Environmental Change and Capacity for Adaptation

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Abstract

This research explores the determinants of human capacity for adaptation and the variation in its prevalence across regions and linguistic groups. It advances the hypothesis and establishes empirically that the evolution of the capacity for adaptation in the course of human history can be traced to the response of humans to the changes in the environment that generated a need for adjustment via the process of cultural evolution. Exploiting variations in the environmental changes that occurred in the course of historic migrations or were caused by the introduction of new crops during the Columbian Exchange, the research suggests that consistent with the predictions of the theory, individuals whose ancestors were subjected to a greater accumulated environmental changes are characterised by a higher propensity towards adaptation.

Keywords: capacity for adaptation, cultural evolution, individual learning, migration, evolution of preferences, natural selection, Malthusian epoch, growth, development

JEL Classification: D81, D91, Z10, O10, O40

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1 Introduction

Humans are a unique species. We occupy numerous ecological zones and demonstrate a vast assortment of behavioural adaptations to extremely different environments from tropical forests to arid desserts and polar tundras. Although some of the adaptations can be attributed to biological evolution (e.g., Ruff, 2002; Ingram et al., 2009; Schnorr et al., 2016), most of them have occurred in the process of cultural evolution.[1] In the course of our history, humans have developed an ability to: explore and analyze unfamiliar environments in search of better behavioral practices through the process of individual learning, teach and learn from each other by engaging in social learning, as well as accumulate and pass on the knowledge to future generations.[2] All of these processes are important building blocks of cultural evolution that allowed our species to spread across the globe, flourish in a wide variety of ecological zones, continuously accumulate knowledge, and generate technological advancements and economic growth.

This study focuses on one of the most important elements of cultural evolution – individual learning, i.e., the ability to explore, experiment and adapt to unfamiliar environments to generate novel behavioural practices. The research explores the determinants of predisposition towards individual learning and human capacity for adaptation, as well as the variation in its prevalence across regions and linguistic groups. It advances the hypothesis and establishes empirically that the evolution of capacity for adaptation in the course of human history reflects the response of humans to changes in their environment which were accumulated in the course of historic migrations or occurred due to the Columbian Exchange, initiating the process of cultural evolution that generated a comparative advantage for individuals engaging in learning.

The study develops a theory of co-evolution of culture and individual learning that captures the effect of changes in the environment on the process of cultural evolution and resulting changes in the composition of population in terms of capacity for adaption. In the course of human history groups of people have been subjected to numerous changes in the environment that called for the adjustment of human behavior, norms and culture to assure a productive interaction with the new environmental conditions. These adaptations were achieved in the process of cultural evolution. As groups of people have been exposed to unfamiliar environments, where previous practices proved to be unproductive, members with a greater capacity for adaptation engage in the process of individual learning, experimenting with the new environment and analyzing novel conditions in search of more suitable behaviour. Once the more suitable practices have been discovered, they are propagated across the group and are passed on to next generations. As a result, the general set of behaviours and practices on a group level (i.e., culture in a broad sense) would gradually adjust to complement the new environment. During this transition process, group members with a higher propensity towards adaptation that successfully engage in an individual learning would gain a comparative advantage within the group, which increases their share in the population.

[1] Boyd and Richerson (2005); Henrich (2017)
[2] Richerson and Boyd (2000); Henrich and McElreath (2003); Newson et al. (2007); Mesoudi and Whiten (2008)

The theory generates a fundamental testable prediction about the effect of historic environmental changes on the evolution of capacity for adaptation. It suggests that individuals, as well as societies that were subjected to a greater changes in the environment accumulated in the course of the history of their ancestors, would be characterized by a greater predisposition towards individual learning and adaptation.

The theoretical predictions are tested by exploring an association between the predisposition towards adaptation and individual learning of modern-day individuals and environmental changes that were accumulated during the migrations of their linguistic ancestors or occurred due to the introduction of new crops in the course of the Columbian Exchange. Exploiting variations in the degree of preference for individual learning, as well as the manifestation of adaptability in the observed behaviour, the research suggests that consistent with the predictions of the theory, individuals, whose ancestors were subjected to a greater accumulated environmental change, are characterized by a greater capacity for adaptation.

The empirical analysis is conducted at different layers that are designed to determine the robustness of the findings in distinct samples and units of analysis. It exploits variation in preferences and behavior across individuals in general, as well as first-, second- and higher-generation migrants in particular, based on the European Social Survey (ESS), General Social Survey (GSS). In particular, the analysis explores: (i) variation in predisposition towards individual learning across Indo-European language speakers in Europe as well as the US, accounting for time-invariant country of residence fixed effects, potentially confounding geographical characteristics of the linguistic homeland, as well as individual's characteristics such as age, gender, income and education; (ii) variation in preference for individual learning and manifestation of adaptability in the observed behaviour across the sub-samples of first-, second- and higher-generation migrants of Indo-European linguistic origin in Europe and the US, accounting for time-invariant host country, as well as country of origin fixed effects, potentially confounding geographical characteristics of the linguistic homeland, and individual's characteristics.

In light of the predictions of the theory, the capacity for adaptation is linked to the ancestral environmental changes. Several measures that capture the variation in the historic changes in ancestral environment are introduced in this study. In particular, a novel measure of the accumulated environmental change is constructed to capture the changes in the environmental conditions that gradually occurred during the migrations of humans in the process of the Indo-European expansion. The measure is calculated as the accumulated changes in the first principal component of major environmental characteristics (e.g., agricultural productivity of numerous food crops, various climatic characteristics, elevation and ruggedness) along the reconstructed potential migration paths from the origin of Indo-European expansion according to *Steppe Hypothesis* (Anthony and Ringe, 2015; Anthony, 2010; Klejn, 2017).[3] In addition, a measure of the change in the potential agricultural yield that occurred due to the introduction of new crops in the course of the Columbian exchange is exploited to capture an alternative dimension

[3]The potential migration paths of Indo-European expansion are reconstructed using the least cost path methodology that generates the path connecting a specified origin to the destination point, while minimizing a given measure of traveling cost. The cost of traveling is reflectd by the Human Mobility Index (HMI) developed by Özak (2010, 2018).

of ancestral environmental change and analyse its effect on the evolution of individual learning.[4]

Variations in the prevalence and the distribution of capacity for adaptation across individuals is captured by a variety of newly introduced measures of preference for individual learning. First, exploiting the ESS, the degree of preference for individual learning is captured by individual's valuation of the importance of thinking up new ideas, being creative and doing things in her or his own original way. Importantly, since adaptation to new environment via individual learning implies the departure from common behavioural conventions in search of novel, previously unknown practices, the importance of original thinking and creativity adequately represents propensity towards individual learning. Second, using the GSS he preference for individual learning is captured by individual's evaluation of the specific characteristics one's child should acquire to be prepaid for her or his adult life. In particular, the proxy measure for the propensity towards adaptation through individual learning is based on the preference for child ability to thinks for ones self over child's obedience, which represents individual's own valuation of the importance of individual learning and adaptability in life.

Moreover, to capture the capacity for adaptation, measure of the manifestation of adaptability in the observed behaviour is utilized. In particular, exploiting ESS and GSS, measures that reflect migrant's level of adaptation to an unfamiliar cultural environment of a host country are used to reflect their capacity for adaptation. They are constructed as an opposite of an average absolute distance across a number of cultural traits between an individual migrant and the population of a host country and thus represent the degree of migrant's adaptation to local culture. The specific cultural characteristics used in the construction of the measures are chosen to reflect a broad spectrum of preferences, beliefs and norms.[5]

The first part of the empirical analysis explores the effect of environmental changes accumulated in the course of Indo-European expansion on the preferences of Indo-European speakers in Europe and the US for individual leaning, as reported by the ESS and the GSS. In line with the predictions of the theory, the analysis establishes a statistically and economically significant positive effect of accumulated environmental change of linguistic ancestors on the preference for individual learning. Moreover, consistent with the proposed theory that underlines the role of intergenerational transmission in the evolution of capacity for adaptation, the estimated effects of accumulated environmental change on the sub-samples of first-, second- or higher-generation migrants in the linguistic homeland (rather than those in country of residence) on individual learning, capture the culturally-embodied, intergenerationally-transmitted effect, rather than the direct effect of geography. Furthermore, the findings are robust to the inclusion of country-of-residence and country-of-birth fixed effects, and for accounting for the potentially confounding effects of a wide range of geographical characteristics at the linguistic homeland, and a range of individual characteristics, such as age, gender, education and income.

The second part of the empirical analysis examines the association between the level of adaptation of Indo-

[4]The measures of the potential agricultural yield and its change in the course of the Columbian exchange are constructed following the methodology of Galor and Özak (2016).

[5]The specific cultural traits are summarized and described in Appendix C.

European-language-speaking migrants to the cultural environment of host country in Europe and the US, as captured by GSS and ESS, and accumulated environmental change experienced by their linguistic ancestors in the course of historic migrations. As predicted by the theory, the analysis establishes a statistically and economically significant positive effect of accumulated environmental change of linguistic ancestors on the capacity for adaptation. The findings are robust to the inclusion of country- or region-of-birth fixed effects, and for accounting for the potentially confounding effects of a wide range of geographical characteristics, as well as individual characteristics, such as age, gender, education and income.

The third part of the empirical analysis exploits the "random assignment" of the environmental change caused by the introduction of new, potentially more productive crops in the course of the Columbian Exchange to identify the impact of historic environmental change on the predisposition towards adaptation via individual learning, addressing potential concerns of selective migration of individuals with greater preference for individual learning. Consistent with the theoretical predictions, the findings suggest that historic changes in the environment associated with the Columbian Exchange indeed a positive and highly significant effect on: (i) the preference individual learning, as captured by the valuation of importance of creativity and new ideas; (ii) the level of migrant's adaptation to the cultural environment of the host country. The results identify the effect of a "randomly assigned" environmental change on the evolution of capacity for adaptation and establish that selective migration played an insignificant role in the determination of preference for individual learning.

The results are further robust to a large number of placebo and robustness tests. In particular, the analysis suggests that: (i) the capacity for adaptation across Indo-European-language-speakers is not affected by the migratory distance from the origin of Indo-European expansion, (ii) the effect of accumulated environmental change on preference for individual learning is unaffected when accounting for the migratory distance, (iii) accumulated environmental changes from the placebo origins neither affects the propensity towards adaptation via individual learning nor the ability of migrants to adapt to unfamiliar cultures, (iv) the environmental changes accumulated in the course of migration from Indo-European origin has no effect on the preference for individual learning and cultural adaptation of non-Indo-European speakers, (v) alternative cultural traits that are unrelated to adaptability are not affected by the accumulated environmental change. In addition, the analysis based on the methodology of Altonji et al. (2005) and Oster (2014) establishes that it is highly unlikely that omitted variables could have affected the qualitative results.

The research represents the first attempt to shed light on the historic and environmental determinants of capacity for human adaptation and the distribution of this trait across the globe. Moreover, it contributes to the understanding of the evolution of preferences (e.g., Robson, 1996; Bisin and Verdier, 2001; Galor and Moav, 2002; Robson and Samuelson, 2009), the biogeographical roots of preferences (e.g., Alesina et al., 2013; Galor and Özak, 2016; Buggle and Durante, 2017; Becker, 2018; Galor and Savitskiy, 2018) and the process of cultural adaptation and change (e.g., Galor and Michalopoulos, 2012; Giuliano and Nunn, 2017; Giavazzi et al., 2019; Rapoport et al.,

2020).

In addition, the research builds upon and contributes to a large strain of literature dedicated to the theory of cultural evolution (e.g., Richerson and Boyd, 2000; Boyd and Richerson, 2005; Henrich and McElreath, 2003; Henrich, 2017). It focuses on the evolution of one of the most important elements of cultural evolution, adaptation through individual learning, within a context of migrations and other changes in the environment, which governed the evolutionary pressure that humanity had confronted for most of its existence, producing testable predictions regarding the global distribution of predisposition towards adaptation via individual learning in humans.

2 The Theory of Co-Evolution of Culture and Individual Learning

This section advances the theory of co-evolution of culture and capacity for adaptation. The theory suggests that the contemporary distribution of the propensity towards adaptation via individual learning across individuals can be traced to the adjustment of their ancestral populations to the changes in the environment.

The model captures the process of cultural adjustment and resulting changes in the composition of population in terms of capacity for adaptation triggered by the migrations to unfamiliar environments or changes in the environment caused by other reasons. In the course of human history population migrations have been associated with changes in the environment. Such changes often called for the adjustment of human behavior (e.g., production practices, production of specific clothes, tools, dwellings, etc.) to guarantee a productive interaction with the new environment. These adaptations were achieved in the process of the cultural evolution. As groups of people had migrated to unfamiliar places, where previous practices proved to be unproductive, some members engaged in the process of adaptation through individual learning, experimenting with the new environment and analyzing novel conditions in search of more suitable behaviour. Once the more suitable practices have been discovered, they are propagated across the group and are passed on to next generations. As a result, the general set of behaviours and practices on a group level (i.e., culture in a broad sense) would gradually adjust to complement the new environment. During this transition process, group members with a greater propensity towards adaptation that successfully engage in an individual learning would gain a comparative advantage within the group, which increases the share of such individual in the population.[6] As the culture fully adjusts and all group members adopt new practices this comparative advantage fades away, but the share of individual with a higher propensity towards adaptation through individual learning remains greater than before. As a consequence, societies subjected to a greater degree of environmental changes in the course of migration history would be characterized by a higher average capacity for adaptation and propensity towards individual learning across their members.

[6]Positive association between the disposable income and the number of offspring is a fundamental feature of human economy in a Malthusian epoch (e.g., Galor and Weil, 1999).

2.1 The Basic Structure of the Model

Consider an overlapping-generations economy in a Malthusian stage of development. In every time period the economy is populated by a continuum of two-period lived individuals who are identical in all respects except for their propensity towards adaptation via individual learning, which is transmitted intergenerationally without alterations.[7] Individuals can engage in adaptation through individual learning. If they do, with some probability each individual performing an individual learning can discover a more productive practice. If they are unsuccessful or choose not to engage in individual learning in the first place, individuals resort to a current common practice. Common practice (i.e., culture in a broad sense) evolves by absorbing newly discovered types of behaviour. The type of practice affects individual's disposable income, which is allocated between consumption and fertility. Thus, in line with the one of the main characteristics of the Malthusian epoch, richer individuals have higher reproductive success and the effect of predisposition towards adaptation through individual learning on the choice of behaviour affects the composition of population.

2.2 Production and Adaptation

In every time period (i.e., generation) t individual i's disposable income is a function of individual's behavioural practice $x_{it} \in \mathbb{R}$.[8] In a given environment $e \in E$ there exists an optimal practice $x(e)$, where $x(\cdot)$ is a strictly monotonically increasing function of environment, e,[9] that grants a maximum potential disposable income in period t, $\bar{y}_t$. Deviations from such practice result in a lower output. In particular, the disposable income of individual i of generation t in environment e is a following function of behaviour, x_{it}:

$$y_{it}(e) = y_t(x_{it}; x(e)) \equiv \bar{y}_t \exp\{-\delta(x_{it} - x(e))^2\}. \tag{1}$$

In addition, in every time period t there exists a common practice x_t (i.e, group's culture), which individuals follow in the absence of a better alternative. Such alternative could be discovered in the process of adaptation through individual learning. In particular, an individual who engages in individual learning discovers a practice optimal for an environment e, $x(e)$, with probability p, whereas with probability $1-p$ individual does not succeed and resorts to a common practice x_t. Hence, an agent engaged in adaptation via individual learning adopts a

[7] The international transmission without alteration can be a consequence of genetic or cultural transmission. The assumption could be changed in favour of social learning with success bias (vertical and/or horizontal), which would generate a qualitatively identical effect.

[8] The practice/behaviour is assumed to be one dimensional and is represented by a number on a real axis. Potentially a higher dimensionality could be assumed.

[9] The $x(\cdot)$ function is assumed to be strictly monotonically increasing for the reasons of simplicity. It can be relaxed in favour of the assumption that $x(\cdot)$ is a one-to-one correspondence, so that changes in e, necessarily lead to changes in $x(e)$.

behaviour x_t^{IL}:

$$x_t^{IL} = \begin{cases} x(e), & with\ probability \quad p \\ x_t, & with\ probability\ \ 1-p, \end{cases} \tag{2}$$

which grants a disposable income y_t^{IL}:

$$y_t^{IL} = \begin{cases} \bar{y}_t, & with\ probability \quad p \\ \bar{y}_t \exp\{-\delta(x_t - x(e))^2\}, & with\ probability\ \ 1-p. \end{cases} \tag{3}$$

Individual who choose not to engage in individual learning, follow the common practice

$$x_t^{NIL} = x_t, \tag{4}$$

and produce the disposable income y_t^{NIL}:

$$y_t^{NIL} = \bar{y}_t \exp\{-\delta(x_t - x(e))^2\}. \tag{5}$$

2.3 Individuals

In every period t, a continuum I of two-period lived individuals is born. Individuals are ex-ante identical in all respects except for their propensity towards adaptation. The preference for adaptation via individual learning is heterogeneous within each generation and is transmitted intergenerationally, from parent to child, without alteration.

In the first period of their life – childhood – individuals are passive economic agents. They consume part of their parental resource and observe the behaviour of the adults in their society. Young individuals learn practices from both individual learners and those who follow a common practice, forming a new common practice of their generation. This process of Social Learning performed by the children contributes to the evolution of the group's common practice (i.e., group's culture in a broad sense).

In the second period of their life - adulthood – individuals are active economic agents. Based on their propensity towards adaptation, they choose whether to engage in individual learning, follow a particular behaviour (i.e., either the common practice learned in a childhood or the one acquired by individual learning), produce, and optimally allocate the resulted yield between consumption and child rearing.

In light of the association between the propensity towards adaptation and individual behaviour, the relation between the common practice and environmentally optimal behaviour determines individuals' yield and hence their reproductive success and consequently contributes to the evolution of capacity for adaptation.

2.3.1 Preferences, Constraints, and Optimization

Individuals derive utility from consumption and fertility, but experience a utility cost if they engage in adaptation through individual learning. In particular, the level of utility of an adult i in period t, u_{it}, is:

$$u_{it} = u_i(c_{it}, n_{it}, IL_{it}) = (1-\gamma)\ln c_{it} + \gamma \ln n_{it} - \theta_i IL_{it}, \tag{6}$$

where (i) $c_{it} \geq 0$ is the consumption level, (ii) $n_{it} \geq 0$ – number of children, (iii) $\gamma \in (0;1)$ – relative preference for children, (iv) $IL_{it} \in \{0,1\}$ captures individual decision whether to engage in adaptation through individual learning or not, and (v) $\theta_i > 0$ reflects individual's disutility from individual learning.

Propensity of individual i towards adaptation is inversely related to the disutility parameter θ_i. For instance, individuals with $\theta_i = 0$ bear no cost when engaging adaptation and are extremely prone to it. Individuals with $\theta_i \to \infty$, on the other hand, are extremely averse to adaptation via individual learning and would always avoid it.

An adult i in period t is subjected to a budget constraint. Once the choice over individual learning is made and uncertainty is realized, an adult i in period t allocates the resulting income, $y_{it}(e)$, between consumption and fertility.

$$c_{it} + \tau n_{it} \leq y_{it}(e), \tag{7}$$

where $\tau > 0$ is an income cost of raising a child.

Independently from individual's choice over IL_{it}, an adult i in period t in environment e allocates the income $y_{it}(e)$, between consumption, c_{it}, and fertility, n_{it}, so as to maximize the utility function $u_i(c_{it}, n_{it})$.

$$\begin{aligned} (c_{it}, n_{it}) = &\operatorname{argmax}_{(c,n)} u_i(c, n, IL_{it}) \\ s.t.\ \ &c + \tau n \leq y_{it}(e); \\ &n \geq 0;\ \ c \geq 0; \end{aligned} \tag{8}$$

Given the properties of the utility function, a solution to the maximization problem exists and is unique. In particular, individual splits a disposable income between expenditures on consumption and child-rearing in a fixed proportion.

$$c_{it} = c(y_{it}(e)) = (1-\gamma) y_{it}(e) \tag{9}$$

$$n_{it} = n(y_{it}(e)) = \gamma / \tau y_{it}(e) \tag{10}$$

Given (9) and (10) the utility of individual i in period t can be rewritten as an indirect utility function of

disposable income and decision over individual learning:

$$u_{it} = v_i(y_{it}(e), IL_{it}) \equiv \ln(y_{it}(e)) - \theta_i IL_{it} + const, \tag{11}$$

where $const = (1-\gamma)\ln(1-\gamma) + \gamma\ln(\gamma/\tau)$. The constant is omitted further for convenience.

2.3.2 Decision over Adaptation via Individual Learning

In light of the ex-ante uncertainty associated with the process of adaptation through individual learning, individual decides whether to engage in it or not to maximize expected utility.

As follows from (3) and (11), the expected utility, u_{it}^{IL}, generated by an agent i in period t, who decides to engage in individual learning, is

$$u_{it}^{IL} = \mathbb{E}v_i(y_t^{IL}, 1) = \ln \bar{y}_t - (1-p)\delta(x_t - x(e))^2 - \theta_i \tag{12}$$

Analogously, as follows from (5) and (11), the utility, u_{it}^{NIL}, generated by an agent i in period t, who decides not to engage in individual learning, is

$$u_{it}^{NIL} = \mathbb{E}v_i(y_t^{NIL}, 0) = \ln \bar{y}_t - \delta(x_t - x(e))^2. \tag{13}$$

Individual i in period t chooses to engage in individual learning if and only if the expected utility derived from it, u_{it}^{IL}, is greater than the utility in an alternative case, u_{it}^{NIL}:

$$u_{it}^{IL} \geq u_{it}^{NIL}. \tag{14}$$

In light of the (12) and (13), inequality (14) implies that individuals with a greater propensity towards individual learning choose to engage in it. In particular, agents in period t whose disutility from individual learning, θ_i, is lower than the cut off level:

$$\theta_i \leq p\delta(x_t - x(e))^2, \tag{15}$$

decide to adapt via individual learning. Whereas agents with disutility parameter, θ_i, greater than that, choose not to engage in it.

The decision whether to engage in adaptive behaviour or not affects the behavioral practices available to an individual, as specified in (2) and (4). In light of the relation between the behaviour and individual's income (1),

the yield of individual i in period t is therefore

$$y_{it} = \begin{cases} \bar{y}_t & \textit{with probability} \quad p \quad \textit{if} \quad \theta_i \leq p\delta(x_t - x(e))^2 \\ \bar{y}_t \exp\{-\delta(x_t - x(e))^2\} & \textit{with probability} \quad 1-p \quad \textit{if} \quad \theta_i \leq p\delta(x_t - x(e))^2 \\ \bar{y}_t \exp\{-\delta(x_t - x(e))^2\} & \textit{if} \quad \theta_i > p\delta(x_t - x(e))^2, \end{cases} \tag{16}$$

and, in light of (10), the level of fertility is:

$$n_{it} = \begin{cases} \gamma/\tau\bar{y}_t & \textit{with probability} \quad p \quad \textit{if} \quad \theta_i \leq p\delta(x_t - x(e))^2 \\ \gamma/\tau\bar{y}_t \exp\{-\delta(x_t - x(e))^2\} & \textit{with probability} \quad 1-p \quad \textit{if} \quad \theta_i \leq p\delta(x_t - x(e))^2 \\ \gamma/\tau\bar{y}_t \exp\{-\delta(x_t - x(e))^2\} & \textit{if} \quad \theta_i > p\delta(x_t - x(e))^2. \end{cases} \tag{17}$$

2.4 The Evolution of Capacity for Adaptation

The evolution of the composition of predisposition towards adaptation through individual learning is governed by the effect of adaptation on the differential reproductive success across individuals. Since it is assumed to be transmitted intergenerationally within each dynasty i without any alteration, if a greater capacity for adaptation is associated with a higher income, and thus higher reproductive success, then this trait will become more prevalent in the population in the long-run.

Assume that the group is populated by two types of individuals.[10] Individual of type A are highly predisposed towards adaptation via individual learning and bare no cost when engaged in it:

$$\theta_i = 0 \quad \forall i \in A. \tag{18}$$

Individual of the second type, B, on the other hand, dislike engaging in individual learning and bare an extreme cost when performing it:

$$\theta_i = \bar{\theta} \to \infty \quad \forall i \in B. \tag{19}$$

The total population in the economy in period t, L_t is decomposed into members of group A, L_t^A, and member of group B, L_t^B, i.e.,

$$L_t^A + L_t^B = L_t. \tag{20}$$

In period 0 the share of individual of type A within the group is μ_0. A greater share of individual of type A in the population at a given period t, μ_t, reflects a higher predisposition towards adaptation on a group level.

[10] The example with two types is chosen for purely illustrative purposes. Same qualitative logic applies to cases with a greater number of types or even with a continuum of types.

The intertemporal changes in the share are governed by the differential reproductive success across the types. In particular, as follows from (15), (18) and (19), individual of type A always chose to engage in adaptation through individual learning, whereas individuals of type B never perform it. This pins down the behaviour of individual i in generation t, x_{it}, as following:

$$x_{it} = \begin{cases} x(e) & \textit{with probability} \quad p \quad if \quad i \in A \\ x_t & \textit{with probability} \quad 1-p \quad if \quad i \in A \\ x_t & \qquad\qquad\qquad\quad if \quad i \in B. \end{cases} \tag{21}$$

As a consequence, the reproductive success of an adult i at period t is

$$n_{it} = \begin{cases} \gamma/\tau\bar{y}_t & \textit{with probability} \quad p \quad if \quad i \in A \\ \gamma/\tau\bar{y}_t \exp\{-\delta(x_t - x(e))^2\} & \textit{with probability} \quad 1-p \quad if \quad i \in A \\ \gamma/\tau\bar{y}_t \exp\{-\delta(x_t - x(e))^2\} & \qquad\qquad\qquad\quad if \quad i \in B. \end{cases} \tag{22}$$

Hence, the population of individual of type A in period t, L_t^A, evolves according to the difference equation

$$\begin{aligned} L_t^A &= \int_{i \in A} n_{it} di L_{t-1}^A \\ &= \gamma/\tau\bar{y}_t \left[p + (1-p)\exp\{-\delta(x_t - x(e))^2\}\right] L_{t-1}^A \\ &= \gamma/\tau\bar{y}_t \left[p + (1-p)\exp\{-\delta(x_t - x(e))^2\}\right] \mu_{t-1} L_{t-1}, \end{aligned} \tag{23}$$

while the the population of individual of type B changes according to

$$L_t^B = \gamma/\tau\bar{y}_t \exp\{-\delta(x_t - x(e))^2\}(1-\mu_{t-1})L_{t-1} \tag{24}$$

Thus, (23) and (24) imply that the evolution of the share of individuals predisposed towards adaptation (i.e., individuals of type A) is governed by the difference equation

$$\mu_t = \frac{L_t^A}{L_t^A + L_t^B} = \frac{p\mu_{t-1}\exp\{\delta(x_t - x(e))^2\} + (1-p)\mu_{t-1}}{p\mu_{t-1}\exp\{\delta(x_t - x(e))^2\} + (1-p)\mu_{t-1} + 1 - \mu_{t-1}} \equiv \phi(\mu_{t-1}, x_t; x(e)) \tag{25}$$

2.5 The Evolution of Culture

The evolution of group's culture is governed by a change of the common practice, x_t, between generations, that reflects the absorption of new practices discovered in the process of adaptation through individual learning and its gradual propagation in the group.

Individuals of a generation t, during their childhood learn the common practice, x_t, which is formed under the influence of the adult population of the previous generation $t-1$. The common practice, x_t, reflects both the behaviour of generation $t-1$'s adults that do not engage in individual learning or do not succeed in it and thus follow the common practice of the previous generation, x_{t-1}, as well as those who perform adaptation successfully and discover a new practice, $x(e)$.

In particular, the common practice, x_t, is assumed to be a population weighted average of the two types of behaviour observed in the population: x_{t-1} and $x(e)$. Given that a share μ_{t-1} of individuals engage in adaptation via individual learning and share p out of them succeeds, the common practice, x_t, evolves according to the following difference equation:

$$x_t = (1-\mu_{t-1}p)x_{t-1} + \mu_{t-1}px(e) \equiv \psi(\mu_{t-1}, x_{t-1}; x(e)) \tag{26}$$

2.6 Co-Evolution of Culture and Capacity for Adaptation

The joint evolution of predisposition to adaptation through individual learning and culture in an environment e, $\{\mu_t, x_t\}_{t=0}^{\infty}$, is governed by the two dimensional dynamic system, as follows from (25) and (26):

$$\begin{cases} \mu_t = \phi(\mu_{t-1}, x_t; x(e)) \\ x_t = \psi(\mu_{t-1}, x_{t-1}; x(e)) \end{cases} \tag{27}$$

where the initial conditions, (μ_0, x_0), are given.

The trajectory of the joint evolution of capacity for adaptation and culture and their steady-state equilibria are affected, among other things, by their initial conditions and the environment e.

2.6.1 Phase Diagram

The global joint evolution of predisposition towards adaptation via individual learning in the population and group's culture in an environment e, $\{\mu_t, x_t\}_{t=0}^{\infty}$, is derived based on the phase diagram of the dynamical system.

The '$\Delta\mu_t = 0$' Locus

Let the '$\Delta\mu_t = 0$' Locus be the geometrical place of all pairs, (x_t, μ_t), with $\mu_t \in [0;1]$ such that $\Delta\mu_t \equiv \mu_{t+1} - \mu_t = 0$. As follows from (25),

$$\Delta\mu_t = 0 \Leftrightarrow \begin{cases} x_t = x(e) & \& \quad \forall \mu_t \\ \forall x_t & \& \quad \mu_t = 0 \\ \forall x_t & \& \quad \mu_t = 1. \end{cases} \tag{28}$$

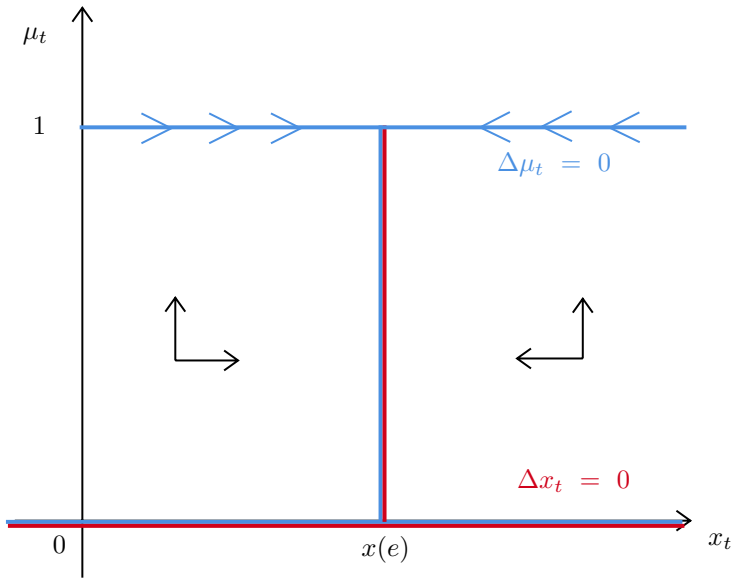


Figure 1: Phase Diagram

Hence, as depicted in Figure 1, the '$\Delta\mu_t = 0$' Locus in the plain (x_t, μ_t) consists of (i) the vertical $[0;1]$ segment intersecting x-axis at a $(x(e), 0)$ point, (ii) the entire x-axis and (iii) the horizontal line intersecting y-axis at a $(0, 1)$ point. Moreover, as follows from (25) and as depicted by the upwards arrows of motion in the Figure 1, for all (x_t, μ_t) that are not on the '$\Delta\mu_t = 0$' Locus, $\Delta\mu_t > 0$.

The '$\Delta x_t = 0$' Locus

Let the '$\Delta x_t = 0$' Locus be the geometrical place of all pairs, (x_t, μ_t), with $\mu_t \in [0;1]$ such that $\Delta x_t \equiv x_{t+1} - x_t = 0$. As follows from (26),

$$\Delta x_t = 0 \quad \Leftrightarrow \quad \begin{cases} x_t = x(e) & \& \quad \forall \mu_t \\ \forall x_t & \& \quad \mu_t = 0. \end{cases} \tag{29}$$

Hence, as depicted in Figure 1, the '$\Delta x_t = 0$' Locus in the plain (x_t, μ_t) consists of (i) the vertical $[0;1]$ segment intersecting x-axis at a $(x(e), 0)$ point and (ii) the entire x-axis. Moreover, as follows from (26) and as depicted by the horizontal arrows of motion in the Figure 1, for all (x_t, μ_t) that are not on '$\Delta x_t = 0$' locus:

$$\begin{cases} \Delta x_t < 0 \iff x_t > x(e) \\ \Delta x_t > 0 \iff x_t < x(e). \end{cases} \tag{30}$$

In addition, for all (x_t, μ_t) where $\mu_t = 1$, as follows from (26), $x_{t+1} = x(e)$.

2.6.2 Steady States

The dynamic system is characterized by two sets of steady states, where both $\Delta x_t = 0$ and $\Delta \mu_t = 0$ (i.e., where both loci intersect):

1. (x_t, μ_t) such that $\mu_t = 0$;
2. (x_t, μ_t) such that $\mu_t \in [0; 1]$ and $x_t = x(e)$.

Given the dynamic forces, described in the previous subsection and depicted on Figure 1, steady states of type 1 can only be reached if $\mu_0 = 0$, otherwise the system converges to one of the steady states of type 2. In particular, for all initial conditions, (x_0, μ_0), such that $\mu_0 > 0$, the dynamic system ultimately convergence to a point $(x(e), \mu_\infty)$. An important proposition can be made.

Proposition 1. $\forall\, \mu_0 \in (0; 1)$, *in the steady state* $\mu_\infty > \mu_0$.

Proof The proposition follows directly from the upward force affecting the dynamics of μ_t off the '$\Delta \mu_t = 0$' locus.

2.7 Changes in the Environment and Evolution of Capacity for Adaptation

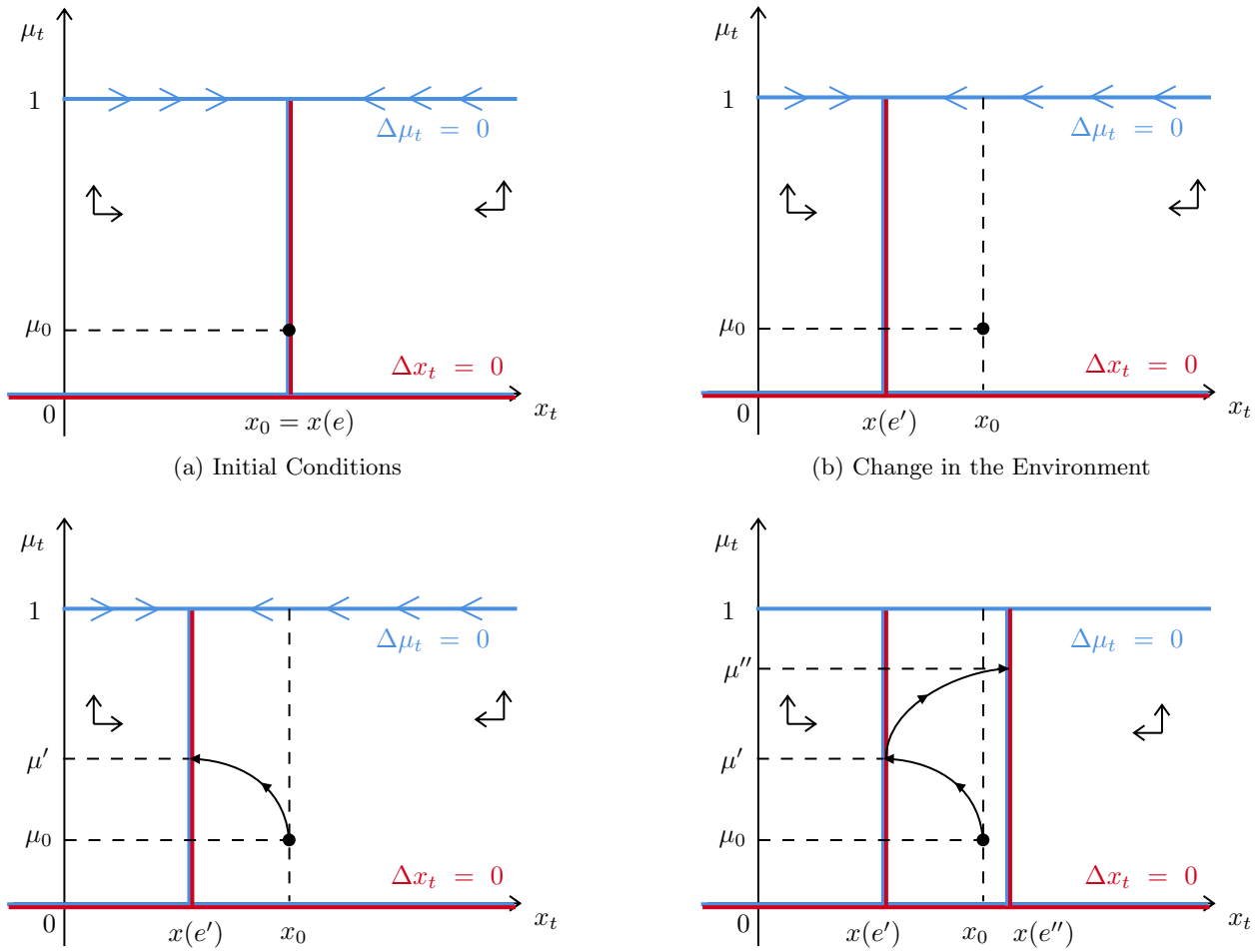
This section explores the effect of the changes in the environment on the co-evolution of culture and predisposition towards adaptation via individual learning within the theoretical framework established above.

2.7.1 Single Change in the Environment

Consider a system with initial conditions $(x(e), \mu_0)$ and $\mu_0 \in (0; 1)$. As depicted on Figure A.1b The system is in the steady state starting from period $t = 0$. Intuitively, the cultural norm, x_0, is equal to its environmental optimum, $x(e)$, and there is no need for cultural evolution, and thus individual learning grants no comparative advantage.

In period $t' > 0$, the environment changes to e', such that $x(e') \neq x(e)$. As illustrated on Figure 2b the system is no longer in the steady state, and is affected by the dynamical forces that move x_t towards $x(e')$ and push μ_t upwards. In terms of model intuition, once the environment changes (e.g., due to migration into unfamiliar conditions) there emerges a demand for cultural evolution and adaptation through individual learning.

During the periods after the change, $t > t'$, the system is affected by the dynamic forces as depicted on Figure 2c and gradually convergence to a new steady state $(x(e'), \mu')$, where by Proposition 1, $\mu' > \mu_0$. Intuitively, once there is a need for cultural evolution, some individuals begin to engage in adaptation through individual learning and gain the comparative advantage within the group. This forces the culture to adapt to a new environment and reach an optimal level, while the share of individual with greater capacity for adaptation in the group's population, μ_t, increases.



(a) Initial Conditions

(b) Change in the Environment

(c) Convergence to a new Steady State

(d) Serial Changes in the Environment

Figure 2: Changes in the Environment and Evolution of Individual Learning

Proposition 2. *Changes in the environment, e, lead to an increase in the share of individuals with higher capacity for adaptation, μ_t, in the steady state.*

Proof The proposition follows directly from Proposition 1, as demonstrated in the subsection above.

2.7.2 Serial Changes in the Environment and Cumulative Effect

Consider an example described above in the period $t'' > t'$, after the $(x(e'), \mu')$ steady state has been reached. In period t'', the environment changes again to e'', such that $x(e'') \neq x(e')$ (this does not exclude the case $x(e'') = x(e)$). As illustrated on Figure 2d, like before the system is no longer in the steady state, and is affected by the dynamical forces that move x_t towards $x(e'')$ and push μ_t upwards. The system gradually convergence to a new steady state $(x(e''), \mu'')$, where by Proposition 1, $\mu'' > \mu' > \mu_0$. In terms of model intuition, the second, and thus all consecutive changes of the environment generates similar forces of cultural evolution that create demand for

adaptation via individual learning and further increase the share of individuals with higher capacity for adaptation in the group.

Proposition 3. *Serial changes in the environment, e, lead to a cumulative effect, increasing the share of individuals with higher capacity for adaptation, μ_t, in the steady state.*

Proof The proposition follows directly from Proposition 1 and 2, as demonstrated in the subsection above.

2.7.3 Comparative Dynamics

Consider two systems with identical initial conditions $(x(e), \mu_0)$ such that $\mu_0 \in (0; 1)$. Both systems reside in the steady state starting from period $t = 0$. In period $t' > 0$ the environment in one system changes to e' and in the other to e'', such that $|x(e'') - x(e)| > |x(e') - x(e)| > 0$. As depicted on Figure 3, both systems are no longer in the steady state, and are affected by the dynamical forces that move x_t to the corresponding optimal levels, while μ_t is being pushed upwards in both cases. Systems gradually convergence to a corresponding steady states of $(x(e'), \mu')$ and $(x(e''), \mu'')$. By Proposition 4, in the steady state $\mu'' > \mu'$.

Proposition 4. *The greater is the change in the environment, e, the greater is the steady state share of individual learners, μ_∞.*

$$\frac{d\mu_\infty}{d|\Delta x(e)|} > 0 \tag{31}$$

Proof (Appendix A).

Proof of Proposition 4 and quantitative simulation of comparative dynamics of the model are presented in Appendix A.

Intuitively, higher change in the environment generates greater potential comparative advantage that can be exploited by engaging in adaptation through individual learning, which ultimately results in higher share of individuals with greater capacity for adaptation in the group's population in the steady state.

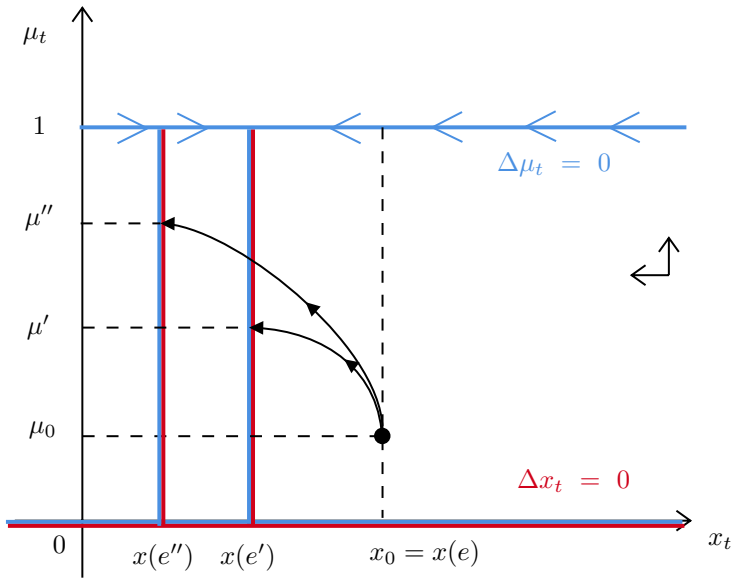


Figure 3: Comparative Dynamics: Changes in the Environment

2.8 Testable Predictions

Results with respect to the effect of environmental changes on the evolution of predisposition towards adaptation through individual learning, demonstrated in Section 2.7 and stated in Propositions 2, 3 and 4, can be summarized in a form of testable predictions:

1. Changes in the environment lead to the increase in the predisposition towards adaptation via individual learning in the population (i.e., the effect is present along the extensive margin).

2. The effect of the environmental changes on capacity for adaptation is cumulative: every change in the environment increases the predisposition towards adaptation via individual learning in the population.

3. The greater is the change in the environment the greater is the increase in the predisposition towards adaptation (i.e., the effect is present along the intensive margin).

Thus, the theory suggests that societies that were subjected to a greater changes in the environment accumulated in the course of the history of their ancestors, would be characterized by a greater capacity for adaptation through individual learning.

3 Empirical Strategy and Data

This section presents the empirical strategy developed to analyze the effect of the historic environmental changes on contemporary variations in the capacity for adaptation. Moreover, it describes the global measure of the environmental changes accumulated in the course of historic migrations designed to capture the change in the environment, which individual's linguistic ancestors were subjected to, as well as a range of proxies of preference for adaptation via individual learning and measures of adaptation to unfamiliar cultural environment at the individual, linguistic group and ethnic group level.

3.1 Identification Strategy

The empirical analysis surmounts significant hurdles in the identification of the causal effect of accumulated environmental change on the evolution of propensity towards adaptation through individual learning. In particular, the research adopts an empirical strategy that is designed to mitigate concerns about the potential role of reverse causality, selection, and omitted variables, in the observed association between historic environmental changes and adaptability.

First, potential concerns about the role of omitted geographical, institutional, cultural, and human characteristics in the observed association between the historic environmental changes and predisposition towards adaptation are mitigated by accounting for a large set of confounding characteristics that might have affected the evolution of adaptability and are correlated with accumulated environmental change. In particular the analysis accounts for: potentially confounding effects of geographical characteristics (e.g., productivity of major food crops, numerous climatic characteristics of the environment, elevation and ruggedness); (ii) regional fixed effects, capturing unobserved time-invariant heterogeneity at the regional level; (iii) individual characteristics (e.g., age, gender, number of siblings, religion, education, and income); (iv) year or wave of survey fixed effect that capture global, time specific characteristics of the environment. In addition, the identifying variation in the historic environmental changes on the level of a linguistic group, rather than country, allows to account for country or sub-national region of residence fixed effects which reflect unobserved time-invariant heterogeneity at that level. Moreover, the selection on unobservables analysis, performed in the study following the methodology of Altonji et al. (2005) and Oster (2014), allows to examines the likelihood that omitted variables could alter the qualitative findings.

Second, the adoption of the epidemiological approach, whenever the determinants of propensity towards adaptation through individual learning are explored among first-, second- and/or higher-generation migrants permits the analysis to overcome two major concerns: (i) it distinguishes between the effect of historic accumulated environmental change in the ancestral linguistic homeland (rather than those in region of residence) on capacity for adaptation, capturing the culturally-embodied, intergenerationally-transmitted component of the effect of historic environments, rather than the direct effect of geography; (ii) it accounts for time invariant unobserved heterogeneity

in the host country as well as the country of origin (e.g., geographical, cultural and institutional characteristics), and thus mitigates possible concerns about the confounding effect of country-specific characteristics.

Third, to alleviate concerns that the selective migration of individuals with greater propensity towards individual learning governs the observed association between the environmental change accumulated in the course of historic migrations and capacity for adaptation, the study exploits the "random assignment" of the historic environmental change caused by the introduction of new, potentially more productive crops in the course of the Columbian Exchange to identify the impact of environmental changes on the preference for adaptation via individual learning and observed level of adaptation to unfamiliar environment. This quasi natural experiment further mitigates concerns about the confounding effects of unobservable geographical factors in the linguistic homeland, while demonstrating the importance of evolutionary processes in the post-1500 period in the formation of capacity for adaptation.

Fourth, to further strengthen the identification of the mechanism that governs the association between the evolution of adaptability and historic environmental changes, numerous placebo tests are conducted. In particular, the analyses explores: (i) the association between the predisposition towards adaptation and the migratory distance from the origin of the historic migration, rather than the environmental change accumulated in the course of this migration, to illustrate that it is precisely the change in the environment rather than the distance of migration that affects the evolution of capacity for adaptation; (ii) the effect of the environmental change accumulated in the course of migration from the placebo origins on adaptability to demonstrate that the evolution of predisposition towards adaptation is affected precisely by the environmental change that occurred in the course ancestral migrations rather than by accumulated environmental change calculated from placebo origins unrelated to those migration; (iii) the effects of the environmental change accumulated in the course of migration on the preference for individual learning and the level of cultural adaptation across placebo language groups (e.g., non-Indo-European speakers in the case of Indo-European expansion as a source of migrations) to show that the environmental change accumulated in a course of specific migrations have no effect on the preference of individuals from language groups that are unrelated to them; (iv) the association between the accumulated environmental change and cultural traits unrelated to adaptability to establish that the effects of the historic environmental changes on the predisposition towards adaptation does not capture its effect on a wide range of other cultural characteristics.

3.2 Dependent Variable: Proxies for Capacity for Adaptation

Adequately capturing variation in the predisposition towards adaptation poses a significant challenge due to the absence of previously established proxies. To overcome this difficulty several novel measures of preference for individual learning as well as measures that capture the manifestation of adaptability in the observed individual behaviour are proposed in this subsection.

3.2.1 Proxies for Preference for Adaptation through Individual Learning

This subsection introduces a variety of novel proxy measures that capture variations in the prevalence and the distribution of preference for adaptation via individual learning across individuals, exploiting European Social Survey (ESS) and General Social Survey (GSS).

Exploiting the ESS the preference for individual learning is captured by individual's valuation of the importance of thinking up new ideas, being creative and doing things in her/his own original way. Importantly, since adaptation through individual learning implies the departure from common behavioural conventions in search of novel, previously unknown practices, the importance of original thinking and creativity adequately represents propensity towards individual learning. The measure is available for 168383 individuals who speak one of Indo-European languages including 18907 first-generation and 11736 second-generation migrants. Moreover, several alternative proxies are introduced based on the ESS, that also reflect preference for adaptation through individual learning: (i) the valuation of the importance of trying and doing new, different things; (ii) the valuation of importance to make own decisions about life and being free; (iii) the inverse of of evaluation of the believe that people should always follow rules and do what is told.

In addition, exploiting the GSS the preference for adaptation through individual learning is captured by individual's evaluation of specific characteristics one's child should acquire to be prepaid for her or his adult life. In particular, the proxy measure for the propensity towards adaptation via individual learning is based on the preference for child ability to thinks for ones self over child's obedience, which represents individual's own valuation of the importance of individual learning in life. The measure is available for 9574 individuals of Indo-European origin including 1031 first-generation, 984 second-generation and 2628 third-generation migrants.

3.2.2 Measures of Cultural Adaptation of Migrants

This subsection describes a measure that will be used to capture the manifestation of capacity for adaptation in the observed individual behaviour. In particular, measures that reflect migrant's level of adaptation to an unfamiliar cultural environment of a host country are used to reflect their predisposition towards adaptation in general.

The level of adaptation of first-, second- or higher-generation migrant i to the cultural environment of country or sub-national region of residence c, CA_{ic}, is calculated according to

$$CA_{ic} = -\frac{1}{K}\sum_{k=1}^{K}\left|\bar{q}_c^k - q_i^k\right|, \tag{32}$$

where q_i^k is the ordinal level of cultural trait k of migrant i, $\bar{q}_c^k$ is the simple average level of a cultural trait k in host country or region c and K is the total number of traits used. The measure captures the opposite of an average absolute distance across a number of ordinal cultural traits between an individual migrant and the population of a host country or region on average and thus represents the degree of migrant's adaptation to local culture. The

measure is equal to zero if all of the migrant's cultural traits are identical to the population average in the host country or region and is negative otherwise, decreasing with the cultural distance between the migrant and the local population.

The specific cultural characteristics used in the construction of the measure of cultural adaptation are chosen to: (i) reflect a broad spectrum of preferences, beliefs and norms regarding human cooperation, altruism, family, religion, attitudes towards government, work and gender roles, as well as other human values capturing culture in a broad sense; (ii) cover a large part of the survey respondents. The choice of the traits that reflects broad culture in the GSS is made closely following the methodology of Giavazzi et al. (2019), while culture in the ESS is represented by the measures of the "Human Values" module of the survey. The individual cultural traits are fully reported and summarized in Appendix C.

3.3 Independent Variable: Accumulated Environmental Change

This section describes the measures that will be used to analyse the impact of the historic changes in the ancestral environment on capacity for adaptation. In particular, the variations in the global distribution of: (i) changes across a wide variety of environmental characteristics accumulated in the process of ancestral migrations; (ii) changes in the agricultural productivity due to the introduction of new, potentially more productive crops in the course of the Columbian Exchange are exploited to reflect the historic environmental changes which, in light of the predictions of the theory, affect the evolution of predisposition towards adaptation.

3.3.1 Accumulated Environmental Change: Indo-European Expansion

A novel measure of the accumulated environmental change is constructed to capture the changes in the environmental conditions that gradually occurred during the migrations of humans in the process of the Indo-European expansion, a historic event that had started around 4000 BCE and resulted in a massive spread of people, language and culture across the Eurasia.

The construction of the measure of the environmental change accumulated in the course of Indo-European expansion is based upon three major elements:

1. The geographic origin of Indo-European expansion that captures the source of the migrations;
2. The migration paths potentially taken by the proto-Indo-Europeans in the course of the expansion;
3. The measure that captures various characteristics of the environment.

The geographic origin of the Indo-European expansion is identified following the well-established *Steppe*, also know as *Kurgan* hypothesis. Based on the archaeological, genetic and linguistic evidence (e.g., Klejn, 2017; Haak et al., 2015; Anthony and Ringe, 2015) the origin of the expansion is placed in the steppe ecoregion in the modern

southern Ukraine and Russia populated at the time prior to the expansion by the Khvalynsk and Don-based Repin cultures and later by the Yamnaya culture which are considered to represent proto-Indo-Europeans (Anthony, 2010). Following the hypothesis, for the purposes of this study the geographic region of the expansion's origin is captured by the ecologically homogeneous region of Pontic–Caspian steppe identified using the data of Global Agro-Ecological Zones (GAEZ) project of Food and Agriculture Organization of the United Nations (FAO).

The potential migration paths of the Indo-European expansion are constructed based on the least cost path methodology, that generates the path connecting a specified origin to the destination point, while minimizing a given measure of traveling cost along the path. The ecoregion of Pontic–Caspian steppe, that captures the source of Indo-European expansion as discussed above, is used as an origin region. The costs of traveling are reflected by the Human Mobility Index (HMI), a measure developed in Özak (2018, 2010) to capture the potential time cost of travel accounting for human biological constraints, as well as geographical and technological factors that determined travel time before the widespread use of steam power. As a result, for any given destination point the least cost path produces a set of adjacent $5' \times 5'$ cells that connects it to the origin of Indo-European expansion and reflects a potential migration path of proto-Indo-Europeans.

To reflect the changes in the environment along the potential migration path the variation in the first principal component of climatic, agricultural and geographical dimensions is utilized. The first principal component is constructed to capture the maximum amount of variation of: (i) agricultural productivity of major food crops (i.e., cereals, roots and tubers); (ii) 19 various climatic characteristics as documented by WorldClim database (e.g., annual mean temperature and precipitation, seasonality, etc); (iii) elevation and ruggedness, all of which are re-scaled to have the same dimension of $5' \times 5'$.[11] As a consequence, changes in the level of this principal component along the migration path represent shifts in the major characteristics of the environment, which proto-Indo-Europeans were subjected to in the course of the expansion. The distribution of the first principal component, the origin of Indo-European expansion according to Steppe hypothesis and an example of the least cost path from the source of the migrations to a geographical location of Paris are depicted on Figure 4.

Ultimately, for any geographic location i the Accumulated Environmental Change in the course of migration from the Indo-European origin, AEC_i, is calculated as

$$AEC_i = \sum_{p_i^k \in P_i} \frac{\left| PC(p_i^{k+1}) - PC(p_i^k) \right|}{PC(p_i^k)}, \tag{33}$$

where $P_i = \{p_i^0, \ldots, p_i^k, \ldots, p_i^K\}$ is the least cost path from the Indo-European origin to location i composed of a set of K adjacent $5' \times 5'$ cells, p_i^k, and $PC(p_i^k)$ represents the first principal component of environmental variables in the cell p_i^k. The measure of accumulated environmental change, AEC_i, is equal to zero if the first principal component is equal across all cells of the least cost path and is positive otherwise, increasing with the difference between any

[11] The environmental characteristics are described in detail in Appendix C.

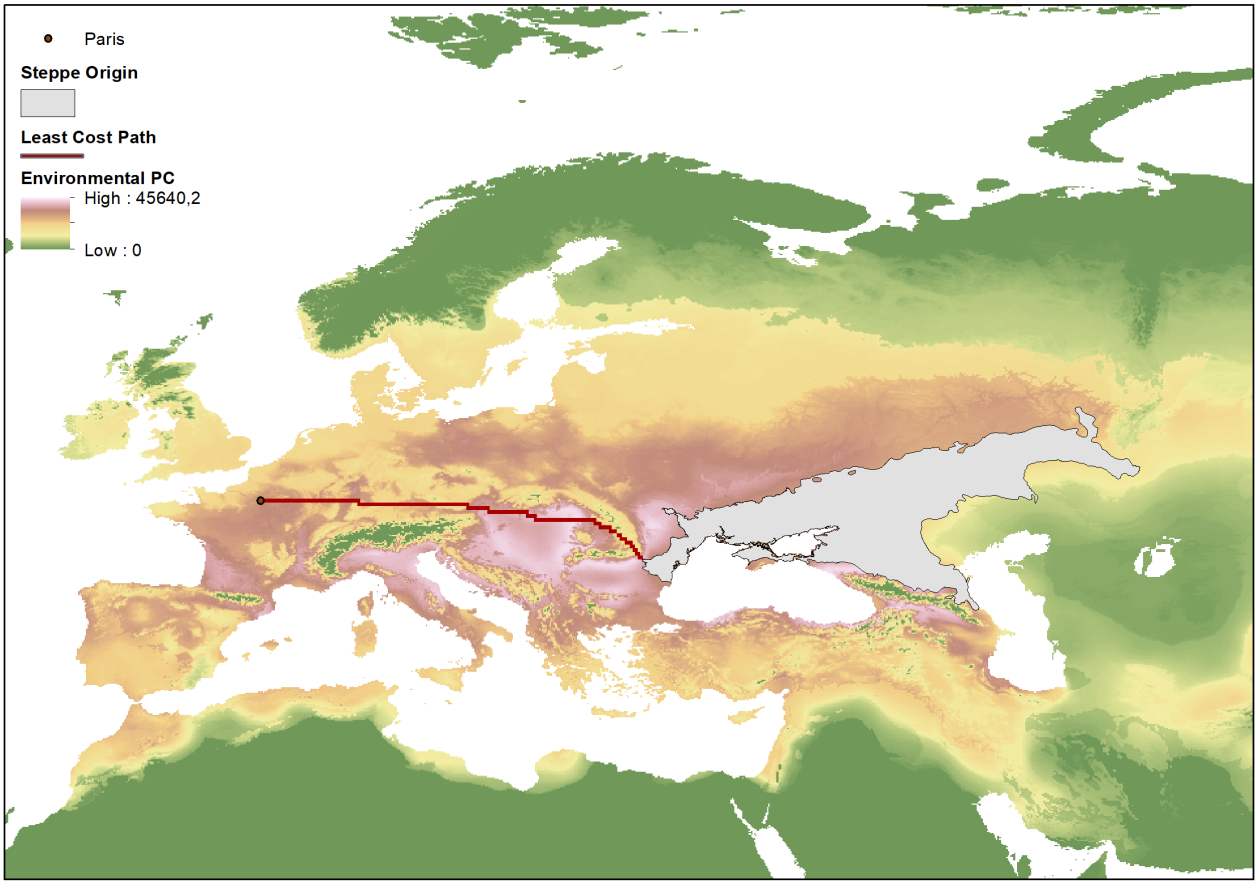


Figure 4: Indo-European Origin, Potential Expansion Path and Environmental Principal Component

two sequential cells of the path. The measure is constructed for each grid cell in Eurasia, and aggregated from a grid-level to a level of linguistic homelands as documented in Ethnologue Atlas.

3.3.2 Environmental Change: the Columbian Exchange

This subsection describes an additional measure that will be used to analyse the impact of the changes in the ancestral environment on the predisposition towards adaptation. In particular, the change in the potential agricultural productivity due to the introduction of new, potentially more productive crops in the course of the Columbian Exchange is used to exploit the implications of this natural experiment on the evolution of adaptability.

Following the methodology of Galor and Özak (2016) the potential agricultural productivity before the year 1500 (i.e., prior to the Columbian Exchange) is captured by the maximal potential caloric yield of food crops native to a particular location and grown under the low levels of input and rain-fed irrigation, based on the data provided by the GAEZ project of FAO. The calculation of the potential agricultural productivity after the year 1500 follows the same methodology and is based on the whole set of food crops available after the Columbian Exchange. The difference between the pre-1500 and post-1500 productivity captures the quasi-randomly assigned change in the ancestral environment and is utilized in the analysis to identify the effect of historic environmental change on the evolution of individual learning. The measure is constructed for each $5' \times 5'$ grid cell, and aggregated from a grid-level to a level of linguistic homelands.

4 Empirical Analysis: Indo-European Speakers in Europe

This section analyzes the effect of the environmental change accumulated in the course of ancestral migrations on the preference for adaptation through individual learning across Indo-European speakers in Europe, as well as on the Indo-European language speaking migrants' ability to adjust to an unfamiliar cultural environment. In particular, it analyzes the effect of the accumulated environmental change (AEC) on the valuation of the importance of creativity and new ideas as reported in the European Social Survey (ESS), and on the level of adaptation of first- and second-generation migrants to the host country culture, calculated based on the ESS. The analysis of Indo-European language speakers accounts for time invariant unobserved heterogeneity in the country of residence (e.g., geographical and institutional characteristics). Moreover, whenever the analysis is conducted on the sample of first- and/or second-generation migrants, since the accumulated environmental change in the country of origin is distinct from that of the country of residence, the estimated effect of the accumulated environmental change in the country of origin captures the culturally-embodied, intergenerationally-transmitted effect, rather than the direct effect of geography. The effect of the accumulated environmental change on the capacity for adaptation is

estimated via ordinary least squares (OLS) according to the following specification

$$IL_{ilct} = \beta_0 + \beta_1 AEC_l + \sum_c \gamma_c \delta_{ic} + \sum_p \gamma_p \delta'_{ip} + \sum_j \gamma_{1j} X_{lj} + \sum_j \gamma_{2j} Z_{ij} + \sum_t \gamma_t \tau_{it} + \epsilon_i \tag{34}$$

where IL_{ilct} captures preference for adaption via individual learning of individual i of Indo-European language group l in country c measured in wave t, AEC_l is the accumulated environmental change measured for the homeland of language l, X_{lj} is geographical characteristic j of the homeland of the language l, Z_{ij} is characteristic j of individual i (age, gender, number of siblings, religion, education level, income), δ_{ic} is the country of residence fixed effect of individual i, δ'_{ip} is the country of origin p fixed effect of individual i (i.e., applicable only to migrants), τ_{it} is the round of survey fixed effect for individual i observed in the survey of wave t and ϵ_i is the error term. The theory predicts positive effect of the accumulated environmental change (i.e., $\beta_1 > 0$). The effect of the accumulated environmental change on the level of cultural adaptation is estimated according to the specification similar to (34) with outcome variable IL_{ilct} capturing the inverse of the cultural distance of migrant i of language group l from the culture of the country of residence c measured in wave t. Once again, the positive effect of the accumulated environmental change is predicted.

4.1 Determinants of Predisposition Towards Individual Learning among Individuals

This subsection analyzes the effect of the accumulated environmental change on the Indo-European language speakers valuation of the importance of creativity and new ideas, in light of the conjectured positive association between preference for creativity and new ideas and predisposition towards adaptation through individual learning. The effect of the accumulated environmental change is estimated via ordinary least squares (OLS) using the empirical model (34).

Table 1 establishes the positive and highly significant effect of the accumulated environmental change on the valuation of the importance of creativity and new ideas as suggested by the theory. The estimated effect implies that increasing the accumulated environmental change in the linguistic homeland by one standard deviation increases individual's valuation of creativity and new ideas importance between 0.14 and 0.08 units.[12]

The univariate relationship between the accumulated environmental change and preferences for creativity and original thinking is demonstrated in column (1). The estimated effect is positive and statistically significant at the 1% level, implying economically significant effects suggested by the theory. Results reported in column (2) are estimated accounting for the country of residence fixed effects and therefore are robust to unobserved time-invariant omitted variables at the country of residence level. The effect remains to be statistically significant at the 1% level.

[12]The importance of creativity and new ideas is evaluated by the scale from 1 to 5.

Table 1: Determinants of Preference for Adaptation through Individual Learning: Individuals in Europe

	Importance of Creativity and New Ideas					
	(1)	(2)	(3)	(4)	(5)	(6)
Accumulated Env. Change	0.143***	0.115***	0.116***	0.093***	0.079***	0.081***
	(0.048)	(0.017)	(0.018)	(0.013)	(0.011)	(0.010)
Country of Residence FE	No	Yes	Yes	Yes	Yes	Yes
Round FE	No	No	Yes	Yes	Yes	Yes
Individual Controls	No	No	No	Yes	Yes	Yes
Geographic Controls	No	No	No	No	Yes	Yes
Country of Origin FE	No	No	No	No	No	Yes
Adjusted-R^2	0.01	0.05	0.05	0.08	0.08	0.08
Observations	168097	168097	168097	168097	168097	168097

Notes: This table establishes that individual's valuation of importance of creativity and new ideas is positively affected by the accumulated environmental change in the course of migration of linguistic ancestors. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

Columns (3) and (4) sequentially account for survey round fixed effects and Indo-European speakers individual characteristics (i.e., age, gender, number of siblings, religion, education level, and income). Column (5) considers potentially confounding effects of geographical characteristics including agricultural productivity of main food crops, numerous climatic dimensions (e.g., mean temperature, precipitation, seasonality etc), elevation and ruggedness. Finally, the results of full specification (34) estimation are reported in column (6), which among other controls, accounts for country of origin fixed effects where applicable.[13] Reassuringly, the effect of accumulated environmental change on preference for individual learning is statistically significant at the 1% level throughout. In addition, the coefficient is remarkably stable in terms of absolute values across all specifications.

4.1.1 Determinants of Predisposition Towards Individual Learning among Migrants

This subsection studies the effect of the accumulated environmental change on the first- and second-generation migrants valuation of the importance of creativity and new ideas. The effect of the accumulated environmental change is estimated using the empirical model (34) separately on the samples of first- and second-generation migrants who speak Indo-European languages.

As demonstrated in Tables 2 and B.1 respectively second- and first-generation migrants valuation of the importance of creativity and new original ideas is positively affected by the accumulated environmental change of linguistic ancestors. The effects are statistically significant at 1% or 5% level in both samples and across numerous specifications that sequentially account for: (i) country of residence fixed effects, (ii) round of survey fixed effects, (iii) individual controls (i.e., age, gender, income, education level), (iv) potentially confounding effects of geographic

[13]Country of origin fixed effects take non trivial values for the first- and second-generation migrants in the sample, while all natives are categorized as one group.

characteristics (e.g., agricultural productivity, climate, elevation and ruggedness) and (v) country of origin fixed effects.

Table 2: Determinants of Preference for Adaptation through Individual Learning: Second Generation Migrants in Europe

	Importance of Creativity and New Ideas					
	(1)	(2)	(3)	(4)	(5)	(6)
Accumulated Env. Change	0.187**	0.098***	0.099***	0.078***	0.063**	0.077***
	(0.074)	(0.022)	(0.021)	(0.018)	(0.027)	(0.024)
Country of Residence FE	No	Yes	Yes	Yes	Yes	Yes
Round FE	No	No	Yes	Yes	Yes	Yes
Individual Controls	No	No	No	Yes	Yes	Yes
Geographic Controls	No	No	No	No	Yes	Yes
Country of Origin FE	No	No	No	No	No	Yes
Adjusted-R^2	0.02	0.07	0.07	0.09	0.09	0.09
Observations	11536	11536	11536	11536	11536	11536

Notes: This table establishes that second generation migrant's valuation of importance of creativity and new ideas is positively affected by the accumulated environmental change in the course of migration of linguistic ancestors. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

4.1.2 Alternative Proxies for Predisposition towards Individual Learning

This subsection analyses the effect of the accumulated environmental change on the alternative proxies measures of the propensity towards adaptation through individual learning across Indo-European speakers in Europe in general and migrants in particular.

Table 3 documents that the environmental change accumulated in the course of linguistic ancestors' migrations has: (i) positive and highly significant effect on the individuals' valuation of the importance to try new and different things in life (columns 1 and 2), (ii) positive and highly significant effect on the importance of making own decisions (columns 3 and 4), (iii) negative and highly significant effect on the importance of following rules and doing what is told (columns 5 and 6). The effects are statistically significant at 1% and 5% and are comparable to the baseline estimates in terms of absolute magnitude.

4.2 Determinants of the Level of Cultural Adaptation among Migrants

This subsection examines the effect of accumulated environmental change on the Indo-European language speaking migrants' level of adaptation to local culture. The effect is estimated via ordinary least squares (OLS) using the

Table 3: Determinants of other Measures of Preference for Adaptation through Individual Learning: Individuals and Migrants in Europe

	Important to:					
	Try Different Things		Make Own Decisions		Follow Rules	
	(1) All	(2) Migrants	(3) All	(4) Migrants	(5) All	(6) Migrants
Accumulated Env. Change	0.059***	0.042**	0.050***	0.048***	-0.073***	-0.055***
	(0.015)	(0.019)	(0.009)	(0.010)	(0.018)	(0.016)
Country of Residence FE	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.06	0.06	0.06	0.05	0.07	0.06
Observations	168383	30109	168611	30138	167583	29978

Notes: This table establishes that individual's and migrant's valuation of the importance of trying new and different things in life and making own decisions are positively affected by the accumulated environmental change of linguistic ancestors, while the valuation of the importance of following rules and doing what is told is negatively affected by the same measure. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

model analogous to (34).

Table 4 demonstrates a positive significant effect of accumulated environmental change on first-generation migrants' level of adaptation to local culture. In particular, Columns (1) through (5) demonstrate the effect of historic changes in the environment on the inverse of distance between migrant and local population across a number of cultural traits, sequentially accounting for the confounding effects of unobserved time-invariant omitted variables at the country of residence level, survey round fixed effects and individual characteristics of a migrant (e.g., age, gender, education level, and income) and geographical characteristics at the linguistic homeland level (e.g., agricultural productivity, climate, elevation and ruggedness). The estimated effects imply that increasing the accumulated environmental change in the linguistic homeland by one standard deviation increases the observed level of cultural adaptation by $4\% - 5\%$.[14] It should be noted that coefficients are remarkably stable across specifications and statistically significant at the 1% level throughout.

In addition, as established in Table B.2, similar positive significant effect of accumulated environmental change on the level of cultural adaptation is present among the Indo-European speaking second-generation migrants in Europe. The effect is estimated across the same set of specifications and is consistently significant at 1% or 5% level and is extremely stable in its absolute magnitude.

[14]The measure of cultural adaptation takes values from 0 to 1.

Table 4: Determinants of Adaptation to Local Culture: First Generation Migrants in Europe

	Level of Cultural Adaptation				
	(1)	(2)	(3)	(4)	(5)
Accumulated Env. Change	0.045***	0.043***	0.043***	0.043***	0.041***
	(0.014)	(0.009)	(0.009)	(0.009)	(0.012)
Country of Residence FE	No	Yes	Yes	Yes	Yes
Round FE	No	No	Yes	Yes	Yes
Individual Controls	No	No	No	Yes	Yes
Geographic Controls	No	No	No	No	Yes
Adjusted-R^2	0.03	0.22	0.22	0.22	0.24
Observations	18907	18907	18907	18907	18907

Notes: This table establishes that first generation migrant's level of adaptation to local culture is positively affected by the accumulated environmental change in the course of migration of linguistic ancestors. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

4.3 Natural Experiment: The Columbian Exchange

This section exploits the "random assignment" of the environmental change caused by the introduction of new, potentially more productive crops in the course of the Columbian Exchange to identify the impact of historic environmental change on the capacity for adaptation, addressing potential concerns of selective migration of individuals with greater preference for adaptation via individual learning. The findings suggest that historic changes in the environment indeed have a positive effect on the predisposition towards adaptation.

The arrival of potentially more productive crops in the course of the Columbian Exchange, had introduced an additional change in the ancestral environment in terms of agriculture. Hence, this quasi natural experiment generated exogenous variation in the change of the environment in each region, permitting the identification of the impact of the historic environmental change. The identifying assumption is that, conditional on the pre-1500 distribution of potential agricultural productivity, the change in potential productivity resulting from the introduction of new crops is distributed randomly, independently of any other attributes of the grid.

As presented in Table 5, the predisposition of Indo-European speakers towards adaptation, as captured by their valuation of importance of creativity and new ideas is positively affected by the potential change in crop yield due to the Columbian Exchange. The effect is highly significant both across all Indo-European speaking individuals in general (column 1) and across Indo-European speaking migrants in particular (column 4). Columns (2) and (5) account for the effect of crop yield prior to the exchange. It is important to note, that the importance of creativity and new ideas is not affected by the crop yield prior to the year 1500 (i.e., before the Columbian

Table 5: Determinants of Preference for Adaptation through Individual Learning: Random Assignment of Envrionemntal Change

	Importance of Creativity and New Ideas					
	All Individuals			Migrants		
	(1)	(2)	(3)	(4)	(5)	(6)
Crop Yield (Change)	0.038***	0.039***	0.049***	0.029**	0.034**	0.034***
	(0.012)	(0.013)	(0.012)	(0.011)	(0.014)	(0.013)
Crop Yield (Pre-1500)		0.091	0.126*		0.095	0.099
		(0.078)	(0.065)		(0.088)	(0.074)
Accumulated Env. Change			0.075***			0.059***
			(0.016)			(0.021)
Country of Residence FE	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.10	0.10	0.10	0.12	0.12	0.12
Observations	168097	168097	168097	27424	27424	27424

Notes: This table establishes that individual's and migrant's valuation of the importance of creativity and new ideas is positively affected by the change in the crop yield caused bu the Columbian Exchange and the accumulated environmental change in the course of migration of linguistic ancestors, but is not affected by the level of crop yield prior to the Columbian Exchange. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

Exchange) demonstrating that it is not the agricultural productivity itself but rather its change that affects the propensity towards individual learning as predicted by the theory. Finally, columns (3) and (6) establish that the environmental change due to the Columbian Exchange and the environmental change accumulated in the course of the ancestral migrations reassuringly have a positive and significant effect on the preference for adaptation through individual learning when estimated simultaneously.

Moreover, Table B.3 documents that the level of cultural adaptation of Indo-European speaking migrants is positively and significantly affected by the "randomly assigned" change in the ancestral environment caused by the introduction of new crops in the course of the Columbian Exchange. The effect is statistically significant at 1% level both across first- and second-generation migrants and is robust to potentially confounding effects of: (i) crop yield prior to year 1500, which has no significant effect on the cultural adaptation of migrants, and (ii) accumulated environmental change, which has positive and significant effect on the level of cultural adaptation, consistently with the baseline results. These findings identify the effect of a "random assignment" of environmental change on the evolution of capacity for adaptation and suggests that selective migration played an insignificant role in the determination of adaptability.

4.4 Placebo Tests and Robustness of the Analysis

This subsection establishes that the results are robust to an extensive number of checks. In particular, placebo tests illustrate that: (i) the predisposition towards adaptation across Indo-European languages speakers is not affected by the migratory distance from the origin of Indo-European expansion, (ii) the effect of accumulated environmental change on preference for individual learning is unaffected when accounting for the migratory distance, (iii) accumulated environmental change when calculated from the placebo origins neither affects the propensity towards adaptation through individual learning nor the ability of migrants to adapt to unfamiliar cultures, (iv) the environmental change accumulated in the course of migration from Indo-European origin has no effect on the preference for individual learning and cultural adaptation of non-Indo-European speakers, (v) alternative cultural traits that are unrelated to adaptability are not affected by the accumulated environmental change. In addition, the analysis based on the methodology of Altonji et al. (2005) and Oster (2014) demonstrates that it is highly unlikely that omitted variables could have affected the qualitative results.

4.4.1 Migratory Distance vs. Accumulated Environmental Change

This subsection demonstrates that unlike the environmental change accumulated due to migrations in the course of Indo-European expansion, the migratory distance from the origin of the expansion has no effect on the preference for adaptation via individual learning of Indo-European speakers. Moreover, it establishes that the quantitative effect of accumulated environmental change on the valuation of importance of creativity and new ideas is unchanged when accounting for the potentially confounding effect of migratory distance.

Table 6 shows that migratory distance has no statistically significant effect on the valuation of importance of creativity and original thinking of Indo-European languages speakers in general (column 1), as well as first- and second-generation migrants in particular (columns 3 and 5). In addition, columns 2, 4 and 6 establish that the effect of the accumulated environmental change on the preference for individual learning in all samples is highly statistically significant and remains qualitatively unchanged when controlling for the migratory distance from Indo-European origin. This finding illustrates that it is precisely the change in the environment in the course of migration rather than the distance of migration that affects the evolution of predisposition towards individual learning.

4.4.2 Accumulated Environmental Change from the Placebo Origins

This subsection examines the effect of the environmental change accumulated in the course of migration from the placebo origins (e.g., Berlin, London, Lisbon) on the preference for adaptation through individual learning as well as migrants cultural adaptation. In particular, Tables 7 establishes that neither of the measures of accumulate environmental change from the placebo origins has an effect on the valuation of importance of creativity and

Table 6: Determinants of Preference for Adaptation through Individual Learning: Migratory Distance vs Accumulated Env Change

	Importance of Creativity and New Ideas					
	All Individuals		First G Migrants		Second G Migrants	
	(1)	(2)	(3)	(4)	(5)	(6)
Accumulated Env. Change		0.084***		0.044**		0.072***
		(0.012)		(0.018)		(0.026)
Migratory Distance from the Origin	0.008	-0.010	-0.002	-0.013	0.021	0.015
	(0.012)	(0.009)	(0.027)	(0.028)	(0.021)	(0.018)
Country of Residence FE	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.08	0.08	0.13	0.13	0.09	0.09
Observations	168097	168097	15873	15873	11536	11536

Notes: This table establishes that individual's and migrant's valuation of the importance of creativity and new ideas is positively affected by the accumulated environmental change in the course of migration of linguistic ancestors, but is not affected by the migratory distance. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

new ideas across Indo-European language speaking individuals in general, as well as first- or second-generation migrants in particular. Furthermore, as shown in Table B.5 the ability of Indo-European migrants to adapt to the host country culture are also unaffected by the accumulate environmental change calculated from the placebo origins. These results demonstrate that the evolution of the capacity for adaptation is affected precisely by the environmental change that occurred in the course migration from the origin of the Indo-European expansion as suggested by the Steppe Hypothesis rather than by accumulated environmental change measures calculated from placebo origins unrelated to the expansion of proto-Indo-European culture and people.

4.4.3 Placebo Language Groups: Non-Indo-European Speakers

This subsection analyzes the effects of the environmental change accumulated in the course of Indo-Eropean expansion on the preference for adaptation via individual learning and the level of cultural adaptation across non-Indo-European language speakers. As reported in Table 8, when estimated across non-Indo-European speakers, accumulated environmental change from the origin of Indo-European expansion has no effect on the predisposition towards adaptation through individual learning as captured by valuation of importance of creativity and new ideas. The result is valid when estimated across all non-Indo-European speakers (columns 1 – 3), as well as on the subsamples of non-Indo-European first-generation migrants (columns 4 – 6) and second-generation migrants (columns

Table 7: Determinants of Preference for Adaptation through Individual Learning: Placebo Origins

	Importance of Creativity and New Ideas								
	All Individuals			First G Migrants			Second G Migrants		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Accumulated Env. Change (Berlin)	0.030			-0.011			0.038		
	(0.018)			(0.027)			(0.025)		
Accumulated Env. Change (London)		-0.010			-0.057			-0.007	
		(0.023)			(0.039)			(0.031)	
Accumulated Env. Change (Lisbon)			0.029			-0.007			0.010
			(0.020)			(0.038)			(0.039)
Country of Residence FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.08	0.08	0.08	0.13	0.13	0.13	0.09	0.09	0.09
Observations	168097	168097	168097	15873	15873	15873	11536	11536	11536

Notes: This table establishes that individual's and migrant's valuation of the importance of creativity and new ideas is not affected by the accumulated environmental change calculated from the Placebo Origins, such as Berlin, London or Lisbon. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

7 – 9). Moreover, as demonstrated in Table B.6, the level of adaptation to local culture of non-Indo-European speaking migrants is also unaffected by the environmental change accumulated in the course of migrations from Indo-Eropean origin. These findings illustrate that the environmental changes that occurred due to the Indo-European expansion affect the evolution of capacity for adaptation only among the Indo-European speakers, whose ancestors were subjected to these changes, and have no effect on the preference of individuals from language groups that are unrelated to the Indo-European expansion.

4.4.4 Orthogonality to other Cultural Dimensions

This subsection demonstrates that the effects of accumulated environmental change on the capacity for adaptation does not capture its effect on a wide range of other cultural characteristics.

In particular, as suggested by Table 9, changes in the environment accumulated in the course of migration from the origin of Indo-European expansion does not affect attitudes towards immigrants (column 1), preference for leisure (column 2), preference for strong government (column 3), attitudes towards material prosperity (column 4), preference for job security capturing the degree of loss aversion (column 5) and views on democracy (column 6) among Indo-European speakers in Europe.

Table 8: Determinants of Preference for Adaptation through Individual Learning: Non-Indo-European Speakers

	Importance of Creativity and New Ideas								
	All Individuals			First G Migrants			Second G Migrants		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Accumulated Env. Change	0.035	0.035	0.020	0.005	0.006	-0.012	0.056	0.052	0.012
	(0.024)	(0.024)	(0.026)	(0.025)	(0.025)	(0.026)	(0.046)	(0.050)	(0.051)
Country of Residence FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Individual Controls	No	No	Yes	No	No	Yes	No	No	Yes
Geographic Controls	No	No	Yes	No	No	Yes	No	No	Yes
Adjusted-R^2	0.04	0.04	0.07	0.02	0.02	0.06	0.03	0.03	0.05
Observations	45556	45556	45556	3592	3592	3592	5369	5369	5369

Notes: This table establishes that among non-Indo-European individual's and migrant's valuation of the importance of creativity and new ideas is not affected by the accumulated environmental change of linguistic ancestors. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

Table 9: Orthogonality of other Cultural Dimensions to Accumulated Environmental Change: Individuals in Europe

	Attitude towards					
	(1) Immigrants	(2) Leisure	(3) Strong Gov	(4) Prosperity	(5) Job Security	(6) Democracy
Accumulated Env. Change	0.023	0.015	-0.006	0.006	-0.004	-0.028
	(0.015)	(0.018)	(0.018)	(0.019)	(0.016)	(0.072)
Country of Residence FE	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.12	0.11	0.11	0.10	0.07	0.15
Observations	165734	168046	167761	168728	41487	28416

Notes: This table establishes that among individual's and migrant's in Europe attitudes towards immigrants, leisure, strong government, prosperity in life, job security and presence of democracy are not affected by the accumulated environmental change of linguistic ancestors. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

4.4.5 Selection on Unobservables

This subsection examines the likelihood that omitted variables could alter the qualitative findings. Table B.7 suggests that it is very improbable that omitted variables could have affected the qualitative results presented in Tables 1, B.1 and 2. In particular, as shown in Column (2), (4) and (6), (using Columns (1), (3) and (5) as the baseline specifications), the estimated value of the coefficient on accumulated environmental change, if

unobservables where as correlated as the observables (i.e., Oster's β^* statistic), are very close to the estimated OLS coefficients. Furthermore, since zero does not belong to the interval created by the estimated value on and Oster's β^*, one can reject the hypothesis that the value of the coefficient is driven exclusively by unobservables. In addition, the indexes AET (Altonji et al., 2005; Bellows and Miguel, 2009) and δ (Oster, 2014) measure how strongly correlated unobservables would have to be in order to account for the full size of the coefficient on accumulated environmental change, are mostly different from the critical value of 1. In addition, Table B.8 establishes similar findings for the qualitative effects of accumulated environmental change on migrants level of adaptation to host country culture as captured in Tables 4 and B.2.

5 Empirical Analysis: Indo-European Speakers in the US

This section explores the effect of the environmental change accumulated in the course of Indo-European expansion on the capacity for adaptation across Indo-European speakers in the United States, as well as on the Indo-European language speaking migrants' ability to adjust to an unfamiliar cultural environment. In particular, it analyzes the effect of the accumulated environmental change on the valuation of the importance of thinking for ones self rather than obeying as reported in the General Social Survey (GSS), and on the migrants' ability to adapt to the host country culture, calculated based on the GSS. The analysis of Indo-European language speakers in the US by design accounts for time invariant unobserved heterogeneity in the country of residence (e.g., geographical and institutional characteristics). Moreover, whenever the analysis is conducted on the sample of first-, second- or higher-generation migrants, since the accumulated environmental change in the country of origin is distinct from that of the country of residence, the estimated effect of the accumulated environmental change in the country of origin captures the culturally-embodied, intergenerationally-transmitted effect, rather than the direct effect of geography. The effect of the accumulated environmental change on the capacity for adaptation is estimated via ordinary least squares (OLS) according to the following specification

$$IL_{iert} = \beta_0 + \beta_1 AEC_e + \sum_c \gamma_r \delta_{ir} + \sum_j \gamma_{1j} X_{ej} + \sum_j \gamma_{2j} Z_{ij} + \sum_t \gamma_t \tau_{it} + \epsilon_i \tag{35}$$

where IL_{iert} captures preference for adaptation for individual learning of individual i of ethnicity e in the US region r measured in year t, AEC_e is the accumulated environmental change measured for the homeland of ethnicity e,[15] X_{ej} is geographical characteristic j of the homeland of the ethnicity e, Z_{ij} is characteristic j of individual i (age, gender, number of siblings, religion, education level, income), δ_{ir} is the region of residence fixed effect of individual i,[16], τ_{it} is the year of observation fixed effect for individual i observed in the year t and ϵ_i is the error term. The

[15] The structure of the GSS allows us to observe the ethnic background of an individual rather than a linguistic group to which she belongs. Consequently, the measure of accumulated environmental change, which is originally calculated on the level of language group is aggregated to the ethnicity level based on the population weighted average of the Indo-European linguistic groups that comprise it

[16] "Regions" within the US capture geographically and culturally distinct areas of the US (e.g., New England, Midwest, Pacific coast etc).

theory predicts positive effect of the accumulated environmental change (i.e., $\beta_1 > 0$). The effect of the accumulated environmental change on the level of cultural adaptation is estimated according to the specification similar to (35) with outcome variable capturing the inverse of the cultural distance of migrant i of ethnicity e from the culture of the region of residence r measured in year t. Once again, the positive effect of the accumulated environmental change is predicted.

5.1 Determinants of Predisposition Towards Individual Learning among Individuals

This subsection examines the effect of accumulated environmental change on the Indo-European speaker valuation of importance of thinking for once self as opposed to being obedient in the US, in light of the conjectured positive association between this preference and propensity towards individual learning. The effect of accumulated environmental change on propensity towards individual learning is estimated via ordinary least squares (OLS) using the model (35).

Table 10: Determinants of Preference for Adaptation through Individual Learning: Individuals in the US

	Preference for Individual Learning						
	Think for Oneself vs Obey					Think	Obey
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Accumulated Env. Change	0.073*	0.096**	0.096**	0.074***	0.137***	0.054***	-0.083***
	(0.041)	(0.039)	(0.039)	(0.019)	(0.039)	(0.017)	(0.028)
Region FE	No	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	Yes	Yes	Yes	Yes
Individual Controls	No	No	No	Yes	Yes	Yes	Yes
Geographic Controls	No	No	No	No	Yes	Yes	Yes
Adjusted-R^2	0.00	0.01	0.01	0.15	0.15	0.11	0.14
Observations	9574	9574	9574	9574	9574	9574	9574

Notes: This table establishes that in the US individual's valuation of importance of ability to think for oneself vs obedience in children is positively affected by the accumulated environmental change in the course of migration of linguistic ancestors. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

Table 10 demonstrates a positive and significant effect of accumulated environmental change on Indo-European language speaking individuals' preference for individual learning. In particular, Columns (1) through (5) demonstrate the effect of accumulated change in the ancestral environment on preferences for individual thinking over obedience, sequentially accounting for the confounding effects of unobserved time-invariant omitted variables at the region of residence level, survey year fixed effects, geographical characteristics (agricultural productivity, climate, elevation and ruggedness), and individual characteristics of an individual (age, gender, number of siblings, religion,

education level, and income). The estimated effects imply that increasing accumulated environmental change in the ancestral homeland by one standard deviation increases the probability of individual thinking being valued more than obedience between 7 and 14 percentage points. It should be noted that coefficient of the accumulated environmental change effect is rather stable across specifications and statistically significant at the 1% level in two final specifications.

Moreover, Columns (6) and (7) of Table 10 analyze the effect of accumulated environmental change on the valuation of importance of thinking for once self and the valuation of importance of obedience separately. Reassuringly, the environmental change accumulated in the course of Indo-European expansion has a positive and highly significant effect on the preference for individual thinking, while having a negative and statistically significant effect on the valuation of the importance of obedience.

In addition, as shown in Table B.9, similar findings are established when analyzing different sub-samples of migrants in the US. In particular, the accumulated environmental change has a positive and statistically significant effect on the preference for individual learning across Indo-European speaking migrants of first, second, third and higher generations.

5.2 Determinants of the Level of Cultural Adaptation among Migrants in the US

This subsection examines the effect of the environmental changes accumulated in the course of the migration from Indo-European origin on the level of cultural adaptation of Indo-European speaking migrants in the US. As shown in columns (1) – (5) of Table 11, accumulated environmental change has a positive and highly significant effect on the level of cultural adaptation of first-generation migrants in the US. The estimation is robust to the potentially confounding effects of region of residence fixed effect, year of observation, as well as geographical and individual controls. Reassuringly, the estimated coefficient is statistically significant at a 1% level across all of the specifications. Furthermore, as established in columns (6) and (7), accumulated environmental change positively and significantly affects the level of cultural adaptation of second- and third-generation migrants.

5.3 Placebo Tests and Robustness of the Analysis

The results are robust to an extensive number of placebo test and checks. In particular, as demonstrated in Tables B.13 and B.14 the migratory distance from the origin of Indo-European expansion, unlike the environmental changes accumulated in the course of this expansion, affects neither the preference of Indo-European speakers for adaptation through individual learning nor their ability to adjust to unfamiliar cultural environment in the case of migration. In addition, Tables B.10 and B.11 establish that both the valuation of importance of individual thinking over obedience and the level of migrants' cultural adaptation among Indo-European languages speakers are unaffected by the environmental changes accumulated in the course of migration from placebo origins (e.g., London, Berlin

Table 11: Determinants of Adaptation to Local Culture: Migrants in the US

	Level of Cultural Adaptation						
	First G Migrants					2nd G	3rd G
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Accumulated Env. Change	1.142***	1.071***	1.018***	1.046***	0.659***	0.434**	0.167*
	(0.216)	(0.207)	(0.217)	(0.208)	(0.213)	(0.162)	(0.091)
Region FE	No	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	Yes	Yes	Yes	Yes
Geographic Controls	No	No	No	Yes	Yes	Yes	Yes
Individual Controls	No	No	No	No	Yes	Yes	Yes
Adjusted-R^2	0.05	0.06	0.11	0.12	0.17	0.23	0.23
Observations	1031	1031	1031	1031	1031	984	2628

Notes: This table establishes that in the US migrant's level of adaptation to local culture is positively affected by the accumulated environmental change in the course of migration of linguistic ancestors. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

or Lisbon). Moreover, as shown in Table B.12, the effects of accumulated environmental change on the capacity for adaptation does not capture its effect on a wide range of other cultural characteristics (e.g., trust, long term orientation, attitudes to gender roles, valuation of the importance of hard work and success in life, altruism), which are unaffected bu the measure of accumulated environmental change. Finally, Table B.8 suggests that it is very improbable that omitted variables could have affected the qualitative results presented in this section.

6 Concluding Remarks

This research explores the evolution of capacity for adaptation and the variation in the prevalence of this important traits across language and ethnic groups. It advances the hypothesis and establishes empirically that the evolution of predisposition towards adaptation in the course of human history can be traced to the adjustment of individuals to the changes in the environment that occurred due to historic migrations and in the course of the Columbian Exchange.

The study develops a theory that captures the co-evolution of culture and human predisposition towards adaptation and explores the effects of changes in the environment on that process. Exploiting variations in the degree of preference for adaptation through individual learning, as well as the level of cultural adaption among Indo-European speaking individuals in general and migrants in particular, the research suggests that consistent with the predictions of the theory, individuals whose ancestors were subjected to a greater historic changes in the environment are characterized by a greater degree of preference for adaptation via individual learning and a higher level of adaptation to an unfamiliar cultural environment.

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Appendix (Supplementary Material)

A Quantitative Simulation

This section explores the comparative dynamics of capacity for adaption established theoretically in Section 2.7.3 through the quantitative simulations of theoretical model of co-evolution of culture and predisposition towards adaption via individual learning.

A.1 Comparative Dynamics: Two Economies

This section quantitatively establishes results demonstrated in Section 2.7.3. Consider two economies, theoretically described in Section 2. In period $t = 0$ both economies reside in a steady state and are identical in all respects: (i) preference for children, γ; (ii) cost of child-rearing, τ; (iii) probability of successfully individual learning p; (iv) cost of sub-optimal behaviour, δ; (v) initial conditions in terms of culture and share of individuals with high capacity for adaptation (x_0, μ_0).

For the baseline simulation the parameters are set as follows:

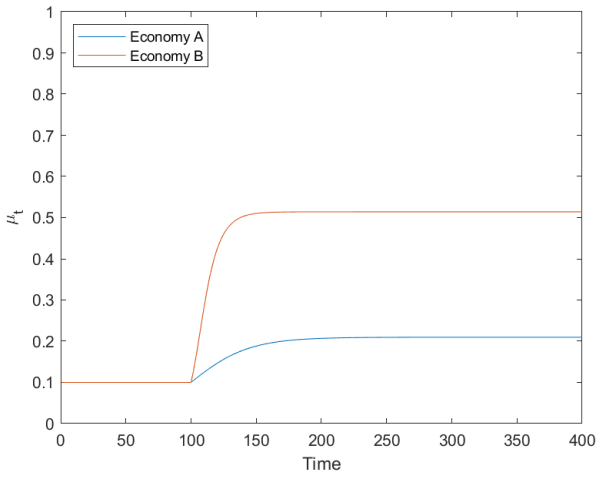
$$\begin{aligned} p &= 0.1 \\ \delta &= 1 \\ x_0 &= 0 \\ \mu_0 &= 0.1. \end{aligned} \tag{36}$$

Note that the dynamics of the model, as captured by the system of difference equations (27) is completely unaffected by the values of parameters γ and τ. The robustness of the results with respect to the values of other parameters (i.e., δ, p and μ_0) is explored in Section A.3.

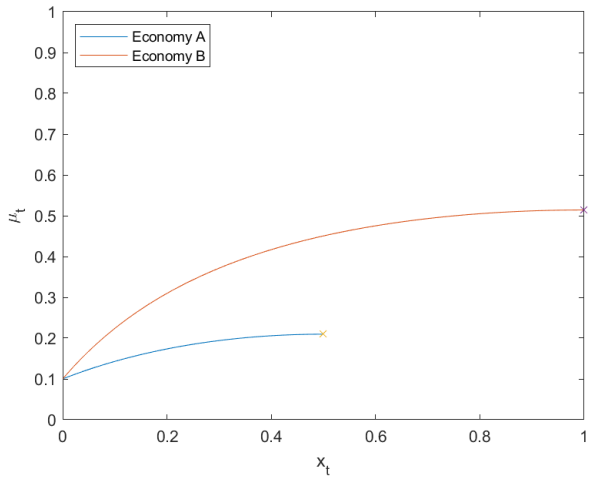
In period $t = t' = 100$ the environment in the economy A changes to a level e^A and in the economy B to e^B, so that $|x(e^B) - x(e)| > |x(e^A) - x(e)| > 0$. Given that the systems reside in the steady state prior to the period $t = t'$, it follows that $x(e) = x_0 = 0$. The changes in the environment in economies A and B are set so that:

$$\begin{aligned} x(e^A) &= 0.5 \\ x(e^B) &= 1 \end{aligned} \tag{37}$$

The dynamics of the dynamic systems characterizing the evolution of culture and share of population with high predisposition towards adaptation is presented on Figure A.1. Consistent with results of Section 2.7.3, both economies reach a steady state where the level of culture, x_t, converges to an environmentally optimal level of $x(e^A)$ and $x(e^B)$ in economy A and B correspondingly, while the share of individuals with high capacity for adaptation,



(a) Dynamics in (t, μ_t) Space



(b) Dynamics in (x_t, μ_t) Space

Figure A.1: Comparative Dynamics of Co-Evolution of Culture and Capacity for Adaptability

μ_t, converges to a stable level of μ^A and μ^B, where, consistent with Proposition 4:

$$\mu^B > \mu^A. \tag{38}$$

A.2 Comparative Dynamics: General Result

This subsection generalizes the result presented in Section A.1. Instead of comparing two economies, consider a continuum of economies identical in their initial conditions and calibrated according to (36). Each of the economies is subjected to a unique change in the environmental conditions, resulting in a change in the optimal behaviour of $\Delta x(e)$. Consistent with the predictions of the theory each economy reaches a steady state, where culture converges to a environmentally optimal level and a certain share of individuals prone to adaptation via individual learning, μ_∞. As depicted on Figure A.2, share of individual with high capacity for adaptation in the steady state is positively associated with the magnitude of the environmental change.

This quantitatively proves Proposition 4:

Proposition 4. *The greater is the change in the environment, e, the greater is the steady state share of individual learners, μ_∞.*

$$\frac{d\mu_\infty}{d|\Delta x(e)|} > 0 \tag{39}$$

Proof Quantitative proof is presented above, demonstrated in Figure A.2 and analyzed for robustness to the parameter values in Section A.3.

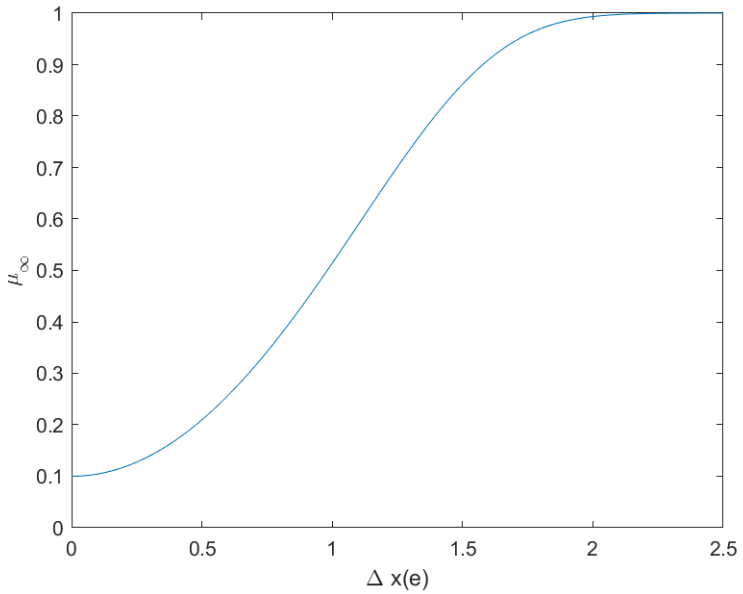
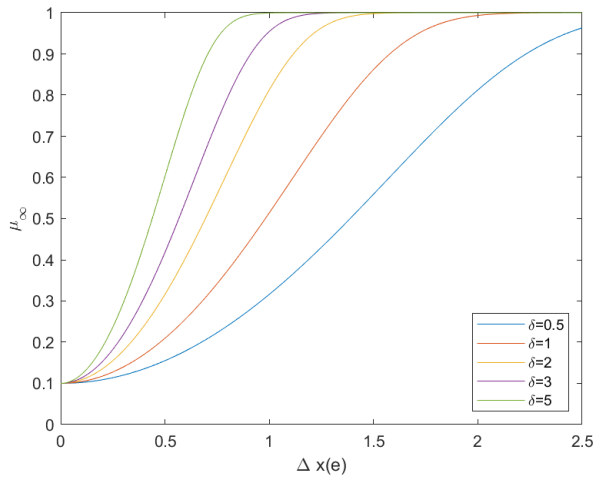


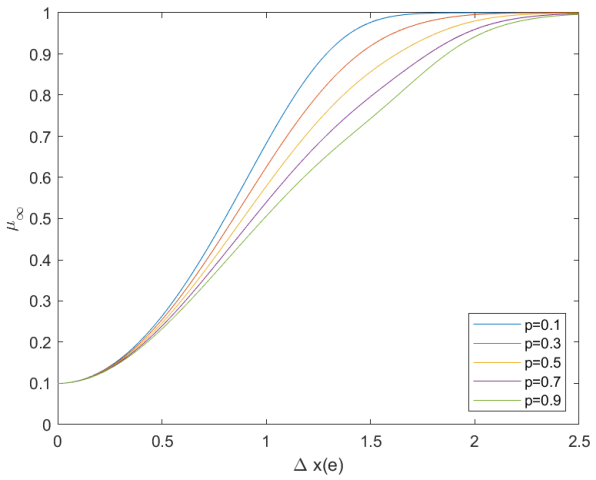
Figure A.2: Environmental Change and Share of Individual with High Capacity for Adaptation

A.3 Robustness to Parameter Values

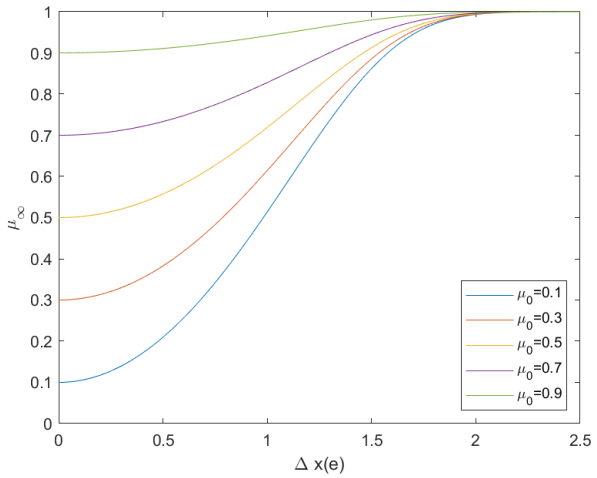
This section establishes the quantitative robustness of the result presented in Section A.2 and summarized in Proposition 4. In particular it demonstrates that the positive quantitative association between the change in the environmental conditions and share of individual with high capacity for adaptation in the steady state is observed under any set of parameters: (i) δ as captured on Figure A.3a; (ii) p as captured on Figure A.3b; (iii) μ_0 as captured on Figure A.3c.



(a) Sensitivity to δ Parameter



(b) Sensitivity to p Parameter



(c) Sensitivity to μ_0 Parameter

Figure A.3: Environmental Change and Share of Individual with High Capacity for Adaptation: Robustness

B Additional Empirical Results

B.1 Additional Empirical Results: Indo-European Speakers in Europe (ESS)

B.1.1 Determinants of Preference for Adaptation through Individual Learning among First-Generation Migrants

Table B.1 establishes that Indo-European speaking first-generation migrants' valuation of the importance of creativity and new original ideas is positively affected by the accumulated environmental change of linguistic ancestors. The effects are statistically significant at 1% or 5% level in both samples and across numerous specifications that sequentially account for: (i) country of residence fixed effects, (ii) round of survey fixed effects, (iii) individual controls (i.e., age, gender, income, education level), (iv) potentially confounding effects of geographic characteristics (e.g., agricultural productivity, climate, elevation and ruggedness) and (v) country of origin fixed effects.

Table B.1: Determinants of Preference for Adaptation through Individual Learning: First Generation Migrants in Europe

	Importance of Creativity and New Ideas					
	(1)	(2)	(3)	(4)	(5)	(6)
Accumulated Env. Change	0.215***	0.088***	0.088***	0.069***	0.073***	0.047***
	(0.067)	(0.012)	(0.012)	(0.012)	(0.015)	(0.018)
Country of Residence FE	No	Yes	Yes	Yes	Yes	Yes
Round FE	No	No	Yes	Yes	Yes	Yes
Individual Controls	No	No	No	Yes	Yes	Yes
Geographic Controls	No	No	No	No	Yes	Yes
Country of Origin FE	No	No	No	No	No	Yes
Adjusted-R^2	0.03	0.09	0.09	0.12	0.12	0.12
Observations	18591	18591	18591	18591	18591	18591

Notes: This table establishes that first generation migrant's valuation of importance of creativity and new ideas is positively affected by the accumulated environmental change in the course of migration of linguistic ancestors. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

B.1.2 Determinants of the Level of Cultural Adaptation among Migrants

As established in Table B.2, positive significant effect of accumulated environmental change on the level of cultural adaptation is present among the Indo-European speaking second-generation migrants in Europe. The effect is estimated across the same set of specifications as in Table 4 and is consistently significant at 1% or 5% level and is extremely stable in its absolute magnitude.

Table B.2: Determinants of Adaptation to Local Culture: Second Generation Migrants in Europe

	Level of Cultural Adaptation				
	(1)	(2)	(3)	(4)	(5)
Accumulated Env. Change	0.028***	0.019**	0.019**	0.020**	0.034***
	(0.007)	(0.008)	(0.008)	(0.008)	(0.011)
Country of Residence FE	No	Yes	Yes	Yes	Yes
Round FE	No	No	Yes	Yes	Yes
Individual Controls	No	No	No	Yes	Yes
Geographic Controls	No	No	No	No	Yes
Adjusted-R^2	0.01	0.20	0.20	0.20	0.21
Observations	11736	11736	11736	11736	11736

Notes: This table establishes that second generation migrant's level of adaptation to local culture is positively affected by the accumulated environmental change in the course of migration of linguistic ancestors. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

B.1.3 Determinants of Adaptation to Local Culture: Random Assignment of Environmental Change

Table B.3 documents that the level of cultural adaptation of Indo-European speaking migrants is positively and significantly affected by the "randomly assigned" change in the ancestral environment caused by the introduction of new crops in the course of the Columbian Exchange. The effect is statistically significant at 1% level both across first- and second-generation migrants and is robust to potentially confounding effects of: (i) crop yield prior to year 1500, which has no significant effect on the cultural adaptation of migrants, and (ii) accumulated environmental change, which has positive and significant effect on the level of cultural adaptation, consistently with the baseline results. These findings identify the effect of a "random assignment" of environmental change on the evolution of propensity towards individual learning and suggests that selective migration played an insignificant role in the determination of preference for individual learning.

Table B.3: Determinants of Adaptation to Local Culture: Random Assignment of Envrionemntal Change

	Level of Cultural Adaptation					
	First Generation Migrants			Second Generation Migrants		
	(1)	(2)	(3)	(4)	(5)	(6)
Crop Yield (Change)	0.015***	0.033***	0.028***	0.019***	0.018***	0.018***
	(0.002)	(0.009)	(0.008)	(0.003)	(0.006)	(0.005)
Crop Yield (Pre-1500)		0.048	0.071		-0.007	-0.011
		(0.041)	(0.045)		(0.025)	(0.022)
Accumulated Env. Change			0.036**			0.035***
			(0.015)			(0.010)
Country of Residence FE	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.24	0.25	0.25	0.21	0.21	0.21
Observations	18907	18907	18907	11736	11736	11736

Notes: This table establishes that first and second generation migrant's level of adaptation to local culture is positively affected by the change in the agricultural yield caused by the introduction of new crops in the course of the Columbian Exchange and the accumulated environmental change in the course of migration of linguistic ancestors, but is not affected by the level of crop yield prior to the Columbian Exchange. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

B.1.4 Accumulated Environmental Change from the Alternative Origins

As established by Table B.4 although the accumulated environmental change from the origins suggested by alternative hypotheses of Indo-European expansion (i.e., Anatolian and Armenian hypotheses) has a positive and statistically significant effect on the preference for individual learning (columns 2 and 4), only the accumulated environmental change calculated from the origin suggested by the Steppe hypothesis has a positive and significant effect than estimated accounting for the environmental change accumulated from the alternative origins (columns 3, 5 and 6).

B.1.5 Accumulated Environmental Change from the Placebo Origins

As shown in Table B.5 the ability of Indo-European migrants to adapt to the host country culture are also unaffected by the accumulate environmental change calculated from the placebo origins. These results demonstrate that the evolution of the predisposition towards individual learning is affected precisely by the environmental change that occurred in the course migration from the origin of the Indo-European expansion as suggested by the Steppe Hypothesis rather than by accumulated environmental change measures calculated from placebo origins unrelated to the expansion of proto-Indo-European culture and people.

Table B.4: Determinants of Preference for Adaptation through Individual Learning: Alternative Origin Hypotheses

	Importance of Creativity and New Ideas					
	(1)	(2)	(3)	(4)	(5)	(6)
Accumulated Env. Change	0.075***		0.068**		0.047**	0.056**
	(0.011)		(0.029)		(0.021)	(0.028)
Accumulated Env. Change (Anatolia)		0.079***	0.010			-0.028
		(0.019)	(0.038)			(0.052)
Accumulated Env. Change (Armenia)				0.078***	0.037	0.051
				(0.014)	(0.024)	(0.034)
Country of Residence FE	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.08	0.08	0.08	0.08	0.08	0.08
Observations	168097	168097	168097	168097	168097	168097

Notes: This table establishes that individual's and migrant's valuation of the importance of creativity and new ideas although positively assosiated with the accumulated environmental change calculated from Armenia or Anatolia, is not affected by them if accumulated environmental change from the Stepp Origin is taken into account. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

Table B.5: Determinants of Migrants' Adaptation to Local Culture: Placebo Origins

	Level of Cultural Adaptation					
	First G Migrants			Second G Migrants		
	(1)	(2)	(3)	(4)	(5)	(6)
Accumulated Env. Change (Berlin)	0.021			0.001		
	(0.015)			(0.008)		
Accumulated Env. Change (London)		0.004			-0.019**	
		(0.008)			(0.008)	
Accumulated Env. Change (Lisbon)			0.010			0.022
			(0.009)			(0.015)
Country of Residence FE	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.25	0.25	0.25	0.21	0.21	0.21
Observations	18907	18907	18907	11736	11736	11736

Notes: This table establishes that first and second generation migrant's level of adaptation to local culture is not affected by the accumulated environmental change calculated from the Placebo Origins such as Berlin, London or Lisbon. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

B.1.6 Placebo Language Groups: Non-Indo-European Speakers

This subsection analyzes the effects of the environmental change accumulated in the course of Indo-Eropean expansion on the level of cultural adaptation across non-Indo-European language speaking migrants. As reported in Table B.6, when estimated across non-Indo-European speakers, accumulated environmental change from the origin of Indo-European expansion has no effect on the predisposition towards individual learning as captured by the level of cultural adaptation. The result is valid when estimated across all non-Indo-European speakers (columns 1 – 3), as well as on the sub-samples of non-Indo-European first-generation migrants (columns 4 – 6) and second-generation migrants (columns 7 – 9).

Table B.6: Determinants of Migrants' Adaptation to Local Culture: Non-Indo-European Speakers

	Level of Cultural Adaptation					
	First G Migrants			Second G Migrants		
	(1)	(2)	(3)	(4)	(5)	(6)
Accumulated Env. Change	0.006	0.004	0.005	0.009	0.007	0.005
	(0.045)	(0.044)	(0.044)	(0.008)	(0.010)	(0.009)
Country of Residence FE	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	No	Yes	Yes	No	Yes	Yes
Individual Controls	No	No	Yes	No	No	Yes
Geographic Controls	No	No	Yes	No	No	Yes
Adjusted-R^2	0.11	0.12	0.13	0.05	0.05	0.05
Observations	1491	1491	1491	2760	2760	2760

Notes: This table establishes that non-Indo-European first and second generation migrant's level of adaptation to local culture is not affected by the accumulated environmental change from the Indo-European origin. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

B.2 Selection on Unobservables

This subsection examines the likelihood that omitted variables could alter the qualitative findings. Table B.7 suggests that it is very improbable that omitted variables could have affected the qualitative results presented in Tables 1, B.1, and 2. In particular, as shown in Column (2), (4) and (6), (using Columns (1), (3) and (5) as the baseline specifications), the estimated value of the coefficient on accumulated environmental change, if unobservables where as correlated as the observables (i.e., Oster's β^* statistic), are very close to the estimated OLS coefficients. Furthermore, since zero does not belong to the interval created by the estimated value on and Oster's β^*, one can reject the hypothesis that the value of the coefficient is driven exclusively by unobservables. In

addition, the indexes AET (Altonji et al., 2005; Bellows and Miguel, 2009) and δ (Oster, 2014) measure how strongly correlated unobservables would have to be in order to account for the full size of the coefficient on accumulated environmental change, are mostly different from the critical value of 1. In addition, Table B.8 establishes similar findings for the qualitative effects of accumulated environmental change on migrants level of adaptation to host country culture as captured in Tables 4, B.2 and B.9.

Table B.7: Determinants of Preference for Adaptation through Individual Learning: Robustness to Selection on Unobservables (ESS)

	Importance of Creativity and New Ideas					
	All		Migrants			
	(1)	(2)	(3)	(4)	(5)	(6)
			1st-G	1st-G	2nd-G	2nd-G
Accumulated Env. Change	0.14***	0.08***	0.22***	0.05***	0.19**	0.08***
	(0.05)	(0.01)	(0.07)	(0.02)	(0.07)	(0.02)
Country of Residence FE	No	Yes	No	Yes	No	Yes
Round FE	No	Yes	No	Yes	No	Yes
Individual Controls	No	Yes	No	Yes	No	Yes
Geographic Controls	No	Yes	No	Yes	No	Yes
Country of Origin FE	No	No	No	No	No	Yes
AET		2.18		1.14		3.80
δ		2.55		1.11		3.61
β^*		0.05		0.00		0.06
R^2	0.01	0.08	0.03	0.13	0.02	0.11
Adjusted-R^2	0.01	0.08	0.03	0.12	0.02	0.09
Observations	168097	168097	18591	18591	11536	11536

Notes: This table shows the robustness of the results to selection by unobservables. It presents the Altonji et al. (2005) AET ratio as extended by Bellows and Miguel (2009). Additionally, it presents the δ and $\beta^*(1, R^2\_max)$ statistics suggested by Oster (2014), where R^2_max is 1.33 of R^2 in the full specification. All statistics suggest that the results are not driven by unobservables. Heteroskedasticity robust standard errors in round parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

Table B.8: Determinants of Adaptation to Local Culture: Robustness to Selection on Unobservables

	Level of Cultural Adaptation							
	ESS				GSS			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	1st-G	1st-G	2nd-G	2nd-G	1st-G	1st-G	2nd-G	2nd-G
Accumulated Env. Change	0.04***	0.04***	0.03***	0.03***	1.14***	0.68**	0.42***	0.23***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.22)	(0.27)	(0.11)	(0.08)
Country/Region FE	No	Yes	No	Yes	No	No	No	No
Round/Year FE	No	Yes	No	Yes	No	No	No	No
Individual Controls	No	Yes	No	Yes	No	No	No	No
Geographic Controls	No	Yes	No	Yes	No	No	No	No
AET		20.00		-6.05		1.46		1.20
δ		4.47		-10.45		2.52		3.25
β^*		0.03		0.04		0.47		0.16
R^2	0.03	0.25	0.01	0.21	0.06	0.21	0.02	0.25
Adjusted-R^2	0.03	0.24	0.01	0.21	0.05	0.16	0.02	0.23
Observations	18907	18907	11736	11736	1031	1031	3612	3612

Notes: This table shows the robustness of the results to selection by unobservables. It presents the Altonji et al. (2005) AET ratio as extended by Bellows and Miguel (2009). Additionally, it presents the δ and $\beta^*(1, R^2\_max)$ statistics suggested by Oster (2014), where R^2_max is 1.33 of R^2 in the full specification. All statistics suggest that the results are not driven by unobservables. Heteroskedasticity robust standard errors in round parenthesis. *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

B.3 Additional Empirical Results: Indo-European Speakers in the US (GSS)

B.3.1 Determinants of Predisposition Towards Individual Learning among Migrants (GSS)

Table B.9 demonstrates a positive and significant effect of accumulated environmental change on preference for individual learning among first-, second-, third- and higher-generation Indo-European migrants in the US. In addition, the effect of accumulated change in the ancestral environment on preferences for individual thinking over obedience, is robust to accounting for the confounding effects of unobserved time-invariant omitted variables at the region of residence level, survey year fixed effects, geographical characteristics (agricultural productivity, climate, elevation and ruggedness), and individual characteristics of an individual (age, gender, number of siblings, religion, education level, and income).

B.3.2 Accumulated Environmental Change from the Placebo Origins

Tables B.10 and B.11 establish that the migratory distance from the placebo origins (London, Lisbon and Paris) affects neither the preference of Indo-European speakers for individual learning nor their ability to adjust to unfamiliar cultural environment in the case of migration.

Table B.9: Determinants of Preference for Adaptation through Individual Learning: Migrants in the US

	Preference for Thinking for Oneself vs Obedience				
	All	Migrants			
	(1)	(2) 1st-G	(3) 2nd-G	(4) 3rd-G	(5) Higher-G
Accumulated Env. Change	0.137***	0.289*	0.259**	0.171**	0.046*
	(0.039)	(0.154)	(0.116)	(0.067)	(0.024)
Region FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Individual Controls	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.15	0.14	0.14	0.13	0.11
Observations	9574	1473	1029	2751	4658

Notes: This table establishes that in the US migrant's valuation of importance of ability to think for oneself vs obedience in children is positively affected by the accumulated environmental change in the course of migration of linguistic ancestors. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

Table B.10: Determinants of Preference for Adaptation through Individual Learning: Placebo Origins (GSS)

	Preference for Thinking for Oneself vs Obedience								
	First G Migrants			Second G Migrants			Third G Migrants		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Accumulated Env. Change (Berlin)	-0.116			0.192			0.053		
	(0.194)			(0.143)			(0.067)		
Accumulated Env. Change (London)		0.167			0.107			-0.083	
		(0.163)			(0.129)			(0.075)	
Accumulated Env. Change (Lisbon)			0.096			0.073			0.034
			(0.062)			(0.070)			(0.085)
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.15	0.15	0.15	0.14	0.13	0.13	0.12	0.12	0.12
Observations	1136	1136	1136	1029	1029	1029	2322	2322	2322

Notes: This table establishes that in the US migrant's valuation of importance of ability to think for oneself vs obedience in children is not affected by the accumulated environmental change that is calcuted from the placebo origin such as Berlin, London or Lisbon. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

B.3.3 Orthogonality to other Cultural Dimensions

As suggested by Table B.12, changes in the environment accumulated in the course of migration from the origin of Indo-European expansion does not affect interpersonal trust (column 1), long term orientation (column 2),

Table B.11: Determinants of Adaptation to Local Culture: Placebo Origins (GSS)

	Level of Cultural Adaptation								
	First G Migrants			Second G Migrants			Third G Migrants		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Accumulated Env. Change (Berlin)	0.373			0.203			0.139		
	(0.226)			(0.150)			(0.088)		
Accumulated Env. Change (London)		-0.277			-0.174			0.014	
		(0.341)			(0.313)			(0.139)	
Accumulated Env. Change (Lisbon)			-0.157			-0.187*			-0.049
			(0.137)			(0.103)			(0.083)
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.17	0.16	0.17	0.23	0.23	0.23	0.23	0.23	0.23
Observations	1016	1016	1016	984	984	984	2628	2628	2628

Notes: This table establishes that in the US migrant's level of adaptation to local culture is not affected by the accumulated environmental change calculated from the placebo origins such as Berlin, London or Lisbon. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

attitudes towards gender (column 3), valuation of the importance of hard work (column 4), and success (column 5) and altruism (column 6) among Indo-European speakers in the US.

Table B.12: Orthogonality of other Cultural Dimensions to Accumulated Environmental Change: Individuals in the US

	Attitudes towards					
	(1) Trust	(2) LTO	(3) Gender	(4) Work	(5) Succes	(6) Altrusim
Accumulated Env. Change	0.010	-0.008	0.010	-0.009	-0.014	-0.003
	(0.010)	(0.013)	(0.010)	(0.012)	(0.011)	(0.014)
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.08	0.08	0.07	0.05	0.05	0.02
Observations	11219	2590	5817	9098	9098	9109

Notes: This table establishes that in the US individual's attitudes towards trust, long term orientation, as captured by propensity to smoke, female work participation, importance of hard work, success and altruism are not affected by the accumulated environmental change of linguistic ancestors. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

B.3.4 Migratory Distance vs. Accumulated Environmental Change

Tables B.13 and B.14 establish that the migratory distance from the origin of Indo-European expansion, unlike the environmental changes accumulated in the course of this expansion, affects neither the preference of Indo-European speakers for individual learning nor their ability to adjust to unfamiliar cultural environment in the case of migration.

Table B.13: Orthogonality of Preference for Adaptation through Individual Learning to Migratory Distance: Individuals and Migrants in the US

	Preference for Thinking for Oneself vs Obedience				
	All	Migrants			
	(1)	(2) 1st-G	(3) 2nd-G	(4) 3rd-G	(5) Higher-G
Migratory Distance to the Origin	0.058	0.098	0.070	0.069	0.042
	(0.057)	(0.140)	(0.153)	(0.045)	(0.029)
Region FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes
Individual Controls	Yes	Yes	Yes	Yes	Yes
Adjusted-R^2	0.15	0.15	0.13	0.13	0.10
Observations	9574	1473	1029	2751	6708

Notes: This table establishes that in the US individual's valuation of importance of ability to think for oneself vs obedience in children is not affected by the the migratory distance of their linguistic ancestors. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

Table B.14: Orthogonality of Adaptation to Local Culture to Migratory Distance: Migrants in the US

	Level of Cultural Adaptation						
	First G Migrants					2nd G	3rd G
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Migratory Distance to the Origin	0.015	-0.033	-0.064	0.265	0.085	0.165	0.079
	(0.204)	(0.184)	(0.171)	(0.241)	(0.212)	(0.100)	(0.055)
Region FE	No	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	Yes	Yes	Yes	Yes
Geographic Controls	No	No	No	Yes	Yes	Yes	Yes
Individual Controls	No	No	No	No	Yes	Yes	Yes
Adjusted-R^2	0.02	0.03	0.09	0.11	0.16	0.23	0.23
Observations	1031	1031	1031	1031	1031	984	2628

Notes: This table establishes that in the US migrant's level of adaptation to local culture is not affected by the migratory distance to the origin of the linguistic ancestors. Additional geographical controls are temperature and precipitation, crop yield, elevation and the principal component of core geographic variables. Individual controls include age, gender, education level, religiosity and income. All independent variables have been normalized by subtracting their mean and dividing by their standard deviation. Thus, all coefficients can be compared and show the effect of a one standard deviation in the independent variable. Heteroskedasticity robust standard error estimates clustered at the language group level are reported in parentheses; *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

C Variable Definitions

This section describes the construction and summarizes: (i) main outcome variables; (ii) placebo outcomes; (iii) independent, explanatory variables; (iv) placebo independent variables; (v) control variables.

C.1 Outcome Variables

C.1.1 Measures of Preference for Adaptation through Individual Learning

- **Importance of Creativity and New Ideas (ESS):** Based on the answer to the question: " Please listen to the description and tell me how much each person is or is not like you. Use this card for your answer. Thinking up new ideas and being creative is important to her/him. She/he likes to do things in her/his own original way" taken from the "Human Values" module of European Social Survey. Coded as 6 if the answer is "Very much like me" and 1 if – "Not like me at all".

- **Importance of Trying Different Things (ESS):** Based on the answer to the question: "Please listen to each description and tell me how much each person is or is not like you. Use this card for your answer. She/he likes surprises and is always looking for new things to do. She/he thinks it is important to do lots of different things in life." taken from the "Human Values" module of European Social Survey. Coded as 6 if the answer is "Very much like me" and 1 if – "Not like me at all".

- **Importance of Making Own Decisions (ESS):** Based on the answer to the question: "Please listen to each description and tell me how much each person is or is not like you. Use this card for your answer. It is important to her/him to make her/his own decisions about what she/he does. She/he likes to be free and

not depend on others." taken from the "Human Values" module of European Social Survey. Coded as 6 if the answer is "Very much like me" and 1 if – "Not like me at all".

- **Importance of Following Rules (ESS):** Based on the answer to the question: "Please listen to each description and tell me how much each person is or is not like you. Use this card for your answer. She/he believes that people should do what they're told. She/he thinks people should follow rules at all times, even when no-one is watching." taken from the "Human Values" module of European Social Survey. Coded as 6 if the answer is "Very much like me" and 1 if – "Not like me at all".

- **Importance of Thinking for Once Self (GSS):** Based on the answer to the question: "If you had to choose, which thing on this list would you pick as the most important for a child to learn to prepare him or her for life?" from the Core module of General Social Survey. Coded as 5 if the option "To think for ones self" is chosen as the most important and 1 if it is chosen as the least important.

- **Importance of Obedience (GSS):** Based on the answer to the question: "If you had to choose, which thing on this list would you pick as the most important for a child to learn to prepare him or her for life?" from the Core module of General Social Survey. Coded as 5 if the option "To obey" is chosen as the most important and 1 if it is chosen as the least important.

- **Importance of Thinking for Once Self vs Obedience (GSS):** Calculated as the difference between the ranks of options "To think for ones self" and "To obey" in the question "If you had to choose, which thing on this list would you pick as the most important for a child to learn to prepare him or her for life?". Takes values from 4 to -4.

C.1.2 Measures of Level of Cultural Adaptation of Migrants

The level of adaptation of first-, second- or higher-generation migrant i to the cultural environment of country or sub-national region of residence c, CA_{ic}, is calculated according to

$$CA_{ic} = -\frac{1}{K}\sum_{k=1}^{K}\left|\bar{q}_c^k - q_i^k\right|, \tag{40}$$

where q_i^k is the ordinal level of cultural trait k of migrant i, $\bar{q}_c^k$ is the simple average level of a cultural trait k in host country or region c and K is the total number of traits used. The measure captures the opposite of an average absolute distance across a number of ordinal cultural traits between an individual migrant and the population of a host country or region on average and thus represents the degree of migrant's adaptation to local culture. The measure is equal to zero if all of the migrant's cultural traits are identical to the population average in the host country or region and is negative otherwise, decreasing with the cultural distance between the migrant and the local population.

Table C.1: List of Cultural Dimensions in ESS: Groups, Abbreviations, Descriptions

Conformity	ipfrule	Important to follow rules
	ipbhprp	Important to always behave properly.
Tradition	ipmodst	Important to be humble and modest.
	imptrad	Tradition is important, important follow the customs.
Benevolence	iphlppl	Important to help the people around her/him. She/he wants to care for their well-being.
	iplylf	Important to be loyal to her/his friends.
Universalism	ipeqopt	Important that every person in the world should be treated equally and have equal opportunities.
	ipudrst	Important to her/him to listen to people who are different, even when she/he disagrees with them.
	impenv	People should care for nature. Looking after the environment is important.
Self-Direction	ipcrtiv	Important to think up new ideas and be creative.
	impfree	Important to make her/his own decisions. She/he likes to be free and not depend on others.
Stimulation	impdiff	Important to do lots of different things in life.
	ipadvnt	She/he looks for adventures and likes to take risks. She/he wants to have an exciting life.
Hedonism	ipgdtim	Having a good time is important to her/him. She/he likes to 'spoil' herself/himself.
	impfun	She/he seeks every chance to have fun. It is important to her/him to do things that give pleasure.
Achievement	ipshabt	Important to show her/his abilities. She/he wants people to admire what she/he does.
	ipsuces	Important to be very successful.
Power	imprich	Important to be rich. She/he wants to have a lot of money and expensive things.
	iprspot	Important to get respect from others. She/he wants people to do what she/he says.
Security	impsafe	Important to live in secure surroundings and avoid anything that might endanger safety.
	ipstrgv	Important that the government ensures safety against all threats and defends its citizens.

Notes: All of the cultural variables are taken from the "Human Values" module of European Social Survey. Each variable takes ordinal values from 1 to 6 reflecting the importance of corresponding value for the respondent.

The specific cultural characteristics used in the construction of the measure of cultural adaptation are chosen to: (i) reflect a broad spectrum of preferences, beliefs and norms regarding human cooperation, altruism, family, religion, attitudes towards government, work and gender roles, as well as other human values capturing culture in a broad sense; (ii) cover a large part of the survey respondents. In particular, culture in the ESS is represented by 21 variables from the "Human Values" module of the survey that are split into 10 groups. Cultural dimensions are summarized and described in the Table C.1. In addition, the choice of the traits that reflects broad culture in the GSS is made closely following the methodology of Giavazzi et al. (2019). The particular variables are summarized and described in Tabel C.2.

Table C.2: List of Cultural Dimensions in GSS: Groups, Abbreviations, Descriptions

Cooperation	trust	Can people be trusted or cannot be too careful? (coded 1 if yes, 0 if no)
	fair	Will people take advantage of you? (coded 1 if yes, 0 if no)
	helpful	People are mostly helpful or looking out for themselves (coded 1 if yes, 0 if no)
Government/Politics	eqwlth	Government should equalize income between poor and rich (ordinal from 1 – 7)
	helppoor	Government should improve the standard of living of the poor (ordinal 1 – 5)
	polviews	Political views: liber – conservative (ordinal 1 – 7)
Religion	attend	Frequency of religious services attendance (ordinal 0 – 8)
	pray	Frequency of prayer (ordinal 1 – 6)
	reliten	Intensity of religious affiliation (ordinal 1 – 4)
	postlife	Belief in life after death (1 if yes, 0 if no)
	prayer	Approval of prayer in public schools (1 if yes, 0 if no)
Family	thnkself	Independence of a child is highly important quality (ordinal 1 – 5)
	obey	Obedience of a child is a highly important quality (ordinal 1 – 5)
	pillok	Birth control available to teenagers without parental consent (ordinal 1 – 4)
	aged	Approval of sharing home with grown children (1 if yes, 0 if no)
	divlaw	Should divorce be easier? (ordinal 1 – 3)
	socrel	Frequency of social evenings with relatives (ordinal 1 – 7)
Gender Roles	fechild	Working mother can have a good relationship with children (ordinal 1 – 4)
	fepol	Women not suited for politics (1 if yes, 0 if no)
Abortion	abany	Approval of abortion for any reason (1 if yes, 0 if no)
Sexual Behavior	premarsx	Approval of premarital sex (ordinal 1 – 4)
	homosex	Approval of same-sex sexual relations (ordinal 1 – 4)
Mobility/Success	getahead	Work or luck/help as a source of social mobility (ordinal 1 – 3)

Notes: All of the cultural variables are taken from the Core module of General Social Survey. Each variable takes ordinal or binary values reflecting the importance of corresponding value, or agreement with a corresponding statement for the respondent.

C.1.3 Alternative Cultural Dimensions

- **Attitudes towards immigrants (ESS):** Based on the answer to the question: "Is country made a worse or a better place to live by people coming to live here from other countries?" taken from the "Politics" module of ESS. Coded ordinally from 1 – 10.

- **Preference for Leisure (ESS):** Based on the answer to the question: "Having a good time is important to her/him. She/he likes to 'spoil' herself/himself." taken from the "Human Values" module of ESS. Coded ordinally from 1 – 5.

- **Preference for Strong Government (ESS):** Based on the answer to the question: "It is important to her/him that the government ensures her/his safety against all threats. She/he wants the state to be strong so it can defend its citizens." taken from the "Human Values" module of ESS. Coded ordinally from 1 – 5.

- **Importance of Prosperity (ESS):** Based on the answer to the question: "It is important to her/him to be rich. She/he wants to have a lot of money and expensive things." taken from the "Human Values" module of ESS. Coded ordinally from 1 – 5.

- **Importance of Job Security (ESS):** Based on the answer to the question: "For you personally, how important do you think each of the following would be if you were choosing a job? A secure job" taken

from the "Family work and well-being" module of ESS. Coded ordinally from 1 – 5. In light of the results established in Galor and Savitskiy (2018) reflects intensity of loss aversion of respondent.

- **Importance of Democracy (ESS):** Based on the answer to the questions of the "Understanding of democracy" module of ESS.

- **Interpersonal Trust (GSS):** Based on the answer to the question: "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people?" taken from the Core module of GSS. Coded binary.

- **Long Term Orientation (GSS):** Based on the answer to the question: "Do you smoke?" taken from the Core module of GSS. Coded binary. Chosen to reflect the long term orientation of the responded following the methodology of Galor and Özak (2016).

- **Attitudes towards Gender Roles (GSS):** Based on the answer to the question: "A working mother can establish just as warm and secure a relationship with her children as a mother who does not work." taken from the Core module of GSS. Coded ordinally from 1 – 4.

- **Importance of Hard Work (GSS):** Based on the answer to the evaluation of the importance of quality "to hard work" for children. Taken from the Core module of GSS. Coded ordinally from 1 – 5.

- **Importance of Success (GSS):** Based on the answer to the evaluation of the importance of quality "to be popular" for children. Taken from the Core module of GSS. Coded ordinally from 1 – 5.

- **Importance of Altruism (GSS):** Based on the answer to the evaluation of the importance of quality "To help others when they need help" for children. Taken from the Core module of GSS. Coded ordinally from 1 – 5.

C.2 Independent Variables: Accumulated Environmental Change

This section describes the construction of one of the main independent explanatory variable – Accumulated Environmental Change (AEC). In particular, for any geographic location i the Accumulated Environmental Change in the course of migration from a given origin, AEC_i, is calculated as

$$AEC_i = \sum_{p_i^k \in P_i} \frac{\left|PC(p_i^{k+1}) - PC(p_i^k)\right|}{PC(p_i^k)}, \tag{41}$$

where $P_i = \{p_i^0, \ldots, p_i^k, \ldots, p_i^K\}$ is the least cost path from the origin to location i composed of a set of K adjacent $5' \times 5'$ cells, p_i^k, and $PC(p_i^k)$ represents the first principal component of environmental variables in the cell p_i^k. The measure of accumulated environmental change, AEC_i, is equal to zero if the first principal component is equal

across all cells of the least cost path and is positive otherwise, increasing with the difference between any two sequential cells of the path.

C.2.1 Origins of the Migration

Several locations are used to construct different measures of environmental change from the corresponding origins, in particular:

- The geographic origin of Indo-European expansion according to Steppe hypothesis is captured by the ecologically homogeneous region of Pontic–Caspian steppe identified using the data of Global Agro-Ecological Zones (GAEZ) project of Food and Agriculture Organization of the United Nations (FAO).
- Placebo origins are represented by the geographic coordinates of: (i) London ($55°30'$, $00°07'$); (ii) Berlin ($52°31'$, $13°23'$); (iii) Lisbon ($38°43'$, $9°10'$).
- The geographic origin of Indo-European expansion according to alternative hypotheses are captured by geographic coordinates of: (i) Ereven ($40°11'$, $41°31'$) to represent the Armenian hypothesis (Gamkrelidze, 2010); (ii) Geographic coordinated in southern Turkey ($37°$, $33°$) to represent Anatolian hypothesis (Bouckaert et al., 2012).

C.2.2 Least Coast Path

The potential migration paths are constructed based on the least cost path methodology implimented in ArcGIS software, that generates the path connecting a specified origin to the destination point, while minimizing a given measure of traveling cost along the path. The costs of traveling are reflected by the Human Mobility Index (HMI), a measure developed in Özak (2018, 2010) to capture the potential time cost of travel accounting for human biological constraints, as well as geographical and technological factors that determined travel time before the widespread use of steam power. As a result, for any given pair of destination point and origin the least cost path produces a set of adjacent $5' \times 5'$ cells that connects them together.

C.2.3 Environmental Dimensions

Environment in a given location i is captures as a first principal component of several dimensions:

1. Agricultural productivity of major food crops, captured as the Caloric Suitability Index constructed by Galor and Özak (2016, 2015). The major food crops are: barley, rye, wheat, rice, maize, oat, buckwheat, sorghum, foxtail millet, potato, cassava, yam, sweet potato and all of their variations presented in the FAO GAEZ dataset.
2. Climatic dimensions captured by the 19 bioclimatic variables from the WorldClim dataset described in Table C.3.

3. Measure of global elevation and ruggedness from the National Oceanic and Atmospheric Administration (NOAA) dataset.

Individual environmental variables described above are also used as geographic controls used in the estimation of the baseline results. Individual variables and their principal component are first calculated at $5' \times 5'$ grid-cell-level and then aggregated at a regional level.

C.3 Independent Variable: Change of Agricultural Productivity in due to Columbian Exchange

- **Crop Yield (pre-1500)** Maximal potential caloric yield identified across all indigenous crops using the methodology developed in Galor and Özak (2016, 2015). Measure is calculated at the grid cell level and then aggregated at the regional level.
- **Crop Yield (post-1500)** Maximal potential caloric yield identified across all crops (i.e., indigenous or not) using the methodology developed in Galor and Özak (2016, 2015). Measure is calculated at the grid cell level and then aggregated at the regional level.
- **Crop Yield (Change)** Difference between the Crop Yield after the Columbian Exchange (post-1500) and Crop Yield prior to the exchange (prior-1500).

C.4 Individual Controls

- **Individual level controls (ESS)**: Age, Gender, Education level (classified according to ICSDE, coded as a separate dummy variable for each category), Religiosity (based on the question "How often pray apart from at religious services"), Income (coded as a separate dummy variable for each income bracket) for each individual in the ESS data sets.
- **Individual level controls (GSS)**: Age, Gender, Education level (highest year of school completed), Religion in which raised (coded as a separate dummy variable for each denomination), Income (coded as a separate dummy variable for each income bracket) for each individual in the GSS data sets.

Table C.3: Bioclimatic variables

BIO1	Annual Mean Temperature
BIO2	Mean Diurnal Range (Mean of monthly (max temp - min temp))
BIO3	Isothermality (BIO2/BIO7) (100)
BIO4	Temperature Seasonality (standard deviation 100)
BIO5	Max Temperature of Warmest Month
BIO6	Min Temperature of Coldest Month
BIO7	Temperature Annual Range (BIO5-BIO6)
BIO8	Mean Temperature of Wettest Quarter
BIO9	Mean Temperature of Driest Quarter
BIO10	Mean Temperature of Warmest Quarter
BIO11	Mean Temperature of Coldest Quarter
BIO12	Annual Precipitation
BIO13	Precipitation of Wettest Month
BIO14	Precipitation of Driest Month
BIO15	Precipitation Seasonality (Coefficient of Variation)
BIO16	Precipitation of Wettest Quarter
BIO17	Precipitation of Driest Quarter
BIO18	Precipitation of Warmest Quarter
BIO19	Precipitation of Coldest Quarter