Ecological Imperialism: Climate and the Demographic Success of European Settlement*

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Abstract

Since 1500, millions of Europeans settled overseas, and by 2000 nearly half of all people of European descent lived outside Europe. Yet, the scale and persistence of European settlement varied dramatically across destinations. What explains where Europeans settled overseas and why some settler populations expanded while others did not? We test Alfred Crosby's *Ecological Imperialism* hypothesis that ecological compatibility between Europe and overseas territories shaped the demographic success of European settlement. We combine genealogical microdata on more than 290,000 Europeans born between 1500 and 1850 who died outside Europe with high-resolution climate and agronomic data to measure ecological similarity between settlers' origins and destinations. We first show that both temperature and agronomic distance reduced permanent European settlement. We then document that temperature, but not agronomic, distance also reduced settlers' longevity and fertility. Finally, we show that locations where European settlers faced greater temperature and agronomic distance have lower agricultural output today, even within countries. Temperature distance further predicts lower nighttime luminosity, suggesting that its relationship with long-run development extended beyond agriculture, whereas agronomic distance was related only to agricultural output.

Keywords: Climate, ecology, European overseas settlement, demography.
JEL Codes: N0, N30, J61, O13.

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1 Introduction

Since 1500, millions of Europeans settled overseas, reshaping the demographic geography of the Americas, Oceania, and beyond. By 2000, approximately 576 million people of European descent lived outside Europe, compared to roughly 687 million in Europe itself (Putterman and Weil, 2010). This expansion was deeply uneven: Europeans came to form the majority in North America, the Southern Cone, and Australasia, while remaining a thin minority across most of Africa and Asia. What explains the global distribution of Europeans and their descendants? One influential hypothesis, advanced by Alfred Crosby in *Ecological Imperialism*, is that the success of European overseas settlement depended on ecological compatibility between Europe and colonial destinations (Crosby, 1986). Europeans were more likely to establish enduring settler societies in places where the ecology allowed them to survive, reproduce, and sustain growing populations, while climatically and agronomically distant environments limited permanent settlement. Therefore, climate and agronomic distance between European origins and overseas destinations should have shaped not only where Europeans settled, but also the global distribution of their descendants today.

In this paper, we bring Crosby (1986)'s hypothesis to the data. We examine whether ecological distance between European origins and overseas destinations influenced migration, longevity, and fertility of European settlers. We use population-scale genealogical records on more than 290,000 Europeans born between 1500 and 1850 who died in former colonies. These records report individuals' birth and death locations and dates, as well as their longevity and fertility, allowing us to study permanent overseas migration and demographic success of European settlers. Because the genealogical records are constructed from user-submitted family trees, we validate them against independent historical sources. Settlement patterns closely track historical estimates of European population shares (Easterly and Levine, 2016), and the timing and regional origins of Spanish migration to Latin America closely match newly compiled archival records (Arroyo Abad and Espín-Sánchez, 2025).

We link the genealogical records to high-resolution climate and agronomic data, and aggregate origins and destinations to $1° \times 1°$ grid cells. Building on the trade and migration literature (Anderson and Van Wincoop, 2003; Obolensky et al., 2024), we estimate gravity models relating permanent migration flows to geographic distance and climate distance, measured as the absolute difference in temperature and precipitation between origin and destination. We further augment the specification with an agronomic distance measure that captures the transferability of European crops, livestock, and production systems across origins and destinations. Our preferred specification includes country-of-origin-by-period and subnational-region-of-destination-by-period fixed effects. Identification therefore comes

from comparing, within the same period, migration flows from different European origins to locations within the same destination region that differ in their climatic similarity to the origin.

This specification absorbs time-varying shocks at both origin and destination. It also mitigates potential selection into the genealogical records, since reporting differences would have to be systematically correlated with climate within narrowly defined origin-destination-period groups. One remaining concern is that ecological distance may proxy for destination characteristics that attracted European migrants. To address this possibility, we control for destination characteristics, including precipitation, malaria ecology, and population density in 1500. We also flexibly control for destination temperature including temperature bins. This addresses the concern that Europeans preferred destinations with mild climates, and ensures that the estimated effect of temperature distance is identified by comparing locations with similar climates that differ in their ecological similarity to migrants' European origins.

We find that temperature distance reduced permanent European settlement. According to our estimates, a 5°C increase in temperature distance—comparable to moving from London to Buenos Aires or from Madrid to Johannesburg—reduces migration flows by 40.2%. The relationship is asymmetric, with the deterrent effect driven by aversion to colder destinations. Consistent with Crosby (1986)'s emphasis on the successful transplantation of European crops, livestock, and farming systems, we also find that agronomic distance reduced permanent settlement. A one-standard-deviation increase in agronomic distance lowered migration flows by approximately 40%. By contrast, and consistent with evidence from the United States (Obolensky et al., 2024), precipitation distance has weak and unstable effects.

These results are robust to alternative measures of geographic distance and travel costs. They also remain unchanged after including origin-country by destination-country fixed effects, implying that identification comes from comparisons across locations within the same migration corridor rather than across different country pairs. The results are also robust to sequentially excluding each major European colonial power, restricting the sample to the major colonial powers, and restricting attention to origins with large migration flows. Finally, the estimated effects are largely unaffected by controlling for additional bilateral measures of ecological similarity, including latitude, elevation, terrain ruggedness, coastal access, and other climatic characteristics.

We next examine whether ecological distance affected the demographic viability of European settlement, using information on settlers' age at death and completed fertility. This analysis is subject to two caveats. First, the estimates may partly reflect selection into climate

matching, if healthier or wealthier migrants were more likely to settle in climatically similar destinations. Second, fertility is observed only when children are recorded in the genealogical data. As a result, we cannot distinguish between settlers who had no children and settlers whose children were simply not reported. Moreover, because our sample includes only settlers who died overseas, it excludes those who returned to Europe; if climatic mismatch pushed struggling settlers to return, our estimates understate the demographic costs of mismatch.

We find that settlers who moved to climates farther from their origin lived shorter lives and had fewer children. A 5°C increase in temperature distance is associated with 164 fewer days of life and 0.13 fewer children. Unlike the migration results, these patterns are driven by moves to hotter destinations. This contrast suggests that colder climates primarily deterred settlement ex ante, whereas hotter climates imposed larger demographic costs on those who migrated. Neither precipitation nor agronomic distance has robust effects on settlers' longevity or fertility.

Taken together, these results provide support for Crosby's hypothesis that ecological similarity shaped the demographic success of European settlement overseas. Temperature and agronomic distance both reduced permanent migration, but only temperature distance also shortened settlers' lives and lowered their fertility. This distinction is informative about the margins through which ecological compatibility operated. Agronomic distance captures whether the crops, livestock, and farming systems Europeans carried could be reproduced at the destination. A poor agronomic match made a location less attractive to settle, which deterred migration, but it did not directly endanger the settlers who nonetheless arrived. Temperature distance, by contrast, bore on human physiology and the disease environment. A large temperature gap not only discouraged settlement but also raised mortality and depressed fertility among those who migrated. The two dimensions of ecological distance thus acted through distinct channels: the viability of European production systems and the survival of European settlers.

In the last part of the paper, we examine whether historical ecological distance among European settlers left a lasting imprint on economic development. Crosby's hypothesis points to a specific mechanism: where climate resembled that of their European origins, settlers could more easily reproduce familiar agricultural systems, transplanting their crops, livestock, and production techniques. Because systematic subnational data on agricultural production are unavailable for the colonial period, we examine whether these historical differences persist today. We relate present-day agricultural production and revenues in each $1^\circ \times 1^\circ$ destination cell to the migrant-share-weighted average climate and agronomic distance of European settlers over the period 1500–1850. The specification includes country fixed effects and the

same set of geographic, climatic, and historical characteristics used in the previous analyses, including flexible controls for local climate, malaria ecology, elevation, terrain ruggedness, and population density in 1500.

We find that locations whose European settlers faced greater temperature and agronomic distance have lower agricultural output today: a 5°C (resp., one-standard-deviation) increase in average temperature (resp., agronomic) distance is associated with a 16.9% (resp., 10.3%) decline in agricultural GDP. We then study whether this relationship extends beyond agriculture to broader measures of economic activity. Following the literature (Michalopoulos and Papaioannou, 2013, 2014; Alesina et al., 2016; Henderson et al., 2018; Chiovelli et al., 2026), we proxy local development using satellite-based nighttime luminosity. We document that greater historical temperature distance is associated with lower contemporary development: a 5°C increase in temperature distance predicts a 24% decline in luminosity. There is no relationship between agronomic distance and nighttime luminosity.

In this analysis, identification comes from comparing locations within the same country that differed in the climatic and agronomic similarity of their European settlers. Because climate and agronomic distances are constructed from settlers' origins, the variation reflects differences in the composition of settlers rather than the overall scale of European settlement. However, two remaining caveats are important for interpretation. First, settlers who selected into more climatically similar destinations may have differed systematically, for example, in wealth, skills, or other unobserved characteristics. Second, even after conditioning on country fixed effects and a rich set of controls, locations attracting more or less ecologically matched settlers may have differed along unobserved dimensions that also shaped long-run development.

With these caveats in mind, the results are consistent with Crosby's hypothesis and, in particular, with the central role he assigned to agriculture. The negative relationship between both temperature and agronomic distance and agricultural output suggests that ecological compatibility facilitated the successful transplantation of European crops, livestock, and production techniques. At the same time, the finding that only temperature distance predicts broader measures of economic activity suggests that the consequences of ecological compatibility extended beyond agriculture. This contrast indicates that while agronomic similarity operated primarily through the transferability of European agricultural systems, temperature captured broader dimensions of ecological compatibility with lasting implications for economic development.

Agriculture is unlikely to be the only mechanism linking climate distance to long-run de-

velopment. A complementary channel is institutional development. Locations where Europeans could settle more successfully may have developed more inclusive institutions, whereas greater climatic distance may have favored more extractive arrangements (Acemoglu et al., 2001). Consistent with a role for national-level factors, part of the association we estimate operates across countries: moving from continent to country fixed effects reduces the temperature-distance coefficient by roughly 45% for agricultural GDP and 14% for luminosity. Because country fixed effects absorb all national differences—including institutions, but also policies, market access, and state capacity—this decomposition is suggestive rather than decisive. In both cases, the coefficient remains economically large and statistically significant within countries, indicating that national factors alone cannot account for the relationship between climate distance and long-run development. Climatic similarity may also have encouraged trade and investment, facilitated the diffusion of European technologies, or generated agglomeration economies through larger and more persistent settlements. Disentangling the relative importance of these mechanisms is an important direction for future research.

This paper provides the first systematic, individual-level evidence on Crosby's hypothesis. Combining genealogical microdata with high-resolution climate and agronomic information, we trace the consequences of ecological compatibility from migration decisions to settlers' longevity and fertility. A central implication of Crosby's hypothesis is that ecological compatibility operated through agriculture: settlers succeeded where they could transplant familiar crops, livestock, and cultivation techniques. This connects our work to research on how climate-specific agricultural knowledge and agro-climatic conditions shape economic activity. Steckel (1983) shows that 19th-century U.S. migrants moved along lines of latitude, staying within familiar climatic zones. Bazzi et al. (2016) find that farmers relocated under Indonesia's Transmigration Program were more productive in agro-climatic conditions resembling their origins. Galor and Özak (2016) document that agro-climatic suitability leaves durable imprints on economic behavior. We show that a similar logic governed European overseas settlement and that its agricultural imprint persists.

By identifying ecology as a determinant of both where Europeans settled and how those settlements fared, our paper connects three distinct literatures. The first seeks to explain the sources of European overseas expansion, emphasizing violence (Lindqvist, 1992; Stannard, 1992; Elkins, 2022), military and technological superiority (Thomas, 1993), capitalist expansion (Wallerstein, 1974; Pomeranz, 2000; Elliott, 2006), and broader biogeographic advantages (Diamond, 1997). The second examines the deep geographic and ancestral roots of comparative development (Spolaore and Wacziarg, 2013), showing that current prosperity

reflects the historical origins of a region's population (Putterman and Weil, 2010; Ashraf and Galor, 2013) and its physical geography (Henderson et al., 2018). The third studies the long-run economic consequences of European settlement.[1] A large body of work links European settlement to the institutions and economic trajectories of former colonies (Hall and Jones, 1999; Acemoglu et al., 2001, 2002), and documents the persistence of local economic activity (Maloney and Valencia Caicedo, 2016) and the long-run effects of colonial institutions and policies (Banerjee and Iyer, 2005; Nunn and Wantchekon, 2011; Michalopoulos and Papaioannou, 2016; Valencia Caicedo, 2019; Dell and Olken, 2020; Chiovelli et al., 2024). Most closely related, Feyrer and Sacerdote (2009) and Easterly and Levine (2016) show that the duration and scale of European settlement predict development today. We connect these literatures by showing that ecological compatibility shaped both where Europeans established enduring settlements and the long-run development of the territories they occupied. Our results suggest that what mattered was not a location's absolute geography, but its ecological match to settlers' origins—a bilateral distance that varies across origin populations within the same destination.

Finally, our findings contribute to work documenting climate matching in migration. Obolensky et al. (2024) show that climate distance reduced both international and internal migration in the United States between 1850 and 2019, and document adverse effects on migrants' longevity, fertility, and child mortality. Huybers et al. (2026) provide evidence that climatic similarity shaped migration patterns in Western Eurasia over the last 10,000 years. We complement this literature by examining European overseas settlement—a defining episode in world history—and by showing that ecological distance shaped not only migration and demographic success, but also the long-run economic consequences of European settlement.

2 Historical Background

2.1 European Overseas Expansion and Settlement

Osterhammel (1997) defines colonialism as "a relationship between an indigenous (or forcibly imported) majority and a minority of foreign invaders. The fundamental decisions affecting the lives of the colonized people are made and implemented by the colonial rulers in pursuit of interests that are often defined in a distant metropolis." As noted by Manjapra (2020), this asymmetrical relationship of domination was not unique to the modern era. Earlier empires—

[1] See Fenske et al. (2025) for a recent review.

such as the Roman, Mongol, and Ottoman—also ruled over conquered territories far from their political centers. What distinguished the modern era, however, was the combination of maritime technology and oceanic expansion. Beginning in the 15th century, European powers established colonies separated from their metropoles by vast oceans, creating for the first time a truly global system that integrated the Americas, Africa, Asia, and Oceania.

European overseas expansion unfolded gradually from the late 15th century onward. Iberian powers first established Atlantic outposts and, by the early 16th century, conquered large territories in the Americas (Dunn and Kelley, 1989; Subrahmanyam, 1997). From the 17th century, northern European powers entered the imperial arena, creating trading posts, plantation colonies, and settler outposts across the Atlantic, Indian Ocean, and Asia (Osterhammel, 1997). In Africa, large-scale territorial control expanded later, particularly during the late 19th century "Scramble for Africa," when European powers partitioned most of the continent into formal colonies (Michalopoulos and Papaioannou, 2014, 2016, 2020). By the 18th and 19th centuries, European empires spanned the globe, though their effective control and demographic presence remained highly uneven across regions.

Forms of colonial rule varied widely, reflecting both metropolitan strategy and local ecological and demographic conditions. In some territories—such as North America, Australia, New Zealand, and temperate regions of South America, particularly Argentina and Uruguay—Europeans migrated in large numbers and established enduring settler societies (Acemoglu et al., 2001). In others, particularly in the Caribbean and Brazil, European elites developed plantation economies reliant on enslaved African labor (Engerman and Sokoloff, 2000, 2002). Still elsewhere, colonial activity centered on mineral extraction, as in Potosí, or on strategic ports and trading hubs such as Goa, Batavia in Java, and Singapore, where European presence was often commercial and administrative rather than demographic (Dell, 2010; Dell and Olken, 2020). Similar patterns characterized much of tropical Africa and South Asia, where European control often extended over vast territories without large-scale settler migration (Easterly and Levine, 2016).

Institutional arrangements mirrored these differences. In "extractive states," colonial rulers imposed few checks on executive power and directed resources to the metropole, often through coerced or slave labor. By contrast, where Europeans settled in large numbers, they established institutions that protected property rights and constrained executive authority—institutions that were inclusive primarily for European settlers. Across both extractive and settler settings, however, colonial rule entailed profound disruption for indigenous populations through coercion, displacement, extermination, and political exclusion. Acemoglu et al. (2001, 2002) emphasize settler mortality and pre-colonial population density as key

determinants of this divergence and its long-run consequences. A complementary perspective stresses factor endowments and geographic conditions (Diamond, 1997; Engerman and Sokoloff, 1997, 2002): where climate and soils favored plantation crops or mineral extraction, production relied on coerced labor and entrenched inequality; where smallholder farming was viable, more egalitarian institutions emerged.

2.2 Crosby's Hypothesis

While the perspectives described earlier emphasize disease environments, factor endowments, or institutions, they do not directly examine how ecological compatibility between Europe and overseas territories shaped the scale and sustainability of European settlement. In *Ecological Imperialism*, Alfred W. Crosby advanced precisely this argument. He contended that the success of European colonization depended on whether local environments could sustain the transfer and reproduction of European organisms (Crosby, 1986). As Crosby put it, "the prospective settlement had to be placed where the land and climate were similar to those in some part of Europe," and sufficiently removed from the Old World to limit exposure to predators and pathogens adapted to European species (Crosby, 1986, p.102).

Central to Crosby's framework is the notion of "Neo-Europes:" geographically distant territories united by temperate climates and, ultimately, by majority-European populations. These lands shared ecological conditions that allowed European settlers to replicate familiar crops and livestock. Even within these broader temperate zones, settlement clustered where local conditions most closely resembled those of Europe—the eastern seaboard of North America, southeastern Australia, much of New Zealand, and the Río de la Plata grasslands of South America.

Crosby's argument implies that climatic and agronomic similarity between origin and destination should predict the intensity of European migration and settlement. The mechanism operated through what he termed the *portmanteau biota*: the bundle of crops, livestock, weeds, and pathogens that Europeans carried abroad. In familiar settings, European grains and animals flourished and often displaced native species. Mortality shocks among native populations, combined with the ecological dominance of European species, tilted the balance decisively in favor of settlers.[2] In settings where climatic conditions differed from Europe,

[2] A large epidemiological and historical literature argues that Eurasian populations evolved and sustained crowd diseases because of higher population densities, sustained urbanization, and close contact with domesticated animals. These conditions gave rise to pathogens capable of causing large epidemics—such as smallpox, measles, and influenza—to which many indigenous populations outside the Old World had little prior exposure (McNeill, 1976; Crosby, 1986; Diamond, 1997). This asymmetry in exposure and immunity helps explain why pathogen transmission following first contact produced catastrophic mortality among indigenous populations, reinforcing the "one-sided" ecological advantage emphasized by Crosby.

by contrast, European crops frequently failed, livestock succumbed to local diseases, and settlers faced high mortality from malaria, yellow fever, and other pathogens.

Crosby's argument resonates with contemporary records stressing the relevance of environmental fit. The *Relaciones Geográficas* (1577–1586), a systematic survey commissioned by the Spanish crown, asked local officials to document climate, soils, flora and fauna, and the healthfulness of their jurisdictions. Climate and disease environments were central to assessments of colonial viability: questions inquired whether provinces were "cold or hot, dry or damp," whether towns were "healthful or unhealthful," and how well European animals bred in local conditions. Similar concerns appear in English sources. In 1622, Sir Ferdinando Gorges described New England as "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). A few decades later, Thomas Newe observed from Carolina that settlers typically endured a "seasoning" but that mortality was limited (Newe, 1911). Such testimonies reveal a shared awareness across empires that climate compatibility shaped the sustainability of colonial projects, anticipating Crosby's later synthesis.

3 Data and Measurement

This section describes the main datasets used in the analysis. Section 3.1 presents the genealogical records. Section 3.2 describes the climate and agronomic data. Section 3.3 describes the data on long-run economic development. Additional variables are introduced as they become relevant below.

3.1 Genealogical Records

Measuring European overseas settlement. To measure historical overseas migration of European settlers, we rely on the FamiLinx database. FamiLinx is a genealogical resource that records individual-level demographic information from user-submitted family trees hosted on the online platform Geni.com, harmonizing details on birth and death dates and locations, sex, and kinship ties over several centuries (Colasurdo and Omenti, 2024). The dataset was assembled by Kaplanis et al. (2018) and has since been extended and applied in subsequent work in economics, including Blanc and Wacziarg (2025). It links together population-scale family trees covering approximately 13 million individuals, compiled from 86 million user-contributed profiles.

We restrict the sample to individuals born in Europe between 1500 and 1850 who died in non-European territories classified as colonies by Acemoglu et al. (2001). This restriction isolates cases of long-distance, permanent migration during the early modern colonial period and excludes temporary sojourns or return movements.[3] We further clean the data in three steps. First, we drop observations geocoded to country centroids, which FamiLinx assigns when profiles report only a country rather than a specific locality. Second, because the same individual may appear in multiple user-submitted family trees, we collapse near-duplicate profiles sharing the same sex, birth and death years, coordinates, and number of children. Third, we reassign observations geocoded offshore—an artifact of imprecise geocoding of coastal locations—to the nearest first-level administrative unit within 25 kilometers. After these cleaning steps, the final sample contains 293,872 European settlers.

Figure 1, Panel A, displays the distribution of European settlers in our sample across destinations. Settlement is highly concentrated in North America—particularly the United States—as well as in temperate regions of South America, Australia, and New Zealand. By contrast, European presence is more limited and spatially dispersed across Africa and South and Southeast Asia, consistent with lower levels of permanent settlement in these regions. Table A.1 reports the distribution of individuals by European country of origin. The bulk of observations come from a small number of sending countries, most notably Great Britain, France, Germany, Ireland, and the Netherlands, which together account for the vast majority of cases. Scandinavian countries also contribute a non-trivial number of migrants. While Scandinavian overseas expansion during the early modern period was limited, these flows reflect both Denmark–Norway's colonial possessions in the Caribbean and, more importantly, the large-scale 19th-century emigration from Sweden and Norway to North America and other settler destinations (Abramitzky and Boustan, 2017). Southern European countries such as Spain and Portugal are also represented, though in smaller numbers, while origins from the rest of Europe are relatively rare.

Figure A.1 displays settlement patterns for four major colonial European origins: Spain (Panel A), Portugal (Panel B), Great Britain (Panel C), and the Netherlands (Panel D). Migration flows are substantially larger for Great Britain and the Netherlands, as indicated by the thicker and more numerous connections, while flows from Spain and Portugal are smaller in our data. There is also marked variation across origins in the geography of settlement. Spanish and Portuguese migrants are concentrated in Latin America, reflecting early colonial expansion in the Americas, whereas British and Dutch settlers are more widely

[3] Europe is defined as the intersection of a bounding box (−10° to 40° longitude, 30° to 71° latitude) with the Natural Earth "Europe" polygons (WGS84). Individuals are classified as European-born if their origin lies within this area. Country boundaries are harmonized to contemporary Natural Earth definitions.

dispersed, with flows extending to North America, Africa, Asia, and Oceania. Notably, even within each empire there is considerable heterogeneity in destination choices: migrants from the same origin country move to a wide range of locations across continents. This within-origin variation is central to our empirical strategy, as it allows us to compare settlement patterns across destinations that differ in ecological characteristics while holding origin-specific factors constant.

Data validation and potential limitations. Because FamiLinx does not capture the full universe of European settlers, we assess how closely the observed settlement patterns align with independent historical evidence on European presence overseas. First, we aggregate our sample to the country-of-destination level and correlate the log number of settlers in our data with the log European population during the colonial period as estimated by Easterly and Levine (2016). Figure A.2 plots the resulting relationship and reveals a strong positive correlation between the two independent sources.[4] The relationship remains robust when excluding the four countries with especially large European populations—United States, Canada, New Zealand, and Australia (dashed line).

Second, we focus on migrants born in Spain and compare our counts to the comprehensive archival estimates in Arroyo Abad and Espín-Sánchez (2025).[5] Figure A.3 presents this comparison. Panel A displays the number of Spanish-born individuals in our data by year of birth, while Panel B maps their regional origins within Spain. Panels C and D report the corresponding figures from Arroyo Abad and Espín-Sánchez (2025). The temporal dynamics and regional composition align closely across datasets. The peak in migration appears slightly later in the archival data (Panel C) than in our series (Panel A), as expected: their data record year of departure, whereas ours record year of birth.

One remaining caveat is that missingness may be selective. Individuals with reported demographic information are more likely to have other variables recorded, and completeness tends to cluster within families. Compared to official registers, FamiLinx population displays

[4] For each country we compute the average European population across the benchmark years reported in Easterly and Levine (2016) for the period 1500–1900. There are no former colonies for which Easterly and Levine (2016) report a strictly positive European population between 1500 and 1900 but for which we observe no genealogical migrants. Conversely, we identify 50 former colonies for which we observe at least one migrant in our data but for which Easterly and Levine (2016) either lack data or record a zero European population over the same period. Three of these countries—Indonesia (566 migrants), India (528 migrants), and Uruguay (393 migrants)—account for the largest shares. Easterly and Levine (2016) explicitly mention India, noting that their measure of European population excludes individuals who served temporary terms in the colonial administration, as it counts only those identified as permanent private settlers. The remaining 47 countries exhibit considerably smaller migrant counts, with a maximum of 49 and a mean of 9.4. Collectively, these 50 countries account for only 0.59% of our total genealogical sample.

[5] Arroyo Abad and Espín-Sánchez (2025) compile a comprehensive dataset of Spanish migration to Spanish America for the period 1492–1830, drawing on licenses, ship manifests, notarial records, and other archival sources from the *Archivo General de Indias* and related repositories. Their dataset records over 250,000 migrants and documents geographic origins, destinations, gender, and occupational characteristics.

systematically higher survival, with underrepresentation of women and individuals who died young, leading to biased age-sex distributions (Colasurdo and Omenti, 2024). Mortality patterns derived from FamiLinx, for example, are lower than those in official registers, particularly for earlier cohorts. While these patterns affect representativeness and thus external validity, they are less likely to threaten identification. Given our empirical design (discussed in the next sections), selection would have to vary systematically with ecological distance within narrowly defined origin-country-by-period and destination-region-by-period groups.

3.2 Climate and Agronomic Data

We measure climate using gridded data from TerraClimate (Abatzoglou et al., 2018), accessed and processed in Google Earth Engine. TerraClimate provides monthly mean temperature and total precipitation at approximately 4 km spatial resolution globally from 1958 onward. To obtain measures of local climate, we average monthly values over the period 1960–2000, and aggregate them to a 1° grid. Mean annual temperature and precipitation are defined, respectively, as the average of monthly maximum and minimum temperatures (expressed in degrees Celsius) and the sum of monthly precipitation totals (expressed in millimeters per year). These long-run means are held fixed across cohorts and are used to characterize climatic conditions at both European origins and overseas destinations.

To capture the agricultural dimension of ecological similarity emphasized by Crosby (1986), we also construct an agronomic distance measure based on crop suitability from the Global Agro-Ecological Zones (GAEZ) database. We use rainfed, low-input, no-CO_2 fertilization suitability for three broad agricultural systems representative of European farming: temperate grains, olive cultivation, and pasture grasses for livestock. For each European origin, we combine these dimensions into an origin- and a destination-specific agronomic profile. Whereas temperature and precipitation characterize local climatic conditions, these agronomic profiles capture the suitability of local environments for European crops, livestock, and farming systems.

Panels B and C of Figure 1 display the spatial distribution of mean annual temperature and temperate grain suitability across European origins and overseas regions in our data. Temperate zones—such as North America, southern South America, Australia, and New Zealand—exhibit temperatures and grain suitability broadly similar to those of Europe, whereas tropical regions in Africa, South Asia, and parts of Southeast Asia differ substantially along both dimensions. Contrasting Panels B and C with Panel A reveals that European settlement was disproportionately concentrated in regions that were both climatically and agro-

nomically similar to Europe and more limited in hotter tropical environments. Figure A.4 reports the remaining two agronomic layers—olive cultivation and pasture grasses—which, together with grains, define our agronomic measure. These display similar spatial patterns, reinforcing the close correspondence between European settlement and ecological similarity.

For each origin–destination pair, we define temperature and precipitation distance as the absolute difference between the corresponding origin and destination grid cells. We construct agronomic distance as an origin-weighted Euclidean distance between rank-normalized (deskewed) suitability scores for three broad farming systems: temperate grains, olive cultivation, and pasture grasses.[6] The resulting index is standardized across all origin–destination pairs, so that higher values indicate greater differences in the agricultural environments of origins and destinations, making the successful transfer of European crops, livestock, and production systems less likely.

Figures 2–4 illustrate the relationship between European settlement and ecological similarity using Argentina and Australia as examples. Figure 2 maps the distribution of Spanish and British settlers in the two destinations. Figures 3 and 4 report, respectively, temperature distance and agronomic distance from Seville and London. Two patterns emerge. First, Spanish settlement is concentrated in Argentina, whereas British settlement is concentrated in Australia, reflecting the greater climatic and agronomic similarity between these destinations and the corresponding European origins. Second, there is substantial within-country variation in both temperature and agronomic distance. Even within Argentina and Australia, some locations are considerably more similar to Seville or London than others, and settlement patterns closely track this local variation. Regions that are more climatically and agronomically similar to the origin consistently attract more settlers than nearby but less similar locations. These descriptive patterns are consistent with Crosby's hypothesis and motivate the empirical analysis in Section 4.

3.3 Long-Run Economic Development

We use two proxies for long-run economic development. First, to test Crosby's hypothesis that climatic similarity shaped agricultural production, we use the World Bank's Global Gridded Agricultural GDP (AgGDP) dataset (Ru et al., 2023), which disaggregates national and subnational agricultural statistics (crop, livestock, fishery, hunting, and timber production) into a global grid at a native resolution of 1/12° (approximately 0.083°, ∼10km),

[6] The origin-specific weights are a softmax of the origin cell's own suitability scores across the three farming systems, so that each system receives greater weight the more suitable the origin environment is for it.

expressed in 2010 US$ per grid cell.[7] To harmonize these data with the genealogical and climate data, we aggregate the raster to $1° \times 1°$ destination cells by averaging over the underlying sub-cells, and take the log of mean agricultural GDP within each cell.

Second, following the existing literature (Michalopoulos and Papaioannou, 2013; Henderson et al., 2018), we proxy for long-run economic performance using satellite-based nighttime luminosity from the Visible Infrared Imaging Radiometer Suite (VIIRS) Day/Night Band. Nighttime lights provide a spatially disaggregated measure of economic activity that allows us to exploit within-country variation while holding national institutions and policies constant. We use annual composite data for 2015, which provides largely cloud-free global coverage at approximately 500-meter resolution. We aggregate pixel-level values to $1° \times 1°$ grid cells by computing mean luminosity within each cell.

4 Ecological Distance and Migration

This section examines whether climatic and agronomic similarity between European origins and overseas destinations shaped permanent European settlement. Section 4.1 describes the empirical strategy. Section 4.2 presents the main findings, showing that temperature and agronomic distances both reduced migration. Section 4.3 demonstrates that these findings are robust to alternative specifications and sample restrictions.

4.1 Empirical Strategy

We aggregate the individual-level data described in Section 3.1 to the origin–destination–cohort level. Origins correspond to $1° \times 1°$ grid cells in Europe, and destinations to $1° \times 1°$ grid cells in non-European territories classified as colonies in Acemoglu et al. (2001). Cohorts are defined as 50-year birth intervals (e.g., 1500–1549, 1550–1599) spanning 1500 to 1850. Following the trade literature (Anderson and Van Wincoop, 2003), we estimate gravity models that relate migration flows to both geographic and ecological distances. While the standard gravity framework explains flows primarily as a function of geographic distance, we build on recent work by Obolensky et al. (2024) by incorporating climate distance, adding temperature and precipitation distance alongside geography. We further augment the specification with agronomic distance, capturing the transferability of European crops, livestock, and farming systems across origins and destinations, as emphasized by Crosby (1986). Be-

[7] Dataset available at the World Bank Data Catalog (https://datacatalog.worldbank.org/search/dataset/0061507); methodology described in Ru et al. (2023).

cause the migration matrix is sparse, we estimate the model using Poisson pseudo-maximum likelihood (PPML), following Silva and Tenreyro (2006):

$$M_{odt} = \exp[\alpha_{c(o)t} + \delta_{r(d)t} + \beta \text{Dist}_{od}^{\text{Climate}} + \gamma \text{Dist}_{od}^{\text{Agro}} + \theta \log \text{Dist}_{od}^{\text{Physical}} + X_d]\epsilon_{odt} \quad (1)$$

where M_{odt} denotes the number of individuals born in European origin cell o during period t who died in destination cell d, while $\text{Dist}_{od}^{\text{Climate}}$ and $\text{Dist}_{od}^{\text{Agro}}$ denote the bilateral climatic (temperature and precipitation) and agronomic distances between origin o and destination d. We also control for the log of geographic distance ($\log \text{Dist}_{od}^{\text{Physical}}$), to capture migration costs and other unobserved correlates of spatial separation.[8] The preferred specification further includes country of origin by period fixed effects ($\alpha_{c(o)t}$) and ADM-1 region of destination by period fixed effects ($\delta_{r(d)t}$).[9] The former absorb time-varying push factors at the origin (e.g., demographic shocks, political instability, conflicts), while the latter account for time-varying pull factors within the same destination region (e.g., ecological conditions, colonial policies, institutional shifts).

A remaining concern is that climate distance may proxy for destination characteristics that independently affected settlement. Our preferred specification therefore controls for a rich set of destination characteristics (X_d), including destination temperature bins, mean precipitation, elevation, absolute latitude, crop suitability, malaria ecology, and population density in 1500. Controlling for destination temperature bins ensures that the coefficient on climate distance is identified by comparing destinations with similar absolute climates that differ in their climatic similarity to migrants' European origins, rather than by Europeans' general preference for temperate environments. Standard errors are clustered at the country of origin by $2^\circ \times 2^\circ$ destination-cell level.

Crosby's hypothesis predicts that both β and γ are negative: conditional on geographic distance, time-varying shocks at both ends of the migration corridor, and destination characteristics, Europeans should have been less likely to establish permanent settlements in destinations with greater climatic and agronomic distance from their places of origin.

[8] As shown below, results are robust to replacing straight-line geographic distance with a measure of travel costs that decomposes movement into three segments: (i) the inland distance from each origin grid-cell centroid to the principal seaport of the origin country, (ii) the oceanic distance between the principal origin and destination seaports, and (iii) the inland distance from the destination seaport to the destination grid-cell centroid.

[9] ADM-1 units are the first-level administrative divisions below the national level (e.g., states in the United States, provinces in Canada, or departments in Colombia). We take them from the GADM database of global administrative areas. Each destination cell is assigned to the ADM-1 unit in which it falls (using the modal unit for cells that straddle a boundary).

4.2 Results

We report estimates of equation (1) in Table 1. Column 1 presents a parsimonious specification that includes temperature distance, precipitation distance, agronomic distance, and the log of geographic distance. Temperature, precipitation, and agronomic distance all enter with negative and statistically significant coefficients, suggesting that permanent European settlement was less likely in destinations whose climatic and agronomic conditions differed more from those of migrants' origins. Column 2 adds 50-year period fixed effects to absorb global shocks common across all locations, such as technological change or shifts in trade conditions. Column 3 further includes country-of-origin and country-of-destination fixed effects, controlling for time-invariant characteristics such as population size, institutional quality, or average mortality environments. The coefficient on temperature distance remains similar to that in column 1, while that on precipitation distance increases somewhat in magnitude (in absolute value). The coefficient on agronomic distance declines by roughly 40% but remains statistically significant at the 5% level.

Column 4 replaces destination-country fixed effects with destination ADM-1 fixed effects, capturing finer spatial heterogeneity within countries. The coefficient on temperature distance remains negative and statistically significant at the 1% level, although its magnitude declines from –0.176 to –0.115, while the coefficient on precipitation distance becomes substantially smaller and is no longer statistically significant. The coefficient on agronomic distance also remains negative and statistically significant at the 1% level. An interesting pattern emerges for geographic distance. Whereas its coefficient is negative and statistically significant through column 3, it becomes positive once destination ADM-1 fixed effects are introduced. This suggests that the negative association between geographic distance and migration is primarily driven by the choice of destination country.

Column 5 interacts period dummies with origin-country and destination ADM-1 fixed effects, allowing migration patterns to be correlated with time-varying shocks specific to each origin country and destination region. Column 6 further controls for the full vector of destination characteristics, including destination temperature bins, mean precipitation, elevation, absolute latitude, crop suitability, malaria ecology, and population density in 1500. Together, these fixed effects and controls absorb time-varying push factors at the origin and local pull factors common to destinations within the same region, while the destination characteristics account for observed differences in geographic and epidemiological conditions across destinations. Identification therefore comes from comparing, within the same period and destination region, migrants from different European origins who faced different levels of climatic similarity to the same local environment.

The coefficient on temperature distance remains negative, statistically significant, and stable in magnitude. A 5°C increase in temperature distance—comparable to the average annual temperature difference between Madrid and Johannesburg, or between London and Buenos Aires—reduces the number of settlers by about 40%. Agronomic distance also remains negative and statistically significant, returning to a magnitude similar to that in column 1. A one-standard-deviation increase lowers migration by roughly 40%. Both effects are approximately four times as large as that of a 10% increase in population density in 1500 estimated in our specification.[10] By contrast, the coefficient on precipitation distance is quantitatively small and statistically insignificant, consistent with Obolensky et al. (2024), who similarly find that temperature is a more robust determinant of migration than precipitation in the United States between 1850 and 2019.

These results provide support for Crosby's hypothesis that ecological compatibility shaped European overseas settlement. Europeans systematically selected destinations whose ecology more closely resembled that of their places of origin. We next examine whether this relationship differs between moves to hotter and colder destinations, decomposing temperature distance into its signed components. We replace absolute temperature distance with the signed temperature difference, defined at the 1° grid-cell level as the difference between destination and origin temperatures, so that moves to colder destinations take negative values. We then re-estimate the baseline specification using this temperature-difference measure. Figure 5 reports the coefficients by temperature-difference bins, using $(-1, 1]$ as the reference category. The estimates reveal a pronounced asymmetry. Settlement falls sharply as destinations become colder relative to migrants' origins, with the deterrent effect increasing across colder temperature bins. Moves to hotter destinations are instead associated with little or no reduction in settlement.

4.3 Robustness Checks

In this section, we assess the robustness of the baseline specification (column 6 of Table 1).

Geographic distance and travel costs. We first examine whether the results are sensitive to the way geographic distance is measured. Table A.2 reports the results. Column 1 reproduces the baseline specification. Columns 2 and 3 replace the logarithm of geographic distance with its linear specification and a quadratic polynomial, respectively. Columns 4 and 5 instead replace straight-line geographic distance with a travel-cost measure that

[10] The destination-specific controls generally enter with the expected signs. Settlement is greater in locations with lower elevation, lower malaria incidence, higher crop suitability, and greater population density in 1500. Most coefficients are statistically significant.

accounts for inland travel to the origin seaport, oceanic distance between ports, and inland travel from the destination seaport. Finally, column 6 re-estimates the baseline specification using logarithmic transformations of temperature, precipitation, and agronomic distance, consistent with the standard gravity framework (Anderson and Van Wincoop, 2003). Across all specifications, the coefficients on temperature and agronomic distance remain negative, statistically significant, and stable in magnitude.

Alternative samples. Next, we assess robustness to alternative samples. We present the results in Figures A.5 and A.6, reporting the estimated coefficients on temperature and agronomic distance in Panels A and B, respectively. Figure A.5 first restricts the sample to migrants born in the six major colonial empires: Spain, Portugal, Great Britain, France, Germany, and the Netherlands. It then excludes origin countries with fewer than 500 and 1,000 settlers, respectively. Finally, it excludes African destinations. Figure A.6 reports leave-one-period-out estimates obtained by sequentially excluding each 50-year birth cohort from the sample. Across all specifications, the estimated coefficients remain negative, statistically significant, and close to the baseline estimates, shown as the leftmost points for comparison.

Country-of-origin by country-of-destination fixed effects. A remaining concern is that, despite the rich set of fixed effects in the baseline specification, unobserved factors at the country-pair level may still bias the estimates. For example, historical colonial ties, language proximity, or other bilateral relationships between countries may correlate with both migration flows and climatic similarity. To address this issue, column 2 of Table A.3 augments the preferred specification by including country-of-origin $\times$ country-of-destination fixed effects. This specification absorbs all time-invariant factors specific to each country pair. Because migration flows are measured at the origin–destination cell level, identification comes from variation within these country pairs across locations.[11] The results remain negative, statistically significant, and quantitatively similar to the baseline (reported in column 1 for comparison), indicating that the climate-matching effect is not driven by omitted country-pair characteristics.

Additional bilateral distances. Our analysis thus far has focused on mean annual temperature, mean annual precipitation, and agronomic distance as measures of ecological similarity. We now examine whether the results are robust to additional bilateral characteristics. This exercise serves two purposes. First, these factors may be correlated with tempera-

[11] In practice, this means comparing flows from different regions within the same origin country (e.g., Madrid versus Seville) to different locations within the same destination country (e.g., Buenos Aires versus other regions in Argentina), while holding constant all factors common to the Spain–Argentina pair.

ture distance and independently influence migration patterns. Second, Crosby's hypothesis emphasizes a broader notion of ecological compatibility beyond temperature alone. We report results from column 3 onward in Table A.3, where we sequentially add these variables. Column 3 includes absolute latitude distance. Column 4 adds elevation distance, column 5 incorporates terrain ruggedness, and column 6 introduces a dummy indicating whether both origin and destination have coastal access.[12]

Across all specifications, the coefficient on temperature distance remains negative and statistically significant, though it declines somewhat once latitude distance is included—consistent with latitude capturing broader climatic similarities correlated with temperature. Several of these variables are also independently predictive of migration flows. In particular, latitude distance enters with a negative and statistically significant coefficient, indicating that migrants were more likely to settle in regions with similar latitudinal positions, and consistent with patterns documented by Steckel (1983) for 19th-century U.S. internal migration. This likely reflects broader climatic and ecological similarities, such as seasonality, day length, and agricultural cycles, that are not fully captured by temperature alone. Elevation distance also enters with a small but statistically significant negative coefficient, while terrain ruggedness and coastal access are not significantly related to migration.

Alternative climate statistics. Finally, Table A.4 examines the robustness of our results to alternative measures of climate. Column 2 augments the baseline specification with temperature and precipitation ranges. Columns 3 and 4 replace mean temperature distance with distance based on minimum and maximum temperatures, respectively, while column 5 includes both simultaneously.[13] Across all specifications, the coefficient on temperature distance remains negative and statistically significant, indicating that our findings are robust to alternative ways of measuring climatic similarity.

5 Ecological Distance and Demographic Viability

Having established that ecological distance shaped European overseas settlement, we next examine whether it also affected settlers' demographic success. We focus on two key dimensions of settlement success: longevity and fertility. Section 5.1 presents the empirical strategy. Section 5.2 reports the results, showing that settlers in climatically more distant

[12] We define a cell as having coastal access if its centroid lies within 100 kilometers of the coastline.

[13] Minimum and maximum temperatures are hemisphere-adjusted: the warmest (maximum) month is July north of the equator and January south of it, and vice versa for the coldest (minimum) month, computed separately for each location's own hemisphere.

destinations lived shorter lives and had fewer children, and that these effects were driven by moves to hotter environments.

5.1 Empirical Strategy

As in Section 4, we consider European settlers born between 1500 and 1850 who died outside Europe in territories classified as colonies in Acemoglu et al. (2001). We estimate individual-level regressions using OLS of the form:

$$Y_{iodt} = \alpha_{c(o)t} + \delta_{r(d)t} + \beta \text{Dist}_{od}^{\text{Climate}} + \gamma \text{Dist}_{od}^{\text{Agro}} + \theta \log \text{Dist}_{od}^{\text{Physical}} + X_d + Male_i + \epsilon_{iodt} \quad (2)$$

where Y_{iodt} is either the age at death or the number of children of individual i, born in European origin o during birth cohort t and dying in overseas destination d.[14] All variables on the right-hand side follow the notation introduced in equation (1), with the addition of an indicator equal to one if the individual is male ($Male_i$). Standard errors are clustered at the country-of-origin by $2° \times 2°$ destination-cell level, as in Section 4.

Two caveats are worth noting. First, the inclusion of origin-country-by-period and destination-region-by-period fixed effects absorbs systematic differences in mortality and fertility across origin countries, periods, and destination regions. The remaining concern is selection into climate matching within these groups. In particular, settlers from the same origin country and period who selected into more climatically similar destinations may have differed systematically from those who settled in less similar environments. Second, for fertility we cannot distinguish between genuine childlessness and incomplete reporting of children in family trees. If reporting quality varies systematically with climate distance, the estimated fertility effects may be biased.

Finally, we observe only settlers who died overseas, and thus exclude those who returned to Europe. If those who returned had the most to lose demographically from staying, our estimates represent a lower bound on the total demographic cost of ecological distance.

5.2 Results

Baseline estimates. Table 2 reports estimates of equation (2) for settlers' age at death. The structure of the table mirrors that of Table 1. Column 1 presents a parsimonious specification including the male indicator, temperature distance, precipitation distance, agronomic

[14] Age at death is available for approximately 94% of settlers in our sample, while completed fertility is observed for only 33.2%.

distance, and the log of geographic distance. Both climate-distance measures enter with negative and statistically significant coefficients, suggesting that settlers who moved to climatically more distant destinations lived shorter lives. The coefficient on agronomic distance is instead positive and statistically insignificant. Columns 2–6 progressively introduce the same fixed effects and controls as in the migration analysis. The coefficient on precipitation distance declines in magnitude and becomes statistically insignificant. The coefficient on agronomic distance is less stable: it turns negative and statistically significant in the intermediate specifications (columns 2–4), but loses significance under the most demanding fixed effects and is negative, small, and insignificant in our preferred specification (column 6). By contrast, the coefficient on temperature distance remains negative throughout; although it attenuates, it stays economically meaningful and statistically significant at the 10% level in column 6 (p-value equal to 0.063). According to the preferred specification (column 6), a 5°C increase in temperature distance reduces age at death by approximately 164 days (0.7% of the sample mean).

Table 3 turns to completed fertility. The coefficient on temperature distance is negative and statistically significant across all specifications, indicating that settlers who moved to climatically more distant destinations had fewer children. According to the preferred specification (column 6), a 5°C increase in temperature distance reduces completed fertility by approximately 0.13 children (3.1% of the sample mean). As in the mortality analysis, agronomic distance is less stable: it is negative and statistically significant in columns 1–3, but loses significance under the most demanding fixed effects and is close to zero in our preferred specification. Precipitation distance is significant only in the parsimonious specification and small throughout.

Heterogeneity by signed temperature difference. As for migration, we examine whether the demographic effects of climate distance differ depending on whether settlers moved to hotter or colder environments. We replicate the preferred specification (Tables 2 and 3, column 6), replacing temperature distance with the signed temperature-difference bins introduced in Section 4.2. Figure 6 reports the results for age at death (Panel A) and completed fertility (Panel B). The estimates reveal a clear asymmetry. For longevity, the coefficient is statistically significant at the 10% only in the coldest temperature bin, while more moderate decreases in temperature have little effect and are estimated imprecisely. Fertility exhibits a similar but weaker pattern, with generally small and statistically insignificant effects. By contrast, moves to hotter destinations are associated with a systematic deterioration in demographic outcomes. Both longevity and fertility decline monotonically as destinations become progressively hotter than migrants' places of origin, with particularly

pronounced effects for age at death.

These patterns complement the migration results in Figure 5. Europeans were especially reluctant to settle in substantially colder environments, suggesting strong selection away from these destinations. Conditional on migration, however, the demographic penalties are more severe in hotter climates, where settlers experienced both shorter lives and lower fertility. One interpretation is that extreme cold primarily deterred settlement ex ante, whereas hotter environments imposed larger health and reproductive costs on those who migrated.

Discussion. Taken together, these results suggest that climatic similarity influenced not only where Europeans settled, but also how well they fared once they arrived. Settlers who moved to climatically more distant environments lived shorter lives and had fewer children. These findings are consistent with historical accounts emphasizing concerns about the health and demographic consequences of unfamiliar climates (Kupperman, 1984). These results should be interpreted with caution, given the selection and reporting limitations discussed above. With that qualification, they support Crosby's hypothesis that ecological compatibility shaped the demographic viability of European settlement, and provide some evidence on the margins along which it did so.

In our preferred specifications, temperature distance reduced settlers' longevity and fertility, whereas agronomic distance did not. One interpretation is that a poor agronomic match made a destination less viable for European farming, and so weighed on the decision to settle there, but did not robustly affect the survival or fertility of the settlers who arrived. Temperature distance, by contrast, acted on the body, through heat stress and unfamiliar disease environments, and so shaped not only location choice but also survival and reproduction. The two dimensions of ecological distance may thus have operated on different margins: agronomic compatibility governing whether a settlement could take hold, and temperature compatibility whether settlers endured once there.

6 Ecological Distance, Agriculture, and Development

The preceding sections have shown that ecological similarity shaped not only where Europeans settled, but also their longevity and fertility once they arrived. We now ask whether these demographic differences translated into persistent differences in economic development. Crosby (1986) emphasizes agriculture as a key mechanism: where climatic and agronomic conditions resembled those of Europe, settlers could more readily transplant familiar crops, livestock, and farming techniques. Because systematic subnational data on agricultural pro-

duction are unavailable for the colonial period, we examine whether the legacy of settlers' climate and agronomic distance is still visible today. We first relate settlers' ecological distance to contemporary agricultural production and revenues, and then ask whether the relationship extends to broader measures of local economic activity proxied by satellite-based nighttime luminosity (Michalopoulos and Papaioannou, 2013, 2014; Henderson et al., 2018). As discussed below, we lack plausibly exogenous variation in settlers' climate distance. For this reason, the estimates presented in this section should be interpreted as suggestive. Nevertheless, they provide a useful summary of whether the demographic mechanisms documented above accumulated over generations into persistent differences in local economic development.

Section 6.1 outlines the empirical strategy. Section 6.2 presents the results, showing that agricultural production and luminosity are lower in areas where European settlers' ecological distance was larger.

6.1 Empirical Strategy

We restrict the analysis to $1° \times 1°$ destination cells that received at least one European settler born between 1500 and 1850. We estimate cross-sectional OLS regressions relating present-day agricultural production and luminosity to the average climate and agronomic distance between European settlers' origins and each destination:

$$y_d = \mu_{c(d)} + \beta \, \overline{\text{Dist}}_d^{\text{Climate}} + \gamma \, \overline{\text{Dist}}_d^{\text{Agro}} + \theta \, \overline{\text{Dist}}_d^{\text{Geo}} + \mathbf{X}_d' \delta + \varepsilon_d \tag{3}$$

The dependent variable is either the log of agricultural GDP or the log of nighttime luminosity. The main explanatory variables of interest are the settler-weighted average distances at destination d in each ecological dimension, $\overline{\text{Dist}}_d^k$, with $k \in \{\text{Temp}, \text{Precip}, \text{Agro}\}$, computed as:

$$\overline{\text{Dist}}_d^k = \sum_o \omega_{od} \, \text{Dist}_{od}^k. \tag{4}$$

where Dist_{od}^k is the distance in dimension k between European origin o and destination d, and ω_{od} denotes the share of European settlers in destination d who were born in origin o between 1500 and 1850. Unlike the bilateral measures used in the previous sections, $\overline{\text{Dist}}_d^k$ summarizes the average ecological distance faced by settlers in destination d, weighting each origin by its share of settlers. As a result, it captures both the ecological similarity of the destination to European origins and the composition of the settler population: destinations attracting settlers from more ecologically similar origins exhibit lower average ecological

distance.

Equation (3) also controls for geographic distance, constructed analogously to the ecological distance measures. In our preferred specification, we further include the same vector of destination-level controls used in the previous analyses, $\mathbf{X}_d$: mean precipitation, absolute latitude, slope, log elevation, terrain ruggedness, malaria ecology, log population density in 1500, and temperature bins.[15] As before, temperature bins ensure that the coefficient on climate distance is identified by comparing locations with similar absolute climates rather than by differences between temperate and more extreme environments. We also include country fixed effects, $\mu_{c(d)}$, which absorb national characteristics shared across locations, including colonial institutions, national policies, and broad differences in state capacity. Standard errors are clustered at the $2^\circ \times 2^\circ$ grid-cell level.

Unlike the analyses in previous sections, equation (3) exploits only cross-sectional variation across destinations. Country fixed effects imply that identification comes from comparing locations within the same country whose European settlers faced different average levels of ecological distance, conditional on observed characteristics. Furthermore, because average ecological distance is constructed from migrant shares, the identifying variation reflects differences in the composition of settlers rather than the overall scale of European settlement. Two considerations are nevertheless important for interpreting these estimates. First, settlers who selected into more ecologically similar destinations may differ from those who settled in less similar environments. Second, even after conditioning on country fixed effects and destination-specific controls, locations attracting more or less ecologically matched settlers may have differed along unobserved dimensions that also shaped long-run development. For these reasons, we interpret the results as suggestive evidence on the long-run association between ecological distance and development rather than as causal effects.

6.2 Results

Table 4 reports the results. Columns 1–2 examine agricultural GDP. Column 1 includes ecological and geographic distance, the full vector of destination-specific controls, and continent fixed effects. The coefficients on temperature and agronomic distance are both negative—the former significant at the 1% level, the latter at the 10%—indicating that agricultural output today is lower in locations whose European settlers were more ecologically mismatched. Column 2 replaces continent with country fixed effects, so that identification comes from comparing cells within the same country. The coefficient on temperature distance atten-

[15] Following Michalopoulos and Papaioannou (2013), we add 0.01 to 1500 population to retain observations with zero values.

uates but remains statistically significant, while the coefficient on agronomic distance increases in magnitude and becomes significant at the 1% level. The estimates imply that a 5°C (resp., one-standard-deviation) increase in the average temperature (resp., agronomic) distance faced by European settlers is associated with a 16.9% (resp., 10.3%) decline in agricultural GDP.

Columns 3–4 turn to nighttime luminosity, following the same progression of specifications as in columns 1–2. The coefficient on temperature distance remains negative and statistically significant throughout. According to the preferred specification in column 4, a 5°C increase in the average temperature distance faced by European settlers is associated with a 24% decline in nighttime luminosity. Applying the Henderson et al. (2012, 2018) estimate of the elasticity of income with respect to luminosity, this corresponds to an implied decline in local GDP of roughly 7.9%.[16] The coefficient on agronomic distance is instead small, positive, and statistically insignificant.[17]

The contrast between temperature and agronomic distance is informative.[18] Agronomic distance predicts only agricultural output, whereas temperature distance is associated with both agricultural production and broader measures of economic activity. This asymmetry suggests that ecological compatibility shaped long-run development through more than one channel. Agronomic similarity appears to have operated through the successful transfer of European crops, livestock, and production techniques, leaving its imprint on agriculture specifically, while temperature likely captures a broader set of ecological conditions with more diffuse and lasting consequences for local development.

These findings extend Crosby's hypothesis. Crosby (1986) argued that ecological compatibility shaped the demographic success of European settlement by facilitating the transfer of European agricultural systems. Our results suggest that this agricultural advantage also translated into broader differences in economic development that persist today. Agriculture is unlikely to be the only mechanism linking temperature distance to long-run development. One complementary channel is institutional development. Acemoglu et al. (2001) argue that locations where Europeans faced lower settler mortality developed more inclusive institutions. A similar mechanism may have operated through climatic compatibility: locations

[16] We use $\psi \approx 0.30$, from their long-difference specification. The conversion is approximate: ψ is estimated from within-country annual and long-difference growth in DMSP-OLS data, whereas our estimate reflects cross-sectional variation across VIIRS grid cells—and the luminosity–income elasticity is known to vary along precisely these dimensions (satellite series, spatial scale, and levels versus growth) (Gibson et al., 2021). We therefore treat the implied GDP magnitude as illustrative.

[17] The coefficient on precipitation distance is negative and statistically significant across all columns of Table 4. Because precipitation distance was less stable in the settlement and demographic analyses, however, we do not emphasize this result.

[18] The migrant-weighted temperature and agronomic distances are positively correlated across destinations ($\rho \approx 0.5$), but the contrast does not reflect collinearity: entered separately, temperature distance predicts both agricultural GDP and luminosity, whereas agronomic distance predicts agricultural GDP but is insignificant for luminosity even on its own.

where Europeans could establish more successful settler societies may also have developed more inclusive institutions. Consistent with this interpretation, the associations between temperature distance and development attenuate when country fixed effects replace continent fixed effects, substantially for agricultural GDP and more modestly for luminosity. This indicates that a meaningful part of the relationship operates across countries, plausibly through national institutions such as property-rights protection and contract enforcement.

At the same time, both associations remain economically large and statistically significant within countries, indicating that national institutions cannot fully account for the observed pattern. Other mechanisms may also have contributed. Climatic similarity may have facilitated the diffusion of European technologies, encouraged trade and investment by lowering the costs of operating in familiar environments, or generated agglomeration economies through larger and more persistent settler populations. Disentangling the relative importance of these channels lies beyond the scope of this paper.

7 Conclusions

The scale, geography, and durability of European overseas expansion varied widely across regions. In some areas, Europeans settled in large numbers and established enduring societies; in others, their presence remained limited, transient, or extractive. A large literature has sought to explain these differences, emphasizing factors such as disease environments and settler mortality (Acemoglu et al., 2001), factor endowments and inequality (Engerman and Sokoloff, 2000), military and technological advantages (Thomas, 1993), and broader geographic and biogeographic conditions (Diamond, 1997). Complementing these perspectives, Alfred Crosby argued that European expansion depended on the extent to which overseas environments could sustain European populations, crops, and livestock (Crosby, 1986).

In this paper, we test Crosby's hypothesis by combining high-resolution climate and agronomic data with genealogical records on more than 290,000 Europeans born between 1500 and 1850 who died overseas. Estimating gravity models that build on the trade and migration literature (Anderson and Van Wincoop, 2003; Obolensky et al., 2024), we show that temperature and agronomic similarity strongly predicted where Europeans established permanent settlements. Temperature distance also shaped settlers' demographic success once they arrived. Europeans who moved to more climatically distant environments lived shorter lives and had fewer children. Finally, we document that ecological distance is negatively associated with long-run economic development. Consistent with the central role Crosby (1986) assigned to agriculture, locations whose settlers faced greater temperature and agro-

nomic distance have lower agricultural output today. Temperature distance, though not agronomic distance, also predicts lower overall economic activity, plausibly in part through the institutions these settlements developed (Acemoglu et al., 2001).

Our analysis leaves several questions open. A first direction concerns mechanisms on the agricultural side. We document that ecological distance lowered agricultural output centuries later, but we observe this imprint only in present-day production. Measuring which European crops, livestock, and farming techniques settlers adopted during the colonial period, and where they took hold would show how ecological compatibility shaped the diffusion of European production systems as it unfolded. A second direction concerns the broader link between climate distance and development. We have focused on the demographic and agricultural channels central to Crosby's thesis, but climatic compatibility may also have shaped long-run development through institutions, technology diffusion, trade and investment, and agglomeration economies. Estimating the causal effect of mismatch on development would require plausibly exogenous variation in the climatic match between settlers and their destinations, which our cross-sectional design lacks. Moreover, separating the contribution of each channel would demand further variation that moves one channel independently of the others, as well as subnational data to measure these channels at the same fine spatial scale at which we identify the effect of mismatch. We leave these questions for future research.

References

Abatzoglou, J. T., S. Z. Dobrowski, S. A. Parks, and K. C. Hegewisch (2018): "TerraClimate, a high-resolution global dataset of monthly climate and climatic water balance from 1958–2015," *Scientific data*, 5, 1–12.

Abramitzky, R. and L. Boustan (2017): "Immigration in American economic history," *Journal of economic literature*, 55, 1311–1345.

Acemoglu, D., S. Johnson, and J. A. Robinson (2001): "The Colonial Origins of Comparative Development: An Empirical Investigation," *American Economic Review*.

——— (2002): "Reversal of Fortune: Geography and Institutions in the Making of the Modern World Income Distribution," *Quarterly Journal of Economics*.

Alesina, A., S. Michalopoulos, and E. Papaioannou (2016): "Ethnic inequality," *Journal of Political Economy*, 124, 428–488.

Anderson, J. E. and E. Van Wincoop (2003): "Gravity with gravitas: A solution to the border puzzle," *American economic review*, 93, 170–192.

Arroyo Abad, L. and J.-A. Espín-Sánchez (2025): "The First Numbers of the Americas," CEPR Discussion Paper DP20591, CEPR.

Ashraf, Q. and O. Galor (2013): "The Out of Africa Hypothesis, Human Genetic Diversity, and Comparative Economic Development," *American Economic Review*, 103, 1–46.

Banerjee, A. and L. Iyer (2005): "History, Institutions, and Economic Performance: The Legacy of Colonial Land Tenure Systems in India," *American Economic Review*.

Bazzi, S., A. Gaduh, A. D. Rothenberg, and M. Wong (2016): "Skill transferability, migration, and development: Evidence from population resettlement in Indonesia," *American Economic Review*, 106, 2658–2698.

Blanc, G. and R. Wacziarg (2025): "Malthusian Migrations," *National Bureau of Economic Research*.

Chiovelli, G., L. Fergusson, L. R. Martínez, J. D. Torres, and F. V. Caicedo (2024): "Bourbon reforms and state capacity in the Spanish Empire," Tech. rep., Universidad de los Andes, Facultad de Economía, CEDE.

Chiovelli, G., S. Michalopoulos, E. Papaioannou, and T. Regan (2026): "Illuminating the global south," *The Economic Journal*, ueaf134.

Colasurdo, A. and R. Omenti (2024): "Using online genealogical data for demographic research: An empirical examination of the FamiLinx database," *Demographic Research*.

Crosby, A. W. (1986): *Ecological Imperialism: The Biological Expansion of Europe, 900–1900*, Cambridge University Press.

Dell, M. (2010): "The persistent effects of Peru's mining Mita," *Econometrica*.

Dell, M. and B. A. Olken (2020): "The development effects of the extractive colonial economy: The dutch cultivation system in java," *The Review of Economic Studies*, 87, 164–203.

Diamond, J. (1997): *Guns, Germs, and Steel: The Fates of Human Societies*, W. W. Norton & Company.

Dunn, O. and J. E. Kelley (1989): *The diario of Christopher Columbus's first voyage to America, 1492–1493*, University of Oklahoma Press.

Easterly, W. and R. Levine (2016): "The European origins of economic development," *Journal of Economic Growth*, 21, 225–257.

Elkins, C. (2022): *Legacy of Violence: A History of the British Empire*, Alfred A. Knopf.

Elliott, J. H. (2006): *Empires of the Atlantic World: Britain and Spain in America 1492–1830*, Yale University Press.

Engerman, S. L. and K. L. Sokoloff (1997): "Factor Endowments, Institutions, and Differential Paths of Growth among New World Economies: A View from Economic Historians of the United States," in *How Latin America Fell Behind: Essays on the Economic Histories of Brazil and Mexico, 1800–1914*, ed. by S. Haber, Stanford, CA: Stanford University Press, 260–304.

——— (2000): "Institutions, Factor Endowments, and Paths of Development in the New World," *Journal of Economic Perspectives*.

——— (2002): "Factor endowments, inequality, and paths of development among new world economics," .

Fenske, J., B. Gupta, and A. Mukhopadhyay (2025): "Colonial persistence," .

Feyrer, J. and B. Sacerdote (2009): "Colonialism and modern income: islands as natural experiments," *The Review of Economics and Statistics*, 91, 245–262.

Galor, O. and O. Özak (2016): "The Agricultural Origins of Time Preference," *American Economic Review*, 106, 3064–3103.

Gibson, J., S. Olivia, and G. Boe-Gibson (2021): "Night Lights in Economics: Sources and Uses," *Journal of Economic Surveys*, 35, 955–980.

Hall, R. E. and C. I. Jones (1999): "Why Do Some Countries Produce So Much More Output per Worker than Others?" *Quarterly Journal of Economics*, 114, 83–116.

Henderson, J. V., T. Squires, A. Storeygard, and D. Weil (2018): "The global distribution of economic activity: nature, history, and the role of trade," *The Quarterly Journal of Economics*, 133, 357–406.

Henderson, J. V., A. Storeygard, and D. N. Weil (2012): "Measuring Economic Growth from Outer Space," *American Economic Review*, 102, 994–1028.

Huybers, P., M. Tabellini, C. A. Taylor, and F. Toti (2026): "Climate and Prehistoric Migration," Tech. rep., National Bureau of Economic Research.

Kaplanis, J., A. Gordon, T. Shor, O. Weissbrod, D. Geiger, M. Wahl, M. Gershovits, B. Markus, M. Sheikh, M. Gymrek, G. Bhatia, D. G. MacArthur, A. L. Price, and Y. Erlich (2018): "Quantitative analysis of population-scale family trees with millions of relatives," *Science*, 360, 171–175.

Kupperman, K. O. (1984): "Fear of Hot Climates in the Anglo-American Colonial Experience," *The William and Mary Quarterly*.

Lindqvist, S. (1992): *Exterminate All the Brutes*, The New Press.

Maloney, W. F. and F. Valencia Caicedo (2016): "The persistence of (subnational) fortune," *The Economic Journal*, 126, 2363–2401.

Manjapra, K. (2020): *Colonialism in Global Perspective*, Cambridge University Press.

McNeill, W. H. (1976): *Plagues and Peoples*, Garden City, NY: Anchor Press/Doubleday.

Michalopoulos, S. and E. Papaioannou (2013): "Pre-colonial ethnic institutions and contemporary African development," *Econometrica*, 81, 113–152.

——— (2014): "National institutions and subnational development in Africa," *The Quarterly journal of economics*, 129, 151–213.

——— (2016): "The long-run effects of the scramble for Africa," *American Economic Review*, 106, 1802–1848.

——— (2020): "Historical legacies and African development," *Journal of Economic Literature*, 58, 53–128.

Newe, T. (1911): "Letter from Carolina, 1682," in *Narratives of Early Carolina, 1650–1708*, ed. by A. S. Salley, Charles Scribner's Sons, 131–139.

Nunn, N. and L. Wantchekon (2011): "The Slave Trade and the Origins of Mistrust in Africa,"

American Economic Review.

Obolensky, M., M. Tabellini, and C. Taylor (2024): "Migration, Climate Similarity, and the Consequences of Climate Mismatch," Tech. rep., National Bureau of Economic Research.

Osterhammel, J. (1997): *Colonialism: A Theoretical Overview*, Markus Wiener Publishers.

Pomeranz, K. (2000): *The Great Divergence: China, Europe, and the Making of the Modern World Economy*, Princeton University Press.

Putterman, L. and D. N. Weil (2010): "Post-1500 population flows and the long-run determinants of economic growth and inequality," *The Quarterly journal of economics*, 125, 1627–1682.

Ru, Y., B. Blankespoor, U. Wood-Sichra, T. S. Thomas, L. You, and E. Kalvelagen (2023): "Estimating local agricultural gross domestic product (AgGDP) across the world," *Earth System Science Data*, 15, 1357–1387.

Silva, J. S. and S. Tenreyro (2006): "The log of gravity," *The Review of Economics and statistics*, 641–658.

Spolaore, E. and R. Wacziarg (2013): "How Deep Are the Roots of Economic Development?" *Journal of Economic Literature*, 51, 325–369.

Stannard, D. E. (1992): *American Holocaust: The Conquest of the New World*, Oxford University Press.

Steckel, R. H. (1983): "The economic foundations of East-West migration during the 19th century," *Explorations in Economic History*, 20, 14–36.

Subrahmanyam, S. (1997): *The Career and Legend of Vasco da Gama*, Cambridge University Press.

Thomas, H. (1993): *Conquest: Montezuma, Cortés, and the Fall of Old Mexico*, Simon & Schuster.

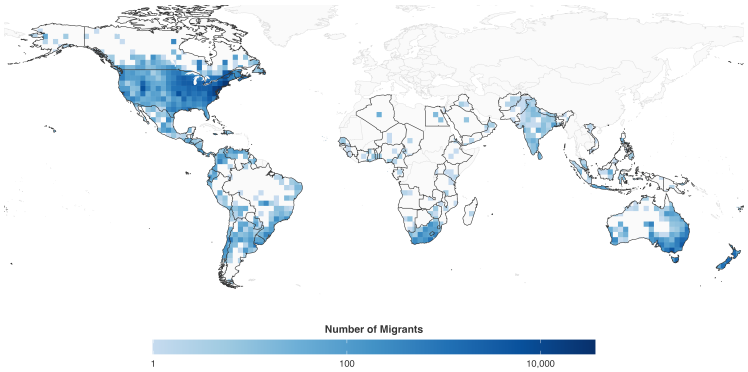
Valencia Caicedo, F. (2019): "The mission: Human capital transmission, economic persistence, and culture in South America," *The Quarterly Journal of Economics*, 134, 507–556.

Wallerstein, I. (1974): *The Modern World-System, Vol. I: Capitalist Agriculture and the Origins of the European World-Economy in the Sixteenth Century*, Academic Press.

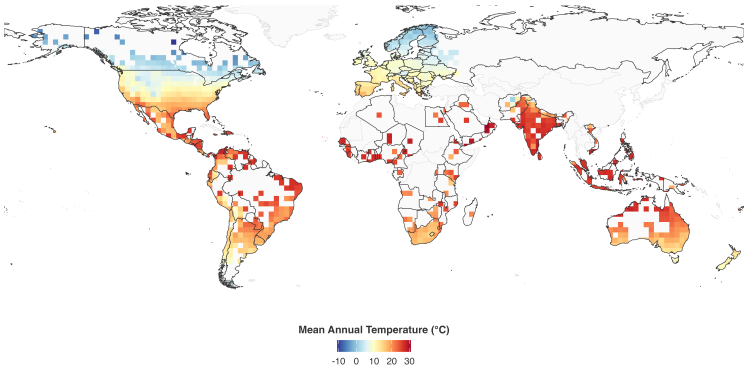
Figures and Tables

Figure 1. Number of Migrants, Average Annual Temperature, and Grain Suitability

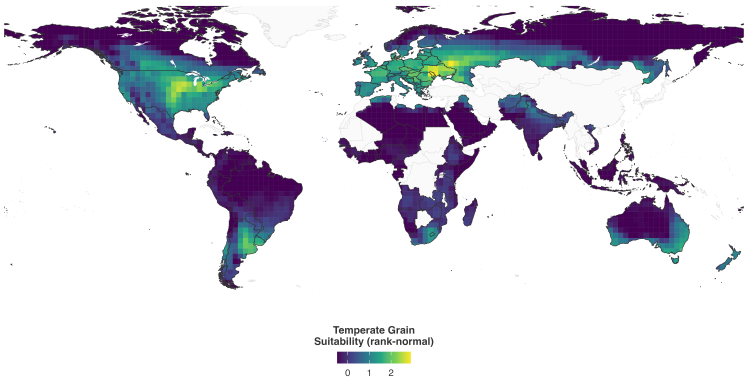
(A) Number of Migrants



(B) Average Annual Temperature



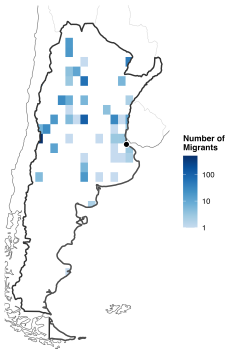
(C) Temperate Grain Suitability



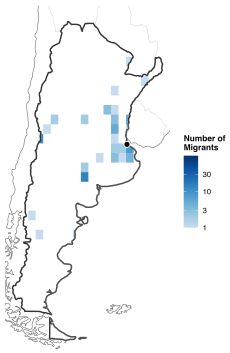
Notes: Panel A reports the number of European migrants (1500–1850) by destination grid cell using FamiLinx data. Panel B reports mean annual temperature (°C) from TerraClimate (1960–2000 averages). Panel C reports rank-normalized suitability for temperate grains (mean of wheat, barley, rye, oat, and rapeseed) from the GAEZ database, under rainfed, low-input, no-CO_2 fertilization conditions. All panels are aggregated to 2.5° × 2.5° cells for visualization.

Figure 2. European Settlement Patterns: Argentina and Australia

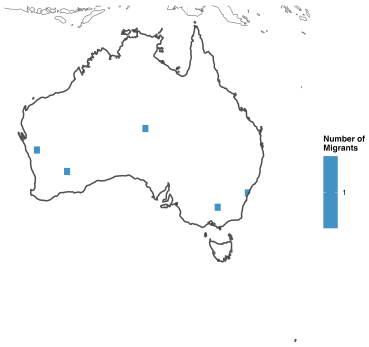
(A) Settlers Born in Spain



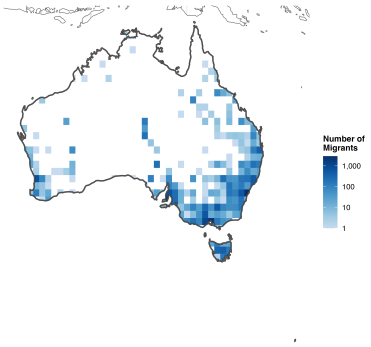
(B) Settlers Born in Great Britain



(C) Settlers Born in Spain



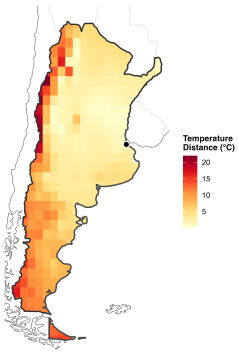
(D) Settlers Born in Great Britain



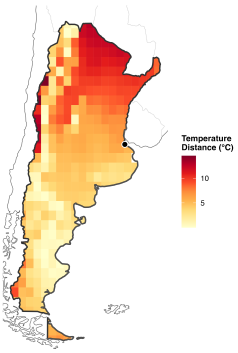
Notes: Panels A and B display the number of settlers born in Spain and in Great Britain, respectively, and dying in each 1° × 1° destination grid cell in Argentina (2,050 and 252 settlers). Panels C and D present the analogous maps for Australia (5 and 21,523 settlers).

Figure 3. Temperature Distance from Origin: Argentina and Australia

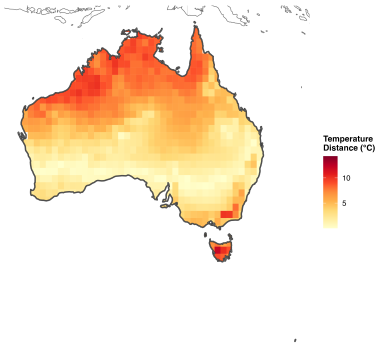
(A) Temperature Distance from Seville



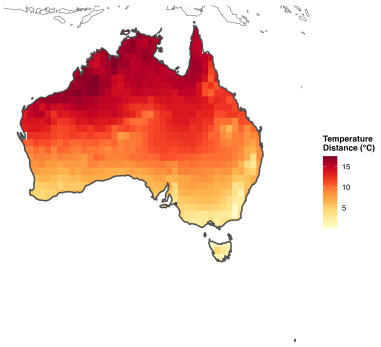
(B) Temperature Distance from London



(C) Temperature Distance from Seville



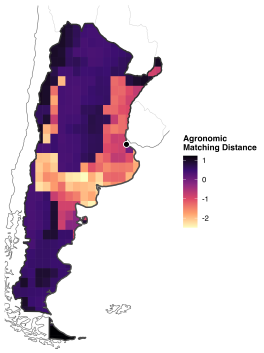
(D) Temperature Distance from London



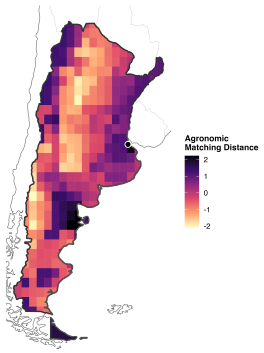
Notes: Panels A and B display temperature distance from Seville and from London, respectively, to each 1° × 1° grid cell in Argentina. Panels C and D present the analogous maps for Australia. Mean annual temperature at the origin is 18.3°C for Seville and 10.9°C for London. Temperature distance is defined as the absolute difference in mean annual temperature (in °C) between origin and destination grid cells.

Figure 4. Agronomic Distance from Origin: Argentina and Australia

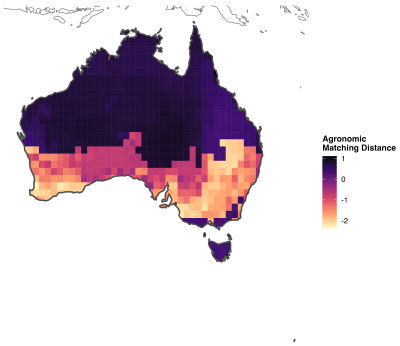
(A) Agronomic Distance from Seville



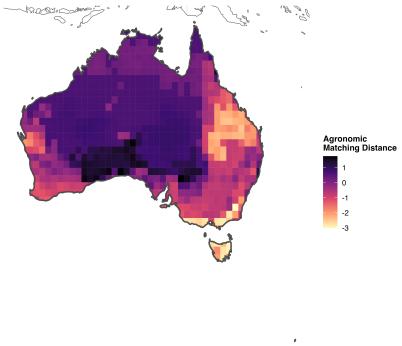
(B) Agronomic Distance from London



(C) Agronomic Distance from Seville

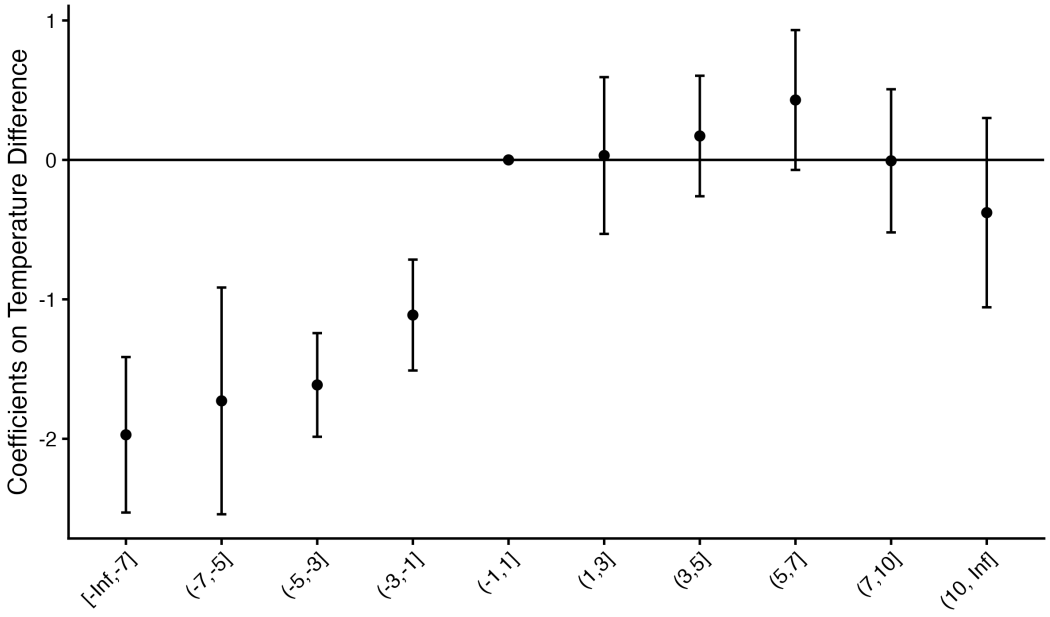


(D) Agronomic Distance from London



Notes: Panels A and B display agronomic matching distance from Seville and from London, respectively, to each $1° \times 1°$ grid cell in Argentina. Panels C and D present the analogous maps for Australia. Agronomic matching distance is the origin-weighted, de-skewed, balanced (grain/olive/grass) GAEZ crop-suitability distance between origin and destination, standardized.

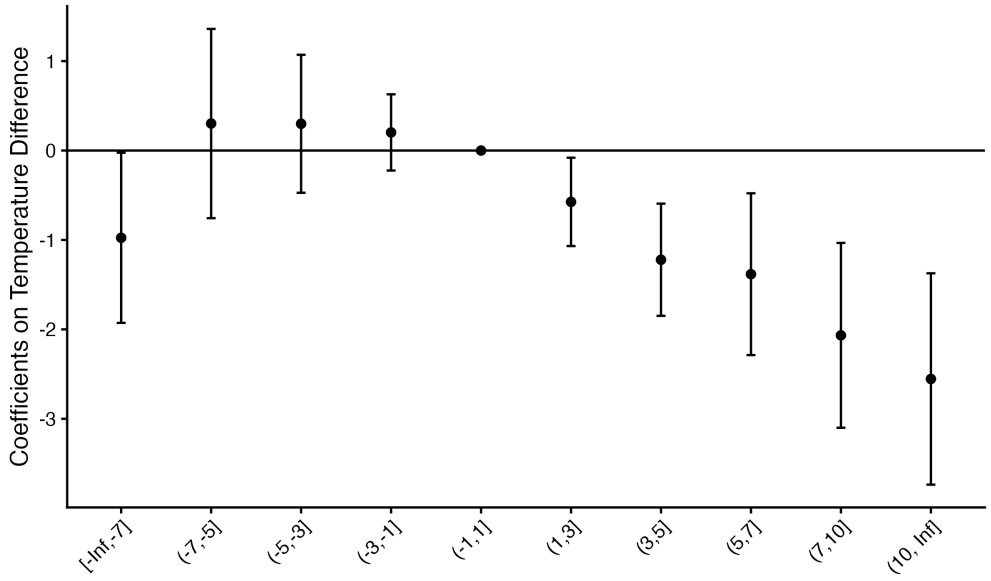
Figure 5. Non-linear Effects of Temperature Distance on Migration Flows



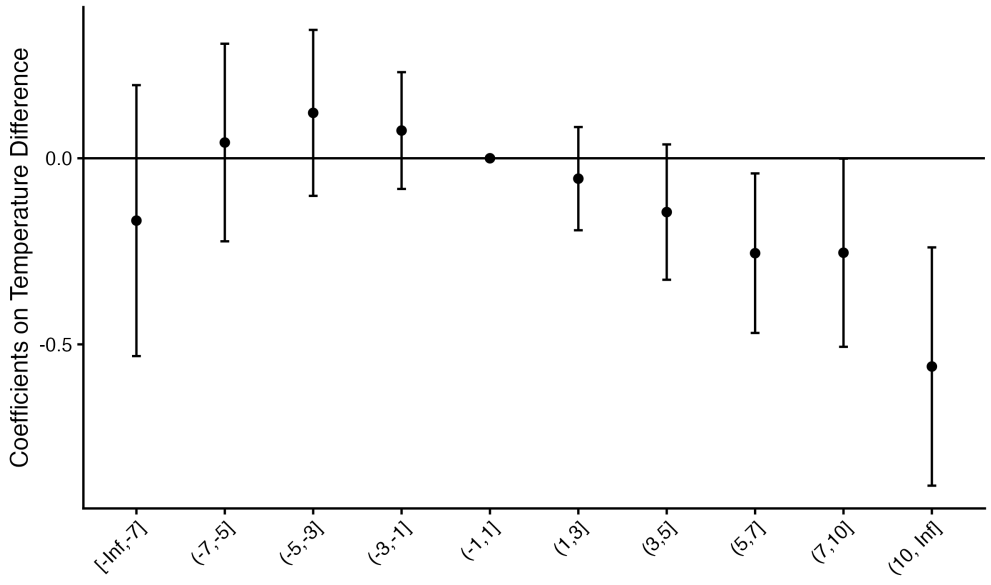
Notes: The figure plots estimated coefficients on temperature-difference bins from a Poisson regression. The dependent variable is the number of migrants in the FamiLinx database born in Europe and dying overseas, aggregated to the origin–destination–period cell at 1° × 1° resolution for 50-year periods between 1500 and 1850. Temperature difference is defined as the signed difference in mean annual temperature between destination and origin grid cells (destination minus origin, in °C). The omitted category is the bin containing zero (i.e., destinations with similar temperatures to the origin). The specification includes precipitation distance, geographic distance and its square, country-of-origin-by-period fixed effects, and ADM-1 destination-region-by-period fixed effects. Confidence intervals at the 95% level are reported. Standard errors are clustered at the country-of-origin × 1° × 1° destination-cell level.

Figure 6. Temperature Distance and Demographic Outcomes: Binned Analysis

(A) Age at Death



(B) Completed Fertility



Notes: The figure plots estimated coefficients from regressions of age at death (Panel A) and completed fertility (Panel B) on temperature-difference bins. Temperature difference is defined as the signed difference in mean annual temperature between destination and origin grid cells (destination minus origin, in °C). The omitted category is the bin containing zero (i.e., destinations with similar temperatures to the origin). All specifications include precipitation distance, geographic distance and its square, country-of-origin-by-period fixed effects, and administrative-level-1-by-period fixed effects. Panel A additionally controls for an indicator for male individuals. Confidence intervals at the 95% level are reported. Standard errors are clustered at the country-of-origin × 1° × 1° destination-cell level.

Table 1. Climate Distance and Migration Flows

Dep. var.:	Number of Migrants					
	(1)	(2)	(3)	(4)	(5)	(6)
Temperature Distance	-0.190***	-0.190***	-0.176***	-0.115***	-0.116***	-0.103***
	(0.026)	(0.026)	(0.030)	(0.025)	(0.022)	(0.022)
Precipitation Distance	-0.669***	-0.669***	-0.818***	-0.272	-0.249	-0.331
	(0.181)	(0.181)	(0.237)	(0.290)	(0.286)	(0.281)
Agronomic Distance	-0.549***	-0.549***	-0.316**	-0.348***	-0.310***	-0.514***
	(0.115)	(0.115)	(0.139)	(0.109)	(0.094)	(0.117)
Log Geographic Distance	-1.987***	-1.987***	-4.542***	4.144***	5.303***	5.034***
	(0.551)	(0.551)	(0.830)	(1.224)	(1.379)	(1.317)
Mean Precip.						1.542***
						(0.355)
Log Elevation						-0.200***
						(0.058)
Malaria Index						-0.285***
						(0.086)
Log Pop. 1500						0.956***
						(0.223)
Absolute Latitude						0.030
						(0.040)
Overall Crop Suitability						0.969***
						(0.161)
Observations	14,979,797	14,979,797	14,979,797	14,776,727	9,571,053	9,320,719
R^2	0.001	0.001	0.005	0.019	0.091	0.126
Mean Temp. Distance	9.22	9.22	9.22	9.22	9.22	9.22
Mean Prec. Distance	0.45	0.45	0.45	0.45	0.45	0.45
Period FE		Yes	Yes	Yes		
Country of Origin FE			Yes	Yes		
Country of Destination FE			Yes			
Administrative Level 1 FE				Yes		
Period × Country *o* FE					Yes	Yes
Period × Administrative Level 1 FE					Yes	Yes
Temp. Bins (Dest.)						Yes

Notes: The sample includes all origin–destination pairs formed by European grid cells (origins) and overseas grid cells (destinations) at 1°resolution, aggregated into 50-year periods between 1500 and 1850. The dependent variable, Number of Migrants, is the count of individuals in the FamiLinx database born in Europe and dying overseas, collapsed to the origin–destination–period cell. Temperature (Precipitation) Distance is the absolute difference in average temperature (precipitation) between origin and destination grid cells. Agronomic Matching is the origin-weighted, de-skewed, balanced (grain/olive/grass) GAEZ crop-suitability distance between origin and destination, standardized. Log Geographic Distance is the natural logarithm of one plus the great-circle distance, in km, between grid cell centroids. Column (6) repeats the most demanding fixed-effects specification from column (5) and adds destination-level controls: temperature bins (reference category: 15–20°C), mean precipitation, log elevation, an index of malaria ecology, log population density in 1500, absolute latitude, and overall crop suitability. Standard errors, reported in parentheses, are clustered at the country of origin by 2°destination-cell level. Significance levels: $***p < 0.01, **p < 0.05, *p < 0.1$

Table 2. Climate Distance and Settlers' Longevity

Dep. var.:	Age at Death					
	(1)	(2)	(3)	(4)	(5)	(6)
Temperature Distance	-0.331***	-0.288***	-0.260***	-0.182***	-0.165***	-0.090*
	(0.062)	(0.050)	(0.044)	(0.047)	(0.045)	(0.046)
Precipitation Distance	-0.037***	-0.017***	-0.010***	-0.004	-0.003	-0.004
	(0.006)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Agronomic Distance	0.251	-0.299*	-0.416***	-0.174*	-0.116	-0.095
	(0.231)	(0.156)	(0.153)	(0.103)	(0.094)	(0.096)
Log Geographic Distance	3.380***	-0.574	1.907	-8.682***	-6.065***	-5.399***
	(0.590)	(0.379)	(1.278)	(1.934)	(1.862)	(1.888)
Mean Precip.						0.002
						(0.006)
Log Elevation						0.632***
						(0.152)
Malaria Index						-0.139
						(0.397)
Log Pop. 1500						-0.077
						(0.556)
Absolute Latitude						0.194**
						(0.078)
Overall Crop Suitability						-0.072
						(0.265)
Observations	277,388	277,388	277,377	277,258	276,935	274,659
Adj. R^2	0.009	0.039	0.048	0.059	0.074	0.076
Mean Temp. Distance	3.356	3.356	3.356	3.356	3.356	3.356
Mean Prec. Distance	29.22	29.22	29.22	29.22	29.22	29.22
Mean Dep. Var.	67.21	67.21	67.21	67.21	67.21	67.21
Period FE		Yes	Yes	Yes		
Country of Origin FE			Yes	Yes		
Country of Destination FE			Yes			
Administrative Level 1 FE				Yes		
Period × Country *o* FE					Yes	Yes
Period × Administrative Level 1 FE					Yes	Yes
Temp. Bins (Dest.)						Yes

Notes: The dependent variable, Age at Death, is the age of death of individuals in the FamiLinx database born in Europe and dying overseas. Temperature (Precipitation) Distance is the absolute difference in average temperature (precipitation) between origin and destination grid cells. Agronomic Matching is the origin-weighted, de-skewed, balanced (grain/olive/grass) GAEZ crop-suitability distance between origin and destination, standardized. Geographic Distance is the natural logarithm of one plus the great-circle distance, in km, between grid cell centroids. Column (6) repeats the most demanding fixed-effects specification from column (5) and adds destination-level controls: temperature bins (reference category: 15–20°C), mean precipitation, log elevation, an index of malaria ecology, log population density in 1500, absolute latitude, and overall crop suitability. All specifications control for individual male dummy. Standard errors, reported in parentheses, are clustered at the country of origin by 2° × 2° destination-cell level. Significance levels: $***p < 0.01, **p < 0.05, *p < 0.1$

Table 3. Climate Distance and Settlers' Fertility

Dep. var.:	Number of Children					
	(1)	(2)	(3)	(4)	(5)	(6)
Temperature Distance	-0.031**	-0.021**	-0.044***	-0.045***	-0.040***	-0.026**
	(0.013)	(0.010)	(0.010)	(0.012)	(0.012)	(0.013)
Precipitation Distance	-0.005***	-0.001	0.001	-0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Agronomic Distance	-0.090*	-0.150***	-0.097**	-0.016	-0.008	0.001
	(0.053)	(0.036)	(0.040)	(0.032)	(0.032)	(0.032)
Log Geographic Distance	1.550***	0.506***	0.191	-0.273	0.235	0.108
	(0.127)	(0.114)	(0.377)	(0.578)	(0.598)	(0.615)
						(0.396)
Mean Precip.						0.000
						(0.002)
Log Elevation						0.034
						(0.022)
Malaria Index						0.189*
						(0.109)
Log Pop. 1500						-0.068
						(0.071)
Absolute Latitude						0.037*
						(0.022)
Overall Crop Suitability						0.077
						(0.067)
Observations	82,284	82,284	82,270	82,190	81,899	81,437
Adj. R^2	0.015	0.045	0.050	0.054	0.054	0.054
Mean Temp. Distance	3.59	3.59	3.59	3.59	3.59	3.59
Mean Prec. Distance	28.63	28.63	28.63	28.63	28.63	28.63
Mean Dep. Var.	4.13	4.13	4.13	4.13	4.13	4.13
Period FE		Yes	Yes	Yes		
Country of Origin FE			Yes	Yes		
Country of Destination FE			Yes			
Administrative Level 1 FE				Yes		
Period × Country *o* FE					Yes	Yes
Period × Administrative Level 1 FE					Yes	Yes
Temp. Bins (Dest.)						Yes

Notes: The dependent variable, Number of Children, is the number of children of individuals in the FamiLinx database born in Europe and dying overseas. Temperature (Precipitation) Distance is the absolute difference in average temperature (precipitation) between origin and destination grid cells. Agronomic Matching is the origin-weighted, de-skewed, balanced (grain/olive/grass) GAEZ crop-suitability distance between origin and destination, standardized. Geographic Distance is the natural logarithm of one plus the great-circle distance, in km, between grid cell centroids. Column (6) repeats the most demanding fixed-effects specification from column (5) and adds destination-level controls: temperature bins (reference category: 15–20°C), mean precipitation, log elevation, an index of malaria ecology, log population density in 1500, absolute latitude, and overall crop suitability. Standard errors, reported in parentheses, are clustered at the country of origin by 2° × 2° destination-cell level. Significance levels: $***p < 0.01, **p < 0.05, *p < 0.1$

Table 4. Climate Distance and Long-Run Development

	Log Agricultural GDP		Log Luminosity	
	(1)	(2)	(3)	(4)
Temperature Distance	-0.067***	-0.037***	-0.064***	-0.055***
	(0.012)	(0.011)	(0.019)	(0.018)
Precipitation Distance	-0.379***	-0.469***	-0.805***	-0.740***
	(0.123)	(0.113)	(0.179)	(0.177)
Agronomic Distance	-0.073*	-0.109***	0.035	0.033
	(0.039)	(0.036)	(0.060)	(0.061)
Log Geographic Distance	0.673***	1.232***	-0.278	-0.425
	(0.224)	(0.223)	(0.314)	(0.418)
Mean Precip.	0.513***	0.371***	0.260*	0.231
	(0.101)	(0.100)	(0.134)	(0.156)
Log Elevation	-0.085***	-0.115***	-0.154***	-0.148***
	(0.021)	(0.021)	(0.037)	(0.040)
Malaria Index	0.037***	0.028	-0.088***	-0.066
	(0.013)	(0.017)	(0.023)	(0.042)
Log Pop. 1500	0.477***	0.361***	0.590***	0.702***
	(0.038)	(0.041)	(0.052)	(0.054)
Absolute Latitude	-0.016***	0.006	-0.009	-0.012
	(0.006)	(0.007)	(0.008)	(0.011)
Overall Crop Suitability	0.517***	0.598***	0.621***	0.742***
	(0.066)	(0.061)	(0.074)	(0.085)
Observations	2,119	2,099	2,116	2,097
Adj. R^2	0.509	0.602	0.479	0.525
Mean Temp. Distance	7.60	7.60	7.58	7.58
Temp. Bins at Dest.	Yes	Yes	Yes	Yes
Continent FE	Yes		Yes	
Country FE		Yes		Yes

Notes: The sample includes destination grid cells at 1° resolution that received European migrants between 1500 and 1850, built from the same cleaned migrant sample as the main gravity pipeline (centroid-drop, dedup, ADM1-snap, death age ≤ 100). Columns 1–2: the dependent variable is the natural log of agricultural GDP from the World Bank Global Gridded Agricultural GDP (AgGDP) dataset (Ru et al., 2023) (2010). Columns 3–4: the dependent variable is log(luminosity), where luminosity is nighttime light intensity from VIIRS 2015 data. Temperature Distance is the migrant-weighted average absolute temperature difference between destination and European origins, where weights equal the number of migrants from each origin. Agronomic Distance is the origin-weighted, de-skewed, balanced (grain/olive/grass) GAEZ crop-suitability distance, migrant-share-weighted to the destination cell and standardized. Precipitation Distance and Geographic Distance are constructed analogously to Temperature Distance; Geographic Distance is migrant-weighted log distance. All columns include the full set of destination-level controls: mean temperature and precipitation, log elevation, malaria ecology index (Kiszewski et al. 2004), log population density in 1500, absolute latitude, and overall crop suitability. Columns 1 and 3 include continent-of-destination fixed effects (North America, Central and Latin America, Africa, Asia, Oceania); columns 2 and 4 replace these with country-of-destination fixed effects. Standard errors, reported in parentheses, are clustered at the 2° × 2° grid-cell level. Significance levels: $***p < 0.01, **p < 0.05, *p < 0.1$

Appendix

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A Additional Table and Figures **2**

A Additional Table and Figures

Figure A.1. Migration Flows from European Origins to Colonial Destinations

(a) Spain



(b) Portugal



(c) Great Britain

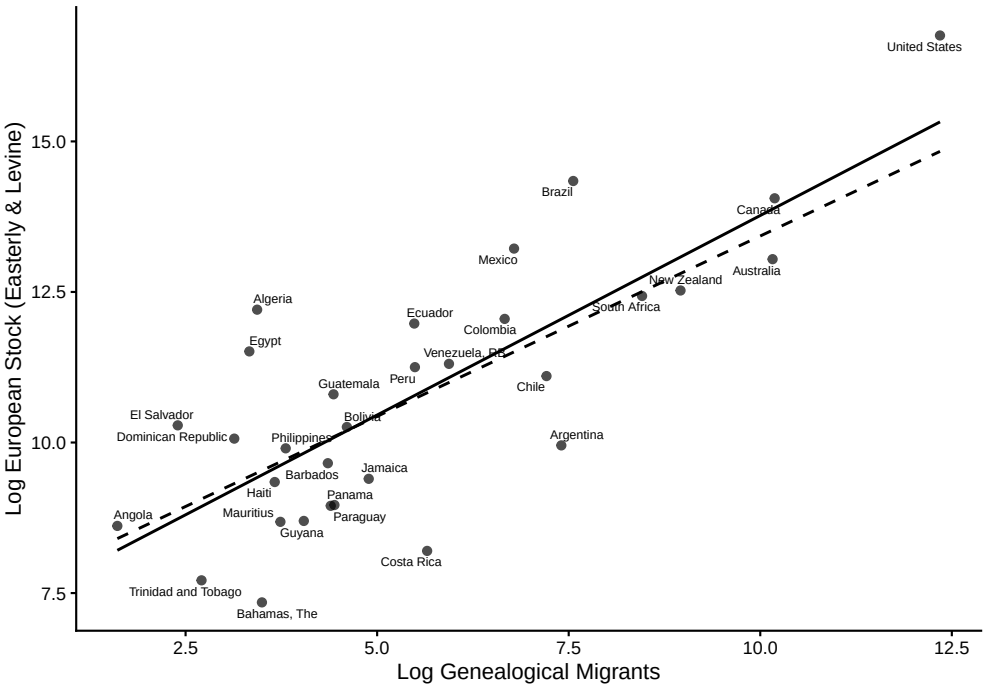


(d) The Netherlands



Notes: The figure displays the geographic distribution of settlers across destination countries by origin country. Lines connect origin capitals (Madrid, Lisbon, London, and Amsterdam) to destination countries. Line thickness is proportional to the number of migrants in the genealogical sample. Panels (a)–(d) correspond to Spain, Portugal, Great Britain, and the Netherlands.

Figure A.2. Validation: Genealogical Migrants vs. Historical European Population



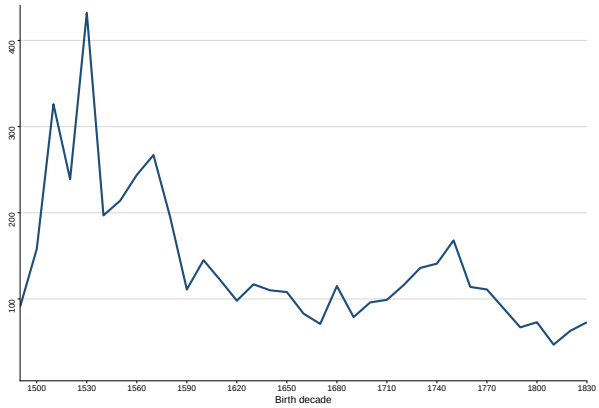
Notes: The figure plots the log number of European settlers in our genealogical data (1500–1850) against the log of the average European population reported by Easterly and Levine (2016) over the period 1500–1900. Each point represents a former colony. The solid line shows the linear fit for the full sample, while the dashed line excludes the Neo-Europes—namely, the United States, Canada, Australia, and New Zealand. The estimated regression coefficient (robust standard errors) is 0.673 (0.089) for the full sample and 0.616 (0.164) for the sample excluding Neo-Europes.

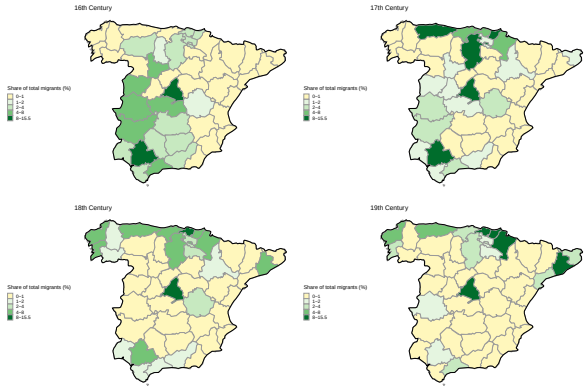
Figure A.3. Comparison of Spanish Migration Patterns: Genealogical Data vs. Historical Records

Genealogical Data

(A) Temporal Distribution

(B) Regional Origins

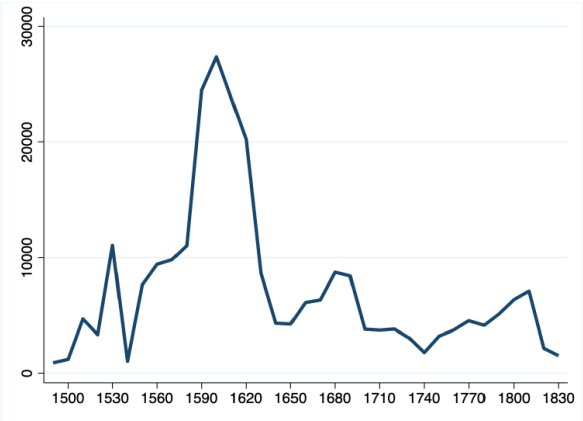


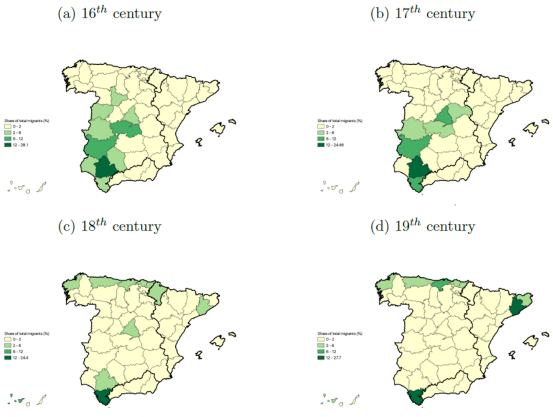


Historical Records (Arroyo Abad and Espín-Sánchez, 2025)

(C) Temporal Distribution

(D) Regional Origins

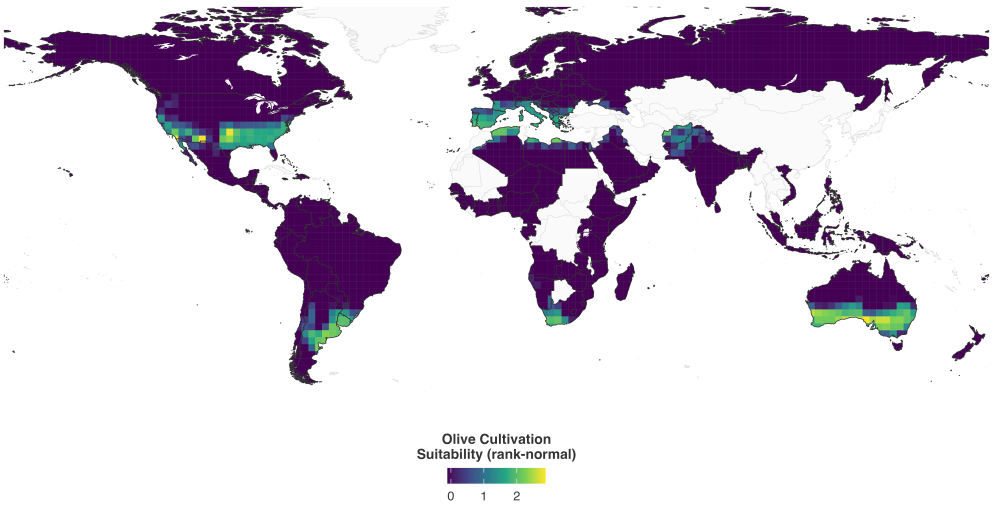




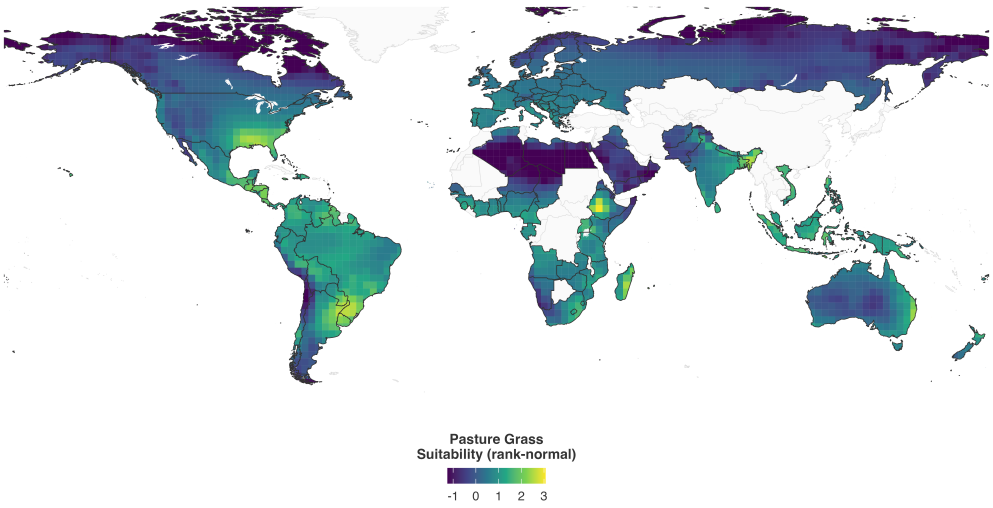
Notes: This figure compares Spanish migration patterns from our genealogical data (Panels A–B) with historical records from Arroyo Abad and Espín-Sánchez (2025) (Panels C–D). Panel A displays the number of Spanish-born individuals by decade of birth, while Panel B maps their regional origins within Spain. Panels C and D report the corresponding patterns using archival data from Arroyo Abad and Espín-Sánchez (2025).

Figure A.4. Olive and Pasture Grass Suitability

(A) Olive Cultivation Suitability



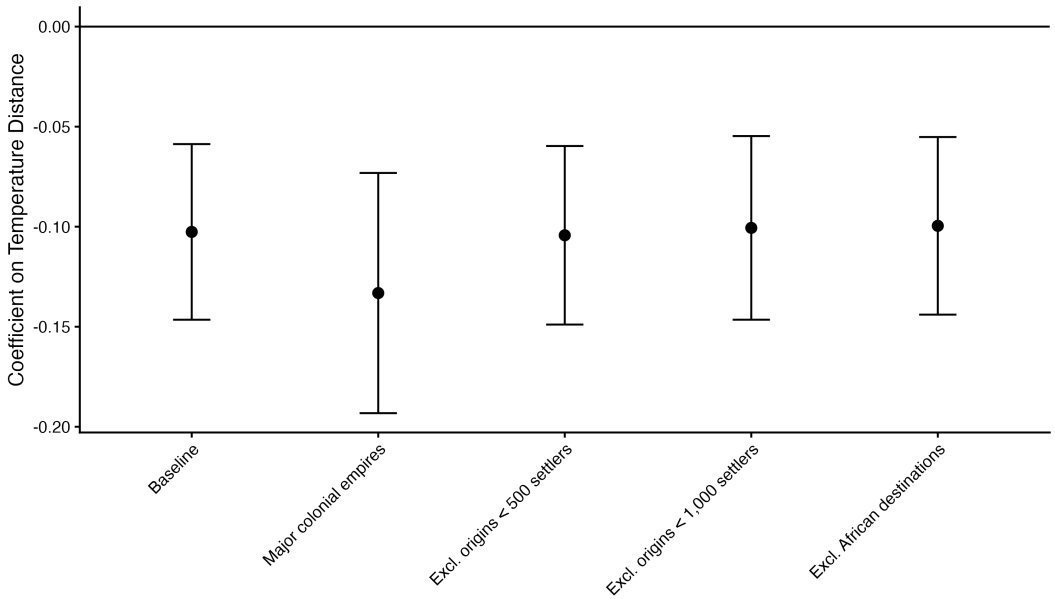
(B) Pasture Grass Suitability



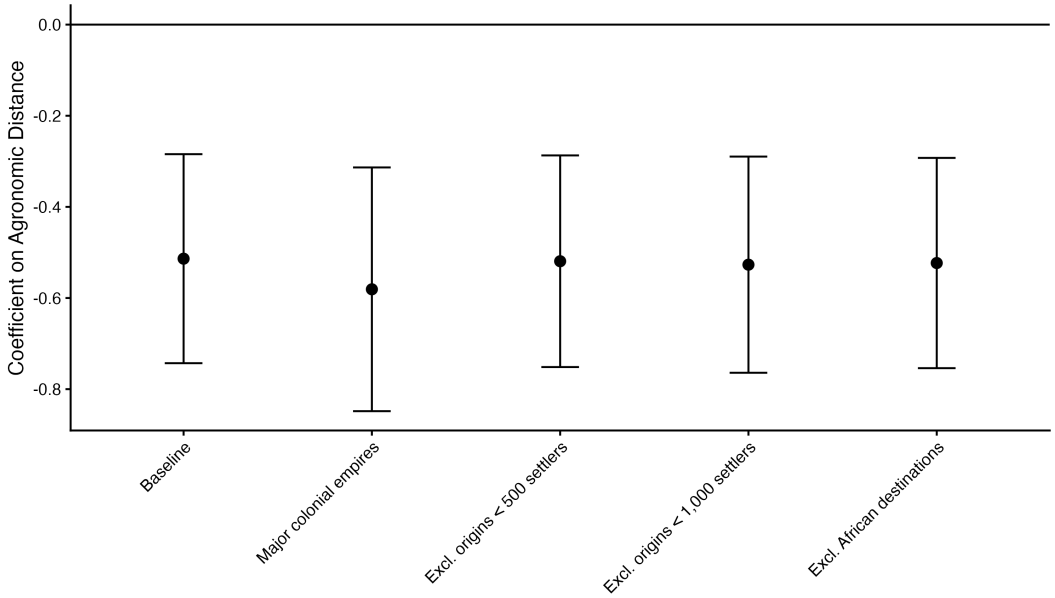
Notes: Panel A reports rank-normalized suitability for olive cultivation from the GAEZ database, under rainfed, low-input, no-CO_2 fertilization conditions. Panel B reports rank-normalized suitability for pasture grasses (livestock forage). Both panels are aggregated to 2.5° × 2.5° cells for visualization, using the same country coverage as Figure 1.

Figure A.5. Robustness: Climate Matching Across Alternative Samples

(A) Temperature Distance



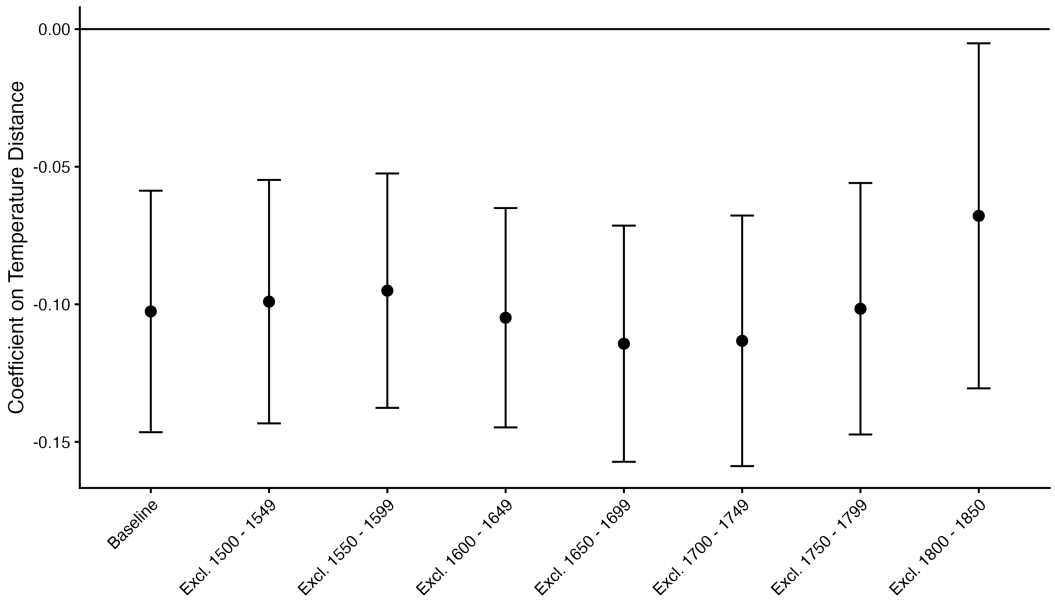
(B) Agronomic Distance



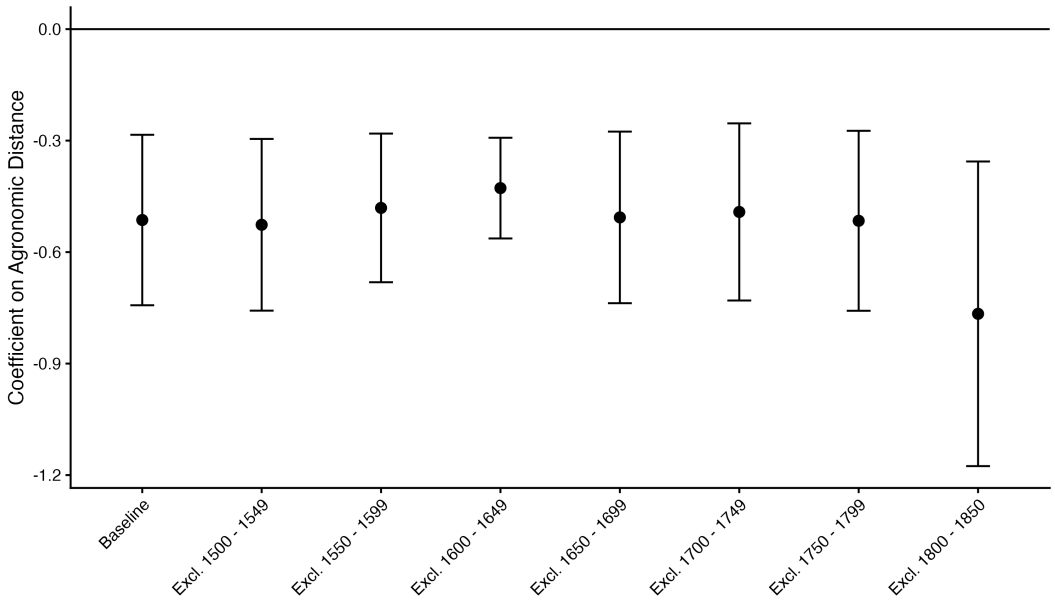
Notes: This figure reports the estimated coefficient on temperature distance (Panel A) and agronomic matching (Panel B) from the preferred specification (column 6 of Table 1) across different sample restrictions. The baseline sample is compared with samples that: (1) include only major colonial empires (France, Germany, Great Britain, Spain, Portugal, and the Netherlands); (2) exclude origin cells with fewer than 500 settlers; (3) exclude origin cells with fewer than 1,000 settlers; (4) exclude African destinations; (5) expand the destination sample to include all countries with any settlers, restoring destinations dropped during data cleaning. The specification includes temperature distance, precipitation distance, agronomic matching, log geographic distance, and the same destination-level controls as the baseline (temperature bins, mean precipitation, log elevation, malaria ecology index, log population density in 1500, absolute latitude, and overall crop suitability), together with Period × Country of Origin FE and Period × Administrative Level 1 (ADM1) FE. Confidence intervals at the 95% level are reported. Standard errors are clustered at the country-of-origin × 2° × 2° destination-cell level.

Figure A.6. Robustness: Leave-One-Period-Out

(A) Temperature Distance



(B) Agronomic Distance



Notes: This figure reports the estimated coefficient on temperature distance (Panel A) and agronomic matching (Panel B) from the preferred specification (column 6 of Table 1), sequentially re-estimated after excluding each 50-year birth cohort from the sample (seven exercises, one per cohort). The baseline estimate (full sample) is shown as the leftmost point for comparison. The specification includes temperature distance, precipitation distance, agronomic matching, log geographic distance, and the same destination-level controls as the baseline (temperature bins, mean precipitation, log elevation, malaria ecology index, log population density in 1500, absolute latitude, and overall crop suitability), together with Period × Country of Origin FE and Period × Administrative Level 1 (ADM1) FE. Confidence intervals at the 95% level are reported. Standard errors are clustered at the country-of-origin × 2° × 2° destination-cell level.

Table A.1. Number of Individuals by Country of Origin (1500-1850)

Country of Origin	N Individuals	Percentage
Great Britain	154,514	52.58
Germany	46,425	15.80
Ireland	26,174	8.91
France	20,697	7.04
Netherlands	10,121	3.44
Norway	8,126	2.77
Switzerland	4,556	1.55
Sweden	4,464	1.52
Spain	4,372	1.49
Denmark	3,375	1.15
Poland	3,000	1.02
Italy	1,252	0.43
Belgium	1,180	0.40
Czech Republic	929	0.32
Portugal	822	0.28
Austria	793	0.27
Luxembourg	578	0.20
Finland	504	0.17
Ukraine	347	0.12
Lithuania	345	0.12
Hungary	222	0.08
Estonia	204	0.07
Bosnia and Herzegovina	167	0.06
Belarus	123	0.04
Russia	106	0.04
Latvia	91	0.03
Romania	87	0.03
Slovakia	74	0.03
Greece	69	0.02
Croatia	42	0.01
Bulgaria	31	0.01
Moldova	20	0.01
Liechtenstein	15	0.01
Slovenia	15	0.01
Republic of Serbia	14	0.00
Macedonia	6	0.00
Montenegro	6	0.00
Malta	3	0.00
Albania	1	0.00
Kosovo	1	0.00
San Marino	1	0.00
Total	293,872	100.00

Table A.2. Climate Distance and Migration Flows: Alternative Distance Specifications

Dep. var.:	Number of Migrants					
	(1)	(2)	(3)	(4)	(5)	(6)
Temperature Distance	-0.103***	-0.099***	-0.103***	-0.088***	-0.088***	
	(0.022)	(0.022)	(0.023)	(0.021)	(0.021)	
Precipitation Distance	-0.331	-0.310	-0.319	-0.551**	-0.550**	
	(0.281)	(0.293)	(0.281)	(0.229)	(0.228)	
Agronomic Distance	-0.514***	-0.534***	-0.523***	-0.294***	-0.296***	
	(0.117)	(0.129)	(0.115)	(0.050)	(0.049)	
Log(Temperature Distance)						-0.336***
						(0.085)
Log(Precipitation Distance)						-0.280
						(0.415)
Log(Agronomic Distance)						-1.549***
						(0.340)
Log(Geographic Distance)	5.034***					4.939***
	(1.317)					(1.183)
Geographic Distance (linear)		0.572***	0.943			
		(0.137)	(0.597)			
Geographic Distance^2			-0.018			
			(0.024)			
Inland Origin Distance				-0.873***		
				(0.285)		
Sea Travel Distance				-0.056		
				(0.105)		
Inland Destination Distance				-1.491***		
				(0.306)		
Log(Inland Origin Distance)					-1.162***	
					(0.409)	
Log(Sea Travel Distance)					-0.567	
					(1.053)	
Log(Inland Destination Distance)					-3.447***	
					(0.582)	
Observations	9,320,719	9,320,719	9,320,719	6,131,915	6,131,915	9,320,719
R^2	0.126	0.117	0.122	0.050	0.053	0.135
Mean Temp. Distance	9.22	9.22	9.22	9.22	9.22	9.22
Mean Prec. Distance	0.45	0.45	0.45	0.45	0.45	0.45
Period × Country *o* FE	Yes	Yes	Yes	Yes	Yes	Yes
Period × Administrative Level 1 FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The sample includes all origin–destination pairs formed by European grid cells (origins) and overseas grid cells (destinations) at 1°resolution, aggregated into 50-year periods between 1500 and 1850. The dependent variable is the count of migrants collapsed to the origin–destination–period cell. Agronomic Distance is the origin-weighted, de-skewed, balanced (grain/olive/grass) GAEZ crop-suitability distance between origin and destination, standardized, included in columns (1)–(5) alongside temperature and precipitation distance. Column (6) instead includes the natural logarithm of one plus the underlying (pre-standardization) agronomic-matching distance, consistent with that column's use of log temperature and log precipitation distance rather than their raw absolute-difference form. All columns include the same destination-level controls as column (6) of Table 1: temperature bins, mean precipitation, log elevation, malaria ecology index, log population density in 1500, absolute latitude, and overall crop suitability. Column (1) reproduces the baseline specification (log geographic distance). Columns (2) and (3) replace log geographic distance with its linear specification and a quadratic polynomial, respectively. Columns (4) and (5) replace geographic distance with three travel-cost components (inland distance from origin to principal seaport, oceanic distance between seaports, inland distance from destination seaport) in levels and logs, respectively. Column (6) re-estimates the baseline using log temperature, log precipitation, and log agronomic-matching distance. Standard errors, reported in parentheses, are clustered at the country of origin by 2° destination-cell level. Significance levels: $***p < 0.01, **p < 0.05, *p < 0.1$

Table A.3. Climate Distance and Migration Flows: Geographic Controls

Dep. var.:	Number of Migrants					
	(1)	(2)	(3)	(4)	(5)	(6)
Temperature Distance	-0.103***	-0.112***	-0.077***	-0.078***	-0.078***	-0.077***
	(0.022)	(0.023)	(0.022)	(0.023)	(0.023)	(0.023)
Precipitation Distance	-0.331	-0.313	-0.182	-0.200	-0.197	-0.189
	(0.281)	(0.280)	(0.309)	(0.311)	(0.316)	(0.311)
Agronomic Distance	-0.514***	-0.587***	-0.425***	-0.409***	-0.397***	-0.394***
	(0.117)	(0.104)	(0.093)	(0.092)	(0.087)	(0.089)
Log Geographic Distance	5.034***	5.524**	3.469***	3.623***	3.624***	3.603***
	(1.317)	(2.404)	(0.895)	(0.882)	(0.873)	(0.886)
Latitude Distance			-0.125***	-0.129***	-0.130***	-0.131***
			(0.018)	(0.018)	(0.018)	(0.018)
Elevation Distance				-0.002***	-0.001***	-0.001***
				(0.000)	(0.000)	(0.000)
Ruggedness Distance					-0.001	-0.001
					(0.001)	(0.001)
Both Coastal						0.092
						(0.154)
Observations	9,320,719	8,607,559	9,320,719	9,320,719	9,320,719	9,320,719
R^2	0.126	0.135	0.136	0.144	0.146	0.145
Mean Temp. Distance	9.22	9.22	9.22	9.22	9.22	9.22
Mean Prec. Distance	0.45	0.45	0.45	0.45	0.45	0.45
Mean Latitude Distance	20.66	20.66	20.66	20.66	20.66	20.66
Mean Elevation Distance	472.11	472.11	472.11	472.11	472.11	472.11
Mean Ruggedness Distance	92.49	92.49	92.49	92.49	92.49	92.49
Mean Both Coastal	0.19	0.19	0.19	0.19	0.19	0.19
Period × Country of Origin FE	Yes	Yes	Yes	Yes	Yes	Yes
Period × ADM-1 Destination FE	Yes	Yes	Yes	Yes	Yes	Yes
Country of Origin × Country of Destination FE		Yes				
Destination-Level Controls	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The sample includes all origin–destination pairs formed by European grid cells (origins) and overseas grid cells (destinations) at 1° resolution, aggregated into 50-year periods between 1500 and 1850. The dependent variable, Number of Migrants, is the count of individuals in the FamiLinx database born in Europe and dying overseas, collapsed to the origin–destination–period cell. Column 1 reproduces the preferred specification (column 6 of Table 1). Column 2 adds country-of-origin × country-of-destination fixed effects, which absorb all time-invariant bilateral factors specific to a given origin-destination country pair. Column 3 adds absolute latitude distance (the absolute difference in distance from the equator between origin and destination). Column 4 further adds elevation distance. Column 5 further adds terrain ruggedness distance (TRI). Column 6 further adds an indicator for whether both origin and destination have coastal access, defined as the grid-cell centroid lying within 100 kilometers of the coastline. Agronomic Matching is the origin-weighted, de-skewed, balanced (grain/olive/grass) GAEZ crop-suitability distance between origin and destination, standardized. Geographic Distance is the natural logarithm of one plus the great-circle distance, in km, between grid cell centroids. All columns include the same destination-level controls as column 6 of Table 1 (temperature bins, mean precipitation, log elevation, malaria ecology index, log population density in 1500, absolute latitude, and overall crop suitability). Standard errors, reported in parentheses, are clustered at the country of origin by 2° × 2° destination-cell level. Significance levels: $***p < 0.01, **p < 0.05, *p < 0.1$

Table A.4. Climate Distance and Migration Flows: Alternative Climate Measures

Dep. var.:	Number of Migrants				
	(1)	(2)	(3)	(4)	(5)
Temperature Distance	-0.103***	-0.102***			
	(0.022)	(0.022)			
Precipitation Distance	-0.331	-0.231			
	(0.281)	(0.273)			
Temperature Range Distance		-0.051**			
		(0.023)			
Precipitation Range Distance		-0.014***			
		(0.001)			
Minimum Temperature Distance			-0.103***		-0.110***
			(0.014)		(0.018)
Maximum Temperature Distance				-0.071**	-0.078**
				(0.031)	(0.037)
Minimum Precipitation Distance			-0.008***		-0.008***
			(0.001)		(0.001)
Maximum Precipitation Distance				-0.003*	-0.002
				(0.002)	(0.002)
Agronomic Distance	-0.514***	-0.429***	-0.556***	-0.551***	-0.483***
	(0.117)	(0.104)	(0.123)	(0.105)	(0.105)
Log Geographic Distance	5.034***	1.868**	2.804**	4.595***	2.288**
	(1.317)	(0.909)	(1.299)	(1.112)	(1.026)
Observations	9,320,719	9,320,719	9,364,371	9,364,371	9,364,371
R^2	0.126	0.149	0.124	0.132	0.126
Mean Temp. Distance	9.22	9.22	9.22	9.22	9.22
Mean Precip. Distance	0.45	0.45	0.45	0.45	0.45
Mean Temp. Range Distance	9.65	9.65	9.65	9.65	9.65
Mean Precip. Range Distance	92.56	92.56	92.56	92.56	92.56
Mean Min Temp. Distance	12.75	12.75	12.75	12.75	12.75
Mean Max Temp. Distance	6.43	6.43	6.43	6.43	6.43
Period × Country of Origin FE	Yes	Yes	Yes	Yes	Yes
Period × ADM-1 Destination FE	Yes	Yes	Yes	Yes	Yes

Notes: The sample includes all origin–destination pairs formed by European grid cells (origins) and overseas grid cells (destinations) at 1° resolution, aggregated into 50-year periods between 1500 and 1850. The dependent variable, Number of Migrants, is the count of individuals in the FamiLinx database born in Europe and dying overseas, collapsed to the origin–destination–period cell. Column 1 reproduces the preferred specification (column 6 of Table 1) with mean annual temperature and precipitation distance. Column 2 adds temperature and precipitation range distance, defined as the absolute difference between origin and destination in the gap between each location's warmest- and coldest-month values. Columns 3–5 replace the mean measures with hemisphere-adjusted minimum- and maximum-month temperature and precipitation distance: the "maximum" (warmest/wettest) month is July north of the equator and January south of it, and vice versa for the "minimum," computed separately for each location's own hemisphere. Column 3 uses minimum-month distances only, column 4 uses maximum-month distances only, and column 5 includes both. Agronomic Matching is the origin-weighted, de-skewed, balanced (grain/olive/grass) GAEZ crop-suitability distance between origin and destination, standardized. Geographic Distance is the natural logarithm of one plus the great-circle distance, in km, between grid cell centroids. All columns include the same destination-level controls as column 6 of Table 1 (temperature bins, mean precipitation, log elevation, malaria ecology index, log population density in 1500, absolute latitude, and overall crop suitability). Standard errors, reported in parentheses, are clustered at the country of origin by 2° × 2° destination-cell level. Significance levels: $***p < 0.01, **p < 0.05, *p < 0.1$