

Irrigation, Collectivism and Long-Run Technological Divergence

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Preliminary and incomplete. Comments welcome.

Abstract

This paper explores the historical origins of collectivist cultural norms and their long-term economic consequences. In its first part, I test the hypothesis that collectivism emerged historically in pre-industrial agricultural economies in which group effort was crucial for subsistence. I find a positive and significant association between the traditional use of irrigation - a production mode that required extensive collaboration and coordination within groups of farmers - and collectivist norms today. Instrumenting traditional irrigation by the environmental suitability for irrigated agriculture lead to similar results that point at a causal interpretation of the findings. I find that the effects persist in migrants, and investigate factors that hinder the transmission of collectivism. The second part of the paper shows that by affecting culture, past irrigated agriculture continues to influence contemporaneous innovation at the national and individual level. While irrigated agriculture is associated with greater technological progress in pre-modern societies, this relationship is reversed in the long-run. In addition, by favoring attitudes towards obedience, past irrigation also predicts patterns of job specialization and selection into routine-intensive jobs of countries and individuals.

Keywords: Agriculture; Culture; Collectivism; Persistence; Innovation; Job Tasks

JEL Classification: N00, O10, O30, Z10

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“Cooperation, such as we find it [...] say in the agriculture of Indian communities is based [...] on the fact, that in those cases, each individual has no more torn himself off from the navel-string of his tribe or community, than each bee has freed itself from connexion with the hive.”

Karl Marx, *Das Kapital* (1867)

1 Introduction

One of the major puzzles in long-run economic development is the explosion of technological progress in Europe after 1500, that was not accompanied by a similar growth in innovations in the more advanced regions of the Middle East or Asia.¹ While there are many explanations for the great divergence in science, innovation and economic fortunes, a prominent argument links it to cultural differences between the “East” and the “West” (Weber, 1958; Landes, 1999). Easterners are argued to live “in a complicated world of social constraints” (Nisbett, 2010), with strong values for group conformity that discourage people to search for unconventional ideas. Westerners are said to emphasize independence and differences between individuals, which motivated individuals to create innovations that were accepted and applied by society (Mokyr, 1992; Landes, 1999). Even though much importance has been attributed to these divergent value systems, our knowledge of their origins and their role for explaining patterns of long-run economic development is limited. Besides the pure academic interest, understanding the historical origins and persistence of norms of obedience and conformity - that ultimately affect innovation and growth - can also be informative for policies aimed at overcoming potential cultural barriers to growth.²

This study provides novel empirical evidence that addresses this gap. In the first part of this paper, I research how different pre-industrial agricultural production modes affected the evolution of cultural traits that either value group conformity (i.e. collectivism) or individual autonomy (i.e. individualism). In particular, I test the hypothesis that group coordination in agriculture has favored the emergence of cultural norms of collectivism that reflect the subordination of the individual to the group. I focus on the historical use of irrigation in agriculture that has been argued to have fostered the embeddedness of farmers in networks with rules and obligations for the coordination of the water supply (Barry III *et al.*, 1957; Wyer *et al.*, 2013). As irrigation could not be efficiently practiced by a single farmer, pre-industrial farmers crucially depended on the collective for survival. This contrasts with rain-fed agriculture that only required a constant level of precipitation, and allowed farmers to grow crops in isolation.

Social scientists, going back at least to Karl Marx, have been interested in studying the influence of cooperation in agriculture for the organization of societies for long times. Marx

¹China at that time, in particular, had all the pre-requisites that are commonly associated with economic success, including a state with a well functioning strong bureaucracy.

²While several Asian states, including China, have been growing extensively during the last decades, this growth was based on technological adoption and imitation, coupled with a strong work-ethic and large investments (Liang, 2010). To sustain high growth in the future, China needs to transition from investment to innovation-led growth (Zilibotti, 2015). That a culture of obedience can be a barrier for growth is already acknowledged by many entrepreneurs. In an interview with the BBC, technology entrepreneur Kai-Fu Lee noted that “before China gets to that level of innovation, it has to overcome a lot of issues that are cultural and about education, where there is emphasis on discipline and obedience.”

analyzed and compared communal structures of agricultural production and the social organizations that they shaped. His famous term “Asiatic Mode of Production” describes subsistence economies (within and outside of Asia) in which economic activity was located in communities, and in which agricultural production techniques, and specifically the use of irrigation, made intra-communal cooperation indispensable (Lubasz, 1984). According to Marx, the subordination of the individual to the community was a defining characteristic of the “Asiatic community”, and it operated under “the presupposition that the individual does not become independent *vis-a-vis* the community” (Marx, 1939 [1858]).

To empirically test whether the past use of irrigation in agriculture predicts norms of collectivism today, my analysis proceeds in several steps. I first compute, using ethnographic data, the fraction of current populations living in countries and sub-national regions whose ancestors used traditionally irrigation. I combine this information with contemporary data that evaluates cultural values of countries and individuals. My baseline empirical specification takes into account correlates of historical irrigation use, in particular a set of important geographic and historical characteristics of ethnic societies that includes average levels of rainfall, the overall suitability for agriculture, and the complexity of pre-colonial ethnic institutions. Nonetheless, measurement error in the ancestral irrigation variable and unobservable characteristics of historic societies that are correlated with the adoption of irrigation could bias the empirical estimates. To address endogeneity, I use an identification strategy that employs information about the agro-climatic constraints of ancestral lands for irrigated agriculture to instrument for the historical adoption of irrigation. I argue that, conditional on geographic and historical controls, irrigation suitability offers plausibly exogenous variation, and affects cultural values today only by its influence on the actual adoption of irrigation in the past.

My analysis shows that irrigation predicts norms of collectivism positively and significantly in Ordinary Least Squares (OLS), Reduced Form and Two-Stage Least Squares (2SLS) regressions. Reassuringly, irrigation suitability is overall a good predictor of the adoption of irrigation by ancestors of current populations. The positive association between ancestral irrigation and measures of collectivism appears in a) cross-country regressions that control for continental fixed effects to account for differences across world regions, and b) regressions across individuals living in more than 900 sub-national districts, conditional on individual controls and either continent or country fixed effects. Furthermore, I investigate whether irrigation use has created heterogeneous effects on norms that reflect acceptance of hierarchy or willingness to cooperate depending on the geographical environment where it was practiced. Consistent with the “Oriental despotism” theory of Wittfogel (1981), irrigation systems close to large rivers and in relatively drier climates are associated with a stronger preference for obedience, as they require a more intensive and centralized form of coordination; while irrigation systems in mountainous areas that relied on communal coordination go along with stronger norms of cooperation.

To test for the transmission of norms of collectivism, I use the epidemiological approach pioneered by Fernández (2008); Fernandez and Fogli (2009). I find evidence that collectivism persists, as past irrigation c) predicts collectivist cultural traits in a sample of 1st and 2nd generation European migrants, controlling for individual controls and either host country or sub-national region fixed effects, and d) is associated with higher rates of endogamous

marriage of 2nd generation US migrants, conditional on individual controls and US State fixed effects. The migrant analysis allows me to study a number of host country characteristics and policies that affect the transmission of collectivism in 2nd generation European migrants. My results suggest that ethnic fractionalization amplifies the historical persistence of collectivism, while greater spending on old age security mitigates persistence by making parents less likely to instill norms such as loyalty and respect in their children.

Having established a strong empirical relationship between ancestral irrigation and collectivist norms, the second part of this study then explores implications for comparative development. Consistent with the idea that conformist norms discourage the search for novel and unconventional ideas, I find a large negative association between the share of a country's population whose ancestors used irrigation and its contemporary scientific output. Moreover, in line with historic accounts of the technological head start of many irrigation countries, I document that these societies were technologically more advanced prior to 1500, but systematically fell back afterwards. This reversal of technological progress is estimated over the very long-run from 1000 BC to today, and appears in both cross-sectional, as well as in panel regressions that take into account time-invariant country effects.

While these are reduced-form estimations, they hint at a cultural mechanism for two reasons. First, the effects of irrigation on technology are driven by its influence on populations, not localities: irrigation suitability computed in the homelands of ancestors of contemporary populations are a superior predictor of innovation than local irrigation suitability. Second, past irrigation also predicts the degree of innovativeness of US migrants that live outside their country of origin. My preferred interpretation of these findings is that irrigation shaped transmittable cultural norm of group conformity, which were beneficial in agricultural economies as they allowed a more efficient coordination of production. However, they turned out to be disadvantageous in the modern growth regime that relies on a rapidly expanding stock of ideas and innovation created by private individuals.

Finally, past irrigation also predicts patterns of occupational specialization across countries and migrants. Descendants of irrigation societies are more likely to select into jobs that are intensive in routine tasks and require rule-following rather than independent behavior.

This paper relates to several existing literatures. Foremost, my study adds to the literature on the historical origins of cultural norms and preferences.³ Past geographical characteristics have been shown to explain variation in cultural beliefs about gender equality (Alesina *et al.*, 2013)⁴, preferences for hard work (Fouka and Schlaepfer, 2014), time preference (Gallor and Özak, 2016), social capital (Litina, 2016)⁵ and the degree of cooperation of societies (Bugge and Durante, 2016).⁶ Moreover, Olsson and Paik (2016) argue that areas within Eu-

³For an overview of the economic literature that links history and cultural evolution see Nunn (2012).

⁴I follow Alesina *et al.* (2013) innovative methodology for constructing ancestral characteristics of modern societies from ethnographic data.

⁵ Litina (2016) argues that higher land productivity has hampered cooperation in agriculture, for example to build irrigation infrastructure, implying positive long-term effects of irrigation on trust and incomes. My study differs in important aspects as I show that extensive cooperation within groups in irrigated agriculture has created in-group orientation and norms of group conformity. To account for Litina's hypothesis, the base set of geographic controls includes the agricultural suitability of ancestral lands.

⁶Persistence of cultural traits is attributed to intergenerational transmission from parents to children, following the seminal model by Bisin and Verdier (2001). Dohmen *et al.* (2012) provide empirical evidence for the intergenerational transmission of values, and Voigtländer and Voth (2012) show long-term persistence of antisemitism

rope that transitioned later to agriculture are more individualistic. Relative to these existing contributions, I provide novel evidence for the emergence of collectivist norms as a result of coordination in pre-industrial agricultural production that has not been studied so far, and conduct an analysis of various external factors that impact the persistence of collectivism. My paper also links to [Enke \(2017\)](#) who, in line with my argument, shows that historical kinship ties predict in-group orientation of societies today.⁷

Few studies in economics have empirically investigated the socio-economic effects of irrigation. The paper most closely related to mine is [Bentzen *et al.* \(2016\)](#) who analyze the reduced form relationship between irrigation suitability and autocratic institutions across countries.^{8,9} I regard the cultural effects of irrigation as complementary to the institutional consequences, given the likely two-way interactions between collectivist norms and institutions ([Gorodnichenko and Roland, 2015](#)).¹⁰ However, an important difference of my study to [Bentzen *et al.* \(2016\)](#) is that I use measures of historical irrigation that take into account the ancestral composition of contemporary societies - rather than irrigation potential of current localities - which allow me to focus on the historically determined cultural impacts of irrigation. In fact, I show that measures of irrigation potential that are not adjusted for ancestry are a much worse predictor of collectivism and innovation. Even the institutional outcomes used by [Bentzen *et al.* \(2016\)](#) are better predicted by suitability measures that take into account ancestral compositions of populations. This suggests that at least some of the effect of irrigation on institutions works through culture.

This study also relates to the literature in cross-cultural research that investigate empirically the origins of collectivism in particular [Fincher *et al.* \(2008\)](#) and [Talhelm *et al.* \(2014\)](#). [Talhelm *et al.* \(2014\)](#) document that students from rice-growing areas in China think more collectively compared to students from wheat growing areas. My results suggests that the underlying mechanism for these differences in thinking between rice and wheat-growing areas could be the historical use of irrigation in rice agriculture. To test more specifically whether rice agriculture affects collectivism or the technique with which it is cultivated, I compare the impact of different types of rice suitability on norms in supplementary regressions. Empirical results suggest that irrigated rice matters for collectivism, but not suitability for rain-fed rice.¹¹

My results on long-term technological divergence also add to the small number of existing

attitudes in Germany over 600 years.

⁷In addition, my paper relates to studies that investigate the consequences of differences in the strength family ties across societies. The family can be regarded as the smallest collectivist group, and societies with strong family ties emphasize the importance of the family over the individual. Strong family bonds can be correlated with worse functioning political institutions ([Banfield, 1958](#)), higher labor market regulation ([Alesina *et al.*, 2015](#)), and lower preferences for innovation and trust ([Alesina and Giuliano, 2013](#)). In a number of article Greif discusses how the dissolving of kinship relations in Western Europe led to institutional and economic modernization, whereas in Asia kinship relations stayed strong ([Greif \(2006\)](#); [Greif and Tabellini \(2010\)](#); [Greif and Tabellini \(2012\)](#)). Relatedly, [Schulz \(2016\)](#) analyzes empirically the effect of the church's ban of cousin-marriages on Europe's modernization.

⁸This is the "oriental despotism" hypothesis by [Wittfogel \(1981\)](#). The idea that Asiatic societies were ruled by despots goes back to Marx who took it from Greek writings ([Lubasz, 1984](#)).

⁹[Bentzen *et al.* \(2016\)](#) were also the first to use a measure of irrigation potential based on geographic constraints.

¹⁰That being said, all regressions control for a measure of pre-colonial ethnic institutions, and results are robust to controlling for current institutions and country fixed effects.

¹¹Compared to [Talhelm *et al.* \(2014\)](#) my paper makes several advances: First, I test a related hypothesis about the use of irrigation and collectivism for the entire world. Second, I aim to move the analysis towards identifying causality. Third, I test whether irrigation affects cultural norms of collectivism that are transmitted. And finally, I examine whether it is a particular crop, such as rice, or the agricultural production technique of irrigation, that affects collectivist norms.

cross-country studies on the impact of collectivism on contemporaneous levels of income and innovation, especially [Gorodnichenko and Roland \(2011a, 2016\)](#), and on the economic effects of culture more generally ([Guiso et al., 2008](#); [Fernández, 2011](#); [Algan and Cahuc, 2013](#)).

My findings on selection into routine-intensive occupations relate to the large literature in labor economics on job tasks, in particular [Autor et al. \(2003\)](#) and [Acemoglu and Autor \(2011\)](#), and labor market sorting based on individual preferences ([Krueger and Schkade, 2008](#)). By documenting the importance of culture for explaining patterns of specialization, my results are similar to [Campante and Chor \(2017\)](#) who establish a relationship between workplace obedience and specialization in routine tasks. In addition, I push the argument one step further back and analyze the historical origins of norms and tasks.

The paper is organized as follows. Section 2 defines collectivism and outlines the main argument. Section 3 discusses the construction of the main variables used and the empirical strategy. Section 4 shows the result of ancestral irrigation on cultural norms of collectivism. Section 5 contains results of ancestral irrigation on innovation. Section 6 concludes.

2 Conceptual Framework & Hypotheses

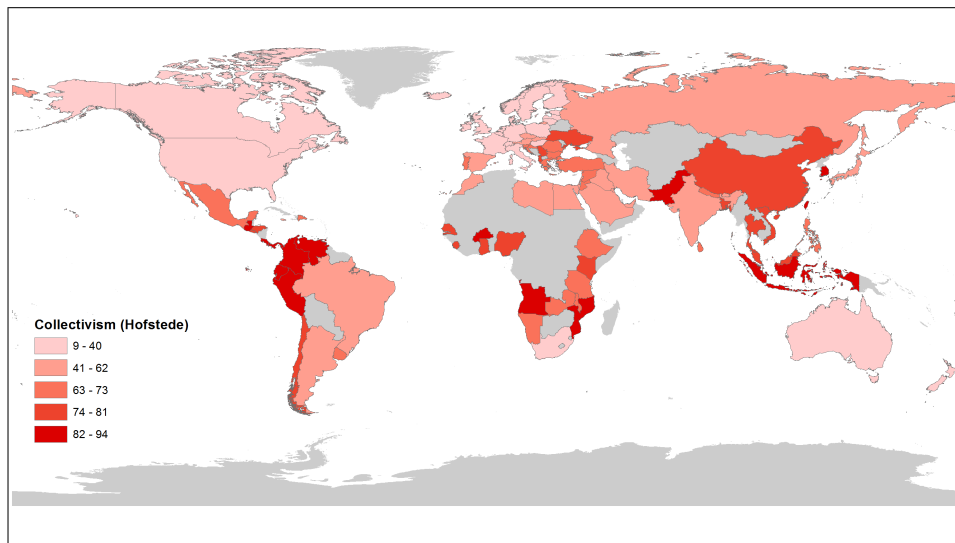
2.1 Defining Collectivism

Cross-cultural research regards the the individualism-collectivism cleavage as a key cultural dimension to describe societies ([Oyserman et al., 2002](#)).¹² Despite the large amount of research on individualism/collectivism, the concept is loosely defined and measured by a great variety of outcomes. The term collectivism describes a set of cultural values that reflect the subordination of the the individual to the group, and his dependency on the group for survival and social security. [Hofstede et al. \(1997\)](#), for example, define collectivism as a “tight social framework in which people distinguish between in-groups and out-groups; they expect their in-group (relatives, clan, organizations) to look after them, and in exchange for that they feel they owe absolute loyalty to it.” [Hofstede et al.](#)’s definition implies that collectivism is a culture of *interdependence*, in which conformity of the individual to the group is crucial, but comes at the cost of reduced personal autonomy ([Wyer et al., 2013](#)). Collectivism can further be divided into a horizontal form in which groups emphasize equality and cooperation between similar individuals; and a vertical form in which hierarchies are pronounced and people defer to authority ([Singelis et al., 1995](#)). In contrast, “individualism implies a loosely knit social framework in which people are supposed to take care of themselves and of their immediate families only.” ([Hofstede et al., 1997](#)). Thus, individualism is the diametric opposite of collectivism, and describes a culture of *independence*.

The self-perception of being socially independent or interdependent has consequences for the shape of interpersonal relationships, and cognitive styles on the individual level; and has been argued to affect a number of important socio-economic outcomes on the aggregate level ([Markus and Kitayama, 1991](#); [Nisbett and Masuda, 2003](#)). Since individuals in collectivist societies are born into cohesive groups with well-defined social relations and obligations, they

¹²The scholarly interest in the relationship between the individual and the group, identifying and comparing the extent to which individuals are independent from or embedded in various groups goes back at least to classical works by Emile Durkheim, Max Weber, and Ferdinand Tönnies, contrasting *Gesellschaft* and *Gemeinschaft*.

Figure 1: COLLECTIVISM ACROSS COUNTRIES



Note: This figure shows average collectivism across countries taken from [Hofstede et al. \(1997\)](#). Scale: 0 - 100.

are less likely to build up and engage in new alternative networks with non-group members ([Gorodnichenko and Roland, 2012](#)). Cooperation is therefore generally limited to in-group members ([van Hoorn, 2014](#)). For example, welfare provision, such as caring for elderly members of the society, is not universal but group-based. Collectivist cultures also demand a constant coordination of behavior in line with the group and do not like individuals to stand out. Obedient behavior and the aversion towards disruptions of group harmony can hamper individuals incentives to innovate and to engage in collective political action ([Gorodnichenko and Roland, 2011a, 2015](#)). The importance put on social relations and the group are also reflected in a corresponding cognitive style that gives more attention to connections, relationships, and contexts, “focusing on the forest rather than the trees” ([Wyer et al., 2013](#)).

Figure 1 illustrates the individualism/collectivism cleavage across countries, measured by the score constructed by [Hofstede et al. \(1997\)](#). The highest levels of collectivism are observed in Vietnam, South Korea, Pakistan, Ecuador and Guatemala, whereas the United States, followed by Australia and Great Britain are among the most individualist countries in the world.

2.2 The Agricultural Origins of Collectivist Norms

A prominent hypothesis in cross-cultural literature links the origins of individualist and collectivist traits to the ecological environment that societies inhabited in the past, and in particular to different types of subsistence economies ([Triandis and Gelfand, 2012](#)).¹³ The argument is that ecological conditions that require group effort and conformity for subsistence production supported the emergence of collectivist cultures. On the other hand, cultural traits of individualism are more likely to be found in ecological environments where self-reliance and independence of individuals in agriculture guarantees subsistence ([Barry III et al.,](#)

¹³More generally, cultural norms can be defined as “rules of thumb” that guide behavior in uncertain situations. The literature in evolutionary anthropology models the emergence of culture as an evolutionary process that selects those behavioral norms that maximize the chances of survival in a given environment. Over time, these behavioral norms become more widespread and establish themselves in a society’s culture ([Boyd and Richerson, 1988, 2004](#)).

1957). The agricultural technique that has been singled out for its extraordinary high reliance on cooperation between interdependent farmers is the use of irrigation in the cultivation of crops (Wyer *et al.*, 2013). While crops can be grown using precipitation as the only source of water, in many parts of the world rainfall levels are insufficient for crop cultivation. As an alternative to rain-fed agriculture farmers can use irrigation, that is the artificial supply of water from sources such as surface water - in particular rivers and lakes, or groundwater - that is channeled to the fields via a system of canals and dams. The use of irrigation has a long history, going back more than 5,000 years in some parts of the world such as Mesopotamia (Vasey, 2002).

Yet, while irrigated agriculture allows farmers to grow crops in the absence of rain, it demands a high level of coordination and cooperation, and hence increases interdependences between farmers. Besides the collective construction and maintenance of irrigation systems, farmers that are connected in an irrigation network need to solve many difficult coordination problems (Janssen, 2007). In particular, farmers need to jointly decide on the optimal timing of harvests, and the cycles of wet and dry phases, in order to avoid water shortages and outbreaks of pests that can severely affect crop yields. For example, pests are most efficiently kept under control if all farmers harvest simultaneously. However, joint harvest would imply a common planting date which increases the risk of water shortages. It is therefore crucial for irrigation communities to coordinate an optimal planting schedule - and to meticulously stick to it. While community welfare is maximized if each farmer respects the planting schedule, each individual farmer has incentives to deviate and to disrespect the groups goals in order to increase his own payoff. Of course, such behavior would jeopardize the groups harvest and welfare. Enforcement mechanisms that deter potential defectors, and that guarantee conformity of the individual with the irrigation community, are commonly used (Wijermans and Schlüter, 2014). They include in particular social punishment, for example in the form of ostracism or the threat to cut the defector off from the irrigation network.

The ethnographic literature indicates that constant coordination and cooperation within members of the irrigation community is crucial in irrigated agriculture. However, whether sustained cooperation needs some degree of centralized authority, or whether coordination can be achieved via community cooperation, is subject of considerable amount of debate in anthropology (Janssen, 2007; Hunt, 1988). Most prominently, Wittfogel (1957) argued that irrigation required political centralization, favored strict social hierarchies and authoritarian political institutions. Evidence in support of Wittfogel's hypothesis is provided by Bentzen *et al.* (2016), who document a positive association between irrigation suitability and autocracy across countries. Anthropological evidence, however, is less supportive of the "oriental despotism" hypothesis, arguing that in many instances the despotic state preceded the construction of irrigation facilities rather than following from it (Adams, 1960; Lanning, 1967).

Apart from centralized coordination in hydraulic states, decentralized cooperation between community members has historically been an equally important way of managing irrigation networks (Molle, 2004). Research on community irrigation in Asia documents that farmer-managed irrigation systems are widespread, and have existed several centuries (Molle, 2004). The most sophisticated and well studied stateless irrigation system is the *Subak* system on Bali (Lansing, 2009). Dating back more than thousand years, the Balinese irrigation

system is composed of communities of farmers (*Subaks*) that jointly manage the water supply of a block of rice fields with a complex schedule specifying the action and date of execution for each *Subak*. While the *Subak* system shows that farmer-managed irrigation can also be large in scale, community irrigation systems are on average smaller in size [Molle \(2004\)](#). On a closer look, the differentiation between community and centralized coordination is consistent with the details of Wittfogel's hypothesis. [Wittfogel \(1957\)](#) argued that centralized authority should emerge particularly in areas that characterized by a) arid climates, b) and a large water source (e.g. the Nile, Hindustan Valley) that requires large-scale irrigation ([Wittfogel, 1957](#); [Hunt et al., 1976](#)). Coordination using centralized authority can therefore be expected to be more beneficial if the coordination problem is more complex, i.e., if the size of the communities involved is larger or if there is a higher degree of water stress.

Based on this discussion I formulate several hypotheses. The main hypothesis argues that irrigation favored the emergence of norms of group orientation, conformity and obedience (i.e., collectivism) rather than independence compared to other forms of subsistence economies. In particular, centralized coordination in large-scale irrigation could be reflected in a stronger acceptance of authority, while cooperation between equals in small scale irrigation networks might have favored norms of cooperation. Regarding the long-term persistence of norms, two channels are possible. Collectivism might have been preserved in the long-run via a mechanism of inter-generational transmission from parents to children.¹⁴ In addition, it is likely that collectivist norms interacted with institutional characteristics, helping to create complementary political institutions that facilitated the persistence of cultural differences over time.¹⁵

2.3 Motivating Evidence

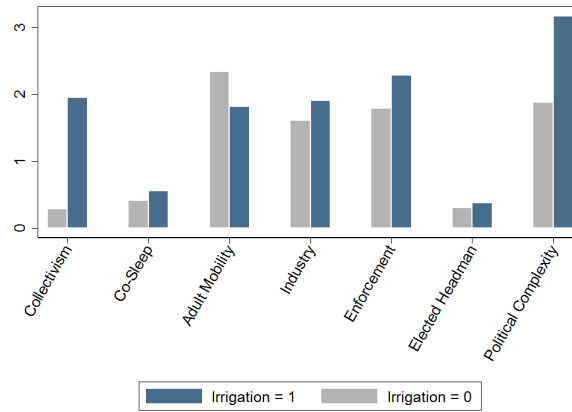
As a first motivating piece of evidence, I compare historical societies that used irrigation to those that did not with respect to a number of cultural and institutional characteristics. Figure 2 documents that irrigation societies differ in several dimensions: Most importantly, they score higher on a measure of collectivism that gives the relative importance parents place on obedience rather than self-reliance in children. Irrigation societies also practice co-sleep more frequently ([Nisbett and Masuda, 2003](#)), adults are less likely to leave the community, and they place higher values on hard-work. Regarding institutional characteristics, irrigation societies are more likely to use formal sanctions and enforcement mechanisms to enforce community decisions, but the election of leaders is, if anything, more democratic. Finally, political institutions of irrigation societies are indeed more centralized.

Figure 2 gives a first indication that citizens in irrigation societies “lived in a complicated

¹⁴The inter-generational transmission of collectivist values is well described in research on cultural-psychology that documents how parents inculcate collectivist or individualist values and thinking in children from early on. According to [Nisbett and Masuda \(2003\)](#) children learn independence or interdependence from very young ages onwards. The authors observed and contrasted the socialization of Western and Asian children and found interesting differences. For instance, while Western babies sleep in beds that are separated from their parents, Asian babies are always surrounded by at least the mother, but oftentimes several generations, even at night. In addition, while American mothers teach their children to focus on objects and their characteristics when playing, Japanese mothers direct their children's focus on feelings and the relationships between objects.

¹⁵See [Gorodnichenko and Roland \(2015\)](#) for the relationship between collectivism and autocratic institutions. A similar argument for the co-evolution of culture and institutions in the long-run has been made by [Buggle and Durante \(2016\)](#) in the case of social trust and political institutions in European regions.

Figure 2: SOCIO-POLITICAL CHARACTERISTICS OF PRE-INDUSTRIAL SOCIETIES



Note: Ethnic groups from the Standard Cross Cultural Sample. See Data Appendix for a variable description.

world of social constraints.” (Nisbett, 2010). Moreover, qualitative evidence and results from a few small-scale empirical studies suggest that agro-climatic conditions go along with collectivist norms (Nisbett, 2010; Welzel, 2013; Huang, 2015; Talhelm *et al.*, 2014).

3 Data and Empirical Strategy

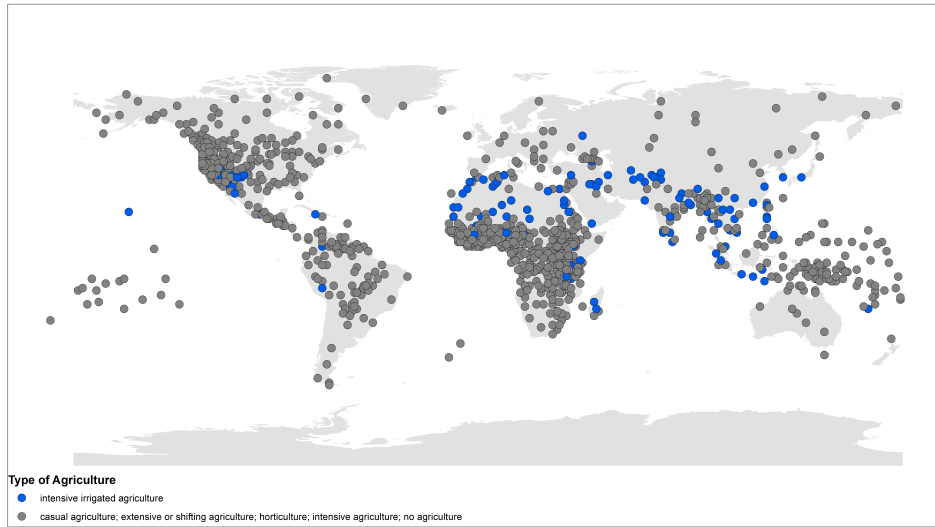
3.1 Ancestral Irrigation

My main variable of interest measures how important irrigation was historically for the ancestors of today’s societies. In particular - following the methodology developed by Alesina *et al.* (2013) and Giuliano and Nunn (2017) - I use information on the characteristics of a total of 1,164 ethnic groups from Murdock’s *Ethnographic Atlas* and link them to the spatial distribution of ethnicities today. This allows to compute population adjusted shares of ancestral characteristics within contemporary borders.¹⁶ Variable v28 of the *Ethnographic Atlas* provides information on the intensity of agriculture, ranging from (1) *no agriculture*, (2) *casual agriculture*, (3) *extensive or shifting agriculture*, (4) *horticulture*, (5) *intensive agriculture* and (6) *intensive irrigated agriculture*. 126 societies are reported to have used irrigation in agriculture (about 11 %). Figure 3 displays the approximate location of each ethnic group and the six types of cultivation. Societies that used irrigation broadly cluster in Asia, Africa, particularly in the North, as well as in South America.

After having linked the groups included in the Atlas to the contemporaneous distribution of ethnic groups using several maps, I compute the population that falls within the boundaries of each contemporary ethnic group - taken from the *Gridded Population of the World* (GPW) shapefile - to construct shares of populations with different ancestral characteristics for any administrative division on which outcome variables are measured (e.g. country or

¹⁶Economists have used the Atlas recently to study historical characteristics of populations and their impact on modern outcomes, e.g. Nunn and Wantchekon (2011); Michalopoulos and Papaioannou (2013). For each ethnic group the Atlas reports a wide range of information, from the type of economic activity, to different marital and other traditions, and the complexity of political institutions etc. Sampling dates of groups range from the 17th century to 1950. The Atlas also reports geographic coordinate of the approximate location of each group.

Figure 3: IRRIGATION ACROSS ETHNIC GROUPS



Note: This figure shows the location of ethnic groups and their type of agriculture as reported in the EA.

sub-national region).¹⁷ This procedure therefore assumes that individuals that reside within the boundaries of an ethnic group, as drawn by the maps of ethnicities today, are of the same ethnicity. To compute a measure of ancestral irrigation, for example, I first construct a variable that takes on the value 1 if the ethnic group used irrigation, and 0 otherwise. For each administrative division, e.g. country, I compute the share of the population that used irrigation by multiplying the population that falls within the boundaries of an ethnic group with the dummy variable for irrigation and dividing it by the total population of the administrative division for which information exists. The resulting variable (labeled *Ancestral Irrigation*) gives the percentage of contemporary populations whose ancestors have used irrigation.¹⁸

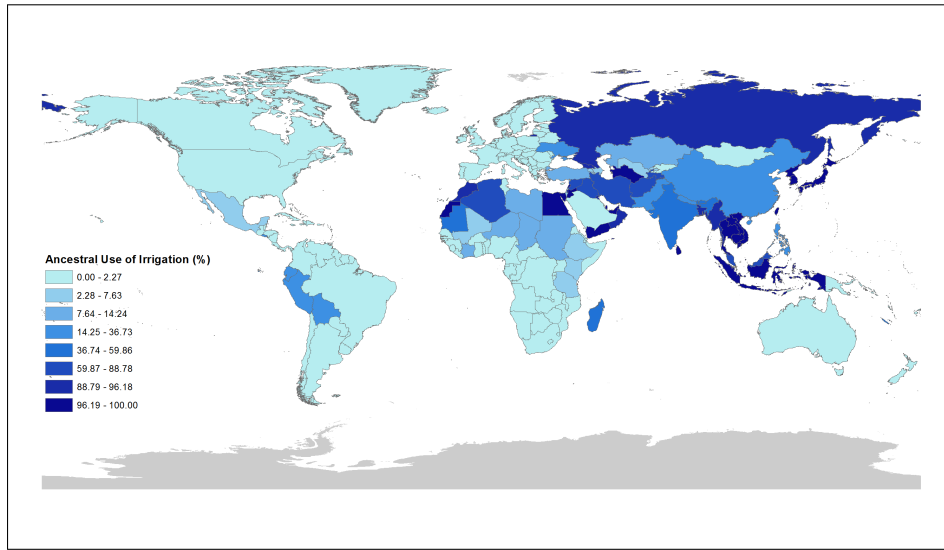
Figure 4 illustrates the global distribution of *Ancestral Irrigation*. It suggests that societies whose ancestors used irrigation are primarily located in Northern and Western Africa, Asia, Russia, as well as South America. A similar conclusions emerges from Figure A5 which shows the same variable computed for sub-national districts.¹⁹

¹⁷In particular, African ethnic groups are merged to the *Map of Ethnic Boundaries* constructed by Murdock; groups outside Africa to the *Ethnologue: Languages of the World* database, which maps the spatial distribution of 7,612 languages in the world as in 2003; if no match can be found in the *Ethnologue*, I use the less detailed *Geo Referencing Ethnic Groups* (GREG) map of Weidmann et al. (2010), which includes boundaries of ethnic groups building on the Soviet Atlas Narodov Mira. Finally, for a handful of groups no match can be found in any of these, therefore I match groups with modern administrative boundaries. See Figure A1 for a visualization of the four different maps used and the areas that they cover, and Figure A2 for a representation of the ethnic groups matched in Mexico. The basic matching procedure follows Fenske (2013) with corrections and adjustments.

¹⁸Cross-validating the measure of ancestral irrigation that I constructed with the methodology developed by Giuliano and Nunn (2017) and used in Alesina et al. (2013) that the authors kindly provided to me shows a very strong correlations of about 0.97, see Figure A11.

¹⁹There are a number of caveats with the measure of ancestral irrigation use that are aggravated on the regional level. First, the methodology assigns ethnicity by the location of residence of individuals within ethnic boundaries. However, even if one assumes that spatial boundaries of ethnic groups are drawn accurately, it does not account for adjustments in spatial boundaries of ethnic groups resulting for example from migration. Second, for several regions information on ethnic groups is only available for a small fraction of the population. Since uncovered areas are coded as missing, the method produces measurement error which can be severe for sub-national regions for which only few data points are available. Consequently, most of the variation in the ancestral measure is at the macro level. A similar issue has been documented by Alesina et al. (2013) for ancestral use of the plough.

Figure 4: ANCESTRAL IRRIGATION ACROSS COUNTRIES



Note: This figure shows the share of a country's population whose ancestors traditionally used irrigation.

3.2 Irrigation Suitability

Not all areas of the world are equally suitable for irrigation. Irrigation suitability depends on rainfall levels, climatic and soil conditions and the suitability of different crops and their water requirement. The Food and Agriculture Organization of the United Nations (FAO) provides a global assessment of the soil suitability for crop cultivation under irrigation (Fischer *et al.*, 2002). Suitability is broken down in five irrigation impact classes, where each class represents the increase in agricultural production - compared to rain-fed agriculture - that can be obtained by fully exploiting irrigation.²⁰ Class (1) contains areas that are suitable for rain-fed agriculture only, class (2) includes areas where irrigation increases agricultural output by 0 - 20 %, class (3) areas where irrigation impacts output by 20 - 50 %, class (4) areas where irrigation increases output by 50 % and class (5) areas where irrigation increases output by more than 100 % (Fischer *et al.*, 2002).²¹ I define land as suitable for irrigation if irrigation increases agricultural production by at least 50 %. Irrigation suitability is therefore computed as the sum of land with impact classes (4) and (5), divided by the total land suitable for agriculture. Crucially, suitability of irrigation is first evaluated at close proximity of the historical ethnic groups, i.e., within a radius of 200 kilometers around the centroid of each ethnic group of the *Ethnographic Atlas*. Irrigation suitability for each historical group is then used to compute *ancestry-adjusted suitability* measure for contemporary societies countries and regions, following the methodology described above. If not stated otherwise, measures of irrigation suitability always take into account the ancestral composition of societies today.²²

²⁰The FAO assessment of irrigation suitability does not quantify the availability of water that can be used for irrigation, but assumes that "water resources of good quality are available" (Fischer *et al.*, 2002).

²¹See Figure A3 for a spatial illustration of irrigation impact classes.

²²Bentzen *et al.* (2016) were the first to use the FAO measure of irrigation suitability. My measure of irrigation suitability differs in two important ways: Contrary to Bentzen *et al.* (2016), who define land as suitable if it falls in the impact class 5, I find that combining classes 4 and 5 predicts ancestral irrigation - as constructed from the *Ethnographic Atlas* - better. In addition, I use an ancestry-adjusted measure of irrigation suitability, while Bentzen *et al.* (2016) use the unadjusted (local) country average. In the empirical analysis I will compare the effects of the

3.3 Geographic and Ethnographic Control Variables

To isolate the effects of irrigation from other geographic and ethnographic characteristics of historical societies I control for a number of covariates of irrigation. Notably, all specifications control for the overall environmental suitability for agriculture (based on [Ramankutty et al. \(2002\)](#)) to account for differences in traditional reliance on agriculture. Other geographic controls include mean levels of precipitation, access to water (distances to the nearest coast and to one of the nearest major rivers), average altitude, and the share of tropical climates. Controlling for tropical climate takes care of differences in disease environments that is much higher in the tropics ([Guernier et al., 2004](#)), and that has been found to be a strong driver of in-group bias of populations ([Fincher et al., 2008](#)). All geographic variables are first evaluated in proximity to traditional ethnic groups, which are then used to compute ancestry-adjusted geographic measures for contemporary countries and regions. Furthermore, ethnographic controls are the degree of centralization of historical political institutions and - as proxies for historical economic development - the type of settlement and the mean size of communities.²³ Again, all country and regional averages of these ethnographic variables are adjusted by ancestry of the population.

3.4 Identification Strategy

To identify the long-term impact of traditional irrigation, I use the following empirical strategy. I begin by estimating OLS regressions of the following form (abstracting from notation):

$$y = \alpha + \beta \text{AncestralIrrigation} + X' \delta + \epsilon \quad (1)$$

where y is an outcome, *AncestralIrrigation* is the measure of ancestral irrigation and X a matrix of control variables. The baseline controls are the geographical covariates and ethnographic covariates described above.

An obvious concern with the OLS model is that a number of unobserved reasons might have influenced the adoption decision of irrigation across societies, which lead to a bias in the coefficient of interest β . Furthermore, the ancestral irrigation variable that is computed from ethnographic data is susceptible to measurement error. To move towards identifying the causal effect of past irrigation, I employ an instrumental variables strategy that uses the environmental suitability for irrigation to predict the actual use of irrigation by ethnic groups in a first-stage regression. The 2SLS model takes on the following form.

ancestry-adjusted to the local measure of irrigation suitability.

²³Political institutions of societies are measured by the number of jurisdictional hierarchies beyond the local community reported in the *Ethnographic Atlas*, ranging from no levels above the community to four levels beyond the community (V33), following [Michalopoulos and Papaioannou \(2013\)](#) and others. Settlement patterns (V30) roughly proxy for the level of historical socio-economic development of ethnic groups and are coded as either (1) nomadic or fully migratory, (2) semi-nomadic, (3) semi-sedentary, (4) compact but impermanent settlements, (5) neighborhoods of dispersed family homesteads, (6) separate hamlets (7) compact and relatively permanent settlements, or (8) complex settlements. The *Ethnographic Atlas* also reports the size of local communities (V31) which allows to assess the degree of historical urbanization and density of populations of ethnic groups. Whether societies were organized in cities or rural communities determines the type of social interactions and might be an important counterfactual of collectivism. The variable is coded into eight classes, where (1) indicates populations of fewer than 50, (2) between 50-99, (3) between 100-199, (4) between 200-399, (5) between 400-1000, (6) 1,000 without any town of more than 5,000, (7) Towns of 5,000-50,000 (one or more), (8) Cities of more than 50,000 (one or more).

$$\begin{aligned} \text{First Stage:} \quad & \text{AncestralIrrigation} = \lambda_1 + \lambda_2 \text{IrrigationSuitability} + X' \lambda_3 + \varphi \quad (2) \\ \text{Second Stage:} \quad & y = \beta_1 + \beta_2 \widehat{\text{AncestralIrrigation}} + X' \beta_3 + \mu \quad (3) \end{aligned}$$

where $\widehat{\text{AncestralIrrigation}}$ indicates the predicted value obtained in the first-stage. The validity of the identification strategy relies on the excludability of the instrument. The exclusion restriction is satisfied if irrigation suitability impacts y only through its effect on actual irrigation use. I argue that the geographical suitability for irrigation is plausibly exogenous to the adoption of irrigation, *conditional* on the set of geographic and ethnographic covariates included. In particular, irrigation suitability could be correlated with geographic characteristics that affect y independently of irrigation. The base set of geographic controls take care of a great deal of potential co-variables of irrigation suitability, in particular rainfall levels, the distance to water sources and the overall suitability for agricultural production that are likely correlated with the suitability for irrigation. However, I will address the influence of other environmental characteristics explicitly in the 2SLS estimation of the cross-country analysis.

4 The Persistent Impact of Irrigation on Collectivism

4.1 Irrigation and Collectivism across Countries

To measure the degree of collectivism across countries, I rely on the collectivism score constructed by Hofstede *et al.* (1997).²⁴

Ordinary Least Squares I start by analyzing the OLS relationship between ancestral irrigation and collectivist norms across countries in Table 1. Column 1 reports the coefficient of the bivariate correlation, that is positive as expected and statistically significant at the 1 % significance level. Conditioning on geographic and ethnographic controls in column 2 increases the size of the effect of ancestral irrigation. Columns 3 to 7 consider a number of countrywide co-variables that are potentially correlated with irrigation use and collectivism. Irrigation retains a positive and significant coefficient controlling for the timing of the transition to agriculture (Putterman, 2008; Olsson and Paik, 2016) (column 4); the presence of early states (Bockstette *et al.*, 2002) (column 5); traditional democracy (column 5); the suitability of the environment for malaria (column 6); and contemporary ethnic fractionalization (column 7). Column 8 adds fixed effects for world regions to rule out that the relationship is driven by differences across continents, in particular dummies for countries in Europe, Africa, North America, Latin America, East Asia and Pacific, Central and West Asia, as well as South Asia, following the classification of the World Bank, that is illustrated in Figure 5a. Finally, column 9 considers all controls jointly, and the effect of irrigation is similar. The magnitudes of the estimated effects are sizable. The bivariate correlation in column 1 implies a beta coefficient

²⁴Hofstede *et al.* (1997) measure has been widely used in both the economic literature (in particular Gorodnichenko and Roland (2016); Gorodnichenko and Roland (2011b); Gorodnichenko and Roland (2012)) and in cross-cultural research (e.g. Chiao and Blizinsky (2010); Fincher *et al.* (2008)). Hofstede originally studied cultural values of IBM employees between 1967 and 1973 and later enlarged the data, by surveying a diverse range of professionals from pilots to students.

**Table 1: IRRIGATION AND COLLECTIVISM ACROSS COUNTRIES:
OLS ESTIMATES**

	Collectivism								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Ancestral Irrigation	13.95*** (4.11)	16.05*** (4.94)	18.39*** (5.94)	17.24*** (5.60)	16.55*** (4.84)	19.37*** (5.24)	18.16*** (5.20)	18.08*** (6.37)	24.08*** (6.17)
Neolithic Revolution			-0.77 (1.16)						3.39** (1.28)
State Antiquity				-12.31 (12.91)					-6.20 (10.83)
Traditional Democracy					-11.45* (6.39)				-0.64 (5.02)
Malaria Suitability						1.24** (0.52)			1.79*** (0.53)
Ethnic Fractionalization							25.68** (11.75)		22.01** (9.88)
Geographic Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	No	No	No	No	No	No	No	Yes	Yes
Observations	97	93	93	86	90	93	93	93	83
R-squared	0.06	0.36	0.36	0.39	0.36	0.39	0.40	0.63	0.72

Note: OLS regressions. The unit of observation is the country. The dependent variable is the [Hofstede et al. \(1997\)](#) Index of Collectivism measured on a scale from 0 to 100. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls, as well as malaria suitability, are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

of 0.24, which moves with the full set of base geographic and ethnographic controls, as well as region fixed effects to 0.38. Increasing ancestral irrigation by one standard deviation (std.) increases the collectivism score by between 5 to 9 percentage points.

Table 2 investigates the effect of ancestral irrigation on alternative cultural outcomes associated with collectivism. As expected, ancestral irrigation predicts positively and significantly group embeddedness (column 1), and negatively measures of affective and intellectual autonomy (columns 2-3). Relatedly, the in-group orientation of traditional irrigation societies is also reflected by higher levels of in-group favoritism (column 4). Irrigation societies are documented to have used punishment and rigid norms to enforce group conformity. Consistent with this observation, columns 5 and 6 show that irrigation societies have indeed stricter social norms and emphasize restraint, and are culturally more tight, i.e. less tolerant towards norm deviance.

Table 3 tests the robustness of the OLS results conditional to a number of other possible confounders - some of which are itself potentially endogeneous to the traditional use of irrigation. Ancestral Irrigation retains a significant and positive effect on collectivism conditional on a quadratic of the migratory distance from Africa ([Ashraf and Galor, 2013](#)); absolute latitude of the country, population density in 1500; and the share of adherents to the world religions. Even when conditioning on institutional quality and per capita income, irrigation predicts collectivism positively, albeit - given the interactions between irrigation, institutions ([Bentzen et al., 2016](#)), collectivism and income - the effects are smaller. Controlling for the share of

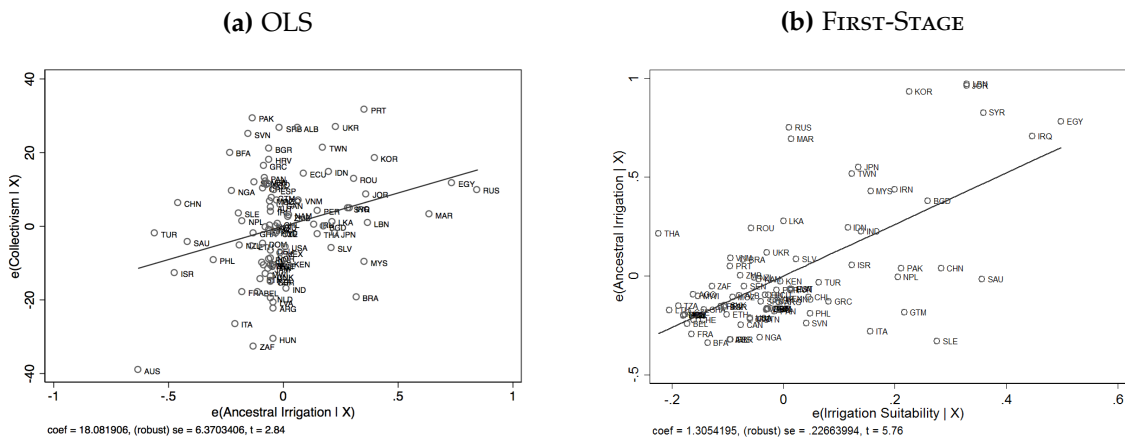
Table 2: IRRIGATION, ALTERNATIVE MEASURES OF COLLECTIVISM AND NORM RIGIDITY

	Embeddedness	Affective Autonomy	Intellectual Autonomy	In-Group Favoritism	Restraint	Social Tightness
	(1)	(2)	(3)	(4)	(5)	(6)
Ancestral Irrigation	0.43*** (0.13)	-0.37 (0.25)	-0.31*** (0.08)	0.90*** (0.16)	27.54*** (5.10)	47.56*** (7.63)
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	70	70	70	109	85	60
R-squared	0.68	0.54	0.55	0.42	0.36	0.62

Note: OLS regressions. The unit of observation is the country. Embeddedness, Affective Autonomy, and Intellectual Autonomy are taken from Schwartz (2004). In-Group Favoritism is taken from Van de Vliert (2011). Restraint builds on Hofstede et al. (1997), and Social Tightness is taken from Uz (2015). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls are adjusted for ancestry. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Europeans and Natives by country, land inequality²⁵, the historical prevalence of pathogens based on Murray and Schaller (2010), as well a dummy for former Soviet countries does not alter the results.

Further Robustness and Additional Results The OLS relationship between ancestral irrigation and collectivism is robust to additional controls, as reported in Appendix section B.3. Table B11 shows robustness to alternative sample selections, while Table B12 the robustness to additional geographic controls. Table B13 shows the effect of irrigated agriculture conditional on other subsistence modes, such as gathering, hunting, fishing, the use of the plow, and the overall dependency on agriculture, while Table B14 for the (potentially endogenous) strength of kinship ties in historical societies.²⁶ Including traditionally kinship structures (measured by the presence of extended families, endogamous communities, and clan communities) does not alter the impact of irrigation. In addition, the effect of irrigation is robust to controlling

Figure 5: SCATTERPLOTS OF THE CROSS-COUNTRY RELATIONSHIPS

²⁵Differences in land inequality have been argued to be the channel linking past irrigation and autocracy by Bentzen et al. (2016).

²⁶This addresses concerns that societies that adopted irrigation were more collectivist to start with.

**Table 3: IRRIGATION AND COLLECTIVISM ACROSS COUNTRIES:
ROBUSTNESS TO ADDITIONAL COUNTRY CONTROLS**

	Collectivism									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Ancestral Irrigation	15.00*** (5.23)	14.39*** (5.34)	16.20** (6.77)	13.02* (7.62)	12.99** (6.33)	14.46** (6.14)	10.69** (4.75)	18.73** (7.31)	14.83** (6.26)	16.61*** (4.85)
Migratory Distance	-1.96 (2.63)									
Migratory Distance Sq.	-0.03 (0.06)									
Latitude		0.23* (0.12)								
Population density in 1500 CE			-0.22 (0.22)							
Buddhism				5.70 (15.37)						
Christianity				5.50 (12.23)						
Hindu				-2.21 (20.63)						
Islam				23.38* (13.73)						
Judaism				9.36 (12.71)						
Polity IV 1980 - 2014					-1.15*** (0.41)					
(ln) Income per capita						-10.79*** (2.35)				
Perc. Natives							11.87 (8.49)			
Perc. Europeans							-30.00** (11.77)			
Land gini								-36.72** (17.48)		
Pathogen Prevalence									14.25** (5.71)	
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Soviet Dummy										Yes
Observations	92	92	91	93	93	92	92	80	93	93
R-squared	0.66	0.65	0.64	0.66	0.65	0.70	0.68	0.73	0.66	0.36

Note: OLS estimations. The unit of observation is the country. The dependent variable is the Hofstede *et al.* (1997) Index of Collectivism measured on a scale from 0 to 100. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

for differences in class stratification and the average year when groups were observed. Finally, Tables B15 investigates the effect of ancestral irrigation on other cultural dimensions constructed by Hofstede. Consistent with the hypothesis, I find that in addition to its effects on collectivism and restraint, ancestral irrigation has moderate negative effects on masculinity (i.e. irrigation societies focus more on modesty, consensus and caring for the weak), and a positive effect on uncertainty avoidance (i.e. irrigation societies have a preference for more rigid codes of belief and lower tolerance towards unorthodox behavior and ideas). Ancestral irrigation does not predict power relations, nor long-term orientation that is the focus of Galor

Table 4: DISENTANGLING ANCESTRAL FROM LOCAL AND CONTEMPORARY IRRIGATION

	Collectivism					
					Below Median (Irrigated Area in 2000)	Above
	(1)	(2)	(3)	(4)	(5)	(6)
Irrigation Suitability (Ancestral)	29.87*** (9.39)		54.45*** (17.06)	64.62*** (12.43)	101.48*** (33.89)	42.07*** (13.73)
Irrigation Suitability (Local)		5.06 (11.05)	-41.80*** (15.63)	-30.56** (12.24)		
Geographic Controls	Yes	Yes	No	Yes	Yes	Yes
Ethnographic Controls	No	No	No	Yes	Yes	Yes
Observations	95	94	96	93	48	45
R-squared	0.34	0.43	0.09	0.41	0.66	0.34

Note: OLS regressions. The unit of observation is the country. The dependent variable is the Hofstede *et al.* (1997) Index of Collectivism measured on a scale from 0 to 100. Geographic and ethnographic controls are adjusted for ancestry. Local irrigation suitability and geographic controls in columns (2) are computed as simple country averages. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

and Özak (2016) and Figlio *et al.* (2016). Finally, I test whether the emergence of collectivism is linked to the use of irrigation or associated with one particular crop. In particular, it has been suggested that growing rice rather than wheat leads to collectivist values (Talhelm *et al.*, 2014). If it is irrigation that matters rather than rice per se, then one should observe a larger impact of irrigated rice than of rain-fed rice. Indeed, Table B16 reports that suitability for irrigated rice predicts collectivism positively across countries (column 1), whereas suitability for rain-fed rice does not (column 2). Similarly, the differential suitability between irrigated and rain-fed rice is associated with higher levels of collectivism (columns 4 and 5).

Ancestral, Local and Contemporaneous Irrigation Does the effect of irrigation on collectivist norms stem from its impact on people or places? Moreover, are the effects driven by differences in contemporary irrigation? Columns 1 to 4 of Table 4 compare the impact of (ancestral-adjusted) irrigation suitability to the unadjusted (local) country average of irrigation suitability (as used by Bentzen *et al.* (2016)). I find that the people-based measure of irrigation suitability is the sole predictor of collectivist norms, which supports that past agriculture affected transmittable characteristics of populations rather than the local environment.²⁷ In addition, columns 5 and 6 document that past irrigation has a positive and significant effect on collectivist norms both in countries that today do and *do not* make much use of irrigation in agriculture.²⁸ These results indicate that irrigation affected culture through its impact on people rather than places, and reflect historically rather than contemporary differences in irrigated agriculture.

Two-Stage Least Squares Next, I instrument ancestral irrigation by the (ancestry-adjusted) environmental suitability for irrigation. Panel A of Table 5 contains the first-stage results,

²⁷Consider the United States as an example: It is one of the most individualist countries, populated by individuals from Europe that traditionally used rain-fed agriculture, even though the suitability for irrigation in the US is very high (about 23 % of the soil).

²⁸The median area equipped for irrigation in 2000 is 5%.

Panel B OLS results, and Panel C the 2SLS coefficients. Column 1 reports results conditional on the base set of geographic and ethnographic controls. The first-stage coefficient of irrigation suitability is positive and highly significant with a F-Stat of 33.²⁹ The 2SLS coefficient obtained is positive, significant at the 1% level and almost twice as large as in OLS. Columns 2 - 8 investigate the sensitivity of the 2SLS results, in particular to controlling for environmental characteristics. This helps to further rule out that the relationship is not driven by a single geographic factor that was used in the assessment of irrigation suitability. In particular, column 2 controls for the average dependency on agriculture taken from the *Ethnographic Atlas*; column 3 for average soil constraints; column 4 controls for salinity of the soil; column 5 for climate constraints; column 6 for the variability in rainfall; column 7 for terrain constraints; and column 8 for ruggedness separately using the measure of Nunn and Puga (2012). Finally, column 9 adds region fixed effects. Throughout all specifications, the first-stage is strong with an F-Stat between 9 and 38, and the 2SLS coefficient estimated is positive and significant, and about twice as large as the comparable OLS coefficient. The increase in magnitude of the 2SLS coefficient could indicate measurement error in the ancestral irrigation variable that is constructed from ethnographic data.

4.2 Irrigation and Collectivism in Sub-National Districts

While the cross-country results give strong support to the hypothesis that past irrigation influenced collectivist norms, they cannot account for all (unobserved) country-wide factors. This section therefore estimates the effect of ancestral irrigation on cultural traits of collectivism using respondents surveyed in sub-national districts in five waves (1981-2014) of the combined *World Values Survey/European Values Survey (WVS/EVS)*.³⁰

I measure collectivist norms at the individual level in three different ways. First, from the list of qualities that parents want their children to learn, I take the mentioning of independence and imagination as indication for individualist values, while obedience and good manners indicate high values for group conformity.³¹ I combine the four questions into a collectivism scale (ranging from -2 to +2) by adding up obedience and good manners, and subtracting independence and imagination. The second measure I consider asks respondents about the degree of control they have over their life, where a score of 1 indicates none at all and 10 a great deal.³² The third measure evaluated respondents' preferences for collec-

²⁹Table B9 explores the first-stage relationship across ethnic groups of the *Ethnographic Atlas*. Consistent with the cross-country results, I find that ethnic groups that live in environments that have a higher suitability for irrigation are significantly more likely to have adopted irrigation.

³⁰The WVS/EVS is a collection of representative national surveys conducted in almost 100 countries on all continents of the world. It contains a wide variety of question that assess individual values, preferences and attitudes. The WVS/EVS has become the standard source to measure and compare cultural traits in the social sciences. The first survey was conducted in 1981 and the data has been extended to a total of six waves until 2014 (WVS), and four waves until 2008 (EVS). Surveys were conducted in 1981-1984 (wave 1), 1990-1994 (wave 2), 1995-1998 (wave 3), 1999-2004 (wave 4), 2005-2009 (wave 5), and 2010-2014 (wave 6). For the purpose of this study I use WVS waves two to six since they contain information on the subnational region in which the respondent lives. As the definition of a region differs across time and countries, I match WVS/EVS regions to the first administrative division of each country, as shown in Figure A4.

³¹More precisely, the survey question asks: "Here is a list of qualities that children can be encouraged to learn at home. Which, if any, do you consider to be especially important?"

³²The question asks: "Some people feel they have completely free choice and control over their lives, and other people feel that what they do has no real effect on what happens to them. Please use the scale to indicate how much freedom of choice and

**Table 5: IRRIGATION AND COLLECTIVISM ACROSS COUNTRIES:
2SLS ESTIMATION**

	Ancestral Irrigation								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A - First-Stage									
Irrigation Suitability	1.09*** (0.15)	1.14*** (0.15)	1.12*** (0.14)	1.03*** (0.18)	0.89*** (0.20)	1.01*** (0.16)	1.06*** (0.15)	0.90*** (0.16)	0.74*** (0.18)
	Collectivism								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel B - OLS									
Ancestral Irrigation	16.05*** (4.94)	15.97*** (5.42)	16.45*** (4.99)	13.83*** (4.98)	14.52** (6.07)	9.65** (4.20)	8.90* (5.02)	9.28* (5.21)	18.08*** (6.37)
Panel C - 2SLS									
Ancestral Irrigation	31.34*** (8.16)	35.00*** (9.25)	31.53*** (8.13)	26.74*** (6.87)	56.69*** (21.18)	18.97*** (6.75)	20.22** (8.74)	20.53** (7.97)	44.61** (20.52)
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Agricultural Dependence		Yes							
Soil Constraints			Yes						
Salt Constraints				Yes					
Climate Constraints					Yes				
Precipitation Variability						Yes			
Terrain Constraints							Yes		
Ruggedness								Yes	
Region FE									Yes
Observations	93	93	93	93	93	93	93	93	93
First Stage F-Stat	33.18	38.28	35.27	27.37	11.13	31.93	26.40	26.22	9.00

Note: The unit of observation is the country. The dependent variable is the [Hofstede et al. \(1997\)](#) Index of Collectivism measured on a scale from 0 to 100. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

tive ownership, and is ranges on a scale from 1-10, where 1 indicates a strong preference for private ownership and 10 strong preference for ownership of firms in the hands of the government.³³ Correlation between the WVS/EVS measures and the cross-country variables reveal that while the collectivism scale and collective ownership are positively correlated with the Hofstede measure of collectivism, the latter shows a stronger correlation. On the other hand, differences in the degree of control individuals have over their lives are highly correlated with restraint.

The individual-level analysis allows to control for individual characteristics of the respondent (age, age squared, gender, marital status, education), as well as survey wave fixed effects. Observations are weighted using survey weights, and standard errors are clustered at the sub-national district. Table 6 contains the main results of the sub-national analysis that uses a maximum of 191,923 individual respondents that live in up to 934 sub-national district.

Panel A of Table 6 shows the reduced form estimates, Panel B results from OLS esti-

control you feel you have over the way your life turns out?''.

³³Table B18 shows pairwise correlation coefficients of the dependent variables with the country measures of collectivism by [Hofstede et al. \(1997\)](#) and [Schwartz \(2004\)](#).

Table 6: IRRIGATION AND COLLECTIVIST NORMS ACROSS SUB-NATIONAL DISTRICTS

	Collectivism Scale		Degree of Control over Life		Collective Ownership of Firms	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Reduced Form						
Irrigation Suitability	0.90*** (0.18)	0.48*** (0.14)	-0.96*** (0.18)	-0.69** (0.29)	1.89*** (0.25)	1.11*** (0.39)
Panel B: OLS						
Ancestral Irrigation	0.17*** (0.06)	0.07* (0.04)	-0.55*** (0.07)	-0.27** (0.12)	0.71*** (0.10)	0.42*** (0.14)
Panel C: 2SLS						
Ancestral Irrigation	0.88*** (0.24)	0.28** (0.12)	-0.89*** (0.17)	-1.06* (0.58)	1.73*** (0.24)	1.63** (0.66)
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes		Yes		Yes	
Country FE		Yes		Yes		Yes
Observations	69378	69378	191923	191923	175787	175787
Mean Dependent Variable	0.45	0.45	6.82	6.82	5.40	5.40
Number of Districts	472	472	934	934	899	899
First Stage F-stat	20.97	16.36	105.29	6.13	103.10	6.86

Note: The unit of observation is the individual. Ancestral Irrigation measures the percentage share of a district's population whose ancestors have used irrigation. All regressions include individual controls for age, age square, gender, marriage status, and education, as well as survey wave indicator variables. Geographic controls include the base set of geographic characteristics, and the and ethnographic controls are adjusted for ancestry. Region fixed effects in equal numbered columns include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. Odd numbered columns control for country fixed effects. Regressions are weighted by survey weights. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses, clustered at the sub-national district. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

mations, and Panel C the 2SLS estimates. I find that past irrigation use is positively and significantly associated with a stronger preference for obedience and good manners rather than independence and imagination in all specifications. Even conditioning on country fixed effects in column 2 that take into account all common countrywide characteristics, such as institutions, educational and other policies. This is a very demanding specification, because out of the 89 countries in the sample more than half have no or only little within-country variation in ancestral irrigation. Nevertheless, the estimated effect of ancestral irrigation is still significant, but smaller in magnitude compared to regressions with region fixed effects. The IV coefficients imply that a one std. increase in ancestral irrigation increase the collectivism index by 0.33 of a std. conditional on region fixed effects, and 0.1 of a std. conditional on country fixed effects. Columns 3 and 4 report a negative effect of traditional irrigation use on the degree of control respondents have over their life. The effect size is about 0.16 of a std. for a one std. increase in ancestral irrigation in the 2SLS specifications.³⁴ Finally, columns 5 and 6 show that ancestral irrigation strongly predicts preference for communal ownership of firms rather than individual ownership. Compared to the previous results, the effect of irrigation on collective ownership is the strongest both in significance and magnitude. Increasing ances-

³⁴Note that the IV loses power when country fixed effects are added in column 4 and 6, and the first-stage F-Stat drops below 10. The loss in power is most likely caused by the limited variation in ancestral irrigation within countries.

tral irrigation by one std. increases preference for government ownership by about 0.25 of a std. in the 2SLS specification. The conditional relationship between the three outcomes at the individual level and traditional irrigation are reported in Figures A6 and A7. Figure A7 illustrates that introducing country fixed effects absorbs large parts of the variation in ancestral irrigation.³⁵

4.3 Centralization, Cooperation and Institutional Complementaries

Communal versus Centrally Managed Irrigation The ethnographic literature suggests that coordination of water in irrigation systems could be achieved via centralized control or by means of community cooperation. However, ethnographic data only reports whether societies adopted irrigation, but not its type or scale. To get a sense of the heterogeneous effects of past irrigation on norms, I make use of geographical constraints that potentially determined the scale of the coordination effort needed. Coordination effort and the demand for centralized authority increases in the scale of the irrigation network, and in the degree of water scarcity that makes a precise water management indispensable, i.e., in relatively drier areas and close to large water sources (Wittfogel, 1957). Small scale irrigation systems, however, relied on community cooperation to enforce community decisions. They were more likely to develop in areas that naturally restrict the size of rivers and lead to more disperse access to water sources, in particular in rugged areas and areas of high altitude (Molle, 2004). In Table 7 I interact geographic characteristics with the historical presence of irrigation to explore its differential effect on norms towards authority (obedience) and cooperation (willingness to help other people).³⁶

Table 7 shows that, consistent with Wittfogel's hypothesis, irrigation has a stronger effect on obedience if it was practiced in areas with large rivers, in relatively drier environments, as well as in locations with lower levels of rainfall (columns 1 - 5). Once the interaction term between irrigation and the presence of rivers or arid climate is included, the independent effect of irrigation on obedience disappears and stems entirely from the interaction with the geographic characteristics. Furthermore, societies that used irrigation in more rugged environments or in higher altitudes show a reduced preference for norms towards authority. Regarding cooperation in columns 6 to 10, I find that irrigation societies are on average less cooperative, but cooperate more in proximity to rivers and in areas of high altitude, which is consistent with the hypothesis that communal forms of irrigation developed in more mountainous areas. Overall, these results suggest that considerable heterogeneity in scope of water coordination existed, and is reflected in corresponding norms of vertical and horizontal collectivism.

Complementarity between Norms and Institutions The previous sections have documented an independent effect of irrigation on norms, conditional on traditional and contemporary institutional measures, as well as country fixed effects. However, complementarities between

³⁵In additional results of Table B19, I show that the high labor intensity of irrigated agriculture in the past is also reflected in a higher preference for hard-work today, consistent with the results in Fouka and Schlaepfer (2014).

³⁶The differentiation between obedience and cooperation dovetails with the differentiation of collectivism into a vertical and horizontal type (Triandis and Gelfand, 2012).

Table 7: HETEROGENOUS EFFECTS: CENTRALIZED VS COMMUNITY COORDINATION

	Obedience					Help People				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Ancestral Irrigation	-0.03 (0.02)	0.12*** (0.02)	0.11*** (0.02)	0.01 (0.02)	0.15*** (0.03)	-0.31*** (0.08)	-0.13 (0.10)	-0.22** (0.09)	-0.15* (0.08)	0.01 (0.18)
Ancestral Irrigation × No. Large River	0.15*** (0.03)					0.31*** (0.11)				
Ancestral Irrigation × Ruggedness		-0.06*** (0.02)					0.03 (0.07)			
Ancestral Irrigation × Altitude			-0.12*** (0.04)					0.27** (0.12)		
Ancestral Irrigation × Arid Climate				0.16** (0.06)					0.19 (0.17)	
Ancestral Irrigation × Mean Precipitation					-0.00*** (0.00)					-0.00 (0.00)
Ancestral Irrigation × Mean Temperature					-0.00 (0.00)					0.00 (0.01)
Individual Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	192624	192624	192624	192624	192624	76108	76108	76108	76108	76108
Mean Dependent Variable	0.36	0.36	0.36	0.36	0.36	4.66	4.66	4.66	4.66	4.66
Number of Districts	918	918	918	918	918	608	608	608	608	608

Note: The unit of observation is the individual. Ancestral Irrigation measures the percentage share of a district's population whose ancestors have used irrigation. All regressions include individual controls for age, age square, gender, marriage status, and education, as well as survey wave indicator variables. Geographic controls include the base set of geographic characteristics, and the measure of geography that is interacted with irrigation. Geographic and ethnographic controls are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. Regressions are weighted by survey weights. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses, clustered at the sub-national district. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

collectivist norms and political institutions are likely. [Gorodnichenko and Roland \(2015\)](#), for example, argue that collectivist norms affect democracy negatively. Indeed, many large-scale irrigation societies are documented to have had more complex and centralized institutions with formal means to enforce community decisions (see Figure 2). Past institutional characteristics of irrigation societies could have spilled over into contemporary differences in political institutions ([Bentzen et al., 2016](#)). Table 8 studies complementarities between collectivist norms and political institutions in the context of ancestral irrigation more systematically. It reports three main results: First, the negative association between collectivism and democracy is not specific to irrigation societies, but exists also in societies that used other forms of subsistence (columns 1 to 3). Second, in any regression, ancestral-adjusted irrigation predicts institutional quality better than local irrigation suitability (column 4 to 7). This suggests that considerable parts of the effect of irrigation on democracy runs through its effect on people rather than places. Third, one potential cultural channel through which past irrigation affects democracy is a reduced likelihood of institutional change in the presence of strong norms of group conformity ([Gorodnichenko and Roland, 2015](#)). In line with this argument, ancestral irrigation suitability predicts negatively protest potential, i.e., the willingness of citizens to engage in political action, even controlling for regime types (column 8 and 9).

4.4 Irrigation and Collectivism across Migrants

Collectivist norms that emerged as a response to agricultural cooperation could have been preserved in the long-run either because they became internalized into policies and institu-

Table 8: IRRIGATION, NORMS AND INSTITUTIONS

	Polity IV (1980-2014)							Protest Potential	
	All	Irrig.=0	Irrig.>0	(4)	(5)	(6)	(7)	(8)	(9)
	(1)	(2)	(3)						
Collectivism (Hofstede)	-0.11*** (0.02)	-0.09*** (0.02)	-0.10** (0.04)						
Irrigation Suitability				-10.26*** (2.46)		-9.69*** (3.37)	-9.74*** (3.36)	-0.43*** (0.13)	-0.28** (0.12)
Irrigation Suitability (Local)					-4.99** (2.41)	-0.98 (3.10)			
Irrigation Suitability Class 5 (Local)							-0.84 (2.97)		
Polity IV 1980 - 2014									0.01*** (0.00)
Geographic Controls	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Observations	96	45	51	144	144	144	144	91	90
R-squared	0.19	0.39	0.09	0.63	0.60	0.63	0.63	0.49	0.56

Note: OLS regressions. The unit of observation is the country. The dependent variable is the Polity IV index in columns (1) to (7) and Protest Potential in columns (8) and (9). Protest potential measures citizens willingness to engage in lawful boycott, demonstrations or to sign a petition, and is constructed from survey responses of the WVS/EVS, following [Nevitte \(2014\)](#). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

tions, or through a process of intergenerational transmission in which parents transmit their norms to their children. While institutional complementarities are surely important, this section tests for a pure cultural mechanism in European and US migrants. Looking at migrants that originate from very diverse background has the benefit that they share the same external environment in the country they live, including the institutions, policies, and the educational system. Country of residence fixed effects take into account this external (institutional) environment.

European Migrants (ESS) I use data from the *European Social Survey* (ESS) to test for differences in values of immigrants living in European countries. The ESS allows to identify the country of origin of the respondent's parents and his place of birth, and whether they are first or second generation immigrants. I define ancestry by the common country of birth of his/her parents.³⁷ To assess collectivism, I combine five questions about the importance of different human values developed by [Schwartz \(2004\)](#) using principal component analysis. These questions measure the core characteristics of collectivism: the importance of respect, of following rules, of behaving properly, of modesty, and loyalty to close people. The principal component is measured in a way that higher scores indicate stronger collectivist values. All regressions control for individual characteristics of the immigrant (age and its square, gender, education fixed effects, marriage status and the indicator for big cities), survey wave dummies, geographic and ethnographic controls as well as for location fixed effects that are either the country of residence or the sub-national district of residence. Standard errors are clustered at the level of the respondent's country of origin.

³⁷Results are robust to using only the father's or mother's country of origin, as reported in the Appendix.

Regression results are reported in Table 9. Considering 1st and 2nd generation migrants jointly in columns 1 and 2, I find that ancestral irrigation predicts collectivist norms positively and significantly in reduced form (Panel A), OLS (Panel B) and 2SLS (Panel C) specifications.³⁸ The effects of past irrigation appear both with host country fixed effects (column 1) and the much smaller sub-national district fixed effects (column 2).³⁹ The instrument is strong with a first-stage F-Statistics above 10. The estimated beta coefficient of ancestral irrigation in the 2SLS estimation of column 1 is 0.24. Column 3 and 4 report similar results using only 1st generation migrants. The remaining columns 5 and 6 focus on the smaller sample of 2nd generation migrants that were born and grew up in the country of residence. Again, I find that past irrigation impacts collectivist norms significantly. The magnitude of the coefficients are economically meaningful. The 2SLS coefficient in column 5 implies that a one std. increase in ancestral irrigation increases collectivism by about 0.25 of a std. Tables B20 and B21 show that the results are robust to defining ancestry of migrants by either their father's or mother's country of birth. Moreover, Table B22 documents robustness of the 2SLS results to controlling for home country characteristics, in particular income, institutions, and ethnic fractionalization.

Factors Affecting the Cultural Transmission of Collectivism Which factors amplify or hinder the cultural persistence of collectivism? To investigate this question, I reduce the sample to 2nd generation immigrants and analyze how characteristics of the country of residence interact with the traditional use of irrigation by ancestors. I focus on 2nd generation migrants for two reasons: first, concerns about endogenous sorting of migrants are mitigated compared to 1st generation migrants that move from abroad to the country of residence. Moreover, 2nd generation migrants were growing up in the country of residence and were subject to its characteristics from birth on.

Table 10 shows coefficients of the interaction terms between ancestral irrigation and host country characteristics, conditional on host and home country fixed effects. Neither the quality of institutions in the host country, nor average income per capita interact with past irrigation significantly. The effect of ancestral irrigation, however, is significantly amplified in 2nd generation migrants that live in countries with relatively higher ethnic fractionalization (see column 3). This results implies that the differentiation between in-and-out group is stronger in places with a larger number of groups. Somewhat surprisingly, local culture measured by host country collectivism does not affect the transmission of collectivism. Columns 4 and 5 explore possible interaction effects of policies, in particular public welfare. The interaction between the share of total public expenditure per capita and ancestral irrigation is negative, albeit not significant. Using instead the share of expenditure on old age security in column 5, however, results in negative and highly significant interaction term, suggesting that universal care for elderly has the power to attenuate the transmission of collectivist norms. This is consistent with the observation that in both historical and contemporary collectivist societies welfare is group-based, and parents restrict children's autonomy in order to assure their loyalty to the family (Friedlmeier *et al.*, 2005; Greif, 2006; Greif and Tabellini, 2012). If public

³⁸The conditional OLS relationship between collectivism and ancestral relationship is illustrated in Figure A8.

³⁹The sample size is reduced for regressions with sub-national districts because only waves 5 and 6 of the ESS have a consistent classification of sub-national regions.

Table 9: CULTURAL TRANSMISSION OF COLLECTIVISM IN EUROPEAN MIGRANTS

	Collectivism					
	All Migrants		1st Generation		2nd Generation	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Reduced Form						
Irrigation Suitability	0.66*** (0.12)	0.89*** (0.14)	0.70*** (0.13)	0.80*** (0.14)	0.57*** (0.16)	1.04*** (0.27)
Panel B: OLS						
Ancestral Irrigation	0.15** (0.06)	0.20*** (0.07)	0.17*** (0.06)	0.17** (0.07)	0.06 (0.09)	0.30** (0.12)
Panel C: 2SLS						
Ancestral Irrigation	0.85*** (0.27)	1.01*** (0.24)	0.80*** (0.24)	0.83*** (0.19)	0.97** (0.45)	1.45*** (0.44)
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes		Yes		Yes	
Sub-National District FE		Yes		Yes		Yes
Observations	17950	8549	13632	6411	4312	2136
R-squared	0.05	0.09	0.06	0.10	0.07	0.17
Number of Countries	153	145	152	142	110	101
First Stage <i>F</i> -Stat	11.03	16.54	14.48	22.04	7.11	11.01

Note: The unit of observation is an immigrant. The dependent variable collectivism is the principal component of respect, loyalty, rule following, proper behavior, and modesty. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation in the immigrant's parents' country of birth. The odd numbered columns control for country of residence fixed effects, the even numbered columns control for sub-national district of residence fixed effects. All regressions control for individual characteristics (age, gender, marriage status, education, city type), geographic & ethnic controls, as well as survey wave indicator variables. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses, clustered at the country of origin. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

spending for elderly is high, parents are less likely to instill obedience and loyalty in children. Finally, the size of the community that share the ancestry of the respondent affects the transmission of collectivism positively. This could indicate that collectivism is transmitted horizontally among peers. Together, these results suggest that ethnic diversity strengthens in-and out-group thinking, but that there is scope for policies to affect collectivist norms.⁴⁰

U.S. Migrants (CPS) In addition to values, I study differential preferences for in-group marriage of US migrants as an outcome measure of collectivist cultures. If irrigation strengthened group identification, then one would expect it to be reflected in a stronger preference to marry with members of the same group (endogamous marriage). Data from the Current Population Survey (CPS) March Supplement (1994-2016) allows to identify, in addition to ancestry, whether a migrant is married to a person from the same country.⁴¹ Intermarriage rates in

⁴⁰Very similar results to the ones reported in Table 10 are found when interacting irrigation suitability - instead of ancestral irrigation - with host country characteristics, as shown in Table B23.

⁴¹Same country marriage as a measure of endogamous marriage of migrants has been used for example by Abramitzky *et al.* (2016) to study cultural assimilation of migrants during the age of mass migration.

Table 10: HETEROGENOUS EFFECTS OF CULTURAL TRANSMISSION

	Collectivism						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ancestral Irrigation \times Polity IV	-0.00 (0.06)						
Ancestral Irrigation \times (ln) Income per capita		-0.21 (0.16)					
Ancestral Irrigation \times Ethnic Fractionalization			0.81** (0.37)				
Ancestral Irrigation \times Collectivism				0.01 (0.01)			
Ancestral Irrigation \times Public Expenditure (2000-2010)					-0.03 (0.02)		
Ancestral Irrigation \times Old Age Expenditure (2000-2010)						-0.11*** (0.03)	
Ancestral Irrigation \times Share Migrants Same Country							0.09* (0.05)
Share Migrants Same Country							-0.06** (0.03)
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country of Origin FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Host Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4475	4475	4475	4467	4087	4087	3167
R-squared	0.12	0.12	0.13	0.13	0.13	0.13	0.15
Number of Origin Countries	116	116	116	116	112	112	113

Note: The unit of observation is a 2nd generation immigrant. The dependent variable collectivism is the principal component of respect, loyalty, rule following, proper behavior, and modesty. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation in the immigrant's parents' country of birth. All regressions control for individual characteristics (age, gender, marriage status, education, city type), geographic & ethnic controls, as well as survey wave indicator variables, country of origin and country of residence fixed effects. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses, clustered at the country of origin. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

the sample of 2nd generation migrants that I focus on are high: about 77% of migrants are married to a person with shared ancestry.

Table 11 regresses the likelihood that the respondent marries within his own group on ancestral irrigation, separately for females, males and both gender combined. Column 1-3 show that migrants from societies that used irrigation in agriculture are more likely to be in an endogamous marriage in reduced-form and OLS regressions. The OLS coefficient of column 3 (0.14) implies that a one std. increase in ancestral irrigation increases the likelihood of an endogamous marriage by 4%. IV coefficients reported in Panel C are, however, not significant and the instrument is weak. The failure of the instrument to predict ancestral irrigation in the first stage could be a result of the unbalancedness of the sample of migrants. In particular, almost 40% of 2nd gen. migrants in the sample are Mexican. Column 4 to 6 address this issue and reestimate the models of columns 1 to 3, but assigning the same weight to each country of origin.⁴² The weighted regressions confirm the positive, and significant effect of irrigation in reduced-form and OLS regressions. In contrast to the unweighted estimation, the first-stage relationship is much stronger (F-Stat consistently larger than 19). The estimated 2SLS coefficients are positive and significant, and imply a 11% increase in the likelihood of an

⁴²This weighting scheme is equivalent to taking the mean for each country and using each country of origin as a single observation.

Table 11: ANCESTRAL IRRIGATION AND IN-GROUP MARRIAGE OF US MIGRANTS

	In-Group Marriage					
	Unweighted			Weights: Same N		
	Females	Males	Females & Males	Females	Males	Females & Males
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Reduced Form						
Irrigation Suitability	0.45** (0.18)	0.54** (0.22)	0.48** (0.19)	0.54*** (0.14)	0.34** (0.13)	0.50*** (0.12)
Panel B: OLS						
Ancestral Irrigation	0.12** (0.05)	0.16** (0.06)	0.14** (0.05)	0.22*** (0.06)	0.19*** (0.06)	0.22*** (0.07)
Panel C: 2SLS						
Ancestral Irrigation	0.54 (0.34)	1.06 (0.88)	0.71 (0.50)	0.38*** (0.11)	0.31*** (0.12)	0.37*** (0.10)
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
U.S. State FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11198	10567	21765	11198	10567	21765
R-squared	0.12	0.06	0.10	0.22	0.27	0.17
Number of Countries	84	87	92	84	87	92
First Stage F-Stat	5.39	2.19	3.70	61.08	19.52	48.56

Note: The unit of observation are married 2nd generation US immigrants surveyed in the Current Population Census March Supplement (1994-2016).; females in columns (1) and (4), males in columns (2) and (5), both females and males in columns (3) and (6). The dependent variable takes on the value 1 if the respondent is married with a person from her/his country of ancestry, defined by the birthplace of her/his father and mother. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. All regressions control for individual characteristics (age, genders, education fixed effects, and survey wave fixed effects), geographic and ethnographic controls, as well as US State fixed effects. See main text and the appendix for more details on the construction of the variables. Columns (1) and (2) estimate unweighted regressions, while columns (3) and (4) give equal weight to each country of ancestry. Heteroscedastic-robust standard errors in parentheses, clustered at the country of origin. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

endogamous marriage for a one std. deviation increase in ancestral irrigation (column 6).

5 The Long-Term Economic Consequences of Irrigation

So far, I have presented evidence consistent with the hypothesis that the historical use of irrigation in the past has had a persistent effect on norms of collectivism. In this section, I investigate its long-run consequences for two types of economic outcomes. First, it has been recurrently argued that collectivist values and thinking are a hindrance for innovation and technological progress - the prime drivers of economic growth (Triandis *et al.*, 1988; Nemeth and Staw, 1989; Leung and Wang, 2015). The focus on conformity rather than independence discourages individuals to differentiate themselves from the group and lowers their willingness to distort group cohesion with radical or unconventional concepts. It is likely that collectivist norms prevent individuals from challenging established concepts, and from creating novel knowledge and innovations. For example, Tatsuno (1990) describes how the Japanese culture of conformity suppresses the expression of ideas, as people "who generate deviant, wild or weird ideas will be punished by social sanctions". Evidence in favor of this

argument shows that students with stronger collectivist values are less creative (Dollinger *et al.*, 2007; Kasof *et al.*, 2007), and that collectivist countries have lower rates of technological progress (Gorodnichenko and Roland, 2011a). In addition to its effect on innovation, a history of irrigation agriculture could also have created long-term impacts on occupational selection and patterns of specializations, where descendants of irrigation societies select into jobs that require rule-following rather than independence.

5.1 Irrigation and Contemporary Innovation across Countries

Table 12 shows that ancestral irrigation has a strong negative effect on scientific productivity - measured by the per capita number of scientific articles - across countries. The estimated negative coefficient is highly significant, robust to controlling for baseline controls and region fixed effects, and a host of other country-wide characteristics such as institutional quality, religion and ethnic fractionalization. It is even robust to controlling for average per capita incomes (column 8), and the sectorial composition of countries today (column 9) to rule out a potential lock in effect of early agriculture.⁴³ The estimated *beta coefficients* are sizable and in the range of -0.17 and -0.29. Columns 10 and 11 estimate 2SLS coefficients with and without region fixed effects. Estimated coefficients are about twice as large as the comparable OLS coefficients.⁴⁴

Importantly, Table B25 shows that, consistent with previous results, the effect of irrigation works through people's cultural ancestry rather than place-specific characteristics: Only the measure of irrigation suitability that is adjusted for ancestry predicts technology today negatively and significantly, which supports the interpretation that irrigation affects current technology through its effects on societies' culture. Table B25 also reports that past irrigation affects an alternative measure of contemporary technology developed by Comin *et al.* (2010), that is highly correlated with scientific productivity.

5.2 Irrigation and Reversal of Technological Progress

While societies that used irrigation in the past are technologically less advanced today, historical accounts suggests that these societies, such as China, were the technologically leaders up until about the year 1500 (Mokyr, 1992). Figure 6 illustrates that traditional societies that used irrigation were indeed technologically more advanced historically. Previous evidence on the persistence of technology over time gives a first indication that many societies that made significant use of irrigation, such as China, Egypt and Syria, stagnated technologically after 1500 (Comin *et al.*, 2010). Using data on historical technological sophistication constructed by Comin *et al.* (2010), I test in this subsection whether and when irrigation societies were systematically falling behind technologically.

Table 13 documents that in a cross-section of nations, societies that used irrigation were technologically more advanced throughout the period before 1500 AD.⁴⁵ The differences in

⁴³Figure A9 displays the cross-country relationship between ancestral irrigation and innovation conditional on geographic and ethnographic controls, as well as region fixed effects.

⁴⁴Table B24 shows that the IV results are robust to including other country controls.

⁴⁵Since the main independent variables are adjusted for ancestry, I also use the ancestry adjusted measures of technological sophistication from Comin *et al.* (2010) that take into account post 1500 population flows.

Table 12: IRRIGATION AGRICULTURE AND INNOVATION ACROSS NATIONS

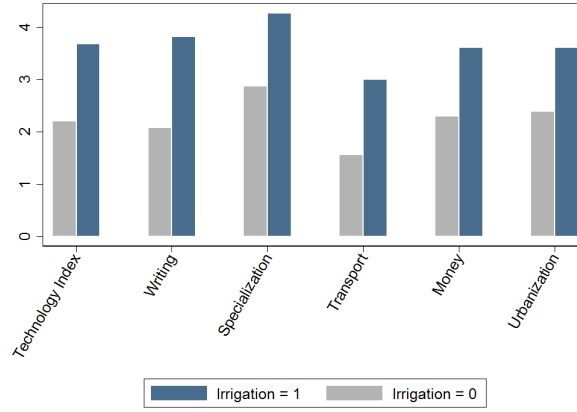
	Scientific Articles (per capita)											
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	IV	IV
	(1)	(2)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Ancestral Irrigation	-0.116*** (0.030)	-0.173*** (0.038)	-0.155*** (0.051)	-0.134*** (0.038)	-0.149** (0.057)	-0.190*** (0.054)	-0.124*** (0.044)	-0.104** (0.041)	-0.143*** (0.046)	-0.113** (0.045)	-0.387*** (0.088)	-0.374*** (0.114)
Neolithic Revolution				-0.026** (0.011)								
Traditional Democracy					0.063 (0.045)							
State Antiquity						0.130 (0.102)						
Polity IV 1980 - 2014							0.010*** (0.003)					
Christianity								0.013 (0.096)				
Hindu								-0.093 (0.105)				
Islam								-0.113 (0.084)				
Judaism								24.851** (11.369)				
(ln) Income per capita									0.066*** (0.019)			
Agriculture (% of GDP)										-0.072* (0.037)		
Industry (% of GDP)										-0.071* (0.037)		
Services (% of GDP)										-0.068* (0.037)		
Geographic Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Observations	143	132	132	128	129	121	125	131	129	126	132	132
R-squared	0.04	0.37	0.56	0.59	0.56	0.60	0.60	0.60	0.61	0.58	0.27	0.51
First Stage F-Stat											43.65	18.03

Note: The unit of observation is the country. The dependent variable is the . Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls, as well as malaria suitability, are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

technological progress are significant and large - beta coefficients range from 0.29 in 1000 BC, to 0.23 in 0 AD to 0.17 in 1500 AD - but decreasing over time.⁴⁶ Column 4 reveals a reversal in technological progress in the period between 1500 to 2000: Societies with larger shares of ancestral irrigation are characterized by lower levels of contemporary technology, which mirrors the negative effects of ancestral irrigation on scientific output documented previously. A one std. increase in ancestral irrigation reduces the index of current technology by about 0.21 of a std.

As an alternative way to test for the reversal of technology, Table B26 replicates the estimation in Comin *et al.* (2010), regressing current technology on historical levels of technology, but adding an interaction between historical technological sophistication and ancestral irrigation. Consistent with the findings in Comin *et al.* (2010), technological progress is highly persistent, but in addition there is a negative and significant interaction term between past technology and irrigation: irrigation societies could not benefit from their early head start. Panel B illustrates that the people-based measure of irrigation suitability drives this reversal.

⁴⁶One might be concerned that the positive association in the agricultural stage of development is driven by the construction of the technology index, since irrigation is itself a technology. However, the measure of past technology constructed by Comin *et al.* (2010) does not consider the adoption of irrigation, but whether agriculture existed, how important it was, and whether the plow was used.

Figure 6: TECHNOLOGICAL SOPHISTICATION OF PRE-INDUSTRIAL SOCIETIES

Note: All variables measured on a scale from 1 to 5. Technology Index is the average of Writing, Specialization, Transport, and Money. Ethnic groups from the Standard Cross Cultural Sample (SCCS).

Table 13: REVERSAL OF TECHNOLOGICAL PROGRESS ACROSS NATIONS

	Technological Progress (Ancestry Adjusted)			
	1000 BC	0 AD	1500 AD	2000 AD
	(1)	(2)	(3)	(4)
Ancestral Irrigation	0.203* (0.116)	0.119*** (0.043)	0.140** (0.064)	-0.117*** (0.044)
Geographic Controls	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	102	122	110	119
R-squared	0.38	0.40	0.79	0.72

Note: OLS regressions. The unit of observation is the country. The dependent variable is the index of technological progress taken from [Comin et al. \(2010\)](#). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Technological progress in 1500 interacts significantly and negatively with irrigation suitability that is adjusted for ancestry - even when controlling for the interaction of technology with (ancestry adjusted) overall agricultural suitability ([Litina, 2016](#)). In contrast, the local average of irrigation suitability does not interact with past technology.

Table 14 exploits the panel dimension of the data and estimates fixed-effect models similar to a differences-in-differences (DiD) estimations of the following form:

$$y_{c,t} = \gamma_t + \delta_c + \beta post1500 * irrigation_c + \lambda post1500 * X_c + \epsilon_{c,t} \quad (4)$$

where $y_{c,t}$ is the ancestral technology index for country c at time period t , γ_t are time fixed that account for characteristics of the periods 1000 BC, 0 AD, 1500 AD, 2000 AD that affect all countries, δ_c country fixed effects that control for country-wide time invariant factors, and $post1500 * irrigation_c$ is an interaction term between the post 1500 period and either the

Table 14: REVERSAL OF TECHNOLOGICAL PROGRESS IN A PANEL OF NATIONS

	Technology (Ancestry Adjusted)				
	OLS	OLS	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)
Irrigation Suitability (Local) \times Post 1500	-0.27*** (0.09)		0.03 (0.10)		
Irrigation Suitability (Ancestral) \times Post 1500		-0.46*** (0.07)	-0.48*** (0.08)		
Ancestral Irrigation \times Post 1500				-0.29*** (0.04)	-0.43*** (0.07)
Controls \times Post 1500	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Observations	453	453	453	453	451
R-squared	0.58	0.61	0.61	0.61	0.60
First Stage F-Stat					63.39

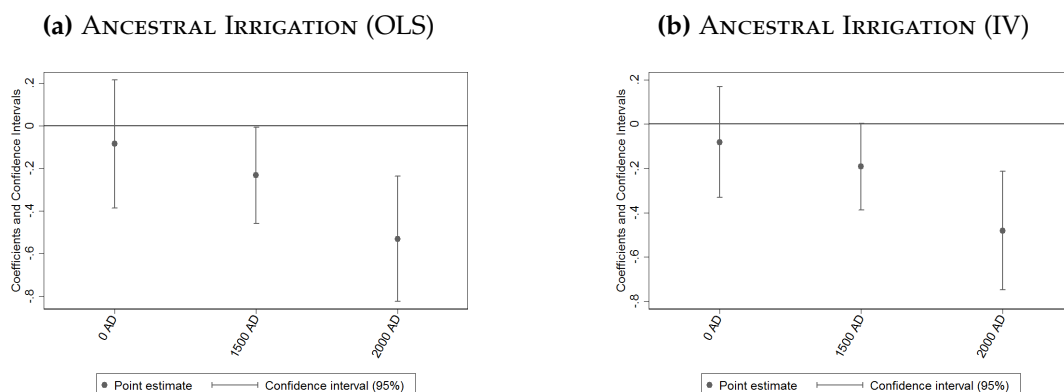
Note: OLS regressions. The unit of observation is the country-period. The dependent variable is the index of technological progress between 1000BC and 2000 taken from [Comin et al. \(2010\)](#). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Controls include geographic and ethnographic controls interacted with the Post 1500 dummy. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors clustered at the country level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

environmental suitability for irrigation, or the measure of ancestral irrigation. All regressions control for the interaction between the time invariant geographic and ethnographic controls ($post1500 * X_c$) with the post-1500 dummy. Col 1 shows that countries with environments more suitable for irrigation experienced a decline in technological progress after 1500. The same negative relationship between technology and irrigation in the post-1500 period appears if one considers the ancestry-adjusted irrigation suitability (column 2). Moreover, comparing the effect of local irrigation suitability against ancestral irrigation suitability in column 3, the decline in technology appears to be driven by the suitability measure that takes into account ancestry of populations - in line with the findings documented previously. This implies that irrigation environments influenced technological progress over time mostly through its effect on transmittable (cultural) characteristics of populations. Finally, columns 4 and 5 document that the actual adoption of irrigation by a countries' ancestors has similar negative influence on technology, in both OLS and IV regressions. The magnitudes of the IV coefficient implies that a std. increase in ancestral irrigation led to a decline in technology of 0.57 of a std. after 1500.

Going beyond the pre/post 1500 comparison, Figure 7 reports coefficients from flexible estimates that interact ancestral irrigation with each time period.⁴⁷ Consistent with the previous results, I find no, or only small, differences in technology before 1500, but large negative, and significant coefficients after 1500. A number of robustness checks confirm the observed pattern of declining technological sophistication in irrigation societies. Tables B28 and B29 show results from DiD and flexible estimates using the technology index that is unadjusted for migration, while Tables B30 and B31 estimates computed excluding historical military technology that is not part of the current technology index. Table B32 addresses concerns

⁴⁷Corresponding estimation results are reported in Table B27.

Figure 7: LONG-RUN FLEXIBLE ESTIMATES BETWEEN TECHNOLOGY AND IRRIGATION



Note: This figure shows point estimates and 95 % confidence intervals from flexible panel estimates of (ancestry adjusted) technological progress between 1000 BC and 2000 AD on a) ancestral irrigation from OLS regressions, and b) ancestral irrigation from 2SLS regressions. See Table B27 for the corresponding regression table.

about data quality in very early periods, and restricts the panel to the periods 1500 and 2000.

Taken together, these results suggest that societies that used irrigation were technologically more advanced in Malthusian economies, in which agriculture is the dominant form of production and technological progress is generally slow, but have lower rates of innovation in the modern growth regime. One interpretation of these reduced-form results, consistent with the cultural effects of irrigation documented above, is that collectivism is beneficial in some stages of development but not in others. In agricultural economies, group conformity allowed societies to coordinate production more efficiently and to increase productivity, which was channeled primarily into higher population growth. Larger populations - potentially coupled with coordinated search efforts for new technologies of centralized authorities - implied a technological advantage of irrigation societies in the agricultural stage of development. The transition to a modern growth regime, however, was based on a rapid and vast accumulation of the stock of new ideas and knowledge generated by private persons, and its broad diffusion in society Mokyr (1992).⁴⁸ Conformist behavior was a hindrance to technological creativity and to challenging existing ideas (Mokyr, 2016). Since conformity was fostered in agricultural societies that used irrigation, they were worse suited for creating the mass of micro-inventions that formed the basis for the industrial revolution.⁴⁹

5.3 Irrigation and Contemporary Innovation across US Migrants

To further strengthen the evidence for a cultural mechanism behind the association between irrigation and innovation - isolated from other institutional explanations - I use information of the innovativeness of US migrants. I draw on data from the *National Survey of College Graduates* (NSCG) which is a a longitude biennial survey that samples individuals living in the US and having at least a Bachelor's degree. The survey aims at evaluating a wide variety

⁴⁸In China, for example the state retracted from supporting technological change after the Middle Ages and this gap was not filled by private innovations (Mokyr, 1992).

⁴⁹A related hypothesis has been put forward by Ashraf and Galor (2011), contrasting the effects of cultural assimilation and diffusion. They argue that greater cultural assimilation increased efficiency in agricultural economies, but greater cultural diffusion eased technological adoption when technological change was rapid.

of outcomes of college graduates, particular those working in science and engineering, and it has been used in previously in the migration-innovation literature by [Hunt and Gauthier-Loiselle \(2010\)](#). The NCGS allows to identify ancestry by respondents' countries of birth. Once more, studying US immigrants has the advantage that they imported their cultural beliefs to an external environment which can be held constant, i.e. concerns about differences in laws or regulations that affect patenting and innovation and vary across countries are mitigated.

To assess the the innovative output of college graduates from the wave 2003 - the only wave that asks respondents about patenting and research productivity - I construct several variables. The first one measures patenting with a dummy equal to 1 if a patent has been granted to the respondent, and zero otherwise. In addition, I measure scientific productivity with a dummy equal to 1 if the respondent has published anything (e.g. a scientific article, a book, or if the respondent contributed an article to a conference) and zero otherwise. I also count the number of publications per respondent. The publication measures dovetail with the country measures of scientific output used above. Third, I create an indicator variable that identifies respondents that attended a professional meeting or conference. Finally, using the waves 1993-2013, I employ a question that asks about respondent's desired job characteristics, and in particular whether he/she thinks that independence is important. I take the mentioning of independence as indication for a cultural preference for individualism.

Table [15](#) reports regression results of reduced-form, OLS, and IV regressions, that control for individual characteristics of the respondent (age, age squared, gender, marital status, age at arrival in US, an dummy indicating whether the respondent has obtained a bachelor's degree or a higher degree, indicators for the level of education completed in the US, current log salary and its square), the set of geographic and ethnographic controls as before, and fixed effects for US macro-regions.⁵⁰

Overall, individuals that originate from countries in which irrigation was used in farming are significantly less likely to be innovative, and have lower levels of scientific output. Negative differences are found in reduced form, OLS, and IV estimations and across all outcome variables considered. As before, 2SLS coefficients are up to twice as large as OLS coefficients. The 2SLS coefficient in column 1 suggests that a one std. increase in traditional irrigation decreases the probability of patenting by about 0.8%, which seems small, but given the sample average of patenting of 0.04 implies a 20 % increase of the sample mean. According to column 2, the likelihood of a publication is reduced by 3%, or 10% of the sample mean, for a one std. increase in ancestral irrigation. In addition, a one std. increase in traditional irrigation translates according to column 3 into about one publication less which is equal to about 24% of the sample mean (or 0.08 of a std.). This effect is slightly larger than the gender difference in the number of publications (0.8 less publications for female), but smaller than the effect of having a degree above a bachelors (4 publications less for individuals with only a BA degree). Column 4 shows that ancestral irrigation also has a negative effect on the likelihood that the respondent attended a conference. Finally, the negative coefficient in column 5 implies that a one std. increase in ancestral irrigation reduces the likelihood that respondents mention independence as an important job characteristic by 8%, or about 0.13 of a std.

Additional results in Table [B33](#) show that the OLS results are robust to controlling for

⁵⁰Macro-regions are the smallest administrative level on which respondents are observed.

Table 15: THE LONG-TERM EFFECT OF IRRIGATION ON INNOVATION ACROSS US MIGRANTS

	Patent Granted	Any Publication	No. of Publications	Conference Attendance	Important in Job: Independence
	(1)	(2)	(3)	(4)	(5)
Panel A: Reduced Form					
Irrigation Suitability	-0.02** (0.01)	-0.08* (0.04)	-2.34** (0.92)	-0.11*** (0.03)	-0.20*** (0.06)
Panel B: OLS					
Ancestral Irrigation	-0.01* (0.01)	-0.06*** (0.02)	-1.23** (0.53)	-0.08*** (0.01)	-0.08** (0.03)
Panel C: 2SLS					
Ancestral Irrigation	-0.02** (0.01)	-0.08** (0.04)	-2.43** (1.12)	-0.10*** (0.03)	-0.21** (0.10)
Individual Characteristics	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes
U.S. Region FE	Yes	Yes	Yes	Yes	Yes
Observations	16127	16127	16127	32948	52029
R-squared	0.05	0.15	0.07	0.13	0.05
Number of Countries	121	121	121	130	128
First Stage <i>F</i> -stat	9.91	9.91	9.91	17.47	8.84

Note: The unit of observation is an US immigrant. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. All regressions control for individual characteristics (age, gender, marriage status, age at arrival in the US, dummies for bachelor, professional and postgraduate degrees, indicators for the level of education that was completed in the US, log salary and its square, and survey wave fixed effects), geographic and ethnographic controls, as well as US macro-region fixed effects. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses clustered at the country of origin. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

home country controls such as institutional quality, ethnic fractionalization and income. Table B34 documents robustness of the OLS relationship controlling for additional respondent characteristics. Finally, Table B35 studies the effect of ancestral irrigation on the entire set of desired job characteristics. The results suggest that descendants from societies that used irrigation have a lower preference for independence, but are not different otherwise. Respondents do not show differential preferences with respect to the degree of societal contribution, security, payment, location, benefits and advancement opportunities of their job.

5.4 Irrigation and Occupational Specialization

Pre-industrial irrigated agriculture could have contributed to patterns of job specialization across areas of the world. By discouraging personal autonomy of the individual, irrigation societies might be less apt to do occupations that require independent decision making and thinking. On the contrary, as irrigated agriculture fostered a culture of obedience and rule following, societies whose subsistence production required coordination might have a comparative advantage in jobs that require to follow procedures and routines.

I study the association between ancestral irrigation and patterns of specialization in two layers. First, Table 16 documents that across countries, past irrigation use predicts occupational specialization, as measured by answers from the WVS/EVS surveys. In particular, countries that used irrigation report significantly higher shares of employment in jobs that require routine tasks (column 1), even when controlling for income differences across countries

Table 16: IRRIGATION AND PATTERNS OF JOB SPECIALIZATION ACROSS COUNTRIES

	Routine			Independent			Manual		
	OLS	OLS	IV	OLS	OLS	IV	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Ancestral Irrigation	0.649*** (0.204)	0.529** (0.203)	0.814** (0.318)	-0.883*** (0.234)	-0.858*** (0.234)	-1.115*** (0.362)	0.310 (0.239)	0.179 (0.218)	0.444 (0.324)
(ln) Income per capita		-0.336*** (0.100)			0.142 (0.122)			-0.414*** (0.123)	
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	71	70	71	71	70	71	71	70	71
R-squared	0.27	0.36	0.26	0.28	0.30	0.27	0.25	0.36	0.25
First Stage F-Stat	.	.	94.74	.	.	94.74	.	.	94.74

Note: The unit of observation is the country. All dependent variables are country averages computed from survey responses of the World Values Survey/European Values Survey. Routine measures whether tasks are mostly routine, Independent measures the degree of independence of tasks, and Manual measures where tasks are mostly manual versus cognitive. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls are adjusted for ancestry. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

(column 2), and when instrumenting ancestral irrigation by its suitability (column 3). The IV coefficient suggests that a one std. increase in past irrigation increases the degree of routineness of tasks by 0.4 of a std. Correspondingly, columns 4 to 6 report a similar, but negative, effect of past irrigation on the degree of independence of occupations that is equally large. While past irrigation affects the degree of independence/routine of jobs, it does not affect whether jobs are mostly manual or cognitive, as shown in columns 7 to 9. Together, these findings imply that parts of the occupational specialization across countries can be linked to pre-industrial economies. They also mirror the results of [Campante and Chor \(2017\)](#) who show that differences in attitudes towards obedience at the workplace predict patterns of specialization across nations.

The second layer of evidence comes from occupational choices of 2nd generation US migrants surveyed in the CPS (19914-2016). Again, this epidemiological approach allows to isolate the effect of transmittable cultural characteristics from the home country environment. I classify migrants' occupations into routine, and non-routine tasks, using the O*Net job classifications. I measure the routineness of jobs by their degree of repetition, accuracy and structure, following [Acemoglu and Autor \(2011\)](#). Relatedly, I study jobs that reflect a preference for following procedures and routines set by an authority (conventional occupations). In addition, I use the degree of innovation, independence, and freedom of decision of jobs to compute a measure of non-routineness (or innovativeness) of tasks. Table 17 investigates job characteristics of high-skilled 2nd generation migrants, defined as having at least a college degree. OLS results reported in column 1 - 3 reveal that migrants whose ancestors used irrigation in agriculture are today more likely to work in occupations that are intensive in routine tasks (column 1), have a preference for conventional jobs (column 2), and are less likely to work in non-routine occupations (column 3) - conditional on their educational level. However, the reduced form and 2SLS coefficients - while having the expected sign - are not significantly different from zero. To account for the unbalancedness of the sample, columns 4 - 6 report results

Table 17: IRRIGATION, AND JOB TASKS OF MIGRANTS

	Unweighted			Weights: Same N		
	Routine	Conventional	Non-Routine (Innovative)	Routine	Conventional	Non-Routine (Innovative)
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Reduced Form						
Irrigation Suitability	0.06* (0.04)	0.03 (0.12)	-0.03 (0.03)	0.21*** (0.07)	1.37*** (0.35)	-0.15** (0.06)
Panel B: OLS						
Ancestral Irrigation	0.03** (0.01)	0.15** (0.06)	-0.03*** (0.01)	0.07** (0.03)	0.32** (0.12)	-0.09*** (0.03)
Panel C: 2SLS						
Ancestral Irrigation	0.09 (0.08)	0.04 (0.17)	-0.04 (0.05)	0.16*** (0.06)	1.08*** (0.34)	-0.12** (0.05)
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
U.S. State FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14779	14779	14779	14779	14779	14779
R-squared	0.06	0.08	0.11	0.09	0.12	0.16
Number of Countries	100	100	100	100	100	100
First Stage F-Stat	4.10	4.10	4.10	40.65	40.65	40.65

Note: The unit of observation is an 2nd generation US immigrant that graduated from College. Data comes from the Current Population Census March Supplement (1994-2016). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. All regressions control for individual characteristics (age, gender, dummies for bachelor, professional and post-graduate degrees, log family income and its square, and survey wave fixed effects), geographic and ethnographic controls, as well as US State fixed effects. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses clustered at the country of origin. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

that assign equal weight to each country of origin. Throughout all specifications, coefficients are significant with the expected sign. Magnitudes of the IV coefficients range between 0.15 to 0.25 of a std. for a one std. increase in past irrigation.⁵¹

6 Conclusion

This paper combined ethnographic data with modern outcomes to test whether intensive group coordination in pre-industrial agriculture is reflected in stronger norms of collectivism today. I find evidence that is consistent with this hypothesis, across countries, individuals in sub-national districts, and migrants - even when instrumenting the historical adoption of irrigation by environmental characteristics that made its use more or less profitable. Regarding mechanisms of persistence, my findings suggest that past irrigation affects collectivism through a persistent change in transmittable cultural norms, while at the same time interacting with political institutions.

The second part of the paper documented a reversal in technological progress over time, ultimately leading to a strong negative effect of pre-industrial irrigation on the level of con-

⁵¹In addition, Table B36 shows that OLS results are robust to controlling for home country GDP; Table B37 reports similar results for the sample of all (1st and 2nd gen) migrants; Table B38 shows that similar, but weaker effects are found in migrants with all education levels.

temporary innovation across nations and individuals. This suggests that the effect on culture on economic outcomes varies in different stages of development. While norms of group conformity were beneficial for coordination in agricultural societies, they became disadvantageous for innovation in modern times. Relatedly, past agriculture predicts patterns of job specialization, where traditional irrigation societies have a comparative advantage in routine occupations that require obedience.

Together, my findings can help to explain trajectories of technology and specialization in historically advanced economies, particularly of the Middle East and Asia, that relied on irrigation and that were ultimately falling behind during the great divergence.

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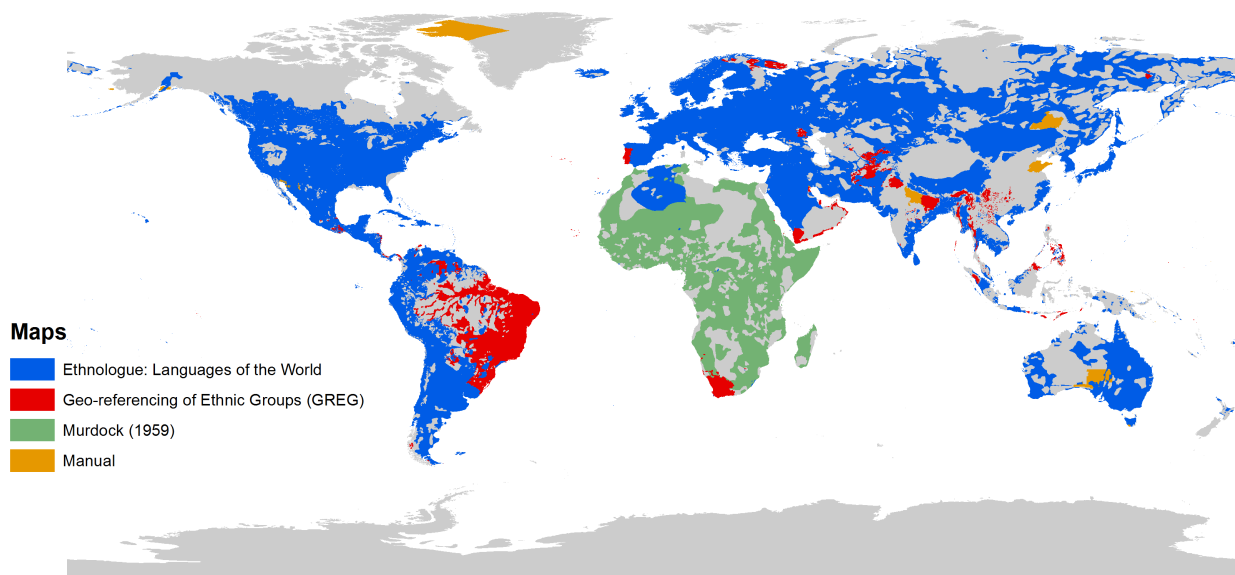
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Online Appendix

A Additional Figures

Figure A1: MAPS OF ETHNIC GROUPS



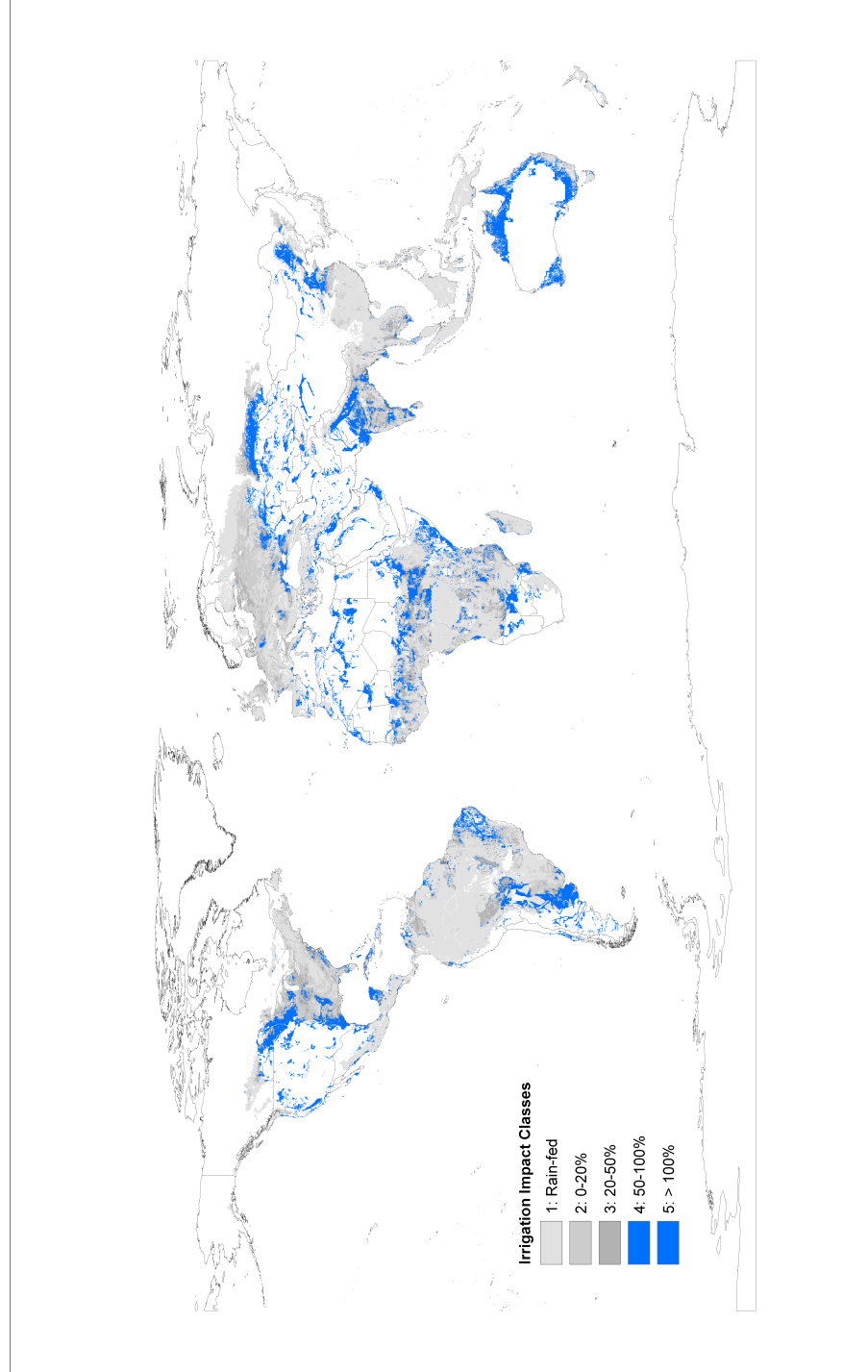
Note: This figure shows the spatial extent of contemporary ethnic groups matched to the Ethnographic Atlas, as well as the maps used.

Figure A2: MATCHED ETHNIC GROUPS IN MEXICO



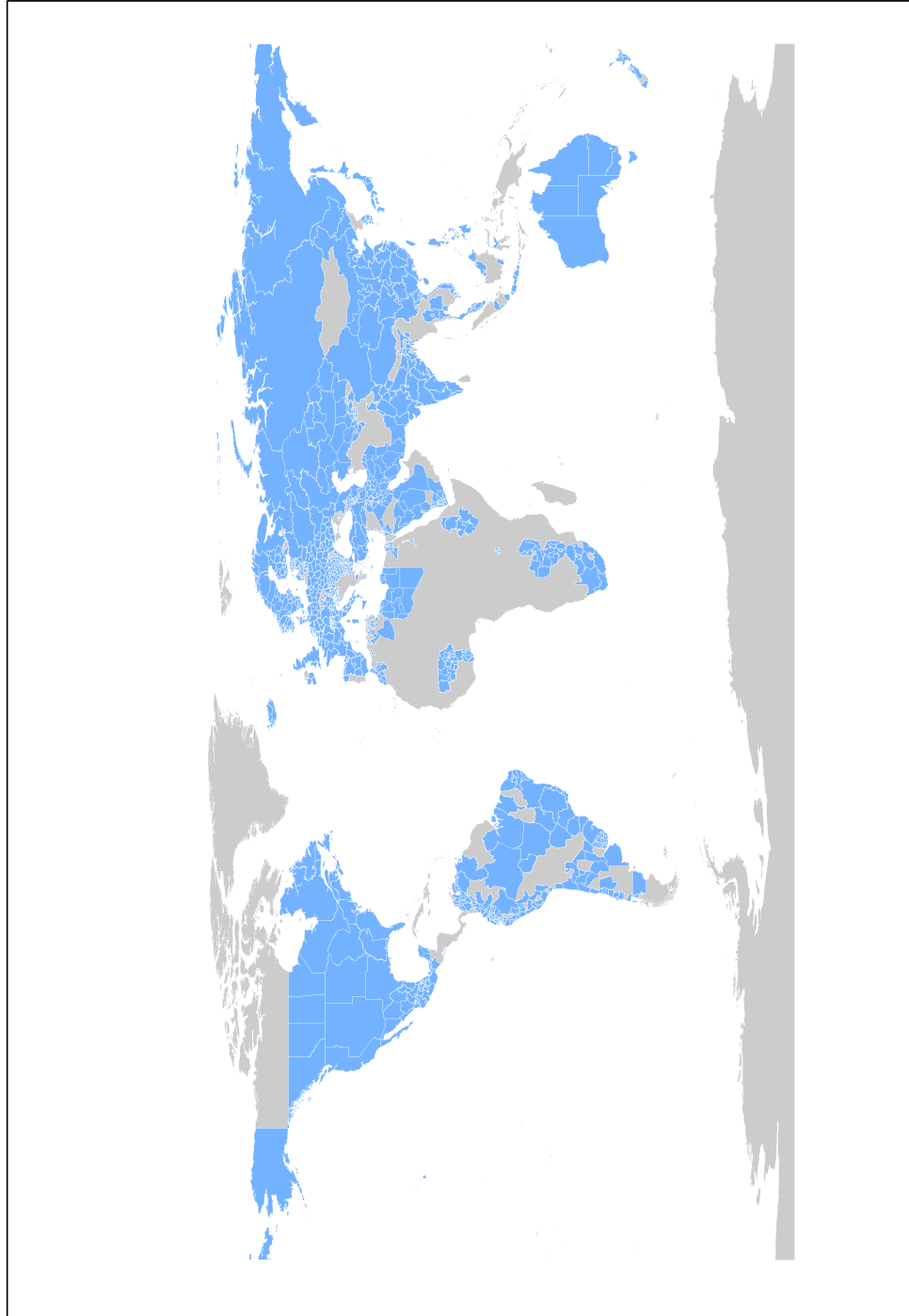
Note: This figure shows the spatial extent of contemporary Mexican ethnic groups that were matched to a group reported in the Ethnographic Atlas.

Figure A3: IRRIGATION IMPACT CLASSES



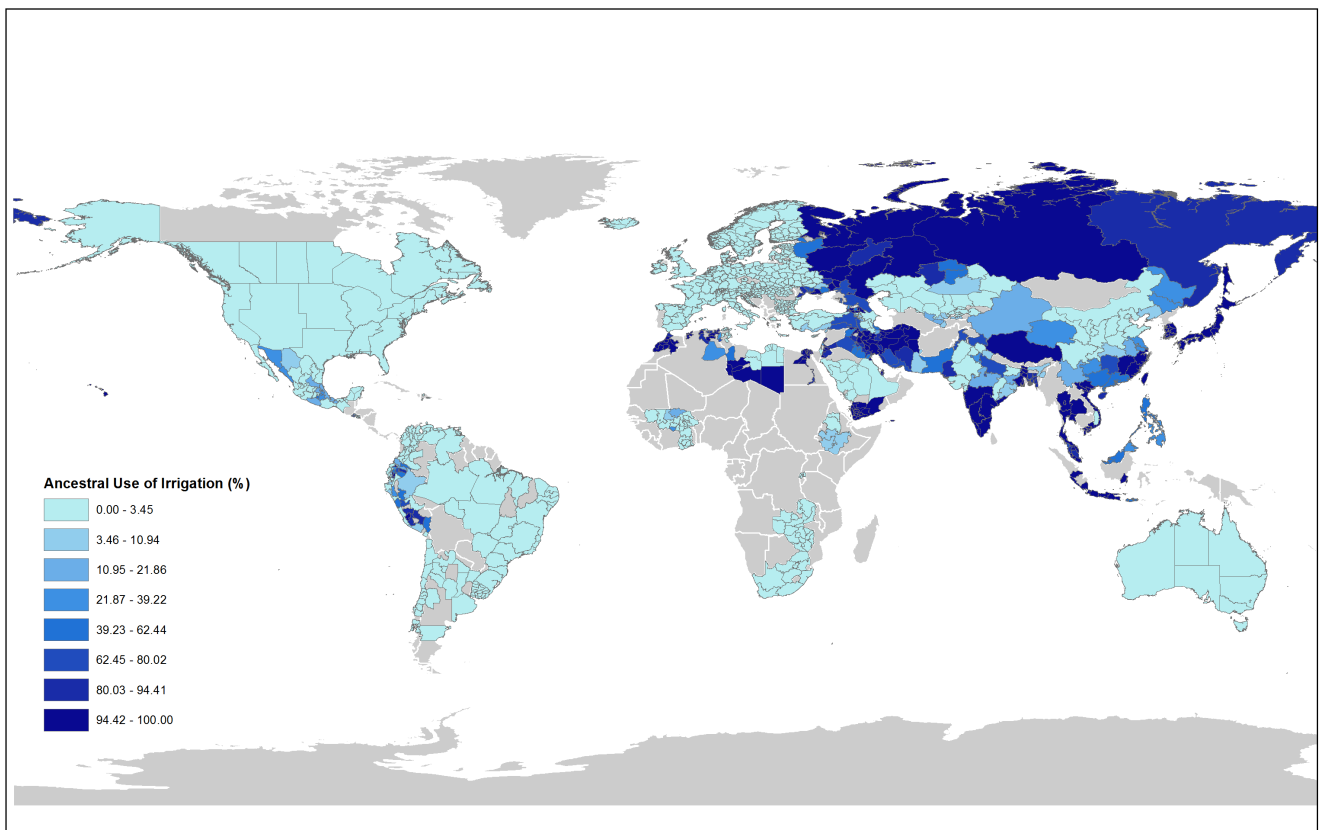
Note: This figure shows the irrigation impact classes, as defined by the FAO. Blue areas characterize locations where irrigation increases agricultural yields by more than 50 percent.

Figure A4: SUB-NATIONAL DISTRICTS IN THE WVS/EVS



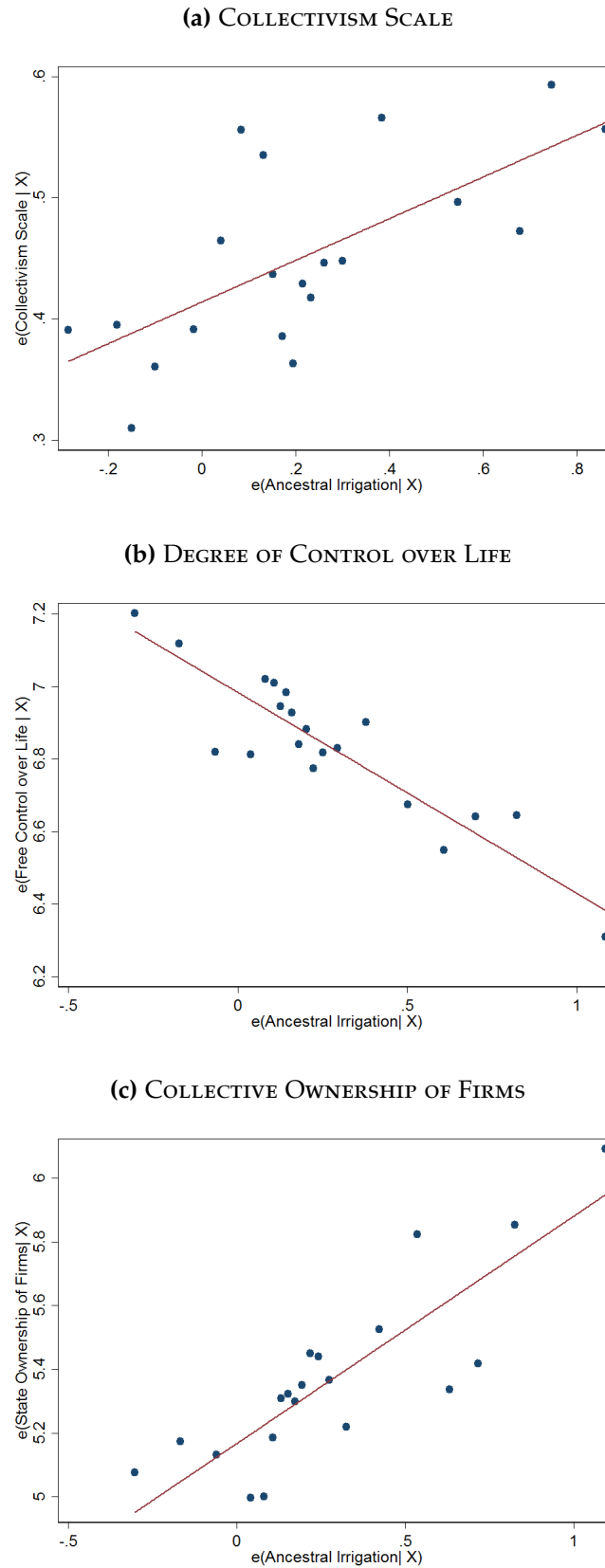
Note: This figure shows the sub-national regions that are surveyed in the WVS/EVS.

Figure A5: ANCESTRAL IRRIGATION ACROSS SUB-NATIONAL WVS/EVS REGIONS



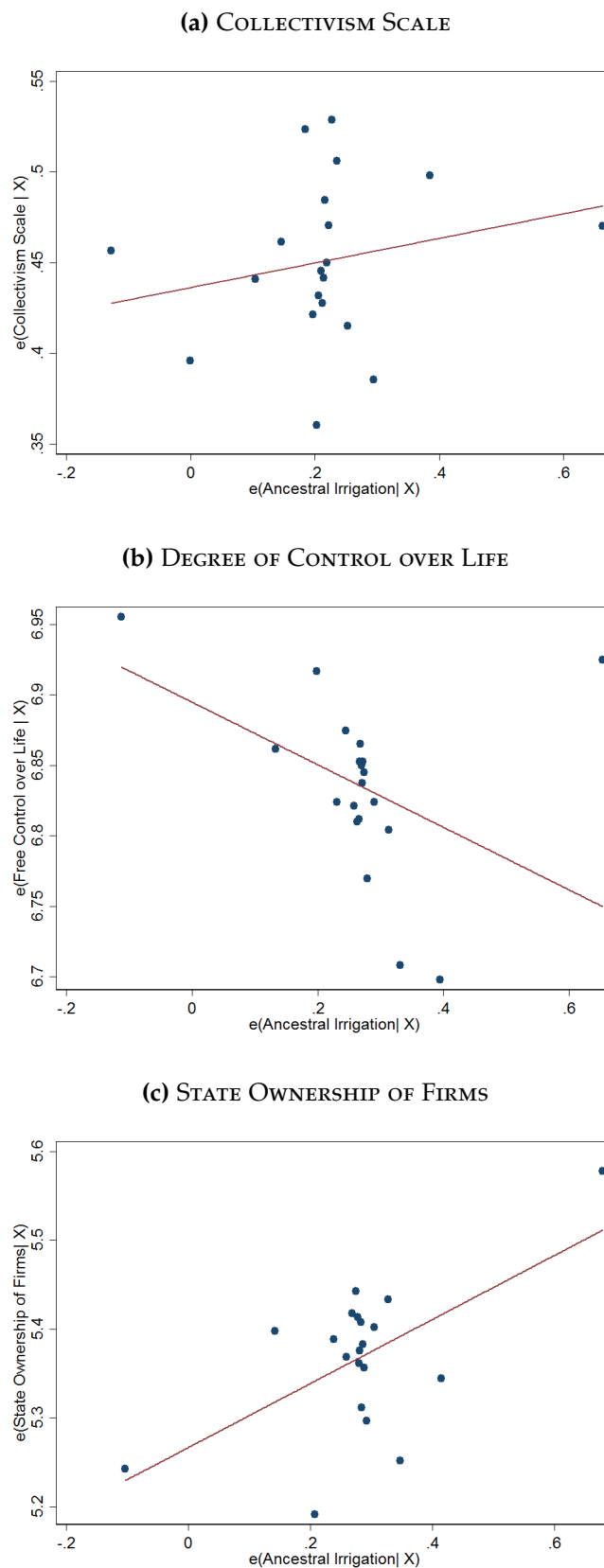
Note: This figure shows the share of a sub-national region's population whose ancestors traditionally used irrigation in agriculture.

Figure A6: IRRIGATION AND COLLECTIVISM ACROSS INDIVIDUALS, CONDITIONAL ON REGION FE



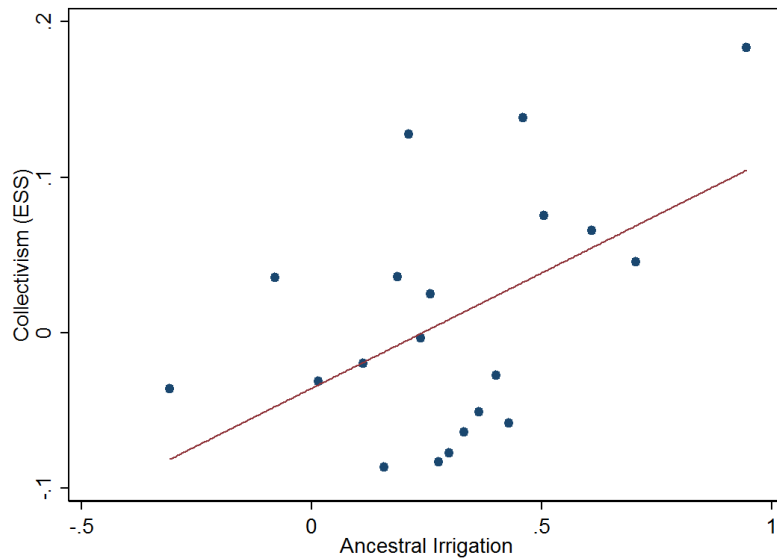
Note: This figure shows binned scatterplots of the relationship between individual survey responses and ancestral irrigation across sub-national districts, conditional on individual controls, geographic and ethnographic controls, as well as region fixed effects.

Figure A7: COLLECTIVISM AND IRRIGATION ACROSS INDIVIDUALS, CONDITIONAL ON COUNTRY FE



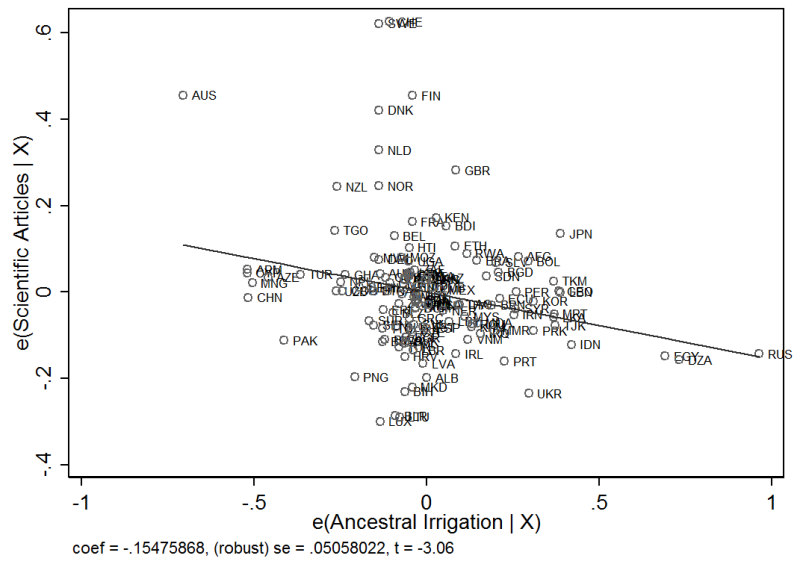
Note: This figure shows binned scatterplots of the relationship between individual survey responses and ancestral irrigation across sub-national districts, conditional on individual controls, geographic and ethnographic controls, as well as country fixed effects.

Figure A8: COLLECTIVISM AND IRRIGATION ACROSS MIGRANTS (ESS)



Note: This figure shows the binned scatterplot of the relationship between individual survey responses and ancestral irrigation across European migrants, conditional on individual controls, geographic and ethnographic controls, as well as country fixed effects.

Figure A9: IRRIGATION AND INNOVATION ACROSS COUNTRIES



Note: This figure shows cross-country relationship between ancestral irrigation and the number of scientific articles par capita, conditional on geographic and ethnographic controls, as well as region fixed effects.

Figure A10: LONG-RUN FLEXIBLE ESTIMATES BETWEEN TECHNOLOGY AND IRRIGATION

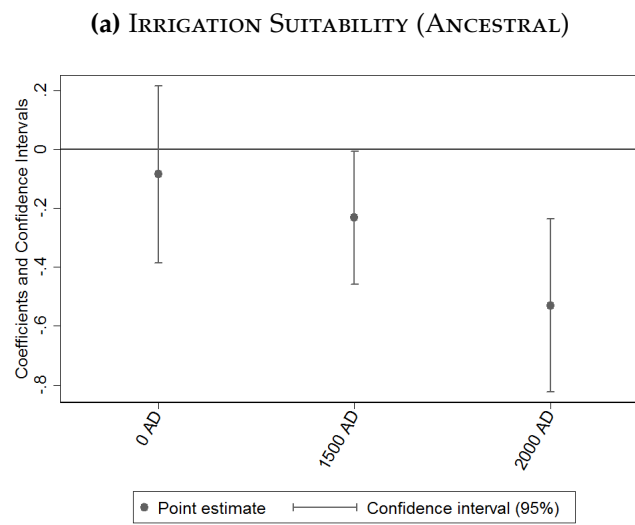
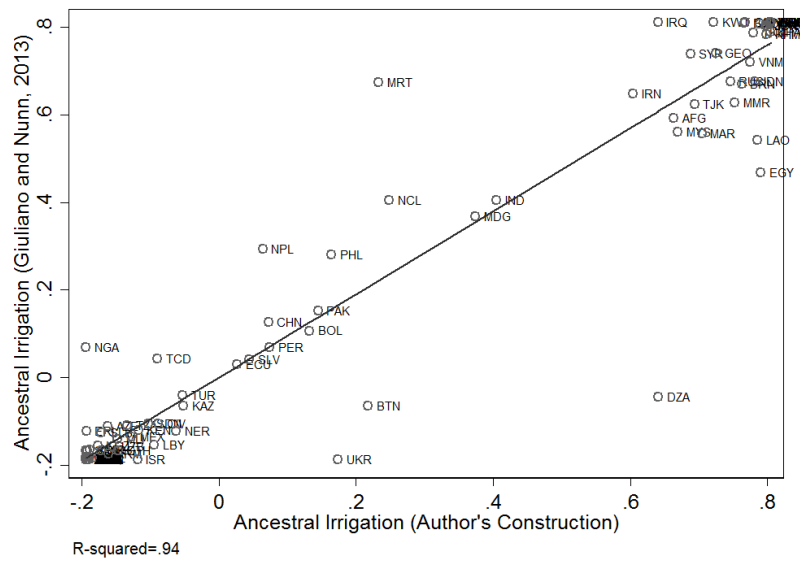


Figure A11: CROSS-VALIDATION OF THE ANCESTRAL IRRIGATION VARIABLE



Note: This figure cross-validates the measure of ancestral irrigation constructed by the author (x-axis) against the Ancestral Irrigation measure included in the "Ancestral Characteristics of Modern Populations" database (y-axis) constructed by [Giuliano and Nunn \(2017\)](#) across countries.

B Additional Tables

B.1 Descriptive Statistics

Table B1: SUMMARY STATISTICS COLLECTIVISM ACROSS COUNTRIES

	Mean	S.D.	N
Collectivism (Hofstede)	60.34	22.00	97
Ancestral Irrigation	0.23	0.37	97
Irrigation Suitability	0.19	0.25	96
Irrigation Suitability (Local)	0.18	0.26	96
Agricultural Suitability	0.48	0.23	96
Tropical Climate	0.18	0.33	97
Distance to River (km)	832.16	1311.72	97
Distance to Coast (km)	211.93	236.25	97
Altitude	442.80	423.84	97
Mean Precipitation	76.20	45.96	97
Settlement Type	6.33	1.60	97
Political Complexity	3.51	1.01	97
Mean Size Local Community	6.12	2.65	94
Neolithic Revolution	5.18	2.54	95
State Antiquity	0.56	0.23	88
Traditional Democracy	0.33	0.42	91
Malaria Suitability	1.72	4.67	97
Ethnic Fractionalization	0.41	0.24	97
Migratory Distance	9.23	7.22	96
Migratory Distance Sq.	136.73	194.47	96
Latitude	24.35	26.32	96
Population density in 1500 CE	7.97	10.03	95
Buddhism	0.05	0.17	97
Christianity	0.55	0.36	97
Hindu	0.03	0.12	97
Islam	0.21	0.34	97
Judaism	0.01	0.07	97
Polity IV 1980 - 2014	4.24	5.68	96
(ln) Income per capita	8.91	1.25	96
Perc. Natives	0.74	0.31	95
Perc. Europeans	0.46	0.45	95
Land gini	0.62	0.14	81
Pathogen Prevalence	-0.00	0.65	97

Table B2: SUMMARY STATISTICS FOR THE INDIVIDUAL LEVEL WVS/EVS ANALYSIS

	Mean	S.D.	N
Collectivism Scale	0.41	1.07	91807
Degree of Control over Life	6.84	2.34	214901
Collective Ownership of Firms	5.24	2.82	194128
Ancestral Irrigation	0.24	0.40	225637
Irrigation Suitability	0.17	0.25	225637
Age	41.52	16.52	225637
Age sq.	1997.05	1542.29	225637
Male	0.48	0.50	225590
Inadequately completed elementary education	0.08	0.27	202037
Completed (compulsory) elementary education	0.15	0.36	202037
Incomplete secondary school: technical/vocational	0.08	0.27	202037
Complete secondary school: technical/vocational	0.18	0.38	202037
Incomplete secondary: university-preparatory	0.10	0.30	202037
Complete secondary: university-preparatory type	0.18	0.39	202037
Some university without degree/Higher education	0.07	0.26	202037
University with degree/Higher education	0.16	0.36	202037
Married	0.57	0.50	225637
Agricultural Suitability	0.51	0.23	225637
Koeppen-Geiger Tropical Climate	0.11	0.29	225637
Distance to River (km)	617.81	807.58	225637
Distance to Coast (km)	252.52	353.91	225637
Altitude	0.41	0.40	225637
Mean Precipitation	69.36	40.31	225637
Settlement Type	6.49	1.47	225637
Political Complexity	3.80	0.98	225637
Mean Size Local Community	6.76	2.33	225637

Table B3: SUMMARY STATISTICS FOR THE MIGRANT ANALYSIS ESS

	Mean	S.D.	N
Collectivism	0.01	1.41	18021
Ancestral Irrigation	0.31	0.41	19363
Irrigation Suitability	0.21	0.24	19363
Age	47.05	17.91	19363
Age sq.	2534.14	1803.88	19363
Male	0.45	0.50	19363
Big City 0/1	0.48	0.50	19363
Married	0.57	0.49	19363
Less than lower secondary education	0.13	0.33	19266
Lower secondary education completed	0.17	0.38	19266
Upper secondary education completed	0.34	0.47	19266
Post-secondary non-tertiary education completed	0.05	0.21	19266
Tertiary education completed	0.31	0.46	19266
Other education	0.00	0.06	19266
Agricultural Suitability	0.56	0.24	19363
Tropical Climate	0.06	0.21	19363
Distance to River (km)	513.25	606.32	19363
Distance to Coast (km)	299.34	298.19	19363
Altitude	404.71	313.54	19363
Mean Precipitation	57.10	29.05	19363
Settlement Type	6.10	1.91	19363
Political Complexity	3.71	1.31	19363
Mean Size Local Community	6.53	2.39	19363

Table B4: SUMMARY STATISTICS CPS IN-GROUP MARRIAGE

	Mean	S.D.	N
In-Group Marriage	0.71	0.45	21765
Ancestral Irrigation	0.17	0.31	21765
Irrigation Suitability	0.14	0.11	21765
Age	51.55	20.72	21765
Age sq.	3086.38	2233.96	21765
Female	0.51	0.50	21765
None or Preschool	0.01	0.07	21765
Grades 1-4	0.01	0.11	21765
Grades 5 and 6	0.02	0.15	21765
Grades 7 and 8	0.05	0.21	21765
Grade 9	0.03	0.17	21765
Grade 10	0.04	0.18	21765
Grade 11	0.04	0.19	21765
Grade 12, no diploma	0.02	0.14	21765
High School	0.33	0.47	21765
Some College	0.15	0.36	21765
Associate's degree, occupational/vocational	0.04	0.19	21765
Associate's degree, academic program	0.04	0.20	21765
Bachelor's degree	0.15	0.36	21765
Professional school degree	0.06	0.23	21765
Professional school degree	0.02	0.15	21765
Doctorate degree	0.01	0.11	21765
Agricultural Suitability	0.66	0.16	21765
Tropical Climate	0.10	0.23	21765
Distance to River (km)	1095.89	659.77	21765
Distance to Coast (km)	111.26	150.04	21765
Altitude	369.57	156.49	21765
Mean Precipitation	71.84	35.26	21765
Settlement Type	6.68	1.23	21765
Political Complexity	3.92	0.84	21765
Mean Size Local Community	7.48	1.38	21765

Table B5: SUMMARY STATISTICS INNOVATION ACROSS COUNTRIES

	Mean	S.D.	N
Scientific articles	0.10	0.21	143
Technology 1000 BD	0.52	0.25	103
Technology 0 AD	0.83	0.17	126
Technology 1500 AD	0.60	0.26	113
Current Technology	0.45	0.20	123
Ancestral Irrigation	0.23	0.38	163
Irrigation Suitability	0.23	0.29	161
Irrigation Suitability (Local)	0.23	0.31	161
Agricultural Suitability	0.44	0.23	160
Tropical Climate	0.26	0.39	163
Distance to River (km)	821.27	1477.12	163
Distance to Coast (km)	318.66	402.61	163
Altitude	523.05	472.73	163
Mean Precipitation	78.84	51.43	163
Settlement Type	6.15	1.69	163
Political Complexity	3.30	1.10	163
Mean Size Local Community	5.33	2.94	152

Table B6: SUMMARY STATISTICS INNOVATION ACROSS US MIGRANTS

	Mean	S.D.	N
Patent Granted	0.04	0.21	16127
Published Book, Article or Conf. Paper	0.29	0.45	16127
No. of Publications	3.66	11.97	16127
Conference Attendance	0.53	0.50	16127
Importance in Job: Independence	3.57	0.60	52029
Ancestral Irrigation	0.37	0.36	52029
Irrigation Suitability	0.19	0.19	52029
Age	45.32	11.99	52029
Age Sq.	2197.90	1146.95	52029
Male	0.39	0.49	52029
Married	0.78	0.41	52029
Age at Arrival	23.79	10.74	52029
Ln Salary	11.60	1.78	52029
Ln Salary Sq.	137.64	45.81	52029
Bachelor	0.41	0.49	52029
US High-School	0.23	0.42	52029
US BA	0.13	0.34	52029
US Grad School	0.22	0.42	52029
All Edu Foreign	0.42	0.49	52029
Agricultural Suitability	0.58	0.20	52029
Tropical Climate	0.26	0.36	52029
Distance to River (km)	731.71	683.70	52029
Distance to Coast (km)	215.38	213.35	52029
Altitude	321.70	241.16	52029
Mean Precipitation	93.79	44.58	52029
Settlement Type	6.16	1.44	52029
Political Complexity	3.67	0.98	52029
Mean Size Local Community	6.58	1.86	52029

Table B7: SUMMARY STATISTICS JOB SPECIALIZATION ACROSS COUNTRIES

	Mean	S.D.	N
Routine	5.41	0.69	71
Independent	6.53	0.79	71
Manual	5.06	0.81	71
Agricultural Suitability	0.49	0.22	71
Tropical Climate	0.14	0.31	71
Distance to River (km)	722.37	1038.26	71
Distance to Coast (km)	315.93	431.86	71
Altitude	435.49	363.05	71
Mean Precipitation	71.12	45.64	71
Settlement Type	6.13	1.85	71
Political Complexity	3.56	1.16	71
Mean Size Local Community	6.12	2.54	71

Table B8: SUMMARY STATISTICS CPS OCCUPATIONS

	Mean	S.D.	N
Routine	2.73	0.33	14779
Conventional	4.36	1.43	14779
Non-Routine (Innovative)	3.99	0.26	14779
Ancestral Irrigation	0.22	0.33	14779
Irrigation Suitability	0.14	0.13	14779
Age	39.62	13.40	14779
Age sq.	1749.65	1249.97	14779
Female	0.49	0.50	14779
Bachelor's degree	0.65	0.48	14779
Professional school degree	0.22	0.41	14779
Professional school degree	0.08	0.27	14779
Doctorate degree	0.05	0.22	14779
Agricultural Suitability	0.62	0.19	14779
Tropical Climate	0.19	0.34	14779
Distance to River (km)	936.05	670.93	14779
Distance to Coast (km)	122.43	156.31	14779
Altitude	323.91	195.78	14779
Mean Precipitation	84.81	42.79	14779
Settlement Type	6.35	1.50	14779
Political Complexity	3.74	0.96	14779
Mean Size Local Community	7.10	1.75	14779

B.2 Irrigation Suitability and Adoption of Irrigation across Ethnic Groups

Table B9: FIRST-STAGE ACROSS ETHNIC GROUPS

	Ancestral Irrigation					
	(1)	(2)	(3)	(4)	(5)	(6)
Irrigation Suitability	0.198*** (0.037)	0.188*** (0.047)	0.300*** (0.048)	0.353*** (0.057)	0.332*** (0.048)	0.242*** (0.044)
Suitability for Rainfed Agriculture				0.065 (0.060)		
Latitude					0.002*** (0.001)	
Longitude					0.001*** (0.000)	
Geographic Controls	No	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	No	Yes	Yes	Yes	Yes
Region FE	No	No	No	No	No	Yes
Observations	1061	1025	991	991	991	991
R-squared	0.04	0.05	0.15	0.15	0.19	0.25

Note: OLS regressions. The unit of observation is ethnic group from the Ethnographic Atlas. Geographic controls are evaluated within a 200 km circle drawn around the reported location of ethnic groups. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B.3 Further Results on the Effect of Irrigation on Collectivism across Countries

Table B10: CROSS-COUNTRY ESTIMATION: ALL CONTROLS REPORTED

	Collectivism								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Ancestral Irrigation	13.95*** (4.11)	16.05*** (4.94)	18.39*** (5.94)	17.24*** (5.60)	16.55*** (4.84)	19.37*** (5.24)	18.16*** (5.20)	18.08*** (6.37)	24.08*** (6.17)
Agricultural Suitability		26.75** (11.48)	27.52** (11.72)	23.03* (13.67)	12.10 (14.76)	30.34** (12.28)	31.03*** (11.17)	20.30** (9.36)	15.71 (10.84)
Tropical Climate		24.98** (10.13)	24.29** (10.05)	27.61** (10.61)	28.09*** (9.26)	13.12 (11.07)	18.92* (10.47)	15.30* (8.11)	1.27 (9.45)
Distance to River (km)		0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	-0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	-0.01*** (0.00)	-0.00** (0.00)
Distance to Coast (km)		-0.01 (0.01)	-0.01 (0.02)	-0.01 (0.01)	-0.02 (0.01)	-0.02 (0.02)	-0.02 (0.01)	-0.00 (0.01)	-0.02 (0.01)
Altitude		0.01* (0.01)	0.01* (0.01)	0.02** (0.01)	0.01** (0.01)	0.01** (0.01)	0.01* (0.01)	0.00 (0.01)	0.01* (0.01)
Mean Precipitation		-0.17** (0.07)	-0.17** (0.07)	-0.15** (0.07)	-0.11 (0.08)	-0.14** (0.07)	-0.14** (0.07)	-0.10 (0.08)	-0.09 (0.08)
Settlement Type		3.20 (1.96)	2.90 (2.04)	2.04 (2.35)	0.98 (2.67)	2.00 (2.05)	1.30 (1.98)	3.19 (2.36)	3.16 (2.31)
Political Complexity		-0.91 (2.99)	-0.87 (2.90)	-0.27 (3.83)	-2.09 (3.03)	0.79 (3.45)	-1.06 (3.01)	-1.04 (2.83)	-2.82 (3.69)
Mean Size Local Community		-3.89** (1.73)	-3.76** (1.81)	-2.48 (2.11)	-1.05 (2.67)	-3.73** (1.63)	-2.60 (1.80)	-4.47** (2.01)	-3.43* (2.03)
Neolithic Revolution			-0.77 (1.16)						3.39** (1.28)
State Antiquity				-12.31 (12.91)					-6.20 (10.83)
Traditional Democracy					-11.45* (6.39)				-0.64 (5.02)
Malaria Suitability						1.24** (0.52)			1.79*** (0.53)
Ethnic Fractionalization							25.68** (11.75)		22.01** (9.88)
Region FE	No	No	No	No	No	No	No	Yes	Yes
Observations	97	93	93	86	90	93	93	93	83
R-squared	0.06	0.36	0.36	0.39	0.36	0.39	0.40	0.63	0.72

Note: OLS regressions. The unit of observation is the country. The dependent variable is the [Hofstede et al. \(1997\)](#) Index of Collectivism measured on a scale from 0 to 100. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls, as well as malaria suitability, are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B11: CROSS-COUNTRY ESTIMATION: ALTERNATIVE SAMPLES

	Collectivism				
	Old World (1)	wo Asia (2)	wo Africa (3)	FE for Middle East (4)	Continent FE (5)
Ancestral Irrigation	14.41** (5.58)	17.38** (8.06)	26.33*** (7.02)	19.26*** (6.90)	13.39** (5.75)
Geographic Controls	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes
Observations	72	70	76	93	93
R-squared	0.56	0.68	0.67	0.63	0.53

Note: OLS regressions. The unit of observation is the country. The dependent variable is the [Hofstede *et al.* \(1997\)](#) Index of Collectivism measured on a scale from 0 to 100. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls are adjusted for ancestry. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B12: CROSS-COUNTRY ESTIMATION: ADDITIONAL GEOGRAPHIC CONTROLS

	Collectivism					
	(1)	(2)	(3)	(4)	(5)	(6)
Ancestral Irrigation	17.44*** (5.23)	17.71*** (6.03)	13.39* (7.20)	14.77** (6.11)	18.38*** (6.47)	18.11*** (6.76)
Std Precipitation	0.39*** (0.11)					
Mean Temperature		1.77*** (0.62)				
Arid Climate			30.31 (230.57)			
Continental Climate			30.20 (230.56)			
Polar Climate			29.48 (230.52)			
Temperate Climate			30.05 (230.57)			
Ruggedness				15.99*** (4.37)		
Caloric Suitability pre 1500					-0.11 (0.13)	
Caloric Suitability post 1500						0.00 (0.12)
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	93	93	93	93	93	93
R-squared	0.66	0.66	0.66	0.68	0.63	0.63

Note: OLS regressions. The unit of observation is the country. The dependent variable is the [Hofstede et al. \(1997\)](#) Index of Collectivism measured on a scale from 0 to 100. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B13: CROSS-COUNTRY ESTIMATION: SUBSISTENCE MODES

	Collectivism					
	(1)	(2)	(3)	(4)	(5)	(6)
Ancestral Irrigation	15.07** (6.27)	21.67*** (6.41)	20.29*** (6.52)	19.29*** (6.52)	14.22** (5.93)	18.65*** (6.66)
Agricultural Dependence	3.93* (2.17)					
Intensity of Agriculture		-12.79 (9.08)				
Traditional Plow Use			-13.06 (10.89)			
Gathering				6.54 (8.71)		
Hunting					-7.54** (3.75)	
Fishing						-4.73 (4.22)
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	93	93	93	93	93	93
R-squared	0.64	0.63	0.63	0.63	0.64	0.63

Note: OLS regressions. The unit of observation is the country. The dependent variable is the [Hofstede et al. \(1997\)](#) Index of Collectivism measured on a scale from 0 to 100. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B14: CROSS-COUNTRY ESTIMATION: ADDITIONAL ETHNOGRAPHIC CONTROLS

	Collectivism				
	(1)	(2)	(3)	(4)	(5)
Ancestral Irrigation	18.02*** (6.53)	22.06*** (6.23)	18.25*** (6.38)	18.60*** (6.41)	17.22** (6.67)
Extended Family	-2.71 (5.85)				
Endogamous Community		19.37*** (6.56)			
Clan Community			3.77 (11.21)		
Class Stratification				-2.05 (2.78)	
Survey Year (avg.)					0.00 (0.00)
Geographic Controls	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes
Observations	93	93	93	93	93
R-squared	0.63	0.66	0.63	0.63	0.63

Note: OLS regressions. The unit of observation is the country. The dependent variable is the [Hofstede et al. \(1997\)](#) Index of Collectivism measured on a scale from 0 to 100. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B15: ANCESTRAL IRRIGATION AND OTHER CULTURAL DIMENSIONS

	Collectivism		Restraint		Power Distance		Masculinity		Uncertainty Avoidance		Long-Term Orientation	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Ancestral Irrigation	16.05*** (4.94)	18.08*** (6.37)	27.54*** (5.10)	25.98*** (6.27)	4.71 (8.70)	12.92 (9.99)	-10.66 (8.77)	-21.31*** (7.81)	14.15 (9.20)	27.47*** (9.31)	7.18 (6.01)	3.39 (6.96)
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Observations	93	93	85	85	67	67	67	67	67	67	86	86
R-squared	0.36	0.63	0.36	0.61	0.48	0.56	0.12	0.20	0.42	0.50	0.53	0.68

Note: OLS regressions. The unit of observation is the country. The dependent variable is the Hofstede *et al.* (1997) Index of Collectivism measured on a scale from 0 to 100. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B16: IRRIGATED VS RAINFED RICE AND COLLECTIVISM ACROSS COUNTRIES

	Collectivism				
	(1)	(2)	(3)	(4)	(5)
Irrigated Rice Suitability	9.87*** (2.16)		11.15*** (2.33)		
Rainfed Rice Suitability		7.84* (3.97)	-4.06 (4.32)		
Δ Suitability (Irrigation-Rainfed)				33.84*** (5.90)	27.10*** (7.77)
Geographic Controls	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes
Region FE	No	No	No	No	Yes
Observations	93	93	93	93	93
R-squared	0.45	0.33	0.46	0.47	0.64

Note: OLS regressions. The unit of observation is the country. The dependent variable is the [Hofstede et al. \(1997\)](#) Index of Collectivism measured on a scale from 0 to 100. Geographic and ethnographic controls are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B17: ANCESTRAL IRRIGATION AND LAND INEQUALITY

	Land Inequality		
	(1)	(2)	(3)
Ancestral Irrigation	0.01 (0.05)		
Irrigation Suitability		0.07 (0.09)	
Irrigation Suitability (Local)			0.24*** (0.08)
Geographic Controls	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Observations	103	103	101
R-squared	0.57	0.58	0.51

Note: OLS regressions. The unit of observation is the country. The dependent variable is land inequality taken from [Bentzen et al. \(2016\)](#) and based on [Frankema \(2010\)](#). Geographic and ethnographic controls are adjusted for ancestry in columns (1) and (2). Geographic controls are computed at the country level in column (3). Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B18: CORRELATION MATRIX OF COLLECTIVISM MEASURES ACROSS SAMPLES

Variables	Collectivism (Hofstede)	Collectivism Scale (WVS)	Free Control over Life (WVS)	Collective Ownership of Firms (WVS)	Collectivism (ESS)	Embeddedness	Affective autonomy	Intellectual autonomy	Ingroup Favoritism	Restraint	Social Tightness
Collectivism	1.00										
Collectivism Scale	0.42	1.00									
Free Control over Life	0.01	0.09	1.00								
Collective Ownership of Firms	0.58	0.35	-0.04	1.00							
Collectivism (ESS)	0.35	0.33	-0.24	0.28	1.00						
Embeddedness	0.60	0.52	-0.18	0.58	0.56	1.00					
Affective autonomy	-0.60	-0.50	0.19	-0.56	-0.47	-0.87	1.00				
Intellectual autonomy	-0.52	-0.51	0.10	-0.49	-0.49	-0.89	0.74	1.00			
Ingroup Favoritism	0.68	0.33	-0.23	0.46	0.29	0.64	-0.62	-0.54	1.00		
Restraint	0.17	-0.17	-0.80	0.22	0.28	0.24	-0.19	-0.14	0.43	1.00	
Social Tightness	0.51	0.28	-0.24	0.38	0.57	0.78	-0.59	-0.65	0.63	0.38	1.00

B.4 Preference for Hard-Work

Table B19: ANCESTRAL IRRIGATION AND PREFERENCE FOR HARD-WORK

	Hard work brings better life		
	OLS (1)	RF (2)	IV (3)
Irrigation Suitability	1.68*** (0.23)		
Ancestral Irrigation		0.31*** (0.10)	1.47*** (0.24)
Individual Controls	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Observations	146994	146994	146994
R-squared	0.04	0.04	0.02
Mean Dependent Variable	6.78	6.78	6.78
Number of Districts	843	843	843
First Stage <i>F</i> -stat	.	.	107.50

Note: The unit of observation is the individual. Ancestral Irrigation measures the percentage share of a district's population whose ancestors have used irrigation. All regressions include individual controls for age, age square, gender, marriage status, and education, as well as survey wave indicator variables. Geographic and ethnographic controls are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. Regressions are weighted by survey weights. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses, clustered at the sub-national district. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B.5 Further Results on the Effect of Irrigation on Collectivism in European Migrants

**Table B20: ESTIMATES OF CULTURAL TRANSMISSION IN MIGRANTS:
FATHER COUNTRY OF ORIGIN**

	Collectivism					
	All Migrants		1st Generation		2nd Generation	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Reduced Form						
Irrigation Suitability	0.48*** (0.10)	0.62*** (0.11)	0.65*** (0.12)	0.70*** (0.12)	0.36*** (0.08)	0.63*** (0.15)
Panel B: OLS						
Ancestral Irrigation	0.10** (0.04)	0.13** (0.06)	0.16*** (0.05)	0.16*** (0.06)	0.01 (0.05)	0.06 (0.08)
Panel C: 2SLS						
Ancestral Irrigation	0.60*** (0.19)	0.68*** (0.17)	0.73*** (0.20)	0.70*** (0.15)	0.53** (0.25)	0.78*** (0.29)
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes		Yes		Yes	
Sub-National District FE		Yes		Yes		Yes
Observations	26581	12599	15717	7372	10856	5223
Number of Countries	160	153	155	146	135	125
First Stage <i>F</i> -Stat	10.75	15.47	14.67	23.08	7.95	10.68

Note: The unit of observation is an immigrant. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation in the immigrant's father's country of birth. The odd numbered columns control for country of residence fixed effects, the even numbered columns control for sub-national district of residence fixed effects. All regressions control for individual characteristics (age, gender, marriage status, education, city type), geographic & ethnic controls, as well as survey wave indicator variables. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses, clustered at the country of origin. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

**Table B21: ESTIMATES OF CULTURAL TRANSMISSION IN MIGRANTS:
MOTHER COUNTRY OF ORIGIN**

	Collectivism					
	All Migrants		1st Generation		2nd Generation	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Reduced Form						
Irrigation Suitability	0.49*** (0.11)	0.58*** (0.13)	0.63*** (0.13)	0.65*** (0.15)	0.36*** (0.10)	0.57*** (0.15)
Panel B: OLS						
Ancestral Irrigation	0.12** (0.05)	0.14** (0.06)	0.19*** (0.06)	0.16** (0.06)	-0.03 (0.05)	0.06 (0.08)
Panel C: 2SLS						
Ancestral Irrigation	0.58*** (0.18)	0.62*** (0.17)	0.69*** (0.19)	0.66*** (0.17)	0.49** (0.23)	0.67*** (0.25)
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes		Yes		Yes	
Sub-National District FE		Yes		Yes		Yes
Observations	26068	12313	15745	7416	10314	4894
Number of Countries	162	150	158	147	139	123
First Stage <i>F</i> -Stat	12.41	17.19	15.38	22.02	9.99	13.28

Note: The unit of observation is an immigrant. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation in the immigrant's mother's country of birth. The odd numbered columns control for country of residence fixed effects, the even numbered columns control for sub-national district of residence fixed effects. All regressions control for individual characteristics (age, gender, marriage status, education, city type), geographic & ethnic controls, as well as survey wave indicator variables. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses, clustered at the country of origin. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

**Table B22: ESTIMATES OF CULTURAL TRANSMISSION
CONDITIONAL ON HOME COUNTRY CONTROLS**

	Collectivism					
	All Migrants		1st Generation		2nd Generation	
	(1)	(2)	(3)	(4)	(5)	(6)
Ancestral Irrigation	1.00** (0.47)	1.24*** (0.47)	0.89** (0.40)	0.95*** (0.34)	1.17** (0.57)	1.80*** (0.57)
Polity IV	0.02 (0.02)	0.03 (0.02)	0.01 (0.01)	0.02 (0.01)	0.03 (0.03)	0.06** (0.03)
Ethnic Fractionalization	-0.01 (0.26)	-0.03 (0.31)	-0.00 (0.24)	-0.00 (0.25)	-0.08 (0.40)	-0.33 (0.63)
(ln) Income per capita	-0.04 (0.07)	-0.07 (0.07)	-0.06 (0.06)	-0.09* (0.05)	-0.01 (0.11)	-0.10 (0.11)
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes		Yes		Yes	
Sub-National District FE		Yes		Yes		Yes
Observations	17159	8103	12988	6044	4165	2057
Number of Countries	136	132	135	130	100	94
First Stage <i>F</i> -Stat	6.35	8.08	6.97	8.88	10.73	15.38

Note: 2SLS estimates. The unit of observation is an immigrant. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation in the immigrant's parents' country of birth. All regressions control for individual characteristics (age, gender, marriage status, education, city type), geographic & ethnic controls, as well as survey wave indicator variables and country of residence fixed effects. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses, clustered at the country of origin. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B23: COUNTRY OF RESIDENCE CHARACTERISTICS AFFECTING THE CULTURAL TRANSMISSION OF COLLECTIVISM IN A SAMPLE OF EUROPEAN IMMIGRANTS

	Collectivism						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Irrigation Suitability × Polity IV	0.05 (0.10)						
Irrigation Suitability × (ln) Income per capita		-0.41 (0.34)					
Irrigation Suitability × Ethnic Fractionalization			2.23*** (0.78)				
Irrigation Suitability × Collectivism				0.01 (0.01)			
Irrigation Suitability × Public Expenditure (2000-2010)					-0.06* (0.03)		
Irrigation Suitability × Old Age Expenditure (2000-2010)						-0.18*** (0.05)	
Irrigation Suitability × Share Migrants Same Country							0.13 (0.28)
Share Migrants Same Country							-0.04 (0.05)
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country of Origin FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Host Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4474	4474	4474	4466	4086	4086	3155
R-squared	0.12	0.12	0.13	0.13	0.13	0.13	0.14
Number of Origin Countries	115	115	115	115	111	111	112

Note: The unit of observation is a 2nd generation immigrant. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation in the immigrant's parents' country of birth. All regressions control for individual characteristics (age, gender, marriage status, education, city type), geographic & ethnic controls, as well as survey wave indicator variables, country of origin and country of residence fixed effects. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses, clustered at the country of origin. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B.6 Further Results on the Effect of Ancestral Irrigation on Innovation across Nations

**Table B24: IRRIGATION AGRICULTURE AND INNOVATION ACROSS NATIONS:
2SLS WITH COUNTRY CONTROLS**

	Scientific Articles (per capita)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ancestral Irrigation	-0.374*** (0.114)	-0.263*** (0.092)	-0.324*** (0.106)	-0.443*** (0.128)	-0.280** (0.113)	-0.261** (0.115)	-0.371*** (0.111)	-0.280*** (0.105)
Neolithic Revolution		-0.022** (0.011)						
Traditional Democracy			0.050 (0.042)					
State Antiquity				0.201** (0.098)				
Polity IV 1980 - 2014					0.008** (0.003)			
Christianity						0.029 (0.090)		
Hindu						-0.083 (0.115)		
Islam						-0.047 (0.087)		
Judaism						24.175** (9.951)		
(ln) Income per capita							0.063*** (0.018)	
Agriculture (% of GDP)								-0.062* (0.036)
Industry (% of GDP)								-0.062* (0.035)
Services (% of GDP)								-0.059* (0.035)
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	132	128	129	121	125	131	129	126
R-squared	0.51	0.57	0.52	0.53	0.57	0.58	0.54	0.55
First Stage F-Stat	18.03	25.14	17.80	20.66	17.50	11.38	17.48	20.46

Note: 2SLS regressions. The unit of observation is the country. The dependent variable are the number of scientific articles per capita. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls, as well as malaria suitability, are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B25: THE EFFECT OF ANCESTRAL VS LOCAL IRRIGATION ON CURRENT TECHNOLOGICAL PROGRESS

	Current Technology			Scientific Articles		
	(1)	(2)	(3)	(4)	(5)	(6)
Irrigation Suitability	-0.236** (0.097)	-0.309*** (0.089)		-0.262** (0.117)	-0.249*** (0.073)	
Irrigation Suitability (Local)	0.054 (0.095)		-0.015 (0.102)	0.094 (0.114)		-0.001 (0.083)
Geographic Controls	No	Yes	Yes	No	Yes	Yes
Ethnographic Controls	No	Yes	Yes	No	Yes	Yes
Region FE	No	Yes	Yes	No	Yes	Yes
Observations	141	132	130	123	119	119
R-squared	0.07	0.57	0.49	0.07	0.73	0.63

Note: OLS regressions. The unit of observation is the country. The dependent variable in columns (1) - (3) is the index of technological progress taken from [Comin et al. \(2010\)](#), and the number of scientific articles per capita in columns (4) - (6). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Geographic and ethnographic controls are adjusted for ancestry. Region fixed effects include dummies for Europe, Africa, North America, Latin America and Caribbean, East Asia and Pacific, Central and West Asia, and South Asia. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B26: REVERSAL OF TECHNOLOGICAL PROGRESS IN A CROSS-SECTION OF NATIONS

	Current Technology		
	(1)	(2)	(3)
Panel A: Ancestral Irrigation			
Ancestral Irrigation	0.235* (0.136)	0.423* (0.252)	0.071 (0.174)
Technology 1000 BD	0.413*** (0.084)		
Technology 1000 BD × Ancestral Irrigation	-0.736*** (0.214)		
Technology 0 AD		0.560*** (0.115)	
Technology 0 AD × Ancestral Irrigation		-0.661** (0.281)	
Technology 1500 AD			0.579*** (0.054)
Technology 1500 AD × Ancestral Irrigation			-0.411 (0.276)
Observations	100	121	109
R-squared	0.25	0.22	0.53
	Current Technology		
	(1)	(2)	(3)
Panel B: Ancestral vs Local Suitability			
Technology 1500 AD	0.623*** (0.066)	0.681*** (0.134)	0.614*** (0.065)
Technology 1500 AD × Irrigation Suitability	-0.851*** (0.246)	-0.814*** (0.222)	-1.059*** (0.345)
Irrigation Suitability	0.310* (0.160)	0.202 (0.142)	0.318 (0.205)
Technology 1500 AD × Agricultural Suitability		-0.015 (0.236)	
Agricultural Suitability		-0.212 (0.137)	
Technology 1500 AD × Irrigation Suitability (Local)			0.268 (0.255)
Irrigation Suitability (Local)			-0.026 (0.135)
Observations	109	109	109
R-squared	0.52	0.56	0.53

Note: OLS regressions. The unit of observation is the country. The dependent variable is the index of technological progress in 2000 taken from [Comin et al. \(2010\)](#). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B27: FLEXIBLE ESTIMATES: REVERSAL OF TECHNOLOGICAL PROGRESS

	Technology (Ancestry Adjusted)		
	OLS	OLS	IV
	(1)	(2)	(3)
Irrigation Suitability (Ancestral) \times 0 AD	-0.084 (0.152)		
Irrigation Suitability (Ancestral) \times 1500 AD	-0.232** (0.114)		
Irrigation Suitability (Ancestral) \times 2000 AD	-0.530*** (0.148)		
Ancestral Irrigation \times 0 AD		-0.103 (0.083)	-0.081 (0.127)
Ancestral Irrigation \times 1500 AD		-0.100 (0.078)	-0.192* (0.100)
Ancestral Irrigation \times 2000 AD		-0.350*** (0.093)	-0.481*** (0.137)
Controls \times Year FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Observations	453	453	451
R-squared	0.72	0.72	0.71
First Stage <i>F</i> -Stat			13.90

Note: The unit of observation is the country-period. The dependent variable is the index of technological progress between 1000BC and 2000 taken from [Comin *et al.* \(2010\)](#). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Controls include geographic and ethnographic controls interacted with period dummies. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors clustered at the country level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B28: REVERSAL OF TECHNOLOGICAL PROGRESS IN A PANEL OF NATIONS
(TECHNOLOGY UNADJUSTED FOR MIGRATION)

	Technology (Unadjusted)				
	OLS	OLS	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)
Irrigation Suitability (Local) \times Post 1500	-0.23 (0.17)		0.27 (0.19)		
Irrigation Suitability (Ancestral) \times Post 1500		-0.64*** (0.10)	-0.80*** (0.17)		
Ancestral Irrigation \times Post 1500				-0.41*** (0.06)	-0.59*** (0.10)
Controls \times Post 1500	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Observations	449	449	449	449	448
R-squared	0.44	0.49	0.50	0.50	0.49
First Stage <i>F</i> -Stat					63.08

Note: OLS regressions. The unit of observation is the country-period. The dependent variable is the index of technological progress between 1000BC and 2000 taken from [Comin *et al.* \(2010\)](#). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Controls include geographic and ethnographic controls interacted with the Post 1500 dummy. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors clustered at the country level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B29: FLEXIBLE ESTIMATES: REVERSAL OF TECHNOLOGICAL PROGRESS IN A PANEL OF NATIONS
(TECHNOLOGY UNADJUSTED FOR MIGRATION)

	Technology (Unadjusted)		
	OLS	OLS	IV
	(1)	(2)	(3)
Irrigation Suitability (Ancestral) \times 0 AD	0.024 (0.149)		
Irrigation Suitability (Ancestral) \times 1500 AD	-0.090 (0.121)		
Irrigation Suitability (Ancestral) \times 2000 AD	-0.607*** (0.159)		
Ancestral Irrigation \times 0 AD		-0.041 (0.086)	0.007 (0.126)
Ancestral Irrigation \times 1500 AD		-0.003 (0.084)	-0.055 (0.105)
Ancestral Irrigation \times 2000 AD		-0.413*** (0.102)	-0.559*** (0.148)
Controls \times Year FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Observations	449	449	448
R-squared	0.59	0.61	0.59
First Stage <i>F</i> -Stat			13.29

Note: The unit of observation is the country-period. The dependent variable is the index of technological progress between 1000BC and 2000 taken from [Comin et al. \(2010\)](#). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Controls include geographic and ethnographic controls interacted with period dummies. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors clustered at the country level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B30: REVERSAL OF TECHNOLOGICAL PROGRESS WITHOUT MILITARY TECHNOLOGY

	(Ancestry adjusted)				
	OLS	OLS	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)
Irrigation Suitability (Local) \times Post 1500	-0.34*** (0.10)		0.07 (0.11)		
Irrigation Suitability (Ancestral) \times Post 1500		-0.58*** (0.08)	-0.63*** (0.10)		
Ancestral Irrigation \times Post 1500				-0.36*** (0.05)	-0.55*** (0.09)
Controls \times Post 1500	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Observations	433	433	433	433	430
R-squared	0.49	0.53	0.53	0.53	0.52
First Stage <i>F</i> -Stat					50.41

Note: The unit of observation is the country-period. The dependent variable is the index of technological progress excluding military technology between 1000BC and 2000 taken from [Comin *et al.* \(2010\)](#). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Controls include geographic and ethnographic controls interacted with the post 1500 dummy. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors clustered at the country level in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B31: FLEXIBLE ESTIMATES WITHOUT MILITARY TECHNOLOGY

	Technology (Ancestry adjusted)		
	OLS	OLS	IV
	(1)	(2)	(3)
Irrigation Suitability (Ancestral) \times 0 AD	-0.036 (0.164)		
Irrigation Suitability (Ancestral) \times 1500 AD	-0.238** (0.120)		
Irrigation Suitability (Ancestral) \times 2000 AD	-0.655*** (0.141)		
Ancestral Irrigation \times 0 AD		-0.075 (0.085)	-0.046 (0.136)
Ancestral Irrigation \times 1500 AD		-0.080 (0.079)	-0.210** (0.106)
Ancestral Irrigation \times 2000 AD		-0.411*** (0.086)	-0.615*** (0.130)
Controls \times Year FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Observations	433	433	430
R-squared	0.65	0.66	0.63
First Stage <i>F</i> -Stat			13.76

Note: The unit of observation is the country-period. The dependent variable is the index of technological progress excluding military technology between 1000BC and 2000 taken from [Comin *et al.* \(2010\)](#). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Controls include geographic and ethnographic controls interacted with the period dummies. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors clustered at the country level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B32: REVERSAL OF TECHNOLOGICAL PROGRESS: SHORT PANEL 1500 - 2000

	Technology (Ancestry Adjusted)				
	OLS	OLS	OLS	OLS	IV
	(1)	(2)	(3)	(4)	(5)
Irrigation Suitability (Local) \times Post 1500	-0.18 (0.11)		0.08 (0.12)		
Irrigation Suitability (Ancestral) \times Post 1500		-0.36*** (0.09)	-0.42*** (0.10)		
Ancestral Irrigation \times Post 1500				-0.31*** (0.05)	-0.38*** (0.08)
Controls \times Post 1500	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Observations	229	229	229	229	216
R-squared	0.59	0.63	0.64	0.69	0.68
First Stage <i>F</i> -Stat					38.45

Note: The unit of observation is the country-period. The dependent variable is the index of technological progress excluding military technology between 1500 and 2000 taken from [Comin *et al.* \(2010\)](#). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. Controls include geographic and ethnographic controls interacted with the post 1500 dummy. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors clustered at the country level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

B.7 Further Results on the Effect of Irrigation on Innovation across Migrants

**Table B33: THE LONG-TERM EFFECT OF IRRIGATION ON INNOVATION ACROSS US MIGRANTS:
CONDITIONAL ON HOME COUNTRY CONTROLS**

	Patent Granted	Any Publication	No. of Publications	Conference Attendance	Important in Job: Independence
	(1)	(2)	(3)	(4)	(5)
Ancestral Irrigation	-0.01** (0.01)	-0.09*** (0.02)	-1.68*** (0.49)	-0.07*** (0.01)	-0.04* (0.02)
Polity IV 1980 - 2014	-0.00 (0.00)	-0.00** (0.00)	-0.00 (0.03)	0.00 (0.00)	0.01*** (0.00)
Ethnic Fractionalization	-0.01 (0.01)	-0.11*** (0.04)	-3.34*** (0.89)	-0.00 (0.03)	0.08** (0.04)
(ln) Income per capita	0.00 (0.00)	0.04*** (0.01)	0.81*** (0.25)	0.01 (0.01)	-0.01 (0.01)
Individual Characteristics	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes
U.S. Region FE	Yes	Yes	Yes	Yes	Yes
Observations	16045	16045	16045	32775	51725
R-squared	0.05	0.16	0.08	0.13	0.06
Number of Countries	115	115	115	122	122

Note: OLS regressions. The unit of observation is an US immigrant. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. All regressions control for individual characteristics (age, gender, marriage status, age at arrival in the US, dummies for bachelor, professional and postgraduate degrees, indicators for the level of education that was completed in the US, log salary and its square, and survey wave fixed effects), geographic and ethnographic controls, as well as US macro-region fixed effects. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses, clustered at the country of origin.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

**Table B34: THE LONG-TERM EFFECT OF IRRIGATION ON INNOVATION ACROSS US MIGRANTS:
ROBUSTNESS TO FURTHER INDIVIDUAL CHARACTERISTICS**

	No. of Publications							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ancestral Irrigation	-1.23** (0.53)	-1.33** (0.54)	-1.01** (0.50)	-0.80* (0.43)	-2.71* (1.39)	-1.06** (0.47)	-1.11** (0.54)	-1.35** (0.53)
Immigration Reason FE		Yes						
Field of Study FE			Yes					
Doctoral Degree				Yes				
Only PhD Graduates					Yes			
Region of Degree FE						Yes		
U.S. Citizen							Yes	
Race FE								Yes
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
U.S. Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16127	16127	16127	16127	3002	16127	16127	16127
R-squared	0.07	0.10	0.11	0.18	0.06	0.08	0.07	0.08
Number of Countries	121	121	121	121	110	121	121	121

Note: OLS regressions. The unit of observation is an US immigrant. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. All regressions control for individual characteristics (age, gender, marriage status, age at arrival in the US, dummies for bachelor, professional and postgraduate degrees, indicators for the level of education that was completed in the US, log salary and its square, and survey wave fixed effects), geographic and ethnographic controls, as well as US macro-region fixed effects. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses, clustered at the country of origin. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

**Table B35: THE LONG-TERM EFFECT OF IRRIGATION ON INNOVATION ACROSS US MIGRANTS:
IMPORTANT JOB CHARACTERISTICS**

	Important in Job:						
	Independence	Contribution	Security	Payment	Location	Benefits	Advancement
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ancestral Irrigation	-0.08** (0.03)	-0.03 (0.03)	0.05 (0.03)	0.01 (0.02)	-0.00 (0.02)	-0.03 (0.03)	0.01 (0.04)
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
U.S. Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	52029	52029	52029	52029	52029	35902	52029
R-squared	0.05	0.06	0.07	0.05	0.05	0.05	0.11
Number of Countries	128	128	128	128	128	122	128

Note: OLS regressions. The unit of observation is an US immigrant. Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. All regressions control for individual characteristics (age, gender, marriage status, age at arrival in the US, dummies for bachelor, professional and postgraduate degrees, indicators for the level of education that was completed in the US, log salary and its square, and survey wave fixed effects), geographic and ethnographic controls, as well as US macro-region fixed effects. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses, clustered at the country of origin. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

**Table B36: TRADITIONAL IRRIGATION, OCCUPATIONAL CHOICE AND TASKS:
CONTROLLING FOR HOME COUNTRY GDP**

	Unweighted			Weights: Same N		
	Routine	Conventional	Non-Routine (Innovative)	Routine	Conventional	Non-Routine (Innovative)
	(1)	(2)	(3)	(4)	(5)	(6)
Ancestral Irrigation	0.03* (0.01)	0.15** (0.06)	-0.03*** (0.01)	0.08** (0.03)	0.32** (0.13)	-0.09*** (0.03)
(ln) Income per capita	-0.01** (0.00)	-0.03 (0.02)	0.01** (0.00)	0.02 (0.01)	-0.04 (0.07)	0.01 (0.01)
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
U.S. State FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14768	14768	14768	14768	14768	14768
R-squared	0.06	0.08	0.11	0.10	0.15	0.16
Number of Countries	98	98	98	98	98	98

Note: The unit of observation is a US immigrant that graduated from College. Data comes from the Current Population Census March Supplement (1994-2016). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. All regressions control for individual characteristics (age, gender, dummies for bachelor, professional and postgraduate degrees, log family income and its square, and survey wave fixed effects), geographic and ethnographic controls, as well as US State fixed effects. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses clustered at the country of origin. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

**Table B37: TRADITIONAL IRRIGATION, OCCUPATIONAL CHOICE AND TASKS:
1ST AND 2ND GENERATION MIGRANTS**

	Unweighted			Weights: Same N		
	Routine	Conventional	Non-Routine (Innovative)	Routine	Conventional	Non-Routine (Innovative)
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Reduced Form						
Irrigation Suitability	0.07** (0.03)	0.27** (0.11)	0.01 (0.04)	0.20*** (0.08)	0.51*** (0.15)	-0.15*** (0.05)
Panel B: OLS						
Ancestral Irrigation	0.03** (0.01)	0.13*** (0.05)	-0.03* (0.02)	0.06*** (0.02)	0.16** (0.06)	-0.05** (0.02)
Panel C: 2SLS						
Ancestral Irrigation	0.08 (0.05)	0.31 (0.19)	0.01 (0.04)	0.19** (0.08)	0.48*** (0.17)	-0.14** (0.06)
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
U.S. State FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	82737	82737	82737	82737	82737	82737
R-squared	0.05	0.07	0.11	0.06	0.08	0.17
Number of Countries	116	116	116	116	116	116
First Stage F-Stat	5.51	5.51	5.51	43.51	43.51	43.51

Note: OLS regressions. The unit of observation is a US immigrant with at least College education. Data comes from the Current Population Census March Supplement (1994-2016). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. All regressions control for individual characteristics (age, gender, dummies for bachelor, professional and postgraduate degrees, log family income and its square, and survey wave fixed effects), geographic and ethnographic controls, as well as US State fixed effects. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses clustered at the country of origin. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table B38: TRADITIONAL IRRIGATION, OCCUPATIONAL CHOICE AND TASKS:
ALL EDUCATION LEVELS

	Unweighted			Weights: Same N		
	Routine	Conventional	Non-Routine (Innovative)	Routine	Conventional	Non-Routine (Innovative)
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Reduced Form						
Irrigation Suitability	0.05 (0.03)	0.09 (0.07)	0.01 (0.04)	0.21*** (0.06)	0.64*** (0.22)	-0.13** (0.06)
Panel B: OLS						
Ancestral Irrigation	0.00 (0.01)	0.06* (0.03)	-0.00 (0.01)	0.06** (0.03)	0.17* (0.10)	-0.05** (0.02)
Panel C: 2SLS						
Ancestral Irrigation	0.09 (0.10)	0.16 (0.17)	0.02 (0.07)	0.18*** (0.06)	0.54*** (0.20)	-0.11** (0.05)
Individual Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Geographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
Ethnographic Controls	Yes	Yes	Yes	Yes	Yes	Yes
U.S. State FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	52712	52712	52712	52712	52712	52712
R-squared	0.07	0.10	0.24	0.11	0.14	0.28
Number of Countries	105	105	105	105	105	105
First Stage F-Stat	2.78	2.78	2.78	37.90	37.90	37.90

Note: The unit of observation is a US immigrant. Data comes from the Current Population Census March Supplement (1994-2016). Ancestral Irrigation measures the percentage share of a country's population whose ancestors have used irrigation. All regressions control for individual characteristics (age, gender, educational fixed effect, log family income and its square, and survey wave fixed effects), geographic and ethnographic controls, as well as US State fixed effects. See main text and the appendix for more details on the construction of the variables. Heteroscedastic-robust standard errors in parentheses clustered at the country of origin. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.