in each migrant-sending country of origin. This figure indicates that immigrants coming from warmer (colder) countries settled in similarly warmer (colder) parts of the US. The migrant-mix in the US in 1880 included large groups with well-established networks (e.g., the Irish and the Germans) as well as pioneers from countries that would later see mass migration (e.g., Italy, Japan, or Poland). While similar patterns hold in other decades (1900, 1920, 1940), this earlier period reduces concerns that Figure 1 merely captures the persistence of ethnic enclaves—a possibility that we further investigate and rule out.[4]

The paper will show that the positive association between climate similarity and migration is remarkably robust, holding across time periods, geographies, migrant groups, and definitions of climate. In Section 2, we provide descriptive evidence from a variety of contexts using different approaches. After verifying that results in Figure 1 hold across time periods, including today, and do not merely reflect factors such as geographic distance, country of origin GDP, or past migration, we turn to a novel dataset. We use US mortality records for 1959-1961, which track the country of origin of each foreign-born individual who died in the US. Comparing the temperature in the capital city of the country of origin to the temperature in the US county of death of foreign-born individuals, we confirm the positive association between climate at origin and climate at destination in Figure 1.

Next, we move beyond cross-country evidence to explore whether the climate-migration relationship holds *within* countries. First, we focus on German immigrants at the turn of the 20$^{\text{th}}$ century—when this group accounted for 30% of the US foreign-born population—and develop a novel measure of climate similarity based on the spatial distribution of surnames in Germany and in the US. Second, we consider Norwegian immigrants between 1865 and 1880,

[2] In 1917, US Congress mandated a literacy test for all immigrants (Goldin, 1994). This was followed by the 1921 and 1924 Immigration Acts, which drastically reduced European immigration until 1965. The quotas did not apply to migrants from Mexico and Canada, but stringent restrictions had been introduced against Chinese and Japanese immigrants in 1882 and 1907, respectively (Abramitzky and Boustan, 2017).

[3] Although the movement of white individuals within the US was largely unregulated, formal and informal restrictions severely limited the movement of African Americans and Native Americans (Alston and Ferrie, 1999; Nichols, 2014).

[4] In 1880, approximately 85% of the US foreign-born population came from Europe (Abramitzky and Boustan, 2017). Results in Figure 1 are unchanged when restricting attention to European immigrants.

when around 250,000 individuals (or, 15% of the 1865 Norwegian population) embarked for the US. Using automated algorithms developed in the literature (Abramitzky et al., 2021), we link the 1865 Norwegian and the 1880 US Censuses to match individuals across locations (and the corresponding climates) over time. Third, we turn to US internal migration from 1850 to 1940—a period characterized by the westward expansion of the United States (Bazzi et al., 2020). We rely on linked datasets assembled by Abramitzky et al. (2020) to follow migrants moving across US counties from one decade to the next. In all cases, the relationship depicted in Figure 1 across countries also holds within countries. That is, German, Norwegian, and US domestic migrants matched on climate: individuals from colder (warmer) origins settled in relatively colder (warmer) destinations in the US.

Motivated by the patterns described thus far, in Section 3 we estimate the effects of climate distance on migration at the origin-by-destination level with gravity equations that are common in the trade literature (Anderson and Van Wincoop, 2003). We focus on the two settings for which we can measure origin and destination climates at a highly granular level. First, we consider the linked dataset of Norwegian migrants mentioned above. We collapse the individual-level data to the Norwegian municipality by US county level, defining the climate distance between origin and destination as the absolute value of the difference in the average climate (temperature or precipitation) in each area. We show that municipality-to-county migration is higher for pairs with more similar climates. Specifically, we find that a decline in temperature distance of 7.5°C—roughly equivalent to the mean sample distance, or the annual difference between New York City and Oslo—increases migration between origin and destination by .86%. This corresponds to a reduction in geographic distance of about 1,600 km (or, the distance between New York City and Minneapolis). Precipitation distance has a similar, albeit somewhat smaller, effect on migration.

When examining the relationship between climate and migration, a key concern is that climate is spatially correlated.[5] For this reason, any association between the two variables may simply reflect geographic, rather than climate, distance. Our Norway-US estimates are unlikely to suffer from this problem because the transatlantic component of migration breaks the potential spatial correlation of climate. Nevertheless, we show that results hold when controlling for US county and Norwegian municipality fixed effects as well as for the difference in several county-municipality pair variables—including other geographic features (e.g., elevation and ruggedness) and measures of economic activity (e.g., employment shares across sectors)—and when using alternative linking methods and time periods to match immigrants across Norwegian and US Censuses.

[5] Climate is no exception to the first law of geography: "Everything is related to everything else, but near things are more related than distant things" (Tobler, 1970).

Second, we consider US internal migration from 1850 to 1940, collapsing and stacking the data at the county pair-decade level to estimate gravity regressions. Concerns about the spatial correlation of climate may be more relevant for US internal migration, since one might expect climate and geographic distances to be correlated. In our setting, however, it turns out that geographic distance explains at most 22% and 31% of the variation in, respectively, temperature and precipitation distance between county-pairs. To err on the side of caution, all our analyses control for county-pair geographic distance. In addition, we *i*) account for non-linearities in geographic distance, *ii*) consider the direction of move (e.g., east-west; north-south) separately, *iii*) control for distance in terms of latitude and longitude, *iv*) drop migration between neighboring counties and within states, *v*) exclude potentially anomalous states (such as California) and counties, *vi*) use travel cost measures other than physical distance that vary over time due to rail expansion; and, *vii*) adjust standard errors to account for spatial correlation.

Regardless of the specification and approach used, climate similarity strongly predicts bilateral migration flows. Reducing temperature and precipitation distance between any county-pair by 5.3°C and 30 mm per month (approximately equal to the mean distances in the internal migration sample) increases migration by 1.4% and .33%, respectively.[6] The implied effect of temperature distance is roughly equivalent to reducing geographic distance by 1,000 km (e.g., New York City to Detroit) or raising wages at destination by 1%. Compared to the US-Norwegian context, coefficients are somewhat larger for domestic migration, but of overall similar magnitudes; moreover, in both cases the effect of temperature is stronger than precipitation.

Besides the exercises already described to account for the potentially confounding effect of climate distance, we verify that results hold when: *i*) considering each decade separately; *ii*) accounting for the county-pair difference in several economic, demographic, and geographic variables (including ruggedness, elevation, coastal access, and soil type); *iii*) controlling for the distance in climate variability as well as for other forces shaping population movement and economic activity during our sample period, such as exposure to the frontier (Turner, 2017; Bazzi et al., 2020), market access (Donaldson and Hornbeck, 2016), and connection to railroads (Atack and Margo, 2011); and, *iv*) defining climate distance in different ways. Because our results are obtained using linked samples, we address concerns about potential bias due to false positive matches and lack of representativeness (Bailey et al., 2020). We use the full count 1940 US Census, which asked individuals where they lived five years earlier, to construct a county-pair migration matrix that does not rely on linking algorithms. Reassuringly, we continue to find that climate similarity strongly predicts migration.

[6] For reference, 5.3°C is comparable to the average annual temperature distance between Chicago (9.8°C) and Washington DC (14.6°C); Seattle (11.3°C) and San Jose, CA (16.4°C); and, Berlin (10.3°C) and Rome (15.2°C).

One may be worried that our estimates partly reflect the persistence of cultural, social, or economic factors correlated with both climate and migration—even after controlling for our large battery of county-pair covariates. To address this potential concern, we leverage shifts in average climate across counties throughout the 20th century, which are influenced by multi-decadal oceanic oscillations (e.g., North Atlantic Oscillation) as well as anthropogenic climate change. We find that *changes* in climate distance from 1900 to 2019 predict *changes* in migration between county-pairs over the same period. Our estimates imply that two counties whose temperature distance declined by 1°C throughout the 20th century experienced a 3.5% increase in migration over the same period. Besides reducing concerns of identification, these results have important policy implications in light of the projected climate change, which we discuss below.

In Section 4, we turn to the mechanisms. We start by exploring the role of ethnic enclaves—examining the possibility that climate similarity determined the location of pioneers, and that subsequent migrants from the same origin merely followed the footsteps of the first movers without taking climate into account. While this scenario would not alter the validity of our findings, it would change their interpretation. We replicate the analysis controlling for migration flows in previous decades from a given origin to a given destination. We also limit the sample to newly settled destinations, where the scope for ethnic networks to influence migrants' location decision is limited. Notably, results remain unchanged: we continue to detect a strong relationship between climate similarity and migration.

Then, we consider two broad classes of complementary mechanisms. First are those capturing climate-specific human capital and skills (Steckel, 1982; Bazzi et al., 2016), such as farming expertise and techniques for surviving extreme heat or cold events. Supporting this channel, results are larger in magnitude for farmers than for non-farmers and become smaller over time as the share of the US population working in agriculture declined. Because skill transferability matters more in more weather-exposed occupations, such as agriculture, these patterns suggest that climate-specific human capital is an important, though not the exclusive, driver of our results.

The second class of factors driving climate matching involve climate as an amenity. Stable and predictable climates favor the transmission of cultural norms across generations (Giuliano and Nunn, 2021), and migrants might value a familiar climate to the extent that it facilitates the persistence of cultural practices. Consistent with this channel, we find that climate distance influences migration also for non-farmers, who work in sectors that are less tied to climate and where climate-specific human capital is less relevant than for farmers. Moreover, using present day data from the US Internal Revenue Service (IRS), we document that climate similarity predicts US domestic migration even at a time when US workers are far more insulated from climate than in the past.

In Section 5, we discuss the implications of our findings. We begin by estimating the value of climate for migrants. In a first exercise, we leverage temporal and spatial variation across US counties generated by the 1862 Homestead Act, which transferred 10% of US land from the federal government to 1.6 million farmers (Edwards et al., 2017). We find that the Homestead Act, by subsidizing land, reduced the role of climate distance in governing migration decisions. Contrasting counterfactual migration flows predicted by our estimates, we calculate that the Homestead Act increased the average temperature mismatch of migrants by .1°C. Using price differentials between Homestead land and other federal lands available for purchase, we estimate the value of an additional 1°C in climate similarity to be about $4,500 in current dollars.

In another exercise, we use the mortality records encompassing the universe of foreign-born individuals who died in the US between 1959 and 1961 to test the relationship between climate mismatch and life expectancy. We estimate individual-level regressions that relate age at death to the temperature distance between the country of birth and the US county of death, controlling for county of death and country of origin fixed effects as well as for individual demographic characteristics. Our analysis suggests that 1°C of climate mismatch is associated with approximately one month reduction in lifespan. Expressing these results in terms of the Environmental Protection Agency (EPA)'s value of a statistical life of $9.6 million (in 2020 dollars) implies that one additional Celsius degree similarity is worth around $14,300 per person in today's dollars.

Next, we examine the link between climate change, migration, and population growth. First, we combine our estimate of the elasticity of migration with respect to climate distance from Section 3 with the change in average temperature distance between each county-pair recorded during the 20$^{\text{th}}$ century. We derive a measure of climate connectivity similar in spirit to rail-based "market access" in Donaldson and Hornbeck (2016). We then show that population growth from 1960 to 2010 was faster in US counties that experienced a stronger increase in their climate connectivity with other parts of the country. Finally, we perform a similar analysis for the future, using localized climate change projections through the 21$^{\text{st}}$ century. Our estimates suggest that spatial heterogeneity in global warming will increase future climate connectivity in the US South, resulting in faster population growth there relative to other regions in the US.

Our findings are relevant to the growing literature on the global impacts of climate change. Recent papers seek to understand the effects of climate shocks on the global economy through general equilibrium models that assume that the migration costs underlying individuals' location and occupational choices are exogenous to climate change (Cruz and Rossi-Hansberg, 2023; Desmet and Rossi-Hansberg, 2023; Bilal and Rossi-Hansberg, 2023). Our evidence indicates that migrants place a large weight on climate similarity between origin and destination.

The value that migrants place on climate distance is a travel cost that depends on the spatial distribution of climate change. Thus, our results can be used to enrich these models, improving the precision of welfare estimates and the assessment of the macroeconomic effects of climate change.

Our paper also speaks to recent work that has used hedonic approaches to cross-sectionally estimate the value of climate as an amenity, finding that, on average, people prefer mild temperatures and seek to avoid excess heat and cold (Albouy et al., 2016; Sinha et al., 2021). These papers assume climate preferences to be homogeneous across individuals, and abstract from the notion that migrants might value climate similarity. A notable exception is Albouy et al. (2021), who compare the location choice of domestic and international migrants across US cities between 2000 and 2014, finding a positive correlation between selected features in the country of origin and city of destination—from safety to coastal proximity to number of winter days with mild temperatures.

We complement this work in several ways. First, we provide systematic evidence on the relationship between origin and destination climate using a broad and generalizable measure like mean annual temperature—which is easily measured, understood, and translatable into climate change models. Second, we show that this relationship is robust to controlling flexibly for the spatial correlation of climate and a wide array of non-geographic characteristics, and that it holds across settings, climate statistics, time periods, and geographic areas. Third, we explore the channels behind the relationship between climate similarity and migration. Fourth, we estimate the value of climate similarity. Fifth, we examine the relationship between climate change, migration patterns, and population growth—both in the past and in the decades ahead.

Finally, to the best of our knowledge, we provide the first piece of systematic evidence in support of the long-standing idea that historical migration patterns in the US were influenced by climate similarity (Coolidge, 1926; Steckel, 1982; Fischer, 1989).[7] By shedding light on a new, important driver of migration—namely, climate similarity—at a critical point in American history, we also contribute to the large literature on US internal (Bazzi et al., 2020, 2023a; Zimran, 2023) and international (Eriksson, 2020; Abramitzky and Boustan, 2022; Collins and Zimran, 2023) migration between 1850 and 1940.

[7] As early as the 1600s, climate matching was an important consideration for English migrants to North America and the West Indies, who expressed "profound anxiety" about the health and productivity impacts of climates that diverged from England's temperate climate. Sir Ferdinando Gorges, who founded the Province of Maine in 1622, argued that New England was "more suitable to the nature of our people, who neither finde content in the colder Climates, nor health in the hotter; but (as hearbs and plants) affect their native temperature, and prosper kindly no where else" (Kupperman, 1984).

2 Motivating Evidence: Climate and Migration

Climate. Throughout the paper, we use temperature and precipitation yearly averages as our main proxy for a location's climate. We obtain measures of climate for US counties by taking averages of yearly variables from the NOAA Monthly US Climate Divisional Database (Vose et al., 2014), over different time periods. For example, historical climate in the US is obtained by averaging yearly temperature and precipitation between 1895 and 1920.[8] To measure climate outside the US, we use TerraClimate monthly gridded data (Abatzoglou et al., 2018). We take the average of yearly temperature and precipitation between the first available year, 1958, and 1980 to proxy for the climate prevailing at the turn of the 20th century. We deem this approximation reasonable, given that the effects of anthropogenic climate change only became noticeable in most countries after 1980 (Burke and Emerick, 2016; Kirchner, 2021).

Figure A1 plots the distribution of climate in the US. Climate gradients follow well-known patterns: it gets colder as one goes north and drier as one goes west. However, geographic features such as mountains and water bodies lead to significant within-country variation in climate. Low average temperatures are recorded in the Rocky Mountains in the US. The east-west precipitation gradient is interrupted in the US Southeast by southerly winds blowing from the Gulf of Mexico and bringing moisture. These disruptions in otherwise continuous climate patterns are not specific to the US and provide useful variation for our analysis.

Cross-country evidence from US Censuses. We first provide additional evidence in support of our headline Figure 1 to showcase the robustness of the positive relationship between climate at origin and climate at destination among migrants. In Panels B to D of Figure A2, we show that results hold for subsequent decades (1900, 1920, and 1940). To account for the possibility that confounders are driving the raw correlation shown in the figures above, Figure A3 controls for: GDP per capita in the country of origin (Panel B); average geographic distance between the capital city of the country of origin and the US counties where individuals from each immigrant group lived in 1880 (Panel C); and, the number of immigrants from each origin country living in each US county in 1870 to proxy for the potential role of ethnic enclaves (Panel D).[9] Results are virtually unchanged and closely resemble those from the baseline specification. Finally, we replicate Figure A3 for the more recent period using data from Manson et al. (2023). In Figure A4, we document that the positive association between origin-destination temperatures holds as of 2015, when the composition of US immigrants differed starkly from that

[8] Because data prior to 1895 are not available at a sufficiently fine resolution for our purposes, we are unable to cover the entire period for which we measure US historical (international and domestic) migration. However, the turn of the 20th century was not characterized by large shifts in climate, and the climate between 1850 and 1900 was rather similar to that prevailing in the subsequent two decades.

[9] We use full count US Censuses (Ruggles et al., 2021) to measure the number of immigrants from each origin in each US county in a given decade. To maximize the sample size, we use GDP (taken from Bolt et al., 2018) measured in 1920, which is available for 50 countries. Results are unchanged when using GDP for other years.

prevailing in the early 20th century.[10]

Evidence from US death certificates. Next, we use publicly available US mortality data, derived from individual-level death certificates, for the three years from 1959 to 1961 (National Center for Health Statistics, 2021). US mortality records typically only report whether an individual was born in the US, a US territory, or the "rest of the world." However, for the years 1959-1961, they also include an individual's country of birth for all locations outside the continental US. Mortality data complement the full count US Census datasets by reporting where in the US the person died—a proxy for where they ended up settling, as opposed to the Census, which captures individuals' residence at a given point in time. Figure 2 compares the temperature in the capital city of the country of birth to the average temperature in the US county of death of foreign-born individuals from each birth country. Consistent with Figure 1, we find a strong and positive relationship between temperature at origin and temperature at destination.

Surname-level analysis for German immigrants. We complement the cross-country evidence described thus far by exploring whether climate and migration are correlated also *within* countries. We begin by focusing on German immigration to the US in the late 19th century. Between 1850 and 1880, approximately $2,450,000$ Germans moved to the US, and, by 1880, they represented the largest immigrant group in the country, accounting for 30% and 4% of the foreign-born and the total population, respectively. Since full count Censuses do not exist for Germany for this historical period, we assemble a novel dataset that assigns to German immigrants in the US the climate in their predicted place of origin. We use German WWI casualty data from Verein für Computergenealogie e.V. (2014), which record each individual's name, surname, and place of birth. This allows us to derive the geographic distribution of surnames in Germany at the turn of the 20th century, and the average temperature associated with each surname (see Appendix B.5 for more details). Then, we leverage the distribution of German immigrant men in the 1880 full count US Census to compute the average temperature (across US counties) associated with each German surname. In Figure 3, we present results of a surname-level regression that correlates the average temperature in Germany with the average temperature in the US. We find that *within* countries there is a positive and statistically significant relationship between the climate at origin and at destination. That is, Germans with surnames highly prevalent in colder (warmer) parts of Germany tended to live in colder (warmer) parts of the US.[11]

[10] In 1920, 85.2% of the US foreign-born population came from Europe, while only 3.8% and 1.6% came from Latin America and Asia, respectively. In 2015, Asian and Latin American immigrants accounted for 29.7% and 51.8% of the US foreign-born population, respectively. Only 11.5% of immigrants living in the US were born in Europe, instead. Panels B to D of Figure A4 verify that results hold when controlling for other variables—most notably, the historical number of immigrants from each origin in each US county.

[11] While not reported for brevity, results are robust to including a large set of control variables defined as surname-level averages

Climate matching at the individual-level for Norwegian immigrants. Finally, we consider the experience of individual migrants. In Appendix B.2, we use automated algorithms developed in the literature (Abramitzky et al., 2020, 2021) to link the 1865 Norwegian and the 1880 US full count Censuses, made available by IPUMS (The Digital Archive, 2008; Ruggles et al., 2021). We create a linked dataset of Norwegian immigrants that reports their municipality of origin in 1865 and their US county of residence in 1880. In Panel A of Figure 4, we present a binned scatterplot produced by regressing the average temperature of the US county where the immigrant was living in 1880 against the average temperature prevailing in the Norwegian municipality of origin in 1865. The positive and statistically significant coefficient indicates that Norwegian immigrants from colder municipalities within Norway located in colder US counties, as compared to Norwegians coming from milder parts of the country.[12]

Climate matching at the individual-level for US domestic migrants. In Panel B of Figure 4, we turn to US domestic migration. We rely on linked samples from 1850 to 1940 assembled by Abramitzky et al. (2020) and available through the Census Linking Project (see Appendix B.3 for more details).[13] Focusing on individuals who moved across counties in each decade between 1850-1860 and 1930-1940, we estimate a regression analogous to the one presented in Panel A for Norwegian immigrants, correlating average temperature in the county of destination with average temperature in the county of origin.[14] Confirming our previous results, US domestic migrants originating from colder counties systematically moved to colder destinations. To assuage potential concerns about spatial correlation of climate in the context of internal migration, Panel B of Figure A5 verifies that results are unchanged when controlling for county-pair geographic distance.

3 Main Results

The evidence in Figures 1 to 4 points to the existence of a positive relationship between climate at origin and climate at destination that holds across datasets, at the individual and at the aggregate level, and between and within countries. Motivated by these patterns, we formally examine the link between climate similarity and migration. Building on the trade literature, we estimate gravity models (Anderson and Van Wincoop, 2003) that express migration flows as a

(e.g., distance from New York City; individual and county-level characteristics of German immigrants in the US).

[12] We cluster standard errors at the US state by Norwegian province level. Results hold when controlling for the distance between destination counties and New York City and between origin municipalities and the closest major Norwegian port (Figure A5, Panel A), or other proxies for the physical distance between origin and destination.

[13] Because women often changed surnames upon marriage, standard linking algorithms focus on men (however, see Olivetti and Paserman, 2015 and Althoff et al., 2022 for exceptions). Following Abramitzky et al. (2021), we restrict our analysis to men. The exact year of migration cannot be measured either in the 1865-1880 Norwegian or in the US domestic linked samples. We thus impose the restriction that individuals must be at least 15 years old in the previous decade.

[14] Standard errors are clustered at the state of origin by state of destination by decade level.

function of the climate distance between origins and destinations. We focus on the two contexts that allow for the measurement of climate at origin and destination at a highly granular level: Norwegian immigration to the United States during the Age of Mass Migration (Section 3.1) and US domestic migration from 1850 to 1940 (Section 3.2). Then, we leverage long-difference variation in the distribution of climate across US counties from 1900 to 2019 to study if changes in climate distance over time predict changes in migration (Section 3.3).

3.1 Norwegian Immigration

Historical context. The first record of Norwegian immigrants to the US dates back to 1825, when 30 families moved to Pennsylvania. More migrants followed in the 1850s, although their numbers remained relatively limited. From the onset, Norwegian pioneers sent letters to their families and friends back home praising the quality of the US soil and emphasizing the similarity between the destination and the origin climates. Describing the conditions prevailing in Vernon, Wisconsin, in 1842, Norwegian immigrant Ole Knudsen Trovatten noted that there was "[...] no difference between the climate here and in Norway. To be sure, some days in the summer are warmer here—but the warmth is not excessive" (Blegen, 1955, p. 433). Along similar lines, Paul Hjelm-Hansen, who settled in Alexandria, Minnesota, wrote to his relatives that "Winter sets in in November with about the same degree of cold as in western Norway, and it continues, as a rule, into March" (Blegen, 1955, p. 441).

Norwegian mass migration did not take off until the 1860s, when severe frosts led to pervasive crop failures and pushed thousands of individuals out of the country. Between 1865 and 1880 alone, 250,000 individuals (15% of Norway's population in 1865) migrated to the United States (Semmingsen, 1960). In 1880, Norwegian immigrants accounted for about .4% and 2.7% of the total and the foreign-born US population, respectively. The size of the Norwegian population in the US continued to increase until the early 1910s, and another large wave of migration was recorded between 1903 and 1910, when around 200,000 individuals left Norway for America (Semmingsen, 1978). After 1910, the number of Norwegians living in the US began to decline, partly as a result of the Immigration Acts of the 1920s. Overall, it is estimated that, between 1825 and 1920, more than 1 million individuals moved to the United States (Eriksson, 2020).

At the onset of Norwegian mass migration, Norway was a predominantly rural country: in 1865, only 15.3% of the male population (15+) resided in urban areas, and about 50% of men (15-64) in the labor force worked in agriculture (Table A1, columns 1-3).[15] Norwegians who

[15] Numbers are very similar when considering both men and women and dropping age restrictions, which are introduced to more meaningfully compare the characteristics of individuals in the linked sample with those of people in the full count. See also Appendix B.2 for more details on the construction and the characteristics of the linked sample.

can be linked to either the 1880 US or the 1900 Norwegian Census are similar to those in the full count, along these and other characteristics (Table A1, columns 4-6). In Table A2, we compare the baseline characteristics of individuals in the linked sample who stayed in Norway to those of individuals who migrated to the US. Consistent with the evidence in Abramitzky et al. (2012), some differences emerge. Movers were more likely to live in urban areas, to be in the labor force, and to work in manufacturing (rather than in agriculture or farming).

Figure A6 contrasts the geographic distribution of Norwegian men in the full count (Panel A) and that of stayers (Panel B) and migrants (Panel C) in the linked sample. It shows that migrants tended to live in the southeast of Norway, whereas stayers were more evenly distributed across all Norwegian municipalities. Given east-west precipitation gradients in Norway, this explains why migrants experienced lower precipitation levels than stayers (97 vs 99 mm per month on average). Because temperature does not follow clear gradients in Norway, the average temperature of stayers and migrants was instead very similar (Table A2).

The residential choices and the occupations of Norwegian men in the US mirrored those prevailing in the country of origin. In 1880, about 18% of Norwegian men in the US lived in urban areas, and approximately 63% of men in the labor force worked in agriculture (Table A3). In 1880, Norwegian enclaves were concentrated in Minnesota, Wisconsin, and Iowa, although some immigrant communities could also be found in parts of California and Washington state (Figure A7). Over time, immigrant settlements expanded and, by 1920, Norwegians lived in most states and counties, except for the South and the East (Eriksson, 2020). Notably, as for the Norwegian Census, the characteristics of Norwegian immigrants in the full count US Census and in the linked samples are very similar to each other in 1880 along both socio-economic and environmental dimensions (Table A3).[16]

Baseline estimates. Using the sample of individuals linked across the 1865 Norwegian and the 1880 US Censuses, we collapse the data at the Norwegian municipality of origin (o) by US county of destination (d) level. We restrict attention to US counties that, as of 1880, had at least one European immigrant, to proxy for the set of destinations available to Norwegians.[17] Since the migration matrix is sparse, we follow the literature (Silva and Tenreyro, 2006) and use Poisson Pseudo Maximum Likelihood (PPML) to estimate:

$$M_{od} = \exp[\alpha_p + \gamma_s + X_o + X_d + \beta_1 \text{Dist}_{od}^{\text{Temp}} + \beta_2 \text{Dist}_{od}^{\text{Precip}}]\epsilon_{od} \tag{1}$$

where M_{od} is the number of immigrants from Norwegian municipality o to US county d between

[16] This holds also for the other years considered in our analysis below. Statistics for these additional Census decades are not reported for brevity.

[17] As we show below, results are unchanged when dropping this restriction or when changing the set of potential US destinations.

1865 and 1880; $Dist_{od}^{Temp}$ and $Dist_{od}^{Precip}$ are the absolute value of the difference between origin o and destination d average temperature and precipitation, respectively; X_o and X_d are vectors of Norwegian municipality and US county controls described below; and, α_p and γ_s are Norwegian province and US state fixed effects. We cluster standard errors at the Norwegian province by US state level.

We present results in Table 1, where we also report standardized beta coefficients in square brackets. In column 1, we estimate a parsimonious specification that only includes temperature and precipitation distance. The negative and statistically significant coefficients indicate that higher temperature and precipitation distances are associated with lower migration. The transatlantic component of migration generates a "geographic break" that reduces concerns that our estimates may be confounded by the spatial correlation of climate. In other words, all migrants must cross an ocean greater in distance than what they would travel either in Norway or within the US. The large travel distance also eliminates the possibility that we are capturing the effect of migrants moving to a neighboring town that happens to have the same climate.[18] To more explicitly account for the effect of physical distance, in column 2, we include the distance between the US destination county and New York City, as well as that between the Norwegian municipality and the closest transatlantic port.[19] Coefficients are unchanged.

In column 3, we add US state and Norwegian province fixed effects. The point estimates, especially for temperature distance, become smaller in absolute value, but remain negative and highly statistically significant. The drop in the magnitude of coefficients should not be surprising. When adding province and state fixed effects, we are effectively comparing migration flows: *i*) between municipalities within the same Norwegian province and any US county; and, *ii*) between any Norwegian municipality and counties within the same US state.[20] It is possible that, even within a US state or a Norwegian province, climate similarity might be correlated with other origin and destination characteristics, which may, in turn, influence bilateral migration flows. For example, migrants from municipalities with more limited economic opportunities may select US counties with a stronger economy. Likewise, migrants from more rural and agricultural municipalities might sort into destinations with similar economic and residential structures.

If such forces are also correlated with climate distance, our estimates may be biased. For this reason, in column 4, we add a large vector of US county and Norwegian municipality controls.[21] We include variables that can be measured consistently in the Norwegian and in

[18] In Figure A8, which displays the climate distance between Oslo (Norway) and each US county, we see significant spatial variation.

[19] We consider the two major ports of this period—Oslo and Kristiansand—but results are unchanged when including other ports.

[20] In our sample, there are only 20 provinces and 435 (historical) Norwegian municipalities, with an average of 21 municipalities within each province.

[21] Because the economic, demographic, and urban structure may be endogenous to climate, these variables may be "bad controls"

the US Censuses: population density, the urban population share, sex ratios, the share of men in the labor force, and the employment share in agriculture and manufacturing. For the US, we also add: the immigrant, the Norwegian, and the Black population share; total frontier experience from Bazzi et al. (2020); and, the measure of market access from Donaldson and Hornbeck (2016).[22] Coefficients remain negative and statistically significant.

According to the estimates in column 4, which we take as our preferred specification, reducing temperature and precipitation distance by 7.5°C and 40 mm per month (approximately equal to the mean sample distance, or the annual temperature difference between New York City and Oslo) increases migration by .80% and .24%, respectively. The effect of temperature distance is quantitatively relevant and comparable to that of decreasing the physical distance between New York City and a US county by about 1,600 km (e.g., from New York City to Minneapolis). Notably, the effects of climate distance on migration are larger for temperature than for precipitation. Indeed, the standardized beta coefficient on temperature distance (which is very similar to that on physical distance) is 2.2 times larger (in absolute value) than that on precipitation distance. As we show below, we systematically observe this pattern across settings and time periods.

Climate similarity vs other forces. The stability of coefficients to the inclusion of Norwegian municipality and US county controls reduces concerns that results might reflect forces other than climate similarity. To more cleanly isolate the role of climate, in Table A4 we estimate more stringent specifications. In column 2, we replace the Norwegian municipality (X_o) and US county (X_d) controls with their difference (X_{od}).[23] In column 3, we simultaneously include X_o, X_d, and X_{od}. In both cases, coefficients remain very similar to those from our preferred specification (reported in column 1 to ease comparison).

In column 4, we replace the vector of controls X_o with municipality fixed effects, thereby absorbing any origin characteristic that might trigger migration to destinations that are systematically a better or worse climate match. Coefficients remain negative and precisely estimated—if anything, the effect becomes stronger. In column 5, we replicate our baseline specification by replacing X_d with US county fixed effects, which account for county-specific pull forces that might attract Norwegian immigrants from origins with a more (or less) similar climate. Coefficients drop, but remain statistically significant and, especially for temperature, quantitatively large. In column 6, we estimate a very demanding specification that simultaneously includes both Norwegian municipality and US county fixed effects. In column 7, we further add the

(Angrist and Pischke, 2009).

[22] All Norwegian and US controls are measured, respectively, in 1865 and 1880. See Appendix B for more details. Results are robust to including more controls or measuring US variables in 1870 or (when available) 1860.

[23] We collect in X_{od} only those variables that can be measured for both Norway and the US. We continue to include in the regression the set of controls that can be measured only at the county-level.

vector of origin-destination difference controls, X_{od}. Even though the coefficient on precipitation distance drops to zero and becomes statistically insignificant, that on temperature distance remains precisely estimated and quantitatively relevant.

Findings in Tables 1 and A4 support the notion that climate distance is an important driver of migration. However, one may wonder whether our results also pick up the effect of other geographic features correlated with climate. For instance, Albouy et al. (2021) find that immigrants moving to the US in the present day tend to select cities that are similar to their countries of origin in terms of distance from coast, elevation, temperate winters, and number of sunny days. To address this possibility, in Table A5 we augment the preferred specification (reported in column 1) by controlling for the origin-destination difference in elevation (column 2) and ruggedness (column 3). We also control for the coastal status of US counties (column 4). In all cases, the coefficients on climate distance are in line with those from the preferred specification. Results also hold when including all additional geographic features simultaneously (column 5).

Sample restrictions and alternative linking methods. Our results point toward the importance of climate similarity in migration decisions. This relationship is unlikely to be confounded by other factors and, as documented in Section 4.1, holds across samples and time periods. We now present two additional sets of robustness checks. First, in Table A6 we replicate the analysis conducted in Table 1 by considering different sets of origins and destinations. In the baseline specification (restated in column 1 of Table A6 to ease comparisons), we consider all US counties with at least one immigrant in 1880 as a proxy for destinations available to Norwegian migrants. In column 2, we consider all US counties, irrespective of the presence of foreign (or native) born individuals. Columns 3 and 4 restrict attention to counties with at least one Norwegian immigrant in the 1880 full count US Census and in the 1880 linked sample, respectively. Columns 5 and 6 (resp., column 7) drop US counties and Norwegian municipalities (resp., county-municipality pairs) in the top 1% of the linked sample population (resp., number of migrants). Finally, column 8 excludes all US counties within Minnesota—the most common destination of Norwegian immigrants during the 1865-1880 period. In all cases, results remain in line with those from the baseline specification.

Second, in Table A7 we address the potential concern that our estimates may be biased due to false positive matches obtained in our linking procedure (Bailey et al., 2020). Column 1 replicates the baseline specification (Table 1, column 4), where the linked sample used to derive the number of immigrants is restricted to men 10+ in 1865. In columns 2, 3, and 4, we consider men: 15-40 in 1865 (in Norway), 18-65 in 1880 (in the US), and without age restrictions. Columns 5 and 6 derive the linked sample using, respectively, the Jaro-Winkler (JW) and the conservative version of the New York State Identification and Intelligence System (NYSIIS) algorithms from Abramitzky et al. (2012).[24] In all cases, results are unchanged.

International immigrants beyond the Norwegians. As noted above, more than 1 million people migrated from Norway to the US during the Age of Mass Migration. While sizeable, this represents only a small fraction of immigrants in the US between 1880 and 1920. One may thus wonder how much the patterns presented in this section apply to international immigrants more broadly. The correlations displayed in Section 2 suggest that climate matching was not specific to the Norwegians. To more formally test this conjecture, we replicate the analysis considering all immigrants in the US from 1880 to 1920.[25] We stack the data at the country of origin by US county of residence by decade level; then, using PPML, we estimate:

$$M_{odt} = \exp[\alpha_{ot} + \gamma_{dt} + \beta_1 \text{Dist}_{od}^{\text{Temp}} + \beta_2 \text{Dist}_{od}^{\text{Precip}}]\epsilon_{odt} \tag{2}$$

M_{odt} is the number of immigrants from country o living in US county d in decade t.[26] Similar to equation (1), $Dist_{od}^{Temp}$ and $Dist_{od}^{Precip}$ are absolute temperature and precipitation differences between o and d. Since we lack full count Censuses for most countries, as in Figures 1 and 2 above, we define origin climate in the capital city of the country. Despite this coarser definition of origin climate, equation (2) complements results obtained with spatially-granular Norwegian data in three ways. First, it allows us to test the hypothesis of climate matching in migration more broadly. Second, it does not rely on linked data, which may be subject to potential limitations (Bailey et al., 2020). Third, it leverages substantial variation across time and climate zones, relative to the Norwegians who were clustered geographically within the US and came from a single, relatively small country. Such variation makes it possible to include a stringent set of fixed effects: country of origin by decade and county of destination by decade fixed effects, α_{ot} and γ_{dt}.

We report results in Table 2.[27] In column 1, we only include climate distances. In column 2, we add the geographic distance between the US county of destination and the capital city of the origin country. In column 3, we control for country, county, and decade fixed effects. In column

[24] Relative to the baseline linking method, the JW algorithm further restricts the sample to matches with names that are similar enough according to the JW similarity measure (we set the same threshold as in Abramitzky et al., 2012, but results are unchanged when using alternative values). The conservative version of the NYSIIS algorithm selects only individuals unique within a 5-year window around their birth date in terms of the matching variables.

[25] The 1890 US Census was destroyed in a fire, and we thus lack data for this decade.

[26] In all decades from 1900 to 1920, we consider the flow of immigrants, defined as individuals arrived in the US during the previous decade. Since the 1880 US Census did not record arrival year, for this decade, we consider immigrant stocks. Results, not reported for brevity, are virtually unchanged when dropping 1880, when considering the immigrant stock in all other years, and when restricting attention to European immigrants (who accounted for more than 85% of the immigrants living in the United States during this period). In our preferred specification, we end the analysis in 1920, as this is the last year before the introduction of the Immigration Acts of 1921 and 1924, which drastically reduced European (and total) immigration (Abramitzky and Boustan, 2017). However, results are robust to extending the sample until 1940 (the last year for which the full count US Census is available), and to considering each Census decade separately.

[27] We cluster standard errors at the US state by country of origin by decade level, and restrict attention to US counties with at least one international immigrant in a given decade. Results, not reported for brevity, are robust to using alternative clustering schemes and different sample restrictions.

4, we replace decade dummies with their interaction with US state dummies. Finally, column 5 estimates our preferred specification, which includes both county by decade fixed effects and country by decade fixed effects. In all cases, the coefficient on temperature distance is negative, quantitative large, and statistically significant. Our estimates imply that a reduction in temperature distance of about 7°C (close to the international sample average) increases migration by approximately 1.3%. This is comparable in magnitude to the effect of temperature distance estimated above for the Norwegians.[28]

3.2 US Internal Migration

Historical context. Between 1860 and 1940, the geographic distribution of the US population changed dramatically. This is shown in Figure A9, which plots population density across counties from 1860 (Panel A) to 1940 (Panel D). In 1860, of the 31.4 million people enumerated by the US Census, 36% and 20% lived in the Northeast and the South, respectively.[29] By 1900, fueled by mass European immigration, the US population had increased to 76.3 million, and its center of gravity had shifted from the East to the Midwest. The US westward expansion, promoted by the diffusion of the railroad networks especially between 1860 and 1900 (Fogel, 1964; Donaldson and Hornbeck, 2016), continued well into the 20$^{\text{th}}$ century. The first four decades of the 20$^{\text{th}}$ century were also marked by the Great Migration of 5 million whites and 1.5 million African Americans from the US South to the rest of the country (Gregory, 2006; Bazzi et al., 2023a). Internal migration patterns changed in the 1930s, due to the Great Depression (Rosenbloom, 2002; Fishback et al., 2006) and environmental shocks like the Dust Bowl (Hornbeck, 2012, 2023).

Demographic and geographic changes were accompanied by massive economic and social transformations. In Table A8, we report the characteristics of the male population in 1860 (Panel A), 1900 (Panel B), and 1940 (Panel C), for the full count (columns 1-3) and the linked sample (columns 4-6).[30] In 1860, 16.7% of men 15 or older lived in urban areas, and 52.5% (resp., 12.6%) of men (15-64) in the labor force were employed in agriculture (resp., manufacturing). Over time, cities grew and manufacturing employment rose, due to the rural-urban gradient of migration (Zimran, 2023) and to the process of structural transformation, which was stronger in initially rural counties (Eckert and Peters, 2022; Eckert et al., 2023). In 1940, at the end of

[28] In line with our previous results, instead, the coefficient on precipitation distance becomes imprecisely estimated and close to zero when adding the more saturated set of controls.

[29] Note that the 1860 US Census did not include enslaved Black Americans and Native Americans.

[30] As for Norwegian immigrants, we restrict attention to the male population to facilitate the comparison between the full count and the linked sample (see also Appendix B.3). In both the full count and the linked sample, we also impose the restriction that men are 15 or older to select those who were more likely to migrate. All results are unchanged when using different age or sample restrictions.

our sample period, the majority of the US population lived in urban areas and manufacturing had become as important as agriculture.

As pointed out in the literature (Bailey et al., 2020; Abramitzky et al., 2021), the linked sample is not fully representative of the (male) US population. This is true in our context as well. Compared to the full count, men in the linked sample are more likely to be white, native born, and literate (Tables A8 and A9). In the first part of our sample period, they are also more likely to be farmers, although this trend reverses after 1900. However, the differences are rather small, suggesting that, overall, the linked sample and the full count are comparable to each other.[31]

In Table A10, we focus on the linked sample and compare the characteristics of stayers (columns 1-3) and migrants (columns 4-6), over the entire period (Panel A) and at different points in time (Panels B and C). Between 1860 and 1900, migrants were more likely to be foreign-born (20.6% vs 11.1%) and live in urban areas (25.3% vs 22.1%), and less likely to be farmers (49.6% vs 58.4%), relative to stayers. However, consistent with the evidence documented in Zimran (2023), the urban-rural gradient of domestic migration changed during the 20$^{\text{th}}$ century: between 1910 and 1940, 50.4% and 52.8% of migrants and stayers lived in urban areas, respectively, and about 31% of men in both groups were farmers.[32]

Baseline estimates. Using the linked sample described above, we stack the data at the county-pair by decade level, from 1850-1860 to 1930-1940, to derive the number of migrants between any origin and destination in each decade. Then, using PPML, we estimate:

$$M_{odt} = \exp[\alpha_{ot} + \gamma_{dt} + \beta_1 \text{Dist}_{od}^{\text{Physical}} + \beta_2 \text{Dist}_{od}^{\text{Temp}} + \beta_3 \text{Dist}_{od}^{\text{Precip}}]\epsilon_{odt} \tag{3}$$

where migration flows from county o to county d are measured between decade $t-10$ and t, climate distances are defined as before, and $Dist_{od}^{Physical}$ is the physical distance between counties o and d. An important advantage of the US domestic migration setting is that we can rely on panel data (at the county-pair level) for several decades. As for international migration in equation (2), this allows us to include a stringent set of fixed effects. In our preferred specification, we interact decade dummies with both county of origin and county of destination dummies, α_{ot} and γ_{dt}. We cluster standard errors at the state of origin by state of destination by decade level.[33]

We report results in Table 3. In column 1, we only include temperature and precipitation distance. Coefficients are negative and precisely estimated. In column 2, we control for physical

[31] See Appendix B.3 for more details.
[32] All characteristics are measured in the baseline decade.
[33] Results are robust to using alternative clustering structures and to adjusting standard errors with the procedure in Conley (1999).

distance to reduce concerns that the spatial correlation of climate may bias our results. The point estimates on temperature and precipitation distance decline from -.375 to -.302 and from -.039 to -.014, respectively, but remain highly statistically significant. In column 3, we add county of origin, county of destination, and decade fixed effects. In column 4, we further interact decade dummies with state of origin and state of destination dummies.

In column 5, we present our preferred specification, which includes county of origin by decade as well as county of destination by decade fixed effects. This set of fixed effects absorbs any temporal and location-specific push and pull forces that might be correlated with county-pair climate distances. For instance, suppose that an economic downturn affecting the dairy industry in western New York state (causing out-migration) coincided temporally with an iron ore mining boom in Minnesota (causing in-migration)—and that the particular regions of New York and Minnesota had similar climates (by chance). County of origin by decade and county of destination by decade fixed effects isolate the variation in migration patterns between counties that remained *after* partialling out the average effect of such economic shocks.

Coefficients remain statistically significant and quantitatively relevant. According to the point estimate in column 5, lowering temperature and precipitation distances by 5.3°C and 30 mm per month (the average distances in our sample) increases migration by 1.4% and .33%, respectively. This is similar to the effect of reducing the physical distance between counties by 1,000 km (e.g., New York City to Detroit) and 220 km (e.g., Baltimore to Richmond), respectively. These estimates are also comparable to the effects of increasing earnings in the destination county in our sample by approximately 1.5%.[34] Relative to the US-Norwegian context, coefficients in the domestic setting are somewhat larger but of overall similar magnitudes.

As before, we find that the climate effect is stronger for temperature than for precipitation. This result resonates with the climate change economics literature, which has consistently found temperature to be an important factor in influencing health and economic outcomes (Carleton and Hsiang, 2016; Heal and Park, 2016; Deryugina and Hsiang, 2017). The precipitation link is less well established. Furthermore, in the agricultural context, temperature is a better predictor of crop yields than precipitation (Lobell and Burke, 2008; Schlenker and Roberts, 2009). Another reason for the more limited effect of precipitation might be that rainfall is spatially heterogeneous, less precisely measured than temperature, and subject to bias when spatially aggregated (Fezzi and Bateman, 2015). In addition, unlike temperature, the impacts of precipitation anomalies are mediated through soil moisture, and can be managed through cropping practices and irrigation (Proctor et al., 2022; Taylor, 2022).

[34] Since the US Census did not record wages prior to 1940, we follow the literature and proxy for earnings using occupational income scores (Abramitzky et al., 2014).

Spatial correlation of climate. Because climate tends to be spatially correlated, one may be worried that our estimates pick up the influence of physical—rather than climate—distance. This issue is potentially more prescient in the US domestic migration context, where we lack the Atlantic Ocean "break" that characterizes the international setting described earlier. However, while there exist general climate gradients within the US, geographic distance turns out to be a relatively weak predictor of climate. Figure A1 shows that in the US it gets colder as one goes north, and wetter as one goes west, but that geographic features such as mountains and water bodies lead to significant within-country variation in climate.[35] Indeed, a model aiming to predict the temperature distance (resp., precipitation distance) between county-pairs with a flexible function of geographic distance explains at most 22% (resp., 31%) of the variation.[36]

The primary way we address remaining concerns is by controlling for the geographic distance between county of origin and county of destination—accounting for the fact that most people make short-distance moves (e.g., to a neighboring county) to places that mechanically have similar climates. Since controlling linearly for physical distance may not adequately address all concerns related to the spatial correlation of climate, we perform a series of additional exercises.[37] First, in Table A11 we control non-linearly for geographic distance, allowing climate to vary across space in a non-linear way. Second, in Table A12 we consider each direction of move (e.g., east-west; north-south) separately. Third, in Table A13 we separately control for latitude and longitude distance (and thus for the horizontal or vertical spatial correlation in precipitation and temperature, respectively). Fourth, in Table A14 we drop: neighboring or next-to-neighboring counties, counties that belong to the same state or to adjacent states, counties within 100 km of geographic distance, and California.[38] Fifth, in Table A15 we allow physical distance to have a time-varying impact on migration by interacting it with decade dummies; and, replace geographic distance with a newly developed measure that takes into account time or cost of travel, which varied over time due to the expansion of the railroad network.[39]

In all cases, the point estimates remain close to those from our baseline. This reaffirms the significance of climate in explaining migration patterns and suggests that results are robust to concerns related to the spatial correlation of climate.

Additional geographic features. So far, we focused on temperature and precipitation distance. However, it is possible that other geographic features correlated with climate might

[35] To illustrate this point, Figure A10 plots the distribution of climate distances for two example locations within the US.

[36] See Appendix B.1 (Tables B1 and B2) for more details.

[37] In all the proceeding tables, we report our baseline results in column 1 to ease comparisons.

[38] California is a peculiar state: it attracted large flows of migrants during our sample period, but many of the early settlements were shaped by Pacific ports of entry or mining opportunities (i.e., the Gold Rush).

[39] See Appendix B.6 for a description of the railroad and transportation costs data.

drive our results. In Table A16 we augment our baseline specification by controlling for the county-pair distance in the following geographic attributes: elevation (column 2), ruggedness (column 3), and coastal access (column 4). Reassuringly, results are virtually unchanged, also when we include all three variables simultaneously (column 5).

Another feature that might be correlated with climate and that might influence migration, especially for farmers, is soil type. For this reason, in Table A17 we augment the baseline specification by controlling for the bilateral distance of key soil characteristics. Using gridded soil data, we derive the county-area average of four soil measures: bulk density (column 2), organic matter concentration (column 3), soil pH (columns 4), and water availability (column 5).[40] In column 6, we include all variables together. Coefficients on precipitation and temperature distance remain unchanged, suggesting that our results are not capturing the influence of soil characteristics. Interestingly, the coefficients on soil distance are negative and statistically significant, though smaller in magnitude than those on climate distance. To our knowledge, this is the first piece of systematic evidence in support of the idea, often discussed in historical and anecdotal accounts, that farmer migrants sought out destinations with similar soils.[41]

Finally, while we have documented a strong relationship between average climate and migration, it is possible that the seasonality of climate influences people's location decisions as well.[42] To this end, Table A18 replicates our preferred specification controlling for the distance in seasonality using two measures of climate variability: the standard deviation of temperature and precipitation across a year (column 2) and the annual range in temperature and precipitation (column 3).[43] In both cases, similarity in climate variability increases migration, suggesting that migrants take seasonality into account. However, the coefficient on average climate remains negative and statistically significant. Moreover, its size is an order of magnitude larger (in absolute value) than that on climate variability.

County-pair economic and demographic differences. One may wonder whether county-pair differences in economic or demographic factors correlated with climate distance might influence the relationship between climate and migration. For instance, even after controlling

[40] Bulk density is the weight of dry soil per unit volume, with higher values indicating compacted soil. Organic matter concentration is the percentage of decomposed plant and animal material in the soil—features that can influence soil fertility and structure. Soil pH is a measure of soil acidity that affects nutrient availability and the types of crops that can be grown. Water availability refers to the water holding capacity of the soil, which depends on soil texture and structure.

[41] Steckel (1982) conjectured that the east-west migration gradient prevailing in the US during the 19th century was partly explained by farmers seeking similar soil types. Another anecdotal example is that of the "Cajun Prairie" region of southwest Louisiana, which was first intensively farmed by Midwestern migrants in the 1880s who were attracted by the similar prairie soils (see `https://www.loc.gov/item/sn88064676/`).

[42] To take an extreme example, Seattle and Boston have the same average annual temperatures (11°C), but their seasonal patterns render them very different climates.

[43] To construct the variables in column 2, we take the standard deviation of monthly temperature and precipitation over each year between 1895 and 1920, average this over the whole period, and then calculate the (absolute value of the) difference between the origin and the destination. The variables in column 3 are computed by taking the absolute value of the origin-destination difference between the 1895-1920 average yearly maximum and 1895-1920 average yearly minimum temperature (resp., precipitation).

for the set of fixed effects included in our preferred specification, it is possible that counties with higher climate similarity also have more similar economic structures, which make it easier for migrants to relocate. On the other hand, given the rural-urban migration gradient prevailing in the first part of our sample period (Zimran, 2023), if county-pairs with more similar climates happened to have (by chance) larger differences in the rural population share, then our estimates might not be entirely attributable to climate distance.

To address these and similar concerns, in Figure A11 we replicate our preferred specification (Table 3, column 5), displayed in the first dot from the left, by including the county-pair difference in several characteristics, measured at the beginning of each decade. The second, third, and fourth dots from the left control for the county-pair difference in labor force participation, manufacturing employment share, and agricultural employment share, respectively.[44] The subsequent dots include the difference in, respectively: the Black, the urban, and the immigrant population share; sex ratios; and, population density. Finally, we consider three forces that have been shown to shape population movement and economic activity during our sample period: exposure to the frontier (Turner, 2017; Bazzi et al., 2020); market access (Donaldson and Hornbeck, 2016); and, connection to railroads (Atack and Margo, 2011).[45] In the very last dot, we include all variables simultaneously. Coefficients on climate distances always remain negative, precisely estimated, and close to those from the baseline specification.

Census linking concerns. Results presented thus far were obtained using linked samples, which offer several advantages but also have two potential shortcomings (Bailey et al., 2020). First, false positive matches may introduce systematic bias in the analysis. Second, individuals in the linked samples are not fully representative of the overall population, leading to questions about the generalizability of results. We address these concerns by using the full count 1940 US Census, which asked individuals where they lived five years before. As in Hornbeck (2023), we derive a county-pair migration matrix from the full count Census that does not rely on linking algorithms.

In column 6 of Table 3, we first replicate our baseline specification (column 5) using the linked sample, restricting attention to the 1930-40 decade. Coefficients on climate distance become somewhat lower (in absolute value) than in the entire sample period—a pattern that we discuss when exploring the mechanisms in Section 4 below. However, they remain negative and statistically significant. In column 7, we turn to the county-pair migration flows obtained from the

[44] In all cases, the variables are defined for men 15–64 in the baseline decade. Results are unchanged when using different age thresholds, extending the sample to women, or when considering a larger set of economic outcomes.

[45] We measure frontier exposure as the total number of years a county was on the frontier, according to Bazzi et al. (2020). Because this is a time-invariant control, we interact it with decade fixed effects to allow for differential trends over time. Both market access and dummies for being connected to railroads in a given decade are taken from Donaldson and Hornbeck (2016). The measure of market access is constant after 1920, and so we use this value for subsequent decades.

1940 full count Census. Coefficients remain close to those obtained with the linked sample.[46] Even though we could not replicate this exercise for Norwegian immigration, the similarity of the findings derived using the (US) linked sample and the full count Census is reassuring. This indicates that false positive matches are unlikely to introduce bias in the regressions, and increases confidence in the generalizability of results obtained from the linked sample.

Additional robustness checks. We conclude this section by presenting additional robustness checks. First, in Table A19 we measure climate distance in different ways. In column 1, we replicate our baseline specification, which defines temperature and precipitation as yearly averages. Then, we define distance using yearly maximum temperature (column 2) and summer (column 3) and winter (column 4) averages—an approach similar to that used to document the link between population growth and a location's average temperature in January or July (Glaeser and Tobio, 2007; Rappaport, 2009).[47] In column 5, we again use average yearly temperature and precipitation, but we attribute to each decade: *i*) before 1910 the climate computed over the 1895-1910 period; *ii*) after 1910 the climate measured as a rolling average of the 15 previous years (e.g., we assign average climate over the period 1905-1920 to 1910-1920 migration flows).

Second, in Table A20 we: *i*) exclude county-pairs that are at the top 1% and 5% of the distribution of bilateral migration (columns 2-3); *ii*) consider only counties that existed already in 1860 (column 4); *iii*) include only county-pairs that are present in the dataset for the entire period (column 5); and, *iv*) restrict attention to observations with strictly positive migration flows (column 6). Finally, we address concerns about the spatial correlation of climate discussed above by estimating standard errors in different ways. In Table A21, we show that the statistical significance of our estimates is unaffected by: clustering standard errors at the state of origin by state of destination level (column 2); and, applying the methodology in Conley (1999) using different lag parameters (columns 3 to 10).

3.3 Long-Run Changes in Climate Distance and Migration

Thus far, we have exploited cross-sectional variation in bilateral climate distance. Our findings are robust to the inclusion of a large set of county-pair controls—such as differences in geographic features (Table A16), soil type (Table A17), railroad connection, frontier exposure as well as many other economic, social, and demographic characteristics (Figure A11). However, one may still be worried that our estimates reflect the influence of other origin-destination spe-

[46] Because the sample in columns 6 and 7 is slightly different, in unreported analyses, we verified that results are unchanged when focusing on county-pairs that are present in both the linked and the full count samples.

[47] Note that in column 2 we do not use the yearly maximum of precipitation since precipitation is far more variable day-to-day than temperature, and thus excessively sensitive to outliers.

cific variables also correlated with climate distance. In this section, we tackle this concern by leveraging variation that arises from *changes* in average climate. Specifically, we test whether the *change* in climate distances between US counties predicts the *change* in migration patterns throughout the 20$^{\text{th}}$ century.

We focus on two periods: a historical window in the early 20$^{\text{th}}$ century and a modern window in the early 21$^{\text{st}}$ century. We measure historical migration using the 1935-1940 migration matrix derived from the 1940 US Census (see also Table 3, column 7). To measure modern migration, we leverage IRS tables that track the number of migrants between each US county-pair from 2011 onwards. In our baseline specification, we consider migration flows recorded between 2018 and 2019.[48] Historical and modern climate are defined by taking the annual average temperature and precipitation over the 1895-1920 and the 1990-2020 periods, respectively.[49] Figure A12 illustrates visually the change in climate distance from two selected US counties—one in the Delta region in the South, and the other one in the Northeast. The map makes it clear that changes in climate distances vary substantially across the country without systematic geographic patterns.

We replicate our baseline domestic gravity model, specified in equation (3), but allowing climate distances to vary between the early and the modern periods. We report results in Table 4. In column 1, we only include origin county-by-period and destination county-by-period fixed effects as well as physical distance. The negative and statistically significant coefficients indicate that county-pairs that became climatically more distant experienced a larger reduction in migration over time. In column 2, we add county of origin by county of destination fixed effects, which absorb any county-pair (time-invariant) characteristic, including physical distance. We also allow geographic distance to have heterogeneous effects by interacting it with period dummies. This specification only exploits the *change* in climate distances between county-pairs over the 100-year period we consider. Coefficients remain negative and statistically significant at the 1% level. According to our estimates, a 20% increase in temperature distance over time—about 1°C, or the average annual temperature distance between Boston and Detroit—reduces migration by about 3.5%. Coefficients on the change in precipitation distance are similar in magnitude. To put these numbers in perspective, consider that global temperatures have risen by about 1°C since the late 19$^{\text{th}}$ century due to anthropogenic climate change.

Subsequent columns of Table 4 explore the robustness of these results. In column 3, we interact period dummies with the battery of historical county-pair controls measured in 1930 (see also Figure A11). This specification addresses the possibility that climate distance changed differentially across county-pairs in a way that was correlated with historical origin-destination

[48] We describe this data in more detail in Section 4.3 and Appendix B.4.
[49] As for historical climate, data on modern climate come from Vose et al. (2014).

variables that may have persistent effects on the change in migration. In columns 4 and 5, we measure modern migration flows using 2011-2012 and 2014-2015, respectively. In column 6, we measure historical and modern migration using average migration flows calculated over different averaging windows: from 1900-1910 to 1930-1940 in the early period (from the linked sample) and from 2011-2012 to 2018-2019 for the modern period (from IRS data). Coefficients on temperature distance are stable and highly robust. Consistent with our previous evidence, the estimates for the effects of precipitation distance are somewhat less robust, and become smaller and imprecisely estimated in column 6.

To more intuitively illustrate the variation exploited in Table 4, we replicate this analysis by taking variables in long differences, as in Burke and Emerick (2016). Using OLS, we estimate:

$$\Delta_t \log(M_{odt}) = \alpha_o + \gamma_d + \beta_1 \Delta_t \log(\text{Dist}^{\text{Temp}}_{odt}) + \beta_2 \Delta_t \log(\text{Dist}^{\text{Precip}}_{odt}) + \epsilon_{odt} \tag{4}$$

where $\Delta_t \log(M_{odt})$, $\Delta_t \log(Dist^{Temp}_{odt})$, and $\Delta_t \log(Dist^{Precip}_{odt})$ are the long-run change in the log of migration and climate distances. Besides its intuitive appeal, this model has a further advantage: since it considers the change in the log of the number of migrants, it effectively exploits only variation between county-pairs with non-zero migration flows in both the historical and the modern periods. This reduces the potential concern that our estimates might pick up compositional changes in the geography of US migration throughout the 20$^{\text{th}}$ century (Molloy et al., 2011; Boustan et al., 2013; Zimran, 2023).

Results are reported in Table A22, which follows the same structure as Table 4. In column 1, we only include county of origin and county of destination fixed effects, which account for county specific trends. In column 2, we present our preferred specification, further controlling for geographic distance. As before, coefficients are negative and statistically significant at the 1% level. Perhaps not surprisingly given that we are only leveraging variation along the intensive margin of migration, the implied magnitudes are somewhat smaller (in absolute value) than in Table 4. The remainder of the table verifies that results are highly robust. In column 3, we include the vector of bilateral controls, allowing county-pairs to be on differential trends according to several historical origin-destination specific variables. In columns 4 to 6, we replicate column 2 measuring migration over different time periods.

4 Mechanisms

In this section, we first document that results cannot be explained by past migration or the persistence of ethnic enclaves alone (Section 4.1). Then, we consider two complementary mechanisms: climate-specific human capital (Section 4.2) and climate-as-amenity (Section 4.3).

4.1 Ethnic Enclaves and Migration Persistence

Given the persistence of ethnic enclaves and migration patterns documented in the literature (Altonji and Card, 1991; Card, 2001), one may wonder whether this mechanism is, at least in part, responsible for the relationship between migration and climate distance. For instance, early settlers might select destinations because of climate similarity, and latecomers may then follow the same routes because of the presence of familiar people, rather than a familiar climate. Climate similarity and the persistence of ethnic enclaves are not mutually exclusive forces, and they may well coexist with each other. However, understanding whether climate has an independent effect on migration even once ethnic enclaves are established has important policy implications.

Norwegian immigration. In Figure 5, we focus on Norwegian immigration. We first estimate our preferred specification (Table 1, column 4) on linked samples obtained by matching individuals across different Census years.[50] The black dots depict the coefficients for the effect of temperature (Panel A) and precipitation (Panel B) distance on migration for each time-period. The first two dots from the left refer to individuals linked between the 1865 Norwegian Census and the US Censuses of 1870 and 1880 (our baseline). In the third and fourth dots, we consider individuals linked between the 1865 Norwegian Census and the 1900 US Census, regardless of the year of immigration and restricting attention to those moving after 1880, respectively. In the remaining three dots, we focus on the second wave of Norwegian migration, which occurred in the early 20$^{\text{th}}$ century. The grey triangles in Figure 5 plot these same coefficients after controlling for the previous period's number of migrants between the Norwegian municipality of origin and the US county of destination.[51] The grey triangles are indistinguishable from the black dots, suggesting that climate matching influences migration independently of historical enclaves.[52]

Interestingly, all coefficients become somewhat smaller in absolute value after 1900, indicating that the relationship between climate similarity and migration weakened over time. One interpretation is that climate distance became less relevant as ethnic networks grew, but this is unlikely since estimates are unchanged when controlling for lagged migration. An alternative interpretation is that Norwegian pioneers settled land that was a better climate match first, while late-comers were more constrained in terms of land availability. Furthermore, to the extent that farmers valued climate more than non-farmers (as shown in Section 4.2), climate

[50] See Appendix B.2 for more details. To ease comparisons, climate distances are standardized in each sample to have zero mean and standard deviation equal to one.

[51] For 1865-1870, we cannot perform this exercise, since we have no data on past migration.

[52] As expected, past migration is positively correlated with subsequent migration (Figure A13). In unreported results, we compared the standardized beta coefficients associated with climate distance to those on past migration. The former were systematically larger (in absolute value) than the latter, indicating that the effect of climate distance may be stronger than that of past migration.

matching may have become less important as the economy shifted away from agriculture.

Even though climate similarity and past settlements independently influence migration, the two forces may also complement each other. Historical accounts stress the role pioneers played in spreading information about the relative attractiveness—economic and climatic—of different destinations. In Table A23, we ask whether the presence of previously arrived migrants amplifies the effect of climate similarity on migration. We replicate the regressions depicted by the grey triangles in Figure 5 by adding the interaction between lagged migration and climate distances. The main effects of both climate similarity and past migrants remain unchanged. Importantly for our purposes, the interaction coefficients are negative and statistically significant for temperature. That is, migrants are better matched climatically in the presence of co-ethnic migrants who can promote the diffusion of information among prospective migrants. Perhaps as expected, coefficients on the interaction terms become smaller (in absolute value) over time—consistent with the idea that migrants are particularly valuable sources of information early on, when knowledge about the conditions prevailing at destination is limited.

US internal migration. While ethnic networks may be particularly important for international migrants, they can favor the persistence of domestic migration routes as well (Stuart and Taylor, 2021). In Figure 6, we replicate the analysis presented in Figure 5 focusing on US internal migration. We plot coefficients on temperature (Panel A) and precipitation (Panel B) distance separately for each Census decade, both for the baseline specification (black dots) and for regressions that control for the number of migrants between each county-pair in the previous decade (grey triangles). As with the Norwegians, results are virtually unchanged when controlling for past migration, suggesting that climate distance has an independent effect on US internal migration.[53]

In Table A24, we provide additional evidence that migrant networks are not driving the relationship between climate similarity and migration. In column 2, we replicate the preferred specification for US internal migration (Table 3, column 5) while controlling for lagged migration flows.[54] To reduce concerns that lagged migration flows over the previous decade may be measured with noise, we control for the stock of migrants (cumulated starting from 1850) in column 3 and for the average of past flows in column 4. In columns 5 and 6, we consider only migration from 1900 onwards, separately controlling for pre-1900 (stock and average flows) migration. Coefficients on climate distance remain negative, precisely estimated, and quantitatively large.

[53] Similarly, coefficients become smaller (in absolute value) over time—a pattern that we discuss in more detail in Section 4.2.

[54] As expected, lagged migration has a positive and strong effect on subsequent migration flows. However, coefficients on climate distance remain negative and precisely estimated. Moreover, as noted before, standardized beta coefficients indicate that the effects of climate distance are as large as (if not larger than) those of past migration.

Finally, we consider a setting where past networks should have limited scope to influence migration, namely US counties with very low population density that had been only recently settled by white individuals (who account for almost 95% of migrants in our sample, as shown in Table A10). To this end, we restrict destinations to the set of counties that were on the American frontier between 1850 and 1890 (Bazzi et al., 2020).[55] Then, in column 2 of Table A25 we replicate the baseline specification for this selected set of origin-destination pairs. Despite the drastic reduction in sample size, the effect of climate distance remains in line with estimates derived using the full sample over the same time period (reported in column 1 to ease comparisons). Subsequent columns verify this when considering each decade separately, especially for temperature distance.

4.2 Climate-Specific Skills

Weather, and extreme heat in particular, has well-documented impacts on labor productivity and economic outcomes (Dell et al., 2012; Heal and Park, 2016; Deryugina and Hsiang, 2017). In this section, we examine an alternate nexus, exploring the possibility that climate-specific skills explain why migrants seek a familiar climate. Climate-specific skills include farming expertise *vis-a-vis* crop suitability and pest management as well as techniques for food preservation, survival to extreme heat or cold, and house construction (insulation, ventilation, and hurricane resilience).[56] Immunity and familiarity with climate-specific illnesses, such as malarial vectors, may also influence migration decisions. In pioneering work on this topic, Steckel (1982) discussed the relationship between climate-specific human capital and the horizontal migration patterns that prevailed in the US during the 19$^{\text{th}}$ century.

One interesting example involves Vietnamese refugees settling the US Gulf Coast after the Vietnam War. The region's hot and humid climate is somewhat similar to the climate of the Mekong Delta region, which is known for its fishing and aquaculture. Climate similarity—and the corresponding knowledge about aquaculture techniques in warm-water wetlands—likely eased the transition of Vietnamese fishermen, especially in comparison to a counterfactual of moving to other prominent fishing states like Alaska or Maine. A compelling non-US case is the Indonesian government's resettlement program of two million people from Java and Bali to the Outer Islands. Bazzi et al. (2016) showed that subsequent productivity was higher in rural villages that received migrants from regions with a more similar climate, suggesting the

[55] Bazzi et al. (2020) trace out the evolution of the American frontier line—defined as the boundary at which population density falls below two people per square mile—over time. For each decade, they then assign to the frontier all counties that are in close proximity (100 km) to the frontier line and that have population density below six people per square mile (a threshold first indicated by Porter et al., 1890). Since we cannot compute migration for the 1880-1890 decade, we consider migration between 1880-1900, and use frontier status in 1890 (the last year considered in Bazzi et al., 2020).

[56] Such knowledge helps explain why mortality from exposure to the same level of extreme heat is lower, on average, in hot places than cold places (Barreca et al., 2015; Heutel et al., 2021; Carleton et al., 2022).

importance of climate-specific human capital and skill transferability.

To test the relevance of this channel in our context, we explore the heterogeneity of results by occupation. Intuitively, skill transferability should be more relevant for individuals working in more weather-exposed occupations, such as farming. We focus on domestic migration to leverage rich variation across US counties and over time. We replicate our preferred specification separately for different subsamples of migrants, based on the industry reported in the US Census.[57] We plot the estimated coefficients, with corresponding 95% confidence intervals, in Figure 7. To ease comparisons, we standardize temperature (Panel A) and precipitation (Panel B) distances so that they have zero mean and unit variance in each sub-sample. The first dot encompasses the full sample (i.e., Table 3, column 5), and the second dot restricts the sample to men 15+ in the labor force. From the third dot onwards, we cut the sample by occupational sector. In line with our hypothesis, the estimated climate-migration elasticity is twice as large (in absolute value) for farmers than for non-farmers—though the pattern is evident only for temperature. Since our main results for precipitation distance are somewhat less stable, we refrain from interpreting the lack of heterogeneity depicted in Panel B of Figure 7.

To further explore the climate-as-skills mechanism, we return to Figure 6, where we examine the evolution of the climate-migration elasticity from 1850-1860 to 1930-1940 (see also Section 4.1). During this period, the US labor force in farming declined from 55% to 17% (Lebergott, 1966), whereas technological innovation may have reduced the value of specific skills.[58] This suggests that the elasticity of migration with respect to climate distance should decline (in absolute value) over time. This is precisely what we observe in Figure 6: coefficients remain relatively stable (negative and precisely estimated) until the turn of the 20$^{\text{th}}$ century, and then gradually become smaller (in absolute value). By 1940, the coefficient on temperature (resp., precipitation) distance is about 25% (resp., 50%) smaller than in 1860. This trend also resonates with the climate change adaptation literature that finds a declining temperature-mortality relationship over time (Barreca et al., 2016), attributable to adaptive technologies that insulated people from climates extremes.

4.3 Climate as Amenity

Climate might also act as an amenity driving migration decisions. Evidence indicates that climate stability favors the transmission of culture across generations (Giuliano and Nunn, 2021). To the extent that climate facilitates the persistence of cultural practices—from hobbies

[57] To reduce endogeneity concerns, we classify individuals based on the industry reported at baseline. Results are unchanged when restricting attention to individuals in the same industry in both Census years.

[58] For instance, the adoption of cold storage in the late 19$^{\text{th}}$ century rendered hot or cold weather-specific crop and food preservation techniques less valuable.

to socializing norms to food preferences to religious rituals—migrants may choose locations with climates that align with such personal and cultural preferences. Consistent with the climate-as-amenity channel, we detect a statistically significant and economically relevant relationship between climate distance and migration among non-agricultural workers, including those employed in the service sector (Figure 7). Because these sectors are less tied to climate, climate-specific human capital should be less relevant than for farmers.

Moreover, the negative association between climate distance and migration persisted through 1940 (Figure 6), when agriculture accounted for less than 20% of the US labor force. Using IRS county-to-county migration tables between 2011 and 2019, we test whether climate distance correlates with migration even today—when farmers represent a negligible share of US employment. Table 5 replicates the preferred specification (Table 3, column 5) for the modern period. Coefficients on climate distance remain negative and statistically significant, even though smaller in absolute value than those obtained for the historical period.[59] In particular, standardizing regressors produces coefficients that are between 30% and 50% smaller in absolute value than those estimated over the pre-1900 sample (not reported for brevity). These trends indicate that, even if climate has become somewhat less relevant for migrants, it still plays an important role in driving location decisions today—consistent with a climate-as-amenity mechanism.

Findings in this section resonate with work by Albouy et al. (2021), who provide evidence of a positive correlation between the characteristics (e.g., number of winter days with mild temperature, distance from coast, safety) of the countries of origin and those of the cities where immigrants settled in the US after 2000. Note, though, that the human capital and the amenity channels are likely to be intertwined, particularly in this context. Take a simple example: immigrants' food preferences are shaped by the foods available and cooking practices in their country of origin. In turn, farming practices and food preservation techniques—a form of climate-specific human capital—determine which foods are produced. Likewise, in the aforementioned case of Vietnamese fishermen in Louisiana, the enjoyment of the Gulf Coast's familiar seafood, wetlands, and weather is difficult to untangle from the climate-specific fishing skills that they brought to the region.

[59] See Appendix B.4 for more details on the IRS data. In our preferred specification, we exclude post-2019 migration data, which may be unduly influenced by COVID-19 (Ramani and Bloom, 2021). In column 2 of Table 5, we verify that results are unchanged when including IRS migration data up until 2021. Columns 3 and 4 replicate column 1 and document that results hold when controlling for historical migration flows.

5 Implications of Climate Similarity and Migration

In this section, we discuss the implications of our findings. In Section 5.1, we estimate the value of climate similarity for migrants in two ways. First, we leverage temporal and spatial variation generated by the Homestead Act of 1862, which altered the price of land for migrants and reduced climate matching for farmers. Second, we provide novel evidence of a negative relationship between climate mismatch and mortality, which we combine with the EPA's value of statistical life to derive an estimate for the value of climate. In Section 5.2, we use data on realized and projected changes in temperature to illustrate how, by altering climate distances between counties, climate change did and will influence the geography of US population growth.

5.1 Estimating The Value of Climate Similarity

5.1.1 The Homestead Act

The Homestead Act of 1862 was the largest land distribution program in US history. It provided up to 160 acres of essentially free land to farmers, conditional on five years of residency and cultivation. Under the Act, 10% of US land was transferred from the federal government to 1.6 million farmers (Edwards et al., 2017).[60] We obtain information on the universe of land patents from the Bureau of Land Management General Office Land records. We aggregate the data from the individual land patent to the county level, and compute the share of the county area that was homesteaded in any given decade, relative to the overall area of the county. Because a Homestead patent was granted five years after the arrival of the homesteader on the land, we attribute patents signed in a given 10-year period to migrants arrived in a place five years before.[61] For example, we assign contracts signed between 1915 and 1925 to the 1910-1920 migration wave. As the vast majority of contracts were signed between 1870 and 1920, we focus on this time period.

Figure A14 plots the distribution of the share of county area that was homesteaded in each decade from 1870 to 1920. It shows that, during this period, between 10 and 30% of available land was homesteaded in the Midwest and the West, but that the Homestead Act also made land available across southern states, such as Florida, Alabama, and Mississippi. We calculate the 80$^{\text{th}}$ percentile of county homesteaded shares, considering all US counties and all years

[60] Under the Homestead Act, individuals would acquire land in a three-step process. First, applicants would register the land by filing an application and an affidavit to a local land office and by paying a $12 fee. Second, they had to settle on the land within six months from the application and provide evidence of permanent and continuous residence as well as of cultivation. Third, homesteaders would file for a deed of title and pay an additional $6 fee. See Mattheis and Raz (2019) and Smith (2020) for more details.

[61] Remember that we are able to measure migration only across decades.

from 1860 to 1920. We then construct a dummy equal to one if the homesteaded share of the destination county in a given decade surpasses this calculated 80$^{\text{th}}$ percentile.[62] Figure A16 maps the counties that meet this threshold across decades, and documents the substantial variation across both time and space.

US internal migration. We augment the baseline specification for domestic migration in equation (3) by interacting the Homestead dummy with both climate and geographic distances.[63] As in the baseline specification, county of origin by decade and county of destination by decade fixed effects absorb any temporal and location-specific push and pull factors that might be correlated with county-pair climate distances. Moreover, the latter set of fixed effects takes into account the possibility that places with a large share of homesteaded land in a given decade also became more (or less) attractive for migrants from other parts of the US that had a more (or less) similar climate.

We present results in Table 6, column 1. Consistent with our baseline estimates, coefficients on temperature and precipitation distance remain negative and statistically significant—and, again, larger for temperature than for precipitation. The coefficient on the interaction between temperature distance and the Homestead dummy is positive and statistically significant. That is, the degree of temperature similarity between origin and destination counties is lower for migrants moving to homesteaded counties as compared to other migrants from the same county (and in the same decade) who selected a non-homesteaded destination. In line with earlier results, the interaction between the Homestead dummy and precipitation distance is quantitatively small and imprecisely estimated.

Since the Homestead Act was explicitly designed to attract farmers, one would expect a stronger pull effect for this population—and thus, less climate matching on the margin. On the other hand, climate matching is more important to farmer migrants than non-farmer migrants (Figure 7). Hence, whether the Homestead Act reduced the importance of climate distance more for farmers than for non-farmers is *ex-ante* ambiguous. In columns 2 and 3, we explore these ideas, focusing on farmer and non-farmer migrants, respectively. Results suggest that farmers' preferences for temperature were relatively less distorted by the prospect of homesteading than those of non-farmers.[64] In particular, the temperature distance elasticity for farmers settling in a Homestead county is 53% smaller than that of farmers settling in a non-Homestead county.

[62] Figure A15 shows graphically the definition of the threshold.

[63] The Homestead dummy is absorbed by the county of destination by decade fixed effects. In our preferred specification, we impose two sample restrictions. First, because most Homestead contracts were signed between 1870 and 1920, we restrict attention to the decades from 1860-1870 to 1910-1920. Second, we define the sample of origin counties as those that are never homesteaded, while leaving the set of destinations unrestricted. All results are robust to using alternative time windows or origin-destination samples, and different thresholds to define the Homestead dummy (see also Tables A26 and A27).

[64] The fact that we find effects for both farmers and non-farmers is also consistent with the possibility that the Homestead Act generated economic spillovers outside the agricultural sector.

Meanwhile, the temperature distance elasticity for non-farmers settling in a Homestead county is 37% of the elasticity observed for the same migrants settling outside of a Homestead county.[65]

Norwegian immigration. The introduction of the Homestead Act coincided temporally with the first wave of Norwegian immigration, and anecdotal accounts indicate that the prospects of free land compelled many Norwegians to embark for the US (Semmingsen, 1978). Indeed, there is a significant degree of overlap between the settlements of Norwegian immigrants and the availability of homesteaded land between 1865 and 1880 (Figures A6 and A16). In column 4 of Table 6, we explore whether the Homestead Act reduced climate distance's influence on location decisions of Norwegians moving to the US. We replicate the specification in Table 1, column 4, by interacting climate (and geographic) distance with the Homestead dummy.[66]

Because the Homestead dummy is not absorbed by the fixed effects in this case, we explicitly control for it. The corresponding coefficient is positive, large, and precisely estimated. That is, Norwegian immigrants were more likely to settle in counties that offered Homestead land, aligning with the historical narrative. Turning to climate distance, the patterns mirror those in Table 1: both temperature and precipitation distances reduce migration, with the effect being larger for the former than for the latter. Finally, the positive and statistically significant coefficient on the interaction between temperature distance and the Homestead dummy indicates that—similar to what we found for domestic migration—Norwegians moving to homesteaded counties had a lower degree of temperature similarity.

Discussion. Results in Table 6 suggest that the Homestead Act induced migrants to match *less* on climate than they would have otherwise. This finding relates to recent work showing that the Homestead Act slowed down economic development in the western US. Allen and Leonard (2021) stress the role of agricultural path dependence due to the Homestead Act's farming obligation, while Mattheis and Raz (2019) posit that homesteaders were negatively selected.[67] Our findings offer a complementary explanation: the Homestead Act may have reduced farmers' productivity by increasing their climate mismatch.

Relatedly, our results are relevant for the literature on migration and labor misallocation (Young, 2013; Bryan et al., 2014; Munshi and Rosenzweig, 2016), particularly Bazzi et al. (2016), who document the importance of migrants' climate-specific human capital for economic development in Indonesia. We complement this literature by showing that skill transferability may shape migration patterns by inducing people to sort based on climate. Our results

[65] We obtain these numbers by dividing the total elasticity of climate distance (e.g., $\beta_3 + \beta_4$) by the elasticity of climate distance net of the Homestead (e.g., β_3) for each sample.

[66] Since we consider individuals that migrated to the United States between 1865 and 1880, we set the Homestead dummy equal to one if the homesteaded share of the county area was above the 80^{th} percentile during this specific period.

[67] Findings in Smith (2020) indicate that these negative effects were partly offset by the Homestead Act's promotion of smaller-scale land cultivation relative to the less productive use of the large plots distributed through railroads grants.

also showcase the potential labor (mis)allocation impacts of public programs, and speak to the literature on place-based policies (Glaeser and Gottlieb, 2008; Kline and Moretti, 2014), with relevance for discussions of managed retreat and climate change adaptation.

Estimating the value of climate. The Homestead Act provides a unique setting to estimate the value of climate for migrants. The main result of this paper—robust across time periods, geography, and migrant groups—is that migrants seek to minimize the climate distance between origin and destination. However, when offered cheap land through the Homestead Act, farmers deviated from the baseline—that is, climate matching was less important when the land was free. Comparing the size of this deviation to the difference in land prices offered under the Homestead Act versus direct government purchase allows us to estimate farmers' valuation of climate similarity. If migrants deviated greatly from their baseline climate preferences when offered Homestead land, this would imply a low valuation of climate similarity. By contrast, a small deviation of migration flows from the baseline implies a large valuation of climate similarity.[68]

To estimate the marginal value of climate similarity, we proceed as follows. First, we compute counterfactual migration flows under two alternative scenarios. In the baseline case, we predict farmer migration based on climate and geographic distances, taking into account the roll-out of the Homestead Act. In a second counterfactual scenario, we predict migration based on distance only, assuming that the Homestead Act was never passed. We use the coefficient from column 2 in Table 6 to derive counterfactual migration flows. These are, in turn, used to obtain measures of migration-weighed average climate and geographic distance between counties. Under the baseline Homestead Act scenario, a migrant would travel to counties that were, on average, 3.74°C apart from their origin. Under the "No Homestead Act" scenario, the average travelled temperature distance drops to 3.66°C. Let us denote the difference between the two counterfactual travelled distances by ΔDist Temp. The .08°C difference between the two scenarios represents the resulting increase in climate mismatch attributable to free land under the Homestead Act.

Then, we assume that all farmers migrating to a Homestead county paid the administrative fee of $345 (in 2020 dollars), whereas those migrating to non-Homestead counties paid the price of a direct purchase (about $4,763 in 2020 dollars), for the same amount of land.[69] As we did for average travelled distance, we use migration flows predicted under the two scenarios to obtain the average price paid for land. In the "No Homestead Act" scenario, the average price paid for

[68] As noted above, the Homestead Act reduced climate matching also for non-farmers. However, we focus on farmers since it is easier to calculate the value of land for this group.

[69] For Homestead land, we assume a cost of $22 for 160 acres that includes average filing fees and commission. Converting this value from 1865 to 2020 dollars, we obtain $345. For direct purchase, we assume $300 for 160 acres, which is the midpoint of $1.25/acre, the price for unclaimed federal land, and $2.50/acre, the price for railroad grant land (Allen and Leonard, 2021). Adjusted for inflation, this $300 equals $4,763 in 2020 dollars.

land is \$4,763, no matter where a migrant settled. In the baseline scenario, instead, a migrant would pay an average of \$4,373 for 160 acres of land.[70] We denote this price difference with Δp. Finally, we recover an estimate for the marginal valuation of climate and geographic distance for farmers using the following formula:

$$MWTP(\text{Temp}) = abs(\frac{\Delta p}{\Delta \text{Dist Temp}})$$

The marginal valuation of temperature is estimated at \$4,506 in current dollars per 1°C. For comparison, farmers would be willing to pay this amount to avoid the cost of travelling an extra 483 km. This estimate may be an upper bound, since homesteaded land was likely of lower quality than nearby alternatives (Mattheis and Raz, 2019).

5.1.2 Mortality and Climate Distance

In this section, we use a different approach to estimate the value of climate similarity. We rely on US mortality data used in Section 2, where we documented a positive relationship between the temperature in the country of birth and the temperature in the US county of death (Figure 2).[71] We leverage the fact that this dataset reports information on the age at death to test whether climate mismatch among immigrants in the US is associated with differences in life expectancy. We estimate individual-level regressions of age at death (in years) on climate distance among the over 700,000 foreign-born individuals who died in the US between 1959 and 1961. We define climate distance as the absolute value of the difference between the temperature (or precipitation) in the capital city of the country of birth and the US county of death.

We present results in Table 7. Column 1 indicates that climate distance is negatively correlated with age at death. That is, migrants who settled in US counties with a climate similar to their country of origin tend to live longer. Column 2 documents that this relationship holds after controlling for US county of death, country of origin, and year of death fixed effects as well as for individual characteristics, such as gender and marital status.[72] The specification in column 2 isolates the relationship between climate distance and mortality for an individual after controlling for demographic characteristics as well as for the average age at death among all immigrants in the US: from the same origin country, in the same county where the individual died (which could be tied to local economic conditions), and who died in the same year. Column 3 further controls for the total number of individuals from the same country of origin who died

[70] This is the average of Homestead and non-Homestead land prices, weighed using predicted migration flows.

[71] As noted above, US mortality records typically report whether an individual was born in the US or the "rest of the world." However, for the years 1959-1961, the individual's country of birth is reported for all locations outside the continental US.

[72] Consistent with other results in this paper, the effect of precipitation distance shows a similar sign but is less robust and statistically insignificant when including a more stringent set of controls.

between 1959 and 1961 in the individual's county of death—a proxy for immigrant network effects.

Even with this rich set of controls, unobservable factors might influence the degree of climate matching for migrants. On the one hand, if migrants who select a more similar climate are richer or healthier, results in Table 7 may over-estimate the effects of climate distance on mortality. On the other hand, if those who sort on climate are less skilled (e.g., because climate-specific skills are more valuable in low skilled jobs) and thus less able to cope with negative economic shocks, our estimates may be a lower bound for the effect of climate distance. To assuage this concern, in column 4, we account for the change in climate distance in the decades preceding an individual's death. This is similar in spirit to Table 4, where we allowed climate distances to vary between the early and the modern periods. Column 4 of Table 7 shows that the change in temperature distance from 1895-1920 to 1950-1970 is negatively associated with age of death. That is, immigrants in locations whose temperature diverged over time, relative to that in their country of origin, died earlier. These arguably random changes in climate across space, which are driven by medium-term oceanic oscillations, are hard for people to notice. As such, they are unlikely to influence migrants' location decisions. The similarity in coefficients on average climate distance and its change reduces concerns that our results are entirely driven by selection.[73]

The patterns in Table 7 can be reconciled with either the climate-specific human capital channel or the climate-as-amenity channel discussed in Section 4 (or both). For instance, climate mismatch might reduce returns to climate-specific skills and thus earnings. This may lead to a deterioration of health outcomes. A mismatch in climate-specific skills may also have a more direct impact on mortality through increased accidental deaths, e.g., driving on icy roads for someone not accustomed to such conditions. Alternatively, hotter temperatures may increase crime and violence (Ranson, 2014; Mukherjee and Sanders, 2021), which could in turn expose people to premature death—more so those coming from colder climates. Climate distance may lower life expectancy also through an amenity channel, for example if mismatched migrants become less happy and less socially connected over time (Holt-Lunstad et al., 2010).

In Figure A17, we ask whether the mortality relationship documented in Table 7 varies with the direction of climate distance (i.e., moving to a hotter or a colder location). To this end, we regress age at death on 1°C temperature distance bins between the US county of death and birth country capital, partialling out the same fixed effects and demographic controls as in our most stringent specification above (column 3). We find an inverted U-shaped curve that resonates

[73] If anything, the coefficient on the change in temperature distance is larger (in absolute value) than that on average temperature distance. This suggests that, at least in this context, selection may lead to an underestimation of the mortality impact of climate mismatch.

with the climate change literature that has documented increased mortality in response to both hot and cold shocks (Barreca et al., 2015; Heutel et al., 2021; Carleton et al., 2022).

Finally, as for the Homestead Act, we use these results to derive an estimate for the value of climate similarity. Coefficients from our preferred specification (Table 7, column 3) imply that a 1°C of temperature distance reduces life expectancy by .11 years, or approximately one month of life. We implement an admittedly crude back-of-the-envelope by taking the EPA's value of a statistical life (VSL) of $9.6 million (2020 dollars), dividing it by the average death age in our sample (73 years), and multiplying this number by .11, i.e., the coefficient from column 3 in Table 7. This implies that 1°C of additional climate distance roughly costs $14,300 per person (in today's currency)—a number three times larger than the $4,506 value we found using the Homestead Act.[74]

5.2 Climate Change, Migration, and Population Growth

In Section 3.3, we leveraged climate change over the 20$^{\text{th}}$ century to identify the impact of climate distance on migration. In this section, we use these estimates to explore the relationship between migration induced by changes in climate similarity and population growth. Since the 1950s, the share of the US population living in the South has increased steadily, moving from 30% in 1950 to 37% in 2010.[75] Several explanations have been offered for this trend—from the introduction of air conditioning (Oi, 1996) to increasing productivity (Glaeser and Tobio, 2007) to changes in the people's willingness to pay for nice weather (Rappaport, 2009). Did changes in climate distances across counties also contribute to the dynamics of US population growth in the post-war period?

To answer this question, we calculate the percent change in all county-pair temperature distances from 1940-1960 to 1990-2010. Combining this with the gravity models estimated in Sections 3.2 and 3.3, we obtain the predicted change in migration between any two counties that resulted from the change in climate distances, $\widehat{\Delta Mig}_{od}$.[76] Since during the 20$^{\text{th}}$ century the US South became closer in temperature to the US Northeast and Midwest (see also Figure A12), our estimates predict a larger increase in migration between counties in these regions.

[74] Note that estimates obtained from the Homestead Act and from the climate distance-mortality settings capture the value of climate similarity along different dimensions. The Homestead Act exercise estimates an individual's willingness to pay in terms of land cost to maintain climate similarity—a trade-off implicitly occurring on the margin. The mortality exercise considers solely the cost to an individual in terms of life-years lost from moving climates based on the correlation we established, but does not incorporate any potential compensating value that the individual would pay (or, receive) to justify moving to such a place.

[75] See also `https://www.census.gov/data/tables/time-series/dec/popchange-data-text.html`.

[76] We use an elasticity of migration with respect to temperature distance of -.235, as per results in Tables 3 and 4.

Using these predicted values, we compute the change in a county's overall connectivity as:

$$CC_o = \sum_d (\omega_{od} \times \widehat{\Delta Mig}_{od}) \tag{5}$$

where ω_{od} is the number of historical (1935-40) migrants between o and d, scaled by total migrants between county o and all other US counties. Intuitively, CC_o is the weighed average of the change in climate-induced migration for each US county, with weights equal to historical county-pair migration links. Similar in spirit to the market access measure from Donaldson and Hornbeck (2016), the index takes on higher values for counties that converged climatically to areas that were relatively more important for exchanging people for that specific county. Panel A of Figure 8 plots the distribution of CC_o on a map, and shows that climate change led to substantial variation in connectivity across counties since the 1960s. Panel B depicts the change in (log) county population from 1960 to 2010. The two panels seem to indicate that counties that became climatically more connected also experienced faster population growth.

In Table 8, we formally test the relationship between population growth and changes in climate connectivity between 1960 and 2010. To ease the interpretation of results, we standardize CC_o by subtracting its mean and dividing it through its standard deviation.[77] Column 1 shows the cross-sectional correlation between the change in log county population and the change in climate connectivity. To account for the direct effects of climate on population growth during this period (Glaeser and Tobio, 2007; Rappaport, 2009), we control for historical temperature and precipitation. In columns 2 and 3, we add state fixed effects and a large battery of baseline county characteristics to allow changes in climate connectivity to be correlated with other factors that may have independently influenced population growth.[78]

In all cases, there is a positive and statistically significant relationship between changes in connectivity and population growth. Results are unchanged when constructing the climate-connectivity index excluding counties within the same state (column 4). According to our preferred specification (column 3), a one standard deviation increase in climate connectivity is associated with a 3.3% increase in log population—or, a 3.3 percentage points faster population growth between 1960 and 2010. This is equivalent to the 32$^{\text{nd}}$ percentile of county population growth in the US, or Hudson County, NJ (home of Jersey City), which grew by 3.3% between 1960 and 2010.[79]

[77] We weigh regressions by 1960 county population, and cluster standard errors at the state level.

[78] In particular, we include the following variables (all measured in 1960): the share of the population that is urban, Black, immigrant, and 65 or over; the share of the 18-65 population in the labor force; and the employment shares in manufacturing and in agriculture. Results are not sensitive to the specific set of controls included in the regressions.

[79] This 3.3% is also equivalent to the difference in the change in log population between 1960 and 2010 of Hudson County, NJ (.033) and Chicago's Cook County, IL (.013)—or, relative to fast-growing counties, Santa Clara, CA (1.02) and Miami-Dade, FL (.982).

Having documented that changes in climate connectivity explain the geography of population growth across counties in the second half of the 20th century, we now turn to the future. We ask what climate projections imply for patterns of county connectivity, bilateral migration flows, and population growth over the 21st century. We rely on daily projections under a moderate warming path (RCP4.5) to compute projected climate averages at the county level for the period 2080-2100.[80] As before, we calculate the change in average temperature distance, and the resulting change in migration flows, between today and this future period for all contiguous US county-pairs.

Figure A18 illustrates the spatial distribution of such predicted changes for two example counties in the US. Relative to present day climate distances, counties shaded in green are projected to get closer to the temperature in the example county over time (i.e., converge), while red counties are projected to diverge (ranging from -4 to 2.5°C in magnitude). Continuing the trend already happening during the 20th century, temperature is projected to diverge between the Northeast and the Midwest. This implies that, *ceteris paribus*, there will be less migration between these two regions in the future relative to today. Conversely, in the second example we find that more migrants will travel between the Midwest and the Delta region in the US South, as the climates of these areas are expected to converge.

We conclude this section by examining the impact of projected climate change from today until 2100 on population growth. First, similar to what we did before in equation (5), we calculate the change in climate connectivity between 1990-2010 and 2080-2100, with bilateral migration flows from 2018-2019 serving as weights. Then, relying on the estimates obtained in Table 8, we link these predicted changes in climate connectivity to future population growth. Our model predicts that, as a result of climate change, population in the US South will grow twice as fast as that in the Northeast. This trend contrasts sharply with the patterns prevailing during the 20th century, when anthropogenic climate change had similar effects on population growth in the two regions.

6 Discussion and Conclusions

In this paper, we provide evidence that, across time periods, geography, and migrant groups, individuals tend to settle in places with climates similar to those of their origins. These patterns cannot be explained by the spatial correlation of climate or pre-existing migrant networks, and do not reflect geographic, economic, and demographic differences between origins and destinations. Exploring the mechanisms, we document that both climate-specific skills and

[80] See https://www.nccs.nasa.gov/services/data-collections/land-based-products/nex-gddp.

climate-as-amenity likely explain our results. To our knowledge, we are the first to estimate the effects of climate distance on historical migration patterns. We also advance and complement different strands of the literature.

First, with relevance to climate change economics, we provide two novel approaches to estimate the value of climate—or, more specifically, the value to an individual of holding climate constant. Using historical data from the Homestead Act and US mortality records, we find that a temperature mismatch of 1°C among migrants is associated with a cost of $4,500-$14,300 in current dollars. Moreover, we derive a measure of climate-induced connectivity that can be used to predict how climate change may alter future migration patterns and, in turn, population growth. In a simple and largely illustrative example, we apply this connectivity measure to project future US internal migration. Future work can build on our approach to compute more precise measures of climate connectivity for both the US and the entire world.

Second, the systematic relationship between climate similarity and migration uncovered in our work can be exploited as a source of identifying variation to study the impact of migration across several domains. Our analysis suggests that climate similarity, if combined with appropriate push shocks, can be used to refine the standard shift-share instrument used in the literature that leverages variation in the pre-determined distribution of settlers (Altonji and Card, 1991; Card, 2001). Our approach has the potential to offer a micro-foundation for such initial settlements, possibly addressing the critiques that this class of instruments has received recently (Goldsmith-Pinkham et al., 2020; Borusyak et al., 2022).

Our findings also open the door to several fascinating questions in economic history and political economy. Combining climate's predictive power on settlement patterns with push shocks like the Dust Bowl (Hornbeck, 2012), the boll weevil (Lange et al., 2009), or severe frosts in mid-19$^{\text{th}}$ century Scandinavia (Karadja and Prawitz, 2019) can provide insights into how climate-driven migration contributed to the structural transformation of the US economy. The relationship between climate similarity and migration documented in our work can also be used to study how migrants affect the political and cultural landscape of receiving areas (Alesina and Tabellini, 2023; Bazzi et al., 2023a,b). This margin may be especially important in the context of climate-driven migration, given the well-documented relationship between agricultural practices and cultural norms (Alesina et al., 2013; Cao et al., 2021; Becker, 2023).

Finally, our results are relevant for the emerging literature that seeks to understand the spatial effects of climate shocks on the global economy through general equilibrium models. Such models assume that migration costs are exogenous to climate change (Cruz and Rossi-Hansberg, 2023; Desmet and Rossi-Hansberg, 2023; Bilal and Rossi-Hansberg, 2023), but our findings indicate that migrants place a large weight on climate similarity between origin and destination.

Climate distance can thus be viewed as a travel cost that depends on the spatial distribution of climate change. We hope that our results can be used to enrich these models, improving the precision of welfare estimates and the assessment of the macroeconomic effects of climate change.

By extension, our results are relevant for climate refugee policy. Over 20 million people annually, on average, have been forcibly displaced by weather-related events since 2008 (UNHCR)—a number that is estimated to increase with further global warming. Even among economic migrants, climate change often acts as a push shock. Given the potential welfare and productivity implications explored in this paper, our findings suggest that climate similarity should be taken into account when resettling existing climate refugees and when designing "managed retreat" policies in anticipation of climate change.

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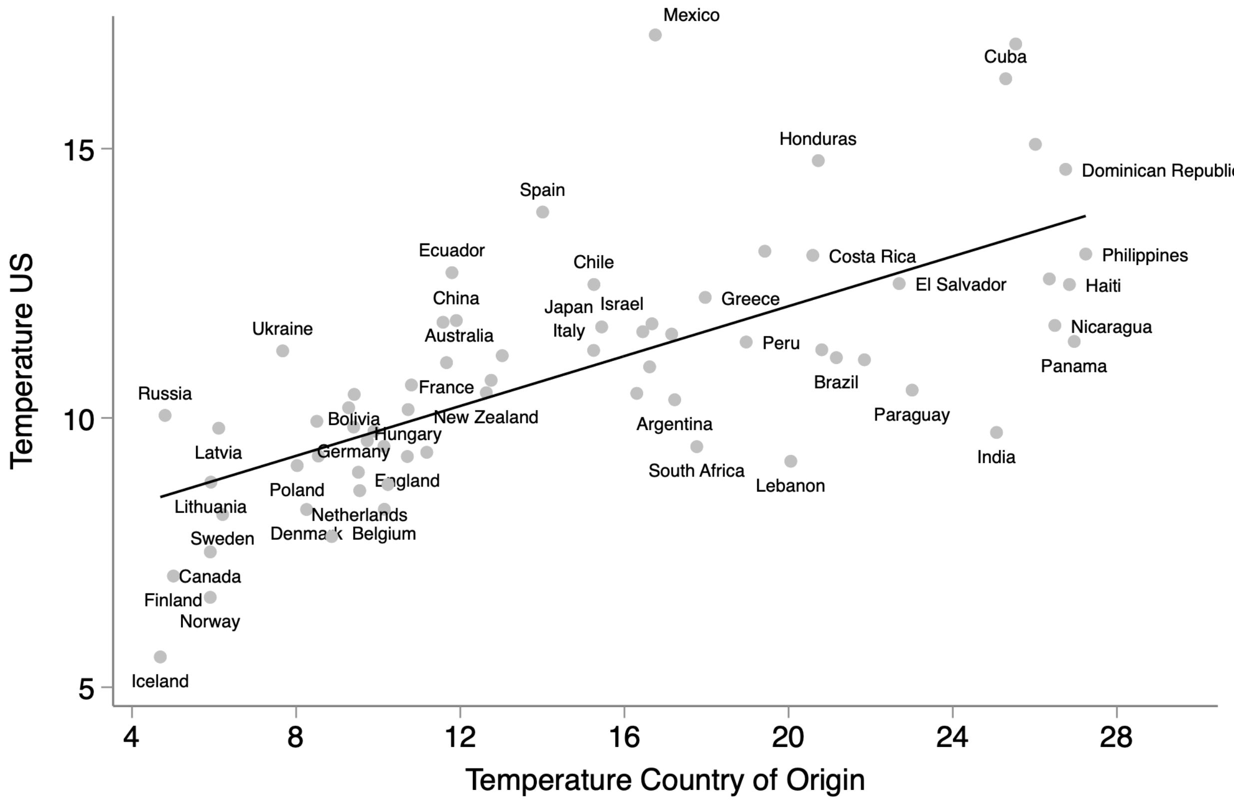
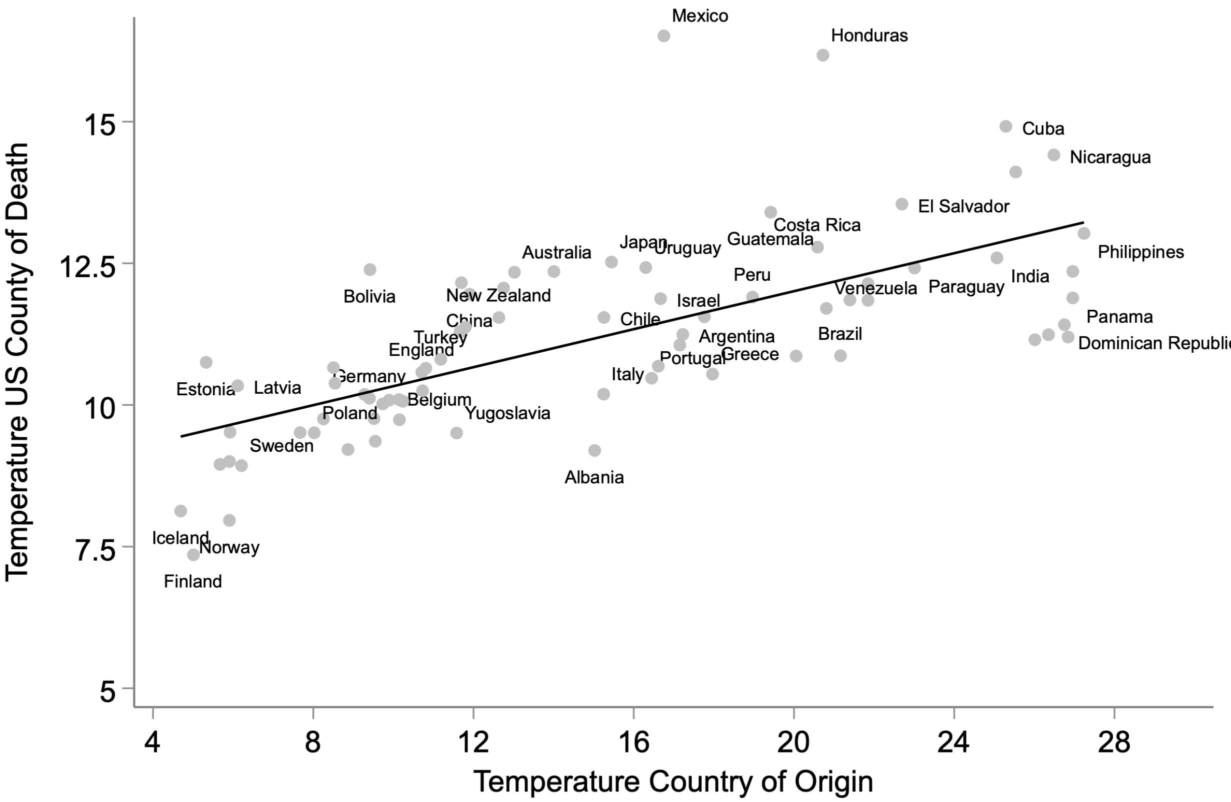
Figures and Tables

Figure 1. Temperature Matching of Immigrants in the US (1880)



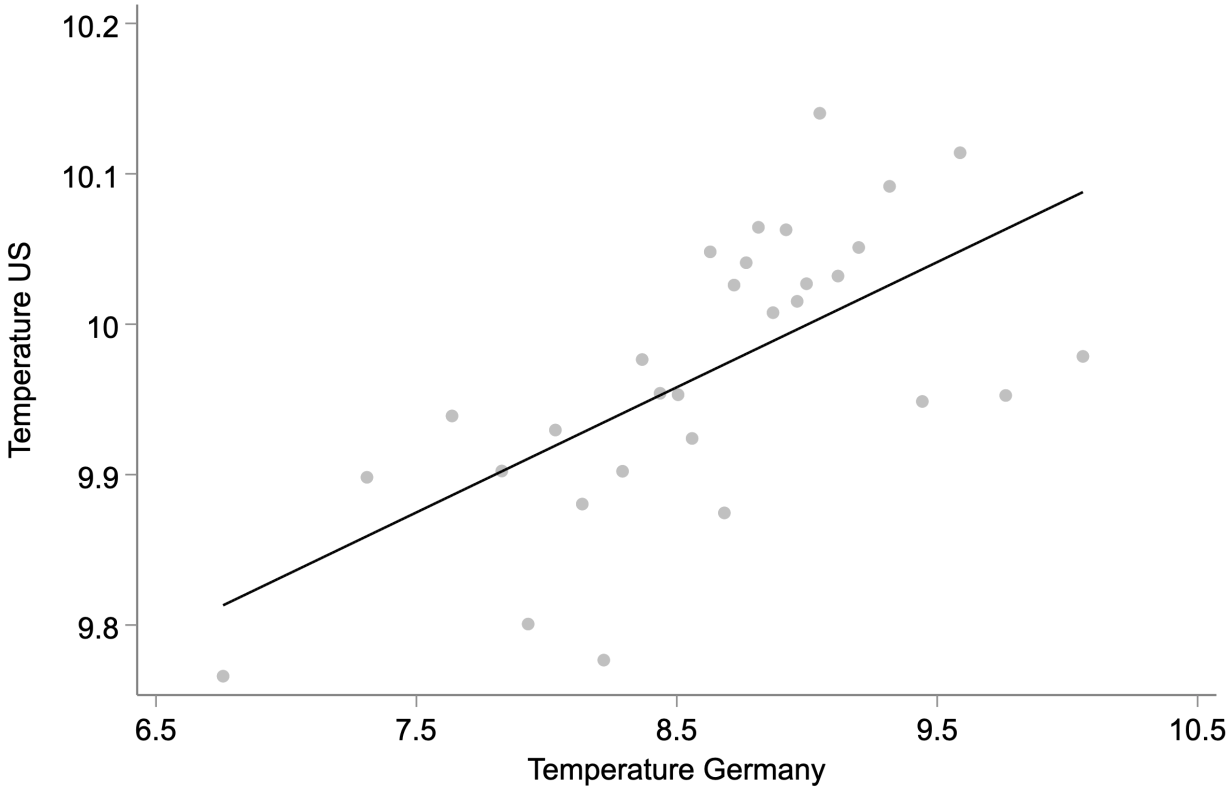
Notes: The figure displays the relationship between average temperature in degrees Celsius across US counties where immigrants from each origin were living in 1880 (y-axis) and the average temperature in the capital city of their country of origin (x-axis). The regression coefficient and the corresponding robust standard errors are, respectively, .231 and .033.

Figure 2. Temperature Matching from US Mortality Data (1959-1961)



Notes: The figure displays the relationship between average temperature across US counties where foreign-born individuals from each country of origin died between 1959 and 1961 (y-axis) and average temperature in the capital city of their country of origin (x-axis). The regression coefficient and the corresponding robust standard errors are, respectively, .168 and .022.

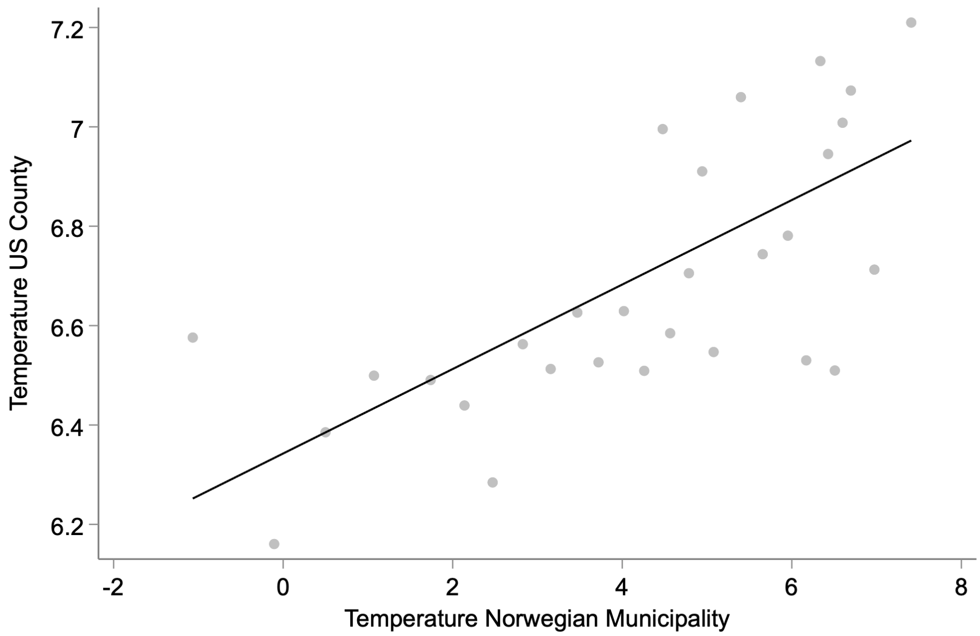
Figure 3. Temperature Matching from German Surnames



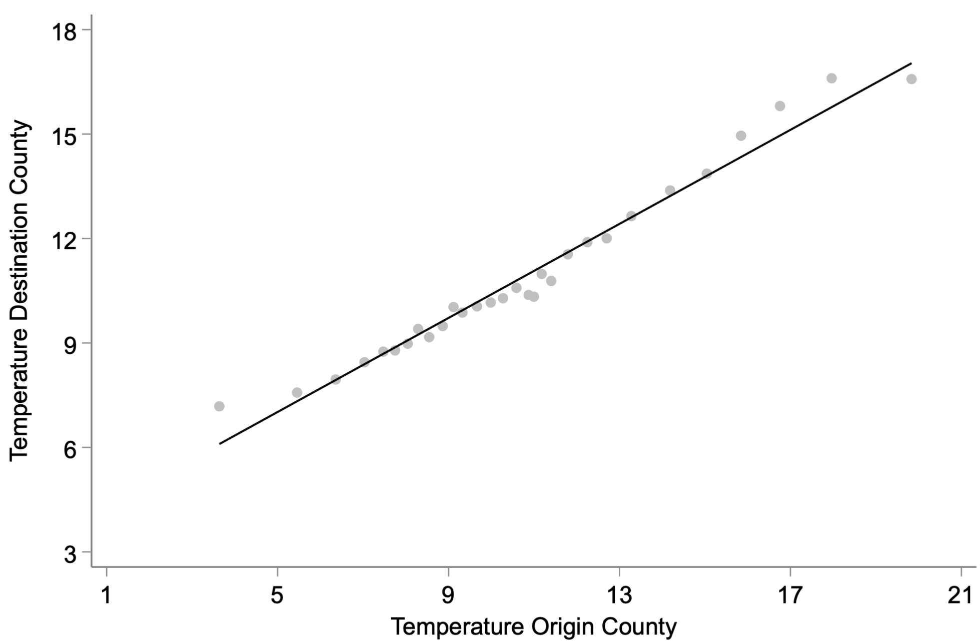
Notes: The figure displays a binned scatterplot obtained from a surname-level regression of average temperature at destination against average temperature at origin. The figure considers the sample of German immigrants' surnames linked between the WWI German casualties list and the 1880 US full count Censuses. The regression coefficient and the corresponding robust standard errors are, respectively, .083 and .011.

Figure 4. Temperature Matching and Migration at the Individual-Level

(a) Norwegian Immigrants



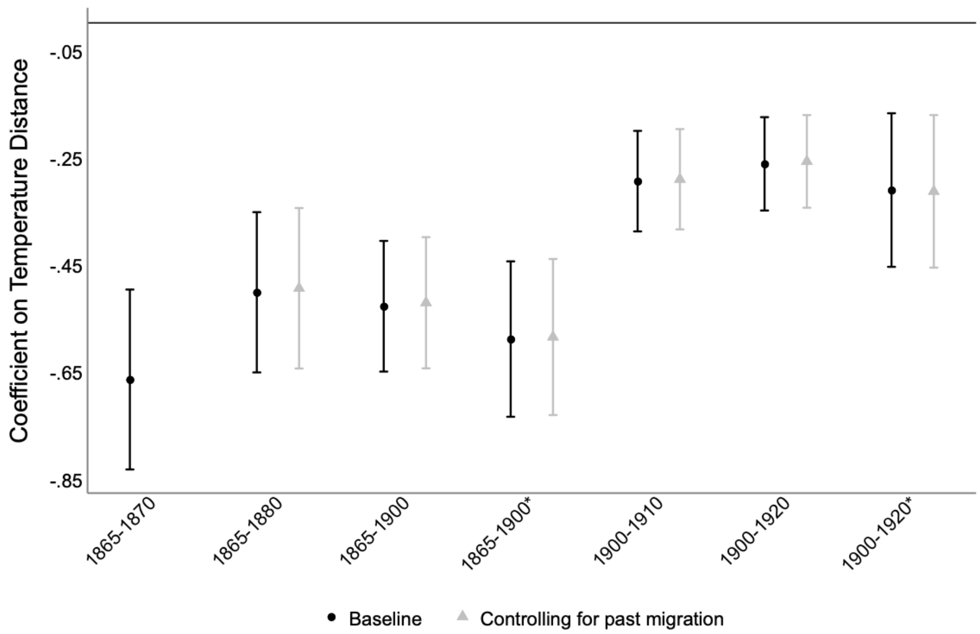
(b) US Internal Migrants



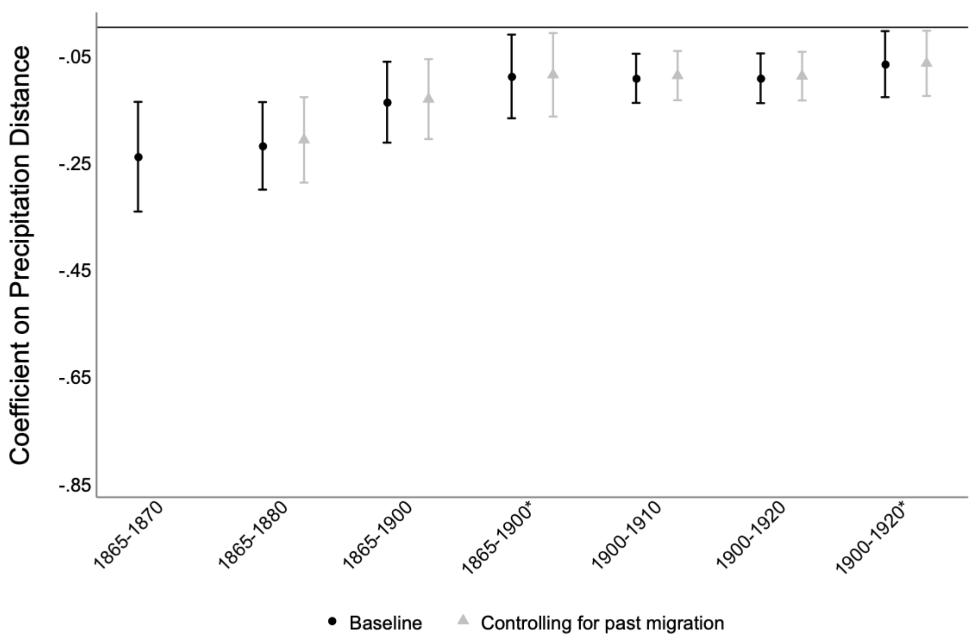
Notes: The figure displays binned scatterplots obtained from individual-level regressions of average temperature at destination against average temperature at origin. Panel A considers the sample of Norwegian immigrants linked between the 1865 Norwegian and the 1880 US full count Censuses. Origins and destinations are, respectively, Norwegian municipalities and counties in the contiguous US. Panel B considers the sample of individual migrants (within the contiguous US) linked across US full count Censuses over the period 1850-1860 to 1930-1940. Origins and destinations are counties in the contiguous US. In Panel A, the regression coefficient and the corresponding standard errors, clustered at the Norwegian province by US state level, are .085 and .038. In Panel B, the regression coefficient and the corresponding standard errors, clustered at the US state of origin by US state of destination by decade level, are .675 and .015.

Figure 5. Climate Distance and Norwegian Immigration, by Period

(a) Temperature



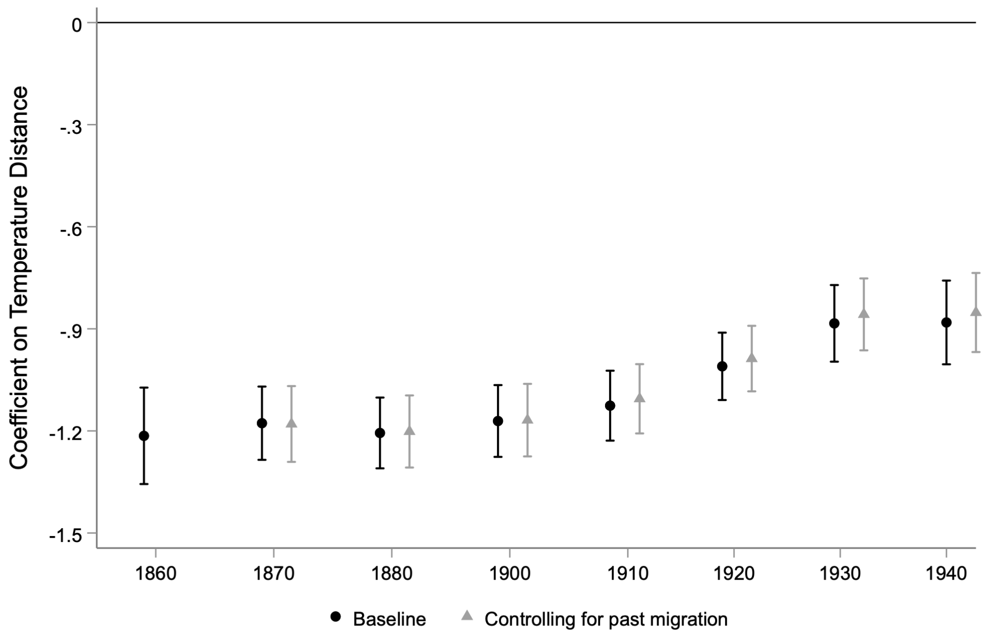
(b) Precipitation



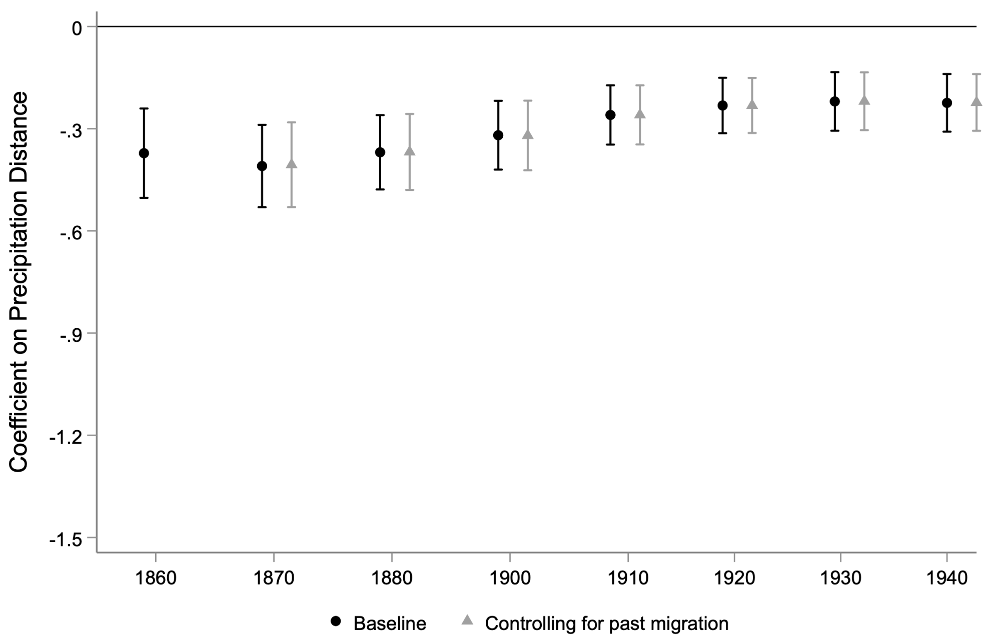
Notes: The figure plots the coefficient, with corresponding 95% confidence intervals, on the absolute value of the difference in temperature (Panel A) and precipitation (Panel B) between Norwegian municipality of origin and US county of destination. Dots refer to the baseline specification, described in the notes of Table 1. Triangles refer to specifications that further controls for lagged number of immigrants from the municipality to the US county. The number of immigrants is defined over the window reported on the x-axis. The fourth (resp., seventh) set of coefficients from the left refers to individuals linked between the 1865 Norwegian and the 1900 US (resp., the 1900 Norwegian and the 1920 US) Censuses and who migrated after 1880 (resp., after 1910). Lagged migration refers to number of immigrants: from 1865 to 1870 in the second to fourth triangles; from 1865 to 1900 the the fifth and sixth triangles; and, from 1900 to 1910 in the last triangle. Temperature and precipitation distances are standardized within the relevant sample to have zero mean and standard deviation equal to one. Standard errors are clustered at the US state by Norwegian province level.

Figure 6. Climate Distance and US Internal Migration, by Period

(a) Temperature



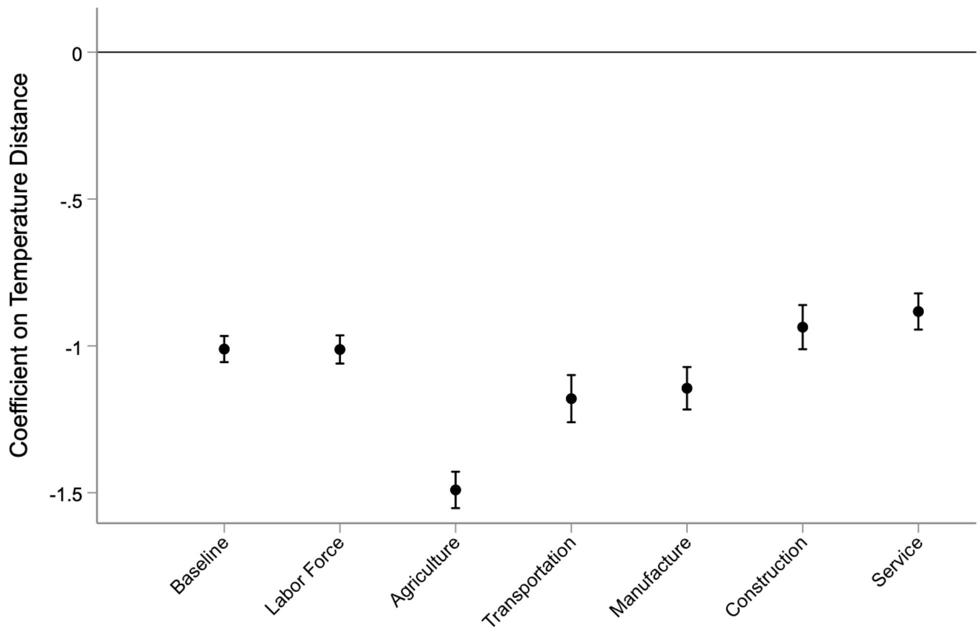
(b) Precipitation



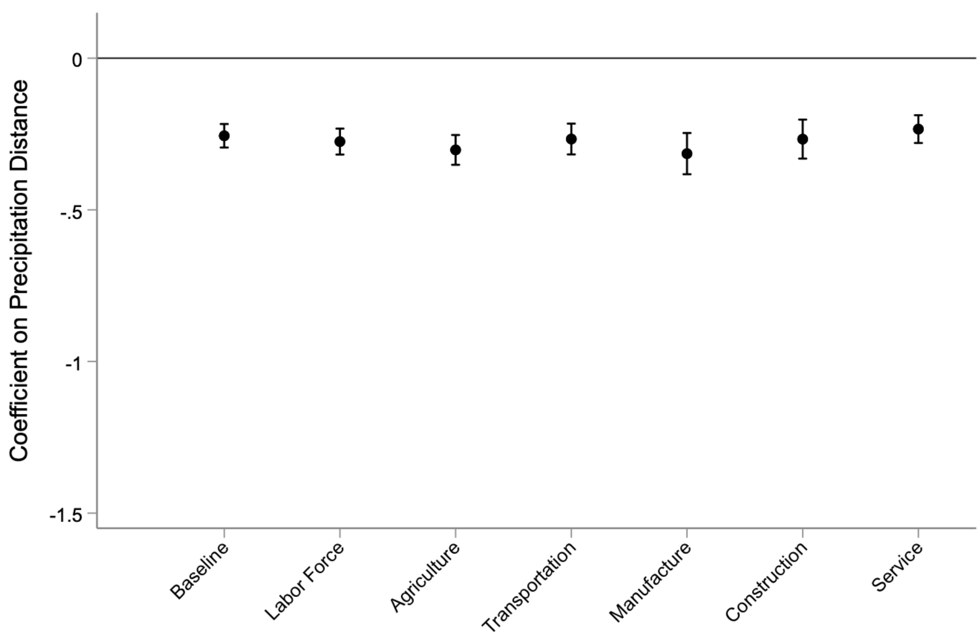
Notes: The figure plots the coefficient, with corresponding 95% confidence intervals, on the absolute value of the difference in temperature (Panel A) and precipitation (Panel B) between origin and destination counties for each decade reported on the x-axis. Dots refer to the baseline specification, described in the notes of Table 3. Triangles refer to specifications that further controls for cumulated lagged number of immigrants. The year reported refers to the end of the decade. The sample includes all US county-pairs in the contiguous US from 1850-1860 to 1930-1940. Temperature and precipitation distances are standardized within the relevant sample to have zero mean and standard deviation equal to one. Standard errors are clustered at the state of origin by state of destination level.

Figure 7. Climate Distance and US Internal Migration: Heterogeneity by Sector

(a) Temperature



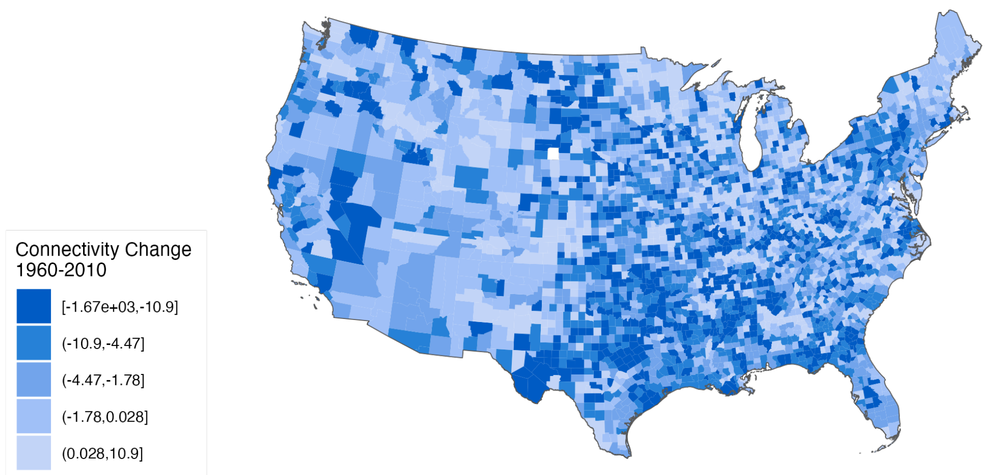
(b) Precipitation



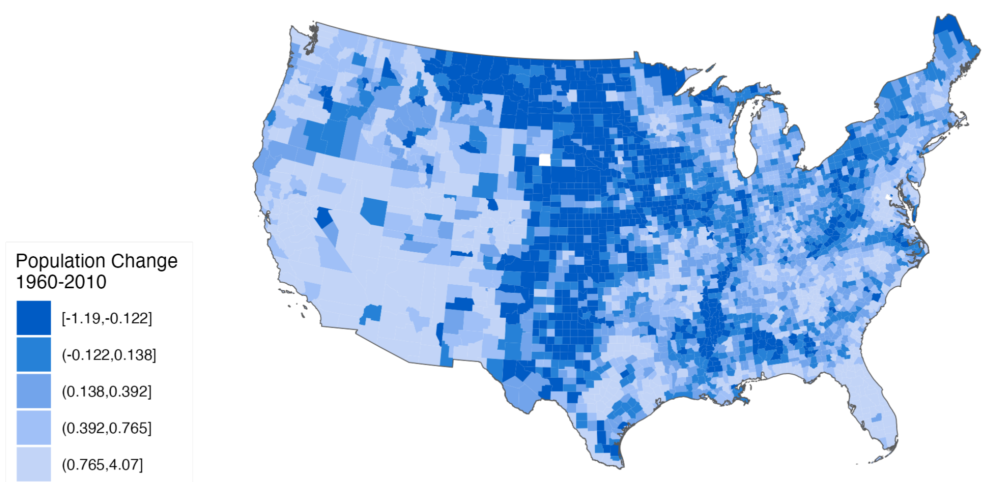
Notes: The figure plots the coefficient, with corresponding 95% confidence intervals, on the absolute value of the difference in temperature (Panel A) and precipitation (Panel B) between origin and destination counties for all migrants (resp., all migrants in the labor force) in the first (resp., second) dot from the left. From the third dot onward, the number of migrants refers to migrant men in the sector reported on the x-axis (defined according to 1-digit IND1950 code from IPUMS). The sample includes all US county-pairs in the contiguous US from 1850-1860 to 1930-1940. Temperature and precipitation distances are standardized within the relevant sample to have zero mean and standard deviation equal to one. Standard errors are clustered at the state of origin by state of destination by decade level.

Figure 8. Change in Temperature Induced Connectivity and Population over the 20$^{\text{th}}$ Century

(a) Temperature Induced Migration Connectivity



(b) Log Population



Notes: Panel A depicts the change in temperature-induced connectivity between each contiguous US county pairs between 1960 and 2010, due to oceanic oscillations and anthropogenic climate change. Temperature-induced connectivity is given by: $CC_o = \sum_d (\omega_{od} \times \widehat{\Delta Mig}_{od})$ where ω_{od} is the number of historical (1935-1940) migrants between o and d, scaled by total migrants between county o and all other US counties. $\widehat{\Delta Mig}_{od}$ is the predicted change in migration between o and d, obtained by combining historical climate change with results from gravity models presented in Sections 3.2 and 3.3. Intuitively, CC_o is the weighted average of the change in climate-induced migration for each US county, with weights equal to historical county-pairs migration and is analogous to the market access index from Donaldson and Hornbeck (2016). Panel B depicts the change in log population over the same period (1960-2010). The US South experienced a decrease in connectivity due to climate change between 1960 and 2010 (Panel A) and a decrease in population over the same period (Panel B).

Table 1. Climate Distance and Norwegian Immigration (1865-1880)

Dep. var.:	Number of Migrants			
	(1)	(2)	(3)	(4)
Temperature Distance	-0.373***	-0.375***	-0.143***	-0.107***
	(0.019)	(0.019)	(0.024)	(0.016)
	[-16.377]	[-16.474]	[-5.683]	[-4.257]
Precipitation Distance	-0.007***	-0.007***	-0.007***	-0.006***
	(0.002)	(0.003)	(0.001)	(0.001)
	[-2.188]	[-2.456]	[-2.135]	[-1.967]
Distance from NYC (in 100km)		0.009**	-0.136***	-0.051**
		(0.004)	(0.035)	(0.025)
		[0.728]	[-10.937]	[-4.130]
Observations	1,002,822	1,002,822	847,894	847,894
Pseudo R-squared	0.121	0.122	0.287	0.401
Mean Temp. Dist.	7.954	7.954	7.429	7.429
SD Temp. Dist.	4.691	4.691	4.609	4.609
Mean Precip. Dist.	40.04	40.04	40.17	40.17
SD Precip. Dist.	35.06	35.06	35.16	35.16
US State FE			Yes	Yes
Norwegian Province FE			Yes	Yes
US Controls				Yes
Norwegian Controls				Yes

Notes: The sample includes pairs formed by all Norwegian municipalities (origins) and all US counties (destinations) with at least one European immigrant in 1880. *Number of Migrants* is the number of Norwegian male immigrants who were at least 10 years old in 1865 linked between the 1865 Norwegian and the 1880 US Censuses. *Temperature Distance* (resp., *Precipitation Distance*) is the absolute value of the difference in temperature (resp., precipitation) between the Norwegian municipality and the US county. *Distance from NYC* refers to the distance between a US county and New York City (expressed in 100 km). From column 2 onwards, we also include the distance between the municipality and closest international port (either Kristiansand or Oslo). US and Norwegian controls include: population density, sex ratios (defined as the ratio between women 18-33 and men 20-35), the urban population share, the share of men (15-64) in the labor force, and the share of male employment in agriculture and manufacturing. US controls also include the following variables, which cannot be computed for Norwegian municipalities: the immigrant population share, the Norwegian population share, the Black population share, total frontier experience from Bazzi et al. (2020), and market access from Donaldson and Hornbeck (2016). All Norwegian controls are measured in 1865; all US controls are measured in 1880. Standardized beta coefficients are reported in square brackets. Standard errors, reported in parentheses, are clustered at the US state by Norwegian province level. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 2. Climate Distance and International Immigration (1880-1920)

Dep. var.:	Number of Migrants				
	(1)	(2)	(3)	(4)	(5)
Temperature Distance	-0.277***	-0.334***	-0.177***	-0.177***	-0.194***
	(0.017)	(0.017)	(0.014)	(0.014)	(0.013)
	[-0.002]	[-0.003]	[-0.001]	[-0.001]	[-0.002]
Precipitation Distance	-0.006***	-0.005***	0.000	0.000	-0.000
	(0.001)	(0.001)	(0.003)	(0.003)	(0.003)
	[-0.000]	[-0.000]	[0.000]	[0.000]	[-0.000]
Distance (in 100km)		-0.023***	-0.103***	-0.103***	-0.098***
		(0.002)	(0.011)	(0.010)	(0.007)
		[-0.001]	[-0.005]	[-0.005]	[-0.005]
Observations	791,484	780,286	779,139	779,139	751,907
Pseudo R-squared	0.098	0.151	0.822	0.830	0.895
Mean Temp. Dist.	6.961	6.960	6.961	6.961	6.992
SD Temp. Dist.	5.262	5.274	5.275	5.275	5.316
Mean Precip. Dist.	39.273	39.376	39.370	39.370	39.235
SD Precip. Dist.	33.003	33.139	33.144	33.144	33.314
Country o FE			Yes	Yes	
US County d FE			Yes	Yes	
Decade FE			Yes		
US State × Decade FE				Yes	
Country o × Decade FE					Yes
US County d × Decade FE					Yes

Notes: The sample includes pairs formed by all countries of origin for which we have climate data and all US counties of destination that received at least one immigrant from 1880 to 1920. *Number of Migrants* is the number of immigrants from country o living in US county d in a given decade. In all decades from 1900 to 1920, we consider the flow of immigrants, defined as individuals arrived in the US during the previous decade. Since the 1880 US Census did not record arrival year, we consider immigrant stocks for this decade. *Temperature Distance* (resp., *Precipitation Distance*) is the absolute value of the difference in temperature (resp., precipitation) between the capital city of the country of origin and the US county of residence. *Distance* refers to the physical distance between the foreign capital city and the US county (expressed in 100 km). Standardized beta coefficients are reported in square brackets. Standard errors, reported in parentheses, are clustered at the US state by country of origin by decade level. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 3. Climate Distance and US Internal Migration

Dep. var.:	Number of Migrants						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Temperature Distance	-0.375***	-0.302***	-0.264***	-0.262***	-0.260***	-0.224***	-0.231***
	(0.011)	(0.008)	(0.006)	(0.006)	(0.006)	(0.016)	(0.020)
	[-0.111]	[-0.089]	[-0.078]	[-0.076]	[-0.070]	[-0.042]	[-0.033]
Precipitation Distance	-0.039***	-0.014***	-0.012***	-0.011***	-0.011***	-0.009***	-0.010***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
	[-0.070]	[-0.025]	[-0.021]	[-0.020]	[-0.018]	[-0.011]	[-0.009]
Distance (in 100km)		-0.138***	-0.149***	-0.148***	-0.149***	-0.176***	-0.237***
		(0.012)	(0.004)	(0.004)	(0.005)	(0.014)	(0.018)
		[-0.085]	[-0.091]	[-0.090]	[-0.085]	[-0.067]	[-0.070]
Observations	35,634,556	35,634,556	35,332,029	34,504,246	30,479,809	4,684,923	4,818,958
Pseudo R-squared	0.169	0.206	0.682	0.691	0.705	0.763	0.746
Mean Temp. Dist.	5.426	5.426	5.418	5.417	5.321	5.461	5.479
SD Temp. Dist.	3.884	3.884	3.879	3.881	3.829	3.917	3.931
Mean Precip. Dist.	31.16	31.16	31.11	30.96	29.61	31.15	31.27
SD Precip. Dist.	23.62	23.62	23.61	23.60	23.21	23.78	23.83
County o FE			Yes	Yes		Yes	Yes
County d FE			Yes	Yes		Yes	Yes
Decade FE			Yes				
State o × Decade FE				Yes			
State d × Decade FE				Yes			
County o × Decade FE					Yes		
County d × Decade FE					Yes		
Sample	Linked	Linked	Linked	Linked	Linked	Linked 30-40	Full Count 35-40

Notes: The sample includes all county-pairs in the contiguous US: for each decade from 1850-1860 to 1930-1940 (columns 1 to 5), for 1930-40 (column 6), and for 1935-1940 (column 7). *Number of Migrants* is the number of men 15+ in the baseline year who moved from the origin to the destination county in each period (decade in columns 1 to 6; 5-year period in column 7). The migration matrix in columns 1 to 6 (resp., column 7) is derived from the linked sample (resp., the 1940 full count US Population Census). See Appendix B for more details. *Temperature Distance* (resp., *Precipitation Distance*) is the absolute value of the difference in temperature (resp., precipitation) between the origin and the destination county. *Distance* refers to the physical distance between counties (expressed in 100 km). County (resp., State) o refers to county (resp., state) of origin; county (resp., State) d refers to county (state) of destination. Standard errors are clustered at the state of origin by state of destination by year of destination level. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 4. Climate Distance and Migration in the Long Run

Dep. var.:	Number of Migrants					
	(1)	(2)	(3)	(4)	(5)	(6)
Temperature Distance	-0.227***	-0.166***	-0.222***	-0.134***	-0.192***	-0.298***
	(0.024)	(0.047)	(0.045)	(0.037)	(0.049)	(0.074)
	[-0.015]	[-0.005]	[-0.007]	[-0.005]	[-0.008]	[-0.009]
Precipitation Distance	-0.015***	-0.018***	-0.020***	-0.018***	-0.019***	-0.007
	(0.003)	(0.005)	(0.004)	(0.005)	(0.006)	(0.006)
	[-0.006]	[-0.004]	[-0.005]	[-0.004]	[-0.005]	[-0.001]
Distance (in 100km)	-0.226***					
	(0.016)					
	[-0.032]					
Observations	7,703,638	2,188,200	2,184,658	2,670,748	2,049,054	1,959,248
Pseudo R-squared	0.771	0.964	0.965	0.963	0.961	0.952
Mean Temp. Dist.	5.302	4.103	4.105	4.052	4.118	3.570
SD Temp. Dist.	3.825	3.391	3.392	3.364	3.403	3.088
Mean Precip. Dist.	31.78	25.61	25.62	25.78	25.58	25.04
SD Precip. Dist.	24.45	23.95	23.96	23.93	23.98	23.22
County o × Period FE	Yes	Yes	Yes	Yes	Yes	Yes
County d × Period FE	Yes	Yes	Yes	Yes	Yes	Yes
County o × County d FE		Yes	Yes	Yes	Yes	Yes
Distance × Period FE		Yes	Yes	Yes	Yes	Yes
Controls × Period FE			Yes			
Modern Period	2018-2019	2018-2019	2018-2019	2011-2012	2014-2015	Avg. 2011-2019
Historical Period	1935-1940	1935-1940	1935-1940	1935-1940	1935-1940	Avg. 1910-1940

Notes: The sample includes all county-pairs in the contiguous US. *Number of Migrants* in historical period is the number of men 15+ in the baseline year who moved from the origin to the destination county. The migration matrix is derived from the linked sample. See Appendix B for more details. *Number of Migrants* in the modern period is the number of people who changed address from the origin to the destination county in each year, and is constructed from IRS Migration data. *Temperature Distance* (resp., *Precipitation Distance*) is the absolute value of the difference in temperature (resp., precipitation) between the origin and the destination county. *Distance* refers to the physical distance between counties (expressed in 100 km). Controls include absolute difference in employment share, manufacturing employment share, agriculture employment share, black share, urban share, immigrant share, sex ratio, population density, exposure to the frontier, access to market distance, and a dummy equals to 1 if the two counties are both connected to the railroad. County o (resp., county d) refers to county of origin (resp., of destination). Standardized beta coefficients are reported in square brackets. Standard errors, reported in parentheses, are clustered at the state of origin by state of destination by period level. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 5. Climate Distance and US Internal Migration (2011-2019)

Dep. var.:	Number of Migrants			
	(1)	(2)	(3)	(4)
Temperature Distance	-0.215***	-0.212***	-0.207***	-0.207***
	(0.014)	(0.013)	(0.014)	(0.014)
	[-0.010]	[-0.009]	[-0.009]	[-0.009]
Precipitation Distance	-0.017***	-0.017***	-0.017***	-0.017***
	(0.002)	(0.002)	(0.002)	(0.002)
	[-0.005]	[-0.005]	[-0.005]	[-0.005]
Distance (in 100km)	-0.215***	-0.215***	-0.207***	-0.207***
	(0.009)	(0.008)	(0.009)	(0.009)
	[-0.022]	[-0.021]	[-0.021]	[-0.021]
Lagged Migration			3.932***	0.482***
			(0.414)	(0.050)
			[0.000]	[0.000]
Observations	25,071,430	31,024,472	25,071,430	25,071,430
Pseudo R-squared	0.781	0.781	0.783	0.783
Mean Temp. Dist.	5.125	5.123	5.125	5.125
SD Temp. Dist.	3.722	3.721	3.722	3.722
Mean Precip. Dist.	31.35	31.30	31.35	31.35
SD Precip. Dist.	25.22	25.21	25.22	25.22
County o × Decade FE	Yes	Yes	Yes	Yes
County d × Decade FE	Yes	Yes	Yes	Yes
Definition Lagged Mig.			Avg. Flows 1850-1940	Stock 1850-1940

Notes: The sample includes all county-pairs in the contiguous US for each year from 2011-2012 to 2018-2019, except for column 2, which includes moves occurring in 2019-2020 and 2020-2021. *Number of Migrants* is the number of people who changed address from the origin to the destination county in each year and is constructed from IRS Migration data. These data are based on year-to-year address changes reported on individual income tax returns filed with the IRS. *Temperature Distance* (resp., *Precipitation Distance*) is the absolute value of the difference in temperature (resp., precipitation) between the origin and the destination county. *Distance* refers to the physical distance between counties (expressed in 100 km). Stock 1850-1940 (resp., Avg. Flows 1850-1940) is the total (resp., the average) number of migrants from the origin to the destination county in each decade between 1850-1860 and 1930-1940 obtained from the linked sample (expressed in 10 thousand). All regressions also control for county of origin (county o) by decade and county of destination (county d) by decade fixed effects. Standardized beta coefficients are reported in square brackets. Standard errors, reported in parentheses, are clustered at the state of origin by state of destination by year of destination level. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 6. Climate, Migration, and the Homestead Act

Dep. var.:	Number of Migrants			
	(1)	(2)	(3)	(4)
Temperature Distance	-0.299***	-0.385***	-0.256***	-0.131***
	(0.007)	(0.009)	(0.007)	(0.017)
	[-0.181]	[-2.833]	[-0.163]	[-5.213]
Temperature Distance × Homestead	0.147***	0.179***	0.159***	0.081***
	(0.011)	(0.015)	(0.011)	(0.021)
	[0.042]	[0.616]	[0.046]	[2.193]
Precipitation Distance	-0.014***	-0.024***	-0.011***	-0.006***
	(0.001)	(0.002)	(0.001)	(0.001)
	[-0.050]	[-1.035]	[-0.042]	[-1.743]
Precipitation Distance × Homestead	0.002	0.013***	0.000	0.000
	(0.002)	(0.004)	(0.003)	(0.001)
	[0.005]	[0.290]	[0.000]	[0.031]
Distance (in 100km)	-0.185***	-0.322***	-0.147***	-0.065**
	(0.009)	(0.013)	(0.009)	(0.026)
	[-0.245]	[-5.206]	[-0.206]	[-5.241]
Distance × Homestead	0.065***	0.066***	0.073***	-0.062***
	(0.007)	(0.011)	(0.007)	(0.014)
	[0.049]	[0.615]	[0.058]	[-4.722]
Homestead				0.975***
				(0.224)
				[3.297]
Observations	27,678,550	26,956,182	26,937,930	847,894
Pseudo R-squared	0.600	0.387	0.719	0.402
Mean Temp. Dist.	5.113	5.071	5.091	7.429
SD Temp. Dist.	3.699	3.668	3.686	4.609
Mean Precip. Dist.	27.22	26.94	27.10	40.17
SD Precip. Dist.	22.06	21.85	22.03	36.16
County o × Decade FE	Yes	Yes	Yes	
County d × Decade FE	Yes	Yes	Yes	
US Controls				Yes
Norwegian Controls				Yes
US State FE				Yes
Norwegian Province FE				Yes
Occupation	Any	Farmer	Non-Farmer	Any
Sample	US	US	US	Norwegian

Notes: The sample includes: for each decade from 1860-1870 to 1910-1920 all county-pairs in the contiguous US, such that origin counties never offered any Homestead land, in columns 1 to 3; pairs formed by all Norwegian municipalities (origins) and all US counties (destinations) with at least one European immigrant in 1880, in column 4. *Number of Migrants* is the number of men: aged 15+ in the baseline year who moved from the origin to the destination county in each period, derived from the US linked sample (columns 1 to 3); age 10+ in 1865 linked between the 1865 Norwegian and the 1880 US Censuses (column 4). See Appendix B for more details. *Temperature Distance* (resp., *Precipitation Distance*) is the absolute value of the temperature (resp., precipitation) difference between origin and destination. *Distance* is the physical distance between counties (resp., between a county and New York City) in columns 1 to 3 (resp., column 4), expressed in 100 km. In columns 1 to 3 (resp., column 4) *Homestead* is a dummy equal to one if the homesteaded share of the area in the county of destination in a given decade (resp., between 1865 and 1880) is above the 80^{th} percentile of the homesteaded share of county area calculated over the entire US for the 1860-1920. Column 1 includes all migrants, while columns 2 and 3 restrict attention to men 15+ (in the baseline year) who were farmers and non-farmers, respectively. See notes to Table 3 (resp., Table 1) for the detailed list of controls included in columns 1 to 3 (resp., column 4). County o (resp., county d) refers to county of origin (resp., of destination). Standardized beta coefficients are reported in square brackets. Standard errors, reported in parentheses, are clustered at the state of origin by state of destination by decade (resp., at the US state by Norwegian province) level in columns 1 to 3 (resp., column 4). Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 7. Climate Distance and Age at Death

Dep. var.:	Age at Death			
	(1)	(2)	(3)	(4)
Temperature Distance	-0.271***	-0.121***	-0.109***	-0.114***
	(0.047)	(0.028)	(0.025)	(0.025)
	[-0.071]	[-0.032]	[-0.029]	[-0.030]
Precipitation Distance	-0.029***	-0.003	-0.003	-0.004
	(0.009)	(0.006)	(0.006)	(0.006)
	[-0.050]	[-0.005]	[-0.004]	[-0.007]
Temperature Distance Change				-0.364**
				(0.155)
				[-0.017]
Precipitation Distance Change				-0.013
				(0.027)
				[-0.004]
Observations	727,818	727,570	727,570	727,570
R-squared	0.008	0.187	0.187	0.187
Mean Temp. Dist.	3.239	3.238	3.238	3.238
SD Temp. Dist.	3.022	3.022	3.022	3.022
Mean Precip. Dist.	31.30	31.30	31.30	31.30
SD Precip. Dist.	19.41	19.41	19.41	19.41
US County *d* FE		Yes	Yes	Yes
Country *o* FE		Yes	Yes	Yes
Death Year FE		Yes	Yes	Yes
Demographic Controls		Yes	Yes	Yes
Country by US County Deaths			Yes	Yes

Notes: The sample includes all foreign-born individuals who died from 1959 to 1961 in the continental US. *Temperature Distance* (resp., *Precipitation Distance*) is the absolute value of the difference in temperature (resp., precipitation) between birth country capital and US county of death over the period 1895-1920. *Temperature Distance Change* (resp., *Precipitation Distance Change*) is the change in temperature (resp., precipitation) distance between periods 1950-1970 and 1895-1920. Column 2 includes fixed effects for US county of death, country of birth, and year of death, as well as individual controls (gender and marital status). Columns 3 and 4 add the number of individuals from the same country of origin who died in that US county between 1959 and 1961 (*Country by US County Deaths*). Standardized beta coefficients are reported in square brackets. Standard errors, reported in parentheses, are clustered at the US state by country of birth level. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.

Table 8. Change in Climate Connectivity and Population Growth (2010-1960)

Dep. var.:	Change in Log Population			
	(1)	(2)	(3)	(4)
Change in Climate Connectivity	0.048**	0.037**	0.033**	0.047**
	(0.021)	(0.016)	(0.017)	(0.018)
Observations	3,100	3,099	2,937	2,937
R-squared	0.160	0.380	0.541	0.546
State FE		Yes	Yes	Yes
County Controls			Yes	Yes
Climate Connectivity	Baseline	Baseline	Baseline	State Leave-Out

Notes: The sample includes all counties in the contiguous US (for which variables are available). Main regressors are standardized to have mean 0 and sd 1. Observations are weighted by the county population in 1960. All specifications control for historical climate (1940-1960). The connectivity index in columns 1 to 3 (*Baseline*) is constructed as described in the main text, summing the predicted percent change in migration across all counties. The index in column 4 (*State Leave-out*) is constructed by omitting counties within the same state from the summation.*County Controls* in columns 3 and 4 include the following 1960 county characteristics: the urban, the Black, the immigrant, and the 65+ share of the population; the share of the 18-65 population in the labor force; and, the employment shares in manufacturing and in agriculture. Standard errors, reported in parentheses, are clustered at the state level. Significance levels: *** p<0.01, ** p<0.05, * p<0.1.