Understanding Cultural Persistence and Change

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Abstract: We examine a determinant of cultural persistence that has emerged from a class of models in evolutionary anthropology: the similarity of the environment across generations. Within these models, when the environment is more similar across generations, the traits that have evolved up to the previous generation are more likely to be optimal for the current generation. In equilibrium, a greater value is placed on tradition and there is greater cultural persistence. We test this hypothesis by measuring the variability of different climatic measures across 20-year generations from 500–1900CE. Employing a variety of tests that use a range of samples and empirical strategies, we find that populations with ancestors who lived in environments with more cross-generational instability place less importance on maintaining tradition today and exhibit less cultural persistence.

Key words: Cultural persistence, cultural change, traditions, customs, evolution.

JEL classification: N10; Q54; Z1.

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1. Introduction

Increasingly, we are coming to understand that cultural traits, which have been shown to be important for economic development, can be remarkably persistent (Fischer, 1989, Fernandez, 2007, Giuliano, 2007, Fernandez and Fogli, 2009, Algan and Cahuc, 2010, Voigtlaender and Voth, 2012). However, we also have numerous examples of rapid cultural change, such as the Protestant Reformation (Becker and Woessmann, 2008, 2009, Cantoni, 2012, 2014) or the Puritan colony that was established on Providence Island (off of the coast of Nicaragua) in the early seventeenth century, where the population abandoned their traditional values and engaged in large-scale slavery and privateering (Kupperman, 1995). There are also many examples of rapid and dramatic cultural change following European contact, such as the well-known cases of the village of Peri on the Island of Manus or the Polynesian community of Tikopia. Within one generation, these societies completely changed their cultures, abandoned their traditional practices, and embraced European customs (Mead, 1956, Firth, 1959).

Given that we have numerous examples of cultural persistence and numerous examples of cultural change, a natural question arises: when does culture persist and when does it change? In particular, what determines a society's willingness to adopt new customs, beliefs, and behaviors rather than holding on to pre-existing traditions? We attempt to make progress on these questions by testing for a determinant that has emerged from the theoretical evolutionary anthropology literature as being important (e.g., Boyd and Richerson, 1985, Aoki and Feldman, 1987, Rogers, 1988, Feldman, Aoki and Kumm, 1996, Boyd and Richerson, 2005). This is the extent to which a society's environment is similar across generations.

To see how cross-generational similarity can be an important determinant of cultural change, consider a population living in a highly-stable environment, where the setting of previous generations is very similar to the current setting. Since the traditions (i.e., customs, beliefs, and values) evolved and survived in environments that were very similar to the current one, they likely contain valuable information that is relevant for the current generation. By contrast, if the environment changes a lot from one generation to the next, then the traditions of previous generations are less likely to be appropriate for the current generation. More generally, this logic suggests that the more similar the environment is across generations, the more likely it is that the evolved traditions of the previous generation are beneficial for the current generation, and, therefore, the more beneficial it is to maintain existing customs.

We begin our analysis by providing a simple model that illustrates this logic. In it, individuals have uncertainty about the optimal action to take, which is determined by the current environment. Individuals choose their action either through costly information acquisition or by following the actions (i.e., traditions) of the previous generation. In equilibrium, the more similar the environment across generations, the higher the proportion of the population that follows tradition. Thus, a more stable environment causes society to place greater importance on maintaining tradition.

We take this hypothesis to the data using a variety of samples and methods. We measure the cross-generational variability of the environment using two sources of paleoclimatic data, both of which date back to 500CE. The first source, which is taken from Mann, Zhang, Rutherford, Bradley, Hughes, Shindell, Ammann, Faluvegi and Ni (2009a), measures temperature anomalies at a 5-degree resolution with global coverage. The second, which is from Cook, Seager, Heim, Vose, Herweijer and Woodhouse, measures drought severity, and has coverage for North America only, but at a very fine spatial resolution (0.5 degree rather than 5 degree) and at a reliable annual resolution. The greater precision of these data is due to the greater prevalence of reliable annual proxy data (e.g., tree rings) in North America.

Using the paleoclimatic data, for each grid-cell, we first calculate the average temperature anomaly or average drought severity experienced by seventy 20-year generations from 500–1900. We then calculate the variability of these averages – i.e., the standard deviation over the seventy generations. This gives us a grid-cell level measure of the extent to which the environment varied across previous generations. The measures are then linked to ethnic groups using information on their pre-industrial locations. We also create country-level measures by using a country's distribution of spoken languages and dialects to estimate its distribution of ancestral ethnicity. When combined with information on the traditional locations of ethnic groups, we are able to construct a measure of the average of cross-generational climatic instability of the ancestors of individuals living in each country today.

Our empirical analysis uses four different strategies to test the hypothesis of interest. The first is to examine self-reported views of the importance of tradition from the *World Values Surveys* (WVS). Looking first across countries, we find that groups with ancestors who experienced more climatic instability across generations have a weaker belief in the importance of maintaining traditions and customs today. The estimates remain stable when we condition on a host of factors that might be correlated with ancestral climatic instability and directly affect the importance of tradition. We also obtain similar estimates when we look across individuals living in the same country but belonging to different ethnic groups.

We also perform a wide range of sensitivity checks. For example, we test the robustness of our findings to the paleoclimatic data that we use. While the Mann et al. (2009a) data has global coverage, it has the shortcoming of early observations being derived from proxy data, like ice cores, coral, sediment, and tree rings, rather than from direct observation from weather stations. Thus, we undertake a number of robustness checks to test the sensitivity of our estimates to the underlying climate data. Motivated by the fact that the availability of proxy data improves steadily over time, we check the robustness of our findings to the construction of our instability measure when using windows of time that are more recent than our baseline window of 500–1900. We also check the sensitivity of our estimates to the use of a high quality 0.5-degree resolution gridded dataset that is constructed using high-frequency observations from meteorological stations around the world but is only available after 1900 (Harris, Jones, Osborn and Lister, 2014). We obtain very similar estimates when these data are used.

The second empirical strategy looks at the persistence of cultural traits across countries over long periods of time, and tests whether the extent of cultural persistence is weaker in countries with greater ancestral instability. The cultural traits that we consider include: gender role norms (measured by female labor-force participation), polygamy, and consanguineous marriage (commonly referred to as cousin marriage). We find that for all traits examined, there is less cultural persistence among countries with more variability in their ancestral environment.

The third empirical strategy tests the persistence of traditions among the descendants of immigrants who have moved to the United States. Having been moved from their ancestral environment, they face a new environment that will tend to weaken their traditional practices. Our analysis compares the behavior of individuals with different cultural backgrounds but who live in the same city in the United States. A benefit of this strategy is that, unlike the cross-country analyses, we can be confident that the estimated effects are not due to a more-mechanical direct effect of the environment on actions. Instead, it is due to the effects of the environment in the ancestral locations. We find that the children of immigrants from countries with a more unstable ancestral environment are less likely to marry someone of the same ancestry, and are also less likely to speak their traditional language at home. We also find that the intergenerational persistence of language, education and occupation is weaker among groups with ancestral environments that were more variable.

Our final strategy examines Indigenous populations of the United States and Canada. Like immigrants, these populations are minority groups whose cultural traditions differ from those of the majority population. They are, therefore, also faced with pressure to change their traditions and customs. We examine the relationship between the cross-generational climatic instability of the lands traditionally inhabited by Indigenous groups and the extent to which they still know how to speak their traditional language today. As with the immigrants, we compare individuals who are living in the same location, but with different Indigenous ancestry (and historical climatic instability). We find that Indigenous populations with a history of greater environmental instability are less likely to speak their traditional language today.

A benefit of the analysis of Indigenous populations is that the geographic scope of ancestral locations is limited to North America. This allows us to use the higher-resolution paleoclimatic data constructed by Cook et al. (2010), which has reliable annual estimates that allow us to credibly distinguish short-run (annual) variability in weather from longer-run (cross-generational) variability in climate. Thus, we are able to estimate the relationship between cross-generational variability and the extent to which the Indigenous populations speak their traditional language while controlling for higher frequency year-to-year variability. We find that the importance of the stability of the environment across generations is robust to controlling for higher-frequency variability. The richer data also allow us to examine the second moment of the climate data. That is, in addition to measuring how the yearly within-generation mean (first moment) changes from one generation to the next, we can also measure how the yearly within-generation standard deviation (second moment) changes from one generation to the next. There are many reasons to believe that, within a person's lifetime, not only the mean of weather but also its standard deviation might matter. We find that, like the cross-generational variability of the first moment, the cross-generational variability of the second moment is negatively associated with the importance of tradition and cultural persistence. We also examine the intergenerational transmission of one's Indigenous language and find that this is weaker among ethnic groups with a more variable ancestral environment.

Despite differences in design and the populations studied, all of our strategies yield the same conclusion. Tradition is less important and culture less persistent among populations with ancestors who lived in environments that were less stable across generations. These findings complement existing studies that provide important insights into the process of cultural change, such as Giavazzi, Petkov and Schiantarelli (2014), Fouka (2015) and Abramitzky, Boustan and Eriksson (2016). Our findings are also consistent with evidence from Voigtlaender and Voth (2012), who show that the persistence of anti-Semitic attitudes in Germany over a 600-year period was weaker in towns that were more economically dynamic or were more open to external trade. These towns were less stable and therefore, consistent with our findings, we would expect less cultural persistence.

Our findings also provide empirical validation of a class of models from evolutionary anthropology that serve as a foundation for the assumptions made in the models used in cultural economics (e.g., Bisin and Verdier, 2000, 2001, Hauk and Saez-Marti, 2002, Francois and Zabojnik, 2005, Tabellini, 2008, Greif and Tadelis, 2010, Bisin and Verdier, 2017, Doepke and Zilibotti, 2017). Within this class of evolutionary models, under general circumstances, some proportion of the population finds it optimal to rely on social learning – that is, culture – when making decisions. This result provides a justification for the assumption in models of cultural evolution that parents choose to and are able to influence the preferences of their children. The only previous empirical tests of the models are done in a laboratory setting with students (McElreath, Lubell, Richerson, Waring, Baum, Edstein, Efferson and Paciotti, 2005, Toelch, van Delft, Bruce, Donders, Meeus and Reader, 2009).

The next section of the paper describes the hypothesis and its mechanisms using a simple model. The model shows, in the simplest possible terms, how a stable environment tends to favor a cultural belief in the importance of tradition and therefore generates cultural persistence. In Section 3, we describe the data used in the analysis. In Section 4, we describe our empirical tests and report the results. Section 5 concludes.

2. The model

We now present a simple model that illustrates how the cross-generational variability of the environment can affect the value individuals place on tradition. The insight that emerges from the model is that it is relatively less beneficial to value (and follow) the traditions of the previous generation when the environment is less stable. Intuitively, this is because the traditions and actions that have evolved up to the previous generation are less likely to be suitable for the environment of the current generation. This insight emerges from a wide range of models on the origins of culture and its evolution (e.g., Boyd and Richerson, 1985, 1988, Rogers, 1988). The model that we present here reproduces the basic logic of Rogers (1988).

The players of the game consist of a continuum of members of a society. Each period, a new generation is born and the previous generation dies. When a player is born, they make a once-and-for-all choice of two possible actions, which we denote y and z. Which of the two actions yields a higher payoff depends on the state of the world (i.e., the current environment), which can be either Y or Z. If the state is Y, then action y yields the payoff $\beta > 0$ and action z yields the negative payoff of $-\beta$. If the state is Z, then action y yields a payoff of $-\beta$ and action z yields the payoff β. Thus, in each state, one of the two actions is better than the other. In each period, with probability $\Delta \in [0,1]$, there is a shock which results in a new draw of the state. It is equally likely that the draw results in the new environment being in state Y or state Z. The state of the world is unknown to the players. However, as we explain below, it is possible to engage in learning (at a cost) to determine the state of the world.

There are two potential types of players. Each uses a different method to choose their action. The first type, whom we call "Traditionalists (T)," value tradition and place strong importance on the actions of the previous generation and choose their action by adopting the action of a randomly chosen person from that generation. This assumption, which allows for both vertical and oblique transmission, means that, in expectation, the distribution of actions/traditions of the previous generation are reproduced among the current generation of traditionalists. The second type, who we call "Non-Traditionalists (NT)," do not value tradition and ignore the actions of the previous generation. They obtain the optimal action with certainty for the current period, but there is a cost of learning, $\kappa \in (0, \beta)$. Thus, although the cost is positive, it is assumed to be fairly modest.[1]

It is assumed that an individual's type (traditionalist or non-traditionalist) is directly inherited from one's parents and that the number of offspring a parent has (i.e., their biological fitness) is increasing in their payoff. Thus, if the payoffs of a type are higher than the payoffs of the other

[1] If $\kappa > \beta$, then the cost of learning is prohibitively high and there will never be non-traditionalists in society. We focus on the empirically-relevant parameter space where both types are possible.

type, then their proportion in the population will increase (e.g., Friedman, 1991, p. 640).[2] Let $x_t \in [0,1]$ denote the proportion of traditionalists in the population in period t. We interpret this as a measure of the overall strength of tradition in the society. Because our interest is in the value of x_t in steady state, moving forward, we drop the subscript and consider the steady-state proportion of traditionalists, which we denote x.

We now turn to an examination of the payoffs of both types of players. We first consider the expected payoff of non-traditionalists. In each generation, they learn, bearing the cost κ, and choose the optimal action with certainty. Thus, the payoff to a non-traditionalist is given by: $\Pi^{NT} = \beta - \kappa$.

We next calculate the expected payoff of non-traditionalists. To do this, first consider the following sequence of possible scenarios, each of which results in a traditionalist choosing the right action given her environment, which yields the payoff β:

1. A traditionalist copies a non-traditionalist from the previous generation and the environment does not experience a shock. In this case, the copied action will be optimal in the current environment and the traditionalist receives β. This occurs with probability $(1-x)(1-\Delta)$.
2. A traditionalist copies a traditionalist from the previous generation, who had copied a non-traditionalist from the previous generation and no shocks occur during this time. In this case, the traditionalist also receives β. This occurs with probability $x(1-x)(1-\Delta)^2$.
3. A traditionalist copies a traditionalist, who copied a traditionalist, who copied a non-traditionalist. No shocks occur during this time. This occurs with probability $x^2(1-x)(1-\Delta)^3$.
4. Etc, etc.

Continuing until infinity and summing the sequence of probabilities gives: $\sum_{t=1}^{\infty} x^{t-1}(1-x)(1-\Delta)^t$. With one minus this probability, $1-\sum_{t=1}^{\infty} x^{t-1}(1-x)(1-\Delta)^t$, a traditionalist does not obtain the correct action with certainty. In these cases, at least one shock to the environment occurs since the most recent non-traditionalist was copied. After a shock, there is an equal probability of being in either state and her expected payoff is 0. Putting this together, the expected payoff to a traditionalist is given by: $\Pi^T = \left[\sum_{t=1}^{\infty} x^{t-1}(1-x)(1-\Delta)^t\right]\beta = \frac{\beta(1-x)(1-\Delta)}{1-x(1-\Delta)}$.

[2] The assumption inherited traits is not necessary for this result. Gintis (1997) has shown that the same dynamic emerges in a setting where individuals can choose their types, but have limited access to information about the payoffs of others. Section A2 of the Appendix derives the dynamic that emerges in such a setting.

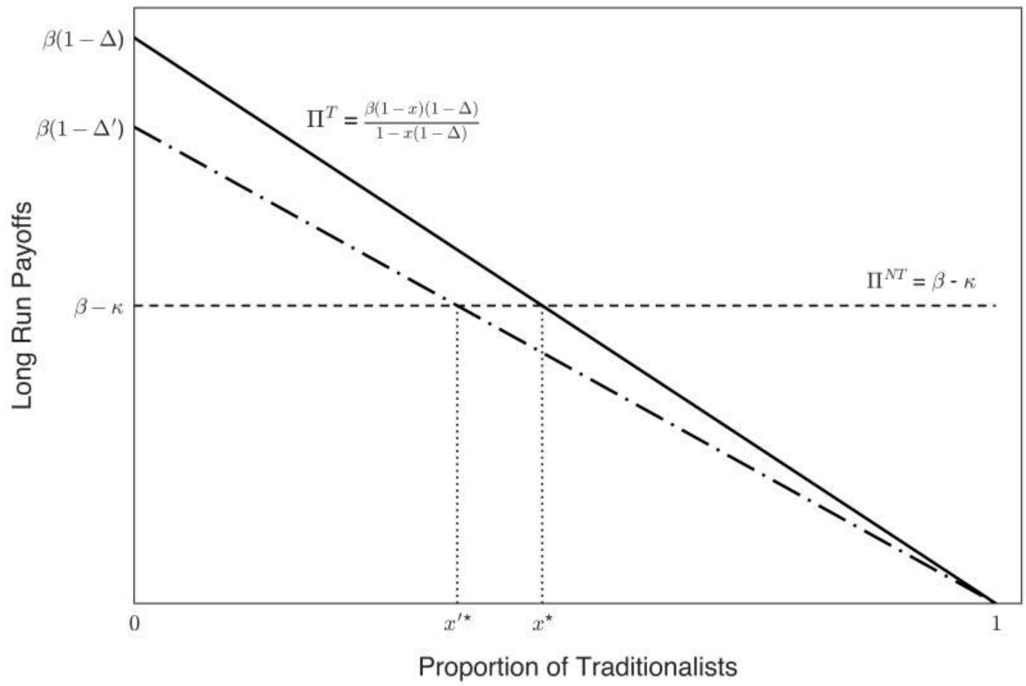


Figure 1: The payoffs to and equilibrium proportion of traditionalists (T) and non-traditionalists (NT), and how they change with an increase in the instability of the environment from Δ to Δ'.

The payoffs to traditionalists and non-traditionalists as a function of the proportion of traditionalists in the society, x, are reported in Figure 1. The expected payoff of a traditionalist, Π^T, is decreasing in x. Intuitively, as the fraction of traditionalists increases, it is less likely that a traditionalist will copy a non-traditionalist who is more likely to have chosen the correct action. At the extreme, where everyone in the population is a traditionalist ($x = 1$), each traditionalist copies another traditionalist and the expected payoff is 0.

At the other extreme, where everyone is a non-traditionalist ($x = 0$), a traditionalist, who will copy someone in the previous generation, will choose the correct action as long as there is no shock to the environment between the two generations. With probability $1 - \Delta$, a traditionalist's payoff is β. If there is a shock, which occurs with probability Δ, then the expected payoff is 0. Therefore, when $x = 0$, the expected payoff to a traditionalist is $\beta(1 - \Delta)$.

From Figure 1, it is clear that under general conditions (namely, $\Delta < \kappa/\beta$) traditionalists are present in society. Their emergence is due to the benefit of cultural transmission, which provides a fairly accurate way of making decisions at low cost. Consistent with this, anthropologists have documented many real-world examples of functional cultural traits being followed despite the population not knowing their benefits (see Henrich, 2015). One of the best known is alkaline processing of maize, which is the traditional method of preparing maize in many parts of Latin America. During the process, dried maize is boiled in a mixture of water and limestone or ash, before being mashed into a dough called 'masa'. Although it was unknown at the time, putting limestone or ash in the water before boiling prevents pellagra, a disease resulting from niacin deficiency, which occurs in diets that consist primarily of maize. The alkaline solution that is created when limestone or ash is added increases the body's absorption of niacin (Katz, Hediger and Valleroy, 1974).

In an equilibrium with both types present, their payoffs must be equal; in an equilibrium with one type, its average payoff must be no less than that of the other type. Therefore, the equilibrium proportion of traditionalists x^* is given by:

$$x^* = \begin{cases} \frac{\kappa - \Delta\beta}{\kappa(1-\Delta)} & \text{if} \quad \Delta \in [0, \frac{\kappa}{\beta}] \\ 0 & \text{if} \quad \Delta \in [\frac{\kappa}{\beta}, 1] \end{cases}$$

Given the dynamics of player types, the equilibria are stable. In an equilibrium where both types are present, if $x > x^*$, the payoff of traditionalists is lower than of non-traditionalists and x will decrease. If $x < x^*$, the payoff of traditionalists is higher than of non-traditionalists and x will increase. Thus, in both cases, there is convergence back to x^*. In an equilibrium with only non-traditionalists, if $x > x^*$, the payoff of traditionalists is lower than of non-traditionalists, x will decrease, and there is convergence back to $x^* = 0$.

Figure 1 also shows how the equilibrium changes as the environment becomes less stable. An increase in instability (from Δ to Δ') causes the traditionalist payoff curve to rotate downwards, but has no effect on the payoffs of non-traditionalists. As a consequence, the equilibrium proportion of traditionalists decreases.[3] If instability Δ increases past the threshold κ/β, then the proportion of traditionalists in the economy becomes zero. Therefore, the change in the equilibrium proportion of traditionalists as a function of cross-generational environmental instability is given by:

$$\frac{\partial x^*}{\partial \Delta} = \begin{cases} \frac{\kappa - \beta}{\kappa(1-\Delta)^2} < 0 & \text{if} \quad \Delta \in [0, \kappa/\beta] \\ 0 & \text{if} \quad \Delta \in [\kappa/\beta, 1]. \end{cases}$$

[3]Since $\kappa < \beta$, $\frac{\partial x^*}{\partial \Delta} < 0$. If $\kappa > \beta$, then for all values of Δ the population is made up of traditionalists only ($x^* = 1$). Here, we assume the empirically relevant scenario in which there is the potential for both types in the society.

Moving from the model to empirics, this can be stated as the following testable hypothesis.

Hypothesis 1. *The greater the instability of the environment across generations, the less the importance society places on maintaining traditions and customs.*

A second hypothesis emerges from the fact that, in the model, non-traditionalists respond to a change in the state of the environment by immediately choosing the new optimal action. That is, when there is a benefit to abandoning their previous action, they do so immediately. By contrast, traditionalists respond more slowly, as their chosen action evolves through their process of copying the actions of those in the previous generation. Thus, previous actions/customs persist over time, even though there is a benefit to abandoning them. This is illustrated in Figure 2, which shows the transition from one action to the other action after a change in the state of the world for different values of Δ and hence x^*. As shown, the higher is Δ (and, thus, lower is x^*), the faster the new action is adopted in the society. This leads to the second hypothesis.

Hypothesis 2. *The greater the instability of the environment across generations, the quicker the transition to the new action following a change in the state of the world.*

In sum, the model presented here shows how variability of the environment Δ results in a weaker importance placed on tradition x^*, which results in less cultural persistence. While the model presented here is clearly stylized, Hypothesis 1 and 2 emerge from a more general class of models of culture – e.g., ones with more sophisticated states, actions, or copying strategies – that have been developed within the field of evolutionary anthropology (e.g., Boyd and Richerson, 1985, Aoki and Feldman, 1987, Feldman et al., 1996, Boyd and Richerson, 2005). We now turn to our empirical analyses, which provide tests of Hypotheses 1 and 2.

3. Data: Sources and their construction

A. *Motivating the measure of environmental instability*

When bringing the predictions of the model to the data, the primary decision is how to measure the variability of the environment, Δ. While there are many aspects of a society's environment that one could measure, we focus on a measure that is exogenous (that is, unaffected by human actions) and is likely to strongly affect the optimal decisions of daily life. Specifically, we use

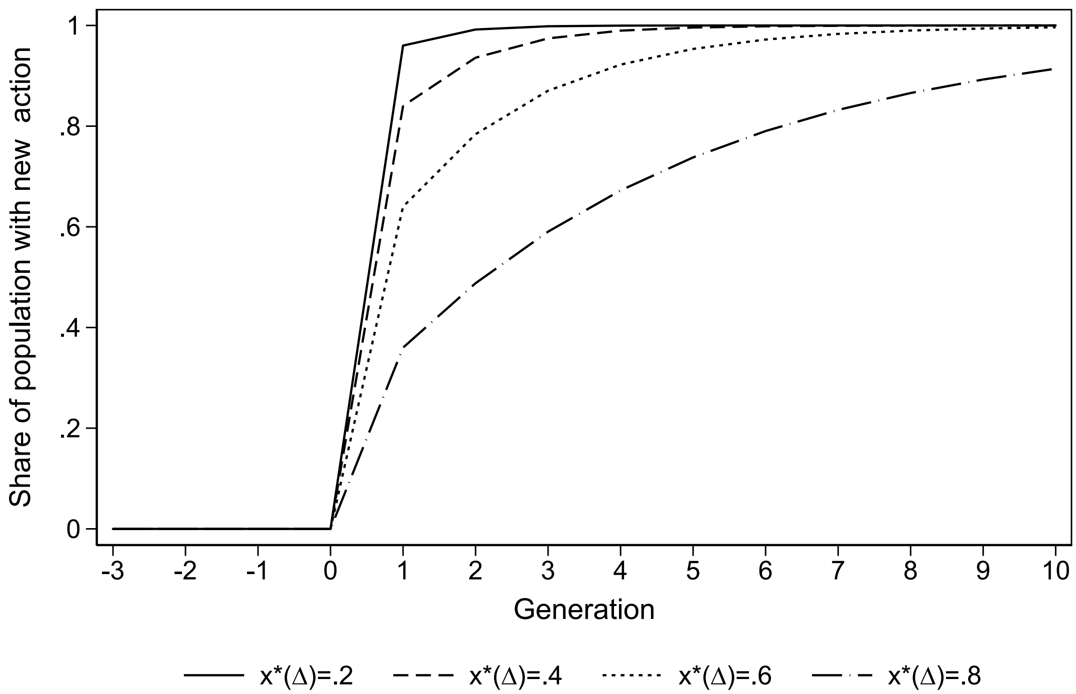


Figure 2: The share of the population choosing the new optimal action following a change in the state of the environment after generation 0. The figure shows paths for societies with different equilibrium proportions of traditionalists x^*, which arise due to different levels of environmental instability Δ.

the variability of temperature and a drought severity index across 20-year generations from 500–1900CE.

There is mounting evidence that changes in the environment affect important equilibrium outcomes like conflict, cooperation, trust, trade, agricultural innovation, and economic prosperity; this suggests that the environment is an important determinant of the optimal actions for society. It has been shown that cooling during the Little Ice Age resulted in worse health outcomes, social unrest, increased conflict, decreased productivity, and slower economic growth (Baten, 2002, Oster, 2004, Waldinger, 2015, Dalgaard, Hansen and Kaarsen, 2015). Matranga (2016) argues that increased seasonal variability in certain locations resulted in the Neolithic transition, one of the most important social changes in human history. Durante (2010) and Buggle and Durante (2016) find that, within Europe, greater year-to-year variability in temperature and precipitation during the growing season is associated with greater trust. Also related are the recent findings that environmental shocks can affect conflict (Bai and Kung, 2011, Jia, 2014) and religiosity (Chaney, 2013, Bentzen, 2015, Belloc, Drago and Galbiati, 2016). There is also evidence from 20th-century data that changes in weather can have important effects on civil conflict, violent crime, economic output, economic growth, agricultural output, political socialization, and political instability (Burke, Miguel, Satyanath, Dykema and Lobell, 2009, Madestam and Yanagizawa-Drott, 2011, Dell, 2012, Dell, Jones and Olken, 2012, Hsiang, Burke and Miguel, 2013, Madestam, Shoag, Veuger and Yanagizawa-Drott, 2013, Burke, Hsiang and Miguel, 2015).

A benefit of using climate as a source of variation is that during the period that we use, 500–1900CE, temperature or drought severity were not affected in any significant manner by human actions. This is one advantage over potential alternative strategies that use changes in more proximate variables, like income, population density, or innovation, which are determined by human actions. To the extent that the climate affects these more-proximate factors, the estimated effects of climatic instability will capture effects working through these mechanisms.

B. *Measuring the instability of the environment across previous generations*

Our analysis uses two sources of data. One has global coverage but has a slightly coarser spatial and temporal resolution. The other has finer spatial and temporal resolutions, but is only available for North America. The global dataset, which is from Mann et al. (2009a), uses a climate field reconstruction approach to reconstruct global patterns of surface temperature for a long historical period. The construction uses proxy data with global coverage that comprise 1,036 tree ring series, 32 ice core series, 15 marine coral series, 19 documentary series, 14 speleothem series, 19 lacustrine sediment series, and 3 marine sediment series (Mann, Zhang, Rutherford, Bradley, Hughes, Shindell, Ammann, Faluvegi and Ni, 2009b). The dataset reports average annual temperature anomalies (deviations from the 1961–1995 reference-period average measured in degrees celsius) at the 5-degree-by-5-degree (approx. 555km by 555km) grid cell level from 500–1900. Although the database reports the data annually, it is clearly stated that due to the nature of the underlying proxy data, some of which is at a decadal resolution only, the reported year-to-year variation is not credible and should not be used (Mann et al., 2009a, p. 1258). Given this, when using these data we only use the coarser cross-generational variation and not the finer annual variation.

The North American climate data are taken from Cook et al. (2010), who provide an annual drought severity index for North America at a 0.5-degree resolution (approx. 55km).[4] The gridded-data are from the *Living Blended Drought Atlas*, which is constructed from 1,845 annual tree ring chronologies. Because of the precision and granularity of the underlying chronologies, these data, unlike the Mann et al., provide credible annual measures. Thus, when using these data, we make use of the annual variation.

We now turn to a description of our cross-generational instability measures. We divide our sample into 20-year generations starting in 500CE; thus, there are 70 generations within our sample. Let t index years, g generations, and j grid-cells. Let $w_{t,g,j}$ denote the environmental measure (either temperature anomaly or drought severity) in a year and let $w_{g,j}$ be the average of the measure during generation g in grid-cell j. Our baseline variable of interest is the standard deviation of $w_{g,j}$ across generations: $[\frac{1}{70}\sum_{g=1}^{70}(w_{g,j}-\overline{w}_j)^2]^{\frac{1}{2}}$. We refer to this variable as "climatic instability". It measures the extent to which climate varied from one generation to the next in grid-cell j.

Examples of the underlying raw data from both sources are reported in Appendix Figures A1 and A2. The constructed grid-cell-level cross-generational stability measures for the two samples are shown in Figures 3a and 3b, respectively. In the figures, yellow (a lighter shade) indicates less variability and brown (a darker shade) greater variability. Although there is variation between nearby cells, there are also some broad patterns. For example, cells that are further from the

[4]For the origin of the drought severity index and details on its construction see Palmer (1965). For an earlier version of the database and methodological details, see Cook, Meko, Stahle and Cleaveland (1999).

equator and from large water bodies tend to have greater variability.

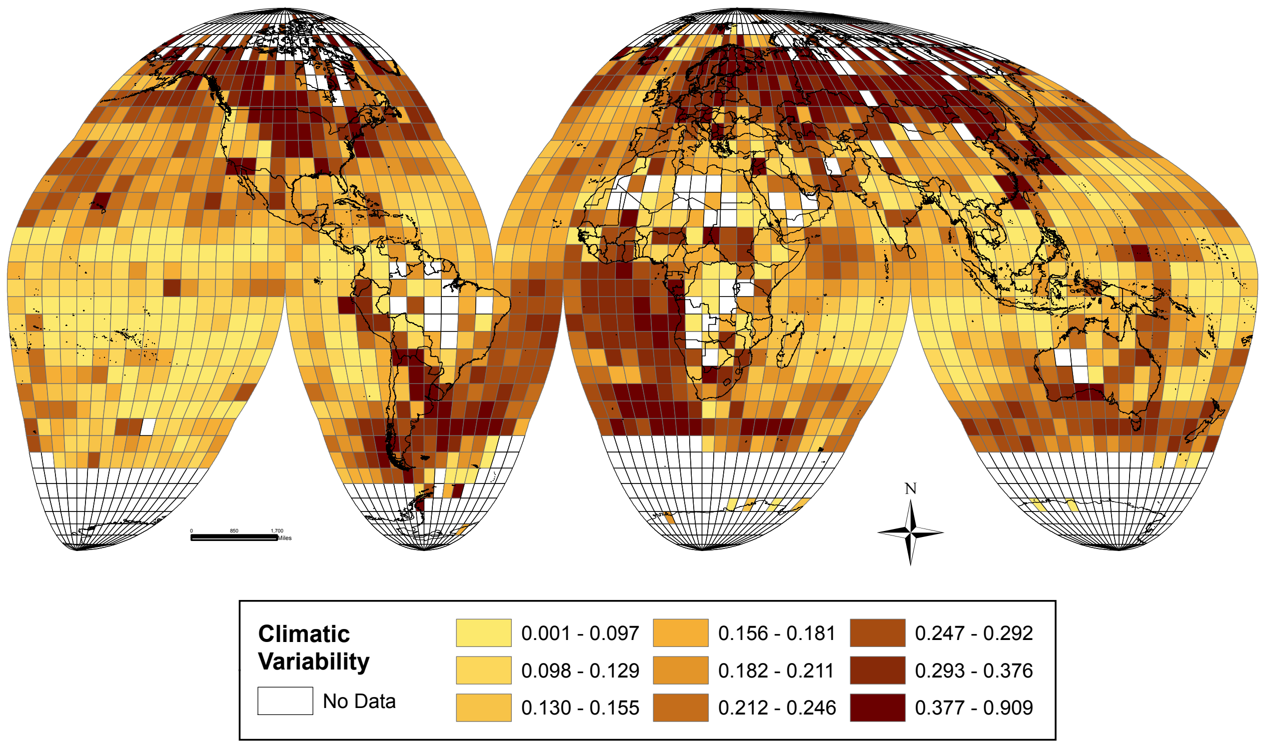
For the analyses that use the finer-resolution North American climate data, we are also able to control explicitly for year-to-year variability to ensure that our measure of cross-generational instability is not driven by higher frequency year-to-year variability which itself could be important. To do this, we first calculate the standard deviation across years within a generation, $\text{SD}_{g,j}(w) = [\frac{1}{20}\sum_{t=1}^{20}(w_{t,j} - \overline{w}_{g,j})^2]^{\frac{1}{2}}$, and then take the average of this measure across all generations to obtain a measure of the average within-generation year-to-year variability of grid cell j, $\text{SD}_j(w)$.

The richness of the North American data also allows us to construct an alternative measure of cross-generational climatic instability. Our baseline measure of climatic instability is the standard deviation of the first moment (mean climate) across generations. Our alternative measure of climatic instability calculates the standard deviation of the second moment: $[\frac{1}{70}\sum_{g=1}^{70}\left(\text{SD}_{g,j}(w) - \overline{\text{SD}_j(w)}\right)^2]^{\frac{1}{2}}$. Intuitively, the measure captures the extent to which within-generation year-to-year variability is different across generations.

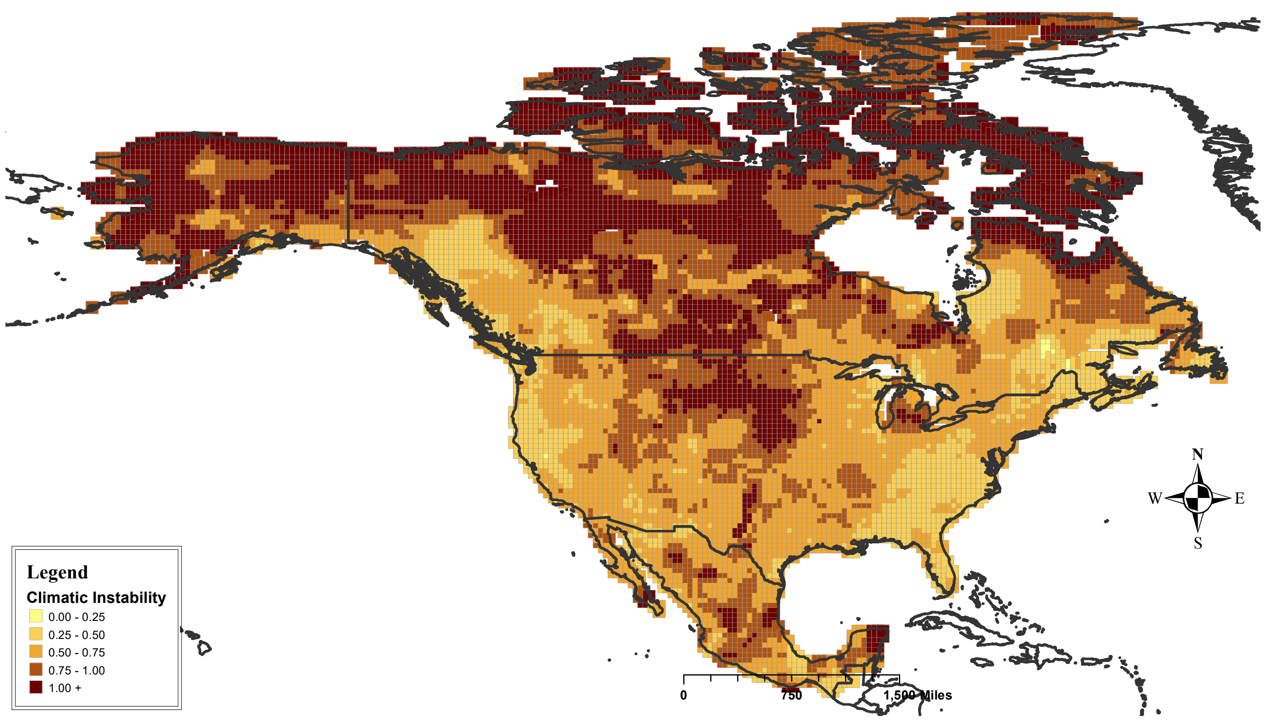
Given that the climate variables are measured at the grid-cell level, and our outcomes of interest involve individuals, an important part of the data construction procedure is to correctly identify the historical locations (i.e., historical grid-cells) of individuals' ancestors. For much of our analysis, this is done using the self-reported ethnicity of individuals. We then identify the historical location of ethnic groups using multiple sources. The first is Murdock's (1967) *Ethnographic Atlas*, which reports the latitude and longitude of the centroid of the traditional location of 1,265 ethnic groups across the world.

To extend the precision and coverage of the *Ethnographic Atlas*, we also use two ethnographic samples that were published in the journal *Ethnology* in 2004 and 2005. *Peoples of Easternmost Europe* was constructed by Bondarenko, Kazankov, Khaltourina and Korotayev (2005) and includes seventeen ethnic groups from Eastern Europe that are not in the *Ethnographic Atlas*. *Peoples of Siberia* was constructed by Korotayev, Kazankov, Borinskaya, Khaltourina and Bondarenko (2004) and includes ten additional Siberian ethnic groups. We use this extended sample of 1,292 ethnic groups as a second ethnographic sample for our analysis.

We also use a third sample that is expanded further to include additional ethnic groups. In 1957, prior to the construction of the *Ethnographic Atlas*, George Peter Murdock constructed the *World Ethnographic Sample*, which was published in *Ethnology* (see Murdock, 1957). Most of the ethnic groups from the *World Ethnographic Sample* later appeared in the *Ethnographic Atlas*, but



(a) Measure using the global sample (temperature anomalies)



(b) Measure using the North American sample (drought severity index)

Figure 3: Grid-cell-level measures of the instability of the climate across previous generations, 500–1900.

seventeen ethnic groups did not. They were ethnic groups for which a number of variables had missing values. In our analysis, we also use a third sample of 1,309 ethnic groups, which adds the *World Ethnographic Sample* to our expanded second sample. As we show, our estimates are very similar irrespective of which sample we use.

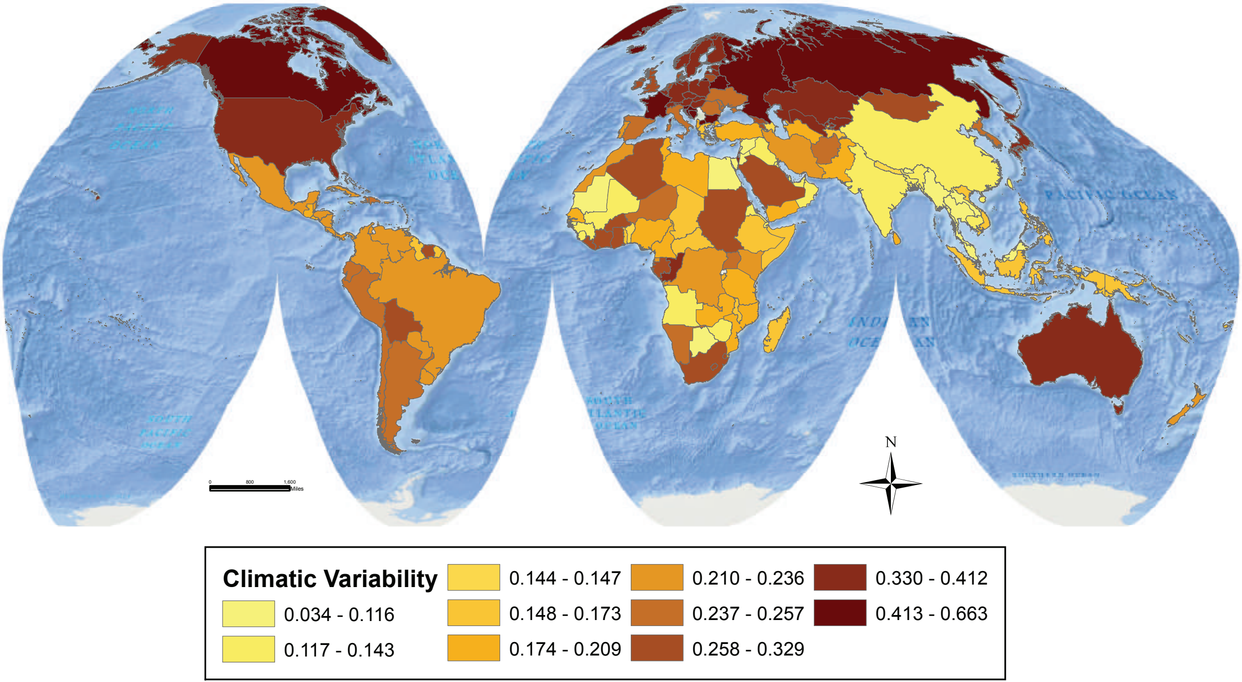
For each ethnic group in our samples, we know the coordinates of the estimated centroid of their historical locations (see Appendix Figure A3). Using climatic data from the grid-cell that an ethnic group's centroid lies within, we are able to obtain a measure of the cross-generational climatic instability that was experienced by the group's ancestors.

For much of our analysis we are able to identify the climatic instability faced by an individual's ancestors using their self-reported ethnicity. However, for other parts of the analysis, we must use a person's country to estimate the historical climatic instability of their ancestors. That is, we construct a measure of the average instability faced by the ancestors of all those living in a country today. We construct this measure using a procedure similar to that used in Alesina, Giuliano and Nunn (2013) and Giuliano and Nunn (2018). By combining information on the location of groups speaking over 7,000 different languages or dialects from *Ethnologue 16* with information on the global population densities (at a one-kilometer resolution) from the Landscan database, we are able to produce an estimate of the mother tongue of all populations around the world, measured at a one-kilometer resolution. By then matching each of the 7,000+ *Ethnologue* languages/dialects with one of the ethnicities from our ethnographic samples, we create a measure of ancestral climatic instability at a one-kilometer resolution globally. We are then able to construct an average measure of ancestral instability across all individuals living in a country today.

The country-level averages are shown in Figure 4. As with the grid-level variation, places further from the equator tend to show more variability. In addition, richer countries also tend to have greater variability. Given that these factors could independently affect our outcomes of interest, in our empirical analysis, we control for the distance from the equator and per-capita income.

4. Tests of the Model

We now test the hypotheses of the model. We begin with Hypothesis 1, by checking for a relationship between ancestral climate variability and the self-reported importance of tradition today. We then turn to tests of Hypothesis 2 by examining settings where populations face



Climatic Variability
0.034 - 0.116
0.117 - 0.143
0.144 - 0.147
0.148 - 0.173
0.174 - 0.209
0.210 - 0.236
0.237 - 0.257
0.258 - 0.329
0.330 - 0.412
0.413 - 0.663
0
800
1,600
Miles
N

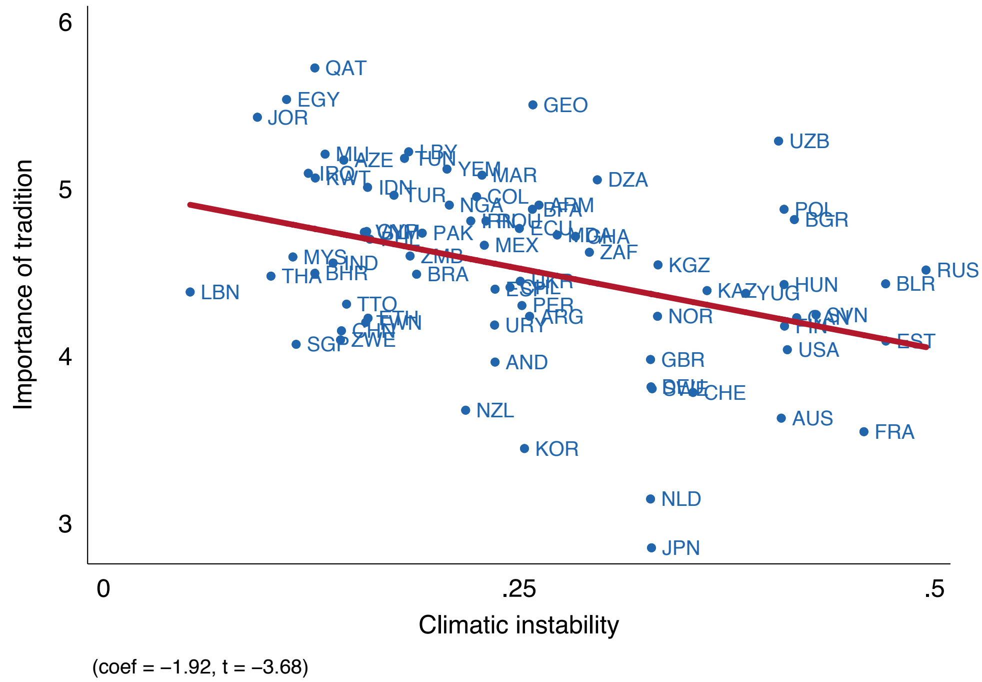


Figure 5: The bivariate cross-country relationship between average instability of the climate across previous generations and the average self-reported importance of tradition today.

create a variable with integer values from 1–6, increasing with the value placed on tradition.

Using the tradition variable, we first examine the country-level relationship between the average self-reported measure on the importance of tradition and the average climatic instability across generations of a country's ancestors. Table 1 reports estimates of the relationship, using each of our three variants of average ancestral climatic instability. In the odd-numbered columns, we report the raw bivariate relationship between the average importance of tradition and average climatic instability across generations for the 75 countries for which both measures are available. We find a negative and significant relationship: greater cross-generational climatic instability in the past is associated with less importance placed on tradition today. The relationship (for the specification from column 3) is shown visually in Figure 5. It appears to be very general and not driven by a small number of influential outliers.

In the even-numbered columns, we examine the same relationship conditioning on a host of covariates. Specifically, we estimate:

$$\mathit{Tradition}_c = \beta\, \mathit{Climatic\ Instability}_c + \mathbf{X}_c^H \mathbf{\Phi} + \mathbf{X}_c^C \mathbf{\Pi} + \varepsilon_c, \qquad (1)$$

where c denotes a country, $\mathit{Tradition}_c$ is the country-level average of the self-reported importance of tradition, and $\mathit{Climatic\ Instability}_c$ is our measure of historical temperature variability for country c. $\mathbf{X}_c^H$ and $\mathbf{X}_c^C$ are vectors of historical ethnographic and contemporary country-level controls. The ethnographic control variables include the following historical characteristics: economic development (proxied by the complexity of settlements),[5] a measure of political centralization (measured by the levels of political authority beyond the local community), and the historical distance from the equator (measured using absolute latitude). To link historical characteristics, which are measured at the ethnicity level, with current outcomes of interest, we follow the same procedure used to construct our measure of cross-generational climatic instability.

We include one contemporary covariate, the natural log of a country's real per capita GDP measured in the survey year. This captures differences in economic development, which could affect the value placed on tradition through channels other than the one we are interested in identifying. It is also possible that with economic development, the cost of learning (i.e., κ in the model) is lower. Thus, per capita GDP also accounts for potential reductions in κ, which affects the prevalence of tradition in the population.

The estimates, which are reported in the even columns of Table 1, show that there is less respect for tradition in countries with more climatic instability across previous generations. Not only are the estimated coefficients for the measure of the instability of the climate across generations statistically significant, but their magnitudes are also economically meaningful. Based on the estimates from column 4, a one-standard-deviation increase in cross-generational instability (0.11) is associated with a reduction in the tradition index of $1.824 \times 0.11 = 0.20$, which is 36% of a standard deviation of the tradition variable.[6]

Examining the coefficient estimates for the control variables, we see that the two measures of economic development – historical and contemporary – are significantly associated with the importance of tradition today. More economic development is associated with weaker beliefs about the importance of tradition. Given that all societies were initially at a similar level of economic development, these measures of income levels also capture average changes in the economic environment over time. Thus, the estimated relationships for the income controls are consistent with the predictions of the model. Countries that experience greater economic instability place less importance on maintaining tradition today. This conclusion, however, is

[5]The categories (and corresponding numeric values) for the settlement complexity variable are: (1) nomadic or fully migratory, (2) semi-nomadic, (3) semi-sedentary, (4) compact but not permanent settlements, (5) neighborhoods of dispersed family homesteads, (6) separate hamlets forming a single community, (7) compact and relatively permanent settlements, and (8) complex settlements.

[6]Summary statistics for all samples used in the paper are reported in Appendix Tables A1 and A2.

Table 1: Country-level estimates of the determinants of tradition

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Importance of tradition, 1-6					
	Ancestral characteristics measures					
	Original EA		With Eastern Europe & Siberia extensions		Also with the World Ethnographic Sample extension	
Climatic instability	**-1.951*** **	**-1.783** **	**-1.923*** **	**-1.824** **	**-1.837*** **	**-1.756** **
	(0.540)	**(0.696)**	**(0.523)**	**(0.696)**	**(0.493)**	**(0.667)**
Historical controls:						
Distance from equator		0.005		0.005		0.006
		(0.005)		(0.005)		(0.005)
Economic complexity		-0.069*		-0.065*		-0.064*
		(0.035)		(0.035)		(0.033)
Political hierarchies		0.025		0.013		0.013
		(0.099)		(0.097)		(0.110)
Contemporary controls:						
Ln (per-capita GDP)		-0.164***		-0.165***		-0.164***
		(0.048)		(0.049)		(0.051)
Mean (st. dev.) of dep var	4.52 (0.55)	4.52 (0.55)	4.52 (0.55)	4.52 (0.55)	4.52 (0.55)	4.52 (0.55)
Observations	75	74	75	74	75	74
R-squared	0.147	0.388	0.148	0.388	0.144	0.384

Notes : The unit of observation is a country. The dependent variable is the country-level average of the self-reported importance of tradition. The mean (and standard deviation) of Climatic instability is 0.25 (0.11). *, ** and *** indicate significance at the 10, 5 and 1% levels.

somewhat speculative. Unlike climatic instability, economic growth may be affected by omitted factors and forms of reverse causality. Thus, it is possible that societies that place less importance on tradition, both historically and today, are able to generate faster economic growth.

As the estimates from Table 1 show, we obtain very similar estimates irrespective of which version of the ethnographic data we use. Therefore, for the remainder of the paper, we use the extended sample of 1,292 ethnic groups as our baseline sample. We do not use the largest sample, which also includes the *World Ethnographic Sample*, because of the missing information for the added observations.[7] However, all of the estimates that we report are very similar if either of the other versions is used.

Sensitivity and robustness checks

We now turn to a discussion of the robustness and sensitivity of our baseline estimates. The first check that we undertake tests the sensitivity of our estimates to the use of shorter more-recent time periods for the climate data. This serves two purposes. The first is that the length of the

[7]In particular, one of the control variables for some specifications (the year in which the ethnic group was observed for the data collection) has missing information for 9 of the 17 ethnic groups in the *World Ethnographic Sample*.

period that is important for determining tradition is uncertain. In the model, if there is variation in instability over time, then as long as there has been sufficient time for convergence to steady state, it is the more recent period that should be relevant. The second is that the quality of the paleoclimatic data is reduced as one moves back in time since less proxy data are available. Thus, the use of more recent data provides a check of the sensitivity of the results to higher quality data.

Our baseline measure of climatic instability uses data from the years 500–1900. As a robustness check, we construct estimates using intervals that continue to end in 1900, but begin in either 700, 900, 1100, 1300, 1500, or 1700. The estimates, which are reported in Appendix Table A3, show a similar relationship between ancestral climatic instability and tradition regardless of the time range used. In each of the six auxiliary regressions, the estimated relationship is negative and in all specifications but one it is statistically significant. In addition, the estimated coefficient is generally larger in magnitude than the baseline estimate, which is consistent with there being more measurement error in the data from earlier time periods and/or with climatic variability in the more recent periods being more important for determining the importance of tradition today.

We also undertake a second strategy that is meant to check the quality of the Mann et al. (2009a) climate data and whether it affects our estimates. We do so by constructing an alternative measure of ancestral climatic instability. This is based on a high resolution global gridded dataset, at a 0.5-degree resolution, from the Climatic Research Unit: CRU TS v.4.01 (Harris et al., 2014). A benefit of the data is that they are constructed from high-frequency observations from meteorological stations located around the world. However, the data are only available starting in 1901. Thus, they do not cover a period with multiple episodes of long-run variation (e.g., medieval warming, little ice age, etc), but a period with only one episode and one where, on average, the temperature has been increasing over time. Therefore, although the data, with only four observations (i.e., generations), are too short to credibly calculate a standard deviation, we are able to use a long-difference – i.e., the change in log temperature from 1901–2000 – as a measure of the stability of the environment.[8] The results using this alternative measure, using either log differences or raw differences, are reported in Appendix Tables A4 and A5. We continue to find that climatic instability is negatively related to the importance of tradition.

A second potential concern that we consider is historical and current population movements.

[8]The cross-country correlation between this measure and our baseline measure using Mann et al. (2009a) is 0.47.

Because our climatic instability measures are linked to current data using ancestry (and not location), recent population movements, such as those due to the Columbian Exchange, are unlikely to cause systematic measurement error. However, it is possible that countries that have large immigrant populations today – like the United States, Canada, etc. – may value tradition less and also happen to have had ancestors who lived in climates with more instability. To check whether our estimates are affected by this, we re-estimate equation (1), omitting from the sample all countries with significant population inflows in recent centuries; namely, all countries in North and South America, as well as Australia, New Zealand, and South Africa. As reported in Appendix Table A6, the estimates from this restricted sample are nearly identical to those from the full sample. This suggests that our findings are not driven by the large migrations that occurred during the Columbian Exchange.

Another potential concern is that for historically migratory populations, our location measures may be less precise. Given this, we also check the robustness of our estimates to omitting countries for which a significant proportion of the population is known to have been nomadic or semi-nomadic, measured using variable *v30* in the *Ethnographic Atlas*. Estimates using a sample that omits countries where: (*i*) more than 25% of the population is traditionally nomadic, and (*ii*) more than 25% of the population is either traditionally nomadic or semi-nomadic, are reported in Appendix Tables A7 and A8. For both subsamples, the estimates are virtually identical to our baseline estimates.

Another concern is that ancestral climatic instability could be correlated with other characteristics that may also affect our outcomes of interest. As we show in Appendix Tables A9 and A10, ancestral climatic instability does not have explanatory power for other standard cultural and psychological traits such as those measured by Schwartz (2010) or Hofstede, Hofstede and Minkov (2010). Thus, our findings are specific to the importance placed on tradition and are not found for other cultural traits.

It is possible that other factors that also affect tradition happen to be correlated with ancestral climatic instability. We now turn to a check of the robustness of our estimates to account for these other factors. Thus, we also control for terrain ruggedness and proximity to large water bodies, both of which might be associated with climatic instability.[9] We also account for two measures of population diversity (ethnic and genetic) since diversity may affect the importance

[9]The measurement and source of the additional control variables are documented in the Appendix.

society places on tradition, and it may be correlated with cross-generational climatic instability. Another potentially important factor is generalized trust. It is possible that our measure of cross-generational climatic instability is correlated with either cross-spatial variability or higher frequency (e.g., seasonal or annual) temporal variability in weather, which has been shown to affect trust (Durante, 2010). We control for each country's average measure of generalized trust taken from the *World Values Survey*. Lastly, we also control for the average level of education in a country, which could affect κ in our model and thus, our outcome of interest. Estimates of equation (1) with these additional covariates added to the regression (either one at a time or all together) are reported in Appendix Table A11. As shown, our estimate of interest remain very similar across the specification.

A final potential concern is that our baseline specification includes a number of covariates that could have been affected by ancestral instability; namely, per capita GDP, ancestral economic complexity, and ancestral political centralization. As we report in Appendix Table A12, our estimates are very similar when these covariates are excluded from equation (1).

Within-country estimates

We also pursue an additional strategy to check the sensitivity of our findings to omitted factors. We examine variation across individuals, which allows us to account for country-level factors with country fixed effects. After matching respondents' self-reported mother tongue from the WVS with ethnicity from the *Ethnographic Atlas*, we estimate:

$$\mathit{Tradition}_{i,e,c} = \alpha_c + \beta\, \mathit{Climatic\,Instability}_e + \mathbf{X}_i \mathbf{\Pi} + \mathbf{X}_e \mathbf{\Omega} + \varepsilon_{i,e,c}, \tag{2}$$

where i denotes an individual who is a member of historical ethnic group e and lives in country c. $\mathit{Tradition}_{i,e,c}$ is the self-reported importance of tradition, measured on a 1–6 integer scale and increasing in the importance of tradition. $\mathit{Climatic\,Instability}_e$ is our measure of the cross-generational variability of temperature in the location inhabited by the ancestors of ethnic group e. Importantly, the specification also includes country fixed effects, α_c, which account for potentially important factors that vary at the country level. $\mathbf{X}_e$ denotes the vector of pre-industrial ethnicity-level covariates described above. $\mathbf{X}_i$ is a vector of individual-level covariates that includes a quadratic in age, a gender indicator variable, eight educational-attainment fixed effects, labor-force-participation fixed effects, a married indicator variable, ten income-category

Table 2: Individual-level estimates of the determinants of tradition, measuring historical instability at the ethnicity level

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Importance of tradition, 1-6					
	Ancestral characteristics measures					
	Original EA		With Eastern Europe & Siberia extensions		Also with the World Ethnographic Sample extension	
Climatic instability	**-0.839*** **	**-0.624** **	**-0.742*** **	**-0.637** **	**-0.772*** **	**-0.651*** **
	(0.268)	**(0.293)**	**(0.276)**	**(0.245)**	**(0.278)**	**(0.249)**
Historical ethnicity-level controls:						
Distance from equator		-0.003		-0.003		-0.003
		(0.003)		(0.003)		(0.003)
Economic complexity		-0.025**		-0.032**		-0.028**
		(0.013)		(0.013)		(0.013)
Political hierarchies		0.016		0.029		0.022
		(0.029)		(0.029)		(0.027)
Gender, age, age squared	yes	yes	yes	yes	yes	yes
Survey-wave fixed effects	yes	yes	yes	yes	yes	yes
Other individual controls	no	yes	no	yes	no	yes
Country fixed effects	yes	yes	yes	yes	yes	yes
Number of countries	75	75	75	75	75	75
Number of ethnic groups	186	171	193	178	193	178
Mean (st. dev.) of dep var	4.50 (1.41)	4.47 (1.41)	4.50 (1.41)	4.47 (1.41)	4.50 (1.41)	4.47 (1.41)
Observations	140,629	112,179	140,681	112,174	139,583	111,242
R-squared	0.179	0.178	0.179	0.178	0.179	0.178

Notes: The unit of observation is an individual. The dependent variable is a measure of the self-reported importance of tradition, which ranges from 1 to 6 and is increasing in the reported importance of tradition. Columns 1, 3 and 5 include a quadratic in age, a gender indicator variable, and survey wave fixed effects. Columns 2, 4 and 6 additionally include eight education fixed effects, labor force participation fixed effects, an indicator variable that equals one if the person is married, and ten income category fixed effects. Standard errors are clustered at the ethnicity level. The mean (and standard deviation) of Climatic instability is 0.27 (0.12). *, ** and *** indicate significance at the 10, 5 and 1% levels.

fixed effects, and fixed effects for the wave of the survey in which the individual was interviewed. Standard errors are clustered at the ethnicity level.[10]

Estimates of equation (2) are reported in Table 2, which has the same basic structure as Table 1. The odd-numbered columns report estimates with a parsimonious set of covariates (gender, age, age squared, and survey-wave fixed effects), while the even-numbered columns report estimates with all covariates. We find that, consistent with the country-level estimates, there is a negative relationship between ancestral instability and the importance of tradition today. In all specifications, the estimated coefficients for $Climatic\ Instability_e$ are negative and significant.[11]

[10]Appendix Tables A13–A15 report the ethnic groups that are in each sample.

[11]The estimated magnitudes are smaller than for the country-level estimates. According to the estimates from column 4, a one-standard-deviation increase in ancestral climatic instability (0.12) is associated with a decrease in the importance of tradition by $0.12 \times 0.637 = 0.076$, which is equal to about 0.05 standard deviations of the tradition index.

B. ***Evidence for the differential persistence of cultural traits***

Our next empirical strategy is to test whether the persistence of cultural traits differs systematically depending on climatic instability of a populations' ancestors (i.e., Hypothesis 2). We examine three outcomes that can be measured over long periods of time: female labor-force participation (FLFP), the practice of polygamy, and the practice of consanguineous marriage.

We examine the differential persistence of these cultural practices by estimating the following regression equation:

$$\begin{aligned} \mathit{Cultural\,Trait}_{c,t} &= \alpha_{r(c)} + \beta_1\,\mathit{Cultural\,Trait}_{c,t-1} + \beta_2\,\mathit{Cultural\,Trait}_{c,t-1} \times \mathit{Climatic\,Instability}_c \\ &\quad + \mathbf{X}_{c,t}\mathbf{\Pi} + \mathbf{X}_{c,t-1}\mathbf{\Omega} + \varepsilon_{c,t} \end{aligned} \tag{3}$$

where c indexes countries and t indexes time periods. Period t is the contemporary period (measured in 2012) and period $t-1$ is a historical period that varies depending on the specification. The dependent variable of interest, $\mathit{Cultural\,Trait}_{c,t}$, is a measure of the cultural characteristic today. We are interested in the relationship between this variable and the cultural trait in the past, $\mathit{Cultural\,Trait}_{c,t-1}$, and how this relationship differs depending on ancestral climatic instability, $\mathit{Cultural\,Trait}_{c,t-1} \times \mathit{Climatic\,Instability}_c$. Our interest is in whether the estimated coefficient β_2 is less than zero, which indicates that the cultural trait is less persistent among countries with an ancestry that experienced a climate that exhibited greater instability between generations.

Equation (3) also includes continent fixed effects, $\alpha_{r(c)}$, which capture broad regional differences in FLFP, polygamy, and consanguineous marriage. The vector $\mathbf{X}_{c,t}$ contains covariates that are measured in the contemporary period: log real per-capita GDP as a measure of contemporaneous development. When we examine FLFP, we also include a quadratic term to account for its well-known nonlinear relationship with income (Goldin, 1995). $\mathbf{X}_{c,t-1}$ denotes our vector of historical covariates: political development (measured by the number of levels of authority beyond the local community), economic development (measured by complexity and density of settlements), average distance from the equator of the ancestral homelands, and the direct effect of the instability of the climate across generations.

We begin by estimating the relationship between average country-level FLFP in 1970 and in 2012. The variables, which are from the *World Development Indicators*, are measured as the percentage of women aged 15–64 who are in the labor force. The estimates are reported in Table 3. Column 1 reports estimates from a version of equation (3) that does not include the interaction

Table 3: Differential persistence of cultural traits: FLFP, polygamy, and cousin marriage

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Modern characteristic (dependent variable):							
	FLFP, 2012				**Polygamy, 0/1**		**Cousin Marriage, 0-100**	
	Historical characteristic (independent variable):							
	FLFP, 1970		**Traditional Female Participation in Agriculture**		**Traditional Practice of Polygamy, 0/1**		**Traditional Practice of Cousin Marriage, 0-100**	
Traditional characteristic	**0.330*** **	**0.717*** **	**0.248*** **	**0.642*** **	**0.324*** **	**0.845*** **	**0.178*** **	**0.401*** **
	(0.079)	**(0.161)**	**(0.072)**	**(0.168)**	**(0.122)**	**(0.212)**	**(0.066)**	**(0.086)**
Traditional char * Climatic instability		**-1.660** **		**-1.703*** **		**-2.177** **		**-1.310** **
		(0.683)		**(0.598)**		**(0.878)**		**(0.556)**
Country-level controls:								
Climatic instability		44.701		69.11***		2.363***		34.22
		(36.845)		(21.55)		(0.667)		(22.27)
Distance from equator	-0.174	-0.135	-0.059	-0.150	-0.004	-0.006*	0.112	0.052
	(0.115)	(0.145)	(0.110)	(0.116)	(0.003)	(0.003)	(0.146)	(0.155)
Economic complexity	1.931	2.663*	0.964	0.717	-0.010	-0.013	0.319	-2.984*
	(1.253)	(1.546)	(1.196)	(1.259)	(0.020)	(0.021)	(1.833)	(1.755)
Political hierarchies	-1.606	-1.878	-0.985	-0.633	-0.033	-0.033	-1.904	-0.492
	(1.567)	(1.397)	(1.844)	(1.883)	(0.039)	(0.036)	(2.683)	(2.598)
Ln (per-capita GDP)	-71.61***	-67.91***	-70.61***	-58.82***	-0.034	-0.043	-3.139	-4.805*
	(24.48)	(23.72)	(14.21)	(14.35)	(0.031)	(0.031)	(2.761)	(2.699)
Ln (per-capita GDP) squared	3.822***	3.649***	3.777***	3.102***				
	(1.255)	(1.212)	(0.772)	(0.779)				
Year ethnicity sampled			2.631	0.292	-0.104**	-0.109**	0.001	0.001
			(1.592)	(1.858)	(0.044)	(0.045)	(0.003)	(0.003)
Continent fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Mean (st. dev.) of dep. var.	50.7 (13.7)	50.7 (13.7)	53.2 (15.4)	53.2 (15.4)	0.44 (0.41)	0.44 (0.41)	12.8 (16.4)	12.8 (16.4)
Observations	77	77	165	165	109	109	60	60
R-squared	0.599	0.633	0.342	0.379	0.539	0.574	0.662	0.702

Notes: OLS estimates are reported with robust standard errors in parentheses. The unit of observation is a country. The female labor-force participation variables (from 1970 and 2012) are measured as the percentage of women aged 15-64 in the labor force. Polygamy is an indicator variable that equals one if having more than one spouse is an accepted or legal practice in the country. Cousin marriage in the modern period is the proportion of total marriages that are consanguineous. The measure is taken from Schulz (2017). Historical controls are defined in the appendix. Climatic instability ranges from approximately 0.05 to 0.45, although this varies slightly depending on the sample. Its mean (and standard deviation) is approximately: 0.24 (0.09). See Appendix Tables A17-A20 for details of each specification. *, *** and *** indicate significance at the 10, 5, and 1% levels.

of interest, $Cultural\,Trait_{c,t-1} \times Climatic\,Instability_c$. We find a strong positive correlation between FLFP in 1970 and 2012. Column 2 reports estimates of equation (3). The persistence of FLFP is weaker in countries with greater cross-generational climatic instability. To assess the magnitude of the heterogeneity in persistence, consider the fact that $Climatic\,Instability_c$ ranges from 0.034 to 0.457. Thus, for the country with the lowest value, the relationship between FLFP in 1970 and FLFP in 2012 is: $0.717 - 0.034 \times 1.66 = 0.66$. For the country with the highest value, the same relationship is: $0.717 - 0.457 \times 1.66 = -0.04$, which is not statistically different from zero.[12]

We next examine persistence over a much longer time span. We measure traditional FLFP dur-

[12]Since FLFP is available annually, an alternative strategy is to estimate the annual autocorrelation in FLFP for each country and to correlate this with $Climatic\,Instability_c$. A benefit of this two-step procedure is that one can visualize the relationship between the two variables. The estimates are reported in Appendix Table A16 and the graphs shown in Appendix Figures A4 and A5.

ing the pre-industrial period using variable $v54$ from the ethnographic sources, where ethnicities are grouped into one of the following categories that measure the extent of female participation in pre-industrial agriculture: (1) males only, (2) males appreciably more, (3) equal participation, (4) females appreciably more, and (5) females only. To make the traditional FLFP variable (which ranges from 1 to 5) more comparable with the contemporary measures of FLFP, we normalize it to range from 0–100. Because traditional female participation in agriculture is measured in different years for different observations depending, in part, on when contact was made with the ethnic group, in these regressions we also control for the year in which the ethnographic data were collected.

We first examine the average relationship between traditional female participation in agriculture and FLFP in 2012. This is reported in column 3 of Table 3, which shows a strong positive relationship between the two measures. The point estimate of 0.248 is slightly lower than the estimate when examining persistence between 1970 and 2012 (column 1). This is not surprising since one expects less persistence over a longer time. Column 4 then reports estimates of equation (3), which allows for differential persistence. We estimate a negative coefficient for the interaction term, suggesting weaker persistence in countries with greater ancestral climatic instability.

Our next estimates of equation (3) examine two practices that, unlike FLFP, have been declining over time. One is polygamy, which is the practice of marrying more than one spouse. The other is consanguineous marriage, which is a marriage between two people who are related as second cousins or closer. It is commonly referred to as "cousin marriage." In both cases, in some countries, the practice has declined significantly over time, while in others, it is still common (Bittles and Black, 2010). We measure the historical presence of the two practices using variables $v9$ (for polygamy) and $v25$ (for cousin marriage) from the ethnographic data. We use this information to construct measures of the proportion of a country's population with ancestors that practiced polygamy and believed that consanguineous marriage was the preferred form of marriage. We measure the prevalence of polygamy today using an indicator that equals one if having more than one spouse is accepted or legal in the country.[13] We measure the current prevalence of cousin marriage using data from Schulz (2017).[14]

[13]The data are from the *OECD Gender, Institutions and Development Database*.

[14]In the data from Schulz (2017), the prevalence of consanguineous marriage is measured in different years in the late 20th century. Therefore, the specifications control for the number of years between the measurement of the historical and contemporary variables.

Estimates are reported in columns 5–8 of Table 3. The coefficients for the interaction terms, β_2, are negative and significant in all specifications. That is, the persistence of polygamy and the persistence of cousin marriage is weaker in countries where the climate faced by the populations' ancestors was more unstable across generations.

Sensitivity and robustness checks

We test the robustness of our findings to interacting the historical characteristic of interest, not only with the climate instability measure, but also with each control variable. The estimates are reported in Appendix Tables A17–A20. We also test the robustness of our findings to controlling for human capital, which may reflect κ in the model. The estimates are reported in Appendix Table A21. We find that our estimates are robust to the inclusion of these additional covariates.

We also examine the robustness of our findings to studying the differential persistence of ethnic groups living within the same country. We use *IPUMS International* Census data, which report respondent ethnicity or mother tongue for the following eight countries: Belarus, Cambodia, Malaysia, Nepal, Philippines, Sierra Leone, Uganda, and Vietnam. We use this information to link individuals to ancestral climatic instability and estimate a variant of equation (3) that is at the ethnicity level and includes country fixed effects.[15] Although the estimates, which we report in Appendix Table A22, are slightly less precise than the country-level estimates, we continue to find that the persistence of FLFP is weaker for ethnicities with ancestors from locations with greater cross-generational climatic instability.

C. *Evidence from the descendants of immigrants to the United States*

Our next set of tests uses immigration as a natural experiment in which to study the differential persistence of cultural traits. We study whether cultural persistence is lower among the descendants of immigrants for whom the ancestral climatic instability of their origin country is higher. To measure cultural persistence we use two traditional practices that are near universal in the origin countries; namely marrying someone from the same ancestry and speaking one's ancestral

[15] The estimating equation is: $FLFP_{e,c,t} = \alpha_{c,t} + \beta_1\, FLFP_{e,t-1} + \beta_2\, FLFP_{e,t-1} \times \ \textit{Climatic Instability}_e + \mathbf{X}_{e,t-1}\boldsymbol{\Omega} + \varepsilon_{e,c,t}$, where e denotes an ethnicity, c a country, and t the survey year. $\alpha_{c,t}$ denotes survey (i.e., country and survey-year) fixed effects; $FLFP_{e,c,t}$ denotes the average FLFP rate of ethnicity e in country c in survey year t; $FLFP_{e,c,t-1}$ is the traditional female participation in pre-industrial agriculture; $\textit{Climatic Instability}_e$ is historical climatic instability of ethnic group e; $\mathbf{X}_{e,c,t-1}$ denotes the ethnicity-level historical covariates. Standard errors are clustered at the ethnicity level.

language at home. We also study the persistence of occupation and educational attainment between immigrant fathers and their sons.

a. Within-group marriage

In all countries, the traditional practice is to marry someone from your own country. For the children of U.S. immigrants, continuing this tradition is difficult and the importance of the practice to parents and their children will affect its persistence. Of course, other factors will also affect this decision, such as the availability of potential partners from one's own cultural background or the cultural distance between the origin country and the United States. We control for these factors in the empirical analysis.

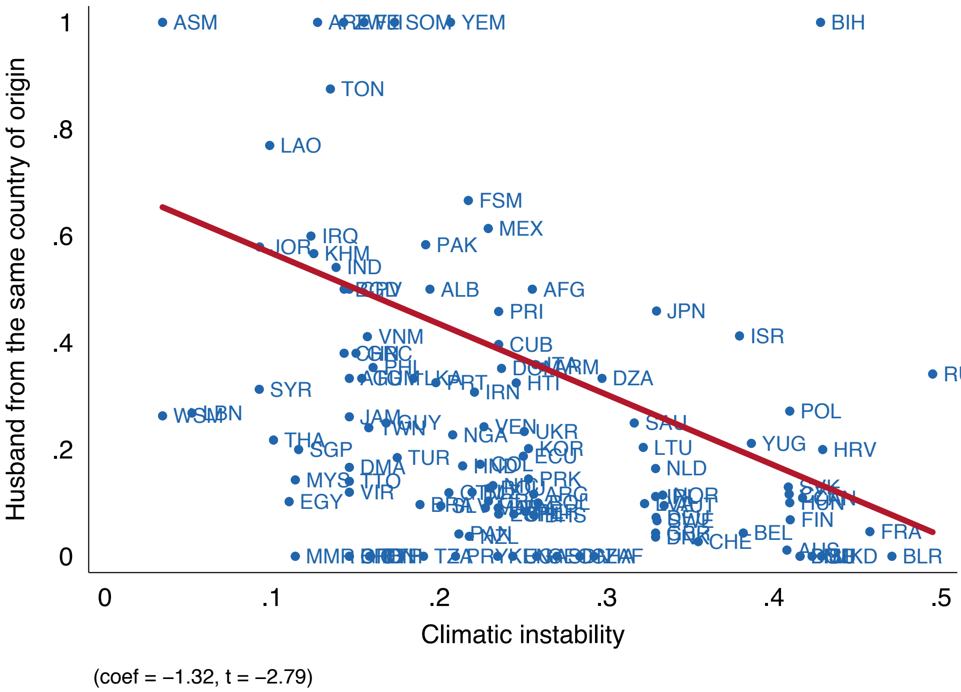
We begin by first examining the raw correlations between within-group marriage and origin-country ancestral climatic instability. Our sample comprises all married women in all waves of the *March Supplement of the Current Population Survey (CPS)* with at least one parent who was born outside the United States.[16] A wife's origin country can be identified by either her mother or father's country of birth. In the empirical analysis, we will report estimates separately for both cases. Here, we use the mother's country of birth. We identify a wife's husband as being of the same ancestry as her if he, or one of his parents, or both, were born in the wife's origin country.

The unconditional relationship between the fraction of wives from an origin country who have married someone with the same ancestry is shown in Figures 6a and 6b. Figure 6a shows the relationship with the observations labeled with their three-digit country ISO code and Figure 6b shows the relationship with countries denoted by circles, where the size of the circle is proportional to the number of wives in the sample who are from that origin country. From the figures, it is clear that a very strong relationship is observed in the raw data: women from origin countries with more cross-generational climatic instability are less likely to have a spouse from the same country.

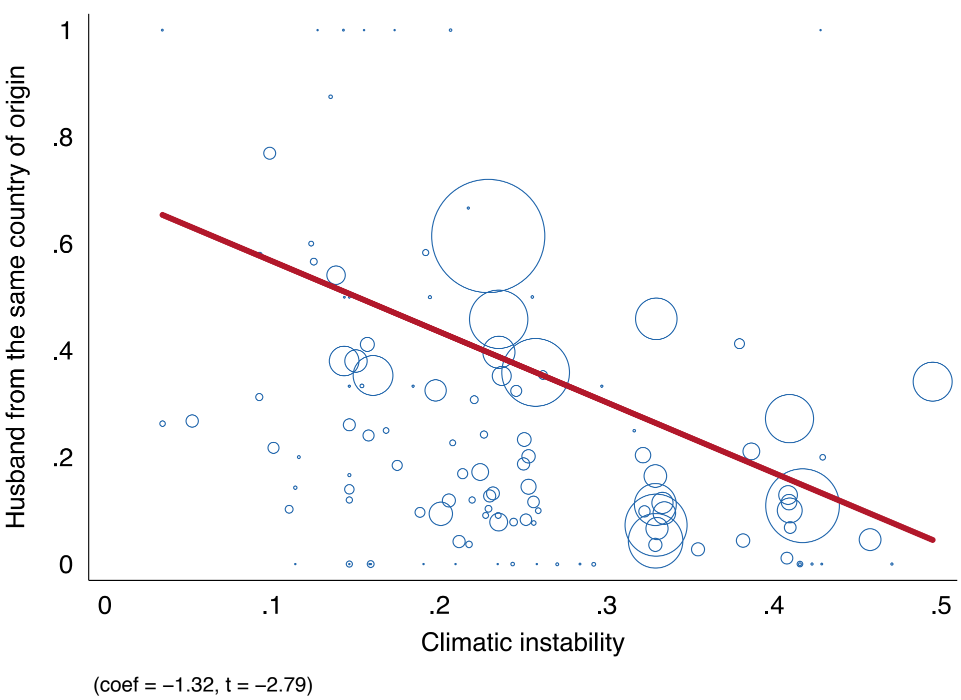
Of course, there are a number of alternative explanations for the observed relationships. Given this, we now turn to a more formal examination of the relationship. We estimate:

$$I_{i,c,k}^{Ingroup\,Marriage} = \alpha_k + \beta\,Climatic\,Instability_c + \mathbf{X}_c\mathbf{\Pi} + \mathbf{X}_{c,k}\mathbf{\Omega} + \mathbf{X}_i\mathbf{\Phi} + \varepsilon_{i,c,k}, \tag{4}$$

[16]Beginning in 1994, for all individuals who were born in the United States, the *March Supplement of the Current Population Survey (CPS)* began recording each parent's country of birth. Our analysis uses all available waves.



(a) Bivariate relationship with the names of the country of origin shown



(b) Bivariate relationship where the circle size denotes the number of individuals from the country of origin in the sample

Figure 6: Unconditional relationship between women marrying men from their country of origin and cross-generational climatic instability

where i indexes married women or men (depending on the sample) who were born in the U.S., but whose parents are immigrants who were born outside the U.S., c indexes the origin country of the individual's parents, and k their current location of residence (metropolitan area). The outcome of interest, $I^{Ingroup\,Marriage}_{i,c,k}$, is an indicator variable that equals one if an individual's spouse was born in origin country c or if his or her mother or father was born in country c. α_k denotes the inclusion of residence (i.e., metropolitan-area) fixed effects. The vector of country-level covariates, $\mathbf{X}_c$, includes the natural log of the current per-capita GDP in the country of origin (measured in the survey year), the historical controls of the origin country (distance from the equator, economic complexity, and political sophistication), the measure of the genetic distance between the country of origin and the United States as a proxy of cultural distance, which could affect out-group marriage.[17] $\mathbf{X}_i$ includes the fraction of the population in the same metropolitan area as the individual who are first- or second-generation immigrants from the same country of origin. Lastly, we also include controls for the following individual-level covariates, $\mathbf{X}_i$: a quadratic in age, educational-attainment fixed effects (less than high school, high school only and more than high school), rural/urban indicator, and survey-year fixed effects.

An important point about equation (4) is that our coefficient of interest, β, is estimated by comparing individuals living in the same metropolitan area. This is important given that weather shocks may have contemporaneous effects. (In fact, this is a key assumption of the model – that the environment determines the best action.) By examining individuals who live in the same location, we are able to hold constant the contemporaneous local environment, while examining the effects of an individual's ancestral environment.

Estimates of equation (4) are reported in Table 4. In columns 1 and 2, the unit of observation is a married woman, while in columns 3 and 4, it is a married man. In columns 1 and 3, we define the origin country by the birthplace of the person's father, while in columns 2 and 4, we define it by the birthplace of the mother. Across all four specifications, we find a negative relationship between ancestral climatic instability and the probability of marrying someone of the same ancestry. The magnitudes and significance are greater for the sample of married women than for the sample of married men, and also greater when we define a person's origin country using the mother. The estimated effects are sizeable. For example, according to the estimates from column 2, a one-standard-deviation increase in cross-generational climatic instability is associated

[17] The measure is from Spolaore and Wacziarg (2009).

Table 4: Women and men marrying a spouse from their origin country, using CPS 1994–2014

	(1)	(2)	(3)	(4)
	Dependent variable: Indicator variable for spouse being from the same origin country			
	Sample: Married women		Sample: Married men	
	Origin country identified from father	Origin country identified from mother	Origin country identified from father	Origin country identified from mother
Climatic instability	**-0.274***	**-0.492*****	**-0.103**	**-0.250***
	(0.156)	**(0.178)**	**(0.138)**	**(0.148)**
Country-level controls:				
Distance from equator	-0.006**	-0.005	-0.008***	-0.009***
	(0.003)	(0.003)	(0.003)	(0.003)
Economic complexity	0.009	0.019	-0.010	-0.021
	(0.026)	(0.035)	(0.039)	(0.037)
Political hierarchies	0.089***	0.084***	0.092**	0.085**
	(0.027)	(0.029)	(0.037)	(0.037)
Ln (per-capita GDP)	-0.005	-0.022	-0.003	-0.004
	(0.030)	(0.033)	(0.036)	(0.035)
Genetic distance from the United States	0.031	0.010	0.011	-0.010
	(0.046)	(0.053)	(0.043)	(0.044)
Fraction of population in location who are 1st or 2nd-generation immigrants from same country of origin	3.314***	3.533***	3.071***	3.409***
	(0.489)	(0.627)	(0.504)	(0.483)
Individual controls	yes	yes	yes	yes
Number of countries	108	105	110	105
Mean (st. dev.) of dependent variable	0.33 (0.47)	0.32 (0.47)	0.28 (0.45)	0.29 (0.45)
Observations	36,082	34,045	38,419	35,639
R-squared	0.239	0.254	0.223	0.245

Notes : OLS estimates are reported with standard errors clustered at the country-of-origin level in parentheses. In columns 1 and 2, the unit of observation is a daughter of at least one immigrant parent who is married at the time of the survey. In columns 1 and 2, the dependent variable is an indicator variable that equals one if the woman is married to someone with the same ancestry (i.e., an individual born in the country or with at least one parent who was born in the country). In columns 3 and 4, the unit of observation is a son of at least one immigrant parent who is married at the time of the survey. In columns 3 and 4, the dependent variable is an indicator variable that equals one if the man is married to someone with the same ancestry. The country of origin of the observation is defined by the country of birth of the father in columns 1 and 3 and the country of birth of the mother in column 2 and 4. The following controls are included in all specifications: a quadratic in age, two indicator variables for educational attainment (less than high school and high school), metropolitan-area fixed effects, and survey-year fixed effects. The mean and standard deviation of climatic instability is 0.29 (0.09). *, ** and *** indicate significance at the 10, 5 and 1% levels.

with a 0.044 decrease in the frequency of within-group marriage, which is equal to 14 percent of the mean of the dependent variable and 9 percent of the standard deviation.

In Table 4 and in the remainder of the tests of the paper, for brevity, we do not report the coefficients for all covariates. Although not the focus of the paper, we do find that educational attainment is negatively associated with the importance placed on tradition, which is consistent with education being associated with a lower κ in the model. These findings are summarized in Section A4 and reported in Table A34 of the Appendix.

b. Speaking a foreign language at home

The second measure of cultural persistence that we use is whether or not English is spoken at home. Since children born to immigrant parents in the United States are almost always fluent in

English, they face the decision of whether to continue speaking their traditional language at home. They face this decision both when they live with their parents as children and when they live on their own with their own family. Thus, as a revealed measure of the importance of maintaining tradition, we examine the extent to which a foreign language is spoken at home among the children of immigrants. Speaking a foreign language at home indicates that the children of the immigrants were taught their origin language, which is a sign of the parents and children valuing their tradition. It also means that the origin language is valued enough for it to be spoken within the household. Since the ease with which parents can learn English will be an important determinant of whether children speak English at home, we always control for a measure of the linguistic distance of the origin language from English.

Information about the language spoken at home is available from the 2000 U.S. Census. Since the Census only records self-reported ancestry (and not the country of birth of one's parents), this is the measure of ancestry that we use.[18] Our sample includes all individuals who were born in the United States and report their ancestry as being a non-English speaking country.

Figures 7a and 7b report the unconditional cross-country relationship between the proportion of individuals in our sample who speak a foreign language at home and the ancestral climatic instability in the origin country. In Figure 7a, observations are labeled with the country's three-digit ISO code, while in Figure 7b observations are denoted by circles with a size that is proportional to the number of individuals with that country's ancestry. In the raw data, one observes a significant negative relationship. Immigrant descendants from countries with more ancestral climatic instability in their origin country are less likely to speak a foreign language at home.

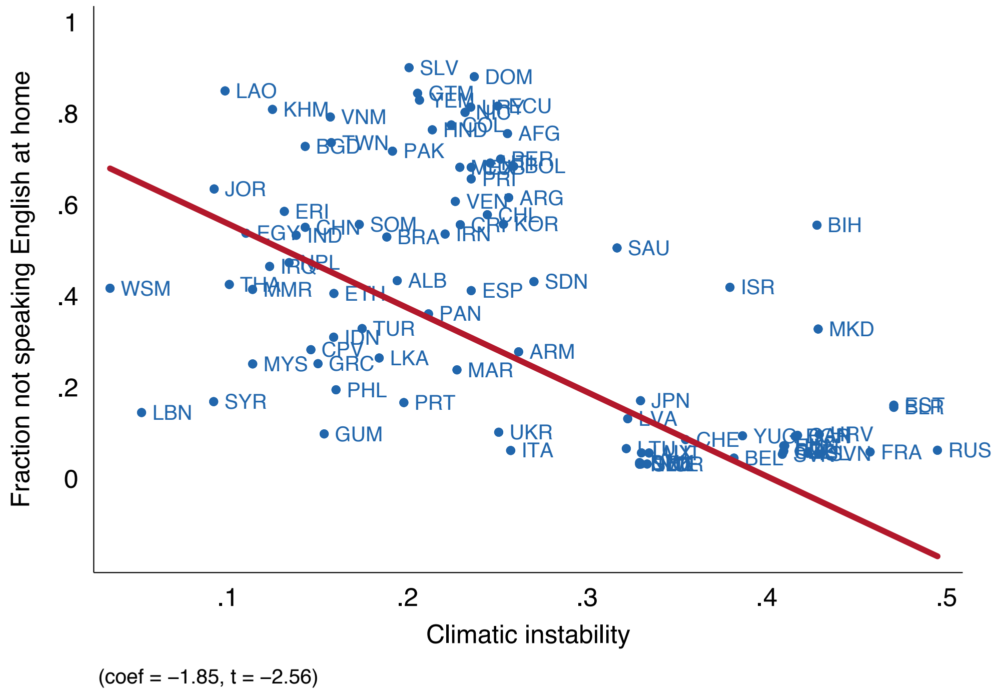
We examine this relationship more formally by estimating the following equation:

$$I_{i,c,k}^{\textit{Foreign Lang}} = \alpha_k + \beta\, \textit{Climatic Instability}_c + \mathbf{X}_c\mathbf{\Pi} + \mathbf{X}_{c,k}\mathbf{\Omega} + \mathbf{X}_i\mathbf{\Phi} + \varepsilon_{i,c,k}, \tag{5}$$

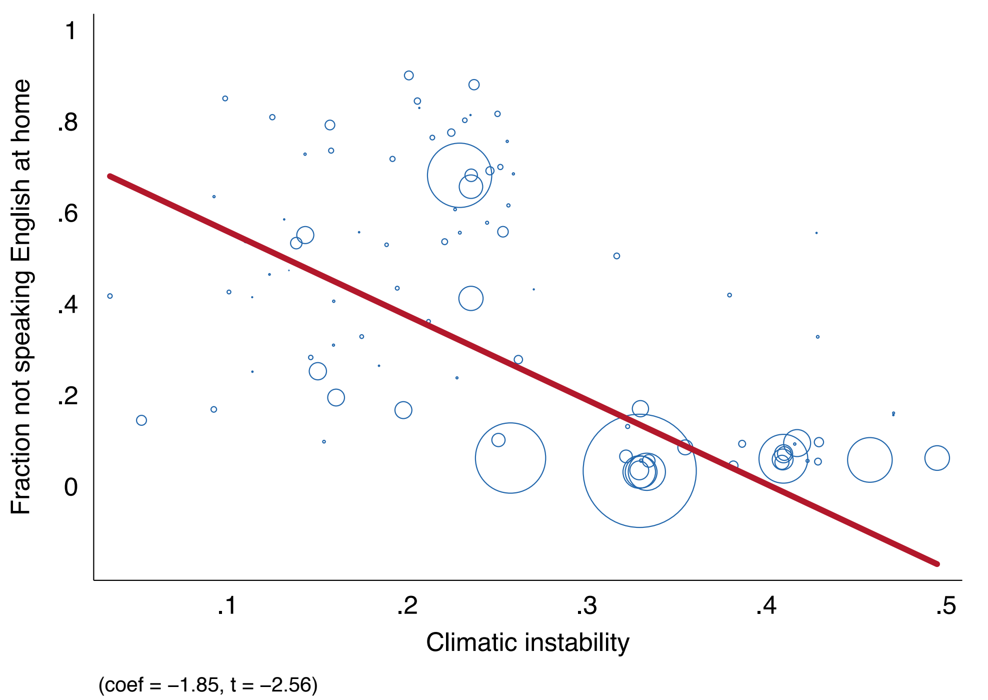
where i denotes an individual, c his/her ancestry, and k a location of residence (metropolitan area).[19] The dependent variable, $I_{i,c,k}^{\textit{Foreign Lang}}$, is an indicator that equals one if a language other than English is the primary language spoken at home. α_k denotes the inclusion of residence (i.e., metropolitan-area) fixed effects. $\mathbf{X}_c$ denotes ancestral country-level covariates: historical distance from the equator, historical economic development, historical political complexity, the

[18] After 1970, the Census stopped recording the parents' countries of birth.

[19] We omit from the sample individuals from origin countries with English as an official language.



(a) Bivariate relationship with the names of the country of origin shown



(b) Bivariate relationship where the circle size denotes the number of individuals from the country of origin in the sample

Figure 7: Unconditional relationship between speaking a foreign language at home and cross-generational climatic instability

Table 5: Speaking a foreign language at home, from 2000 Census

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dep variable: Indicator for speaking a foreign language at home						
	All 2nd gen+ individuals	Not living with parents	Living with parents				
Climatic instability	**-0.447*****	**-0.386****	**-0.767*****	**-0.317*****	**-0.318*****	-0.154	-0.137
	(0.168)	**(0.170)**	**(0.182)**	**(0.083)**	**(0.089)**	(0.123)	(0.119)
Father speaks a foreign language				0.509***		**0.726*****	
				(0.029)		**(0.086)**	
Father speaks foreign lang.* Climatic instability						**-0.800****	
						(0.311)	
Mother speaks a foreign language					0.519***		**0.762*****
					(0.032)		**(0.080)**
Mother speaks foreign lang.* Climatic instability							**-0.890*****
							(0.292)
Individual controls	yes	yes	yes	yes	yes	yes	yes
Number of countries	84	84	84	84	84	84	84
Mean (st. dev.) of dependent variable	0.12 (0.33)	0.11 (0.31)	0.23 (0.42)	0.22 (0.42)	0.23 (0.43)	0.22 (0.42)	0.23 (0.43)
Observations	3,343,097	2,915,673	427,424	330,226	400,062	330,226	400,062
R-squared	0.294	0.269	0.367	0.547	0.567	0.550	0.570

Notes : OLS estimates are reported with standard errors clustered at the ancestry-country level in parentheses. The unit of observation is a person born in the United States with ancestry from a non-English speaking country. The dependent variable is an indicator that equals one if the person speaks a foreign language at home. All specifications include the following control variables: a quadratic in age, two indicator variables for education (less than high school and high school), labor force participation fixed effects, personal income, and location (i.e., MSA) fixed effects. The mean (and standard deviation) of Climatic instability is: 0.33 (0.07). *, ** and *** indicate significance at the 10, 5 and 1% levels.

GDP in the country of origin measured at the time of the survey, and the linguistic distance between the country of origin and the United States. $\mathbf{X}_{c,k}$ includes the fraction of those living in the same metropolitan area who are first-generation immigrants of the same ancestry. This is included to account for the possibility that one's incentives to learn and speak one's ancestral language may be greater the more people there are in the same location whose mother tongue is the ancestral language. The vector of individual-level controls, $\mathbf{X}_i$, includes a quadratic in age, a gender indicator, an indicator for being married, educational-attainment fixed effects (less than high school, high school only, and more than high school), labor-force-status fixed effects (employed, unemployed, and outside of the labor force), the natural log of annual income, and a rural/urban indicator variable.

Estimates of equation (5) are reported in columns 1–3 of Table 5. Column 1 reports estimates using the full sample of individuals who were born in the United States and report a foreign ancestry. We find a negative and significant relationship between ancestral climate instability and speaking a foreign language at home. According to the estimate, a one-standard-deviation increase in cross-generational climatic instability is associated with a reduction in the probability of speaking a foreign language at home of $0.07 \times 0.447 = 0.031$, which is equal to 26% of the sample mean and 9.4% of its standard deviation. In columns 2 and 3, we split the samples into those not living with their parents and those living with their parents. We find effects for both groups.

In the remaining columns we further investigate the sample of individuals who live with their parents. We first re-estimate equation (5), but controlling for indicator variables that equal one if either the father (column 4) or the mother (column 5) speaks a foreign language at home. As shown, this explains an important part of the variation in whether children speak a foreign language at home. Including these controls reduces the estimated effects by about one-half.

Unsurprisingly, we find that there is a strong positive relationship between either parent speaking a foreign language at home and the child. Differences reflect cases where the parents speak English to their children but a foreign language to each other or where the parents speak a foreign language to their children but their children reply in English. We estimate whether the intergenerational transmission of the tradition of speaking one's ancestral language is affected by climatic instability of the ancestral country. We do this by estimating an equation that has the same logic as equation (3), which studies differential persistence of traditions over time, but looks at differential persistence over generations:

$$\begin{aligned} I_{i,c,k}^{Foreign\ Lang} &= \beta_1\, Climatic\ Instability_c + \beta_2 I_{i,c,k}^{Parent\ Foreign\ Lang} + \beta_3 I_{i,c,k}^{Parent\ Foreign\ Lang} \times Climatic\ Instability_c \\ &\quad + \mathbf{X}_c\mathbf{\Pi} + \mathbf{X}_{c,k}\mathbf{\Omega} + \mathbf{X}_i\mathbf{\Phi} + \alpha_k + \varepsilon_{i,c,k}, \end{aligned} \tag{6}$$

Equation (6) is identical to equation (5), and all variables are defined in the same manner, except that now there is the added variable $I_{i,c,k}^{Parent\ Foreign\ Lang}$, which is an indicator variable that equals one if either the father or mother speaks a foreign language at home. The equation also includes this measure interacted with the measure of intergenerational climatic instability. Estimates of equation (6) are reported in columns 6 and 7 of Table 5. The estimates show clearly that while having a parent that speaks a foreign language at home increases the probability that the child speaks a foreign language at home too, this relationship is much weaker if the origin country has greater ancestral climatic instability. In other words, the intergenerational transmission of the tradition of speaking one's ancestral language is weaker if the ancestral climate was more unstable.

c. Education and occupation

We next turn to other traits that we can measure from available data and that plausibly reflect cultural persistence: education and occupation.[20] Examining the transmissions of these traits is not well-suited to the use of the same strategy as for language, which uses a sample of children who are still living with their parents. While language is typically learned at an early age, one's final education and occupation are typically not achieved until after one leaves home.

Given this, we study the intergenerational transmission of education and occupational choice among immigrants and their children using a synthetic cohort approach (Card, DiNardo and Estes, 2000). The approach uses repeated cross-sections from two sources, the 1970 Census and the 1994–2014 waves of the CPS, to create estimates of the variables of interest for (synthetic) groups of fathers and sons.[21]

From the 1994–2014 CPS, we identify all males who are 30 years or older at the time of the survey, have a foreign-born father, and were born between 1961 and 1985. We then group the sample by five-year birth cohorts (1961–1965, 1966–1970 and so on until 1985) and by their father's country of birth. Individuals from each group are then linked to a sample of fathers who have the same country-of-birth and report having at least one son in the relevant birth cohort. For the oldest two cohorts (1961–1965 and 1966–1970), we can use 1970 Census in addition to the CPS.[22]

With these data we are then able to estimate the following equation:

$$\overline{y}_{c,k}^{Sons} = \beta_1 \times \textit{Climatic Instability}_c + \beta_2\, \overline{y}_{c,k}^{Fathers} + \beta_3\, \overline{y}_{c,k}^{Fathers} \times \textit{Climatic Instability}_c + \mathbf{X}_c \boldsymbol{\Gamma} + \varepsilon_{c,k}, \quad (7)$$

where c indexes the fathers' countries of birth and k indexes the sons' five-year birth cohorts. $\overline{y}_{c,k}^{Sons}$ is the average value of the outcome of interest for the sons and $\overline{y}_{c,k}^{Fathers}$ is the same measure but for the fathers. The outcomes are educational attainment, measured as a 0–9 index, and an occupational prestige index that can range from 10–90.[23] We allow the relationship between the fathers' and sons' outcomes to differ depending on the ancestral climatic instability of the origin country, $\textit{Climatic Instability}_c$. Our baseline set of country-level covariates is also included

[20]We thank the editor and referees for suggesting this additional test.

[21]We are able to examine fathers only due to data availability in the Census 1970. Our focus on father-son persistence follows Card et al. (2000).

[22]The use of later Censuses for younger cohorts is not possible because they do not record country of birth of the parents after 1970.

[23]Education and occupation are reported in the CPS and Census. The occupational prestige index, which is used to convert occupation categories to scores, is from Davis, Smith, Hodge, Nakao and Treas (2006).

Table 6: Differential persistence of education and occupation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Groups and observations defined by:							
	Origin country, birth cohort				Origin country, birth cohort, state			
	Average characteristic of sons (dep var) and fathers (indep var):							
	Education		Occupation score		Education		Occupation score	
Fathers' characteristic	**0.266*****	**0.500*****	**0.221*****	**0.277****	**0.157*****	**0.223*****	**0.130*****	**0.273*****
	(0.047)	**(0.089)**	**(0.050)**	**(0.126)**	**(0.030)**	**(0.069)**	**(0.033)**	**(0.076)**
Fathers' characteristic * Climatic instability		**-0.998*****		**-0.250**		**-0.264**		**-0.575****
		(0.313)		**(0.500)**		**(0.213)**		**(0.233)**
Country-level controls:								
Climatic instability	0.831	5.949***	-0.887	10.690	-0.273	1.045	0.846	27.357**
	(0.952)	(1.846)	(5.598)	(24.490)	(1.084)	(1.573)	(7.189)	(12.140)
Distance from equator	0.002	0.003	0.038	0.038	0.004	0.005	0.005	0.006
	(0.005)	(0.005)	(0.033)	(0.033)	(0.006)	(0.006)	(0.045)	(0.043)
Economic complexity	0.117	0.097	-0.410	-0.398	-0.233**	-0.227**	-2.377***	-2.296***
	(0.153)	(0.146)	(0.525)	(0.527)	(0.106)	(0.103)	(0.692)	(0.671)
Political hierarchies	-0.181	-0.188*	-0.041	-0.060	0.153	0.160	1.702	1.773
	(0.115)	(0.113)	(0.715)	(0.722)	(0.146)	(0.144)	(1.211)	(1.193)
State fixed effects	no	no	no	no	yes	yes	yes	yes
Number of countries of origin	116	116	109	109	91	91	88	88
Mean (st. dev.) of the dep. variable	6.45 (1.22)	6.45 (1.22)	49.8 (8.23)	49.8 (8.23)	6.26 (1.57)	6.26 (1.57)	49.1 (10.1)	49.1 (10.1)
Observations	468	468	439	439	2,704	2,704	2,421	2,421
R-squared	0.174	0.194	0.069	0.070	0.111	0.112	0.094	0.097

Notes: OLS estimates are reported with standard errors clustered at the level of the country. In columns 1-4, the unit of observation is a group that is defined by the father's country of birth and the son's birth cohort (1961-1965, 1966-1970, 1971-1975, 1975-1980, 1981-1985). In columns 5-8, the groups are defined by the father's country of birth the son's birth cohort, and the state of residence of the father and son. Equal weights are given to each group regardless of size. Education measured as a variable that ranges from from 0 (8th grade or less) to 9 (more than college). The occupational prestige score, which range from 10-90, is taken from Davis et al (2006). The mean (and standard deviation) of Climatic instability is 0.25 (0.10). *, ** and *** indicate significance at the 10, 5 and 1% levels.

and denoted by $\mathbf{X}_c$. We estimate equation (7) using weighted least squares with weights given by the number of sons in each cell.[24]

Estimates of equation (7) are reported in columns 1–4 of Table 6. Estimating the equation without the interaction, we find a positive and significant relationship between the education (or occupation score) of the fathers and the sons. We also find that the relationships are much weaker where the ancestral climatic was less stable. We also report estimates that extend the methodology of Card et al. (2000) by defining groups by origin-country, cohort, and state of residence. Estimates of equation (7), with state fixed effects also included, are reported in columns 5–8 of Table 6. We find very similar estimates.

d. Potential bias from selective migration

A potential concern with our estimates is that immigrants are a selected group who are not necessarily a representative subsample of the populations in the origin countries. This is problematic if the nature of selection varies systematically with the climatic instability of the origin country. To assess the severity of this concern we check whether the intensity of emigration, both globally and to the United States, is correlated with ancestral climatic instability. The estimates, reported in Appendix Table A24, show no relationship between a country's ancestral climatic

[24]OLS estimates, which have equal weights, produce nearly identical estimates. See Appendix Table A23.

instability and the total number of emigrants from the country (columns 1 and 2) or the number of emigrants going to the United States (columns 3 and 4). In addition, the analysis of the Indigenous populations provides evidence that speaks to this issue. Unlike immigrants, they are not a product of self-selection and immigration. We now turn to these estimates.

D. ***Evidence from Indigenous populations of Canada and the United States***

Among the Indigenous populations of Canada and the United States, there is significant variation in the extent to which language traditions have been maintained (Arthur and Diamond, 2011). Our analysis examines the extent to which part of this variation is explained by ancestral climatic instability.

A benefit of the geographic focus of the analysis is that it allows us to use higher resolution climate data from Cook et al. (2010), which are based on 1,845 chronologies from annual tree rings. The precision of the data allows us to also separately account for short-run year-to-year variability in our analysis. Our analysis proceeds in two steps. For consistency and comparability with the previous estimates, we first conduct our analysis using the coarser Mann et al. (2009a) data. We then replicate the results using the finer Cook et al. (2010) data, while controlling explicitly for short-run variability in our analysis. The greater precision in the data also allows us to move beyond measuring ancestral variability as the cross-generational standard deviation of the mean within a generation – i.e., the first moment – and to also consider the cross-generational variability in the second moment (year-to-year variability) in the data. As we will show, we find that this variability also appears to be important.

a. Estimates using the Mann et al. (2009a) climate data

The U.S. sample comprises all individuals who report a Native American tribal affiliation in the U.S. Censuses with the necessary data (1930, 1990, and 2000). Using information on the traditional location of each ethnic group from the *Ethnographic Atlas*, we then assign a measure of cross-generational climatic instability to each reported tribe. Appendix Figures A11 and A13 show the ethnic groups in our sample (according to the *Ethnographic Atlas* classification), along with the climatic grid-cells.

Our estimating equation is:

$$I_{i,e,k}^{Native\,Lang} = \alpha_k + \beta\, Climatic\, Instability_e + \mathbf{X}_e\mathbf{\Pi} + \mathbf{X}_i\mathbf{\Phi} + \varepsilon_{i,e,k}, \tag{8}$$

Table 7: Whether Indigenous populations of the United States speak their traditional language at home: Individual-level estimates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dep variable: Indicator for speaking an Indigenous language at home						
	All individuals	Not living with parents	Living with parents				
Climatic instability	**-1.097*** **	**-1.195*** **	**-0.946*** **	-0.326**	-0.253**	-0.118	-0.079
	(0.358)	**(0.400)**	**(0.300)**	(0.132)	(0.110)	(0.084)	(0.064)
Father speaks an Indigenous language				0.433***		0.623***	
				(0.038)		(0.051)	
Father speaks an Indigenous lang. * Climatic instability						**-0.838*** **	
						(0.202)	
Mother speaks an Indigenous language					0.455***		0.612***
					(0.030)		(0.044)
Mother speaks an Indigenous lang. * Climatic instability							**-0.690*** **
							(0.198)
Individual controls	yes	yes	yes	yes	yes	yes	yes
Number of ethnic groups	83	83	79	76	77	76	77
Number of clusters (grid cells)	40	40	40	40	40	40	40
Mean (st. dev.) of dependent variable	0.18 (0.39)	0.20 (0.40)	0.15 (0.36)	0.20 (0.40)	0.20 (0.40)	0.20 (0.40)	0.20 (0.40)
Observations	128,005	79,235	48,770	25,794	35,403	25,794	35,403
R-squared	0.334	0.373	0.289	0.464	0.482	0.470	0.486

Notes : OLS estimates are reported with standard errors clustered at the climatic grid cell level in parentheses. The unit of observation is a person who identifies as Native American. The dependent variable is an indicator that equals one if the person speaks an Indigenous (Native American) language at home. All specification include the following covariates: a quadratic in age, a gender indicator, employment-status fixed effects, an indicator for being married, metropolitan-area fixed effects, and an indicator for whether the individual has any education. The mean (and standard deviation) of Climatic instability is 0.27 (0.11). *, ** and *** indicate significance at the 10, 5 and 1% levels.

where i denotes an individual, e his/her ethnic group, and k a location of residence (metropolitan area). The dependent variable, $I_{i,e,k}^{Native\ Lang}$, is an indicator that equals one if the individual i reports speaking an Indigenous language at home.[25] The specification includes location (i.e., metropolitan area) fixed effects, α_k. Thus, the variation used to estimate β is across individuals from different Native American ethnic groups, but living in the same location. $\mathbf{X}_e$ denotes a vector of our baseline ethnicity-level covariates. $\mathbf{X}_i$ denotes a vector of individual-level controls, which includes a quadratic in age, a gender indicator, an indicator for being married, labor-force-status fixed effects (employed, unemployed, and outside of the labor force), and an indicator for being educated.[26] Standard errors are clustered at the level of ancestral climatic grid cells.

Estimates of equation (9) are reported in columns 1–3 of Table 7 for all individuals (column 1), those not living with their parents (column 2), and those living with their parents (columns 3). For all samples, we estimate a sizeable negative and significant relationship between ancestral climatic instability and the likelihood of speaking an Indigenous language at home.

[25]The 1930, 1990, and 2000 U.S. Censuses ask the following question: "Does the person speaks a language other than English at home?" If yes, the person indicates which language. The 1910 Census report an individual's tribe, but it only asks whether one speaks English or not.

[26]In the 1990 and 2000 U.S. Censuses, the indicator is constructed using information on school attainment. In the 1930 census, it is constructed using information on whether the individual is literate.

We also examine the role of parents in transmitted knowledge of the Indigenous language within the home. Columns 4 and 5 report estimates controlling for whether a parent speaks an Indigenous language among the sample of those who live with their parents. As with the immigrants, we find that accounting for this reduces the importance of climatic instability sizably. We again explore the transmission of this cultural practice from parents to children by estimating:

$$\begin{aligned} I^{Native\,Lang}_{i,e,k} &= \beta_1\, Climatic\,Instability_e + \beta_2 I^{Parent\,Native\,Lang}_{i,e,k} + \beta_3 I^{Parent\,Native\,Lang}_{i,e,k} \times Climatic\,Instability_e \\ &\quad + \mathbf{X}_e \mathbf{\Pi} + \mathbf{X}_i \mathbf{\Phi} + \alpha_k + \varepsilon_{i,e,k}, \end{aligned} \tag{9}$$

where all variables are as defined in equation (9) and $I^{Parent\,Native\,Lang}_{i,e,k}$ is an indicator variable that equals one if individual i's parents speak an Indigenous language at home. The estimates, which are reported in columns 6 and 7, show that the relationship between parents speaking their Indigenous language at home and the children doing so is significantly weaker if the ancestral climate of the Indigenous group was more unstable.

A potential concern with the individual-level estimates from equation (9) is that whether an individual reports being Native American in the Census may itself be affected by how one values tradition. If those from ethnic groups that place less importance on tradition are less likely to report having Native American ancestry, they will be under-represented in our sample. Therefore, we also estimate a version of equation (9) that is at the ethnicity-location level, rather than at the individual level.

A benefit of this specification is that it can be replicated using Canadian data, which are not available at the individual level but are available at the ethnicity-location level. These are from the 2001, 2006, and 2011 rounds of the *Census Aboriginal Population Profiles*, produced by Statistics Canada. The source includes all Indigenous populations living on a reserve or a legal land base and reports information on the proportion of the population who: (*i*) have an Indigenous language as their mother tongue (*ii*) speak an Indigenous language at home; and (*iii*) can conduct a conversation in at least one Indigenous language.[27]

The ethnicity-location level estimating equation is:

$$Frac\,Native\,Language_{e,k} = \alpha_k + \beta\, Climatic\,Instability_e + \mathbf{X}_e \mathbf{\Pi} + \varepsilon_{e,k}, \tag{10}$$

[27] Appendix Figures A10 and A12 show the ethnic groups in the Canadian sample (according to the *Ethnographic Atlas* classification) and grid-cells with different categories of climatic instability.

Table 8: Whether Indigenous populations of Canada and the United States speak their traditional language: Ethnicity-level estimates

	(1)	(2)	(3)	(4)	(5)
	United States	**Canada**			**U.S. & Canada**
	Indigenous language is spoken at home	Indigenous language is mother tongue	Indigenous language is spoken at home	Conversational in Indigenous language	Indigenous language is spoken at home
Climatic instability	**-4.879****	**-2.322*****	**-2.215****	**-1.852*****	**-4.645****
	(2.227)	**(0.741)**	**(0.877)**	**(0.626)**	**(1.983)**
Ethnicity-level controls:					
Distance from the equator	0.000	0.053***	0.055***	0.033***	0.003
	(0.023)	(0.009)	(0.011)	(0.008)	(0.020)
Economic complexity	-0.185***	-0.255***	-0.244***	-0.142***	-0.180***
	(0.071)	(0.036)	(0.053)	(0.031)	(0.068)
Political hierarchies	-0.069	0.057	-0.076	-0.009	-0.063
	(0.205)	(0.116)	(0.136)	(0.102)	(0.190)
Location FE	yes	yes	yes	yes	yes
Survey-year FE	yes	yes	yes	yes	yes
Number of ethnic groups	83	36	36	36	108
Number of clusters (grid cells)	40	24	24	24	52
Mean (st. dev.) of dependent variable	0.039 (0.14)	0.29 (0.25)	0.25 (0.26)	0.34 (0.26)	0.07 (0.18)
Observations (ethnicity-year-location)	3,564	546	546	546	4,110

Notes: Poisson estimates are reported with standard errors clustered at the grid-cell level in parentheses. The unit of observation is an Indigenous ethnic group (from the U.S. and/or Canada), in a location, and observed in a census survey. The dependent variables are measures of the fraction of individuals who speak their traditional language. The American sample includes data from the 1930, 1990, and 2000 Censuses. The Canadian sample includes data from the 2001, 2006, and 2011 Censuses. The mean (and standard deviation) of Climatic instability is: 0.30 (0.11). *, ** and *** indicate significance at the 10, 5 and 1% levels.

where e indexes a Native American ethnic group and k a location of residence (i.e., metropolitan area). The dependent variable, $\mathit{Frac\,Native\,Language}_{e,k}$, is the fraction of Native Americans belonging to ethnic group e and living in location k who speak an Indigenous language at home. α_k denotes location-of-residence fixed effects. $\mathbf{X}_e$ denotes our baseline vector of ethnicity-level covariates. Given the significant skew in the distribution of the outcome variable, we estimate equation (10) using a Poisson model.[28] Standard errors are clustered at the ancestral-climatic-grid-cell level.

Estimates of equation (10) are reported in Table 8. Within the United States, we find a negative and significant relationship between ancestral climatic instability and the proportion of the population speaking a Native American language at home (column 1).[29] We also find a similar relationship within Canada, using either of the three measures of language (columns

[28]The distributions of the dependent variables for both samples are shown in Appendix Figures A6–A9.

[29]The largest number of different ethnic groups is observed in 1930. In Appendix Table A25, we report both the individual- and the ethnicity-level estimates for this Census year only.

2–4). This finding is also maintained if we pool the two samples together (column 5) for the variable indicating whether an Indigenous language is spoken at home. Thus, our findings suggest that Indigenous populations, both in the United States and Canada, with ancestors who lived in locations with greater cross-generational climatic instability are less likely to maintain their tradition of speaking their Indigenous language.

b. Estimates using the higher resolution Cook et al. (2010) climate data

We now turn to estimates that use the higher resolution climate data from Cook et al. (2010), which is at a 0.5-degree spatial resolution and has credible annual variation.[30] We first re-estimate equations (9) and (10) using the drought severity data from Cook et al. (2010). When using these data, we are able to also control for within-generation year-to-year instability and, therefore, can be sure that our estimates are not due to a bias induced by this omitted variable.[31]

The estimates are reported in Panel A of Tables 9 and 10. They show that the estimates using the precise drought-severity data are similar to the estimates using the Mann et al. (2009a) data. We also find that the year-to-year variability tends to have effects that are opposite to those of the cross-generational instability measure (i.e., year-to-year variability tends to be *positively* related to the importance of tradition). This is consistent with within-generational variability increasing the cost of learning the true state of the world (i.e., κ in the model), which results in greater cultural persistence. Overall, the estimates suggest that longer-term cross-generational variation in climate, rather than shorter-term year-to-year variation, is what causes weaker tradition and less cultural persistence.

The baseline instability measure captures differences across generations in the first moment (i.e., the mean) of the data. However, cross-generational differences in the second moment (i.e. annual variability) may also be important. To test for this, we calculate the cross-generational instability of the within-generation year-to-year standard deviation of drought.[32]

Estimates of equations (9) and (10), using the cross-generational instability of the annual standard deviation are reported in Panel B of Tables 9 and 10. We find the same patterns

[30] Appendix Figures A12 and A13 show the PDSI data and the locations of the ethnic groups in both samples.

[31] As explained in Section 3.B, we first calculate the annual standard deviation for each 20-year generation. We then take the average of the measure across the 70 generations in the sample. The correlation between this variable and the cross-generational instability measure is 0.69.

[32] In the raw data, the correlation between the cross-generation variability of year-to-year standard deviation and year-to-year standard deviation is 0.84. The correlation between the cross-generation variability of the second moment and the cross-generational variability of the first moment is 0.82.

Table 9: Drought severity and speaking an Indigenous language at home, from the 1930, 1990, and 2000 U.S. Censuses

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dep variable: Indicator for speaking an Indigenous language at home						
	All individuals	Not living with parents	Living with parents				
	Panel A. Ancestral instability of the first moment of PDSI						
Climatic instability (PDSI)	**-0.790*****	**-0.869*****	**-0.672*****	**-0.269*****	**-0.219*****	-0.070	-0.061
	(0.282)	**(0.320)**	**(0.225)**	**(0.074)**	**(0.064)**	(0.050)	(0.043)
Annual standard deviation (PDSI)	0.595***	0.645**	0.521***	0.240***	0.214***	0.088	0.087*
	(0.225)	(0.249)	(0.190)	(0.072)	(0.061)	(0.054)	(0.044)
Father speaks an Indigenous language				0.427***		-0.157	
				(0.035)		(0.129)	
Father speaks Indigenous lang. * Climatic instability (PDSI)						**-0.598*****	
						(0.218)	
Father speaks Indigenous lang. * Annual st. dev. (PDSI)						0.436***	
						(0.063)	
Mother speaks an Indigenous language					0.448***		-0.080
					(0.027)		(0.117)
Mother speaks Indigenous lang. * Climatic instability (PDSI)							**-0.546*****
							(0.201)
Mother speaks an Indigenous lang. * Annual st. dev. (PDSI)							0.394***
							(0.057)
R-squared	0.334	0.373	0.290	0.468	0.486	0.485	0.499
	Panel B. Ancestral instability of the second moment of PDSI						
Climatic instability of annual standard deviation (PDSI)	**-2.294****	**-2.467****	**-2.030****	**-0.856***	**-0.686***	-0.233	-0.208
	(1.084)	**(1.174)**	**(0.947)**	**(0.423)**	**(0.348)**	(0.219)	(0.173)
Annual standard deviation (PDSI)	0.808***	0.873***	0.712***	0.320***	0.278***	0.103	0.099*
	(0.296)	(0.327)	(0.251)	(0.105)	(0.086)	(0.070)	(0.054)
Father speaks an Indigenous language				0.424***		-0.220**	
				(0.035)		(0.087)	
Father speaks Indigenous lang. * Climatic instability of annual st. dev. (PDSI)						**-2.557*****	
						(0.847)	
Father speaks an Indigenous lang. * Annual st. dev. (PDSI)						0.750***	
						(0.156)	
Mother speaks an Indigenous language					0.446***		-0.132*
					(0.027)		(0.078)
Mother speaks Indigenous lang. * Climatic instability of annual st. dev. (PDSI)							**-2.607*****
							(0.661)
Mother speaks an Indigenous lang. * Annual st. dev. (PDSI)							0.726***
							(0.124)
R-squared	0.336	0.374	0.293	0.468	0.486	0.486	0.501
	Both Panels						
Ethnicity-level controls	yes	yes	yes	yes	yes	yes	yes
Individual controls	yes	yes	yes	yes	yes	yes	yes
Number of ethnic groups	82	82	78	76	77	76	77
Number of clusters (grid cells)	80	80	76	39	39	39	39
Mean (st. dev.) of dependent variable	0.18 (0.39)	0.20 (0.40)	0.15 (0.36)	0.20 (0.40)	0.20 (0.40)	0.20 (0.40)	0.20 (0.40)
Observations	127,986	79,224	48,762	25,791	35,397	25,791	35,397

Notes : OLS estimates are reported with standard errors clustered at the level of the climatic grid cell in parentheses. The unit of observation is a person who identifies as a Native American. The dependent variable is an indicator that equals one if the person speaks an Indigenous (Native American) language at home. All specifications include the following covariates: a quadratic in age, a gender indicator, employment-status fixed effects, an indicator for being married, metropolitan-area fixed effects, and an indicator for whether the individual has any education. For panel A, the mean (and standard deviation) of Climatic instability is 0.58 (0.20). For panel B, the mean (and standard deviation) of Climatic instability of the annual standard deviation is 0.35 (0.12). *, ** and *** indicate significance at the 10, 5 and 1% levels.

Table 10: Drought severity and whether the traditional language is spoken by Indigenous populations in the U.S. and Canada

	(1)	(2)	(3)	(4)	(5)
	United States	**Canada**			**U.S. & Canada**
	Indigenous language is spoken at home	Indigenous language is mother tongue	Indigenous language is spoken at home	Conversational in Indigenous language	Indigenous language is spoken at home
	Panel A. Ancestral instability of the first moment of PDSI				
Climatic instability (PDSI)	**-3.922*****	**-1.803****	**-1.727***	**-0.861**	**-3.877*****
	(1.086)	**(0.770)**	**(0.903)**	**(0.663)**	**(1.060)**
Annual standard deviation (PDSI)	3.045***	0.275	-0.133	0.213	2.949***
	(0.848)	(0.327)	(0.551)	(0.303)	(0.851)
	Panel B. Ancestral instability of the second moment of PDSI				
Climatic instability of annual standard deviation (PDSI)	**-10.048***	**-4.566*****	**-2.111**	**-1.543**	**-9.749***
	(5.792)	**(1.580)**	**(2.387)**	**(1.370)**	**(5.107)**
Annual standard deviation (PDSI)	3.560***	0.784	-0.155	0.327	3.448***
	(1.374)	(0.582)	(0.821)	(0.479)	(1.320)
	Both Panels				
Ethnicity-level controls	yes	yes	yes	yes	yes
Location FE	yes	yes	yes	yes	yes
Survey-year FE	yes	yes	yes	yes	yes
Number of ethnic groups	80	30	30	30	100
Number of clusters (grid cells)	78	29	29	29	95
Mean (st. dev.) of dependent variable	0.06 (0.17)	0.25 (0.24)	0.22 (0.24)	0.30 (0.24)	0.06 (0.17)
Observations (ethnicity-year-location)	3,420	411	411	411	3,831

Notes : Poisson estimates are reported with standard errors clustered at the grid-cell level in parentheses. The unit of observation is an Indigenous ethnic group (from the U.S. and/or Canada), in a location, and observed in a census survey. The dependent variables are measures of the fraction of people who speak their traditional language. The American sample includes data from the 1930, 1990, and 2000 Censuses. The Canadian sample includes data from the 2001, 2006, and 2011 Censuses. For panel A, the mean (and standard deviation) of Climatic instability is: 0.66 (0.21). For panel B, the mean (and standard deviation) of Climatic instability of the annual standard deviation is: 0.36 (0.12). *, ** and *** indicate significance at the 10, 5 and 1% levels.

when using the cross-generational variability in the second moment as we did for the first moment. Cross-generational instability is associated with less cultural persistence as reflected by Indigenous populations speaking their traditional language. As before, the year-to-year standard deviation tends to be positively associated with the importance of tradition, which is consistent with greater noise during one's lifetime making it more difficult to learn about the best actions, i.e., a higher κ in the model.

Sensitivity and robustness checks

For Indigenous populations, there is the possibility of imprecision in the measurement of the location of ancestral populations due to historical population movements. To assess the sensitivity of our estimates to this, we consider two restricted subsamples; one where we remove ethnic groups that were traditionally nomadic and a second that removes ethnic groups that were either nomadic or semi-nomadic. Re-estimating the specifications of Tables 7–10 using the two subsamples, we find that our estimates remain very similar (Appendix Tables A26–A33).

5. Conclusion

Our analysis was motivated by a simple but still unanswered question: when does culture persist and when does it change? To make progress on this question we tested a hypothesis that has emerged from the theoretical evolutionary anthropology literature. Populations whose ancestors lived in locations with greater variability of the environment across generations will place less importance on following traditions and customs. When the environment differs significantly from one generation to the next, the cultural practices that have evolved up until the previous generation are less likely to provide information that is relevant to the current generation. By contrast, when the environment is stable, the cultural traits that have evolved up to the previous generation are more likely to be suitable for the current generation and, thus, maintaining tradition is relatively beneficial.

We test this hypothesis using gridded paleoclimatic data to measure the variability of the environment across 20-year generations from 500–1900. Looking across multiple samples and performing multiple tests, we found strong evidence that the importance of tradition and cultural persistence is weaker within populations who had ancestral environments that differed more from one generation to the next.

In addition to providing a better understanding of the determinants of cultural persistence and change, our findings also provide support for the origins and microfoundations of culture as modeled in the evolutionary anthropology literature.[33] Testing these models is important because many of the current models of culture in economics take the presence of culture and its intergenerational transmission as a starting point.[34] The findings outlined in this paper provide empirical validation for this assumption.

References

Abramitzky, Ran, Leah Boustan, and Katherine Eriksson, "Cultural Assimilation During the Age of Mass Migration," 2016. Working Paper, Stanford University.

[33] Namely, Boyd and Richerson (1985), Aoki and Feldman (1987), Rogers (1988), Feldman et al. (1996), Boyd and Richerson (2005).

[34] See Bisin and Verdier (2000), Bisin and Verdier (2001), Hauk and Saez-Marti (2002), Francois and Zabojnik (2005), Tabellini (2008), Bisin and Verdier (2017), and Doepke and Zilibotti (2017).

Alesina, Alberto, Arnaud Devleeschauwer, William Easterly, Sergio Kurlat, and Romain Wacziarg, "Fractionalization," *Journal of Economic Growth*, 2003, *8*, 155–194.

_ , Paola Giuliano, and Nathan Nunn, "On the Origins of Gender Roles: Women and the Plough," *Quarterly Journal of Economics*, 2013, *128* (2), 469–530.

Algan, Yann and Pierre Cahuc, "Inherited Trust and Growth," *American Economic Review*, 2010, *100* (5), 2060–2092.

Aoki, K. and Marcus W. Feldman, "Toward a Theory for the Evolution of Cultural Communication: Coevolution of Signal Transmission and Reception," *Proceedings of the National Academy of Sciences*, 1987, *84*, 7164–7168.

Arthur, Ronan and Jared Diamond, "Understanding Tribal Fates," *Science*, November 2011, *334*, 911–912.

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

Bai, Ying and James Kai-sing Kung, "Climate Shocks and Sino-Nomadic Conflict," *Review of Economics and Statistics*, 2011, *93* (3), 970–981.

Baten, Joerg, "Human Stature and Climate: The Impact of Past Climate on Living Standards," in Gerold Wefer, Wolfgang H. Berger, Karl-Ernst Behre, and Eystein Jansen, eds., *Climate Development and History of the North Atlantic Realm*, Berlin: Springer Berlin Heidelberg, 2002, pp. 327–338.

Becker, Sascha O. and Ludger Woessmann, "Luther and the Girls: Religious Denomination and the Female Education Gap in Nineteenth-Century Prussia," *Scandinavian Journal of Economics*, 2008, *110* (4), 777–805.

_ and _ , "Was Weber Wrong? A Human Capital Theory of Protestant Economic History," *Quarterly Journal of Economics*, 2009, *124* (2), 531–596.

Belloc, Marianna, Francesco Drago, and Roberto Galbiati, "Earthquakes, Religion, and Transition to Self-Government in Italian Cities," *Quarterly Journal of Economics*, 2016, *131* (4), 394–399.

Bentzen, Jeanet Sinding, "Acts of God? Religiosity and Natural Disasters Across Subnational World Districts," 2015. Mimeo, University of Copenhagen.

Bisin, Alberto and Thierry Verdier, "Beyond the Melting Pot: Cultural Transmission, Marriage and the Evolution of Ethnic and Religious Traits," *Quarterly Journal of Economics*, 2000, *115*, 955–988.

_ and _ , "The Economics of Cultural Transmission and the Dynamics of Preferences," *Journal of Economic Theory*, 2001, *97*, 298–319.

_ and _ , "The Economics of Cultural Transmission and Socialization," in Jess Benhabib, Alberto Bisin, and Matt Jackson, eds., *Handbook of Social Economics*, New York: North-Holland, 2011, pp. 339–416.

_ and _ , "On the Joint Evolution of Culture and Institutions," 2017. NBER Working Paper 23375.

Bittles, A.H. and M.L. Black, "Consanguineous Marriage and Human Evolution," *Annual Review of Anthropology*, October 2010, *39*, 193–207.

Bondarenko, Dmitri, Alexander Kazankov, Daria Khaltourina, and Andrey Korotayev, "Ethnographic Atlas XXXI: Peoples of Easternmost Europe," *Ethnology*, 2005, *44* (3), 261–289.

Boyd, Robert and Peter J. Richerson, *Culture and the Evolutionary Process*, London: University of Chicago Press, 1985.

_ and _ , "An Evolutionary Model of Social Learning: The Effects of Spatial and Temporal Variation," in Thomas R. Zentall and Bennett G. Galef, eds., *Social Learning: Psychological and Biological Perspectives*, London: Lawrence Erlbaum Associates, 1988, pp. 29–48.

_ and _ , *The Origin and Evolution of Cultures*, London: Oxford University Press, 2005.

Buggle, Johannes and Ruben Durante, "Climate Risk, Cooperation and the Co-Evolution of Culture and Institutions," 2016. Mimeo, Science Po.

Burke, Marshall B., Edward Miguel, Shanker Satyanath, John A. Dykema, and David B. Lobell, "Warming Increases the Risk of Civil War in Africa," *Proceedings of the National Academy of sciences*, 2009, *106* (49), 20670–20674.

Burke, Marshall, Solomon M. Hsiang, and Edward Miguel, "Global Non-Linear Effect of Temperature on Economic Production," *Nature*, 2015, *527* (7577), 235–239.

Cantoni, Davide, "Adopting a New Religion: The Case of Protestantism in 16th Century Germany," *Economic Journal*, May 2012, *122* (560), 502–531.

— , "The Economic Effects of the Protestant Reformation: Testing the Weber Hypothesis in the German Lands," *Journal of the European Economic Association*, August 2014, *13* (4), 561–598.

Card, David, John DiNardo, and Eugena Estes, "The More Things Change: Immigrants and the Children of Immigrants in the 1940s, the 1970s, and the 1990s," in George J. Borjas, ed., *Issues in the Economics of Immigration*, Chicago: University of Chicago Press, 2000, pp. 227–270.

Chaney, Eric, "Revolt on the Nile: Economic Shocks, Religion, and Political Power," *Econometrica*, 2013, *81* (5), 2033–2053.

Cook, Edward R., David M. Meko, David W. Stahle, and Malcolm K. Cleaveland, "Drought Reconstructions for the Continental United States," *Journal of Climate*, 1999, *12*, 1145–1162.

— , Richard Seager, Richard R. Heim, Russell S. Vose, Celine Herweijer, and Connie Woodhouse, "Megadroughts in North America: Placing IPCC Projections of Hydroclimatic Change in a Long-Term Palaeoclimate Context," *Journal of Quarternary Science*, 2010, *25* (1), 48–61.

Dalgaard, Carl-Johan, Casper Worm Hansen, and Nicolai Kaarsen, "Climate Shocks and (Very) Long-Run Productivity," 2015. Mimeo, University of Copenhagen.

Davis, James A., Tom W. Smith, Robert W. Hodge, Keiko Nakao, and Judith Treas, "Occupational Prestige Ratings from the 1989 General Social Survey," 2006. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2006-01-12. `https://doi.org/10.3886/ICPSR09593.v1`.

Dell, Melissa, "Insurgency and Long-Run Development: Lessons from the Mexican Revolution," 2012. Mimeo, Harvard University.

— , Benjamin F. Jones, and Benjamin A. Olken, "Temperature Shocks and Economic Growth: Evidence from the Last Half Century," *American Economic Journal: Macroeconomics*, 2012, *4* (3), 66–95.

Doepke, Matthias and Frabrizio Zilibotti, "Parenting with Style: Altruism and Paternalism in Intergenerational Preference Transmission," 2017. *Econometrica*, forthcoming.

Durante, Ruben, "Risk, Cooperation and the Economic Origins of Social Trust: An Empirical Investigation," 2010. Mimeo, Science Po.

Feldman, Marcus W., Kenichi Aoki, and Joachen Kumm, "Individual Social Learning: Evolutionary Analysis in a Fluctuating Environment," *Anthropological Science*, 1996, *104* (3), 209–232.

Fernandez, Raquel, "Women, Work and Culture," *Journal of the European Economic Association*, 2007, *5* (2–3), 305–332.

— **and Alessandra Fogli**, "Culture: An Empirical Investigation of Beliefs, Work, and Fertility," *American Economic Journal: Macroeconomics*, 2009, *1* (1), 146–177.

Firth, Raymond, *Social Change in Tikopia: Re-Study of a Polynesian Community after a Generation*, New York: George Allen and Unwin Ltd., 1959.

Fischer, David Hackett, *Albion's Seed: Four British Folkways in America*, New York: Oxford University Press, 1989.

Fouka, Vasiliki, "Backlash: The Unintended Effects of Language Prohibition in US Schools after World War I," 2015. Mimeo, Stanford University.

Francois, Patrick and Jan Zabojnik, "Trust, Social Capital, and Economic Development," *Journal of the European Economic Association*, 2005, *3*, 51–94.

Friedman, Daniel, "Evolutionary Games in Economics," *Econometrica*, May 1991, *59* (3), 637–666.

Giavazzi, Francesco, Ivan Petkov, and Fabio Schiantarelli, "Culture: Persistence and Evolution," 2014. Mimeo, Boston College.

Gintis, Herbert, "A Markov Model of Production, Trade, and Money: Theory and Artificial Life Simulation," *Computation & Mathematical Organization Theory*, 1997, *3*, 19–41.

Giuliano, Paola, "Living Arrangements in Western Europe: Does Cultural Origin Matter?," *Journal of the European Economic Association*, 2007, *5* (5), 927–952.

__ **and Nathan Nunn**, "Ancestral Characteristics of Modern Populations," *Economic History of Developing Regions*, 2018, *33* (1), 1–17.

Goldin, Claudia, "The U-Shaped Female Labor Force Function in Economic Development," in T. Paul Schultz, ed., *Investment in Women's Human Capital and Economic Development*, Chicago: University of Chicago Press, 1995, pp. 61–90.

Greif, Avner and Steven Tadelis, "A Theory of Moral Persistence: Crypto-Morality and Political Legitimacy," *Journal of Comparative Economics*, 2010, *38*, 229–244.

Harris, I., P.D. Jones, T.J. Osborn, and D.H. Lister, "Updated High-Resolution Grids of Monthly Climatic Observations – The CRU TS3.10 Dataset," *International Journal of Climatology*, 2014, *34* (3), 623–642.

Hauk, Esther and Maria Saez-Marti, "On the Cultural Transmission of Corruption," *Journal of Economic Theory*, 2002, *107*, 311–335.

Henrich, Joseph, *The Secret of Our Success: How Culture is Driving Human Evolution*, New York: Princeton University Press, 2015.

Hofstede, Geert, Gert Jan Hofstede, and Michael Minkov, *Cultures and Organizations. Software of the Mind: Intercultural Cooperation and Its Importance for Survival, 3rd Edition*, New York: McGraw-Hill, 2010.

Hsiang, Solomon M., Marshall Burke, and Edward Miguel, "Quantifying the Influence of Climate on Human Conflict," *Science*, 2013, *341* (6151), 12353–67.

Jia, Ruixue, "Weather Shocks, Sweet Potatoes and Peasant Revolts in Historical China," *Economic Journal*, 2014, *124*, 92–118.

Katz, S.H., M.L. Hediger, and L.A. Valleroy, "Traditional Maize Processing Techniques in the New World," *Science*, 1974, *184* (4138), 765–773.

Korotayev, Andrey, Alexander Kazankov, Svetlana Borinskaya, Daria Khaltourina, and Dmitri Bondarenko, "Ethnographic Atlas XXX: Peoples of Siberia," *Ethnology*, 2004, *43*, 83–92.

Kupperman, Karen Ordahl, *Providence Island, 1630–1641: The Other Puritan Colony*, Cambridge: Cambridge University Press, 1995.

Madestam, Andreas and David Yanagizawa-Drott, "Shaping the Nation: The Effect of Fourth of July on Political Preferences and Behavior in the United States," 2011. Mimeo, Bocconi University.

__ **, Daniel Shoag, Stan Veuger, and David Yanagizawa-Drott**, "Do Political Protests Matter? Evidence from the Tea Party Movement," *Quarterly Journal of Economics*, November 2013, *128* (4), 1633–1685.

Mann, Michael E., Zhihua Zhang, Scott Rutherford, Raymond S. Bradley, Malcolm K. Hughes, Drew Shindell, Caspar Ammann, Greg Faluvegi, and Fenbiao Ni, "Global Signatures and Dynamical Origins of the Little Ice Age and Medieval Climate Anomaly," *Science*, 2009, *326*, 1256–1260.

__ **,** __ **,** __ **,** __ **,** __ **,** __ **,** __ **,** __ **, and** __ , "Supporting Online Material for: Global Signatures and Dynamical Origins of the Little Ice Age and Medieval Climate Anomaly," 2009. Online Appendix.

Marvel, Kate, Benjamin I. Cook, Celine J.W. Bonfils, Paul J. Durack, Jason E. Smerdon, and A. Park Williams, "Twentieth-Century Hydroclimatic Changes Consistent with Human Influence," *Nature*, 2019, *569*, 59–65.

Matranga, Andrea, "The Ant and the Grasshopper: Seasonality and the Invention of Agriculture," 2016. Working paper, New Economic School.

McElreath, Richard, Mark Lubell, Peter J. Richerson, Timothy M. Waring, William Baum, Edward Edstein, Charles Efferson, and Brian Paciotti, "Applying Evolutionary Models to the Laboratory Study of Social Learning," *Evolution and Human Behavior*, 2005, *26*, 483–508.

Mead, Margaret, *New Lives for Old: Cultural Transformation – Manus, 1928–1953*, New York: William Morrow & Co., 1956.

Murdock, George Peter, "World Ethnographic Sample," *Ethnology*, 1957, *59* (4), 664–687.

—, *Ethnographic Atlas*, Pittsburgh: University of Pittsburgh Press, 1967.

Nunn, Nathan and Diego Puga, "Ruggedness: The Blessing of Bad Geography in Africa," *Review of Economics and Statistics*, February 2012, *94* (1), 20–36.

Oster, Emily, "Witchcraft, Weather and Economic Growth in Renaissance Europe," *Journal of Economic Perspectives*, 2004, *18* (1), 215–228.

Palmer, Wayne C., "Meteorological Drought," Research Paper No. 45, Office of Climatology, U.S. Weather Bureau, Washington D.C. 1965.

Rogers, Alan R., "Does Biology Constrain Culture?," *American Anthropologist*, 1988, *90* (4), 819–831.

Schulz, Jonathan, "The Churches' Bans on Consanguineous Marriages, Kin Networks and Democracy," 2017. Mimeo, Yale University.

Schwartz, S.H., "The 7 Schwartz Cultural Value Orientation Scores for 80 Countries," 2010. Dataset. Available at: `https://www.researchgate.net/publication/304715744_The_7_Schwartz_cultural_value_orientation_scores_for_80_countries`.

Spolaore, Enrico and Romain Wacziarg, "The Diffusion of Development," *Quarterly Journal of Economics*, 2009, *124* (2), 469–529.

Tabellini, Guido, "The Scope of Cooperation: Values and Incentives," *Quarterly Journal of Economics*, 2008, *123* (3), 905–950.

Toelch, Ulf, Marjolijn J. van Delft, Matthew J. Bruce, Rogier Donders, Marius T.H. Meeus, and Simon M. Reader, "Decreased Environmental Variability Induces a Bias for Social Information Use in Humans," *Evolution and Human Behavior*, 2009, *30* (1), 32–40.

Voigtlaender, Nico and Hans-Joachim Voth, "Persecution Perpetuated: The Medieval Origins of Anti-Semitic Violence in Nazi Germany," *Quarterly Journal of Economics*, 2012, *127* (3), 1339–1392.

Waldinger, Maria, "The Economic Effects of Long-Term Climate Change: Evidence from the Little Ice Age," 2015. Mimeo, London School of Economics.