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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 500–1900. Employing a variety of tests, each using different samples and empirical strategies, we find that populations with ancestors who lived in environments with more cross-generational instability place less importance in maintaining tradition today and exhibit less cultural persistence.

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An online appendix is available at http://www.nber.org/data-appendix/w23617

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 (Nunn, 2012, Spolaore and Wacziarg, 2013). A number of studies document their persistence over very long periods of time (Fischer, 1989, Fernandez, 2007, Giuliano, 2007, Fernandez and Fogli, 2009, Algan and Cahuc, 2010, Voigtlaender and Voth, 2012).[1] However, we also have numerous examples of rapid cultural change. One well-known instance is the Protestant Reformation (Becker and Woessmann, 2008, 2009, Cantoni, 2012, 2014). However, there are also numerous other examples, such as the colony established on Providence Island (off of the coast of Nicaragua) in the early seventeenth century, where the Puritan population abandoned their traditional values and engaged in large-scale slavery and privateering (Kupperman, 1995). There are also numerous documented cases of rapid and dramatic cultural change following European contact, such as Margaret Mead's (1956) documentation of the village of Peri on the Manus Island or Raymond Firth's (1959) study of the Polynesian community of Tikopia. Within one generation, these societies completely changed their culture, abandoning previous practices and adopting European customs.

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 theoretically 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

[1] There is accumulating evidence that vertically transmitted traits, such as culture or a common history, are important determinants of comparative development today (Spolaore and Wacziarg, 2009, Comin, Easterly and Gong, 2010, Chanda and Putterman, 2014) and that deep historical factors can shape persistent cultural traits (Giuliano and Nunn, 2013, Alesina, Giuliano and Nunn, 2013, Talhelm, Zhang, Oishi, Shimin, Duan, Lan and Kitayama, 2014, Becker, Boeckh, Hainz and Woessmann, 2016, Buggle and Durante, 2016, Guiso, Sapienza and Zingales, 2016).

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 across generations, the more likely it is that the evolved traditions of the previous generation are beneficial for the current generation and the more beneficial are values that place importance on following existing traditions.

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. In the model, individuals can choose their action either through costly information acquisition or by following the actions (i.e., traditions) of previous generations. In equilibrium, the proportion of the population who follow tradition is higher the more similar the environment across generations. 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 500AD. The first source, which is taken from Mann, Zhang, Rutherford, Bradley, Hughes, Shindell, Ammann, Faluvegi and Ni (2009a), measures temperature anomalies (i.e., deviations from long-run averages), and has global coverage at a 5-degree resolution.[2] 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 the relevant grid-cells, 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 measure of the extent to which the environmental measures varied in a grid cell 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 language and dialects to estimate its distribution

[2]Temperature anomalies are deviations from a grid-cell's average temperature, measured from a 1961–1995 reference period. They are reported in degrees Celsius. Five degrees is approximately 555 kilometers measured at the equator.

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 number of sensitivity checks. We first test the sensitivity of our estimates 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 (CRU TS v.4.01) that is constructed using high-frequency observation 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 higher-quality but less-historical data are used.

Since our ancestral instability variable measure populations and not places, it accounts for the fact that populations may move. Despite this, large historical population movements can still introduce imprecision in the data. Given this, we also test the robustness of our estimates to the omission of countries that experienced large population inflows following the Columbian Exchange. We also test the robustness of our estimates to the omission of countries with large populations of traditionally nomadic peoples. In both cases, our estimates remain robust.

For the second set of empirical tests, we rely on cultural persistence as a revealed measure of the importance of tradition. First, we test the persistence of traditions among the descendants of immigrants who have moved to the United States. This group is appealing to study for a number of reasons. First, having been moved from their ancestral environment, they face a new environment that will tend to weaken their traditional practices. Second, we can compare individuals with different backgrounds but living in the same location in the U.S. Thus, unlike the cross-country analysis, in this setting, we can be confident that the estimated effects are not due to a direct, more mechanical, and perhaps less-surprising, contemporaneous effect of the environment on actions. Instead, it is due to the effects of the environment in the ancestral locations.

We estimate whether the descendants of immigrants, living in the same city in the U.S. but with different cultural backgrounds, exhibit systematically different amounts of cultural change. Specifically, whether individuals with ancestors who lived in variable environments are less likely to marry someone from the same ancestral group and are less likely to speak their traditional language at home. We find that the children of immigrants from countries with a more unstable ancestral environment are less likely to marry someone from within their group and they are also less likely to speak their traditional language at home.

Our next 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.

In the final exercise, we extend the logic of the immigrant and indigenous-population analyses but looking across a broad cross-section of countries and over two distant time periods. We test whether societies with more ancestral climatic instability exhibit less persistence in the following cultural traits: gender role norms (measured by female labor-force participation), polygamy, and consanguineous marriage (commonly referred to as cousin marriage). In this setting too, we also find less cultural persistence among countries with more variability in the environment across previous generations.

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 in economics 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), which examine cultural assimilation among immigrants in the United States during the 19th century. 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 are also related to a number of recent theoretical papers that model the persistence of cultural values. Greif and Tadelis (2010) examine the persistence of cultural values in a setting with an authority, such as a state or church, that is attempting to change the population's cultural values. Iyigun and Rubin (2017) consider the related question of when societies adopt new institutions and when they hold on to traditional institutions, even if those are less efficient. In their setting, uncertainty associated with the new institutions causes people to place a higher value on traditional practices, which decreases the likelihood of institutional innovation. Doepke and Zilibotti (2017) study the specific strategies – permissive, authoritarian, and authoritative – that parents use to induce the desired outcomes for their children. They show how the strategy chosen by parents has implications for the persistence of behavior across generations.

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 highlights the intuition of how variability of the environment between generations can affect the value which individuals place on tradition.[3] 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

[3] Also see Hirshleifer and Welch (2004) who provide a theory that links the stability of the environment to the persistence of behavior. In their model, remembering previous behavior, and therefore replicating it, is easier when the environment is stable. In volatile environments, memory loss is more likely to occur and thus we observe less replication over time.

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 a and b. Which of the two actions yields a higher payoff depends on the state of the world (i.e., the environment), which can be either A or B. If the state is A, then action a yields the payoff $\beta > 0$ and action b yields a payoff of $-\beta$. If the state is B, then action a yields a payoff of $-\beta$ and action b yields the payoff $\beta > 0$. 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 A or state B. 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, who we call "Traditionalists (T)," value tradition and place strong importance on the actions of the previous generation. They choose their action by following the action of a randomly chosen person from the previous generation.[4] 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.[5]

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 average payoffs to traditionalists are higher in the population their proportion will increase and if their payoff is lower, then it will tend to decrease.[6] We let $x \in [0, 1]$ denote the proportion of traditionalists in the population, and interpret x as a measure of the overall strength of tradition in the society.

[4]This specification, thus, assumes the presence of both vertical and oblique transmission.

[5]If $\kappa > \beta$, then the cost of learning is prohibitively high and there will never be non-traditionalists in society. We focus our attention here on the empirically-relevant scenario that results in the presence of both types in the population.

[6]Formally, this can be modeled using the standard replicator dynamic (Gintis, 1997).

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 and choose the optimal action and receive β. However, they also bear the cost of learning, which is equal to κ. Thus, the payoff to a non-traditionalist is given by: $\Pi^{NT} = \beta - \kappa$.

To calculate the expected payoff of a traditionalist, we first consider the following sequence of possible scenarios, each of which results in a traditionalist choosing the right action given her environment and, thus, receiving β:

1. A traditionalist copies a non-traditionalist from the previous generation; and the environment did not experience a shock between the last and current generation. Since the non-traditionalist from the previous generation chose the action that was optimal in her environment and since a shock did not occur, then this action will also be optimal in the current environment and the traditionalist receives β. This scenario 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. No shocks occurred during this time. In this scenario, the traditionalist 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 occurred during this time. This occurs with probability $x^2(1-x)(1-\Delta)^3$.
4. Etc, etc.

Continuing this until infinity and summing the sequence of probabilities gives: $\sum_{t=1}^{\infty} x^{t-1}(1-T)(1-\Delta)^t$. 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 has occurred since the most recent non-traditionalist was copied. After a shock, there is an equal probability of being in either state. Thus, a traditionalist has a 50% chance of receiving β and a 50% chance of receiving $-\beta$, and her expected payoff is 0. Putting this together, the expected payoff to a traditionalist is given by: $\Pi^T = \left[\sum_{t=1}^{\infty} x^{t-1}(1-x)(1-\Delta)^t\right]\beta = \frac{\beta(1-x)(1-\Delta)}{1-x(1-\Delta)}$.

The payoffs to traditionalists and non-traditionalists as a function of the proportion of traditionalists in the society, x, are given by the solid lines 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

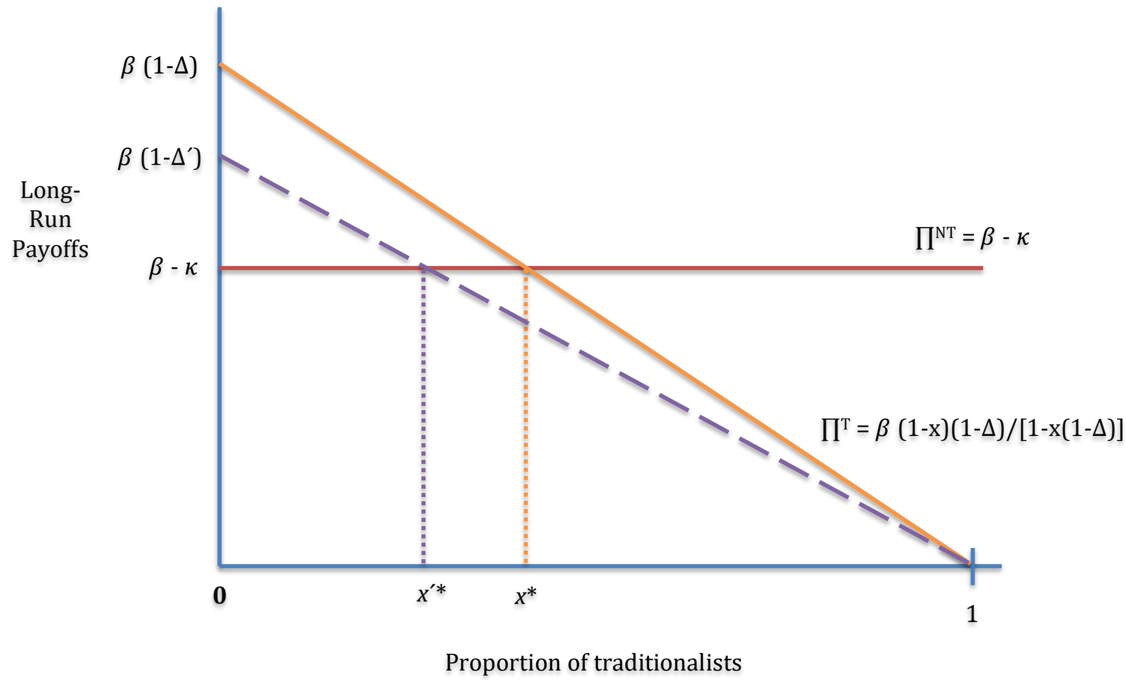


Figure 1: The equilibrium proportion of traditionalists (T) and non-traditionalists (NT) and the effect of an increase in the instability of the environment.

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 (mutant) traditionalist would copy the correct action from someone in the previous generation as long as there was not a shock to the environment between the two generations. Thus, with probability $1 - \Delta$, a traditionalist's payoff is β. If, on the other hand, the environment did change, which occurs with probability Δ, then there is an equal probability that the environment is in either state and the expected payoff is 0. Therefore, the expected payoff to a traditionalist when $x = 0$ is $\beta(1 - \Delta)$.

From Figure 1, it is clear that under fairly general conditions ($\Delta < \kappa/\beta$), 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. One of the best known is alkali 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).[7]

In an equilibrium with both types present, their payoffs must be equal and 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:

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

It is straightforward to show that, given the dynamics of the player types, the equilibria are stable. 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, there is convergence to x^*. In an equilibrium with only non-traditionalists, if $x > x^*$, the payoff of traditionalists is lower than of non-traditionalists and x will decrease and, again, there is convergence to x^*.

Figure 1 also shows how the equilibrium changes as the environment becomes less stable. As indicated by the dashed payoff curve, an increase in Δ causes the traditionalist payoff curve to rotates downwards. By contrast, the payoffs to the non-traditionalists are unaffected. The result is that the equilibrium proportion of traditionalists decreases. Further, if instability 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:

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

Thus, the model generates the following two predictions. First, if the environment is only moderately unstable ($\Delta < \kappa/\beta$), then both traditionalists and non-traditionalists are present. In such equilibria, as instability increases, the proportion of traditionalists x decreases.[8] That is, more cross-generational instability results in less tradition. Second, if the environment is

[7]For other examples and additional evidence along these lines, see Henrich (2015).

[8]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.

sufficiently unstable, such that $\Delta > \kappa/\beta$, then the proportion of traditionalists in the economy is zero. This generates 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.*

In the model, non-traditionalists respond to a change in the state of the environment by immediately by choosing the new optimal action. That is, when there is a benefit to abandoning their previous actions (i.e., customs) 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 appendix Figure A1, which shows the transition from one action to the other action after a change in the state of the world for populations with different values of Δ and hence x^*. As shown, the higher Δ is and thus, the lower is x^*, the faster the society adopts the new action. This leads to the second testable hypothesis.

Hypothesis 2. *The greater the instability of the environment across generations, the quicker the speed of 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 (see e.g., Boyd and Richerson, 1985, Aoki and Feldman, 1987, Feldman et al., 1996, Boyd and Richerson, 2005). We now turn to our empirical analysis which tests Hypothesis 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 affect the optimal decisions of daily life.

To measure environmental instability we use the variability of temperature across 20-year generations from 500–1900AD. During this time, temperature was not affected in any significant manner by human actions. There is also evidence that weather and climate have important effects on societies. 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, Iyigun, Nunn and Qian, 2017). 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 (Burke, Miguel, Satyanath, Dykema and Lobell, 2009, Dell, 2012), violent crime (Hsiang, Burke and Miguel, 2013), economic output (Burke, Hsiang and Miguel, 2015, Dell, Jones and Olken, 2012), economic growth (Dell et al., 2012), agricultural output (Dell et al., 2012), political socialization (Madestam and Yanagizawa-Drott, 2011, Madestam, Shoag, Veuger and Yanagizawa-Drott, 2013), and political instability (Dell et al., 2012, Dell, 2012).

Although we cannot observe the relationship between the environment and the optimal action (or the payoffs to different actions), there is mounting evidence that changes in the environment affect important equilibrium outcomes like conflict, cooperation, trust, trade, and economic prosperity. This provides evidence that the environment is an important determinant of the optimal actions for society at a given time. The evidence suggests that temperature has important effects on the returns to cooperation, to trade, and to conflict. Thus, it plausibly affects the optimal level of cooperation, entrepreneurship, conflict, and so on. In addition, it directly and more mechanically affects the optimal decisions in agriculture, the optimal intensity of agriculture, what crops should be planted and when, and what agricultural implements to use. Thus, our constructed variable then measures how average temperature – and therefore the optimal actions in a society – changes from one generation to the next.

An alternative strategy would be to look at changes in more proximate variables, like income, population density, or innovation.[9] While such an exercise would be informative, these determinants are potentially endogenous. In addition, to the extent that cross-generational climatic instability has an effect on these more proximate factors, the reduced-form relationship between climatic instability and the importance of tradition already captures 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 a reference-period average measured in degrees Celsius) at the 5-degree-by-5-degree (approx. 555km by 555km) grid cell level from 500–1900.[10] 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).[11] The gridded-data are from the *Living Blended Drought Atlas*, which is constructed from 1,845 annual tree ring chronologies.[12] 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.

[9]See 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 more open to external trade.

[10]The reference period is from 1961–1995.

[11]For the origin of the drought severity index and details on its construction see Palmer (1965).

[12]For an earlier version of the database and methodological details, see Cook, Meko, Stahle and Cleaveland (1999).

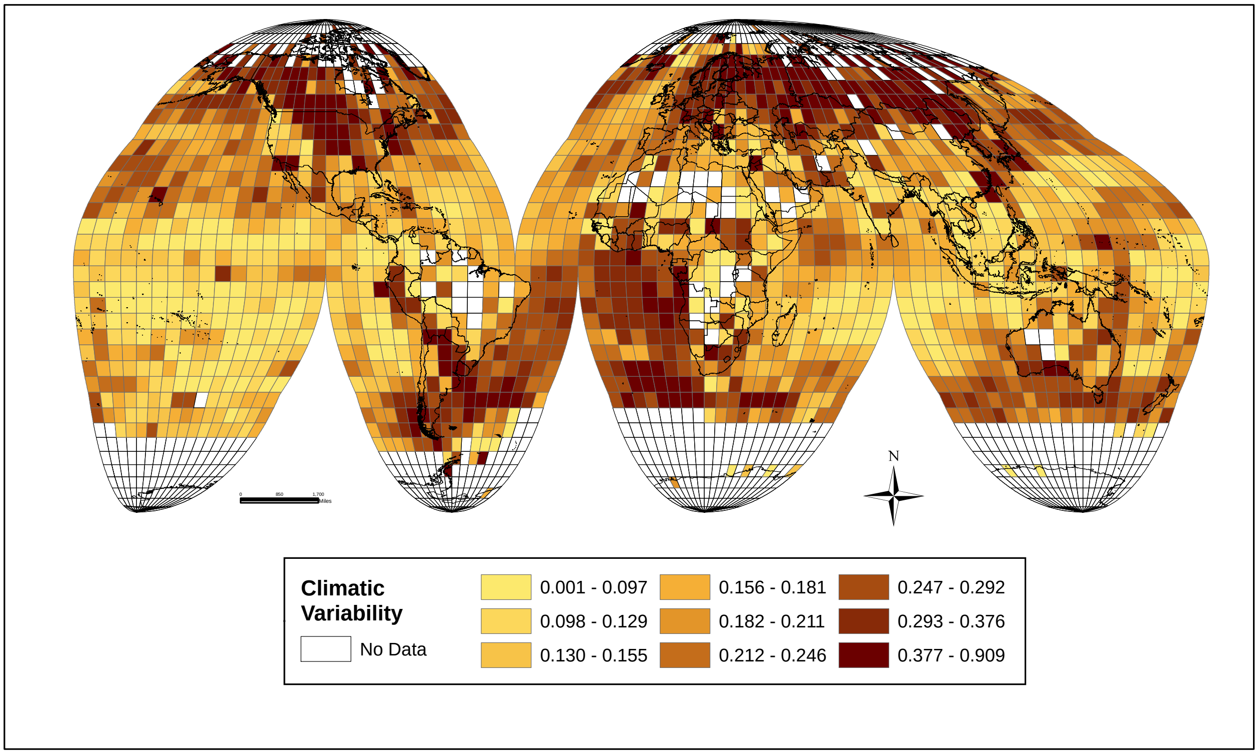
We now turn to a description of our cross-generational instability measures. We divide our sample into 20-year generations starting in 500AD; thus, there are 70 generations within our sample. Let t index years, g generations, and i grid-cells. Let $w_{t,g,i}$ denote the environmental measure (either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

The climatic instability by grid-cell for the global and North American samples is shown in Figures 2a and 2b, 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 equator and from large water bodies tend to have greater variability.

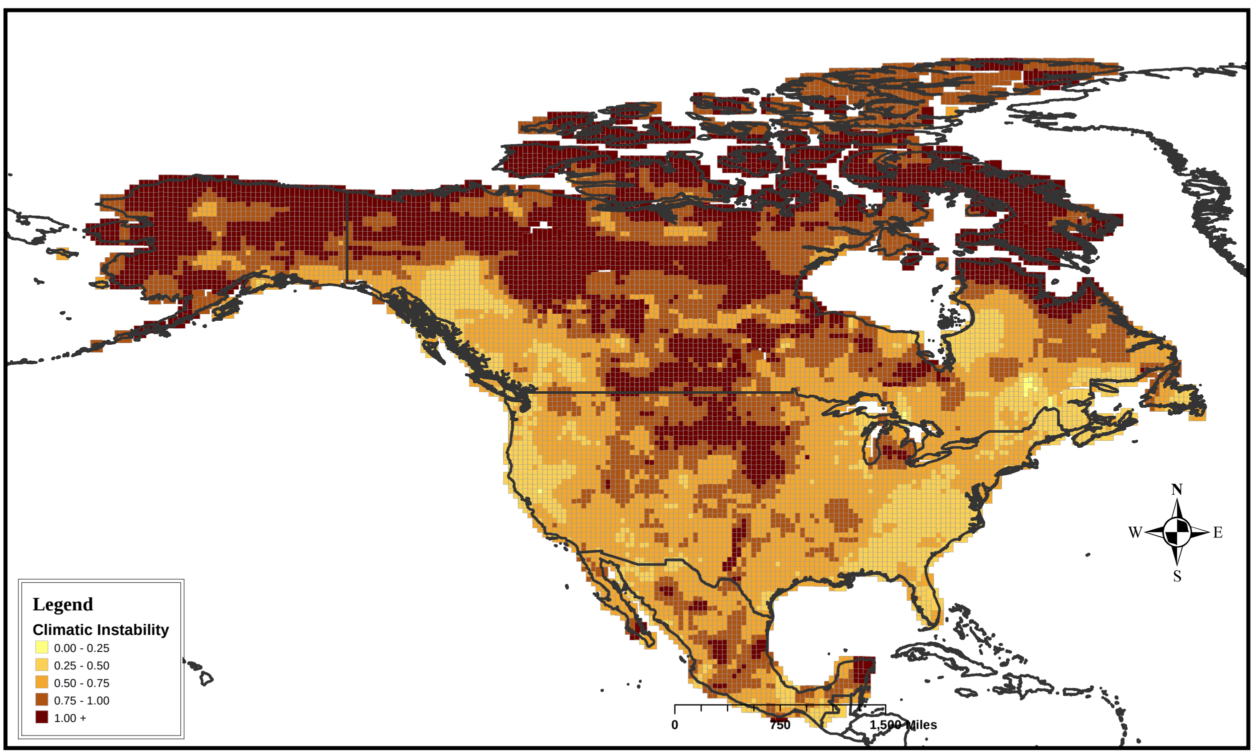
In analyses that use the finer-resolution North American climate data, we are also able to control explicitly for year-to-year variability to ensure that our measure of cross-generational instability is not driven by higher frequency year-to-year variability which itself could be important. To do this,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

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: $[\frac{1}{70}\sum_{g=1}^{70}\left(\text{SD}_{g,i}(w)-\overline{\text{SD}_i(w)}\right)^2]^{\frac{1}{2}}$. 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



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



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

Figure 2: Grid-cell-level measures of the instability of the climate across previous generations, 500–1900.

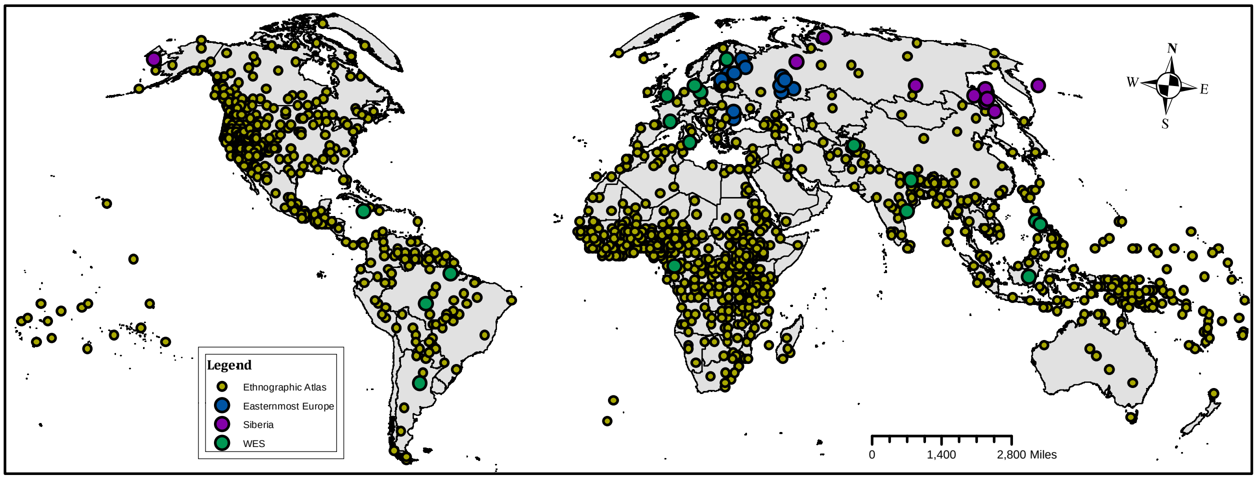


Figure 3: Locations of the centroids of ethnic groups in the *Ethnographic Atlas*, *Peoples of Easternmost Europe*, *Peoples of Siberia*, and *World Ethnographic Sample (WES)*.

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 seventeen ethnic groups did not. They were ethnic groups for which information was more limited; if they had been included in the *Ethnographic Atlas*, they would have had a number of variables with 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 will show, our estimates are very similar irrespective of which ethnographic sample we use.

For each ethnic group in our samples, we know the coordinates of the estimated centroid of their location historically. These are shown in Figure 3. Using the climatic grid-cell that the centroid of each ethnic group lies within, we are able to estimate the cross-generational climatic instability that was experienced by the ancestors of each ethnic group.

For much of our analysis we are able to identify the climatic instability faced by an individual's ancestors using their self-reported ethnicity. For other parts of the analysis, however, 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 et al. (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 as well as average per-capita income.

An important aspect of our empirical strategy is that we connect individuals to their ancestors using either an individual's self-reported ethnicity or the ethnicities/languages of the residents of a country. Because we trace ancestry using ethnicity or language, our measure is not directly affected by the migration of groups. For example, our methodology continues to connect individuals who descend from the Portuguese even if they live in the Americas. That said, a potential problem with our constructed measure is that if ancestral populations moved locations prior to the period in which they are observed in the ethnographic data, then the location that we assign to them may be imprecise. Although the largest movements predate our period of interest – e.g., the Bantu migration within Africa occurred from 1000BCE–500AD; the migrations of Austronesian ancestors from the Mainland of Southern China was complete by 6000BC – smaller-scale movements may still result in measurement error. We examine this potential issue in Section 4.A.

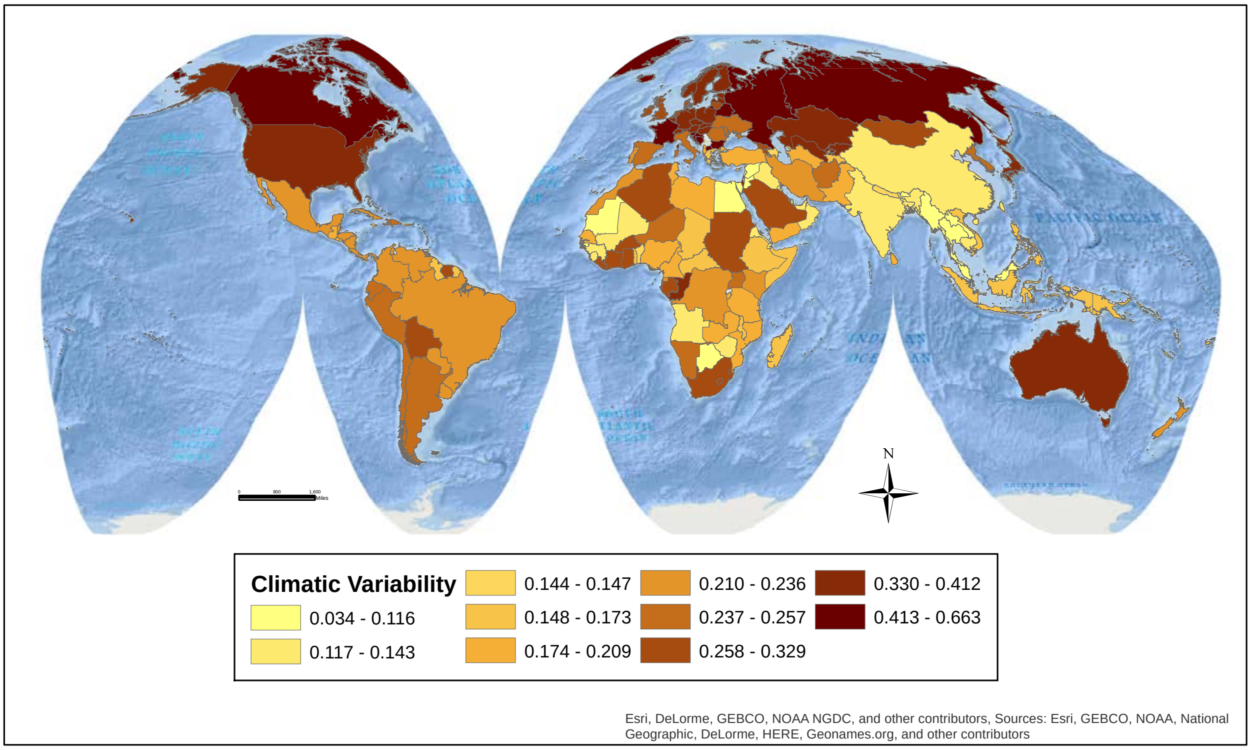


Figure 4: Country-level average historical temperature variability across generations from 500–1900.

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 the second hypothesis by examining settings where populations face changes in their external environment and we study the extent of cultural persistence. The first analysis studies whether the descendants of U.S. immigrants continue to marry within their ancestral group and whether they continue to speak their ancestral language at home. The second examines whether indigenous populations in the United States and Canada continue to speak their traditional languages. The final test of Hypothesis 2 looks globally and over much longer time spans and studies the extent to which there is change or persistence in the following cultural traits: female gender attitudes (measured by female labor-force participation), the practice of consanguineous marriage, and the practice of polygamy.

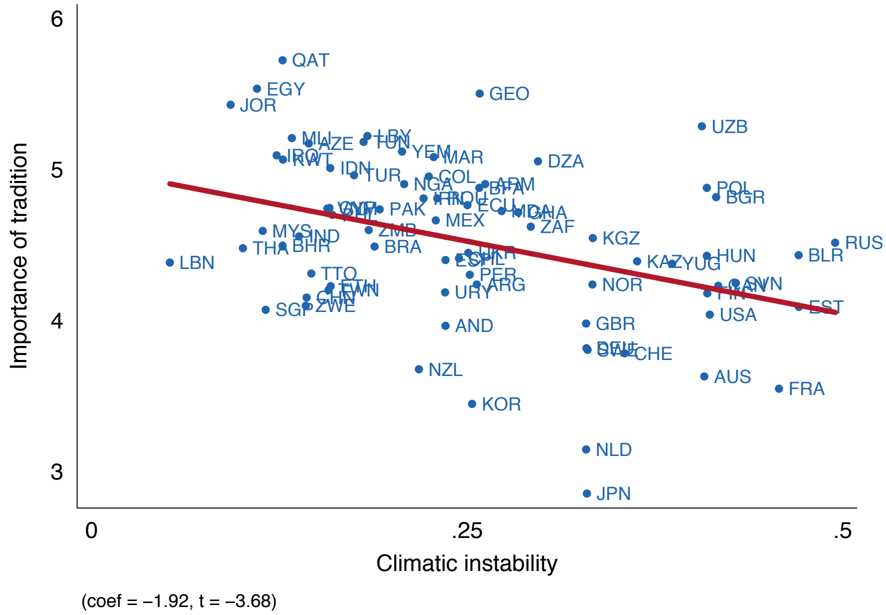


Figure 5: The bivariate cross-country relationship between average instability of the climate across previous generations and the average self-reported importance of tradition today.

A. *Evidence from the self-reported importance of tradition*

We begin by examining a measure of tradition taken from the *World Values Survey* (WVS). Respondents are given the description of a person: "Tradition is important to this person; to follow the family customs handed down by one's religion or family." Respondents then choose the response that best describes how similar this person is to them: very much like me; like me; somewhat like me; a little like me; not like me; and not at all like me. We code the responses to 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 is shown visually (for the specification from column 3) 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:

$$Tradition_c = \beta \, Climatic\, Instability_c + \mathbf{X}_c^H \mathbf{\Phi} + \mathbf{X}_c^C \mathbf{\Pi} + \varepsilon_c, \tag{1}$$

where c denotes a country, $Tradition_c$ is the country-level average of the self-reported importance of tradition, and $Climatic\, Instability_c$ 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);[13] 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.[14]

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.[15]

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

[13] The categories (and corresponding numeric values) that measure the complexity of ethnic groups' settlements 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. We construct a variable that takes on integer values, ranging from 1 to 8 and increasing with settlement density.

[14] It is possible that with economic development (and greater education), the cost of learning c in the model is lower. Thus, the inclusion of this covariate accounts for potential reductions in c, which would result in a lower proportion of traditionalists in the population.

[15] 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.

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 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 shows, we obtain very similar estimates irrespective of which version of the ethnographic data we use. Therefore, for the remainder of the paper, we take as our baseline sample the extended sample of 1,292 ethnic groups. We do not use the largest sample, which also includes the *World Ethnographic Sample*, because of the missing information for the added observations.[16] However, all of the estimates that we report are very similar if either of the

[16]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*.

other versions is used.

Sensitivity and robustness checks

We now turn to a discussion of the robustness and sensitivity of our baseline estimates. A potential concern with our estimates is the quality of the paleoclimatic data that we use. While the Mann et al. (2009a) data were chosen because they have global coverage and date back to 500AD, a shortcoming of the data is that they are interpolated based on proxy data like tree rings and ice cores. Therefore there is a potential concern about imprecision in the data, which may affect our estimates. The concern is particularly acute for data from the beginning of the sample period, since as one moves further back in time, less proxy data are available. Given this, we test the sensitivity of our estimates to using narrower windows of time to construct our ancestral climatic instability measure. Our baseline measure uses data from 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 Table 2, 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 less measurement error in the measures that omit data from the earliest time periods.

As a second strategy to check the quality of the Mann et al. (2009a) climate data and whether it affects our estimates, we construct 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 with only four observations (i.e., generations), the data 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.[17]

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

Table 2: Robustness of estimates to different climate windows

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Importance of tradition, 1-6						
	Initial year of the time range for which climatic instability is calculated (final year is 1900):						
	500 (baseline)	700	900	1100	1300	1500	1700
Climatic instability	**-1.824****	**-1.864****	**-1.576***	**-2.639****	**-3.147*****	**-2.699**	**-2.713****
	(0.696)	**(0.789)**	**(0.857)**	**(1.138)**	**(1.165)**	**(1.673)**	**(1.334)**
Historical controls:							
Distance from equator	0.005	0.004	0.001	0.003	0.004	0.001	0.000
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Economic complexity	-0.069*	-0.061	-0.058	-0.063*	-0.075**	-0.061	-0.063*
	(0.035)	(0.037)	(0.039)	(0.037)	(0.035)	(0.039)	(0.036)
Political hierarchies	0.025	0.003	0.000	-0.006	-0.006	0.007	0.013
	(0.099)	(0.098)	(0.098)	(0.092)	(0.087)	(0.092)	(0.090)
Contemporary controls:							
Ln (per-capita GDP)	-0.164***	-0.165***	-0.165***	-0.168***	-0.172***	-0.169***	-0.162***
	(0.048)	(0.049)	(0.049)	(0.047)	(0.046)	(0.050)	(0.052)
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)	4.52 (0.55)
Observations	74	74	74	74	74	74	74
R-squared	0.388	0.377	0.359	0.383	0.402	0.343	0.346

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.

The results using this alternative measure are reported in Table 3. We continue to find that climatic instability is negatively related to the importance of tradition. Comparing standardized beta coefficients (reported at the bottom of the table), we find that the magnitude of the estimated effects are similar (-0.30 versus the baseline estimates of -0.36). While this measure uses log differences in temperature, the estimates are very similar if we use raw differences. These estimates are reported in Appendix Table A3.

A second potential concern that we consider is historical and current population movements. Because our climatic instability measures are linked to current data using ancestry (and not location), recent population movements – that is, during or after the Columbian Exchange – are unlikely to cause systematic measurement error. However, it is possible that countries that today have large non-indigenous/immigrant populations – 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 A4, 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

Table 3: Robustness of estimates to using 20th-century climate data

	(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:	**-1.614*****	**-1.446*****	**-1.609*****	**-1.415*****	**-1.770*****	**-1.555*****
Log change in temp, 1901-2000	**(0.544)**	**(0.495)**	**(0.548)**	**(0.504)**	**(0.546)**	**(0.522)**
Historical controls:						
Distance from equator		-0.001		-0.001		-0.001
		(0.004)		(0.004)		(0.004)
Economic complexity		-0.102***		-0.095***		-0.097***
		(0.032)		(0.033)		(0.032)
Political hierarchies		0.047		0.030		0.044
		(0.089)		(0.088)		(0.101)
Contemporary controls:						
Ln (per-capita GDP)		-0.127**		-0.128**		-0.117**
		(0.052)		(0.052)		(0.055)
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)
Standardized `beta coeff'	-0.343	-0.307	-0.341	-0.299	-0.374	-0.329
Observations	76	75	76	75	76	75
R-squared	0.118	0.365	0.116	0.358	0.140	0.367

Notes : The unit of observation is a country. The dependent variable is the country-level average of the self-reported importance of tradition. The Climatic instability measure used is the natural log of temperature in 2000 minus the natural log of temperature in 1901 (multiplied by 100), with temperatures measured in degrees Celsius. The mean (and standard deviation) of the variable is 0.24 (0.11). ***, ** and * indicate significance at the 10, 5 and 1% levels.

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. (This information is taken from variable *v*30 in the *Ethnographic Atlas* and other ethnographic sources.) 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 A5 and A6. For both subsamples, estimated effects are nearly identical to our baseline estimates. This finding is consistent with the evidence we provide below, in Section 5.C, showing that contemporary migration flows appear are uncorrelated with cross-generational climatic instability.

Another concern is that ancestral climatic instability could be correlated with other characteristics that may also affect our outcomes of interest. For example, ancestral climatic instability is potentially related to geographic characteristics, namely the ruggedness of the terrain and the proximity to large water bodies. Since both could also affect tradition, we test the robustness of our estimates to controlling for average ancestral ruggedness and average ancestral distance from the coast.[18] We also consider two measures of population diversity – namely, ethnic and genetic diversity – since diversity may affect the importance society places on tradition, and it may be correlated with cross-generational climatic instability.[19] The final factor that we consider 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. The study by Durante (2010) finds that in pre-industrial Europe, such weather fluctuations – either across space or year-to-year during the growing season – are associated with more trust today. Therefore, if these shorter-run weather fluctuations are correlated with our longer-run measure of cross-generational instability and if generalized trust is correlated with the importance placed on tradition, then this could bias our estimates of interest.[20] To address this concern, we control for each country's average measure of generalized trust.[21]

Estimates of equation (1) with these additional covariates added to the regression (either one at a time or all together) are reported in Table 4.[22] Our finding of interest remains robust. The coefficient for ancestral climatic instability is always negative and significant and the point estimates remain stable, ranging from about -1.7 to -2.1.

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 A7, our estimates are very similar when these covariates are not included in equation (1).[23]

[18]Ruggedness is measured using the terrain ruggedness index from Nunn and Puga (2012).

[19]The measure of ethnic diversity is from Alesina, Devleeschauwer, Easterly, Kurlat and Wacziarg (2003). Genetic diversity is from Ashraf and Galor (2013).

[20]In our analysis of North American Native populations in Section 4.C, we explicitly control for the annual variation of weather in the location of a population's ancestors.

[21]The measure is based on the following survey question from the *World Values Survey*: "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?" Respondents chose one of the following answers: "Most people can be trusted" (which we code as 1) or "Cannot be too careful" (which we code as 0).

[22]Due to space constraints, we only report estimates for the extended sample of 1,292 ethnic groups. The estimates using either of the other two ethnicity samples are nearly identical.

[23]The estimates are reported in Appendix Table A7, where we first omit contemporary per-capita GDP and then ancestral economic complexity and political centralization.

Table 4: Robustness of estimates to controlling for additional observables

	(1)	(2)	(4)	(5)	(6)	(7)
	Dependent Variable: Importance of Tradition, 1-6					
Climatic instability	**-1.732****	**-1.871****	**-2.131*****	**-1.663****	**-1.827****	**-1.867****
	(0.769)	**(0.848)**	**(0.689)**	**(0.661)**	**(0.693)**	**(0.773)**
Historical controls:						
Distance from equator	0.005	0.006	0.013**	0.002	0.008	0.010
	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)
Economic complexity	-0.066*	-0.061	-0.044	-0.059*	-0.054*	-0.031
	(0.035)	(0.038)	(0.038)	(0.033)	(0.030)	(0.036)
Political hierarchies	0.010	0.011	-0.026	0.035	0.039	0.021
	(0.097)	(0.098)	(0.098)	(0.102)	(0.088)	(0.091)
Contemporary controls:						
Ln (per capita GDP)	-0.158***	-0.162***	-0.153***	-0.145***	-0.145***	-0.109**
	(0.045)	(0.055)	(0.046)	(0.053)	(0.048)	(0.052)
Additional controls:						
Ruggedness	0.042					0.021
	(0.061)					(0.053)
Distance from the coast		0.037				-0.001
		(0.227)				(0.207)
Ethnic fractionalization			0.658**			0.550*
			(0.313)			(0.314)
Genetic Diversity				1.555		1.708**
				(0.941)		(0.843)
Trust					-1.007**	-1.045**
					(0.389)	(0.427)
Mean (st. dev.) of the dep var	4.52 (0.55)	4.52 (0.55)	4.51 (0.55)	4.51 (0.55)	4.52 (0.55)	4.52 (0.55)
Observations	74	74	73	73	74	72
R-squared	0.391	0.388	0.440	0.404	0.445	0.513

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

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 reported from the WVS with ethnicity from the *Ethnographic Atlas*, we estimate:

$$Tradition_{i,e,c} = \alpha_c + \beta\, Climatic\, Instability_e + \mathbf{X}_i \mathbf{\Pi} + \mathbf{X}_e \mathbf{\Omega} + \varepsilon_{i,e,c}, \quad (2)$$

where i denotes an individual who is a member of historical ethnic group e and lives in country c. $Tradition_{i,e,c}$ is the self-reported importance of tradition, measured on a 1–6 integer scale and increasing in the importance of tradition. $Climatic\, Instability_e$ 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

Table 5: 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*****	**-0.582****	**-0.742*****	**-0.548****	**-0.772*****	**-0.561****
	(0.268)	**(0.282)**	**(0.276)**	**(0.244)**	**(0.278)**	**(0.248)**
Historical ethnicity-level controls:						
Distance from equator		-0.003		-0.004		-0.004
		(0.004)		(0.003)		(0.003)
Economic complexity		-0.033***		-0.039***		-0.035***
		(0.012)		(0.012)		(0.012)
Political hierarchies		0.015		0.026		0.024
		(0.028)		(0.030)		(0.028)
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	176	193	183	193	183
Mean (st. dev.) of dep var	4.50 (1.41)	4.49 (1.41)	4.50 (1.41)	4.49 (1.41)	4.50 (1.41)	4.49 (1.41)
Observations	140,629	127,667	140,681	127,685	139,583	126,630
R-squared	0.179	0.181	0.179	0.181	0.179	0.182

Notes: The unit of observation is an individual. The dependent variable is a measure of the self-reported importance of tradition. It ranges from 1 to 6 and is increasing in the self-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.

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 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.[24]

Estimates of equation (2) are reported in Table 5, 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

[24]Appendix Tables A8–A10 report the ethnic groups that are in each sample.

is a negative relationship between ancestral instability and the importance of tradition today. In all specifications, the estimated coefficients for $\textit{Climatic Instability}_e$ are negative and significant.[25]

B. ***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 (i.e., Hypothesis 2). We examine whether the persistence of traditional practices among the descendants of immigrants is predicted by the cross-generational instability of the ancestral climate of their origin country. We examine two traditional practices that are universal in the origin countries: marrying someone from the same ancestry and speaking one's ancestral language at home.

a. Within-group marriage

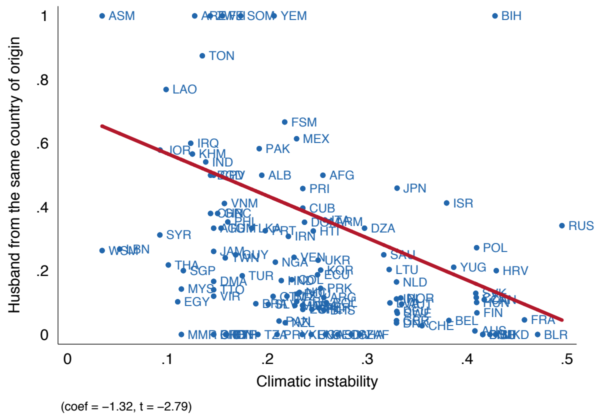
In all countries, the traditional practice is to marry someone from your own country. For the children of U.S. immigrants continuing this tradition is difficult and the importance of the practice to parents and their children will affect its persistence. Of course, other factors will also affect this 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.[26] 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.

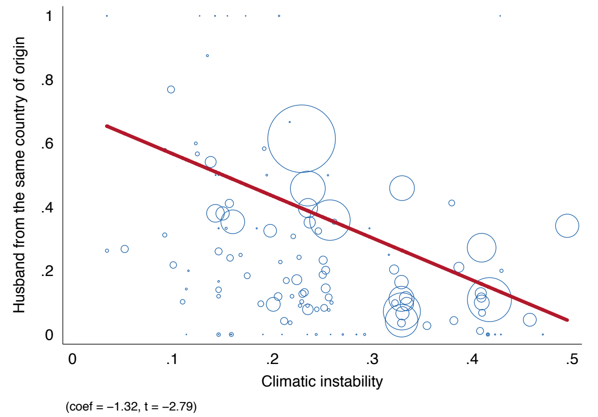
The relationship between the fraction of wives from an origin country who have married someone with the same ancestry is shown in Figures 6a and 6b. Figure 6a shows the relationship

[25]Although the magnitude of the estimates are sizable, they are smaller than the country level estimates. For example, according to the estimates from column 4, a one-standard-deviation increase in cross-generational climatic instability (0.12) is associated with a decrease in the self-reported importance of tradition by $0.12 \times 0.548 = 0.07$, which is equal to about 0.05 standard deviations of the tradition index.

[26]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 21 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: Bivariate relationship between women marrying men from their country of origin and cross-generational climatic instability

with the observations labeled with their three-digit country ISO code. Figure 6b reports 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, a negative relationship between the two measures is apparent. Women from origin countries with more cross-generational climatic instability are less likely to have a spouse from the same country.

We now turn to a more formal examination of this relationship by estimating:

$$I_{i,c,k}^{\textit{Ingroup Marriage}} = \alpha_k + \beta\, \textit{Climatic Instability}_c + \mathbf{X}_c \mathbf{\Pi} + \mathbf{X}_{c,k} \mathbf{\Omega} + \mathbf{X}_i \mathbf{\Phi} + \varepsilon_{i,c,k}, \tag{3}$$

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, $I_{i,c,k}^{\textit{Ingroup Marriage}}$, 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), a 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

Table 6: Women and men marrying a spouse from their origin country, using CPS 1994–2014

	(1)	(2)	(3)	(4)
	Dependent variable: Indicator varible for spouse being from their 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 first- or second-generation immigrants from their country of origin	3.314***	3.533***	3.071***	3.409***
	(0.489)	(0.627)	(0.504)	(0.483)
Individual-level 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.

marriage.[27] $\mathbf{X}_i$ 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.[28] 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 (3) is that our coefficient of interest, β, is estimated by comparing individuals living in the same metropolitan area. This is important given the concern that weather shocks also 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

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

[28] For individuals who do not live in a metropolitan area, we use the fraction of the population living in non-metropolitan areas within the same state.

examining the effects of an individual's ancestral environment.

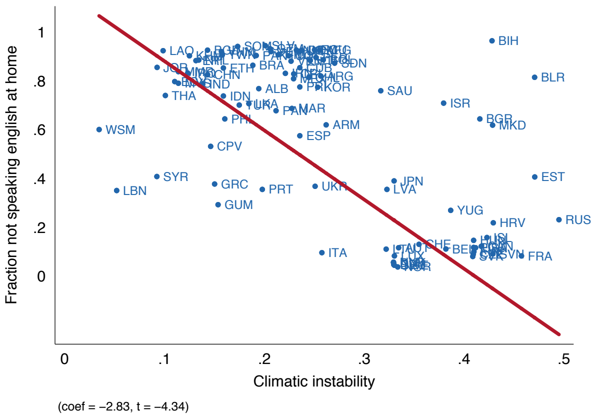
Estimates of equation (3) are reported in Table 6. In columns 1 and 2, the unit of observation is a married woman, while in columns 3 and 4, it is a married man. In columns 1 and 3, we define the origin country by the birthplace of the person's father, while in columns 2 and 4, we define it by the birthplace 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. The effects also appear stronger when we define a person's origin country using the mother. According to the estimates for married women from column 2, a one-standard-deviation increase in cross-generational climatic instability is associated with a decrease in within-group marriage of 0.044, which is equal to 14 percent of the mean of the dependent variable and 9 percent of its standard deviation.[29] Thus, our estimated effects are sizeable.

b. Speaking a foreign language at home

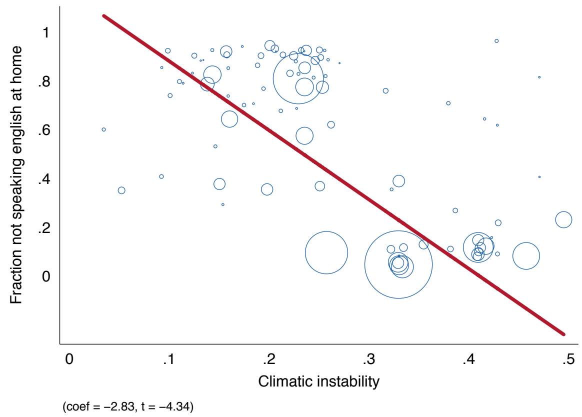
The second measure of cultural persistence that we use is whether or not English is spoken at home. Since children born to immigrant parents in the United States are almost always fluent in English, they face the decision of whether to continue speaking their traditional language at home. They face this 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

[29] According to the estimates for men from column 4, we find that a one-standard-deviation increase in ancestral climatic instability is associated with a decrease in within-group marriage by 0.022, which is 8 percent of the mean of the dependent variable and 5 percent of its standard deviation.



(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: Bivariate relationship between speaking a foreign language at home and cross-generational climatic instability

is the measure of ancestry that we use.[30] Our sample includes all individuals who were born in the United States and report their ancestry as being a non-English speaking country.[31]

Figures 7a and 7b report the bivariate 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:

$$I_{i,c,k}^{Foreign\ Lang} = \alpha_k + \beta\, Climatic\ Instability_c + \mathbf{X}_c \mathbf{\Pi} + \mathbf{X}_{c,k} \mathbf{\Omega} + \mathbf{X}_i \mathbf{\Phi} + \varepsilon_{i,c,k}, \quad (4)$$

where i denotes an individual, c his/her ancestry, and k a location of residence (metropolitan area). The dependent variable, $I_{i,c,k}^{Foreign\ Lang}$, 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

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

[31] Ancestry is less precisely defined relative to one's parents country of birth and is, thus, potentially measured with more error. This shortcoming should be kept in mind when interpreting the estimates.

Table 7: Speaking a foreign language at home, from 2000 Census

	(1)	(2)	(3)	(4)	(5)
	Dep variable: Indicator for speaking a foreign language at home				
	All 2nd gen+ individuals	Not living with parents	Living with parents		
			All ages	18 or younger	Over 18
Climatic instability	**-0.346****	**-0.279***	**-0.731*****	**-0.642*****	**-0.783*****
	(0.161)	**(0.162)**	**(0.195)**	**(0.188)**	**(0.202)**
Country-level controls:					
Distance from equator	-0.015***	-0.016***	-0.011***	-0.009***	-0.012***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)
Economic complexity	-0.164***	-0.160***	-0.172***	-0.147***	-0.189***
	(0.047)	(0.048)	(0.048)	(0.044)	(0.050)
Political hierarchies	0.122	0.105	0.169*	0.151*	0.183**
	(0.090)	(0.086)	(0.087)	(0.088)	(0.086)
Ln (per-capita GDP)	0.017	0.016	0.012	0.004	0.016
	(0.021)	(0.019)	(0.025)	(0.025)	(0.026)
Genetic distance from the US	0.154**	0.144*	0.191***	0.202***	0.180**
	(0.075)	(0.076)	(0.066)	(0.060)	(0.069)
Fraction of population with the same ancestry	0.093	0.098	0.019	0.034	0.009
in the same location	(0.059)	(0.059)	(0.065)	(0.063)	(0.068)
Individual level controls	yes	yes	yes	yes	yes
Number of countries	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 (0.42)
Observations	3,343,097	2,915,673	427,424	176,893	250,531
R-squared	0.304	0.278	0.383	0.367	0.399

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 an ancestry from a non-English speaking country. The dependent variable is an indicator that equals one if the person does not speak English at home. All specifications include the following control varaibles: 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. Standard errors are clustered at the ancestry-country level. The mean (and standard deviation) of Climatic instability is: 0.33 (0.07). ***, ** and * indicate significance at the 10, 5 and 1% levels.

from the equator, historical economic development, historical political complexity, the GDP in the country of origin measured at the time of the survey, and the genetic distance between the country of origin and the United States.[32] $\mathbf{X}_{c,k}$ 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 (4) are reported in Table 7. Column 1 reports estimates using the full

[32]Although linguistic distance is a conceptually cleaner control variable, it is available for fewer countries than genetic distance, and the two are very highly correlated. Estimates using linguistic distance are nearly identical but with a smaller sample size.

sample of individuals who were born in the United States and report a foreign ancestry. We find a negative and significant relationship between the ancestral climate instability in the ancestral country and a foreign language being spoken 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 $0.07 \times 0.346 = 0.02$, which is equal to 20% of the sample mean and 7% of its standard deviation.

In columns 2 and 3, we split the samples into two groups: those not living with their parents (column 2) and those living with their parents (column 3). The decision of whether or not to speak English at home is potentially different for a child who is living with their parents relative to a child who is living alone with their own family. We find that the magnitude of the estimated effect of interest is larger for those living with their parents, although this is, in part, explained by the fact that the mean of the dependent variable is higher for this group. In columns 4 and 5, we further split the sample of children living with their parents by age: those who are 18 or younger (column 4) and those who are older than 18 (column 5). We find that the negative relationship between cross-generational climatic instability and speaking a foreign language at home is similar for both groups, although the effect is slightly larger in magnitude for those over 18.[33]

Due to data availability, we are forced to rely on self-reported ancestry (rather than the parents' countries of birth). It is possible that ancestry is less precisely defined and measured, and that it is potentially endogenous to the importance of tradition. The bias this might introduce is unclear ex-ante. The bias might be towards zero due to classical measurement error. However, if those who value tradition more are more likely to report a foreign ancestry, then this could result in nonclassical measurement error. Since the observed sample will tend to disproportionately include these individuals, if the estimated effect of ancestral climatic instability is particularly strong for this group, then our estimates would be biased away from zero. Given these issues, we test the robustness of our results to the use of estimates that give equal weight to each origin country. Appendix Table A12 reports estimates of a variant of equation (4) where the unit of observation is an origin country and a location of residence. The estimates are qualitatively identical to those in Table 7.

[33]We omit from the sample individuals from origin countries that have English as an official language. The estimates are very similar if we include these individuals (see Appendix Table A11).

c. 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 A13, show no relationship between a country's ancestral climatic 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. These populations comprise minority groups whose cultural traditions differ from those of the dominant population and, thus, face pressure to change their traditions and customs. However, unlike immigrants, they are not a product of self-selection into migration. We now turn to these estimates.

C. *Evidence from indigenous populations of Canada and the United States*

Among the indigenous population of Canada and the United States, there has been significant variation in the extent to which language traditions have been maintained. While the majority of the population for many groups have lost their original language completely, others, such as the Navajo, have done very well at retaining it (Arthur and Diamond, 2011). Our analysis examines the extent to which Native populations continue to speak their traditional language.

An important benefit of the more-geographically confined sample in 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 sample from the United States, which is taken from the U.S. Census, includes all individuals who identify themselves as Native Americans. We use data from all comparable Census years for which data are available (1930, 1990, and 2000). We link an individual to a Native American ethnic group using self-reported tribal affiliation. 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 tribe. Appendix Figures A7 and A9 show the ethnic groups in our sample (according to the *Ethnographic Atlas* classification), along with the climatic grid-cells.

Our estimating equation is:

$$I_{i,e,k}^{Native\,Lang} = \alpha_k + \beta\, Climatic\ Instability_e + \mathbf{X}_e \mathbf{\Pi} + \mathbf{X}_i \mathbf{\Phi} + \varepsilon_{i,e,k}, \tag{5}$$

where i denotes an individual, e his/her ethnic group, and k a location of residence (metropolitan area). The dependent variable, $I_{i,e}^{Native\,Lang}$, is an indicator that equals one if the individual i reports speaking an indigenous language at home.[34] 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 our baseline vector of 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.[35] Standard errors are clustered at the ancestral-climatic-grid-cell level.

Estimates of equation (5) are provided in Table 8, which reports the same samples as in Table 7: all individuals (column 1); those not living with their parents (column 2); and those living with their parents, either all ages, 18 or younger, or over 18 (columns 3–5). 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. Based on the estimates from column

[34]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, which does report an individual's tribe, does not report all languages spoken. It only reports whether or not one speaks English.

[35]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.

Table 8: Whether indigenous populations of the United States speak their traditional language at home: Individual-level estimates

	(1)	(2)	(3)	(4)	(5)
	Dep variable: Indicator for speaking an Indigenous language at home				
			Living with parents		
	All individuals	Not living with parents	All ages	18 or younger	Over 18
Climatic instability	**-1.097***** **(0.358)**	**-1.195***** **(0.400)**	**-0.946***** **(0.300)**	**-0.856***** **(0.288)**	**-1.323***** **(0.352)**
Ethnicity-level controls:					
Distance from equator	-0.008** (0.004)	-0.009** (0.004)	-0.007** (0.003)	-0.006* (0.003)	-0.010** (0.004)
Economic complexity	-0.022 (0.014)	-0.024 (0.016)	-0.020* (0.011)	-0.018* (0.010)	-0.026 (0.016)
Political hierarchies	-0.118** (0.046)	-0.132** (0.049)	-0.097** (0.042)	-0.088** (0.042)	-0.137*** (0.044)
Individual controls	yes	yes	yes	yes	yes
Number of ethnic groups	83	83	79	78	67
Number of clusters (grid cells)	40	40	40	40	40
Mean (st. dev.) of dependent variable	0.18 (0.39)	0.20 (0.40)	0.15 (0.36)	0.13 (0.34)	0.25 (0.43)
Observations	128,005	79,235	48,770	39,800	8,970
R-squared	0.334	0.373	0.289	0.250	0.424

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 him/herself 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 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).

1, a one-standard-deviation increase in climatic instability is associated with a 0.12 percentage-point reduction in the probability of speaking a Native American language, which is 67% of the sample mean and 31% of its standard deviation.

A potential concern with the individual-level estimates from equation (5) 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 underrepresented in our sample. Therefore, we also estimate a version of equation (5) that is at the ethnicity-location level, rather than at the individual level.

An added 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*)

Table 9: 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****	**-2.486*****	**-2.394*****	**-1.957*****	**-4.668****
	(2.116)	**(0.754)**	**(0.890)**	**(0.623)**	**(1.889)**
Ethnicity-level controls:					
Distance from the equator	0.000	0.054***	0.058***	0.035***	0.003
	(0.023)	(0.010)	(0.012)	(0.009)	(0.020)
Economic complexity	-0.185***	-0.264***	-0.285***	-0.166***	-0.181***
	(0.072)	(0.048)	(0.068)	(0.033)	(0.067)
Political hierarchies	-0.069	0.058	-0.061	-0.002	-0.060
	(0.227)	(0.111)	(0.132)	(0.098)	(0.209)
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 different measures of the fraction of people who can speak their traditional language. The American sample includes data from the 1930, 1990, and 2000 Censuses. The Canandian 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.

can conduct a conversation in at least one indigenous language.[36]

The ethnicity-location level estimating equation is:

$$\textit{Frac Native Language}_{e,k} = \alpha_k + \beta\, \textit{Climatic Instability}_e + \mathbf{X}_e \mathbf{\Pi} + \varepsilon_{e,k}, \tag{6}$$

where e indexes a Native American ethnic group and k a location of residence (i.e., metropolitan area). The dependent variable, $\textit{Frac Native Language}_{e,k}$, 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 (6) using a Poisson model.[37] Standard errors are clustered at the ancestral-climatic-grid-cell level.

Estimates of equation (6) are reported in Table 9. Within the United States, we find a negative and significant relationship between ancestral climatic instability and the proportion of the

[36] Appendix Figures A6 and A8 show the ethnic groups in the Canadian sample (according to the *Ethnographic Atlas* classification) and grid-cells with different categories of climatic instability.

[37] The distributions of the dependent variables for both samples are shown in appendix Figures A2–A5.

population speaking a Native American language at home (column 1).[38] We also find a similar relationship within Canada, using either of the three measures of language (columns 2–4). This finding is also maintained if we pool the two samples together (column 5). 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 more-precise 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.[39] We first re-estimate equations (5) and (6) 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.[40]

The estimates are reported in Panel A of Tables 10 and 11. They show that the estimates using the precise drought-severity data are similar to the estimates using the Mann et al. (2009a) data. In addition, we also find that conditional on the cross-generational instability measure, year-to-year variability tends to actually be *positively* related to the importance of tradition (and not *negatively* related). In the U.S. sample, the estimated coefficient is positive and significant, while for the Canadian sample it is positive in two of three specifications, although always insignificant. This effect is consistent with within-generational variability increasing the cost of learning the true state of the world, κ, in the model and, therefore, resulting 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 important for explaining weaker tradition (and less persistence of culture).[41]

The precision of the drought severity data allows us to explore further instability across generations. The baseline measure used throughout the paper calculates the standard deviation

[38]The largest number of different ethnic groups is observed in 1930. In Appendix Table A14, we report both the individual- and the ethnicity-level estimates for this Census year only.

[39]Appendix Figures A8 and A9 show the PDSI data along with the locations of ethnic groups in the Canadian and U.S. samples.

[40]As explained in Section 3.B, we first calculate the standard deviation across the 20 years within each of the 70 generations from 500–1900. We then take the average of the standard deviation across the generations. The estimates that we report are almost identical if we instead use the annual standard deviation across the full time period.

[41]In the raw data, the correlation between the two measures is 0.69.

Table 10: Drought severity and speaking an indigenous language at home, from the 1930, 1990, and 2000 U.S. Censuses

	(1)	(2)	(3)	(4)	(5)
	Dep variable: Indicator for speaking an Indigenous language at home				
		Not living with	Living with parents		
	All individuals	parents	All ages	18 or younger	Over 18
	Panel A. Ancestral instability of the first moment of PDSI				
Climatic instability (PDSI)	**-0.790*** **	**-0.869*** **	**-0.672*** **	**-0.607*** **	**-0.968*** **
	(0.282)	**(0.320)**	**(0.225)**	**(0.208)**	**(0.295)**
Annual standard deviation (PDSI)	0.595***	0.645**	0.521***	0.488***	0.663***
	(0.225)	(0.249)	(0.190)	(0.180)	(0.228)
R-squared	0.334	0.373	0.290	0.253	0.419
	Panel B. Ancestral instability of the second moment of PDSI				
Climatic instability of annual standard deviation (PDSI)	**-2.294** **	**-2.467** **	**-2.030** **	**-1.831** **	**-2.957** **
	(1.084)	**(1.174)**	**(0.947)**	**(0.877)**	**(1.152)**
Annual standard deviation (PDSI)	0.808***	0.873***	0.712***	0.658***	0.952***
	(0.296)	(0.327)	(0.251)	(0.236)	(0.297)
R-squared	0.336	0.374	0.293	0.256	0.423
	Both Panels				
Ethnicity-level controls	yes	yes	yes	yes	yes
Individual controls	yes	yes	yes	yes	yes
Number of ethnic groups	82	82	78	77	66
Number of clusters (grid cells)	80	80	76	75	66
Mean (st. dev.) of dependent variable	0.18 (0.39)	0.20 (0.40)	0.15 (0.36)	0.13 (0.34)	0.25 (0.43)
Observations	127,986	79,224	48,762	39,795	8,967

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 him/herself 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 average annual standard deviation is 0.35 (0.12). ***, ** and * indicate significance at the 10, 5 and 1% levels.

of the first moment (i.e., the mean) of climate within a generation. However, differences across generations in the second moment (i.e. variability) may also be important.[42] To check for this possibility, we calculate the cross-generational instability of the within-generation year-to-year standard deviation of drought.[43]

Estimates of equations (5) and (6), using the cross-generational instability of cross-year standard deviation measure, are reported in Panel B of Tables 10 and 11. We find that the same patterns emerge when examining the cross-generational variability in the second moment as for the first moment. Cross-generational instability is associated with less importance of tradition and cultural persistence as reflected in indigenous populations being less likely to speak their traditional language. As before, the year-to-year standard deviation tends to be positively

[42]For example, Buggle and Durante (2016) show that within Europe, historical year-to-year standard deviation was associated with a greater need for storage and cooperation, which resulted in higher levels of trust.

[43]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 11: 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*** **	**-2.181*** **	**-1.899** **	**-1.046** **	**-3.876*** **
	(1.086)	**(0.528)**	**(0.773)**	**(0.523)**	**(1.062)**
Annual standard deviation (PDSI)	3.045***	0.318	-0.087	0.249	2.949***
	(0.848)	(0.326)	(0.558)	(0.285)	(0.851)
	Panel B. Ancestral instability of the second moment of PDSI				
Climatic instability of annual standard deviation (PDSI)	**-10.048***	**-5.263*** **	**-2.914**	**-2.067***	**-9.716***
	(5.792)	**(1.097)**	**(1.902)**	**(1.094)**	**(5.097)**
Annual standard deviation (PDSI)	3.560***	0.893	-0.011	0.426	3.443***
	(1.374)	(0.586)	(0.825)	(0.467)	(1.314)
	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 different measures of the fraction of people who can speak their traditional language. The American sample includes data from the 1930, 1990, and 2000 Censuses. The Canandian 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.

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 c 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 their movement over time. 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 8–11 using the two subsamples, we find that our estimates remain very similar (Appendix Tables A15–A22).

D. ***Evidence from the differential persistence of cultural traits***

Our final empirical strategy is to test whether the persistence of cultural traits differs systematically depending on climatic instability of a populations' ancestors. 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:

$$\begin{aligned} \mathit{Cultural\,Trait}_{c,t} \quad = \quad & \alpha_{r(c)} + \beta_1\,\mathit{Cultural\,Trait}_{c,t-1} + \beta_2\,\mathit{Cultural\,Trait}_{c,t-1} \times \mathit{Climatic\,Instability}_c \\ & + \mathbf{X}_{c,t}\mathbf{\Pi} + \mathbf{X}_{c,t-1}\mathbf{\Omega} + \varepsilon_{c,t} \end{aligned} \tag{7}$$

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 (7) 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 non-linear 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.

This analysis has pros and cons relative to our previous analyses, which examines cultural persistence among the descendants of immigrants and indigenous populations. In these settings, we are able to examine cultural persistence among individuals living in the same locations but with different ancestral environments. Thus, we are able to hold constant any contemporaneous effect of the environment. In this analysis, we are not able to do this. It does allow us to examine variation across broader populations and to consider a larger range of cultural traits that we can also observe at different points in time.

Our estimates of equation (7) study the differential persistence of FLFP. We begin by estimating the relationship between average country-level FLFP in 1970 and in 2012.[44] 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 12. Column 1 reports estimates from a version of equation (7) that does not include the interaction of interest, $\textit{Cultural Trait}_{c,t-1} \times \textit{Climatic Instability}_c$. We find a strong positive correlation between FLFP in 1970 and 2012. Column 2 reports estimates of equation (7). 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 $\textit{Climatic Instability}_c$ 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.

We next examine persistence over a much longer time span. We measure traditional FLFP during the pre-industrial period using variable *v*54 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 12, 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

[44] Female labor-force participation has been widely used as a measure of the equality in gender roles (e.g., Fernandez and Fogli, 2009, Fogli and Veldkamp, 2011, Alesina et al., 2013, Fernandez, 2013).

Table 12: 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		69.112***		2.363***		34.223
		(36.845)		(21.545)		(0.667)		(22.269)
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)	-71.614***	-67.906***	-70.613***	-58.820***	-0.034	-0.043	-3.139	-4.805*
	(24.480)	(23.724)	(14.214)	(14.349)	(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 the notes of appendix Tables A11, A12, A14 and A15 for the exact statistics for each specification. ***, ** and * indicate significance at the 10, 5, and 1% levels.

since one expects less persistence over a longer time. Column 4 then reports estimates of equation (7), 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 (7) 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.[45] We measure the current prevalence of cousin marriage using data from Schulz (2017) on the proportion of all marriages that are consanguineous.[46]

Estimates are reported in columns 5–8 of Table 12. The coefficients for the interaction terms, β_2, are negative and significant in all specification. 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 estimates to interacting the historical characteristic of interest with each of the control variables and not only with the climatic instability measure. The estimates, which are reported in Tables A23–A26, show that the estimated coefficients of interest remain robust to the inclusion of these interaction controls, either one at a time or all together.

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 (7) that is at the ethnicity level and includes country fixed effects.[47] Although the estimates, which we report in Appendix Table A27, 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.

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

[46]In the data from Schulz (2017), the prevalence of consanguineous marriage is measured in different years in the late 20th century. Thus, rather than control for the year of measurement in the historical ethnographic data, we control for the difference between the years of measurement in the contemporary and historical periods.

[47]The estimating equation is: $FLFP_{e,c,t} = \alpha_{c,t} + \beta_1\, FLFP_{e,t-1} + \beta_2\, FLFP_{e,t-1} \times \, Climatic\, Instability_e + \mathbf{X}_{e,t-1}\mathbf{\Omega} + \varepsilon_{e,c,t}$, where e denotes an ethnicity, c denotes a country, and t the year of the survey in which contemporary FLFP was measured. $\alpha_{c,t}$ denotes survey (i.e., country and survey-year) fixed effects; $FLFP_{e,c,t}$ denotes the average female labor force participation 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; $Climatic\, Instability_e$ is historical climatic instability of ethnic group e; $\mathbf{X}_{e,c,t-1}$ denotes historical controls measured at the ethnicity level. The standard errors are clustered at the ethnicity level.

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 (e.g., Boyd and Richerson, 1985, Aoki and Feldman, 1987, Rogers, 1988, Feldman et al., 1996, Boyd and Richerson, 2005). The primary contribution of the models is to show how a reliance on culture can emerge endogenously in an environment where information is imperfect. A testable prediction from this class of models is that populations whose ancestors lived in locations with greater variability of the environment across generations will place less importance on traditions and customs. When the environment is highly variable, 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.

To test this hypothesis, we used grid-cell-level paleoclimatic data on the average temperature across 20-year generations from 500–1900AD to measure the stability of the environment across generations. Looking across multiple samples and using multiple tests, we found consistent evidence that populations with ancestors who lived in more variable environments place less importance on tradition today and exhibit less cultural persistence.

In addition to providing a better understanding of the determinants of cultural persistence and change, our study also provides support for the origins and microfoundations of culture as modeled in this literature. Testing these models is important because many of the current models of culture in economics – e.g., 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) – take the presence of culture and its (vertical) transmission as a starting point of analysis. The findings here give support to the class of models that provide a theoretical justification for important assumptions that form the foundation of the core models in the cultural economics literature.

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