Natural Land Productivity, Cooperation and Comparative Development*

Anastasia Litina†

August 15, 2014

Abstract

This research advances the hypothesis that natural land productivity in the past, and its effect on the desirable level of cooperation in the agricultural sector, had a persistent effect on the evolution of social capital, the process of industrialization and comparative economic development across the globe. Exploiting exogenous sources of variations in land productivity across a) countries; b) individuals within a country, and c) migrants of different ancestry within a country, the research establishes that lower level of land productivity in the past is associated with more intense cooperation and higher levels of contemporary social capital and development.

Keywords: Land productivity, Cooperation, Social Capital, Trust, Growth, Development, Agriculture, Industrialization

JEL Classification Numbers: O11, O13, O14, O31, O33, O41, O50

*I would like to thank participants at the NBER Summer Institute, the CAGE/CEPR Long Run Growth Conference at Warwick, the "Long-Run Factors in Comparative Development and International Interactions" conference at Brown, the AMSE workshop, 8th BETA-Workshop, the "Intergenerational Transmission of Entrepreneurship Occupations and Cultural Traits in the Process of Long-run Economic Growth" conference at Naples, the CRETE conference, the RES conference, and seminar participants at Brown, Copenhagen, CREA, Gothenburg, Groningen, IRES, Luxembourg, Namur, and Porto, for their helpful comments and suggestions.

†University of Luxembourg, Faculty of Law, Economics and Finance, 148, Avenue de la Faiencerie, L - 1511 Luxembourg (e-mail: anastasia.litina@uni.lu)

1 Introduction

The origins of the remarkable transformation of the world income distribution in the past two centuries have been the focus of an intense debate in recent years. The long shadow of history on comparative economic development has been established empirically, underlying the role of variations in historical and pre-historical bio-geographical conditions, as well as the persistent effects of cultural, institutional, and human capital characteristics, in the vast inequality across the globe.

This research advances the hypothesis that natural land productivity in the past, and its effect on the desirable level of cooperation in the agricultural sector, had a persistent effect on the evolution of social capital, the process of industrialization and comparative economic development across the globe. Places with favorable natural land productivity had a reduced incentive to cooperate in the development of agricultural infrastructure. While their favorable land endowment permitted their domination during the agricultural era, their lower incentive for cooperation resulted in a lower level of social capital which was crucial for the development of the industrial sector. Consequently, lacking some of the necessary elements for the emergence of industrialization, they were overtaken in the transition to the industrialization era.

The fundamental hypothesis of this research originates from the realization that the evolution of the wealth of nations has been driven in part by the trade-off between land productivity and the associated level of cooperation and social capital, in different stages of development. The theory is based on an underlying mechanism consisting of five intermediate elements that account for the differential development of economies and their asymmetric transition from an epoch of Malthusian stagnation to a regime of sustained economic growth.[1] Each of the steps of the mechanism builds upon *a comparison* between high and low natural productivity places, while assuming *everything else being constant*. This allows to identify *the partial effect of natural land productivity* in the process of development. Crucially, the paper *does not* claim a *reversal of fortune* along the lines of Acemoglu et al. (2002) on colonized countries or Olsson and Paik (2014) on the *Western reversal*. The current analysis aims at identifying *a reversal on the effect of land suitability* on economic outcomes, where land suitability is one of the many forces that affected the fate of countries, *without* arguing that it is the *dominating* force.

The first element of the mechanism suggests that whereas agricultural infrastructure can be beneficial to both productive and less productive places, yet less productive places had *relatively* more incentives to develop agricultural infrastructure, that could mitigate the adverse effect of the natural environment. Resources allocated to the development of agricultural infrastructure enhanced productivity indirectly, but came on the account of direct agricultural production. Hence, the opportunity cost of the construction of agricultural infrastructure was higher in more productive places and therefore investment in infrastructure was more beneficial in places with unfavorable land endowment.

The second element establishes that the development of public agricultural infrastructure generated an incentive for cooperation. Since agricultural infrastructure is primarily a public good, collective action is essential for its optimal provision, in light of the incentive of individuals to minimize the allocation of their private resources to the production of public goods. Moreover, since collective action is conducive to cooperation, places with lower natural land productivity generated higher incentives for

[1] Appendix A provides a number of sources on which the suggested mechanism builds upon.

cooperation. Traditional forms of agricultural infrastructure include, among others, irrigation systems, storage facilities and drainage systems. Importantly, all major forms of agricultural infrastructure were associated with large-scale cooperation at the community or at the state level, and particularly in early societies, collective action and broad participation was required to undertake and construct the necessary infrastructure.[2]

The third element of the mechanism advances the hypothesis that the emergence of social capital can be traced to the level of cooperation in the agricultural sector, in the creation of infrastructure that could mitigate the adverse effect of the natural environment. Indeed, according to the *social structural approach*, differences in the manifestation of social capital are driven by the social interactions in which individuals are involved (Bowles and Gintis, 2002). Similarly, the emergence and prevalence of norms that facilitate fruitful interaction (such as norms of mutual trust) can be traced to the need for large-scale cooperation (Henrich et al., 2001). Relatedly, Putnam (2000) suggests that social capital is primarily embedded in networks of reciprocal social relations.

The fourth element of the mechanism suggests that social capital has persisted over time via different transmission mechanisms. Evolutionary theories, advance the *social learning* hypothesis, according to which norms and cultural traits that survive and are transmitted across generations are the ones that contribute to individual and group survival (Boyd and Richerson, 1985, 1995; Cavalli-Sforza and Feldman, 1981). The cultural transmission hypothesis suggests that preferences, beliefs and norms are intergenerationally transmitted via socialization processes, such as social imitation and learning (Bisin and Verdier, 2001). Finally, political institutions are argued to have a crucial role in the transmission of social capital across generations (Tabellini, 2008; Guiso et al., 2008).

The fifth element of the mechanism suggests that social capital is complementary not only to the agricultural but also to the industrial sector. This assumption is designed to capture the importance of social capital in promoting socioeconomic transitions to an industrialized regime. Evidence suggests, that economic activities such as commercial transactions, entrepreneurship, innovation, accumulation of human capital, credit markets and enforcement of contracts, all of which are building blocks of the industrial sector, are further enhanced and boosted in societies with high levels of social capital and trust.[3]

The proposed mechanism is aimed to identify the intermediate elements that can account for the emergence of social capital, the effect of natural land endowment on the evolution of economies, and their transition from agriculture to industry. What can be viewed initially as a drawback in economic development, namely the adverse effect of unfavorable land endowment on agricultural production, triggers a process that can ultimately lead to better current economic outcomes and higher levels of social capital.

To model this mechanism a Malthusian model is employed that allows to model the transition. Social capital is represented as an argument in the utility function of the individuals following (Becker, 1996).[4] At early stages of development, the economy is in a Malthusian regime where output is generated entirely by an agricultural sector that is subject to decreasing returns to labor. Aggregate

[2]See Appendix A for historical evidence.

[3]See Appendix A for additional evidence.

[4]One could model the development of social networks instead, yet this approach allows to capture in a simple model both the transition from the Malthusian era to industrialization and the evolution of social capital and to provide a clear testable hypothesis.

productivity in the agricultural sector, is partly determined by the natural land productivity, and can be further enhanced by agricultural infrastructure. A fraction of the labor employed in the agricultural sector is allocated to the production of the private good, whereas the remaining fraction is allocated to the production of agricultural infrastructure. Technological progress in the agricultural sector is a gradual process fuelled by knowledge creation, which is positively affected by the size of the workforce in the agricultural sector. Resources generated by technological progress are channeled primarily towards an increase in population size, and the economy evolves towards a Malthusian equilibrium where income per capita remains stagnant along a dynamic path characterized by growing population and total factor productivity.

The transition from agriculture to industry in the process of development, is driven by sustained growth in the latent productivity of the industrial sector. The indirect effect of cooperation on the industrial sector, through the accumulation of social capital, drives growth in the latent industrial productivity, which ultimately leads to the transition to industry in later stages of development. Once the industrial technology is adopted, the economy emerges into a Post-Malthusian regime of development, where the economy operates in both the agricultural and the industrial sector. The endogenous growth of total factor productivity in the industrial sector, along with intersectoral labor mobility, generates a dynamic path characterized by endogenously growing population and income per capita.

The interaction between natural land productivity, cooperation, social capital and the process of development is examined based on the significance of their coevolution in the agricultural stage of development and also in the timing of the take-off from agriculture to industry. In the agricultural stage, an economy characterized by a relatively higher degree of cooperation in the development of agricultural infrastructure, aimed to mitigate the adverse effect of low land productivity, is associated with a *relatively* inferior Malthusian steady state in terms of the economy's level of productivity per worker and the size of its working population. This inferiority, stems from the fact that the adverse effect of unfavorable land endowment is significant in the context of an economy that operates only in the agricultural sector, and therefore natural land endowments are crucial for agricultural output.

The resulting level of cooperation in the agricultural sector, as triggered by natural land productivity, has also an effect on the timing of industrialization and, thus, on the take-off to a state of sustained economic growth. The earlier take-off from the Malthusian steady state by a society with an unfavorable natural land endowment, stems from the fact that the beneficial effect of cooperation in the agricultural sector, as perceived by the effect of the emerging social capital on the advancement of knowledge, and therefore on the advancement of industrial productivity relative to that in agriculture, outweighs the adverse effect of unfavorable land endowment on agricultural production.[5]

The empirical section of this paper aims to establish the phenomenon of overtaking partly via the mechanism described above, as well as to establish that land suitability in the past is associated with more intense cooperation and higher levels of contemporary social capital. The analysis takes place in three layers exploiting exogenous sources of variations in land productivity across: a) countries; b) individuals within a country, and c) migrants of different ancestry within a country. The *cross-*

[5] In the context of the theoretical model it is crucial to assume that social capital is *relatively* more complementary to the industrial sector, in order to obtain a simple and intuitive testable hypothesis. Yet, in the context of the empirical analysis this assumption is not essential.

country analysis (a) allows to establish the overtaking and to further explore the suggested mechanisms associated with it. The *individual (b)* and the *migrant (c)* analysis allow to establish the reduced form effect of land suitability on the current levels of trust while capturing an increasing number of unobservables.

Analytically, exploiting exogenous sources of variations in land suitability for agriculture across countries, the first part of the empirical analysis *(a)* establishes the following testable predictions of the theory: (i) the effect of natural land productivity on the economic prosperity was reversed in the process of development. While a favorable land endowment had a positive effect on development in the Malthusian era, its adverse effect on the production of agricultural infrastructure and thus cooperation, had a detrimental effect on economic prosperity in the modern era, (ii) cooperation, as reflected by agricultural infrastructure, emerged primarily in places where land was not highly productive and collective action could diminish the adverse effects of the environment and enhance agricultural output, and (iii) lower level of land suitability in the past is associated with higher levels of contemporary social capital which expedited the process of industrialization.

Consistent with the predictions of the theory, the empirical analysis first establishes the change *on the effect of land productivity* in the process of economic development.[6] Following Ashraf and Galor (2011), the research employs historical data on population density, as a proxy for productivity in the agricultural stage of development, as opposed to income per capita and examines the hypothesized effect of land suitability on population densities in the years 1 CE, 1000 CE and 1500 CE. Land suitability is proxied by an index of the average suitability of land for cultivation, based on geospatial data on various ecological factors including (i) growing degree days, (ii) the ratio of potential to actual evapotranspiration, (iii) soil carbon density, and (iv) soil pH.[7] The historical analysis reveals a positive and significant relationship between log land suitability and log population density in the year 1500 CE.

To establish the change on the effect of natural land productivity, the analysis exploits cross country variations in land suitability, to explain the cross-country variations in log average income per capita in the years 1990-2000 CE. A number of potentially confounding factors and alternative hypothesis suggested by the related literature on comparative development are accounted for such as the geography channel, institutions, disease environment, ethnic fractionalization and religion shares.

Importantly, as suggested by the theory, it is not the direct effect of land suitability that drives the change in its effect, but instead the portable component associated with land suitability, namely the social capital that emerged as the outcome of cooperation. In the absence of migration, the country's level of social capital is captured by its natural land endowment. However, in the post-colonial era, where mass migration has taken place, the level of social capital in each country reflects the weighted

[6] The suggested changing effect captures the partial effect of natural land productivity without necessarily implying that this is the dominating effect. In particular, as established in Ashraf and Galor (2011), consistently with the predictions of a long-run Malthusian equilibrium, productivity in the preindustrial era, as captured by overall land quality and the timing of the Neolithic Revolution, had a significant positive effect on population density and a negligible impact on income per capita. For the contemporary era, the relevant variable that captures aggregate productivity is income per capita. Thus, establishing that countries that had high population density in the preindustrial era also have low per-capita incomes in the contemporary era, is tantamount to establishing a reversal in terms of aggregate productivity.

[7] The index is based on geospatial soil pH and temperature data, as reported by Ramankutty et al. (2002) and aggregated to the country level by Michalopoulos (2012). The average of land quality is thus the average value of the index across the grid cells within a country.

average of land suitability among its ancestral population. Hence, in order to capture this distinction, two empirical strategies are adopted that address potential concerns on migration.[8]

Second, the empirical analysis establishes that higher suitability of land for agriculture is associated with a lower level of cooperation in the agricultural sector, as reflected by the potential for irrigation and the actual fraction of irrigated land. The measure of irrigation potential captures the potential productivity boost due to irrigation. Hence, it can be viewed as an ex ante measure of the potential for cooperation. The actual fraction of irrigated land can be perceived as an ex-post measure of actual cooperation. In the absence of extensive cross-country data on actual irrigation prior to industrialization, the analysis is based on the fraction of irrigated land in a sample of non-industrial countries in the year 1900. Consistently with the predictions of the theory, the empirical analysis reveals a statistically significant and robust negative effect of the log land suitability on the potential for irrigation and on the fraction of irrigated land in the year 1900.

The adverse effect of natural land productivity on cooperation in earlier periods is further examined based on several proxies of cooperation: a) communication in the year 1 CE, b) transportation in the year 1 CE, and c) medium of exchange in the year 1 CE. According to the theory, sophisticated means of communication, transportation and medium of exchange have been catalysts in the advancement of large-scale cooperation, and thus, under-development of these technologies reflects the adverse effect of land suitability on the extent of cooperation. Whereas these three measures could be viewed as proxies for the stage of development, the analysis suggests that this is not the case. There appears indeed to be an element in this technologies associated with the stage of development, as suggested by Comin et al. (2010) nevertheless their correlation with *population density* whereas positive, is not sufficiently high to be considered solely as proxies of development in the Malthusian era.

Third, having established the intermediate elements of the mechanism linking land suitability of agriculture with the current levels of trust, the analysis establishes the adverse effect of natural land productivity on social capital as reflected by the contemporary level of generalized trust. Similarly to first hypothesis, the measure of land suitability is ancestry adjusted to capture the portable component of natural land endowment, namely social capital. In particular, the corresponding standardized beta coefficient indicates that a one standard deviation increase in the ancestry adjusted land suitability index, is associated with a 0.608 standard deviation decrease in the level of trust, controlling for the full set of relevant (for the era) controls. The cross country analysis further explores the mediating channel of cooperation as proxied by irrigation potential. Reassuringly, the coefficient of land suitability diminishes both in magnitude and significance, thereby suggesting that land suitability partly operates via the scope for cooperation it generates.

The second part of the empirical analysis reexamines the hypothesis using a sample of individual data from the four waves of the WVS (1981-2002). The analysis explores the effect of ancestry adjusted natural land productivity on the current levels of individual trust, accounting for geographical and institutional characteristics. Importantly, in contrast to the cross country analysis, this disaggregated individual data allows to account for individual controls, such as education, religious denomination, age and gender. In line with the results of the cross country analysis, a 10 percentage point increase

[8] The strategies are fully analyzed in the empirical section of the paper.

in land suitability, is associated with a 2 percentage points decrease in probability that an individual is trustful.[9]

The third part of the empirical analysis examines the hypothesis using the European Social Survey (ESS) sample, and in particular the sample of first and second generation migrants residing in ESS countries. The analysis employs a sample of 5940 migrants from 116 countries of origin, residing in 26 European countries. This approach allows to explicitly identify the portable cultural component associated with their country of origin.[10] Using this sample, the analysis establishes that land suitability in the country of origin has a significant adverse effect on the migrants level of trust. The analysis is further enhanced by employing a vector of geographical and institutional controls at the country of origin as well as a set of individual controls, such as age, religion group, gender and education. Throughout the analysis, regional fixed effects (NUTS 2 European Regions) are employed, thereby eliminating most of the unobserved heterogeneity. In line with the hypothesis advanced in the paper, this section establishes that a ten percentage point increase in land suitability at the country of origin, is associated with a 4 percentage points decrease in the probability that a migrant is trustful.[11]

The analysis is concluded by extensive robustness checks. In particular, the cross-country robustness section explores the effect of slavery, trade and eliminates the possibility that the results are drive by regions with very low natural productivity. It also establishes the validity of the identifying assumption of the paper, i.e. that the measures of current productivity are a good proxy for past productivity. The ESS results are further validated via accounting for the potential selection of migrants by limiting the sample to second generation migrants only and by controlling for parental and partner characteristics.

The remainder of the paper is organized as follows: Section 2 reviews the related literature. Section 3 presents a model that derives the testable hypotheses. Section 4 presents empirical findings consistent with the proposed hypotheses. Finally, section 5 concludes.

2 Advances with Respect to the Related Literature

This research contributes to the literature that explores the origins of comparative development and the emergence of social capital.

First, the research sheds new light on the origins of the contemporary differences in income per capita across the globe. Various theories of comparative development have been advanced in the literature. The role of geography, institutions, colonialism, culture, human capital, ethnolinguistic fractionalization and genetic diversity has been at the center of research attempting to account for differential development patterns across the globe.

The geographical hypothesis suggests that environmental conditions affected economic performance directly, through their effect on health, work effort, productivity and multiple other channels (Hunting-

[9] The numbers are drawn from the marginal effect estimated from the logit regression of the model, reported in the Appendix C (table C.3).

[10] See Fernandez and Fogli (2009); Algan and Cahuc (2010); Luttmerand Singhal (2011).

[11] The numbers are drawn from the marginal effect estimated from the logit regression of the model, reported in the Appendix D (table D.5).

ton, 1915; Myrdal, 1968; Jones, 1981; Landes, 1998; Sachs and Malaney, 2002). The indirect effect of geography on economic outcomes via several channels has been explored by a number of researchers.[12]

The role of institutions in fostering economic growth has been advanced by North and Thomas (1973), Mokyr (1990), and Greif (1993), and has been empirically established by Hall and Jones (1999), La Porta et al. (1999), Rodrik et al. (2004). In addition, initial geographical conditions and their association with inequality gave rise to persistent differences in institutional quality across regions (Engerman and Sokoloff, 2000; Galor et al., 2009).

The cultural hypothesis, as advanced by Weber (1905, 1922) and Landes (1998, 2006) proposes, that norms and ethics that enhanced entrepreneurial spirit and thus innovation brought about a rapid transition at industrial stages of development. The adverse effect of ethnolinguistic fractionalization on economic development has been examined by Easterly and Levine (1997) and Alesina et al. (2003). Ashraf and Galor (2011b), establish that societies that were geographically isolated, and thus culturally homogeneous, operated more efficiently in the agricultural stage of development, but their lack of cultural diversity reduced their adaptability and thus delayed their industrialization. The hump-shaped effect of genetic diversity on economic outcomes, reflecting the trade-off between the beneficial and the detrimental effects of diversity on productivity, is explored in Ashraf and Galor (2013).

Finally, the role of human capital formation has been advanced as an alternative hypothesis, according to which the technologically driven demand for human capital, during the second phase of industrialization, led to an expansion in investment in human capital, which in turn led to an even more rapid increase in technological progress and accelerated the transition to a regime of sustained growth (Galor and Weil, 2000; Galor and Moav, 2002; Lucas, 2002; Glaeser et al., 2004; Galor, 2011).

This research, in contrast, identifies a novel mechanism through which geographical characteristics affect contemporary economic outcomes, underlining the role of unfavorable land endowment in the emergence of cooperation, and thus social capital, and its persistent effect on comparative economic development.

Second, the research contributes to the understanding of the geographical elements that contributed to the emergence of social capital. Existing studies suggest that cooperation, risk sharing attitude and sociopolitical networks gave rise to social capital (Bowles and Gintis, 2002; Henrich et al., 2001).[13] This research extends the argument and suggests that indeed the origins of social capital can be traced to large-scale cooperation, which however emerged as early as thousands of year ago, coinciding with the emergence of agriculture and the need of the community to cooperate for the development of agricultural infrastructure that could mitigate the adverse effect of the natural environment.

[12] See e.g., Diamond (1997); Michalopoulos (2012); Ashraf and Michalopoulos (2013); Fenske (2013); Fenske and Kala (2013); Michalopoulos et al. (2013)

[13] Unlike the proposed mechanism that focuses on the effect of unfavorable natural land productivity on cooperation in the construction of physical agricultural infrastructure, Durante (2010) explores the role of climatic variability and thus the insurance motive in the emergence of trust. Moreover, in contrast to Durante who establishes empirically only the reduced form relationship between climatic variability in the past and contemporary level of trust, the current paper explores empirically the channel through which unfavorable land productivity affected the contemporary level of trust, establishing the intermediate effect on cooperation in the agricultural stage of development. Furthermore, the current research also focuses primarily on comparative development, whereas the emergence of trust is an intermediate element of the mechanism.

Crucially, the paper *does not* claim a reversal of fortune along the lines of Acemoglu et al. (2002) on colonized countries or Olsson and Paik (2013) on the Western reversal.[14] The current analysis aims at identifying *a reversal on the effect of land suitability* on economic outcomes, with land suitability being one of the may forces affecting the fate of countries, without arguing that it is the *dominating* force.

3 The Basic Structure of the Model

The theoretical part employs a Malthusian model that captures the transition to industrialization partly driven by the social capital developed in the agricultural sector. Social capital enters as an argument in the utility function following Becker (1996). Whereas there are several alternative ways to model the emergence of social capital, this approach allows to capture in a simple model both the transition from the Malthusian era to industrialization and the evolution of social capital as well as to provide a clear testable hypothesis.

Consider a perfectly competitive overlapping-generations economy in the process of development where economic activity extends over infinite discrete time.[15]

3.1 Production in the Agricultural and Industrial Sector

In every period, a single homogenous good is being produced either in an agricultural sector or in both an agricultural and an industrial sector. In early stages of development, the economy operates exclusively in the agricultural sector, whereas the industrial sector is not economically viable. However, since productivity grows faster in the industrial sector, it ultimately becomes economically viable and therefore, in later stages of development, the economy operates in both sectors.

The output produced in the agricultural sector in period t, Y_t^A, is determined by land, X_t, and labor employed in the agricultural sector, L_t^A, as well as by aggregate agricultural productivity. Aggregate agricultural productivity comprises three components: the natural level of land productivity, $\xi \in (0,1)$, acquired productivity (based on learning by doing), A_t^A, and public infrastructure, G_t.

The production is governed by a Cobb-Douglas, constant-returns-to-scale production technology such that

$$Y_t^A = \left[\xi A_t^A + G_t\right]^a X^a \left[L_t^A\right]^{1-a}; \quad a \in (0,1), \tag{1}$$

where the supply of land is constant over time and is normalized such that $X = 1$.[16] Hence, natural land productivity, ξ, is complemented by acquired productivity, A_t^A.

The labor force in the agricultural sector is allocated between the production of public infrastructure and the direct production of final output. A fraction $(1 - z_t)$ of the labor force employed in the agricultural sector is employed in the production of the final output, whereas the remaining fraction z_t is devoted to the production of public infrastructure, G_t. Hence, the output of public infrastructure

[14] The reversal of fortune has been extensively debated in a series of papers, see e.g., (Putterman and Weil, 2010; Spolaore and Wacziarg, 2013; Chanda et al., 2014).

[15] The full version of the model with all the intermediate steps and the proofs can be found in the online Appendix (Part A).

[16] For the emergence of a stable Malthusian equilibrium in the agricultural stage of development, diminishing returns to labor, implied by the presence of a fixed factor, is essential.

is $G_t = z_t L_t^A/\xi$, reflecting the supposition that the marginal productivity of labor devoted to the development of agricultural infrastructure is higher in less productive places.[17]

Hence the production of agricultural output is

$$Y_t^A = \left[\xi A_t^A + \frac{1}{\xi} z_t \theta_t L_t\right]^a X^a \left[(1-z_t)\,\theta_t L_t\right]^{1-a}, \tag{2}$$

where θ_t is the faction of labor employed in the agricultural sector and L_t denotes the total labor force of the economy in every time period t. Aggregate productivity in the agricultural sector, $\left[\xi A_t^A + G_t\right]$, captures the trade-off between allocating labor in the production of the final good and the production of the public good. Places that are faced with favorable land endowment, may find it optimal to allocate more resources to the production of the final good, whereas unfavorably endowed places, may find it optimal to invest more in infrastructure to further enhance land productivity.[18]

The output of the industrial sector in period t, Y_t^I, is determined by a linear, constant-returns-to-scale production technology such that

$$Y_t^I = A_t^I L_t^I = A_t^I (1-\theta_t) L_t \tag{3}$$

where L_t^I is the labor employed in the industrial sector, $(1-\theta_t)$ is the fraction of total labor force employed in the industrial sector in period t, and A_t^I is the level of industrial productivity in period t.

The total labor force in period t, L_t, is allocated between the two sectors. As will become evident, in early stages of development, the productivity of the industrial sector, A_t^I, is low relative to that of agricultural sector, and output is produced exclusively in the agricultural sector. However, in later stages of development, A_t^I rises sufficiently relative to the productivity of agricultural sector, and ultimately the industrial technology becomes economically viable.

3.1.1 Collective Action in the Production of the Agricultural Infrastructure

Labor in the agricultural sector is allocated between two different activities. A fraction of the labor, $1-z_t$, is employed in the production of the final good, whereas the remaining fraction, z_t, is employed in the production of agricultural infrastructure that is aimed to further enhance land productivity. Therefore the community faces a trade-off in the decision to allocate labor to the production of agricultural infrastructure. More labor in the production of agricultural infrastructure increases land productivity, but it reduces the labor employed in the production of the final good.

Members of the community in every time period t, choose the fraction of labor employed in the agricultural sector that will be allocated to the production of the public good, so as to maximize agricultural output, i.e. $\{z_t\} = \arg\max Y_t^A$.

Hence, noting (1),

$$z_t = a - \left[(1-a)\xi^2 A_t^A/\theta_t L_t\right]. \tag{4}$$

[17] The substitutability between natural land productivity and agricultural infrastructure is further explored in the empirical section of the paper. In particular, it will be established that higher land suitability for agriculture is associated with lower incentives to invest in agricultural infrastructure.

[18] Different formulations of the production function, e.g. $Y_t^A = A_t^A\left[\xi + G_t(\xi)\right]^a X^a \left[L_t^A\right]^{1-a}$ would yield qualitatively similar results under certain assumptions, nevertheless they would complicate the model to the level of intractability.

Interestingly, the optimal fraction of labor allocated to the development of agricultural infrastructure is a decreasing function of natural land productivity, ξ, as well as of acquired agricultural productivity, A_t, thereby implying that countries with more favorable land endowment have a reduced incentive to invest in infrastructure and therefore, choose to allocate more labor to the direct production of the final good.

3.1.2 Factor Prices and Aggregate Labor Allocation

The markets for labor and the production of the final good are perfectly competitive. Workers in the agricultural sector receive their average product, given that there are no property rights to land, and therefore the return to land is zero. Given (2), the wage rate of agricultural labor in time t, w_t^A, is

$$w_t^A \equiv \frac{Y_t^A}{\theta_t L_t} = \left[\frac{\xi A_t^A}{\theta_t L_t} + \frac{1}{\xi} z_t\right]^a (1 - z_t)^{1-a} \tag{5}$$

The inverse demand for labor in the industrial sector, given by (3), is $w_t^I = A_t^I$, where w_t^I is the wage rate of the industrial labor in period t.

Evidently as employment in the agricultural sector decreases, the demand for labor increases without bound, while productivity in the industrial sector remains finite. Hence, the agricultural sector will be operative in every period, whereas the industrial sector will be operative if and only if labor productivity in this sector exceeds the marginal productivity of labor in the agricultural sector, if the entire labor force is employed in the agricultural sector. Once the two sectors become operative, the perfect labor mobility assumption implies an equalization of wages across sectors (Figure 1).

[FIGURE 1 HERE]

3.2 Individuals

In every period t, a generation comprising a continuum of L_t economically identical individuals, enters the labor force. Each member of generation t lives for two periods. In the first period of life (childhood), $t-1$, individuals are raised by their parents who face a fixed cost of child-rearing for every child in the household.[19] In the second period of life (parenthood), t, individuals are endowed with one unit of time, which they allocate entirely to labor force participation.

The preferences of members of generation t (those born in period $t-1$) are defined over consumption as well as the number of their children. They are represented by the utility function

$$u_t = (c_t)^\gamma (n_t)^{1-\gamma}; \qquad \gamma \in (0,1), \tag{6}$$

where c_t is consumption, and n_t is the number of children of individual t.

Let $\tau > 0$ be the cost (in terms of the consumption good) faced by a member of generation t for raising a child. Income from labor force participation is allocated between expenditure on children

[19] It is assumed that each child is associated with a fixed cost that can be interpreted as purchasing child-rearing services. Imposing a time cost would not qualitatively change the predictions of the model, as long as technological progress reduces the amount of time required to raise a child.

(at a real cost of τ per child) and consumption. Hence, the budget constraint faced by a member of generation t is $c_t + \tau n_t \leq w_t$,where w_t is the labor income of individual t.

Members of generation t choose the number of their children and, therefore, their own consumption so as to maximize their utility subject to the budget constraint. The optimal number of children for a member of generation t is therefore

$$n_t = \frac{1-\gamma}{\tau} w_t, \tag{7}$$

4 The Time Paths of the Macroeconomic Variables

The time paths of the macroeconomic variables are governed by the dynamics of acquired factor productivity in both the agricultural and the industrial sector, A_t^A and A_t^I, as well as the evolution of the size of the working population, L_t. The evolution of industrial productivity and the size of the working population are in turn governed by the amount of labor allocated to the production of agricultural infrastructure and therefore by natural land endowment.[20]

4.1 The Dynamics of Sectoral Productivity

The level of the acquired productivity in the agricultural and industrial sectors, A_t^A and A_t^I, is affected by the productivity level in the previous time period as well as by technological progress, which reflects the incorporation of new knowledge into existing technologies. Industrial productivity is further enhanced by the level of social capital on industrial specific knowledge creation.

In each time period, a fraction of the workforce that is employed in the agricultural sector is allocated to the construction of the public good. The newly created infrastructure has two effects on the economy as a whole. A short run and a long run effect. In the short run, it boosts agricultural production directly, by mitigating the adverse effect of unfavorable natural land endowment.[21] In the long run, the cooperation in the production of agricultural infrastructure, contributes to societal social capital that ultimately benefits the process of industrialization.[22]

4.1.1 Industrial Productivity

Industrial productivity is being enhanced by two distinct components. The first component reflects improvements in industrial technology, driven by the new knowledge added by the population employed in the industrial sector. The second component can be viewed as the social component, namely the acquired level of social capital (as emerging from cooperation in the agricultural sector), and its beneficial effect on industrial specific new knowledge.[23]

The evolution of productivity in the industrial sector between periods t and $t+1$ is determined by

$$A_{t+1}^I = A_t^I + (\omega + z_t\theta_t)L_t A_t^I \quad \equiv A^I\left(A_t^A, L_t, A_t^I\right), \tag{8}$$

[20] The structure of the dynamical system is inspired by Ashraf and Galor (2011b).

[21] For simplicity it is assumed that agricultural infrastructure fully depreciates within a period.

[22] It is plausibly assumed that when the community decides to construct agricultural infrastructure, it cannot internalize the externality of the emerging social capital in the latent industrial sector.

[23] Higher levels of social capital are associated with higher innovation and entrepreneurship, via reducing the associated risks and providing the necessary network (Putnam, 2000; Greif, 1993)

where the initial level of industrial productivity, $A_0^I > v\xi^{-a}$, is given.

In particular, A_t^I reflects the inertia of past productivity in the industrial sector, $\omega L_t A_t^I$, captures the advancement in productivity due to the application of new knowledge to the existing level of productivity; $\omega \in (0,1)$.[24]

The beneficial effect of cooperation for the creation of agricultural infrastructure, on the industrial productivity, is captured by $z_t\theta_t L_t A_t^I$, where $z_t\theta_t$ is the fraction of the population employed in the production of agricultural infrastructure.[25]

The beneficial effect of past cooperation on the industrial sector through the creation and accumulation of social capital and ultimately through its effect on the creation of industrial specific knowledge, is being captured by the level of past productivity, A_t^I. Cooperation at time t is captured implicitly as social capital in period $t+1$.

4.1.2 Agricultural Productivity

Similarly, the evolution of productivity in the agricultural sector between periods t and $t+1$ is determined by

$$A_{t+1}^A = \beta A_t^A + (L_t)^\lambda (A_t^A)^b \quad \equiv A^A\left(A_t^A, L_t\right) \ , \tag{9}$$

where the initial level of agricultural productivity, $A_0^A > 0$, is given.

βA_t^A captures the inertia from past productivity of the agricultural sector in period t, where $\beta \in (0,1)$ captures the erosion in agricultural productivity due to imperfect transmission from one generation to the other.[26] The term $(L_t)^\lambda (A_t^A)^b$ captures a "learning by doing effect". In particular the formulation implies both diminishing returns to population driven knowledge creation, and a "fishing out" effect (i.e. $\lambda \in (0,1)$), namely the negative effect of past discoveries on current discoveries. In addition, it is assumed that there is a lower degree of complementarity between the advancement of the knowledge frontier and the existing stock of sector-specific productivity in the agricultural, namely $b < 1$. Furthermore $\lambda + b < 1$.

It should be noted that agricultural infrastructure is assumed to be fully depreciated within one period, and the productivity in the agricultural sector is not affected by the level of agricultural infrastructure.[27]

[24] $\omega \in (0,1)$ captures the fact that only a fraction of the population contributes to the creation of new knowledge in the industrial sector. While it can be argued that people employed in the industrial sector can contribute to the creation of new knowledge in the industrial sector, indirectly, it would be less plausible to argue that all people employed in the agricultural sector can positively influence knowledge creation in the industrial sector. It is therefore assumed that a constant fraction of the total workforce is positively affecting knowledge creation in industry.

[25] One can assume that once the industrial sector is active each extended household allocates labor to both the industrial and the agricultural sector. Hence, the entire society is exposed to the externalities of contemporary cooperation in the agricultural sector.

[26] It is assumed that erosion takes place in the agricultural sector, since agricultural technology reflects mostly human embodied knowledge and therefore imperfect transmission, as opposed to industrial knowledge. The assumption that there is no erosion in the industrial sector is a simplification aimed to capture this particular aspect. Nevertheless the results would hold under any parameterization that would assure smaller depreciation in the industrial sector.

[27] If contemporary infrastructure is long lasting and society would internalize its future effects on agricultural output, the qualitative analysis will remain similar, however it would complicate the model to the level of intractability.

4.2 The Dynamics of Population Size

The size of the labor force in any period is determined by the size of the preceding generation and its fertility rate. As follows from (7), the adult population size evolves over time according to[28]

$$L_{t+1} = n_t L_t = \begin{cases} \left[(1-\gamma)/\tau\right] w_t^A & \equiv L^A\left(A_t^R, L_t\right) \quad \text{if} \quad L_t < \hat{L}_t \\ \left[(1-\gamma)/\tau\right] w_t^I & \equiv L^I\left(A_t^I, L_t\right) \quad \text{if} \quad L_t \geq \hat{L}_t, \end{cases} \tag{10}$$

In the agricultural stage of development the dynamics of the population are governed by acquired productivity in the agricultural sector as well as the size of the adult population, whereas when both sectors become active, population dynamics are determined by the level of the productivity in the industrial sector and the size of the adult population.

5 The Process of Development

This section focuses on the role of natural land endowment in determining the characteristics of the Malthusian equilibrium and the timing of the take-off from an epoch of Malthusian stagnation to a state of sustained economic growth. The analysis demonstrates that countries with unfavorable natural land endowment are being dominated by more favorably endowed countries in the Malthusian regime. Hence, in an effort to mitigate the adverse effect of land, they cooperate more intensely in the production of agricultural infrastructure, which ultimately results to the emergence of higher levels of social capital. Due to the complementarity of social capital with the industrial sector, these countries industrialize faster, and therefore, escape Malthusian stagnation to enter a state of sustained economic growth.

The process of economic development, given the natural land productivity, ξ, is fully determined by a sequence $\left\{A_t^A, A_t^I, L_t; \xi\right\}_{t=0}^{\infty}$ that reflects the evolution of the acquired productivity in the agricultural sector, A_t^A, the productivity in the industrial sector, A_t^I, and the size of adult population, L_t. The dynamic path of the economy is given by eqs. (8), (9), and (10)

5.1 The Evolution of the Economy

In early stages of development, the economy operates exclusively in the agricultural sector due to the fact that the productivity in the (latent) industrial sector, A_t^I, is too low to allow the industrial sector to become operative (satisfying assumptions (A1) and (A3)). In this stage of development, the economy is in a Malthusian regime and the dynamical system, illustrated in Figure 2, has a globally stable steady-state equilibrium, (A_{ss}^I, L_{ss}), towards which it gravitates monotonically.

[FIGURES 2 AND 3 HERE]

The driving force behind the transition from agriculture to industry, is the growth of productivity in the (latent) industrial sector. In the process of development, increases in the industrial productivity, rotate the Conditional Malthusian Frontier, $MM_{|A_t^I}$ clockwise in the $\left(A_t^A, L_t\right)$ space of Figure 2. Eventually, productivity of the industrial sector surpasses the critical threshold level which renders

[28] The initial size of the adult population, $L_0 > 0$, is given.

the industrial sector operative and drops the Conditional Malthusian Frontier below the LL locus as depicted in Figure 3.

As the economy enters the era of industrialization, there no longer exists a globally stable Malthusian steady state in the $\left(A_t^A, L_t\right)$ space. Upon entering into the industrialization regime, the economy enters into an era of sustained endogenous growth, where income per worker is growing over time driven by the growth of industrial productivity.

5.2 Natural Land Endowment and Comparative Development

The effect of natural land endowment on comparative development, through the emergence of cooperation and social capital, can be examined based on the effect of the land endowment on Malthusian equilibrium outcomes in the agricultural stage of development, and on the timing of industrialization and the take-off to a state of sustained economic growth.

Proposition 1 *(The Effect of Natural Land Endowment on the Equilibrium in the Agricultural Stage of Development) An increase in the quality of natural land endowment has a beneficial effect on the steady-state levels of productivity in the agricultural sector and the size of the adult population,i.e.* $dA_{ss}^A/d\xi > 0$ *and* $dL_{ss}/d\xi > 0$

[FIGURES 4 AND 5 HERE]

Geometrically, as depicted in Figure 4, a higher value of ξ, while it leaves the AA locus unaffected, it causes the LL locus to reside closer to the L_t-axis in $\left(A_t^A, L_t\right)$ space, thereby yielding higher steady-state levels of adult population size and agricultural productivity. Therefore, an economy that is characterized by more favorable natural land endowment, is also associated with a relatively superior conditional Malthusian steady state in terms of the economy's level of agricultural productivity per worker and the size of its working population.

Variations in natural land endowment, however, have an effect on the level of cooperation in the production of agricultural infrastructure and on the timing of industrialization (through the creation and transmission of social capital) and thus, on the take-off to a state of sustained economic growth. This effect is summarized in the following proposition.

Proposition 2 *(The Effect of Natural Land Endowment on the Timing of Industrialization and the Take-off from Malthusian Stagnation) Consider an economy in a conditional Malthusian steady-state equilibrium. An increase in natural land productivity, can have a detrimental effect on the timing of the adoption of industry and, thus, on the timing of the take-off from Malthusian stagnation, i.e.,* $dg_{ss}^I/d\xi > 0$

Following Propositions 1 and 2, variation in natural land endowment across societies is associated with the phenomenon of overtaking.

Corollary 1 *(Natural Land Endowment and Overtaking) Consider two societies indexed by* $i \in \{U, P\}$*. Suppose that society* U *is characterized by a lower natural land endowment and that* $\xi^U < \xi^P$*, where*

ξ^i is the natural land endowment of society i. Society U will then be characterized by an inferior productivity in the Malthusian regime, but it can overtake society P via an earlier take-off into the industrial regime.

6 Empirical Evidence

The empirical section aims to establish the phenomenon of overtaking, to account partly for it via the mechanism described above as well as to establish that land suitability in the past is associated with more intense cooperation and higher levels of contemporary social capital. The analysis takes place in three layers exploiting exogenous sources of variations in land productivity across: a) countries; b) individuals within a country, and c) migrants of different ancestry within a country. The *cross-country analysis (a)* allows to establish the overtaking and to further explore one potential mechanism associated with it. The *individual (b)* and the *migrant (c)* analysis allow to establish the reduced form effect of land suitability on the current levels of trust while capturing an increasing number of unobservables.

6.1 Cross-Country Evidence

Exploiting exogenous sources of variation in land suitability for agriculture across countries, the first part of the empirical analysis establishes the following testable predictions of the theory: (i) the effect of natural land productivity on the economic prosperity was reversed in the process of development. While a favorable land endowment had a positive effect on development in the Malthusian era, its adverse effect on the production of agricultural infrastructure and thus cooperation, had a detrimental effect on economic prosperity in the modern era, (ii) cooperation, as reflected by agricultural infrastructure, emerged primarily in places where land was not highly productive and collective action could diminish the adverse effects of the environment and enhance agricultural output, and (iii) lower level of land suitability in the past is associated with higher levels of contemporary social capital which expedited the process of industrialization.

6.1.1 Empirical Strategy and Data

Empirical Strategy

Testable Hypothesis I: Consistent with the predictions of the theory, the empirical analysis first establishes that the effect of land suitability varied over time, depending on the stage of development and on whether its direct effect on the economy, through increasing agricultural output, or its indirect effect, via determining the desirable level of cooperation in the agricultural sector, was a first order effect in each era. The examination of comparative development at the agricultural stage of development employs a Malthusian perspective, thereby assuming that technologically advanced economies had a larger rather than richer population (Ashraf and Galor, 2011). Hence, as a proxy for prosperity in the agricultural stage of development, the research employs historical data on population density as opposed to income per capita and examines the hypothesized effect of land suitability on population densities in the years 1, 1000 CE and 1500 CE.[29] In examining the impact of land suitability on economic outcomes in agricultural societies, the analysis controls for a number of alternative channels. These channels include the timing of the Neolithic Revolution, due to its impact on the advancement and diffusion of agricultural technologies, as well as geographical factors, such as absolute latitude, access to waterways, average ruggedness, average elevation as well as dummies for landlocked countries, islands and continental fixed effects, all of which may have had a persistent effect on agricultural output and economic outcomes.

To establish the change on the effect of land suitability on current economic outcomes the analysis employs cross country variation in land suitability, to explain the cross-country variation in log average income per capita in the years 1990-2000 CE. A number of potentially confounding factors and alternative hypothesis suggested by the related literature on comparative development are accounted for. The geography channel is controlled through a number of geographical controls that may affect economic outcomes today. The institutional hypothesis, that suggests that a "reversal of fortune" can be traced to the impact of European colonization on comparative development, is accounted for through a number of controls including European colonies dummies, legal origins dummies and institutional quality controls.[30] Furthermore, controls for the disease environment, ethnic fractionalization and religion shares are employed.

Importantly, as suggested by the theory, it is not the direct effect of land suitability that drives the change in its effect but instead the portable component associated with land suitability, namely the social capital that emerged as the outcome of cooperation. In the absence of migration, the country's level of social capital is captured by its natural land endowment. However, in the post-colonial era, where mass migration has taken place, the level of social capital in each country reflects the weighted average of land suitability among its ancestral population. Hence, in order to capture this distinction, two alternative empirical strategies are adopted. First, the sample is restricted to countries with a large percentage of native population, thereby implying that the social capital that has been accumulated in the past, is still a prevalent norm among the native population. Second, the measure of land suitability is ancestry adjusted to capture the portable component of natural land endowment. Therefore a measure of ancestry adjusted land suitability is constructed using the weighted average of the land suitability of the ancestral population of each country today. The adjustment of the land suitability index is based on the migration matrix constructed by Putterman and Weil (2010), which provides estimates of the proportion of the ancestors in the year 1500 CE of one country's population today that were living within what are now the borders of that and each of the other countries.

Testable Hypothesis II: Second, the empirical analysis explores the mediating factor of co-operation, by establishing that higher suitability of land for agriculture is associated with a lower level of cooperation in the agricultural sector, as reflected by the scope for irrigation as well as the actual fraction of irrigated land. The scope for irrigation measure captures the potential productivity due to irrigation.[31] Hence it can be viewed as an ex ante measure of the potential for cooperation.

[29] The tables for the years 1000 CE and 1 CE can be found in the Appendix B.

[30] Other institutional controls have been explored as well, such as constraints on the executive or expropriation risk, without affecting the results (results not available in the paper).

[31] The advantage of this approach has also been highlighted by Bentzen et al. (2012) who have constructed an alternative measure for irrigation potential.

The actual fraction of irrigated land can be perceived as an ex-post measure of actual cooperation. In the absence of extensive cross-country data on irrigation prior to industrialization, the analysis is based on the fraction of irrigated land for a sample of non-industrial countries in the year 1900. The exclusion of industrialized countries is based upon membership in the OECD in the year 1985, under the assumption that membership was restricted to advanced, and thus early industrialized countries. In the light of the fact that industrialized countries are more advanced technologically, the restriction of the sample is aimed to eliminate the possibility that the extent of irrigation is capturing the stage of development as opposed to the trade-offs associated with the development of infrastructure.

Given that in the year 1900 mass migration has already taken place in a number of countries, a potential concern would be that actual irrigation is affected by some sort of specific human capital carried by the migrants, which could reduce the opportunity cost associated with the development of irrigation. Hence in order to capture this aspect the sample is restricted to countries with a large percentage of native population.[32]

In the absence of more extensive data on agricultural infrastructure in antiquity, the adverse effect of natural land productivity on cooperation in earlier periods is examined based on several proxies of cooperation: a) communication in the year 1 CE, b) transportation in the year 1 CE, and c) medium of exchange in the year 1 CE. According to the theory, sophisticated means of communication, transportation and medium of exchange have been catalysts in the advancement of large-scale cooperation, and thus, under-development of these technologies reflects the adverse effect of land suitability on the extent of cooperation.

Two main concerns may arise with respect to these proxies. First that they are not proxies of cooperation, instead that they could be proxies of development. The analysis suggests that this is not the case. There appears indeed to be an element in this technologies associated with the stage of development, as suggested by Comin et al. (2010) nevertheless their correlation with population density whereas positive, is not sufficiently high to be considered as proxies of development (<0.4). Moreover, the fact that land suitability has a positive effect on population density in the past but a negative effect on the level of these technologies indicates that there is an element in these technologies that is orthogonal to the measure of development in the Malthusian era.

Second, it could be plausibly argued that the advancement of these technologies captures the degree of trade, that could be potentially associated with higher land suitability, as opposed to the emergence of cooperation in an environment characterized by lower land suitability. Reassuringly however, a more suitable land for agriculture in these societies had an adverse effect on the technological levels of these three sectors, suggesting that the dominating effect was indeed that of reduced cooperation. Moreover, the adverse effect of land suitability on the development of these technologies remains significant if the degree of inequality in the suitability of land for agriculture – a more direct proxy for the trade channel in early stages of development – is accounted for.[33]

The analysis further controls for a number of channels, that may have had a persistent effect on cooperation, including the timing of the Neolithic Revolution, geographical factors, such as absolute

[32] It could be plausibly argued though that since early industrialized countries are excluded from the sample, migration is unlikely to be a major factor in the analysis.

[33] All the baseline regressions are repeated in the Appendix B while controlling for the trade channel.

latitude, access to waterways, average ruggedness, average elevation as well as dummies for landlocked countries, islands and continents.

Testable Hypothesis III: Third, the empirical analysis establishes that the change on the effect of natural land productivity captures its adverse effect on social capital as reflected by the contemporary level of generalized trust. Importantly, since the portable component associated with land suitability, namely the social capital that emerged as the outcome of cooperation, affects the current level of trust, the measure of land suitability is ancestry adjusted to capture the portable component of natural land endowment, namely social capital, using the weighted average of the land suitability of the ancestral population of each country today. A number of alternative channels are accounted for, namely geographical and institutional factors, ethnic fractionalization, disease environment and dummies for continents, legal origins, European colonies and major religion shares. In addition, alternative measures of trust are employed, e.g. distrust in civil servants. Furthermore, as an additional robustness check, the unadjusted measure of land suitability is employed and the sample of countries is restricted to those with native population larger than 80%.[34]

In order to establish that natural land productivity is partly affecting the current levels of trust through the incentives for cooperation it generated in the agricultural sector, a horse race regression is employed between the measure of natural land productivity and the irrigation potential which proxies the scope for cooperation. The measure of irrigation potential, is also ancestry adjusted in order to capture the portable component associated with it, i.e. the incentives it generated for developing irrigation infrastructure and thus the cooperation incentives associated with it. Reassuringly the significance and the magnitude of the coefficient of natural land productivity is reduced.

A theory on the emergence of social capital due to geographical conditions, generates plausible concerns such as the potential use of slavery and the effect of very low land productivity countries. All these concerns are addressed in the robustness section of the model, along with a number of robustness checks on the validity of the model.

The Data Data on historical population density (in persons per square km) are derived by McEvedy and Jones (1978). Despite the inherent measurement problems associated with historical data, they are widely regarded as a standard source for population and income per capita data in the long-run growth literature.[35]

Land suitability measure is an index of the average suitability of land for cultivation, based on geospatial data on various ecological factors, related to climatic factors and soil quality. These factors include (i) growing degree days, (ii) the ratio of potential to actual evapotranspiration, (iii) soil carbon density, and (iv) soil pH. Therefore biophysical factors, such as topography and irrigation, and socioeconomic factors such as market price or incentive structure, which are important for determining whether land will be cultivated, are not part of the index.[36] The index is reported at a half-degree

[34] The result is robust to other thresholds as well.

[35] For a more extensive discussion on this data see Ashraf and Galor (2011). Moreover the concerns associated with measurement errors are mitigated by the introduction of continental fixed effects.

[36] The argument for adopting such an approach is based upon the observation that at the global scale, climate and soil factors form the major constraints on cultivation, and adequately describe the major patterns of agricultural land (Ramankutty et al., 2002),

resolution by Ramankutty et al. (2002). The average of land quality is thus the average value of the index across the grid cells within a country. This measure is obtained from Michalopoulos (2012).

Current suitability as a proxy for past suitability: One potential source of concern with respect to the measure of land suitability is whether current data on the suitability of land for cultivation reflect land suitability in the past. Importantly, the critical aspect of the data for the tested hypothesis is the ranking of countries with respect to their land suitability as opposed to the actual measure of land suitability. Hence the identifying assumption is that the ranking of land suitability as measured today, reflects the ranking of land suitability in the past.[37]

If intense cultivation and human intervention affected soil quality over time, this could have affected all countries proportionally and therefore it would introduce a non-systematic error. This would not only leave the ranking of countries with respect to land suitability for agriculture unaffected, but would also enhance the difficulty to detect a significant effect on land suitability. Importantly, even in the presence of a systematic error, it would be implausible to argue that the ranking of countries with respect to land suitability has been reversed, based on two arguments, similar to the ones made by Michalopoulos (2012). First, one of the two components of the index is based upon climatic conditions, which have not significantly changed during the period of examination (Durante, 2010; Ashraf and Michalopoulos, 2013).[38] Therefore, even if the characteristics of soil quality have significantly changed over time, this would still have a limited effect on the total index of land suitability. Second, given that the measure of land suitability captures the average level of land suitability within a given country, it would be implausible to anticipate that deteriorations in land quality in particular segments of the country, could affect the average land quality of a country, to the extent that it would change its overall ranking. Finally, to further alleviate potential concerns about the importance of the effect of human intervention on soil quality, the baseline regressions are repeated using each component of the land suitability index separately, namely climatic suitability and soil suitability. Reassuringly the qualitative results remain intact.[39]

Accounting for migration: The adjustment of the land suitability index is based on the use of the migration matrix constructed by Putterman and Weil (2010) which provides estimates of the proportion of the ancestors in the year 1500 CE of one country's population today that were living within what are now the borders of that and each of the other countries. The measure of ancestry adjusted land suitability is the weighted average of the land suitability of the ancestral population of each country today. The migration matrix of Putterman and Weil (2010) is also the basis of the measure of the percentage of native population, as constructed by Ashraf and Galor (2011).

[37] It should be noted that it is not the ranking of countries that is used as the measure of the explanatory variable, instead it is the actual measure of land suitability. The argument about the ranking of countries aims to highlight that changes in land productivity, as captured by the index, are hardly so drastic to change the ranking of countries.

[38] Durante (2010) has examined at the relationship between climatic conditions for the years 1900-2000 and 1500-1900. In particular he looks at the relationship separately for average precipitation, average temperature, precipitation variability and temperature variability. His findings confirm that regions with more variable climate in the present years were also characterized by more variate climate in the past, thereby reassuringly implying that climatic conditions have not significantly changed over time. A similar argument has been made by Ashraf and Michalopoulos (2013).

[39] The robustness section addresses these concerns by employing as the explanatory variable climatic and soil suitability respectively.

Data on irrigation potential are obtained from the FAO-Aquastat dataset. The index of irrigation potential is calculated as the extend of land that becomes marginally suitable for cultivation under rainfed conditions and irrigation conditions over the fraction of total arable land under only rain-fed conditions. It therefore captures the potential boost in the productivity of land due to irrigation.

Proxies of cooperation: Data on actual irrigation are reported by Freydank and Siebert (2008), who have constructed a set of annual values of area equipped for irrigation for all 236 countries during the time period 1900 - 2003.[40] The *Irrigation* variable employs data for the year 1900 and is expressed as the fraction of irrigated land over arable land. Despite the fact that data is from the year 1900, evidence suggests that most countries have changed little with respect to the land equipped for irrigation during the 20th century, thereby implying that major expansions in their irrigation systems have primarily occurred prior to industrialization. In addition, data for the period prior to 1900 were used as a basis for interpolation, again indicating that a significant part of the irrigation infrastructure had been constructed in the years prior industrialization (Framji et al., 1981).

Data on a) Communication in the year, 1 b) Transportation in the year 1, and c) Medium of Exchange in the year 1 are constructed from Peregrine's (2003) *Atlas of Cultural Evolution*, and aggregated at the country level by Ashraf and Galor (2011). Each of these three sectors is reported on a 3-point scale, as evaluated by various anthropological and historical sources. The level of technology in each sector is indexed as follows. In the communications sector, the index is assigned a value of 0 under the absence of both true writing and mnemonic or non-written records, a value of 1 under the presence of only mnemonic or non-written records, and a value of 2 under the presence of both. In the transportation sector, the index is assigned a value of 0 under the absence of both vehicles and pack or draft animals, a value of 1 under the presence of only pack or draft animals, and a value of 2 under the presence of both. In the Medium of Exchange sector, the index is assigned a value of 0 under the absence of domestically used articles and currency, a value of 1 under the presence of only domestically used articles and the value of 2 under the presence of both. In all cases, the sector-specific indices are normalized to assume values in the [0,1]-interval. Given that the cross-sectional unit of observation in Peregrine's dataset is an archaeological tradition or culture, specific to a given region on the global map, and since spatial delineations in Peregrine's dataset do not necessarily correspond to contemporary international borders, the culture-specific technology index in a given year is aggregated to the country level by averaging across those cultures from Peregrine's map that appear within the modern borders of a given country.

Data on trust come for the *World Values Survey*. They are built upon the fraction of total respondents within a given country, from four different waves (1981-2002) based on their answers on the question "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people".

6.1.2 Empirical Findings

Hypothesis I-The Impact of Land Suitability on Development in the Agricultural Stage
Table 1 establishes, in line with the theory, that favorable land endowment had a beneficial impact

[40] The values are provided in 1000 ha units.

on economic development in the agricultural stage. Specifically, accounting for a variety of potentially confounding factors, the table demonstrates the positive effect of land suitability on log population density in the year 1500 CE.[41]

Employing a 130 cross-country sample for which the full set of controls is available, Column (1) reveals that log land productivity possesses a statistically significant and positive relationship with population density in the year 1500 CE, conditional on continental fixed effects. Column (2) augments the analysis with the full set of exogenous geographical controls.

The regression presented in Column (3) further augments the analysis with additional controls on the timing of the Neolithic Revolution, a major determinant of prosperity in the Malthusian era. Column (4) introduces into the analysis the log of the distance from the nearest technological frontier. As predicted in the research of Ashraf and Galor (2011), distance from the nearest technological frontier has a significant negative impact on economic development. In all columns the point estimate and statistical significance of the coefficient associated with log land suitability remains quite stable.

The evidence presented in Table 1 therefore establishes, in accordance with the theory, that favorable land endowment had a beneficial impact on economic development during the agricultural stage of development. The positive effect of land suitability on economic outcomes in the year 1500 CE is depicted on the scatter plot in Figure B.3. Importantly, as suggested in the footnote and the robustness section the result is not driven by the very low productivity places.[42]

[TABLE 1 HERE]

Hypothesis I-The Impact of Land Suitability on Development in the Industrial Stage Table 2 establishes, in line with the theory, a change *on the effect of land productivity on aggregate productivity* in the industrial era.

In particular the empirical analysis establishes that favorable land endowment has an adverse effect on current economic outcomes as proxied by the average level of income per capita in the years 1990-2000 CE. As already argued in the empirical implementation section, the measure of ancestry adjusted land suitability is employed, in order to capture the portable component associated with natural land productivity. Specifically, accounting for a variety of potentially confounding factors, the table demonstrates the negative effect of the log ancestry adjusted land suitability on the log of average income per capita in the years 1990-2000 CE.

[TABLE 2 HERE]

[41] Similar results are established for the effect of log land on log population density in the years 1 CE and 1000 CE. and can be found in the Appendix B.

[42] One concern would be the case of some countries which are uninhabited due to being non-suitable for agriculture (e.g. Egypt which is largely uninhabited due to the desert). In this case, population density would be underestimated and this could lead to a spurious positive correlation between land suitability and population density. To mitigate this concern, the regression in Column (4) has been repeated using a measure of population density defined as population in 1500 CE divided by arable land. The results remain intact. The same concern could be raised for the measure of land suitability as well. In this case however, the index of land suitability is underestimated thereby attenuating the coefficient on land suitability towards zero. Constructing the corresponding index of suitability while taking into account only the fraction of arable land would strengthen the results.

Exploiting variations across a sample of 132 countries for which the full set of controls is available, Column (1) reveals that, conditional on continental fixed effects, ancestry adjusted land suitability possesses a statistically significant negative relationship with average income per capita in the years 1990-2000 CE.[43] Column (2) augments the analysis with exogenous geographical controls capturing the direct effect of geography, as well as with the timing of the Neolithic Revolution, ancestry adjusted.

Column (3) explores the institutional hypothesis by introducing into the analysis controls for ethnolinguistic fractionalization, institutional controls (e.g. the quality of institutions) and disease environment. To ensure that the change in the impact of *ancestry adjusted land suitability on economic outcomes* is not being driven by the institutional channels associated with European colonialism, the regression in Column (4) introduces controls for legal origins and colonial dummies. Moreover it introduces some cultural controls for major religion shares as well as for a proxy of human capital, namely average enrollment rates during the years 1990-2000 CE.

Column (5) is employing a measure of unadjusted land suitability and is restricting the analysis to a sample of 89 countries that have native population over 80% of the total population, while retaining all the controls introduced in Column (4). Remarkably, despite the smaller size of the sample, the results strongly support the hypothesis. [44]

Column (6) gives credence to an intermediate element of the mechanism. More analytically, the mechanism suggests that low land suitability is associated with better economic outcomes today due to the fact that it allows for an early industrialization. Thus, the last column establishes, for a sample of 46 countries[45], that higher land suitability is associated with an earlier transition to industrialization, while controlling for all the relevant controls employed in Column (5).[46]

The evidence presented in Table 2 therefore demonstrates, consistently with the theory, that land suitability has had a persistent detrimental impact on economic development in the course of industrialization. As is established in the following sections, this adverse effect is operating via the reduced incentive it generated for cooperation in the agricultural sector and ultimately the lower level of social capital that emerged as the outcome of the reduced cooperation. The negative effect of ancestry adjusted land suitability on current economic outcomes proxied by the average income in the years 1990-2000 CE is depicted on the scatter plot in Figure B.4.[47]

[43] The sample is extended to the maximum number of countries available for the industrial era. These countries already contain the 130 countries that are available in the Malthusian era.

[44] The threshold level of the native population is chosen in a way that minimizes the trade-off between the reduced observations and a sufficiently high fraction of the native people that allows to infer that the portable component of land suitability is present within the population. As a robustness different thresholds have been employed as well and the results remain qualitatively the same.

[45] It should be noted that the sample is restricted to the countries with a fraction of native population higher than 80%. Since the migration matrix is referring to the ancestors of the population in the year 2000 CE, it is not possible to calculate the ancestry adjusted land suitability. Similarly, certain controls such as schooling are not relevant for this analysis.

[46] The timing of industrialization is determined as the year in which the share of agricultural sector became less than 30% of the aggregate economic activity. The measure used is provided by Oded Galor. Bentzen, Kaarsen and Wingender (2013) have also constructed and provided a measure of industrialization, where the timing of industrialization is determined as the year in which the share of agricultural sector became less than 50% of the aggregate economic activity.

[47] One potential concern may be that the adverse effect of land productivity on current economic outcomes is reflecting the effect of the "natural resource curse". Reassuringly though, the negative correlation between the index of land productivity and income from natural resources as a fraction of GDP (-0.4), implies that the adverse effect of land productivity on contemporary economic outcomes does not capture the resource curse. Controlling though for OPEC countries as an additional robustness check, does not qualitatively affect the

Hypothesis II-Cooperation: The Impact of Land Productivity on Cooperation in the Agricultural Stage The evidence presented so far establishes a change of the effect of natural land productivity during the process of economic development. As described in the mechanism, natural land productivity had an indirect effect on the incentives to invest in agricultural infrastructure and thus on the opportunities to cooperate for its development. Tables 3 and 4 establish this particular element, i.e. that this indirect effect operates through the cooperation that emerged in the agricultural sector in an effort to mitigate the adverse effect of land. Cooperation, as reflected by agricultural infrastructure, emerged primarily in places where land was not highly productive and collective action could diminish the adverse effects of the environment and enhance agricultural output.[48]

Irrigation Potential and Actual Irrigation Consistently with the assumptions of the model, Table 3 establishes that the returns to the development of agricultural infrastructure are higher in countries with unfavorable land endowment. In particular, the analysis reveals a statistically significant and robust negative effect of the log land suitability on irrigation potential. As has been elaborated in a previous section, the measure of irrigation potential reflects the returns to irrigation and therefore the scope for cooperation. It also establishes a significant and robust negative effect of the log land suitability on the fraction of irrigated land in the year 1900.

Exploiting variations across a sample of 130 countries already employed for the Malthusian era analysis, Column (1) in Table 3 controls for continental fixed effects.[49] Column (2) enriches the analysis with a number of exogenous geographical controls that can confer a significant effect on the scope for irrigation. Columns (3) and (4) introduce some additional controls such as the timing of the Neolithic Revolution and the distance from the nearest technological frontier in the year 1500 CE.[50] The coefficient retains both its significance and its magnitude suggesting that higher land suitability is associated with less incentives to invest in infrastructure.

Column (5) in Table 3 employs an alternative measure of irrigation, i.e., actual irrigation. As already analyzed in the empirical implementation section, the analysis on ex-ante cooperation is employing the fraction of irrigated land for a sample of non-industrial countries in the year 1900. The reason for choosing non-industrialized countries is to mitigate the problem of reverse causality running from the stage of industrialization to actual irrigation. Moreover given that in the year 1900 mass migration has already taken place in a number of countries, a potential concern would be that irrigation is affected by some sort of specific human capital carried by the migrants, which could reduce the opportunity cost associated with the development of irrigation. Hence in order to capture this aspect and in the absence of the equivalent of the migration matrix data for the year 1900, the sample is restricted to countries with a percentage of native population higher than 80%, thereby implying that migration

results (results are reported in the Appendix B).

[48] If coordination problems among members of the community dictate a suboptimal level of investment in infrastructure, the qualitative results would be enhanced. Since the complexity of coordination increases with the size of the community, less favorably endowed places, and therefore more sparsely populated places (according to the Malthusian mechanism) would coordinate more easily than more densely populated places. Hence, the sub-optimally level of investment in infrastructure will be larger in favorably endowed places, enhancing the hypothesis that less favorably endowed places invest more in infrastructure.

[49] As in Table 1, which refers to the Malthusian era, the relevant sample for Table 4 is that of the 130 countries for which the full set of controls is available.

[50] The full set of controls is sustained for the shake of symmetry with the baseline regressions.

has not affected the composition of the human capital of the native population. This restricts the sample to 42 observations. Note that the number of observations differs from that in Columns (1)-(4) since the measure employed in these columns was that of potential irrigation which i) is available for a large number of countries, and ii) does not suffer from endogeneity concerns.

Column (5) in Table 3 thus reports a statistically significant effect of land suitability on the actual fraction of irrigated land. Despite the large number of observations the results are confirmed, i.e. that natural land productivity negatively correlates with actual levels of irrigation.

[TABLE 3 HERE]

Overall, the evidence presented in table 3, establishes the adverse effect of land suitability on ex ante and ex post measures of irrigation, and thus as is argued, on proxies of ex-ante and ex-post cooperation. The negative effect of land suitability on irrigation potential is depicted on the scatter plots in Figure B.5.[51]

Medium of Exchange, Transportation and Communication In the absence of more extensive data on agricultural infrastructure in antiquity, the adverse effect of natural land productivity on cooperation in earlier periods is examined based on several proxies of cooperation: a) medium of exchange in the year 1 CE, b) communication in the year 1 CE, and c) transportation in the year 1 CE. According to the theory, sophisticated means of communication, transportation and medium of exchange have been catalysts in the advancement of large-scale cooperation, and thus, under-development of these technologies reflects the adverse effect of land suitability on the extent of cooperation.

Exploiting variations across a sample of 130 countries, Column (1) in Table 4 establishes a statistically significant negative effect of land suitability on the development of sophisticated medium of exchange in the year 1 CE, while controlling for continental fixed effects, a number of geographical controls, the timing of the Neolithic Revolution and distance from the nearest technological frontier. Similarly Columns (2) and (3) establish a statistically significant negative effect of land suitability on means of communication and transportation in the year 1 CE.

It could be argued that the advancement of means of communication, transportation and medium of exchange could be driven by larger volumes of trade flows, that could be potentially associated with higher land suitability. This would suggest that higher land suitability is positively associated with each of these measures. Reassuringly however, more suitable land for agriculture in these societies had an adverse effect on the technological level of this sector, suggesting that the dominating effect was indeed that of reduced cooperation. Moreover, to control for this channel, an additional control is added, namely inequality in the land suitability for agriculture, a more direct proxy for trade in early stages of development. Consistently with the predictions of the theory, the adverse effect of land suitability on the development of these technologies remains significant, despite the positive and statistically significant effect of land inequality on cooperation technology.[52]

[51] The argument that irrigation as well as any other type of infrastructure can be associated with autocratic regimes and the use of slaves is extensively discussed in the robustness section and empirically addressed in the Appendix B.

[52] Results are reported in the Appendix B.

A second concern could be that the advancement in the technology of each sector could be attributed to the use of slaves, in which case cooperation would not be the final outcome. The intuition why this should not be a concern is similar to the first argument, i.e. that in such a case higher land suitability would be negatively associated with all these proxies of cooperation which supported by the empirical evidence. Moreover, to net out the potential effect of slavery, a measure of the level of stratification of societies in the year 1 CE is employed that captures the potential use of slaves in the development of infrastructure. The results remain intact suggesting that the scope for cooperation remains valid even in the presence of slaves.[53]

Overall the analysis in Tables 3 and 4 and the scatter plots depicted in Figures B.6, B.7 and B.8, suggests that there is a statistically significant adverse effect of land suitability on a number of proxies for cooperation during the agricultural stage of development, namely a) irrigation potential, b) fraction of irrigated land in the year 1900, c) medium of exchange in the year 1 CE, d) communication in the year 1 CE, and e) transportation in the year 1 CE.

The validity of the results is enhanced by employing ex ante and ex post proxies of cooperation in the agricultural sector as well as alternative measures that can be viewed as by-products of cooperation in the process of building agricultural infrastructure.[54]

[TABLE 4 HERE]

Hypothesis III-Trust: The Impact of Land Suitability on Trust in the Industrial Stage The purpose of the first two sub-sections was to establish some intermediate elements of the mechanism that associate lower land suitability with higher levels of trust today. This section explores explicitly the effect of land productivity on the current levels of trust, as well as the mediating factor of cooperation.

Consistently with the predictions of the theory, Table 5 establishes that countries with unfavorable land endowment manifest higher levels of social capital and trust today. In particular, the analysis reveals a statistically significant and robust negative effect of the ancestry adjusted land suitability[55] on the index of trust.

Exploiting variations across a sample of 67 countries for which all controls are available, Column (1) controls for continental fixed effects. Column (2) explores the direct and/or indirect effect of geography on current levels of trust. whereas Column (3) further extends the analysis by introducing additional controls for ethnolinguistic fractionalization, institutional controls and disease environment.

[53] Results are reported in the Appendix B.

[54] It could be argued that the threat of war and the fear of being invaded could enforce cooperation in the past. However, the presence of this plausible effect would suggest that the identified adverse effect of land productivity on cooperation represents an upper bound of the actual effect. First, if one plausibly assumes that the more fertile places faced an increased risk to be invaded then land productivity would generate a positive effect on cooperation via this channel, mitigating the actual adverse effect identified in the regression analysis. Moreover, even if implausibly, less fertile places were faced with an increased probability of being invaded, it would only constitute a complementary channel through which land productivity is affecting cooperation and trust, since as the established effect of low land productivity on cooperation, via irrigation, medium of exchange, and communication technologies are tangential to cooperation for defensive purposes.

[55] As already argued, adjusted land suitability is the appropriate measure of land suitability since vast migration has taken place in current years.

[TABLE 5 HERE]

To ensure that the observed impact of land suitability on trust is not being driven by the institutional channels associated with European colonialism, the regression in Column (4) introduces controls for legal origins, colonial dummies as well as dummies for major religion shares. Even after controlling for all this additional channels, the regression coefficient associated with the land suitability remains largely robust.[56] The corresponding standardized beta indicates that a one standard deviation increase in the land suitability index, is associated with a 0.608 standard deviation decrease in the levels of trust.

Whereas ancestry adjusted land suitability is one way to capture the portable component associated with land suitability, Column (5) conducts a robustness check by using the measure of unadjusted land suitability and restricting the sample to the countries that have a percentage of native population higher than 80%, thereby making implicitly the assumption that the norms of social capital and trust are still prevalent among the native population. The results indicate that the coefficient increases in magnitude and its statistical significance remains unaffected.

Reassuringly, similar results, that establish a negative and statistically significant effect of land productivity on current levels of social capital are obtained, when employing an alternative proxy of social capital, namely distrust in civil servants, as indicated in Column (6). Column (6) uses the ancestry adjusted measure of suitability and employs the full set of controls. Overall the negative effect of ancestry adjusted land suitability on the generalized level of trust is depicted in the scatter plot in Figure B.9.[57]

The Mediating Factor of Cooperation The evidence presented in Table 5 therefore demonstrates, consistently with the theory, that land suitability has had a persistent detrimental impact on the current levels of trust. As argued by the theory, the channel through which geography is indirectly affecting current levels of trust is via the reduced incentives it generated for cooperation in the agricultural sector and ultimately the lower level of social capital that emerged and persisted as the outcome of reduced cooperation.

Table 6 explores the mediating factor of cooperation, i.e. it employs as a proxy for the scope of cooperation the measure of irrigation potential and introduces it to the existing analysis.[58] In particular using the same sample of countries employed in Table 5 it establishes that high land

[56] Further analysis in the robustness section explores the channel of slavery by controlling for a measure of stratification ancestry adjusted. Reassuringly the results are unaffected, thereby suggesting that despite the fact that in some cases infrastructure may have been developed by slaves, nevertheless non fertile land is associated with more incentives for cooperation and higher levels of trust today.

[57] One concern that may arise is that land productivity is correlated with the degree of land diversity and high land diversity may generate conflict and therefore hinder cooperation and ultimately trust. To address this concern, one could capture this channel by controlling for land diversity. Reassuringly, as established in the Appendix, controlling for land diversity does not affect the qualitative results. In addition, the coefficient of land diversity is positive thereby implying that if indeed conflict emerges, it is not the dominating effect. In particular, it is plausibly suggested by the positive coefficient, that unequal land productivity fostered cooperation and trade among regions, generating positive effects on economic outcomes in the past and the present as well as on the current levels of trust.

[58] There are three reasons for focusing on irrigation potential. First it is more precisely measured than all other variables, second it is available for a larger number of countries and last it is more exogenous control than actual irrigation.

productivity is associated with lower levels of trust today operating partly through the incentives that it generates for cooperation.

In particular, Column (1) of Table 6 employs a sample of 67 countries for which all controls including the control for irrigation potential is available, and repeats the regression in Column (4) of Table 5.[59] Column (2) introduces in the analysis the mediating factor of cooperation, using as a proxy of the incentive to cooperate the measure of irrigation potential, ancestry adjusted. Importantly the coefficient of irrigation potential is positive and significant, suggesting that the higher the scope for irrigation (and thus for cooperation), the higher the current levels of trust. Moreover, the coefficient of land suitability reduces in magnitude, implying that the adverse effect of ancestry adjusted land suitability on current levels of trust is partly operating via the associated reduced incentives for cooperation. Columns (3) and (4) repeat the same exercise using the restricted sample of countries with native population higher than 80% and remarkably the coefficient reduces both in magnitude and significance, confirming the findings of the first two columns.

[TABLE 6 HERE]

6.1.3 Robustness

The aim of this section is to establish the robustness of the results. All tables can be found in the Appendix B, along with a number of scatter plots and summary statistics.

Validity of the Land Suitability Index One potential source of concern with respect to the measure of land suitability is whether current data on the suitability of land for cultivation reflect land suitability in the past. It can be plausibly argued that human intervention may have affected soil quality (e.g. the use of fertilizers or the heavy plow) and therefore current land suitability may not be a good proxy for past suitability. As has already been discussed in the description of the data, it is the ranking of countries that is crucial for the hypothesis advanced in the paper. Given the construction of the variable, it has been argued that the identifying assumption, i.e. that the ranking of land suitability as measured today reflects the ranking of land suitability in the past, is plausible.

Nevertheless, to further alleviate concerns about the effect of human intervention on soil quality, all the baseline regressions are repeated using each component of the land suitability index separately, namely climatic suitability and soil suitability.[60] Employing the climatic component, given that the climate is less vulnerable to human intervention, is reassuring with respect to the validity of the results.[61] The soil suitability index is employed as well, which yields interesting information as to the impact of each component.

[59] The repetition of the results is to make the two samples comparable.

[60] Soil suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH whereas climatic suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation such as growing degree days and the ratio of actual to potential evapotranspiration.

[61] Durante (2010) has examined at the relationship between climatic conditions for the years 1900-2000 and 1500-1900. His findings confirm that regions with more variable climate in the present years were also characterized by more variate climate in the past, thereby reassuringly implying that climatic conditions have not significantly changed over time.

Table B.2 in the Appendix repeats the baseline regressions of past outcomes (Population Density in 1500 CE, Irrigation Potential, Medium of Exchange in the Year 1 CE, Communication in the Year 1 CE, Transportation in the Year 1 CE) using the climatic component of the land suitability index and the full set of controls (geographical controls, years since the Neolithic transition and distance from the nearest technological frontier). Reassuringly the results are very robust to this specification and interestingly the coefficients are very similar to the coefficients obtained under the specification that is employing the aggregate land suitability index.

Table B.3 repeats the baseline regressions for past outcomes (Population Density in 1500 CE, Irrigation Potential, Irrigation in 1900, Medium of Exchange in the Year 1 CE, Communication in the Year 1 CE, Transportation in the Year 1 CE) using the soil component of the land suitability index and the full set of controls (geographical controls, years since the Neolithic transition and distance from the nearest technological frontier). Similarly the results are very robust to this specification as well.

Table B.4 repeats the baseline regressions for current outcomes (Average Income per Capita in 1990-2000 CE, Trust) employing both the climatic and the soil component. Columns (A.1) and (A.2) employ the ancestry adjusted climatic component and the full set of controls (geography, institutions, disease environment, ethnolinguistic fractionalization). The results of Table B.4 establish a statistically significant adverse effect of ancestry adjusted climatic suitability on current outcomes. Columns (B.1) and (B.2) employ the ancestry adjusted soil component and the full set of controls (geography, institutions, disease environment, ethnolinguistic fractionalization).[62] The results suggest that the soil component is also statistically significant.

Overall, the results in tables B.2, B.3 and B.4 confirm the robustness of the results to each of the components of the suitability index. Reassuringly, given that human intervention has a smaller effect on climate rather than on soil quality, this analysis suggests that the identifying assumption, i.e. that the ranking of land suitability as measured today reflects the ranking of land suitability in the past, is plausible.

Validity of Historical Population Estimates Data on historical population density (in persons per square km) are primarily derived by McEvedy and Jones (1978). Despite the inherent measurement problems associated with historical data, they are widely regarded as a standard source for population and income per capita data in the long-run growth literature. The robustness of the results regarding the effect of land suitability on population density is established also for the years 1000 CE and 1 CE.

Historical population estimates are also available from Maddison (2003), albeit for a smaller set of countries than McEvedy and Jones. Table B.5 in Appendix B repeats the baseline regressions, while employing the Maddison (2003) data on population density. It establishes that land suitability has a statistically significant effect on population density in the years 1500 CE, 1000 CE and 1 CE respectively, while controlling for the full set of controls, i.e. geographical factors, years since the

[62] A measure of adjusted climatic (soil) suitability is constructed using the weighted average of the climatic (soil) suitability of the ancestral population of each country today. The adjustment of the land suitability index is based on the migration matrix constructed by Putterman and Weil (2010), which provides estimates of the proportion of the ancestors in the year 1500 of one country's population today that were living within what are now the borders of that and each of the other countries. The adjustment captures the portable component associated with land suitability, namely the social capital that emerged as the outcome of cooperation.

Neolithic transition and distance from the nearest technological frontier. Reassuringly the baseline results are quantitatively unchanged under Maddison's alternative population estimates.

Potential Omitted Heterogeneity and Spatial Autocorrelation An attempt to deal with specific unobservables is already made in the baseline regressions by including continental fixed effects. Therefore all the results are robust to the fixed effects specification. An alternative attempt to capture unobserved heterogeneity, is to use regional fixed effects instead of continental fixed effects. The fixed effects that have been used are regional dummies for (i) Sub-Saharan Africa (ii) Middle East and North Africa, (iii) Europe and Central Asia, (iv) South Asia, (v) East Asia and Pacific and (vi) Latin America and the Caribbean. The results are robust to this specification as well (Tables B.12 and B.13 in Appendix B).

It is important to note that all the results have been replicated without the use of regional fixed effects. The results remain unaffected with the exception of the effect of land suitability on population density which is marginally insignificant with a positive coefficient. This finding suggests that the patterns observed are applied both globally and within regions (results not reported).

Furthermore, given the possibility that the disturbance terms in the baseline regression models may be non-spherical in nature, particularly since economic development has been spatially clustered in certain regions of the world, the standard errors of the point estimates are corrected for spatial autocorrelation following the methodology of Timothy G. Conley (results not reported).

Validity of the Estimation This section establishes that the main results are not driven by the employed specification. More analytically, the baseline analysis is repeating by weighting influential observations in the sample. The choice of influential observations is conducted using quantile regression analysis.[63] Reassuringly all the results are robust and in line with the baseline regressions (Tables B.10 and B.11 in Appendix B).

Competing Channels When exploring the emergence of trust as driven by geography, three concerns could be raised throughout the analysis. The first concern could be associated with the modern era analysis (GDP in 2000 CE and Trust) and the presence of potential corner solutions i.e. that the results may be driven by very unproductive places. One explanation would be that some countries have almost zero suitability for agriculture and thus it is the presence of corner solutions that drives the results. Or even more plausibly, it could be argued that oil-producing places are driving the results since while they have low land productivity, nevertheless they have high income due to the presence of oil. In order to mitigate these concerns the current era analysis adopts two alternative strategies: i) it censors the sample by excluding a number of countries that have very low land productivity and ii) it employs a dummy for OPEC countries. The findings suggest that the results are robust to these tests (Table B.14 in Appendix B).

A second argument is related to the potential presence of slaves. It can be argued that if slaves were used in the development of infrastructure then increased need for agricultural infrastructure would not be associated with more cooperation. The use of slaves in the development of infrastructure would

[63] Quantile regression analysis aims at estimating either the conditional median of the response variable and thus the estimates are more robust against outliers.

operate against the advanced hypothesis and thus one would anticipate that high land suitability in the past would positively affect current levels of trust today. Therefore, since the coefficient of land suitability would capture two opposite effects, the sign of the coefficient would reflect the dominating effect. Reassuringly, after controlling for all relevant controls the results suggest that the channel of cooperation is the dominating effect. Moreover this result is consistent with both the coefficient of land suitability and the coefficient of irrigation potential. However, to further mitigate these concerns, the analysis employs a measure of stratification that captures the degree of stratification in early societies and the presence of slaves. All the results are robust to this specification (Tables B.8 and B.9 in Appendix B).

Finally the last concern would be associated with the role of trade in fostering cooperation. More productive places could be associated with higher propensity to trade and this could lead to better communication, transportation and exchange technology. Following the rational of the second argument, the negative effect of land suitability on trust is associated with lowers levels of cooperation, thereby suggesting that the dominating effect is that of reduced cooperation due to the reduced incentives to develop infrastructure. Nonetheless, to net out the potential effect of trade, the analysis employs as a proxy for the propensity to trade in the Malthusian era, i.e. the degree of inequality in land suitability within a country (Litina, 2013). The results are robust to this specification as well (Tables B.6 and B.7 in Appendix B).

To capture more explicitly the channel suggested by Durante (2010), i.e., the effect of weather variability on the emergence of trust, the analysis has also controlled for a measure of climatic suitability range. The results remain stable (results not available in the paper).

6.2 World Values Surveys

The second part of the empirical analysis reexamines the hypothesis using a sample of individual data from the four waves of the WVS (1981-2002). The analysis explores the effect of ancestry adjusted natural land productivity on the current levels of individual trust, accounting for geographical and institutional characteristics. Importantly, in contrast to the cross country analysis, this disaggregated individual data allows to account for individual controls, such as education, religious denomination, age and gender. Since a fraction of the individuals are migrants, the measure of ancestry adjusted land suitability is employed, thereby capturing the portable component associated with it, i.e. the trait of cooperation.[64]

6.2.1 Empirical Strategy and Data

Empirical Strategy The goal of this section is to further explore the effect of ancestry adjusted land suitability on current levels of trust, by introducing all the country controls employed in the cross

[64] The WVS sample is not sufficiently detailed to trace all migrants and their country of origin (except for the Vth wave in which case the sample size is dramatically reduced) Therefore the analysis in this section, employs the same measure of ancestry adjusted land suitability for each individual in the country. Importantly though recall that the results are robust to the use of the measure of unadjusted land suitability in the sample of countries with a high fraction of native population as Table 5 suggests.

An analysis exploiting variations in land suitability associated with migrants, is conducted in the next section of the paper, using a much more extensive sample from the ESS.

section analysis, as well as a number of individual controls that can co-determine the current levels of trust.

To conduct this analysis, the four waves of the WVS (1981-2002) are employed. In particular the analysis takes into consideration 86.498 individuals living in 54 countries. Whereas the analysis is conducted at the country level, nevertheless it establishes that land suitability is a good predictor of individual levels of trust even after controlling for a large set of individual characteristics. More analytically the estimated equation is given by:

$$T_{ji} = \alpha_0 + \alpha_1 S_i + \boldsymbol{\alpha}_2 \mathbf{X}_i + \boldsymbol{\alpha}_3 \mathbf{I}_j + \boldsymbol{\alpha}_4 \boldsymbol{\Omega}_j + \boldsymbol{\alpha}_3 \boldsymbol{\Delta}_i + \varepsilon_{ji} \tag{11}$$

where j indicates the individual and i indicates the country. T_{ji} is the level of trust of individual j living in country i. S_i is the index of the ancestry adjusted suitability of land for agriculture which is invariant for all individuals living in the same country and thus varies only across countries; $\mathbf{X}_i$ is a vector of geographical, historical controls and institutional controls that are applicable only at the country level. These controls are critical for netting out potentially confounding factors related to country characteristics; I_j is a set of individual controls that have been already established in the trust literature to affect the current levels of trust, such as age, gender, education and religious group to which they belong.; Ω is a vector of dummies for each round of the survey; Δ_i is a vector of continental fixed effects and ε_{ji} is an individual specific error term. The standard errors are corrected for clustering at the dimension of the country where the interview was taken as well as at the religious group dimension.[65]

Consistent with the predictions of the theory, the empirical analysis establishes that ancestry adjusted land suitability has an adverse effect on the average individual of each country. This effect remains negative and statistically significant even after including all geographical and institutional controls associated with the country of origin as well as a full set of individual controls.

As a robustness test, the analysis, restricts the sample to countries with the fraction of native population higher than 80% and uses as the explanatory variable, the measure of unadjusted land suitability. The rational in this exercise is similar to the one used in the cross country analysis, i.e. that when the native population is sufficiently high, the portable component associated with land suitability is still present in the population. This robustness test further reinforces the analytical results.

Moreover the results are robust to a number of alternative tests, i.e. the decomposition of the index into its climatic and soil component, the specification of the model and potentially competing channels (such as the slavery channel and the trade channel).

In line with the cross-country analysis, it is explored whether the effect of land suitability on trust is operating via the scope for cooperation. For that purpose the analysis employs as a proxy for cooperation the irrigation potential measure used in the cross country analysis. The positive and significant coefficient of irrigation potential suggests that higher scope for irrigation is associated with higher levels of trust, via the increased incentives it provides for cooperation. Moreover the

[65] In principle it would be preferable to use ethnic group instead of religious groups. However, responses on ethnic groups are much more limited and therefore significantly reduce the sample size. Yet, religious group are so detailed (90 religious groups are reported) that can be viewed as a good proxy for ethnic groups.

magnitude of the coefficient of land suitability is reduced, thereby suggesting that the effect of land suitability is partly operating via the reduced incentives to cooperate for the development of agricultural infrastructure.

The Data All the data that are associated with the country of origin and vary only at the ancestry level are the same data employed in the cross-country analysis (land suitability for agriculture, irrigation potential, geographical and institutional controls).

The individual data come from all four rounds of the World Values Survey (1981-2002), a cross sectional survey conducted in a number of countries all over the world.

The analysis reports attitudes of N=86.498 individuals from 54 countries. The survey design weights, as provided by the WVS dataset, have been taken into account.

Respondents are given the statement "Using this card, generally speaking, would you say that most people can be trusted, or that you need to be very careful in dealing with people?". The index is scaled on a two-point scale, with the value 0, capturing indicating that "Most people can be trusted" and the value of 1 indicating that "Need to be very careful". The variable in this paper has been re-ordered with the value of 1 indicating more trust, so as to make the interpretation easier.

The WVS also provides information about the age of the respondent, the gender, the religious denominations where he belongs and the highest level of education achieved.[66] All this information about the individual is introduced in the analysis as controls.

6.2.2 Empirical Findings

The Impact of Land Suitability on Current Levels of Trust In line with the theory and the empirical findings of the cross country section, Table 7 establishes that higher land suitability, is associated with lower levels of trust of the average individual.

In particular Column (1) controls only for continental fixed effects. Column (2) introduces the full set of relevant controls that have been employed in the cross-country analysis, i.e. geographical and institutional controls (ruggedness, elevation, distance to waterways, absolute latitude and ancestry adjusted years since the Neolithic) as well as institutional and current controls such as ethnic fractionalization, disease environment, quality of institutions and fixed effects for dominant religion, former colony and legal origins. Column (3) introduces in the analysis individual controls that have been established as critical determinants of trust in the related literature, such as the age of the respondent, the gender, the educational level and the religious group in which the respondent belongs. Reassuringly, the negative and significant coefficient of trust indicates that even after controlling for the full set of country and individual controls, land suitability confers a negative effect on individual levels of trust. The magnitude of the coefficient is difficult to interpret since trust is a binary variable and the regression in Column (3) is a linear regression. Column (1) in Table C.3 of the Appendix C

[66] The questionnaire covers 90 categories of religious denominations. As to education attained, the questionnaire distinguishes seven different levels of education (inadequately completed elementary education, completed (compulsory) elementary education, (compulsory) elementary education and basic vocational qualification, secondary, intermediate vocational qualification, secondary, intermediate general qualification, full secondary, maturity level certificate, higher education - lower-level tertiary certificate, higher education - upper-level tertiary certificate).

reports the marginal effect of the suitability index. In particular a ten percentage point increase in land suitability, increases the probability of an individual being trustful by 2 percentage points.

Column (4) replicates the analysis, by excluding from the sample countries with native population lower than 80% and using the unadjusted measure of land suitability instead. The results remain qualitatively intact.[67]

Finally, Column (5) explores whether the adverse effect of land suitability is operating via the reduced incentives that fertile land provided for cooperation. For this purpose, the analysis introduces the control on irrigation potential, proxying for cooperation potential, as the mediating factor. Indeed the reduced, in magnitude, coefficient on land suitability suggests that the adverse effect of and suitability on the current levels of trust, is partly mitigated by the scope for cooperation. Moreover the coefficient of irrigation potential is positive and significant thereby suggesting that the higher the scope for cooperation, the higher the current levels of trust.

[TABLE 7 HERE]

6.2.3 Robustness

The aim of this section is to establish the robustness of the results. All tables can be found in the Appendix C.

Validity of the Land Suitability Index Similarly to the cross country study, in order to mitigate the concerns about the measure of land suitability, the analysis employs separately the climatic component and the soil component.

Overall, the results in Table C.2 in Appendix C, confirm the robustness of the results to the use of each of the components of the suitability index.

Validity of the Estimation: Model Specification Table C.3 explores the validity of the estimation to the use of a non-linear model and to the model specification. In particular, since the trust variable is binary, Column (1) estimates a logit model employing the full set of controls. The results are quite similar, confirming the robustness of the linear model. Column (2) is estimating the linear model and controls for the ancestry adjusted measure of stratification in the year 1 CE, in order to net out the potential effect of slavery. Column (3) introduces in the analysis a control for the range of land suitability for agriculture, a proxy for trade in the past. Column (4) employs a fixed effect for OPEC countries in order to exclude non-fertile countries that may have very high levels of current income due to the presence of natural resources. Finally Column (5) is eliminating corner solutions by censoring the sample to values of land suitability higher than 0.1.[68] The results are robust to all the different specifications.

[67] The information provided from the WVS is not sufficient to exclude migrants and to repeat the same analysis for the natives only. This approach will be adopted in the next section of the paper, where this information is available for the full sample.

[68] The rational behind these robustness tests is analytically described in the robustness part of the cross country section.

6.3 European Social Survey

The last part of the analysis explores the effect of natural land productivity on the current levels of trust. The aim of this section is to capture directly the portable component of land productivity.[69] To this end, the analysis adopts the strategy of the literature that is exploring the transmission of the cultural traits.

In particular, using a sample of first and second generation migrants from the European Social Surveys, it is established that lower land suitability in the country of origin is associated with higher levels of social capital, thereby suggesting that what is captured is the portable component associated with land productivity.

6.3.1 Empirical Strategy and Data

Empirical Strategy The goal of this section is to examine to what extend cultural parameters embedded in land suitability at the country of origin, are affecting the current levels of trust of first and second generation migrants in a number of European countries.

To conduct this analysis, the fifth wave of the ESS micro dataset is employed. In particular the analysis takes into consideration 5.940 first and second generation migrants, coming from 116 countries of origin, who are residing in 26 European countries. Whereas in the baseline analysis both generations of migrants are chosen, the robustness section explores the intergenerational transmission of cultural traits by focusing exclusively on second generation migrants. The choice of second generation migrants is addressing two concerns: i) First it mitigates concerns about selection of migrants,[70] and ii) practical difficulties associated with the process of assimilation of migrants that could affect their trust levels (e.g. language barriers).

Overall the identifying assumption is that if indeed selection occurred along certain dimensions, it has not occurred in a systematic way that is biasing the coefficient in favor of the results.

The reduced form model is

$$T_{jri} = \alpha_0 + \alpha_1 S_i + \boldsymbol{\alpha}_2 \mathbf{X}_i + \boldsymbol{\alpha}_3 \mathbf{I}_j + \boldsymbol{\alpha}_4 \boldsymbol{\Phi}_r + \varepsilon_{jri} \tag{12}$$

where T is an index of the level of trust of individual j, residing in region r, with ancestry i. S_i proxies for the cultural component embedded in land suitability associated with individual j, living in region r, who is of ancestry i. Notice that S_i is the same for all individuals with the same ancestry i, as it denotes the average level of land suitability for agriculture in the country of origin.

Since the analysis explores the indirect effect of geography on current economic outcomes, a vector of geographical, historical and institutional controls associated with individual j of ancestry i are introduced in the analysis, denoted by X_i. Similar to the reasoning about the portable component of land productivity, the reason for including this type of controls is to capture the portable components

[69] In the previous two sections, in order to indirectly capture the cultural component associated with natural land productivity, the analysis employed the measure of adjusted land productivity.

[70] As already discussed on Luttmer and Singhal (2011) though, who also use the European Social Survey dataset, the fact that migrants from many different countries move to a number of European countries, makes it less likely that selection is a major concern. Moreover, selective migration would attenuate the coefficients, thereby biasing the estimates downward. In the extreme case where all migrants would select their destination country, it would not be feasible to trace any effect of culture.

associated with these controls that could also have an effect on trust, such as legal origin or colonial legacy. This approach relies on the literature that explores how geography shaped ethnic groups today (e.g. Michalopoulos, 2012) and controls for the vector of country of origin geographical as well as institutional controls, thereby capturing indirectly different ethnic characteristics. The controls that are used are the same controls employed in the cross country analysis when testing the third hypothesis, i.e. the effect of land suitability on trust (Table 5, Column (4)).

I_j is a set of individual controls that have been already established in the trust literature to affect the current levels of trust, such as age, gender, education and religious group.

Φ_r is a vector of regional fixed effects, i.e. NUTS 2 regions following the classification of Eurostat. The advantage of the using the fifth wave of ESS is that it traces individuals to the region where they reside and therefore much unobserved heterogeneity can be eliminated by introducing the regional fixed effects.

ε_{jri} is an individual specific error term. The standard errors are corrected for clustering at the dimension of the country-of-ancestry and of the country where the interview was taken.

Consistent with the predictions of the theory, the empirical analysis establishes that land suitability has an adverse effect on the current levels of trust of migrants in Europe even after controlling for the full set of individual and aggregate controls. The results are robust to a number of alternative tests, related to both the cross-country analysis and to the individual level analysis.

The last part of this section explores whether the effect of land suitability on trust is operating via the scope for cooperation. For that purpose it employs as a proxy for cooperation the irrigation potential measure used in the cross country analysis. Introducing into the analysis the irrigation potential measure associated with the country of origin of the migrant, captures the portable component of the scope of cooperation. The positive and significant coefficient of irrigation potential suggests that higher scope for irrigation is associated with higher levels of trust, via the increased incentives it provides for cooperation. Moreover the magnitude of the coefficient of land suitability is reduced, thereby suggesting that the effect of land suitability is partly operating via the reduced incentives to cooperate for the development of agricultural infrastructure.

The Data All the data that are associated with the country of origin and vary only at the ancestry level are the same data employed in the cross-country analysis (land suitability for agriculture, irrigation potential, geographical and institutional controls).

The individual data come from the fifth round of the European Social Survey (2010), a cross sectional survey conducted in a number of European countries. Using the fifth round allows to control for regional fixed effects as it traces the location of the individual at the NUTS 2 level, based on the classification of Eurostat.

The analysis reports attitudes of N=5.940 first and second generation migrants, whose father's originate from 116 countries all over the globe and have migrated in 26 European countries. The survey design weights, as provided by the ESS dataset, have been taken into account.

Respondents are given the statement "Generally speaking, would you say that most people can be trusted, or that you can't be too careful in dealing with people? Please tell me on a score of 0 to 10, where 0 means you can't be too careful and 10 means that most people can be trusted." In order to keep the symmetry with the "Trust" variable employed in the cross country sample, derived from the

WVS, the variable is rescaled on a two-point scale, with the value 0, capturing the values 0-5 of the original variable and the value 1 capturing the values 6-10. Therefore 0 is now reflecting the answer "Strongly Disagree-Disagree" and 1 reflecting the answer "Strongly Agree-Agree".

The ESS also provides information about the age of the respondent, the gender, the religious denomination in which he belongs and the highest level of education achieved.[71]

6.3.2 Empirical Findings

The Impact of Land Suitability on Current Levels of Trust In line with the theory and the empirical findings of the previous section, Table 8 establishes that higher land suitability in the country of ancestry, is associated with lower levels of trust of the individuals and that part of this effect is operating via the scope for cooperation it generates.

In particular Column (1) controls only for regional fixed effects for 286 NUTS 2 regions of Europe, based on the respondents region of residence. Crucially, land suitability can be associated with a large number of cultural traits such as agriculture specific human capital, work ethics and effort etc., that could affect the current levels of trust in many different ways. For this reason, Column (2) introduces the full set of relevant controls that have been employed in the cross-country analysis, thereby netting out any effects associated with these controls. Column (3) introduces in the analysis individual controls that have been established as critical determinants of trust in the related literature, such as the age of the respondent, the gender, the educational level and the religious in which the respondent belongs, if applicable. The negative and significant coefficient of trust suggests that even after controlling for the full set of ethnic and individual controls, land suitability still has a negative effect on migrants' levels of trust.

Finally, Column (4) explores whether the adverse effect of land suitability is operating via the reduced incentives that fertile land provided for cooperation. For this purpose, the analysis introduces irrigation potential, proxying for cooperation potential, as the mediating factor. Indeed the reduced coefficient of land suitability suggests that the adverse effect of land suitability on the current levels of trust, is partly mitigated by the scope for cooperation. Moreover the coefficient of irrigation potential is positive and significant thereby suggesting that the higher the scope for cooperation, the higher the inherited trust.

[TABLE 8 HERE]

6.3.3 Robustness

The aim of this section is to establish the robustness of the results. All tables can be found in the Appendix D, along with a number of scatter plots and summary statistics.

[71] The questionnaire covers 8 broad categories of religious denominations (Roman Catholic, Protestant, Eastern Orthodox, Other Christian denomination, Jewish, Islamic, Eastern Religions, Other non-Christian Religions) and a category of non-religious people.

As to education attained the questionnaire distinguishes seven different levels of education (less than lower secondary, lower secondary, lower tier upper secondary, upper tier upper secondary, advanced vocational, lower tertiary BA level, higher tertiary > MA level).

Validity of the Land Suitability Index In line with the cross country study, to mitigate potential concerns about the measure of land suitability, the analysis employs separately the climatic component and the soil component. Overall, the results in Table D.2 in the Appendix D, confirm the robustness of the results to each of the components of the suitability index.

Robustness to Ethnic Controls This part conducts some robustness analysis with respect to the controls capturing ethnic characteristics. In particular, Column (1) of Table D.3 controls for stratification in the year 1 CE, in order to net out the potential effect of slavery. Column (2) introduces in the analysis a control the range of land suitability for agriculture, a proxy for trade in the past. Column (3) employs a fixed effect for OPEC countries in order to exclude non-fertile countries that may have very high levels of current income due to the presence of natural resources. Column (4) eliminates corner solutions by censoring the sample via the exclusion of migrants whose ancestors land suitability for agriculture was less than 0.1. Reassuringly all the results remain largely unaffected.

Robustness to Individual Controls The aim of this part is to further mitigate concerns that the results are driven by unobserved characteristics such as parental and partners' human capital. Column (1) in Table D.4 of the Appendix D , controls for the level of human capital of the respondents' father as well as his employment status at the age of 14. Column (2) augment the analysis with the same set of controls for the respondents' mother, whereas Column (3) adds the same controls for the respondent's partner. The significance and the magnitude of the coefficient remains largely unaffected thereby reinforcing the presence of an adverse effect of land suitability on the current levels of trust.

Validity of the Estimation Table D.5 explores the validity of the estimation. In particular, since the trust variable is binary, Column (1) estimates a logit model employing the full set of controls. The coefficient on land suitability is somewhat reduced, yet the results are robust under this specification.

Column (2) explores the robustness of the results with respect to the sample. More analytically, in Column (2) all four waves of the ESS for which data on migrants origin are available, are employed. It should be noted that the first wave of the ESS does not provide the country of birth of the father and is thus omitted. Moreover, since the region where the respondent resides is not available in all waves, the analysis in this column employs country fixed effects. The results remain unaffected by the expansion of the sample.

Column (3) replicates the analysis while clustering the standard errors only at the country of origin dimension. The coefficient reduces in magnitude yet the results remain significant at the 10%level.

Intergenerational Transmission of Cultural Traits. As already discussed in the main body of the text, even if selection of migrants would be present, it would operate against the suggested finding. Nevertheless, to further mitigate these concerns, Table D.6 explores the hypothesis by restricting the sample to second generation migrants. In particular, Column (1) includes only the second generation migrants whose fathers' have been born in another country. Column (2) keeps only the second generation migrants whose none of the two parents have been born in the country. The coefficients remain negative and significant at the 1% and 10% respectively. Column (3) replicates the analysis by keeping only first generation migrants whose none of the two parents has been born in the host country. Comparing Columns (2) and (3) where there the coefficient in Column (2) is reduced both in significance and the magnitude of the coefficient in Column (3) suggests that the cultural traits dissipate across the two generations under examination, yet the effect is still tractable.

7 Concluding Remarks

This research argues that land productivity in the past had a persistent effect on social capital and ultimately on the process of industrialization, through its effect on the desirable level of cooperation in the agricultural sector. Importantly, the effect of natural land productivity has been reversed in the process of development. In the Malthusian era, unfavorable land endowment enhanced the economic incentive for cooperation in the creation of agricultural infrastructure that could mitigate the adverse effect of the natural environment. Nevertheless, despite the beneficial effects of cooperation on the intensive margin of agriculture, low land productivity countries lagged behind during the agricultural stage of development. However, as cooperation, and its persistent effect on social capital, have become increasingly important in the process of industrialization, the transition from agriculture to industry among unfavorable land endowment economies was expedited, permitting some of the economies that lagged behind in the agricultural stage of development, to overtake the high land productivity economies in the industrial stage of development.

Variations in natural land productivity and their effect on the emergence of agricultural infrastructure and cooperation had therefore a profound effect on the differential pattern of development across the globe. Interestingly, investment in infrastructure that has been widely advocated as a growth boosting strategy for developing countries spontaneously emerged centuries earlier in an effort to mitigate the adverse effect of natural environment. Unfortunately, however, the beneficial externalities that were associated with these activities in the past are no longer present.

In accordance with the predictions of the theory, empirical evidence suggests that, accounting for a wide variety of potentially confounding factors, a lower level of land suitability in the past is associated with higher levels of contemporary social capital. The result is valid using a wider range of different samples. In particular the analysis exploits exogenous sources of variations in land productivity i) across countries; ii) across individuals within a country, and iii) across migrants of different ancestry within a country. This approaches allow both to establish the intermediate elements of the theory, the mediating factor of cooperation and more importantly to capture the portable component associated with land suitability.

References

Acemoglu, D., Johnson, S. and Robinson, J. A. (2002). Reversal of Fortune: Geography and Institutions in the Making of the Modern World Income Distribution, *The Quarterly Journal of Economics* **117**(4): 1231–1294.

Alesina, A., Devleeschauwer, A., Easterly, W., Kurlat, S. and Wacziarg, R. (2003). Fractionalization, *Journal of Economic Growth* **8**(2): 155–194.

Ashraf, Q. and Galor, O. (2011). Dynamics and Stagnation in the Malthusian Epoch, *American Economic Review* **101**(5): 2003–2041.

Ashraf, Q. and Galor, O. (2011b). Cultural Assimilation, Cultural Diffusion, and the Origin of the Wealth of Nations. NBER Working Paper No. 17640.

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

Ashraf, Q. and Michalopoulos, S. (2013). Climatic Fluctuations and the Diffusion of Agriculture. NBER Working Paper.

Becker, G. S. (1996). *Accounting For Tastes*, Harvard University Press.

Bisin, A. and Verdier, T. (2001). The Economics of Cultural Transmission and the Dynamics of Preferences, *Journal of Economic Theory* **97**(2): 298–319.

Bowles, S. and Gintis, H. (2002). Social Capital and Community Governance, *Economic Journal* **112**(483): 419–436.

Boyd, R. and Richerson, P. J. (1985). *Culture and the Evolutionary Process*, University of Chicago Press, Chicago, IL.

Boyd, R. and Richerson, P. J. (1995). Why Does Culture Increase Human Adaptability?, *Ethology and Sociobiology* **16**(2): 125–143.

Cavalli-Sforza, L. L. and Feldman, M. W. (1981). *Cultural Transmission and Evolution: A Quantitative Approach*, Princeton University Press, Princeton, NJ.

Chanda, A., Cook, C. J. and Putterman, L. (2014). Persistence of Fortune: Accounting for Population Movements, There was no Post-Columbian Reversal, *American Economic Journal: Macroeconomics* **6**(3): 1–28.

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

Easterly, W. and Levine, R. (1997). Africa's Growth Tragedy: Policies and Ethnic Divisions, *Quarterly Journal of Economics* **112**(4): 1203–1250.

Engerman, S. L. and Sokoloff, K. L. (2000). History Lessons: Institutions, Factor Endowments, and Paths of Development in the New World, *Journal of Economic Perspectives* **14**(3): 217–232.

Fenske, J. (2013). Ecology, Trade and States in Pre-Colonial Africa, *Journal of the European Economic Association (forthcoming)* .

Fenske, J. and Kala, N. (2013). Climate, Ecosystem Resilience and the Slave Trade.

Galor, O. (2011). *Unified Growth Theory*, Princeton University Press, Princeton, NJ.

Galor, O. and Moav, O. (2002). Natural Selection and the Origin of Economic growth, *Quarterly Journal of Economics* **117**(4): 1133–1191.

Galor, O., Moav, O. and Vollrath, D. (2009). Inequality in Landownership, the Emergence of Human-Capital Promoting Institutions, and the Great Divergence, *Review of Economic Studies* **76**(1): 143–179.

Galor, O. and Weil, D. N. (2000). Population, Technology, and Growth: From Malthusian Stagnation to the Demographic Transition and Beyond, *American Economic Review* **90**(4): 806–828.

Glaeser, E. L., La Porta, R., Lopez-de-Silanes, F. and Shleifer, A. (2004). Do Institutions Cause Growth?, *Journal of Economic Growth* **9**(3): 271–303.

Greif, A. (1993). Contract Enforceability and Economic Institutions in Early Trade: The Maghribi Traders' Coalition, *American Economic Review* **83**(3): 525–548.

Guiso, L., Sapienza, P. and Zingales, L. (2008). Long Term Persistence. National Bureau of Economic Research.

Hall, R. E. and Jones, C. I. (1999). Why Do Some Countries Produce So Much More Output Per Worker Than Others?, *The Quarterly Journal of Economics* **114**(1): 83–116.

Henrich, J., Boyd, R., Bowles, S., Camerer, C., Fehr, E., Gintis, H. and McElreath, R. (2001). In Search of Homo Economicus: Behavioral Experiments in 15 Small-Scale Societies, *American Economic Review* **91**(2): 73–78.

Huntington, E. (1915). *Civilization and Climate*, Yale Univeristy Press, New Haven.

Jones, E. L. (1981). *The European Miracle: Environments, Economies and Geopolitics in the History of Europe and Asia*, Cambridge University Press, Cambridge, UK.

La Porta, R., Lopez-de-Silanes, F., Shleifer, A. and Vishny, R. W. (1999). The Quality of Government, *Journal of Law, Economics, and Organization* **15**(1): 222–279.

Landes, D. S. (1998). *The Wealth and Poverty of Nations: Why Some Are So Rich and Some So Poor*, W. W. Norton & Co., New York, NY.

Landes, D. S. (2006). Why Europe and the West? Why Not China?, *Journal of Economic Perspectives* **20**(2): 3–22.

Litina, A. (2013). The Geographic Origins of States, *Working Paper* .

Lucas, Jr., R. E. (2002). The Industrial Revolution: Past and Future, *in* R. E. Lucas, Jr. (ed.), *Lectures on Economic Growth*, Harvard University Press, Cambridge, MA, pp. 109–188.

McEvedy, C. and Jones, R. (1978). *Atlas of World Population History*, Penguin Books Ltd., New York, NY.

Michalopoulos, S. (2012). The origins of ethnolinguistic diversity, *American Economic Review* **102**(4): 1508–39.

Michalopoulos, S., Naghavi, A. and Prarolo, G. (2013). Trade and Geography in the Origins and Spread of Islam, *NBER w18438* .

Mokyr, J. (1990). The Lever of Riches: Technological Creativity and Technological Progress.

Myrdal, G. (1968). Asian Drama: An Inquiry Into the Poverty of Nations.

North, D. C. and Thomas, R. P. (1973). *The Rise of the Western World: A New Economic History*, Cambridge University Press, Cambridge, UK.

Putnam, R. D. (2000). *Bowling Alone: The Collapse and Revival of American Community*, Simon and Schuster.

Putterman, L. and Weil, D. N. (2010). Post-1500 Population Flows and the Long-Run Determinants of Economic Growth and Inequality, *Quarterly Journal of Economics* **125**(4): 1627–1682.

Ramankutty, N., Foley, J. A., Norman, J. and McSweeney, K. (2002). The Global Distribution of Cultivable Lands: Current Patterns and Sensitivity to Possible Climate Change, *Global Ecology and Biogeography* **11**(5): 377–392.

Rodrik, D., Subramanian, A. and Trebbi, F. (2004). Institutions Rule: The Primacy of Institutions Over Geography and Integration in Economic Development, *Journal of Economic Growth* **9**(2): 131–165.

Sachs, J. D. and Malaney, P. (2002). The Economic and Social Burden of Malaria, *Nature* **415**(6872): 680–685.

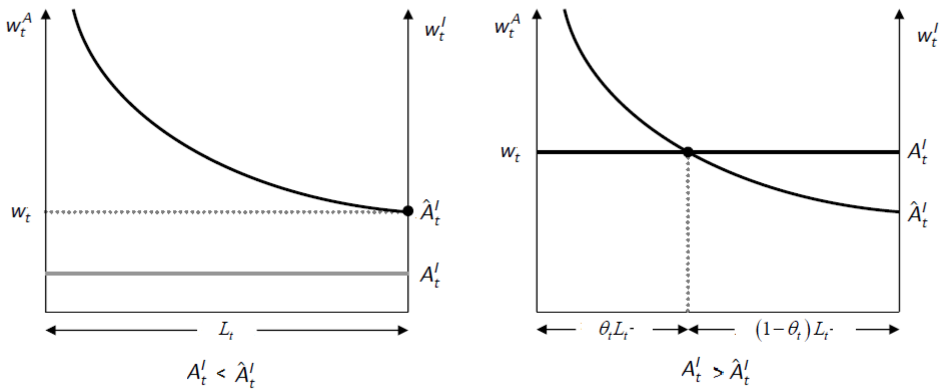
Spolaore, E. and Wacziarg, R. (2013). Long-Term Barriers to Economic Development.

Tabellini, G. (2008). Presidential Address: Institutions and Culture, *Journal of the European Economic Association* **6**(2-3): 255–294.

Weber, M. (1905). *The Protestant Ethic and the Spirit of Capitalism*, Translated by T. Parsons, and A. Giddens, 1930. Allen & Unwin, London, UK.

Weber, M. (1922). *The Religion of China: Confucianism and Taoism*, Translated and edited by H. H. Gerth, 1951. Free Press, Glencoe, IL.

Tables and Figures



Only Sector A Active | Both Sectors A and I Active

Figure 1: The Labor Market Equilibrium

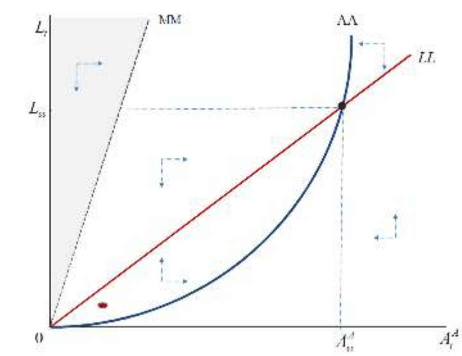


Figure 2: Agricultural Stage of Development

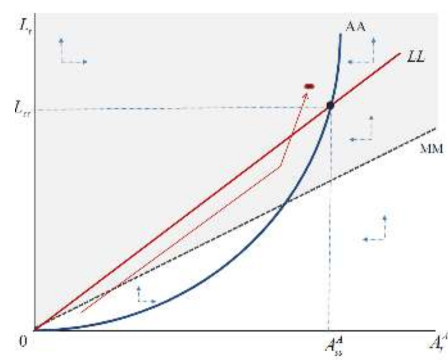


Figure 3: Industrialization and Take-off

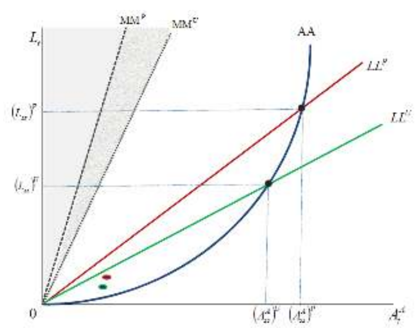


Figure 4: Increase in Land Endowment

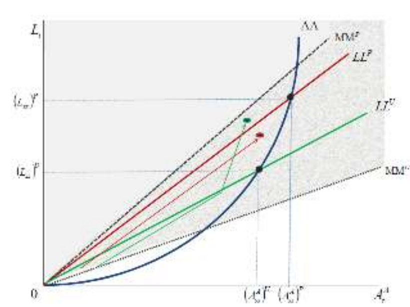


Figure 5: Overtaking in Industrialization Era

Table 1: Land Suitability and Comparative Development in the Agricultural Stage

	(1)	(2)	(3)	(4)
	Log Population Density in 1500 CE			
Land Suitability	2.308***	1.176**	1.019**	0.978**
	(0.532)	(0.496)	(0.462)	(0.445)
Log Average Ruggedness		0.195	0.284**	0.293**
		(0.153)	(0.142)	(0.133)
Log Average Elevation		0.032	-0.088	-0.125
		(0.144)	(0.132)	(0.117)
Log Absolute Latitude		-0.440**	-0.327**	-0.398**
		(0.172)	(0.154)	(0.154)
Log %Land within 100 km Water		2.234***	2.237***	2.075***
		(0.655)	(0.590)	(0.568)
Log Years Since Neolithic			1.083***	0.855***
			(0.231)	(0.241)
Log Dist. to Frontier in 1500 CE				-0.191***
				(0.039)
St. Beta of Suit.	0.353***	0.180**	0.156**	0.149**
Continental Dummies	Yes	Yes	Yes	Yes
Landlocked-Island Dummy	No	Yes	Yes	Yes
Observations	130	130	130	130
R-square	0.490	0.621	0.672	0.700

Summary: This table establishes the significant positive effect of land suitability on population density in the year 1500, while controlling for average ruggedness, average elevation, absolute latitude, access to navigable waterways, years since the Neolithic transition, distance from the nearest technological frontier and fixed effects for landlocked country, island, and unobserved continental fixed effects. Notes: (i) Log land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration, as well as ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (ii) the set of continent dummies includes a fixed effect for Africa, the Americas, Australia, Europe and Sub-Saharan Africa; (iii) a single continent dummy is used to represent the Americas, which is natural given the historical period examined; (iv) robust standard error estimates are reported in parentheses; (v) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table 2: Land Suitability and Comparative Development in the Industrial Era

	(1)	(2)	(3)	(4)	(5)	(6)
	Log Per Capita Av, Income 1990-2000					YSI
Adj Land Suit.	-1.707***	-2.027***	-1.863***	-1.743***		
	(0.610)	(0.619)	(0.598)	(0.576)		
Land Suit.					-1.249*	-35.310**
					(0.727)	(14.080)
Log Av. Ruggedness		-0.168	-0.169	-0.086	-0.032	-5.444
		(0.154)	(0.144)	(0.145)	(0.198)	(8.157)
Log Av. Elevation		0.298**	0.184	-0.092	-0.128	7.115
		(0.143)	(0.139)	(0.132)	(0.231)	(8.156)
Log % Land 100 km Water		1.709**	0.672	0.040	-0.546	56.72**
		(0.749)	(0.681)	(0.641)	(0.885)	(27.59)
Log Absolute Latitude		0.278*	-0.004	0.100	-0.223	-0.796
		(0.160)	(0.164)	(0.160)	(0.227)	(4.037)
Log Adj Years Since Neol.		0.126	0.449	0.481		
		(0.373)	(0.321)	(0.371)		
Log Years Since Neol.					0.034	-1.449
					(0.359)	(9.528)
Ethn. Fract.			-1.053**	-0.556	-0.794	
			(0.497)	(0.467)	(0.524)	
Polity IV			0.184***	0.107***	0.108**	
			(0.0361)	(0.035)	(0.047)	
Disease Environment			-0.0165*	-0.011	-0.021	
			(0.00935)	(0.010)	(0.014)	
Log Schooling				0.410***	0.219	
				(0.141)	(0.201)	
St. Beta of Suit.	-0.223***	-0.265***	-0.243***	-0.227***	-0.170*	-0.258**
Continental Dummies	Yes	Yes	Yes	Yes	Yes	Yes
Landlock.-Island	No	Yes	Yes	Yes	Yes	Yes
Leg. Origin-Col -Relig.	No	No	No	Yes	Yes	Yes
Native Pop. >0.80	No	No	No	No	Yes	Yes
Observations	132	132	132	132	89	49
R-square	0.508	0.602	0.705	0.808	0.855	0.818

Summary: This table establishes the significant negative effect of adjusted land suitability on per capita income in the year 2000 as well as on the timing of industrialization, while controlling for average ruggedness, average elevation, access to navigable waterways, absolute latitude, adjusted years since the Neolithic transition, ethnolinguistic fractionalization, quality of institutions, disease environment, average enrollment ratio and fixed effects for landlocked country, island, legal origin, European colony, major religion shares and unobserved continental fixed effects. Column (5) restricts the sample to countries with a fraction of native population higher than 80 percent and is employing a measure of land suitability as opposed to adjusted land suitability, as an alternative approach to capture the social component associated with land suitability, namely the social capital being the outcome of cooperation in agriculture. Column (6) employs years since industrialization as the dependent variable

Notes: (i) Log land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration, as well as ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (ii) adjusted land suitability is the cross-country weighted average of the land suitability measure. The weight associated with a given country represents the fraction of the year 2000 population that can trace its ancestral origins to the given country in the year 1500; (iii) the set of continent dummies in Columns (1)-(4) includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (iv) the set of legal origins dummies in columns (4) and (5) includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (v) the set of major religion shares dummies in columns (4) and (5) includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (vi) the set of European colony dummies in columns (4) and (5) includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (vii) years since industrialization refer to the number of years elapse since the share of agriculture became less than 30% of the total economy; (viii) robust standard error estimates are reported in parentheses; (ix) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table 3: Cooperation in the Agricultural Stage-Irrigation Potential and Actual Irrigation

	(1)	(2)	(3)	(4)	(5)
	Log Irrigation Potential				Log Actual Irrigation
Land Suitability	-1.745***	-1.983***	-2.023***	-2.047***	-2.421**
	(0.527)	(0.576)	(0.593)	(0.594)	(1.075)
Log Average Ruggedness		0.219	0.227	0.237	0.035
		(0.170)	(0.174)	(0.173)	(0.400)
Log Average Elevation		0.183	0.164	0.146	0.823*
		(0.136)	(0.138)	(0.132)	(0.422)
Log Absolute Latitude		0.134	0.109	0.059	0.225
		(0.619)	(0.614)	(0.602)	(0.482)
Log %Land within 100 km Water			-0.034	-0.069	6.398***
			(0.128)	(0.133)	(1.580)
Log Years Since Neolithic			0.187	0.057	1.447
			(0.285)	(0.284)	(1.151)
Log Distance to Frontier in 1500 CE				-0.091*	-0.081
				(0.053)	(0.136)
St. Beta of Suit.	-0.327***	-0.372***	-0.379***	-0.384***	-0.344**
Continental Dummies	Yes	Yes	Yes	Yes	Yes
Landlocked-Island Dummy	No	Yes	Yes	Yes	Yes
OECD Member in 1985	Yes	Yes	Yes	Yes	No
Native Population >0.80	No	No	No	No	Yes
Observations	130	130	130	130	42
R-squared	0.253	0.380	0.383	0.392	0.752

Summary: This table establishes the significant adverse effect of land suitability on the scope for cooperation, as proxied by the irrigation potential and on actual cooperation as proxied by actual irrigation (Column 5), while controlling for average ruggedness, average elevation, absolute latitude, access to navigable waterways, years since the Neolithic transition, distance from the nearest technological frontier in the year 1500, and fixed effects for landlocked country, island, and unobserved continental fixed effects. Column (5) restricts the sample to a subset of countries with a fraction of native population higher than 80% and excludes early industrialized countries, ensuring that it is the adverse effect of land that is positively affecting cooperation in the year 1900 and not early industrialization or the specific human capital of the migrant population. Notes: (i) Log irrigation potential, employed in Columns (1)-(4), measures the fraction of land that becomes marginally arable upon the use of irrigation; (ii) data on actual irrigation, used only in Column (5), capture the area equipped for irrigation in the year 1900 CE. The measure is expressed as the log ratio of irrigated land over arable land. This dataset excludes countries that were not a member of the OECD in 1985, in an attempt to exclude the countries that had already industrialized in 1900. It also excludes countries with native population less than 80%; (iii) log land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate and soil suitability for cultivation; (iv) the set of continent dummies includes a fixed effect for Africa, the Americas, Australia, Europe and Sub-Saharan Africa; (v) a single continent dummy is used to represent the Americas, which is natural given the historical period examined; (vi) robust standard error estimates are reported in parentheses; (vii) *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

Table 4: Proxies of Cooperation in the Agricultural Stage

	(1)	(2)	(3)
	Exch. in Year 1	Comm. in Year 1	Transp. in Year 1
Land Suitability	-0.402**	-0.445**	-0.342***
	(0.161)	(0.196)	(0.119)
Log Average Ruggedness	0.089*	0.080	0.033
	(0.048)	(0.055)	(0.037)
Log Average Elevation	-0.076*	-0.057	-0.023
	(0.040)	(0.048)	(0.036)
Log Absolute Latitude	0.031	0.082*	0.044
	(0.039)	(0.048)	(0.039)
Log %Land within 100 km Water	-0.170	-0.092	-0.055
	(0.222)	(0.268)	(0.182)
Log Years Since Neolithic	0.243***	0.275***	0.244***
	(0.080)	(0.095)	(0.071)
Log Distance to Frontier in 1 CE	-0.043***	-0.054***	-0.030***
	(0.013)	(0.016)	(0.010)
St. Beta of Suit.	-0.199**	-0.208**	-0.176***
Continental Dummies	Yes	Yes	Yes
Landlocked-Island Dummy	Yes	Yes	Yes
Observations	130	130	130
R-square	0.561	0.405	0.714

Summary: This table establishes the significant adverse effect of land suitability on cooperation, as proxied by the medium of exchange, communication and transportation in the year 1 CE, while controlling for log land suitability diversity, average ruggedness, average elevation, absolute latitude, access to navigable waterways, years since the Neolithic transition, distance from the nearest technological frontier in the year 1, and fixed effects for landlocked country, island, and unobserved continental fixed effects. Notes: (i) Log land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate and soil suitability for cultivation; (ii) the measures of medium of exchange, communication and transportation and in the year 1 CE are reported on a 3-point scale, as evaluated by various anthropological and historical sources; (iii) the land suitability diversity measure is based on the distribution of a land suitability index across grid cells within a country; (iv) the set of continent dummies includes a fixed effect for Africa, the Americas, Australia, Europe and Sub-Saharan Africa; (v) a single continent dummy is used to represent the Americas, which is natural given the historical period examined; (vi) robust standard error estimates are reported in parentheses; (vii) *** denotes statistical significance at the 1% level, ** at the 5% level, and * at the 10% level, all for two-sided hypothesis tests.

Table 5: Adjusted Land Suitability and Trust

	(1)	(2)	(3)	(4)	(5)	(6)
			Trust			Civil Dist.
Adj. Land Suit.	-0.358***	-0.384***	-0.403***	-0.305***		0.218***
	(0.068)	(0.084)	(0.086)	(0.087)		(0.075)
Land Suitability					-0.359***	
					(0.092)	
Log Ruggedness		0.007	0.009	-0.023	-0.043	-0.018
		(0.032)	(0.033)	(0.034)	(0.044)	(0.024)
Log Elevation		-0.024	-0.024	0.0004	0.009	0.048
		(0.043)	(0.044)	(0.038)	(0.049)	(0.030)
Log %Land within 100 km Water.		0.068	0.059	0.135	0.212	-0.025
		(0.115)	(0.123)	(0.115)	(0.158)	(0.115)
Log Absolute Lat.		0.016	0.008	0.036	0.022	0.031
		(0.027)	(0.028)	(0.031)	(0.058)	(0.026)
Log Years to Neol. (Adj/Unadj.)		0.062	0.058	0.174*	0.188	-0.081
		(0.081)	(0.076)	(0.102)	(0.113)	(0.077)
Ethn. Fract.			-0.158*	-0.005	0.116	0.084
			(0.089)	(0.093)	(0.126)	(0.072)
Polity IV			0.0017	-0.012*	-0.00950	0.005
			(0.005)	(0.006)	(0.009)	(0.004)
Disease Environment			0.001	0.001	0.0004	0.0007
			(0.001)	(0.002)	(0.002)	(0.001)
Log Schooling				0.003	0.0331	-0.017
				(0.032)	(0.040)	(0.025)
St. Beta of Suit.	-0.541***	-0.579***	-0.608***	-0.608***	-0.595***	0.540***
Continental Dum.	Yes	Yes	Yes	Yes	Yes	Yes
Land.-Island	No	Yes	Yes	Yes	Yes	Yes
Leg. Or.-Col.-Relig.	No	No	No	Yes	Yes	Yes
Native Pop. >0.80	No	No	No	No	Yes	No
Observations	70	70	70	70	51	53
R-square	0.412	0.540	0.580	0.748	0.794	0.820

Summary: This table establishes the significant adverse effect of adjusted land suitability on the current level of generalized trust, while controlling for geography, adjusted years since the Neolithic transition, ethnolinguistic fractionalization, quality of institutions, disease environment, and unobserved continental fixed effects. Column (5) restricts the sample to countries with a fraction of native population higher than 80% and is employing the measure of unadjusted land productivity, as an alternative approach to capture the portable component of land productivity. Column (6) employs an alternative measures of social capital namely distrust in civil servants. Notes: (i) Generalized levels of trust captures the fraction of total respondents within a given country, that answer that "most people can be trusted " in the question "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people". Civil distrust captures distrust in civil servants; (ii) log land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration, as well as ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (iii) adjusted land suitability is the cross-country weighted average of the land suitability measure. The weight associated with a given country represents the fraction of the year 2000 population that can trace its ancestral origins to the given country in the year 1500; (iv) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (v) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (vi) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (vii) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (viii) robust standard error estimates are reported in parentheses; (ix) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table 6: Land Suitability and Trust: The Mediating Factor of Cooperation

	(1)	(2)	(3)	(4)
			Trust	
Adj. Land Suit	-0.283**	-0.217**		
	(0.109)	(0.097)		
Land Suit			-0.307***	-0.233**
			(0.103)	(0.087)
Adj. Irrig. Potent.		0.142*		
		(0.083)		
Irrrig. Potent.				0.128*
				(0.072)
Log Ruggedness	-0.026	-0.037	-0.049	-0.066
	(0.036)	(0.037)	(0.043)	(0.044)
Log Elevation	0.003	0.012	0.026	0.049
	(0.040)	(0.042)	(0.048)	(0.048)
Log %Land within 100 km Water.	0.035	0.044	0.026	0.030
	(0.031)	(0.033)	(0.060)	(0.061)
Log Absolute Lat.	0.125	0.138	0.229	0.246
	(0.118)	(0.114)	(0.169)	(0.160)
Log Years to Neol. (Adj/Unadj.)	0.147	0.108	0.141	0.076
	(0.124)	(0.107)	(0.128)	(0.111)
Ethn. Fract.	0.023	0.043	0.165	0.168
	(0.093)	(0.090)	(0.130)	(0.109)
Polity IV	-0.011*	-0.009	-0.009	-0.007
	(0.006)	(0.006)	(0.009)	(0.009)
Disease Environment	0.001	0.002	0.0002	0.0007
	(0.002)	(0.002)	(0.002)	(0.002)
Log Schooling	0.008	-0.005	0.049	0.030
	(0.034)	(0.031)	(0.037)	(0.032)
St. Beta of Suit.	-0.419**	-0.321**	-0.500***	-0.379**
Continental Dum.	Yes	Yes	Yes	Yes
Land.-Island	Yes	Yes	Yes	Yes
Leg. Or.-Col.-Relig.	Yes	Yes	Yes	Yes
Native Pop. >0.80	No	No	Yes	Yes
Observations	67	67	49	49
R-square	0.744	0.768	0.799	0.825

Summary: This table establishes that the adverse effect of ancestry adjusted land suitability on current levels of trust partly operates via the reduced incentives for cooperation associated with fertile land, while controlling for geography, adjusted years since the Neolithic transition, ethnolinguistic fractionalization, institutions, disease environment, and unobserved continental fixed effects. Columns (3) and (4) restrict the sample to countries with a fraction of native population > 80% and employ the measure of unadjusted land productivity. Notes: (i)Trust captures the fraction of total respondents that answer that "most people can be trusted " in the question "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people"; (ii) log land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration, as well as ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (iii) irrigation potential measures the fraction of land that becomes marginally arable upon the use of irrigation; (iv) adjusted land suitability is the cross-country weighted average of the land suitability measure. The weight associated with a given country represents the fraction of the year 2000 population that can trace its ancestral origins to the given country in the year 1500; (v) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (vi) the set of legal origins dummies includes a fixed effect for British, French, German, Scandinavian and Socialist legal origin; (vii) the set of major religion shares dummies includes a fixed effect for Catholic, Muslim, Protestant, and other religious shares; (viii) the set of European colony dummies includes a fixed effect for British, French, Spanish, other European and non-colony; (ix) robust standard error estimates are reported in parentheses; (x) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table 7: Land Suitability and Trust-WVS Sample

	(1)	(2)	(3)	(4)	(5)
			Trust		
Adj. Land Suit	-0.344***	-0.303**	-0.352***		-0.318***
	(0.097)	(0.148)	(0.103)		(0.097)
Land Suit.				-0.172***	
				(0.021)	
Adj. Irrrig. Potent.					0.057**
					(0.025)
Log Ruggedness		0.028	0.030	-0.013***	0.027
		(0.034)	(0.027)	(0.004)	(0.030)
Log Elevation		-0.049	-0.074**	-0.031***	-0.072*
		(0.042)	(0.036)	(0.004)	(0.039)
Log % Land within 100 km Water		0.055	0.053	0.202***	0.051
		(0.091)	(0.081)	(0.018)	(0.085)
Log Absolute Lat		-0.0294	-0.016	0.043***	-0.016
		(0.025)	(0.021)	(0.004)	(0.021)
Log Adj. Years to Neol.		0.192**	0.200***		0.182***
		(0.089)	(0.072)		(0.062)
Log Years to Neol.				0.155***	
				(0.019)	
Ethn. Fract.		-0.033	0.090	0.391***	0.091
		(0.116)	(0.114)	(0.021)	(0.109)
Polity IV		-0.014**	-0.020***	-0.020***	-0.019***
		(0.0075)	(0.006)	(0.0009)	(0.005)
Disease Environment		0.002	0.0007	0.004***	0.0008
		(0.002)	(0.001)	(0.0002)	(0.001)
Age			0.0005*	-0.00008	0.0005*
			(0.0003)	(0.00005)	(0.0003)
Continental F.E	Yes	Yes	Yes	Yes	Yes
Geography-Institutional Dummies	No	Yes	Yes	Yes	Yes
Gender	No	No	Yes	Yes	Yes
Religion	No	No	Yes	Yes	Yes
Education	No	No	Yes	Yes	Yes
Observations	86498	86498	86498	63035	86498
R-square	0.068	0.107	0.121	0.097	0.121

Summary: This table establishes the adverse effect of ancestry adjusted land suitability on the current levels of trust of the average individual. The analysis controls for a full set of geographic and institutional controls, as well as for a number of individual characteristics such as age, education, gender and religious group. Column (4) restricts the sample to native population and uses the unadjusted measure of land suitability. Column (5) introduces the mediating factor of the scope for irrigation (used as a proxy for the scope of cooperation). Notes: (i) The "Trust" index is the response to the question whether most people can be trusted. The index takes values 0-1 with 1 indicating more trust; (ii) land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration, as well as ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (iii) irrigation potential measures the fraction of land that becomes marginally arable upon the use of irrigation; (iv) adjusted land suitability is the cross-country weighted average of the land suitability measure. The weight associated with a given country represents the fraction of the year 2000 population that can trace its ancestral origins to the given country in the year 1500; (v) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (vi) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (vii) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (viii) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (ix) robust standard error clustered at the country level and at the religious denomination level are reported in parentheses; (x) the variable on religious group is very detailed (90 religious groups are reported) and is thus used as a proxy for ethnic groups that are not available in the WVS; (xi) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table 8: Land Suitability and Trust of Second Generation Migrants

	(1)	(2)	(3)	(4)
			Trust	
Land Suit (A)	-0.036***	-0.078***	-0.088***	-0.082***
	(0.011)	(0.015)	(0.015)	(0.015)
Irrrig. Potent.(A)				0.021***
				(0.006)
Log Ruggedness (A)		0.012*	0.023***	0.023***
		(0.006)	(0.005)	(0.006)
Log Elevation (A)		-0.011	-0.016**	-0.016**
		(0.008)	(0.007)	(0.007)
Log % Land within 100 km Water		0.055***	0.051***	0.051***
		(0.021)	(0.018)	(0.018)
Log Absolute Lat (A).		0.019***	0.008	0.007
		(0.007)	(0.007)	(0.007)
Log Years to Neol. (A)		0.044***	0.039***	0.034***
		(0.009)	(0.009)	(0.009)
Ethn. Fract. (A)		-0.081***	-0.095***	-0.100***
		(0.015)	(0.014)	(0.013)
Polity IV (A)		-0.001	-0.003**	-0.002**
		(0.001)	(0.001)	(0.001)
Disease Environment (A)		0.002***	0.002***	0.002***
		(0.0002)	(0.0002)	(0.0002)
Age			0.0002**	0.0002**
			(0.00009)	(0.00009)
Regional F.E	Yes	Yes	Yes	Yes
Geography-Institutional Dummies (A)	No	Yes	Yes	Yes
Gender	No	No	Yes	Yes
Religion	No	No	Yes	Yes
Education	No	No	Yes	Yes
Observations	5940	5940	5940	5940
R-square	0.103	0.111	0.130	0.130

Summary: This table establishes the adverse effect of adjusted land suitability on the current levels of trust of first and second generation migrants. Column (4) introduces the mediating factor of scope for irrigation (used as a proxy for the scope of cooperation) and suggests that this effect is partly operating via the reduced incentives for cooperation. The analysis controls for geography, adjusted years since the Neolithic transition, ethnic fractionalization, quality of institutions, disease environment, schooling, and fixed effects for legal origin, dominant religion shares, European colony, individual controls (age, gender, education, religious group) and unobserved regional fixed effects. Notes: (i) The "Trust" index is the response to the question whether most people can be trusted. The index takes values 0-1 with 1 indicating more trust; (ii) land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration, as well as ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (iii) irrigation potential measures the fraction of land that becomes marginally arable upon the use of irrigation; (iv) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (v) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (vi) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (vii) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (viii) (A) denotes that the controls are derived from the ancestry of the respondent; (xi) the set of regional dummies includes a fixed effect for 251 NUTS 2 regions; (x) robust standard error estimates are reported in parentheses; (xi) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Natural Land Productivity, Cooperation and Comparative Development

Anastasia Litina*

August 15, 2014

*University of Luxembourg, Faculty of Law, Economics and Finance, 148, Avenue de la Faiencerie, L - 1511 Luxembourg (e-mail: anastasia.litina@uni.lu)

Appendices

A Elements of the Proposed Mechanism: Evidence

The theory is based on an underlying mechanism consisting of five intermediate elements that account for the differential development of economies and their asymmetric transition from an epoch of Malthusian stagnation to a regime of sustained economic growth.

The first element suggests that less productive places had more incentives to develop agricultural infrastructure, that could mitigate the adverse effect of the natural environment. Resources allocated to the development of agricultural infrastructure enhanced productivity indirectly, but came on the account of direct agricultural production. Hence, the opportunity cost of the construction of agricultural infrastructure was higher in more productive places and therefore investment in infrastructure was more beneficial in places with unfavorable land endowment.

The second element of the mechanism establishes that the development of public agricultural infrastructure generated an incentive for cooperation. Since agricultural infrastructure is primarily a public good, collective action is essential for its optimal provision, in light of the incentive of individuals to minimize the allocation of their private resources to the production of public goods. Moreover, since collective action is conducive for cooperation, places with lower natural land productivity generated higher incentives for cooperation.

Traditional forms of agricultural infrastructure include, among others, irrigation systems, storage facilities and drainage systems. In Egypt, as early as 4000 years ago, surface irrigation was used, exploiting the annual flooding of the Nile (Adams, 1965; Butzer, 1976). Surface irrigation was also exploited in Mesopotamia and China, and canals were built to funnel larger volumes of water to more distant fields. Finally in Western Europe, the first large-scale irrigation was developed by the Romans, who built aqueducts to channel water from the mountains exploiting gravity as well as reservoirs to store the channelled water. Other forms of agricultural infrastructure to enhance land productivity, included drainage and storage technologies. Ancient civilizations like the Egyptians, the Greeks, and the Chinese developed drainage systems, technologies that were further advanced by the Romans. In England, land drainage was initiated in the tenth century, in an attempt to re-claim areas adjoining the North Sea. By the late eighteenth and nineteenth centuries, the vast majority of available land had already been reclaimed by surface draining of lakes, marshes and fens. In addition, draining and diking was inaugurated by the Dutch in the 16th century to increase the fraction of arable land. Similarly, drainage in the United States took place primarily within two developmental periods, during 1870-1920 and 1945-1960, in an attempt to enlarge the fraction of land capable of agricultural production. Overall, an estimated region of 110 million acres of agricultural land in the United States, is claimed to have benefited from artificial drainage as of 1985. At least 70 percent of this drained land is allocated to crops, 12 percent to pasture, 16 percent to woodland, and 2 percent in miscellaneous uses.

Storage technologies were also widespread. Prior to industrialization in England, the cost of storage was overwhelming from the viewpoint of individual farmers (McCloskey and Nash, 1984). To mitigate the risk associated with agricultural production, collective action, either in the form of risk sharing or by developing communal facilities, was often adopted (Stead, 2004). Similarly, storage facilities were developed at the community level in Sweden in an attempt to cope with adverse climatic conditions, and had a significant effect on grain banks (magasins) during 18th and 19th century (Berg, 2007).

Importantly, all major forms of agricultural infrastructure were associated with large-scale cooperation at the community or at the state level, and particularly in early societies, collective action and broad participation was required to undertake and construct the necessary infrastructure. Natural experiments that took place in recent years in developing countries, found evidence that after the development of irrigation infrastructure, the average yearly production for a bad year exceeded the average yearly production of a good year prior to the usage of irrigation (Bardhan (2000) for communities in rural India, Uphoff and Wijayaratna (2000) for Sri-Lanka, and Ostrom (2000) for Nepal). In all cases, large scale cooperation at the community level was developed, thereby strengthening the communal ties.

The third element of the mechanism advances the hypothesis that the emergence of social capital can be traced to the level of cooperation in the agricultural sector, in the creation of infrastructure that could mitigate the adverse effect of the natural environment. Indeed, according to the Social Structural Approach, differences in the manifestation of social capital are driven by the social interactions in which individuals are involved (Bowles and Gintis, 2002). Similarly, the emergence and prevalence of norms that facilitate fruitful interaction (such as norms of mutual trust) can be traced to the need for large-scale cooperation (Henrich et al., 2001).[A.1] Relatedly, Putnam (2000) suggests that social capital is primarily embedded in networks of reciprocal social relations. Putnam et al. (1993) in their influential study about social capital, studied the cases of Northern and Southern Italy. They argue that in Northern Italy, where the structure of the society was more civic, a higher level of social capital was obtained, ultimately leading to higher economic prosperity. Regions in Southern Italy were faced with a more hierarchical structure which resulted in underdevelopment of social capital that eventually led to inferior economic outcomes.

The fourth element of the mechanism suggests that social capital has persisted over time via different transmission mechanisms. Evolutionary theories, advance the "social learning" hypothesis, according to which norms and cultural traits that survive and are transmitted across generations are the ones that contribute to individual and group survival (Boyd and Richerson, 1985, 1995; Cavalli-Sforza and Feldman, 1981). The cultural transmission hypothesis suggests that preferences, beliefs and norms are intergenerationally transmitted via socialization processes, such as social imitation and learning (Bisin and Verdier, 2001). There are different mechanisms through which social capital can be intergenerationally transmitted, such as imitation or deliberate inculcation by parents. The empirical literature documents a strong correlation in the propensity to trust between parents and children (Katz and Rotter, 1969; Dohmen et al., 2011). The persistence of trust between second-generation immigrants and current inhabitants of the country of origin, has also been explored in the literature (Borjas, 1992; Uslaner, 2002; Algan and Cahuc, 2010).

Finally, political institutions are argued to have a crucial role in the transmission of social capital across generations (Tabellini, 2008; Guiso et al., 2008). Tabellini (2008) advances the hypothesis that regions that had developed better institutions and imposed more checks and balances on the executive, experienced higher levels of trust in contemporary societies. Guiso et al. (2008) attribute

[A.1] In the context of a cross-cultural study, Henrich et al. (2001) conducted ultimatum, public good, and dictator game experiments, with subjects from fifteen small-scale societies, exhibiting a wide variety of economic and cultural conditions. They find that, in societies where the payoff from extra-familial cooperation in economic activity is higher, subjects display significantly higher levels of cooperation in the experimental games.

current differences in social capital between the Northern and the Southern regions of Italy to the fact that the Northern regions developed free city-states in the Middle Ages, as opposed to the hierarchical structures that were developed in the South. Thus they conclude that at least 50% of the North-South gap in social capital is due to the lack of a free city state experience in the South. Nunn and Wantchekon (2011) trace the origins of mistrust in contemporary Africa to the impact of the transatlantic slave trade.

The fifth element of the mechanism suggests that social capital is complementary not only to the agricultural but also to the industrial sector. It is designed to capture the importance of social capital in promoting socioeconomic transitions to an industrialized regime. Evidence suggests, that economic activities such as commercial transactions, entrepreneurship, innovation, accumulation of human capital, credit markets and enforcement of contracts, all of which are building blocks of the industrial sector, are further enhanced and boosted in societies with high levels of social capital and trust. As Arrow (1972) put it: "Virtually every commercial transaction has within itself an element of trust, certainly any transaction conducted over a period of time. It can be plausibly argued that much of the economic backwardness in the world can be explained by the lack of mutual confidence". Knack and Keefer (1997) argue that trust and civic cooperation are associated with stronger economic performance (better enforcement of contracts, innovation, credit markets, human capital accumulation). Putnam (2000) advances the hypothesis that networks of mutual obligation may encourage entrepreneurship, whereas Greif (1993) provides evidence that large networks make it more likely for a potential entrepreneur to mobilize resources to start a new enterprise and find the necessary suppliers, customers, and employees.

B The Full Version of the Model

Consider a perfectly competitive overlapping-generations economy in the process of development where economic activity extends over infinite discrete time. To capture the endogenous transition from agriculture to industry the analysis will employ a unified growth theory framework (Ashraf and Galor, 2011b; Galor, 2011).

B.1 Production

In every period, a single homogenous good is being produced either in an agricultural sector or in both an agricultural and an industrial sector. In early stages of development, the economy operates exclusively in the agricultural sector, whereas the industrial sector is not economically viable. However, since productivity grows faster in the industrial sector, it ultimately becomes economically viable and therefore, in later stages of development, the economy operates in both sectors.

B.1.1 Production in the Agricultural and Industrial Sectors

The output produced in the agricultural sector in period t, Y_t^A, is determined by land, X_t, and labor employed in the agricultural sector, L_t^A, as well as by aggregate agricultural productivity. Aggregate agricultural productivity comprises three components: the natural level of land productivity, $\xi \in (0,1)$, acquired productivity (based on learning by doing), A_t^A, and public infrastructure, G_t.

The production is governed by a Cobb-Douglas, constant-returns-to-scale production technology given by

$$Y_t^A = \left[\xi A_t^A + G_t\right]^a X^a \left[L_t^A\right]^{1-a}; \quad a \in (0,1), \tag{B.1}$$

where the supply of land is constant over time and is normalized to $X = 1$.[B.1] Hence, natural land productivity, ξ, is complemented by acquired productivity, A_t^A.

The labor force in the agricultural sector is allocated between the production of public infrastructure and the direct production of final output. A fraction $(1 - z_t)$ of the labor force employed in the agricultural sector is employed in the production of the final output, whereas the remaining fraction z_t is devoted to the production of public infrastructure, G_t. Hence, the output of public infrastructure is

$$G_t = \frac{z_t L_t^A}{\xi}, \tag{B.2}$$

reflecting the supposition that the marginal productivity of labor devoted to the development of agricultural infrastructure is higher in less productive places.[B.2]

[B.1] For the emergence of a stable Malthusian equilibrium in the agricultural stage of development, diminishing returns to labor, implied by the presence of a fixed factor, is essential.

[B.2] The substitutability between natural land productivity and agricultural infrastructure is further explored in the empirical section of the paper. In particular, it will be established that higher land suitability for agriculture is associated with lower incentives to invest in agricultural infrastructure.

Hence the production of agricultural output is

$$Y_t^A = \left[\xi A_t^A + \frac{1}{\xi} z_t \theta_t L_t\right]^a X^a \left[(1 - z_t)\,\theta_t L_t\right]^{1-a}, \tag{B.3}$$

where θ_t is the faction of labor employed in the agricultural sector and L_t denotes the total labor force of the economy in every time period t. Aggregate productivity in the agricultural sector, $\left[\xi A_t^A + G_t\right]$, captures the trade-off between allocating labor in the production of the final good and the production of the public good. Places that are faced with favorable land endowment, may find it optimal to allocate more resources to the production of the final good, whereas unfavorably endowed places, may find it optimal to invest more in infrastructure to further enhance land productivity.[B.3]

In the industrial sector, the output in period t, Y_t^I, is determined by a linear, constant-returns-to-scale production production function such that

$$Y_t^I = A_t^I L_t^I = A_t^I (1 - \theta_t) L_t \tag{B.4}$$

where L_t^I denotes the labor employed in the industrial sector, $(1-\theta_t)$ is the fraction of total labor force, L_t, employed in the industrial sector in period t, and A_t^I denotes industrial productivity in period t.

The total labor force in period t, L_t, is employed in both the industrial and the agricultural sector (once both sectors have become active). Therefore,

$$L_t^A + L_t^I = L_t, \tag{B.5}$$

where $L_t > 0$ in every period t.

In early stages of development, productivity in the industrial sector, A_t^I, is rather low, particularly compared to that of agricultural sector, and therefore the industrial sector is not viable implying that output is produced solely in the agricultural sector. However, in later stages of development, as the economy evolved driven by population growth, industrial productivity A_t^I rises sufficiently relative to the productivity of agricultural sector, thereby rendering the industrial sector economically viable.

B.1.2 Collective Action in the Production of the Agricultural Infrastructure

Labor in the agricultural sector is allocated between two different activities. A fraction of the labor, $1 - z_t$, is employed in the production of the final good, whereas the remaining fraction, z_t, is employed in the production of agricultural infrastructure that is aimed to further enhance land productivity. The decision over what fraction of the labor is allocated to the production of each good, is made at the community level before production takes place. The objective of the community is to maximize output in the agricultural sector.

The community faces a trade-off in the decision to allocate labor to the production of agricultural infrastructure. More labor in the production of agricultural infrastructure increases land productivity, but it reduces the labor employed in the production of the final good.

[B.3] Different formulations of the production function, e.g. $Y_t^A = A_t^A \left[\xi + G_t(\xi)\right]^a X^a \left[L_t^A\right]^{1-a}$ would yield qualitatively similar results under certain assumptions, nevertheless they would complicate the model to the level of intractability.

Optimization Members of the community in every time period t, choose the fraction of labor employed in the agricultural sector that will be allocated to the production of the public good, so as to maximize agricultural output, i.e.,

$$\{z_t\} = \arg\max Y_t^A. \tag{B.6}$$

Hence, noting (B.1),

$$z_t = a - \frac{(1-a)\xi^2 A_t^A}{\theta_t L_t}. \tag{B.7}$$

Interestingly, the optimal fraction of labor allocated to the development of agricultural infrastructure is a decreasing function of natural land productivity, ξ, as well as of acquired agricultural productivity, A_t, thereby implying that countries with more favorable land endowment have a reduced incentive to invest in infrastructure and therefore, choose to allocate more labor to the direct production of the final good. Conversely, unfavorably endowed countries, choose to commit more resources to the development of agricultural infrastructure, as a means to further enhance natural land productivity.

B.1.3 Factor Prices and Aggregate Labor Allocation

The markets for labor and the production of the final good are perfectly competitive. Workers in the agricultural sector receive their average product, given that there are no property rights to land, and therefore the return to land is zero. Given (B.3), the wage rate of agricultural labor in time t, w_t^A, is

$$w_t^A \equiv \frac{Y_t^A}{\theta_t L_t} = \left[\frac{\xi A_t^A}{\theta_t L_t} + \frac{1}{\xi} z_t\right]^a (1-z_t)^{1-a} = v\xi^{1-a}\left[\frac{\xi A_t^A}{\theta_t L_t} + \frac{1}{\xi}\right], \tag{B.8}$$

where $v \equiv a^a(1-a)^{(1-a)} \in (0,1)$.

The inverse demand for labor in the industrial sector, given by (B.4), is

$$w_t^I = A_t^I, \tag{B.9}$$

where w_t^I is the wage rate of the industrial labor in period t.

From (B.8) and (B.9) it is evident that as employment in the agricultural sector decreases, the demand for labor increases without bound, while productivity in the industrial sector remains finite. Hence, the agricultural sector will be operative in every period, whereas the industrial sector will be operative if and only if labor productivity in this sector exceeds the marginal productivity of labor in the agricultural sector, under the assumption that the entire labor force is employed in the agricultural sector. Upon the activation of both sector, equalization of wages across the two sectors is the outcome of the assumption on perfect mobility of labor.

The conditions on the level of industrial productivity and the size of the working population that renders the industrial sector viable, are described in the following Lemma and the associated corollary.

Lemma 1 *(Condition for the Activation of the Industrial Sector) The industrial sector becomes economically viable and thus operative in period t if and only if industrial productivity A_t^I, exceeds a* *critical threshold level given by*

$$A_t^I \geq v\xi^{1-a}\left[\frac{\xi A_t^A}{L_t}+\frac{1}{\xi}\right] \equiv \hat{A}^I\left(\xi, A_t^A, L_t\right) \equiv \hat{A}_t^I.$$

Proof. Follows from (B.8)-(B.9) and the perfect mobility of labor between sectors. □

The threshold level of productivity, $\hat{A}_t^I$, reflects the fact that workers will start being employed in the industrial sector if their productivity in that sector, A_t^I, is equal to or exceeds the marginal productivity in the agricultural sector, w_t^A, as long as the entire labor force, L_t, is employed in the agricultural sector (i.e. $\theta_t = 1$).

Corollary 1 *(Condition on the Population Threshold for the Activation of the Industrial Sector) The industrial sector is economically viable and thus operative in period t if and only if total population L_t, exceeds a critical level given by*

$$L_t \geq \frac{v\xi^{2-a}A_t^A}{A_t^I - v\xi^{-a}} = \hat{L}\left(A_t^A, A_t^I\right) \equiv \hat{L}_t.$$

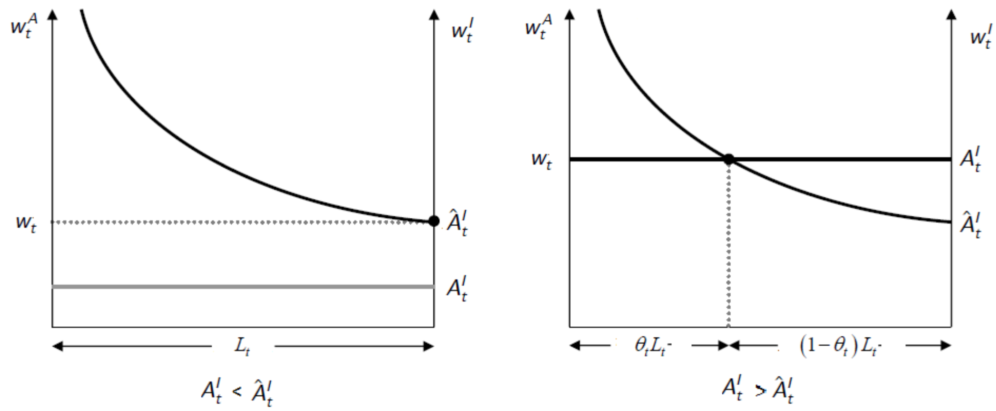
To ensure the emergence of the industrial sector, additional restrictions must be imposed on the initial value of the industrial productivity, i.e. $A_0^I > v\xi^{-a}$.

The fraction of the total labor force that is employed in the agricultural sector in period t, is denoted by $\theta_t \equiv L_t^A/L_t$, where $\theta_t \in (0, 1]$. According to Lemma 1, if industrial productivity is sufficiently low, i.e. if $A_t^I < \hat{A}_t^I$, the the industrial sector is not economically viable and thus the economy operates only in the agricultural sector, implying as well that the total labor force is employed in the agricultural sector (See Figure 1). In this stage of development, the wage rate of the economy w_t, will be exactly identified with the wage rate in agriculture w_t^I. As the economy grows however driven by population growth, industrial productivity surpasses the critical level $A_t^I \geq \hat{A}_t^I$, thereby rendering the industrial sector economically viable. As suggested by the perfect mobility assumption, wages will be equalized across the two sectors, i.e. $w_t = w_t^A = w_t^I$. Therefore, in equilibrium, the labor forces will be allocated between the two sectors, as described by θ_t,

$$\theta_t \equiv L_t^A/L_t = \begin{cases} 1 & \text{if} \quad A_t^I < \hat{A}_t^I \\ \frac{v\xi^{2-a}A_t^A}{A_t^I - v\xi^{-a}}\frac{1}{L_t} & \text{if} \quad A^I \geq \hat{A}_t^I, \end{cases} \quad . \tag{B.10}$$

Given (B.8) and (B.9), the equilibrium wage rate in the economy in period t, w_t, is

$$w_t = \begin{cases} w_t^A = v\xi^{1-a}\left[\frac{\xi A_t^A}{L_t}+\frac{1}{\xi}\right] & \text{if} \quad A_t^I < \hat{A}_t^I \\ w_t^I = A_t^I & \text{if} \quad A_t^I \geq \hat{A}_t^I. \end{cases} \tag{B.11}$$



Only Sector A Active Both Sectors A and I Active

Figure 1: The Labor Market Equilibrium

To ensure that the model is consistent with historical evidence suggesting that at early stages of development the agricultural sector preceded the emergence of the industrial sector, it is assumed that the industrial sector is not economically viable in period 0. Using Lemma 1, it is assumed that

$$v\xi^{-a} < A_0^I < v\xi^{1-a}\left[\frac{\xi A_0^A}{L_0} + \frac{1}{\xi}\right]. \tag{A1}$$

B.2 Individuals

It is assumed that a continuum of L_t homogeneous individuals enters the labor market. All individuals live for two periods. During the first period of their lives, $t-1$, denoted as childhood, they are not economically active, they are just being raised by their parents at some fixed cost.[B.4] In the second period of their lives, t, denoted as parenthood, they join the labor force where they provide their one unit of time.

B.2.1 Preferences and Constraints

The preferences of an individual that is in adulthood in period t are defined over consumption and number of offsprings. They are represented by the utility function

$$u_t = (c_t)^{\gamma}(n_t)^{1-\gamma}; \qquad \gamma \in (0,1), \tag{B.12}$$

where c_t denotes consumption, and n_t denoted the number of children. To ensure the existence of an interior solution to the maximization problem, the utility function is strictly monotonically increasing and strictly quasi-concave.

[B.4] It is assumed that each child is associated with a fixed cost that can be interpreted as purchasing child-rearing services. Imposing a time cost would not qualitatively change the predictions of the model, as long as technological progress reduces the amount of time required to raise a child.

Denoting the fixed cost of raising a child by $\tau > 0$, the budget constraint of the individual implies that the total income from labor force participation is allocated between child-rearing and consumption. Hence, the budget constraint faced by a member of generation t is

$$c_t + \tau n_t \leq w_t, \tag{B.13}$$

where w_t denotes the labor income of individual t, as described by (B.11).

B.2.2 Optimization

Each individual is choosing the number of offsprings, and thus implicitly his own level of consumption that will maximize his utility subject to the budget constraint. Substituting (B.13) into (B.12), the optimization problem takes the following form

$$n_t = \arg\max \left\{ (w_t - \tau n_t)^{\gamma} (n_t)^{1-\gamma} \right\}. \tag{B.14}$$

The optimal number of children for a member of generation t is therefore given by

$$n_t = \frac{1-\gamma}{\tau} w_t, \tag{B.15}$$

In accordance with the Malthusian theory, the number of offsprings increases with the level of income.

Substituting for w_t using (B.11), yields

$$n_t = \begin{cases} \frac{1-\gamma}{\tau} v \xi^{1-a} \left[\frac{\xi A_t^A}{L_t} + \frac{1}{\xi} \right] & \text{if} \quad A_t^I < \hat{A}_t^I \\ \\ \frac{1-\gamma}{\tau} A_t^I & \text{if} \quad A_t^I \geq \hat{A}_t^I. \end{cases} \tag{B.16}$$

B.3 The Time Paths of the Macroeconomic Variables

The time paths of the macroeconomic variables are governed by the dynamics of acquired factor productivity in both the agricultural and the industrial sector, A_t^A and A_t^I, as well as the growth of the total labor force, L_t. Whereas the evolution of agricultural productivity is driven by the creation of knowledge by the population employed in that sector, the evolution of industrial productivity is driven both by knowledge creation and the creation of social capital driven by the fraction of individuals employed in the creation of agricultural infrastructure, i.e. it is implicitly driven by natural land endowment.

B.3.1 The Dynamics of Sectoral Productivity

The level of the acquired productivity in the agricultural and industrial sectors, A_t^A and A_t^I, is affected by the productivity level in the previous time period as well as by technological progress, which reflects the incorporation of new knowledge into existing technologies. Industrial productivity is further enhanced by the level of social capital on industrial specific knowledge creation.

In each time period, a fraction of the workforce that is employed in the agricultural sector is allocated to the construction of the public good. The newly created infrastructure has two effects on the economy as a whole. A short run and a long run effect. In the short run, it boosts agricultural production directly, by mitigating the adverse effect of unfavorable natural land endowment.[B.5] In the long run, the cooperation in the production of agricultural infrastructure, contributes to societal social capital that ultimately benefits the process of industrialization.[B.6]

B.3.2 Industrial Productivity

Industrial productivity is being enhanced by two distinct components. The first component reflects improvements in industrial technology, driven by the new knowledge added by the population employed in the industrial sector. The second component can be viewed as the social component, namely the acquired level of social capital (as emerging from cooperation in the agricultural sector), and its beneficial effect on industrial specific new knowledge.[B.7]

The evolution of productivity in the industrial sector between periods t and $t+1$ is determined by

$$A_{t+1}^I = A_t^I + (\omega + z_t\theta_t)L_t A_t^I \quad \equiv A^I\left(A_t^A, L_t, A_t^I\right), \tag{B.17}$$

where the initial level of industrial productivity, $A_0^I > v\xi^{-a}$, is given.

In particular, A_t^I reflects the inertia of past productivity in the industrial sector, $\omega L_t A_t^I$, captures the advancement in productivity due to the application of new knowledge to the existing level of productivity; $\omega \in (0,1)$.[B.8]

The beneficial effect of cooperation for the creation of agricultural infrastructure, on the industrial productivity, is captured by $z_t\theta_t L_t A_t^I$, where $z_t\theta_t$ is the fraction of the population employed in the production of agricultural infrastructure.[B.9]

The beneficial effect of past cooperation on the industrial sector through the creation and accumulation of social capital and ultimately through its effect on the creation of industrial specific knowledge, is being captured by the level of past productivity, A_t^I. Cooperation at time t is captured implicitly as social capital in period $t+1$.

[B.5] For simplicity it is assumed that agricultural infrastructure fully depreciates within a period.

[B.6] It is plausibly assumed that when the community decides to construct agricultural infrastructure, it cannot internalize the externality of the emerging social capital in the latent industrial sector.

[B.7] Higher levels of social capital are associated with higher innovation and entrepreneurship, via reducing the associated risks and providing the necessary network (Putnam, 2000; Greif, 1993)

[B.8] $\omega \in (0,1)$ captures the fact that only a fraction of the population contributes to the creation of new knowledge in the industrial sector. While it can be argued that people employed in the industrial sector can contribute to the creation of new knowledge in the industrial sector, indirectly, it would be less plausible to argue that all people employed in the agricultural sector can positively influence knowledge creation in the industrial sector. It is therefore assumed that a constant fraction of the total workforce is positively affecting knowledge creation in industry.

[B.9] One can assume that once the industrial sector is active each extended household allocates labor to both the industrial and the agricultural sector. Hence, the entire society is exposed to the externalities of contemporary cooperation in the agricultural sector.

B.3.3 Agricultural Productivity

Similarly, the evolution of productivity in the agricultural sector between periods t and $t+1$ is determined by

$$A_{t+1}^A = \beta A_t^A + (L_t)^\lambda (A_t^A)^b \quad \equiv A^A\left(A_t^A, L_t\right) \ , \tag{B.18}$$

where the initial level of agricultural productivity, $A_0^A > 0$, is given.

βA_t^A captures the inertia from past productivity of the agricultural sector in period t, where $\beta \in (0,1)$ captures the erosion in agricultural productivity due to imperfect transmission from one generation to the other.[B.10] The term $(L_t)^\lambda (A_t^A)^b$ captures a "learning by doing effect". In particular the formulation implies both diminishing returns to population driven knowledge creation, and a "fishing out" effect (i.e. $\lambda \in (0,1)$), namely the negative effect of past discoveries on current discoveries. In addition, it is assumed that there is a lower degree of complementarity between the advancement of the knowledge frontier and the existing stock of sector-specific productivity in the agricultural, namely $b < 1$. Furthermore $\lambda + b < 1$.

It should be noted that agricultural infrastructure is assumed to be fully depreciated within one period, and the productivity in the agricultural sector is not affected by the level of agricultural infrastructure.[B.11]

B.3.4 The Dynamics of Population Size

The labor force is evolving over time based on the fertility rate of the previous generation. The equation describing the evolution of the adult population size is given by

$$L_{t+1} = n_t L_t = \begin{cases} \frac{1-\gamma}{\tau} v \xi^{1-a}\left[\xi A_t^A + \frac{L_t}{\xi}\right] & \equiv L^A\left(A_t^R, L_t\right) \quad \text{if} \quad L_t < \hat{L}_t \\ \\ \frac{1-\gamma}{\tau} A_t^I L_t & \equiv L^I\left(A_t^I, L_t\right) \quad \text{if} \quad L_t \geq \hat{L}_t, \end{cases} \tag{B.19}$$

where $L_0 > 0$ denotes the initial size of the adult population and is exogenously given.

In the agricultural stage of development the dynamics of the population are governed by acquired productivity in the agricultural sector as well as the size of the adult population, whereas when both sectors become active, population dynamics are determined by the level of the productivity in the industrial sector and the size of the adult population. Interestingly, natural land endowment directly affects population dynamics when the economy operates exclusively in the agricultural sector, whereas after industrialization it affects population dynamics only indirectly, through its effect on industrial productivity.

[B.10] It is assumed that erosion takes place in the agricultural sector, since agricultural technology reflects mostly human embodied knowledge and therefore imperfect transmission, as opposed to industrial knowledge. The assumption that there is no erosion in the industrial sector is a simplification aimed to capture this particular aspect. Nevertheless the results would hold under any parameterization that would assure smaller depreciation in the industrial sector.

[B.11] If contemporary infrastructure is long lasting and society would internalize its future effects on agricultural output, the qualitative analysis will remain similar, however it would complicate the model to the level of intractability.

B.4 The Process of Development

This section focuses on the role of natural land endowment in determining the characteristics of the Malthusian equilibrium and the timing of the take-off from an epoch of Malthusian stagnation to a state of sustained economic growth. The analysis demonstrates that countries with unfavorable natural land endowment are being dominated by more favorably endowed countries in the Malthusian regime. Hence, in an effort to mitigate the adverse effect of land, they cooperate more intensely in the production of agricultural infrastructure, which ultimately results to the emergence of higher levels of social capital. Due to the complementarity of social capital with the industrial sector, these countries industrialize faster, and therefore, escape Malthusian stagnation to enter a state of sustained economic growth.

The process of economic development, given the natural land productivity, ξ, is fully determined by a sequence $\left\{A_t^A, A_t^I, L_t; \xi\right\}_{t=0}^{\infty}$ that reflects the evolution of the acquired productivity in the agricultural sector, A_t^A, the productivity in the industrial sector, A_t^I, and the size of adult population, L_t. Specifically, noting (B.17), (B.18), and (B.19), the dynamic path of the economy is given by

$$\begin{cases} L_{t+1} = n_t L_t = \begin{cases} \frac{1-\gamma}{\tau} \upsilon \xi^{1-a} \left[\xi A_t^A + \frac{L_t}{\xi}\right] & \equiv L^A\left(A_t^R, L_t\right) \quad \text{if} \quad L_t < \hat{L}_t \\ \frac{1-\gamma}{\tau} A_t^I L_t & \equiv L^I\left(A_t^I, L_t\right) \quad \text{if} \quad L_t \geq \hat{L}_t, \end{cases} \\ A_{t+1}^A = \beta A_t^A + (L_t)^\lambda (A_t^A)^b = A^A\left(A_t^A, L_t\right) \\ A_{t+1}^I = A_t^I + (\omega + z_t\theta_t) L_t A_t^I = A^I\left(A_t^A, A_t^I, L_t\right) \end{cases} \tag{B.20}$$

where, consistent with the process of development, the initial conditions, $\left(A_0^A, A_0^I, L_0\right)$, are set to satisfy assumption (A1).

B.4.1 The Dynamical System

To analyze the evolution of the economy from the agricultural to the industrial regime, a series of phase diagrams is employed, that captures the evolution of the system within the Malthusian epoch, as well as the endogenous transition to industrialization. The analysis underlines the role of natural land endowment and cooperation in the development of infrastructure in the agricultural sector, in determining the characteristics of the Malthusian equilibrium and the timing of the take-off to the industrial era.[B.12]

The phase diagrams, depicted in Figures 2-3, describe the evolution of the system in the $\left(A_t^A, L_t\right)$ plane, conditional on the level of A_t^I. The evolution of industrial productivity, A_t^I, driven by knowledge creation and social capital, triggers a phase transition of the dynamical system and allows for the onset

[B.12] The analysis is focusing on the transition from a Malthusian regime to an industrialization regime and the forces that led to a faster industrialization. The forces that eventually led to the demographic transition and the emergence of the modern growth regime are not being explored in the context of this research. The underlying assumption behind this approach is the historical observation that a "reversal of fortune" has been observed initially with respect to the timing of industrialization. The model could be expanded to account for the current growth regime however this extension would just increase the complexity of the model without adding new insights.

of industrialization and the take-off to an era of sustained economic growth, driven by the evolution of the industrial sector.

Three geometric elements are crucial for building the phase diagrams and are instrumental for the determination of motion within the system: the Conditional Malthusian Frontier, which separates the regions in which the economy is exclusively operating in the agricultural sector from those where it operates in both the industrial and the agricultural sector; the AA locus, which denotes the set of all pairs $\left(A_t^A, L_t\right)$ for which the acquired productivity in the agricultural sector is constant; and the LL locus, which denotes the set of all pairs for which the size of the workforce is constant, conditional on the latency of the industrial sector.

The Conditional Malthusian Frontier The Conditional Malthusian Frontier is a geometric locus, in $\left(A_t^A, L_t\right)$ space, that separates the phase diagram into two regions. Below the Malthusian frontier is the region where the economy operates exclusively on the agricultural sector, whereas below the Malthusian frontier is the region where it operates in both sectors. Once the economy's trajectory crosses this frontier, the industrial sector becomes operative.

The Conditional Malthusian Frontier denotes the set of all pairs $\left(A_t^A, L_t\right)$ such that, for a given level of industrial productivity, A_t^I, individuals are indifferent as to whether to work in the industrial sector or in the agricultural sector. Following Corollary 1, the Conditional Malthusian Frontier, $MM_{|A_t^I}$ (see Figures 3-4), is

$$MM_{|A_t^I} \equiv \left\{\left(A_t^A, L_t\right) : L_t = \hat{L}\left(A_t^A, A_t^I\right)\right\}. \tag{B.21}$$

Lemma 2 *(The Properties of the Conditional Malthusian Frontier) If $\left(A_t^A, L_t\right) \in MM_{|A_t^I}$, then along the $MM_{|A_t^I}$ frontier,*

$$L_t = \frac{v\xi^{2-a}A_t^A}{A_t^I - v\xi^{-a}} \equiv \hat{L}\left(A_t^A, A_t^I\right),$$

where $\partial\hat{L}\left(A_t^A, A_t^I\right)/\partial A_t^A > 0$, and $\partial\hat{L}\left(A_t^A, A_t^I\right)/\partial A_t^I < 0$.

Proof. Follows immediately from (B.21), Corollary 1, and differentiation. □

The Conditional Malthusian Frontier is therefore an upward sloping ray from the origin in the $\left(A_t^A, L_t\right)$ space. From Corollary 1, it becomes evident that the region strictly below the frontier denotes that production takes place exclusively in the agricultural sector whereas the region (weakly) above the frontier, denotes that the economy operates both in the industrial and the agricultural sector. As A_t^I increases in the process of development, the Conditional Malthusian Frontier rotates clockwise in $\left(A_t^A, L_t\right)$ space.

Lemma 3 *(The Dynamics of Population Size with respect to the Conditional Malthusian Frontier) Given $A_t^A > 0$ and $A_t^I > 0$, for all $L_t \geq \hat{L}\left(A_t^A, A_t^I\right)$,*

$$L_{t+1} - L_t \gtreqless 0 \quad \Leftrightarrow \quad A_t^I \gtreqless \tfrac{\tau}{1-\gamma}$$

Proof. Follows immediately from (B.19). □

Hence, if the industrial sector has become economically viable, the evolution of the labor force relies upon the level of A_t^I with respect to the threshold level, $\tau/(1-\gamma)$. More analytically, for a level of industrial productivity being below the critical level, $\tau/(1-\gamma)$, the wage rate in the economy is not sufficiently high to sustain fertility beyond replacement, thereby implying that the size of the workforce declines in size over time. Conversely if A_t^I is above the critical threshold, then the wage rate is sufficiently high to sustain fertility above the replacement level and hence the workforce increases in size over time.

The AA **Locus** Let the AA locus be the set of all pairs $\left(A_t^A, L_t\right)$ such that the level of agricultural productivity, A_t^A, is in a steady state:

$$AA \equiv \left\{\left(A_t^A, L_t\right) : A_{t+1}^A - A_t^A = 0\right\}. \tag{B.22}$$

Lemma 4 *(The Properties of the AA Locus) If* $\left(A_t^A, L_t\right) \in AA$*, then along the AA locus,*

$$L_t = (1-\beta)^{1/\lambda}\left(A_t^A\right)^{(1-b)/\lambda} \equiv L^{AA}\left(A_t^A\right),$$

where $\partial L^{AA}\left(A_t^A\right)/\partial A^A > 0$ *and* $\partial^2 L^{AA}\left(A_t^A\right)/\left(\partial A_t^A\right)^2 > 0$.

Proof. Noting (B.22), the functional form of $L^{AA}\left(A_t^A\right)$ is obtained by algebraically manipulating (B.18) under $A_{t+1}^A = A_t^A$. The remainder follows directly from differentiation. □

Corollary 2 *(The Dynamics of Agricultural Productivity with respect to the AA Locus) Given* $A_t^A > 0$,

$$A_{t+1}^A - A_t^A \gtreqless 0 \quad \text{if and only if} \quad L_t \gtreqless L^{AA}\left(A_t^A\right)$$

Hence, the AA locus (see Figures 3-4), is a curve originating from the origin in $\left(A_t^A, L_t\right)$ space, strictly convex and upward sloping. Above the AA locus, A_t^A grows over time, due to the fact that there is a sufficiently large cohort of adults that ensure the advancement of the knowledge frontier to a level that can overcome the erosion effect of imperfect intergenerational transmission of knowledge on A_t^A. Respectively, below the AA locus, the advancement of the knowledge frontier is not sufficient to overcome the eroding effects of imperfect intergenerational transmission on A_t^A, and therefore, agricultural productivity diminishes over time.

The LL **Locus** Let the LL locus be the set of all pairs $\left(A_t^A, L_t\right)$ such that, conditional on the latency of the industrial sector, the size of the adult population, L_t, is in a steady state:

$$LL \equiv \left\{\left(A_t^A, L_t\right) : L_{t+1} - L_t = 0 \mid L_t < \hat{L}\left(A_t^A, A_t^I\right)\right\}. \tag{B.23}$$

Lemma 5 *(The Properties of the LL Locus) If* $\left(A_t^A, L_t\right) \in LL$*, then along the LL locus,*

$$L_t = \frac{(1-\gamma)v\xi^{2-a}A_t^A}{\tau - (1-\gamma)v\xi^{-a}} \equiv L^{LL}\left(A_t^A\right),$$

where $\tau > (1-\gamma)v\xi^{-a}$, $dL_t^{LL}/dA_t^A > 0$*, and* $d^2L_t^{LL}/\left(dA_t^A\right)^2 = 0$.

Proof. Noting (B.23), $L^{LL}\left(A_t^A\right)$ is derived from using eq. (B.19) under the assumption that $L_{t+1} = L_t$ and upon differentiation. □

Corollary 3 *(The Dynamics of Population Size with respect to the LL Locus) Given* $A_t^A > 0$ *and* $A_t^I > 0$*, for all* $L_t < \hat{L}\left(A_t^A, A_t^I\right)$*,*

$$L_{t+1} - L_t \lesseqqgtr 0 \quad \textit{if and only if} \quad L_t \gtreqqless L^{LL}\left(A_t^A\right)$$

Hence, the LL locus (see Figures 3-4), originates from the origin in $\left(A_t^A, L_t\right)$ space, and is an upward sloping ray. Below the LL locus, L_t grows over time due to the fact that since population is sufficiently low, it allows for a high wage rate which permits fertility to be above replacement. Reversely, L_t declines over time above the LL locus, since the population is higher than its steady state level, thereby implying a sufficiently low wage rate that sustains fertility below the replacement level. The following lemma is setting the conditions that determine the position of the LL locus, in $\left(A_t^A, L_t\right)$ space, relative to the Conditional Malthusian Frontier, $MM_{|A_t^I}$.

Lemma 6 *(The Position of the LL Locus relative to the Conditional Malthusian Frontier) Given* $A_t^I > 0$*, for all* A_t^A *such that* $\left(A_t^A, \hat{L}\left(A_t^A, A_t^I\right)\right) \in MM_{|A_t^I}$ *and* $\left(A_t^A, L^{LL}\left(A_t^A\right)\right) \in LL$*,*

$$\hat{L}\left(A_t^A, A_t^I\right) \gtreqqless L^{LL}\left(A_t^A\right) \quad \textit{if and only if} \quad A_t^I \lesseqqgtr \frac{\tau}{(1-\gamma)}.$$

Proof. Follows from comparing the functional forms of $\hat{L}\left(A_t^A, A_t^I\right)$ and $L^{LL}\left(A_t^A\right)$ as specified in Corollary 1 and Lemma 5 respectively. □

Thus, for low levels of industrial productivity, $A_t^I < \tau/(1-\gamma)$, the Conditional Malthusian Frontier, $MM_{|A_t^I}$, is located above the LL locus, suggesting that only the agricultural sector is operative. In the process of development though, $MM_{|A_t^I}$ rotates clockwise driven by the growth of A_t^I and ultimately the two loci coincide when $A_t^I = \tau/(1-\gamma)$. After this point, for $A_t^I > \tau/(1-\gamma)$ the Conditional Malthusian Frontier, $MM_{|A_t^I}$, drops below the LL locus, rendering the industrial sector viable.

So far it has become evident that growth in the latent industrial sector productivity, A_t^I, has an influence on the global dynamics of the size of the workforce, which in turn reflects a transition of the system from the Malthusian to the Post-Malthusian regime. The following lemma is summarizing the dynamics of the workforce.

Lemma 7 *(The Dynamics of the Workforce with respect to the LL Locus and the Conditional Malthusian Frontier) Given* $A_t^I > 0$*, for all* $A_t^A > 0$*,*

1. *If* $A_t^I < \frac{\tau}{(1-\gamma)}$*, then*

   the Conditional Malthusian Frontier is above the LL locus, i.e.,

$$\hat{L}\left(A_t^A, A_t^I\right) > L^{LL}\left(A_t^A\right),$$

   and

$$L_{t+1} - L_t \begin{cases} < 0 & \textit{if} \quad L_t > L^{LL}\left(A_t^A\right) \\ = 0 & \textit{if} \quad L_t = L^{LL}\left(A_t^A\right) \\ > 0 & \textit{if} \quad L_t < L^{LL}\left(A_t^A\right); \end{cases}$$

2. If $A_t^I > \frac{\tau}{(1-\gamma)}$*, then*

the Conditional Malthusian Frontier is below the LL locus, i.e.,

$$\hat{L}\left(A_t^A, A_t^I\right) < L^{LL}\left(A_t^A\right),$$

and, for all L_t*,*

$$L_{t+1} - L_t > 0.$$

Proof. Part (1) follows immediately from Lemmas 3 and 6, and Corollary 3. Part (2) follows from the same Lemmas while observing that, above the Conditional Malthusian Frontier, $L_{t+1} - L_t > 0$ if $A_t^I > \tau/(1-\gamma)$, and if L_t is below the LL locus. □

B.4.2 The Phase Diagrams

Figures 2-3, illustrated the steady state in agricultural stage of development, and the transition from agriculture to industry. Figure 2 illustrates the agricultural stage of development, in which the economy is in a steady state and is characterized by Malthusian dynamics, Figure 3 illustrates the endogenous take-off to industrialization, where the economy enters a regime of sustained growth in per worker output and population.

The Agricultural Stage of Development Figure 2 illustrates the economy while operating exclusively in the agricultural stage of development, i.e. when population is rather low and thus productivity in the (latent) industrial sector, A_t^I, is below the critical level $\tau/(1-\gamma)$.

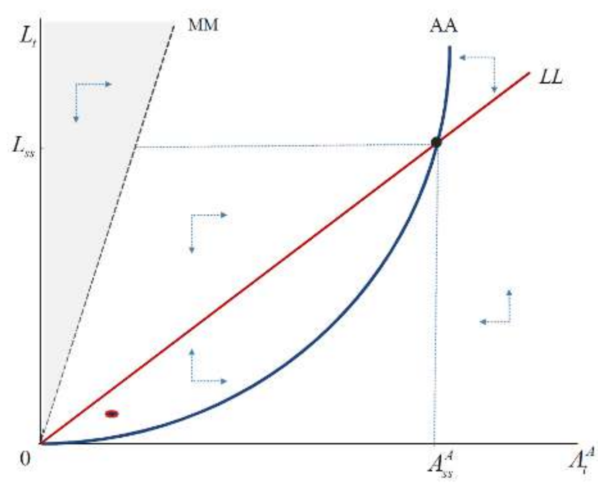


Figure 2 : The Agricultural Stage of Development

This implies that the $MM_{|A_t^I}$ frontier in this stage resides above the LL locus, thereby implying that the economy is in a Malthusian regime and is characterized by a globally stable steady state equilibrium, $(A_{ss}^A,\ L_{ss})$, as defined by the point of intersection of the AA and LL loci. Using the functional forms of $L^{AA}\left(A_t^A;\xi\right)$ and $L^{LL}\left(A_t^A;\xi\right)$, specified in Lemmas 4 and 5 respectively, the

Malthusian steady-state values of productivity in the agricultural sector, A^A_{ss}, and the size of the adult population, L_{ss}, are given by

$$A^A_{ss} = \frac{1}{(1-\beta)^{\frac{1}{1-b-\lambda}}}\left[\frac{\tau-(1-\gamma)\,v\xi^{-a}}{(1-\gamma)v\xi^{2-a}}\right]^{\frac{\lambda}{-1+b+\lambda}} \equiv A^A_{ss}(\xi)\,; \tag{B.24}$$

$$L_{ss} = \frac{1}{(1-\beta)^{\frac{1}{1-b-\lambda}}}\left[\frac{\tau-(1-\gamma)\,v\xi^{-a}}{(1-\gamma)v\xi^{2-a}}\right]^{\frac{1-b}{-1+b+\lambda}} \equiv L_{ss}(\xi)\,. \tag{B.25}$$

The system is characterized by a globally stable steady-state equilibrium.[B.13] At early stages of development, productivity in the latent industrial sector is quite low and therefore the economy operates exclusively in the agricultural sector. Therefore the $MM_{|A^I_t}$ locus is located above the LL locus. In addition, in the region above the $MM_{|A^I_t}$ locus, as follows from Lemma 3, the size of the workforce diminishes over time, which eventually places the economy below the Conditional Malthusian Frontier. Since the industrial sector is not yet sustainable in this stage of development, the economy converges to an agricultural regime characterized by a Malthusian equilibrium. In the region below the $MM_{|A^I_t}$ locus and above the LL locus, there is rather high workforce that implies wage rates so small as to place fertility below replacement rates and therefore the workforce diminishes over time. Conversely, below the LL locus, the size of the workforce is sufficiently small to allow for high wage rates and therefore for fertility above replacement, thereby implying an increasing population size.

Since the analysis takes place in the context of a discrete dynamical system, additional conditions are necessary to ensure that convergence to the steady state takes place monotonically over time and not in an oscillatory way.[B.14] Figure 2 is depicting the trajectories under the assumption that the parametric conditions described in Lemma 8 that ensure that the conditional dynamical system is locally nonoscillatory in the vicinity of the conditional Malthusian steady state.

The following Lemma imposes conditions on the eigenvalues of the Jacobian matrix of the conditional dynamical system evaluated at the steady-state equilibrium.

Lemma 8 *(The Local Stability Properties of the Conditional Malthusian Steady State) If $A^I_t < \tau/(1-\gamma)$, then the conditional steady-state equilibrium, $\left(A^A_{ss}, L_{ss}\right)$, of the dynamical system in (B.20) is:*

1. *characterized by the local monotonic evolution of both state variables, A^R_t and L_t, if and only if the Jacobian matrix,*

$$J\left(A^R_{ss}, L_{ss}\right) = \begin{bmatrix} \partial A^A\left(A^A_{ss}, L_{ss};\omega\right)/\partial A^A_t & \partial A^A\left(A^A_{ss}, L_{ss};\omega\right)/\partial L_t \\ \partial L\left(A^A_{ss}, L_{ss}\right)/\partial A^R_t & \partial L\left(A^R_{ss}, L_{ss}\right)/\partial L_t \end{bmatrix},$$

[B.13] The unstable trivial steady state located at the origin of $\left(A^A_t, L_t\right)$ space is eliminated given $A^A_0 > 0$ and $L_0 > 0$.

[B.14] The analysis would not be qualitatively different even in the case where the evolution towards the steady state took place in an oscillatory manner, since this is a feature that appears to be present during the Malthusian epoch. See, for example Galor (2011).

has eigenvalues that are real and positive, i.e., if

$$\xi < \left[\frac{(1-\gamma)\, v}{\tau} \frac{[\beta(1-\beta)^{\frac{b}{1-b}} + b(1-\beta)^{\frac{1}{1-b}} + \lambda(1-\beta)^{\frac{1}{(1-b)}}]}{\lambda} \right]^{1/a}.$$

2. is locally asymptotically stable.

Proof. Under $A_t^I < \tau/(1-\gamma)$, the Jacobian matrix of the conditional dynamical system, comprising eqs. (18) and (19), is given by

$$\begin{aligned} J\left(A_t^A, L_t\right) &= \begin{bmatrix} \partial A_{t+1}^A/\partial A_t^A & \partial A_{t+1}^A/\partial L_t \\ \partial L_{t+1}/\partial A_t^A & \partial L_{t+1}/\partial L_t \end{bmatrix} \\ &= \begin{bmatrix} \beta + b(L_t)^{\lambda}(A_t^A)^{b-1} & \lambda(L_t)^{\lambda-1}(A_t^A)^{b} \\ \frac{1-\gamma}{\tau} v\xi^{2-a} & \frac{1-\gamma}{\tau} v\xi^{-a} \end{bmatrix}, \end{aligned} \tag{B.26}$$

which, when evaluated at the conditional steady state given by (24) and (25), yields

$$J\left(A_{ss}^A, L_{ss}\right) = \begin{bmatrix} \beta + b(1-\beta) & \lambda(1-\beta)\left[\frac{\tau-(1-\gamma)v\xi^{-a}}{(1-\gamma)v\xi^{2-a}}\right] \\ \frac{1-\gamma}{\tau} v\xi^{2-a} & \frac{1-\gamma}{\tau} v\xi^{-a} \end{bmatrix} \equiv J_{ss}. \tag{B.27}$$

To ensure that the system has two positive eigenvalues, it must be established that:

$$\begin{aligned} Det\left(J_{ss}\right) &> 0, \text{and} \\ Tr\left(J_{ss}\right) &> 0, \forall \xi \in (0,1). \end{aligned}$$

From (B.27) it follows that for $Det\left(J_{ss}\right) > 0$, $\xi < \left[\frac{(1-\gamma)v}{\tau}\left(\frac{\beta+b(1-\beta)}{\lambda(1-\beta)} + 1\right)\right]^{1/a}$ is a sufficient condition. In addition it is clear from (B.27), that $Tr\left(J_{ss}\right) > 0, \forall \xi \in (0,1)$.

Given so far that the discrete dynamical system has two positive eigenvalues, it is clear from the phase diagram in Figure 3, that $\left(A_{ss}^A, L_{ss}\right)$ is a locally asymptotically stable node of the conditional dynamical system for any ξ, and convergence takes places monotonically. □

The Industrial Stage of Development Figure 3 illustrates the dynamical system in the industrial stage of development, i.e. when population is sufficiently high and thus industrial productivity, A_t^I, exceeds the critical level, $\tau/(1-\gamma)$.

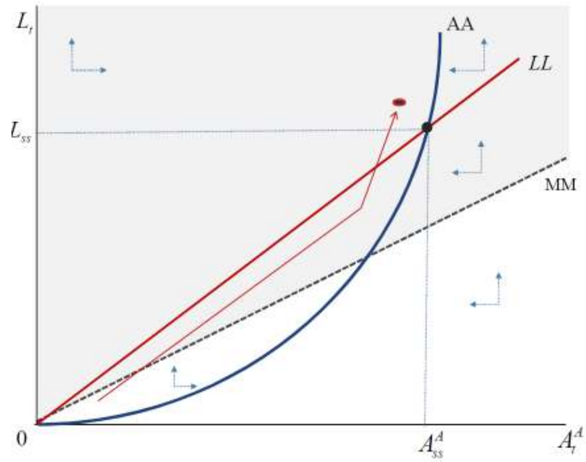


Figure 3: Industrialization and the Take-off

At this stage of development, the $MM_{|A_t^I}$ frontier resides below the LL locus, as established in Lemma 7, and the economy enters a stage of sustained growth. Above the $MM_{|A_t^I}$ frontier, the wage rate increases over time, thereby allowing an increase in the size of the workforce as well as a sustained increase in productivity and output per worker.

The Transition from Agriculture to Industry The growth in productivity of the latent industrial sector in the process of development, from its initial level below the critical threshold, $\tau/(1-\gamma)$, to a level beyond this threshold is driving the transition from agriculture to industry.

Consistent with historical evidence, the transition from agriculture to industry, requires the emergence of the agricultural sector prior to the emergence of the industrial sector, i.e. the initial level of industrial productivity must satisfy the following condition.

$$A_0^I < \tau/(1-\gamma). \tag{A3}$$

To assure the transition to the industrialization era, it is sufficient to assume that (latent) industrial productivity grows monotonically and eventually exceeds the critical magnitude, $\tau/(1-\gamma)$.

Let g_{t+1} denote the rate of productivity growth in the industrial sector between periods t and $t+1$. It follows directly from (B.17) that

$$g_{t+1}^I \equiv \frac{A_{t+1}^I - A_t^I}{A_t^I} = (\omega + z_t) L_t \equiv g^I \left(L_t, A_t^A, \xi\right). \tag{B.28}$$

thereby implying that productivity in the industrial sector is growing over time, which ensures the transition from the agricultural stage of development to industry.

B.5 The Evolution of the Economy

The evolution of the economy is initially characterized by a Malthusian steady-state. The economy initially operates exclusively in the agricultural sector but ultimately it experiences an endogenous industrialization and a subsequent take-off to a state of sustained economic growth.

B.5.1 The Agricultural Economy

In early stages of development, the economy operates exclusively in the agricultural sector due to the fact that the productivity in the (latent) industrial sector, A_t^I, is too low to allow the industrial sector to become operative (satisfying assumptions (A1) and (A3)). In this stage of development, the economy is in a Malthusian regime and the dynamical system, illustrated in Figure 2, has a globally stable steady-state equilibrium, $(A_{ss}^I,\, L_{ss})$, towards which it gravitates monotonically.

Since at this stage of development only the agricultural sector is operative, the whole adult population is employed in this sector, and therefore from (B.3) it follows that the steady-state level of income per worker is

$$y_{ss} = \frac{\tau}{1-\gamma} \tag{B.29}$$

Using (B.24) and (B.25), the steady-state level of income per worker captures the property of the Malthusian steady-state, that the long-run level of income is constant and independent of the level of technology. Therefore a higher productivity per worker is counterbalanced by a larger size of the working population.

B.5.2 The Transition to Industry

The driving force behind the transition from agriculture to industry, is the growth of productivity in the (latent) industrial sector. In the process of development, increases in the industrial productivity, rotate the Conditional Malthusian Frontier, $MM_{|A_t^I}$ clockwise in the $\left(A_t^A, L_t\right)$ space of Figure 2. Eventually, productivity of the industrial sector surpasses the critical threshold level $\frac{1-\gamma}{\tau} v \xi^{1-a} \left[\frac{\xi A_t^A}{L_t} + \frac{1}{\xi}\right]$, which renders the industrial sector operative and drops the Conditional Malthusian Frontier below the LL locus as depicted in Figure 3.

As the economy enters the era of industrialization, there no longer exists a globally stable Malthusian steady state in the $\left(A_t^A, L_t\right)$ space. Upon entering into the industrialization regime, the economy enters into an era of sustained endogenous growth, where income per worker is growing over time driven by the growth of industrial productivity.

B.6 Natural Land Endowment and Comparative Development

The effect of natural land endowment on comparative development, through the emergence of cooperation and social capital, can be examined based on the effect of the land endowment on Malthusian equilibrium outcomes in the agricultural stage of development, and on the timing of industrialization and the take-off to a state of sustained economic growth.

Proposition 1 *(The Effect of Natural Land Endowment on the Equilibrium in the Agricultural Stage of Development) Under assumption (A2), as long as the economy remains exclusively agricultural, an increase in the quality of natural land endowment has no effect on steady state income per capita and a beneficial effect on the steady-state levels of productivity in the agricultural sector and the size of the adult population,i.e.*

$$dy_{ss}/d\xi = 0$$

and for $\xi > \left[\frac{2(1-\gamma)v}{(2-a)\tau}\right]^{1/a}$

$$dA^A_{ss}/d\xi > 0 \quad and \quad dL_{ss}/d\xi > 0$$

Proof. Follows immediately from differentiating (B.24), (B.25), and (B.29) with respect to ξ while noting assumption (A2).[B.15] □

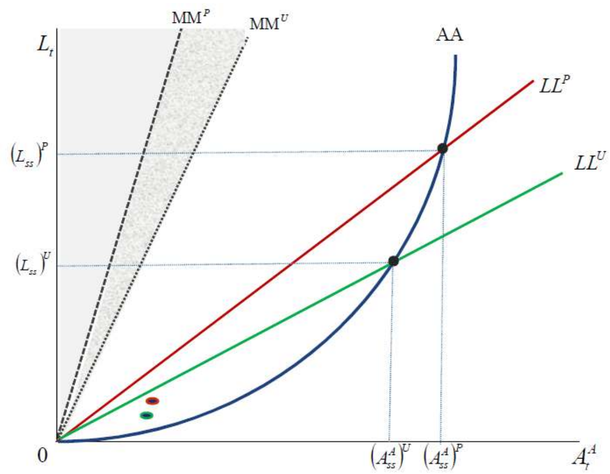


Figure 4: The Effect of an Increase in Natural Land Endowment on the Malthusian Equilibrium

Geometrically, as depicted in Figure 4, a higher value of ξ, while it leaves the AA locus unaffected, it causes the LL locus to reside closer to the L_t-axis in $\left(A^A_t, L_t\right)$ space, thereby yielding higher steady-state levels of adult population size and agricultural productivity.

Therefore, an economy that is characterized by more favorable natural land endowment, is also associated with a relatively superior conditional Malthusian steady state in terms of the economy's level of agricultural productivity per worker and the size of its working population.

In accordance with the predictions of the Malthusian theory (Ashraf and Galor, 2011), the long-run level of income per capita is not affected by variations in natural land productivity, thereby implying that adjustments in population and productivity were such that equalized long-run income per capita across countries.

The inferiority of the conditional Malthusian steady state, in a society with more favorable natural land endowment, stems from the fact that agricultural production in these places is higher, and they can therefore sustain a larger population.

Variations in natural land endowment, however, have an effect on the level of cooperation in the production of agricultural infrastructure and on the timing of industrialization (through the creation and transmission of social capital) and thus, on the take-off to a state of sustained economic growth. This effect is summarized in the following proposition.

[B.15] Note that if $\xi < \left[\frac{2(1-\gamma)v}{(2-a)\tau}\right]^{1/a}$, then this would imply that $dA^A_{ss}/d\xi < 0$ and $dL_{ss}/d\xi < 0$, i.e. that for sufficiently low levels of land productivity, an increase in land productivity may adversely affect steady state values of population and agricultural productivity. However, this result captures the effect of land productivity through the incentives for investment in infrastructure. Had this channel been shut off, i.e., investment in infrastructure is not feasible, then $dA^A_{ss}/d\xi > 0$ and $dL_{ss}/d\xi > 0 \ \forall \ \xi$. Therefore to be consistent with historical evidence that suggests that more fertile places were sustaining larger populations, the analysis is limited to the range of productivities where $\xi > \left[\frac{2(1-\gamma)v}{(2-a)\tau}\right]^{1/a}$.

Proposition 2 *(The Effect of Natural Land Endowment on the Timing of Industrialization and the Take-off from Malthusian Stagnation) Consider an economy in a conditional Malthusian steady-state equilibrium. Under assumptions (A2) and (A4), an increase in natural land productivity, can have a detrimental effect on the timing of the adoption of industry and, thus, on the timing of the take-off from Malthusian stagnation, i.e.,*[B.16]

$$dg^I_{ss}/d\xi > 0 \quad iff \quad \xi > \left[\frac{2(1-\beta)(1-\gamma)v}{\tau(2-2b-a\lambda)}\right]^{1/a}$$

Proof. Follows immediately from differentiating (B.28) in the steady state with respect to ξ. It should be noted that the constraint $\xi > [2(1-\beta)(1-\gamma)v/\tau(2-2b-a\lambda)]^{1/a}$ is a necessary but not sufficient condition[B.17]. □

Hence, if natural land productivity is sufficiently high, then it can have an adverse effect on productivity growth in the (latent) industrial sector at the conditional Malthusian steady-state equilibrium. The earlier take-off from the conditional Malthusian steady state by a society with less favorable natural land endowment, stems from the fact that the cooperation in the agricultural sector to develop infrastructure that could mitigate the adverse effect of land, generates higher social capital, a crucial element for the development of the industrial sector. Therefore productivity growth in the (latent) industrial sector is higher for less productive countries in the process of development.

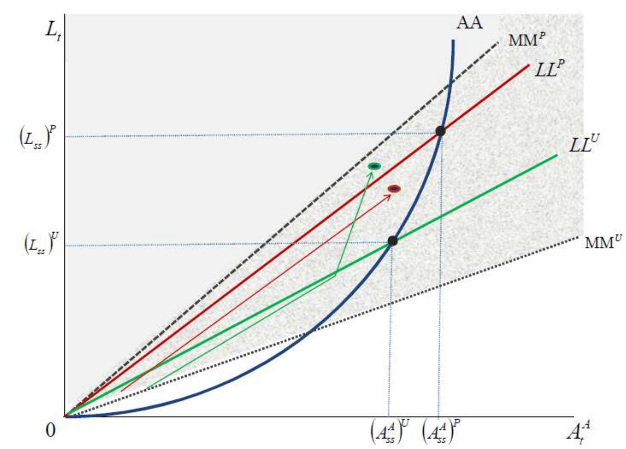


Figure 5: Overtaking of the Low Land Productivity Economy in the Industrialization Era

Geometrically, as depicted in Figure 4, for sufficiently high ξ, a higher value of ξ causes the $MM_{|A^I_t}$ frontier to reside closer to the L_t-axis in $\left(A^A_t, L_t\right)$ space. This, combined with the fact that industrial productivity in the more productive place takes place at a lower pace, implies that favorably endowed places may industrialize later, as depicted in Figure 5.

Following Propositions 1 and 2, variation in natural land endowment across societies is associated with the phenomenon of overtaking.

[B.16]It should be noted that the restrictions on ξ in Propositions 1 and 2 and Lemma 8, are mutually consistent for a range of parameter values.

[B.17]Solving the model numerically confirms the predictions of the model for a range of plausible parameter values that satisfy all the constraints.

Corollary 4 *(Natural Land Endowment and Overtaking) Consider two societies indexed by* $i \in \{U, P\}$*. Suppose that society* U *is characterized by a lower natural land endowment and that* $\xi^U < \xi^P$*, where* ξ^i *is the natural land endowment of society* i*. Society* U *will then be characterized by an inferior productivity in the Malthusian regime, but it can overtake society* P *via an earlier take-off into the industrial regime.*

C Robustness-Cross Country Regressions

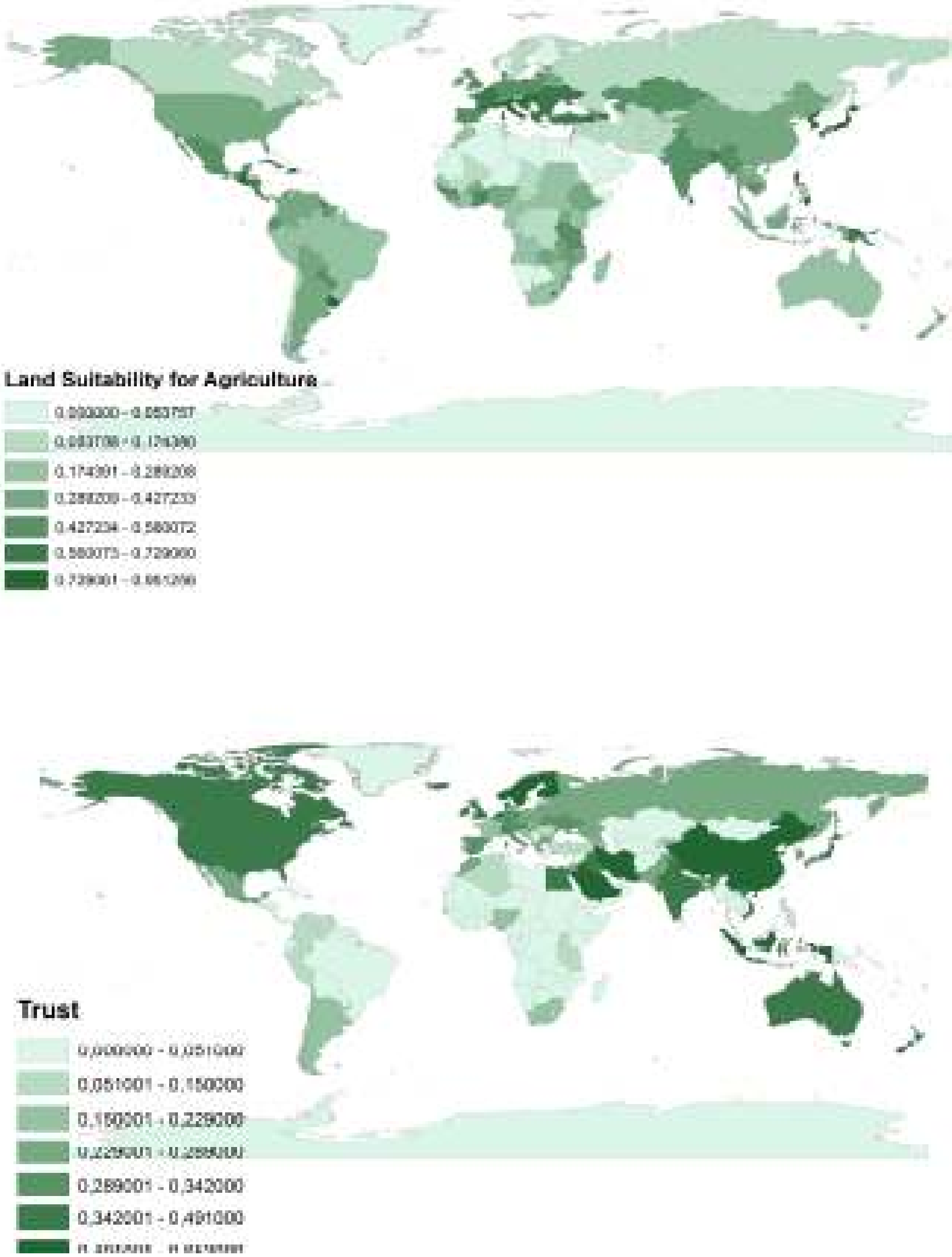


Figure C.1: Land Suitability and Trust - World Map

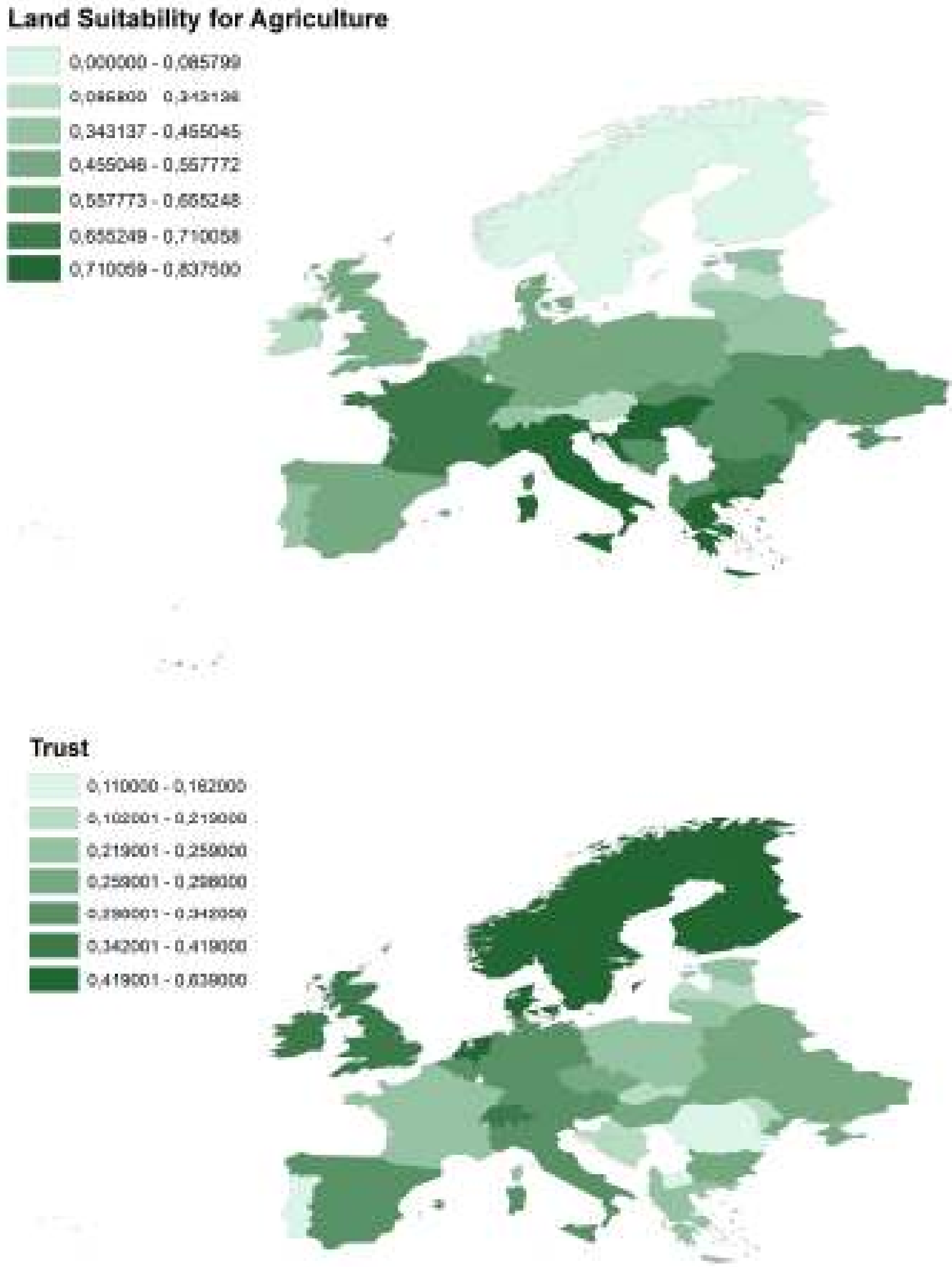


Figure C.2: Land Suitability and Trust-Europe

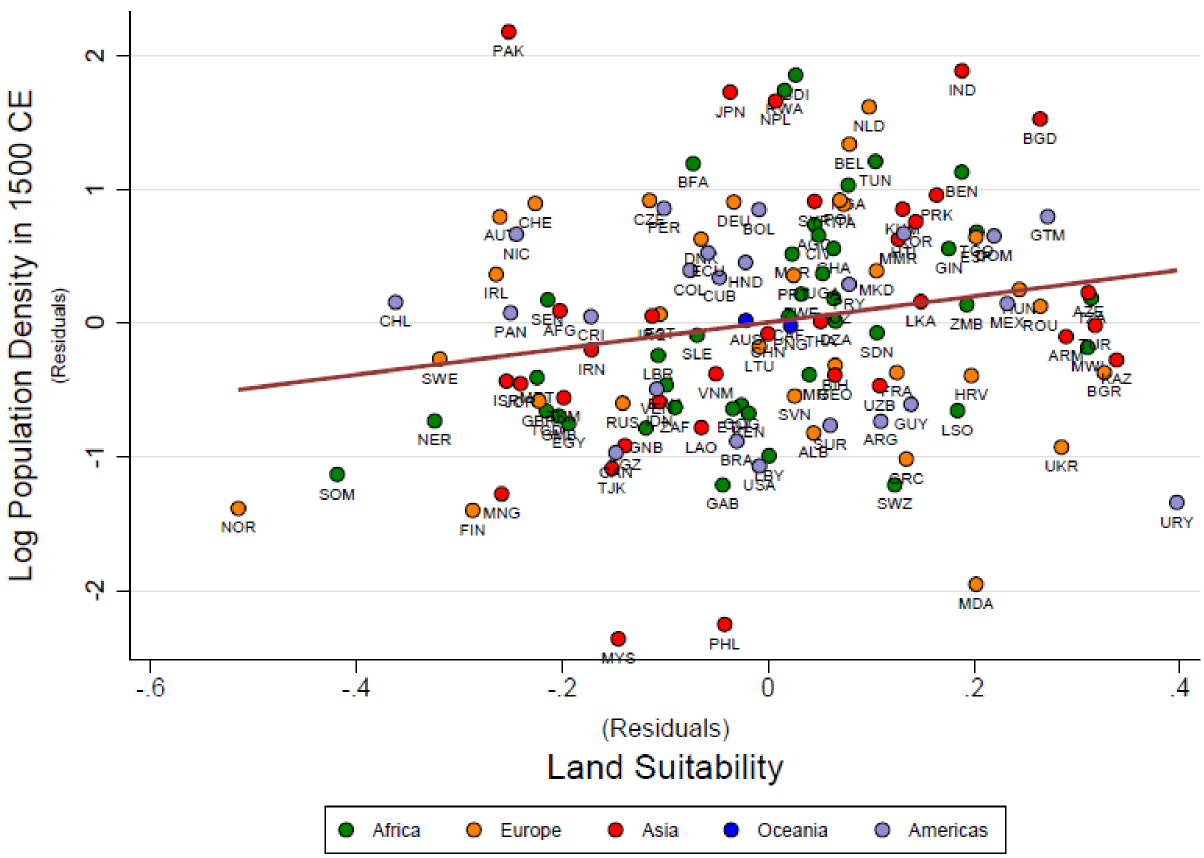


FIGURE C.3: Land Suitability and Population Density in the Year 1500 (conditional on geographical characteristics, years since the Neolithic transition, distance from the nearest technological frontier and continental fixed effects)

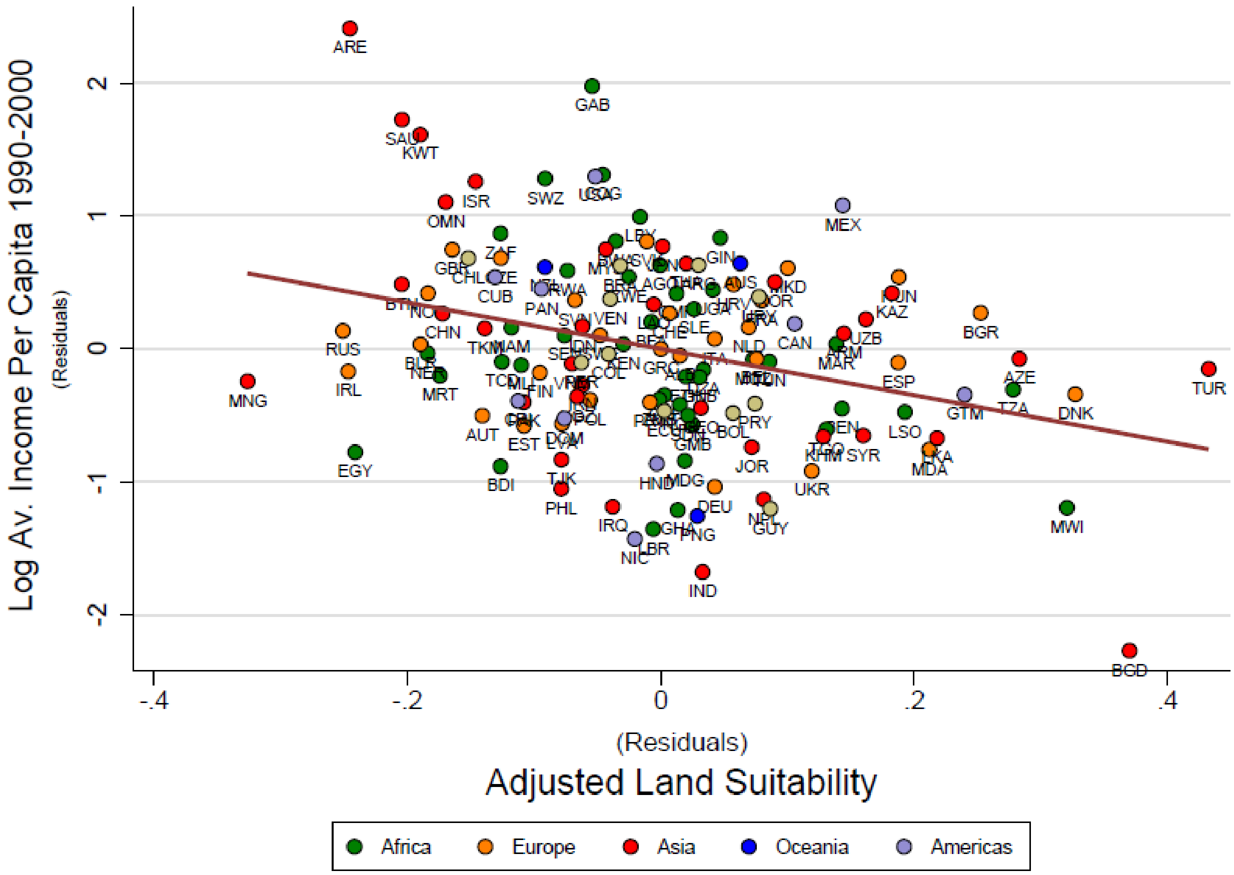


FIGURE C.4: Land Suitability and Economic Outcomes in the Industrial Era (conditional on geographical and institutional characteristics, years since the Neolithic transition, distance from the nearest technological frontier, disease environment, schooling and continental fixed effects)

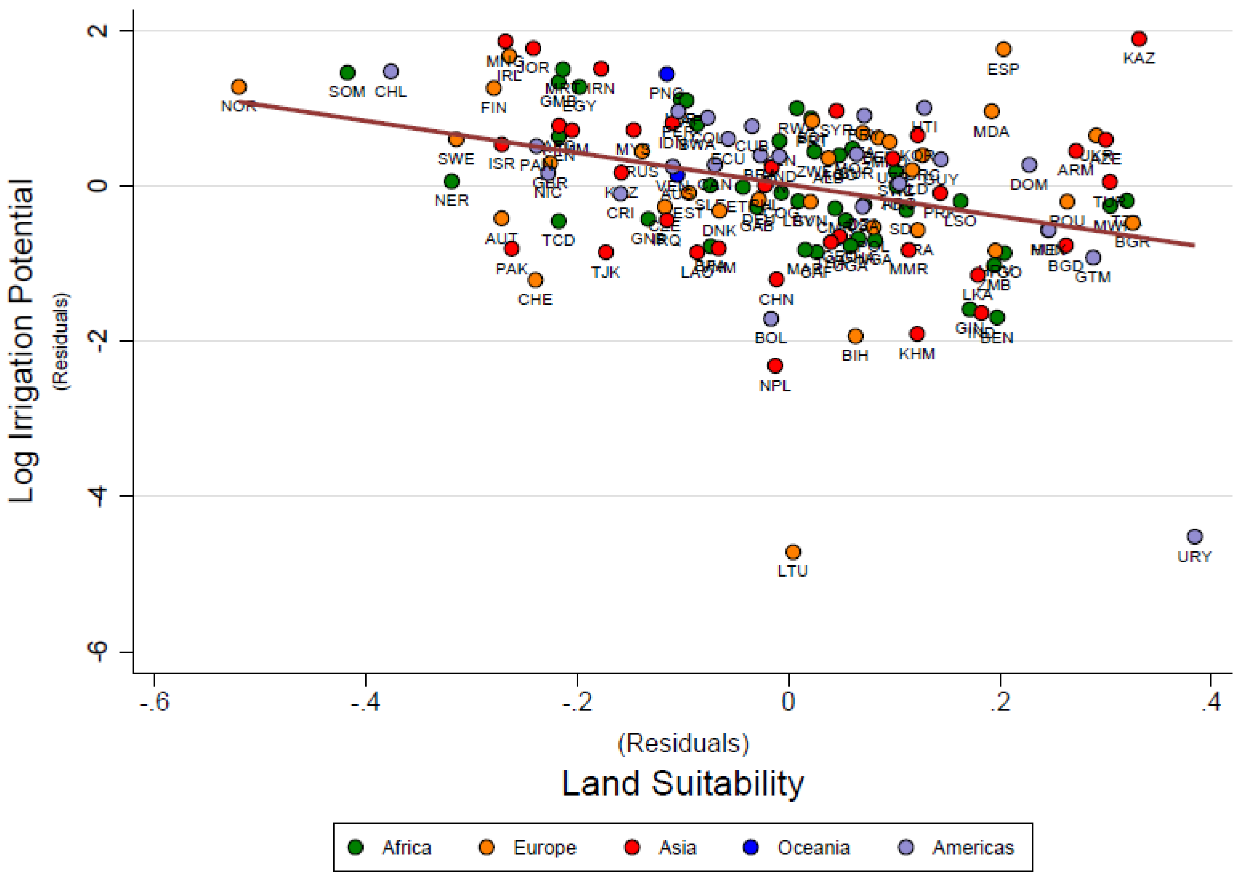


Figure C.5: Land Suitability and Irrigation Potential (conditional on geographical characteristics, years since the Neolithic transition, distance from the nearest technological frontier and continental fixed effects)

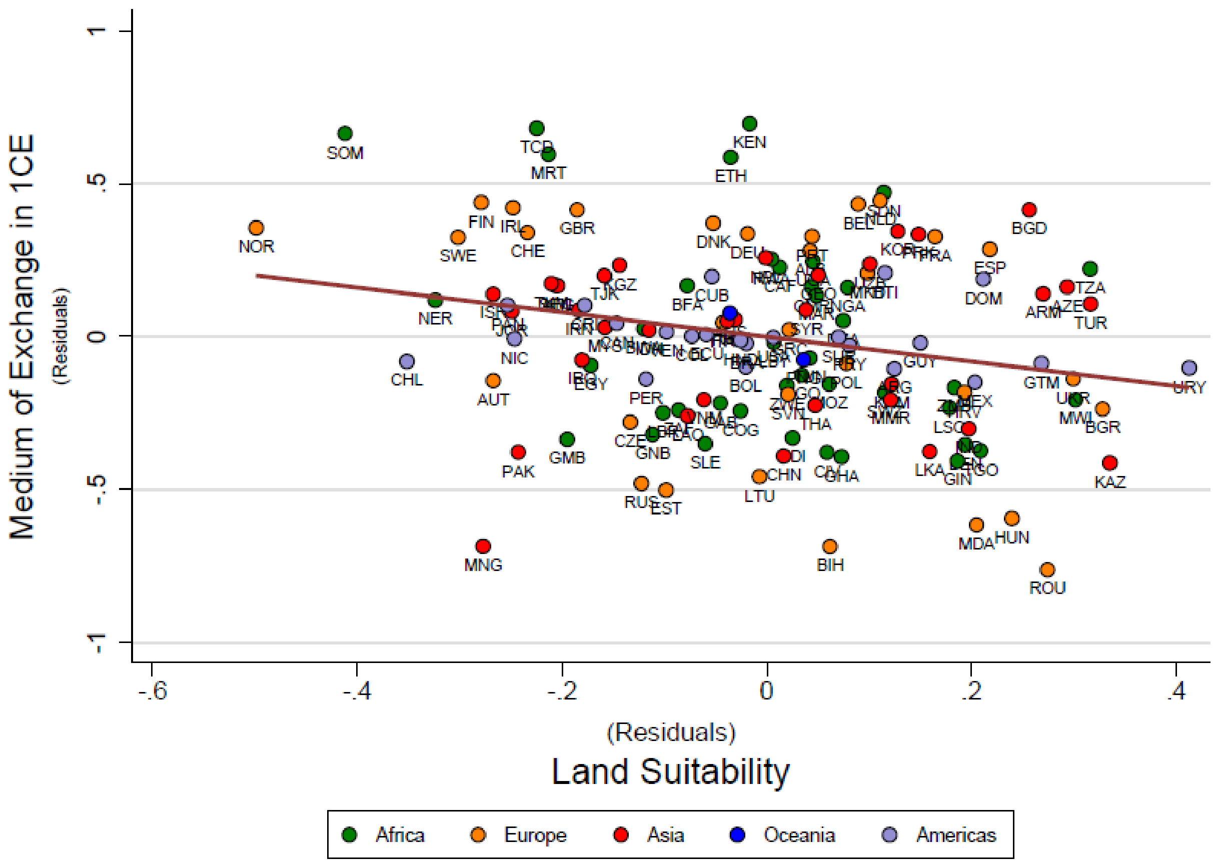


FIGURE C.6: Land Suitability and Medium of Exchange in the Year 1CE (conditional on geographical characteristics, years since the Neolithic transition, distance from the nearest technological frontier and continental fixed effects)

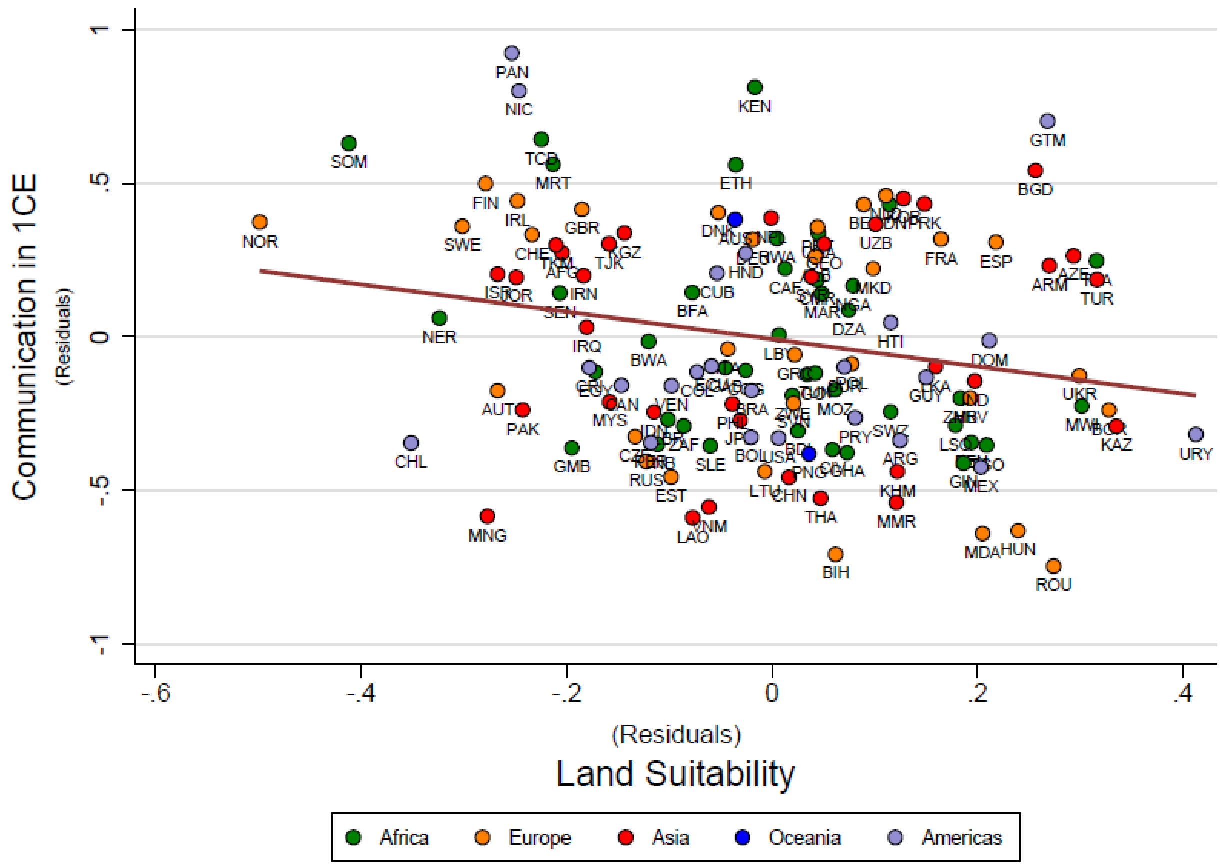


FIGURE C.7: Land Suitability and Medium of Communication in the Year 1CE (conditional on geographical characteristics, years since the Neolithic transition, distance from the nearest technological frontier and continental fixed effects)

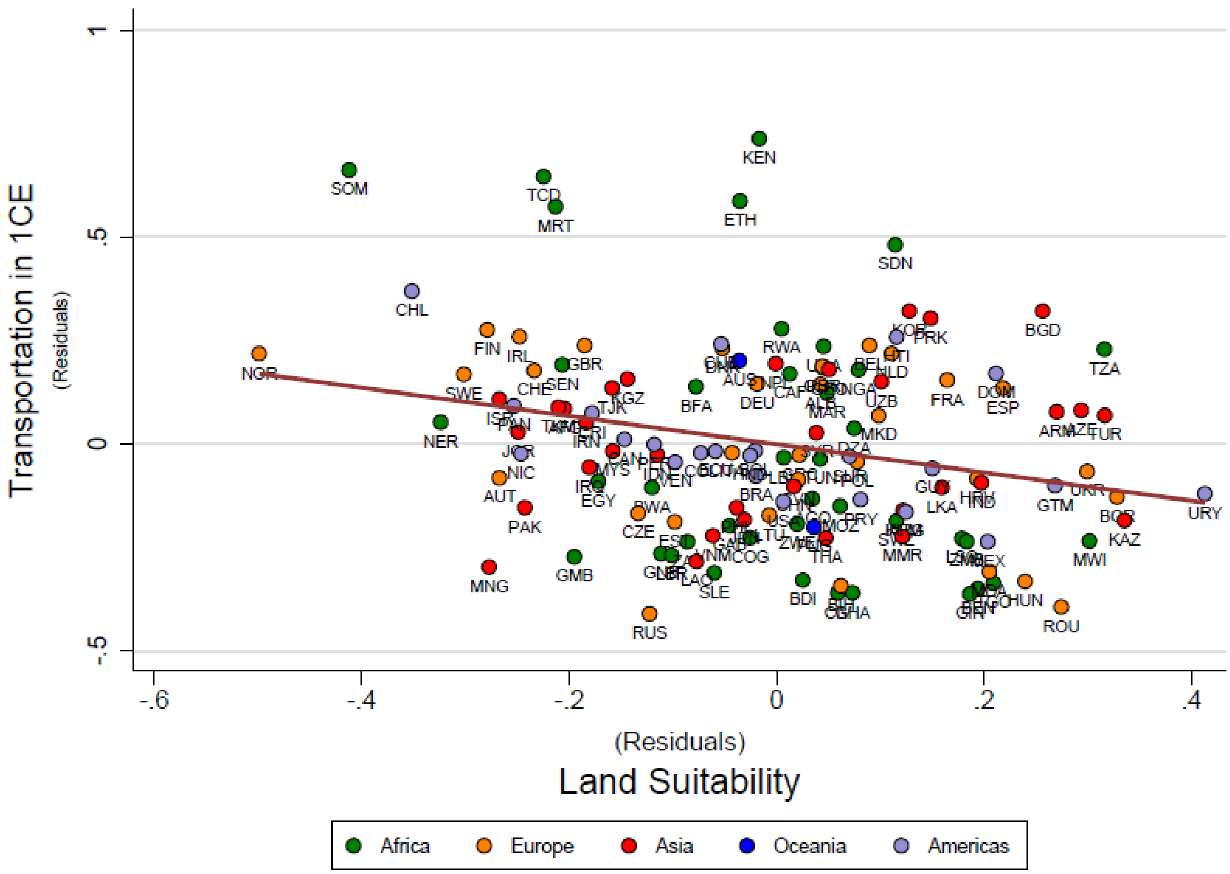


FIGURE C.8: Land Suitability and Medium of Transportation in the Year 1CE (conditional on geographical characteristics, years since the Neolithic transition, distance from the nearest technological frontier and continental fixed effects)

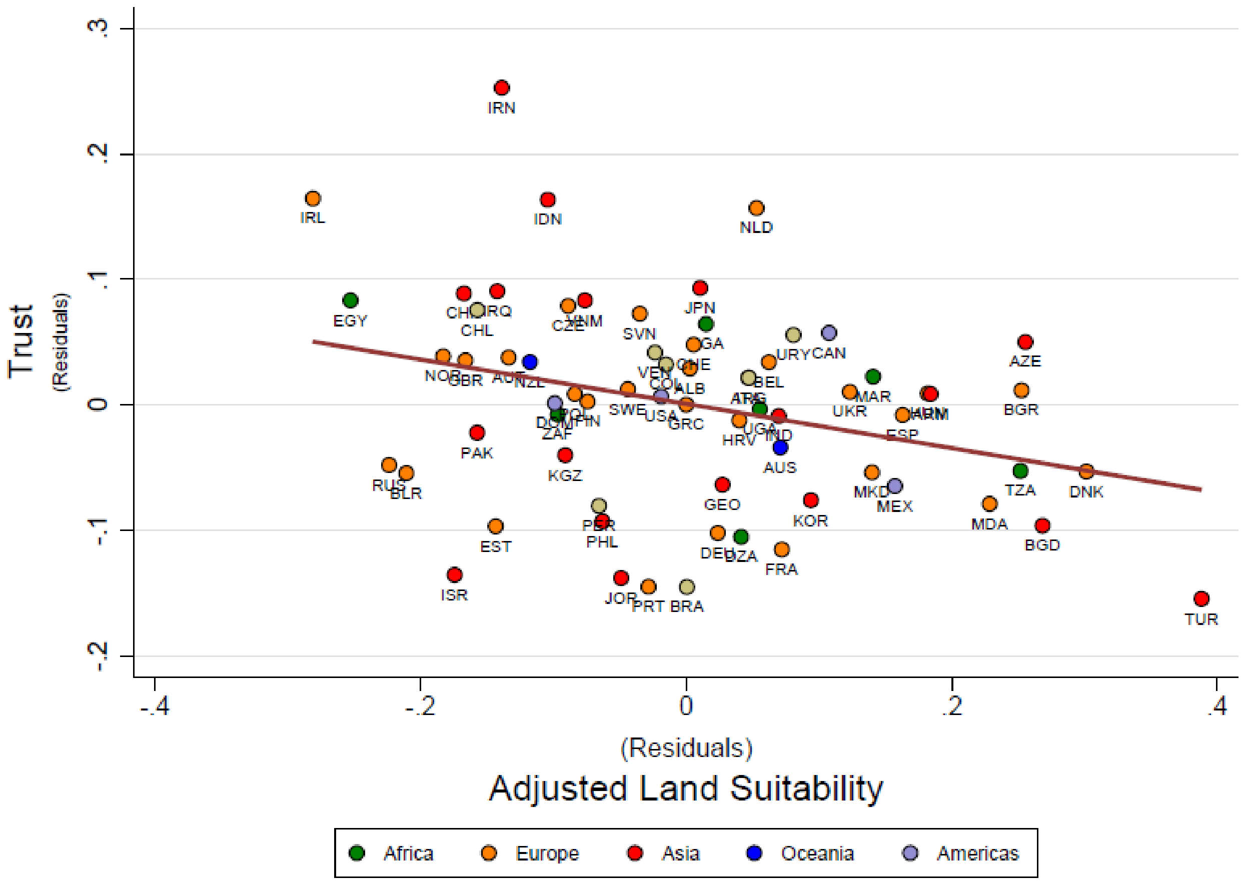


FIGURE C.9: Adjusted Land Suitability and Trust (conditional on geographical and institutional characteristics, years since the Neolithic transition, distance from the nearest technological frontier, disease environment and continental fixed effects)

TABLE C.1: Summary Statistics-Reduced Form Model-Cross Country Sample

		Summary Statistics				Pairwise Correlations										
		Mean	S.D.	Min.	Max.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1)	Trust	0.297	0.147	0.051	0.653	1.000										
(2)	Adjusted Land Suitability	0.499	0.218	0.020	0.876	-0.436	1.000									
(3)	Log Adjsuted Years Since Neolithic	4.571	0.994	1.282	6.218	-0.125	0.166	1.000								
(4)	Log Average Ruggedness	5.988	0.965	3.051	7.908	-0.250	-0.060	0.728	1.000							
(5)	Log Average Elevation	3.425	0.751	0.000	4.159	0.399	-0.057	0.027	-0.255	1.000						
(6)	Log Absolute Latitude	0.396	0.243	0.000	0.693	0.104	0.393	-0.076	-0.613	0.285	1.000					
(7)	% of Land within 100 km of Coast or River	8.696	0.307	7.824	9.250	0.101	0.230	0.286	0.146	0.366	0.028	1.000				
(8)	Ethnic Fractionalization	0.352	0.234	0.002	0.930	-0.300	-0.098	0.051	0.375	-0.544	-0.462	-0.268	1.000			
(9)	Polity IV	5.541	3.704	0.000	10.000	0.270	0.034	-0.057	-0.316	0.369	0.363	0.011	-0.297	1.000		
(10)	Disease Environment	208.119	15.164	186.000	248.000	-0.230	0.025	0.016	0.332	-0.655	-0.430	-0.198	0.425	-0.310	1.000	
(11)	Log Schooling	4.030	0.553	0.928	4.498	0.275	0.112	-0.088	-0.340	0.509	0.409	0.085	-0.436	0.404	-0.297	1.000

Note: Number of Observations = 67

Table C.2: Robustness of the Land Suitability Index-Climatic Component in the Malthusian Era

	(1)	(2)	(3)	(4)	(5)
	Log Pop. Dens. in 1500 CE	Log. Irrig. Potent.	Med. of Exch. in 1 CE	Comm. in 1 CE	Transp. in 1 CE
Climatic Suitability	1.047***	-1.526***	-0.432***	-0.516***	-0.454***
	(0.316)	(0.401)	(0.133)	(0.140)	(0.106)
Continental Dummies	Yes	Yes	Yes	Yes	Yes
Geographical Controls	Yes	Yes	Yes	Yes	Yes
Observations	130	130	130	130	130
R-square	0.710	0.379	0.581	0.437	0.749

Summary: This table establishes robustness of the results to the climatic component. Analytically it establishes the significant positive effect of climatic suitability for agriculture on population density in the year 1500, on irrigation potential, on medium of exchange, communication and transportation in the year 1 CE, while controlling for geography, years since the Neolithic transition, distance from the nearest technological frontier and unobserved continental fixed effects.
Notes: (i) Climatic suitability for agriculture is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration; (ii) irrigation potential measures the fraction of land that becomes marginally arable upon the use of irrigation; (iii) the set of continent dummies includes a fixed effect for Africa, the Americas, Australia, Europe and Sub-Saharan Africa; (iv) a single continent dummy is used to represent the Americas, which in natural given the historical period examined; (v) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (vi) robust standard error estimates are reported in parentheses; (vii) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table C.3: Robustness of the Land Suitability Index-Climatic Component in the Malthusian Era

	(1)	(2)	(3)	(4)	(5)
	Log Pop. Dens. in 1500	Irrig. Potent.	Med. of Exch. in 1 CE	Comm. in 1 CE	Transp. in 1 CE
Soil Suitability	0.616	-2.352***	-0.431**	-0.452	-0.203
	(0.616)	(0.785)	(0.206)	(0.281)	(0.158)
Continental Dummies	Yes	Yes	Yes	Yes	Yes
Geographical Controls	Yes	Yes	Yes	Yes	Yes
Observations	130	130	130	130	130
R-square	0.690	0.368	0.551	0.392	0.698

Summary: This table establishes robustness of the results to the soil component. Analytically it establishes the significant positive effect of soil suitability for agriculture on population density in the year 1500, on irrigation potential, on medium of exchange, communication and transportation in the year 1 CE, while controlling for geography, years since the Neolithic transition, distance from the nearest technological frontier and unobserved continental fixed effects.
Notes: (i) Soil suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (ii) irrigation potential measures the fraction of land that becomes marginally arable upon the use of irrigation; (iii) the set of continent dummies includes a fixed effect for Africa, the Americas, Australia, Europe and Sub-Saharan Africa; (iv) a single continent dummy is used to represent the Americas, which in natural given the historical period examined; (v) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (vi) robust standard error estimates are reported in parentheses; (vii) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table C.4: Robustness of the Land Suitability Index-Climatic and Soil Component and Current Outcomes

	(A.1)	(A.2)	(B.1)	(B.2)
	Log Per Capita Av. GDP 1990-2000	Trust	Log Per Capita Av. GDP 1990-2000	Trust
Adjusted Climatic Suitability	-1.371***	-0.191**		
	(0.498)	(0.090)		
Adjusted Soil Suitability			-2.523***	-0.351***
			(0.734)	(0.105)
Continental Dummies	Yes	Yes	Yes	Yes
Geographical Controls	Yes	Yes	Yes	Yes
Leg.l Orig.-Eur. Col.-Rel. Sh.	Yes	Yes	Yes	Yes
Log Adj. Years Since Neol.	Yes	Yes	Yes	Yes
Ethn. Fractionalization	Yes	Yes	Yes	Yes
Polity IV	Yes	Yes	Yes	Yes
% of Pop at Risk of Malaria	Yes	Yes	Yes	Yes
Log Schooling	Yes	Yes	Yes	Yes
Observations	132	70	132	70
R-square	0.765	0.714	0.776	0.750

Summary: This table tests the robustness of the validity of the land suitability index. In particular it establishes the significant adverse effect of ancestry adjusted climatic suitability (Panel A) and ancestry adjusted soil suitability (Panel B) on income per capita in the year 2000 and the level of generalized trust, while controlling for geography, adjusted years since the Neolithic transition, ethnic fractionalization, quality of institutions, disease environment, schooling, and fixed effects for legal origin, major religion shares, European colony, and unobserved continental fixed effects. Notes: (i) Generalized levels of trust captures the fraction of total respondents within a given country, that answer that "most people can be trusted " in the question "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people"; (ii) climatic suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation such as growing degree days and the ratio of actual to potential evapotranspiration; (iii) Soil suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (iv) adjusted climatic (soil) suitability is the cross-country weighted average of climatic (soil) suitability. The weight associated with a given country represents the fraction of the year 2000 population that can trace its ancestral origins to the given country in the year 1500; (v) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (vi) the set of geographical controls include log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (vii) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (viii) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (ix) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (x) robust standard error estimates are reported in parentheses; (xi) *** denotes statistical significance at the 1 % ** at the 5%, and * at the 10%, all for two-sided hypothesis tests.

Table C.5: Robustness of the Population Density Measure

	(1)	(2)	(3)	(4)	(5)	(6)
	L Pop. Den in 1500-(E&J)	L. Pop. Den in 1000-(E&J)	L.Pop. Den in 1-(E&J)	L. Pop. Den in 1500-(M)	L Pop. Den in 1000-(M)	L. Pop. Den in 1-(M)
Land Suit.	0.373***	0.355***	0.255**	0.456***	0.495***	0.499***
	(0.084)	(0.090)	(0.103)	(0.081)	(0.072)	(0.114)
Continents	Yes	Yes	Yes	Yes	Yes	Yes
Geography	Yes	Yes	Yes	Yes	Yes	Yes
Obs	130	126	117	45	44	42
R-square	0.718	0.640	0.682	0.887	0.898	0.916

Summary: This table establishes the robustness of the effect of land suitability on past economic outcomes using different population density measures. In particular it employs population density in the 1500, 1000 and 1, both from McEvedy and Jones (1978) as well as from Maddison (2003) historical estimates. The analysis controls for geography, years since the Neolithic transition, distance from the nearest technological frontier and unobserved continental fixed effects. Notes: (i) Data on historical population estimates come from Mc Evedy and Jones (1978) and from Maddison (2003); (ii) log land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration, as well as ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (iii) the set of continent dummies includes a fixed effect for Africa, the Americas, Australia, Europe and Sub-Saharan Africa; (iv) a single continent dummy is used to represent the Americas, which in natural given the historical period examined; (v) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (vi) robust standard error estimates are reported in parentheses; (vii) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table C.6: Robustness-Trade Channel in the Malthusian Era

	(1)	(2)	(3)	(4)	(5)
	Log Pop. Dens. in 1 CE	Log. Irrig. Potent.	Med. of Exch. in 1 CE	Comm. in 1 CE	Transp. inr 1 CE
Land Suitability	0.865*	-1.988***	-0.432***	-0.463**	-0.364***
	(0.446)	(0.613)	(0.162)	(0.199)	(0.120)
Log Land Suit.. Diversity	0.381**	-0.205	0.101	0.063	0.077
	(0.152)	(0.198)	(0.061)	(0.062)	(0.053)
Continental Dummies	Yes	Yes	Yes	Yes	Yes
Geographical Controls	Yes	Yes	Yes	Yes	Yes
Observations	130	130	130	130	130
R-square	0.710	0.396	0.570	0.408	0.720

Summary: This table explores the trade channel. It establishes the significant positive effect of land suitability on population density in the year 1500 as well as the adverse effect of land suitability on irrigation potential, medium of exchange, communication and transportation in the year 1 CE, while controlling for geography, land inequality, years since the Neolithic transition, distance from the nearest technological frontier and unobserved continental fixed effects.
Notes: (i) Log land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration, as well as ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (ii) land diversity measure is based on the distribution of a land suitability index across grid cells within a country; (iii) irrigation potential measures the fraction of land that becomes marginally arable upon the use of irrigation; (iv) the set of continent dummies includes a fixed effect for Africa, the Americas, Australia, Europe and Sub-Saharan Africa; (v) a single continent dummy is used to represent the Americas, which in natural given the historical period examined; (vi) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (vii) robust standard error estimates are reported in parentheses; (viii) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table C.7: Robustness-Trade Channel in the Modern Era

	(1)	(2)
	Log Per Capita Av GDP 1990-2000	Trust
Adjusted Land Suitability	-1.276**	-0.322***
	(0.508)	(0.115)
Log Adjusted Land Suitab. Diversity	-0.405*	0.017
	(0.215)	(0.047)
Continental Dummies	Yes	Yes
Geographical Controls	Yes	Yes
Legal Origin-European Colony-Major Relig. Shares	Yes	Yes
Insitututional Controls-Education	Yes	Yes
Observations	132	70
R-square	0.8019	0.749

Summary: This table explores the trade channel in the modern era. It establishes the significant adverse effect of adjusted land suitability on income per capita in the year 2000 and the level of generalized trust, while controlling for geography, adjusted land suitability diversity, adjusted years since the Neolithic transition, ethnic fractionalization, quality of institutions, disease environment, fixed effects for legal origin, European colony, major religion shares and unobserved continental fixed effects.
Notes: (i) Generalized levels of trust captures the fraction of total respondents within a given country, that answer that "most people can be trusted " in the question "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people"; (ii) land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate and soil suitability for cultivation; (iii) land suitability diversity is the range of the land suitability index; (iv) adjusted land suitability (diversity) is the cross-country weighted average of the land suitability (diversity) measure. The weight associated with a given country represents the fraction of the year 2000 population that can trace its ancestral origins to the given country in the year 1500; (v) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (vi) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (vii) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (viii) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (ix) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (x) robust standard error estimates are reported in parentheses; (xi) *** denotes statistical significance at the 1 % ** at the 5%, and * at the 10%, all for two-sided hypothesis tests.

Table C.8: Robustness-Slavery in the Malthusian Era

	(1)	(2)	(3)	(4)	(5)
	Log Pop. Dens. in 1 CE	Log. Irrig. Potent.	Med. of Exch. in 1 CE	Comm. in 1 CE	Transp. inr 1 CE
Land Suitability	1.239***	-2.213***	-0.299*	-0.222	-0.228**
	(0.439)	(0.588)	(0.163)	(0.169)	(0.114)
Log Social Stratification in 1 CE	1.094***	-0.783**	0.416***	0.892***	0.458***
	(0.392)	(0.394)	(0.143)	(0.147)	(0.126)
Continental Dummies	Yes	Yes	Yes	Yes	Yes
Geographical Controls	Yes	Yes	Yes	Yes	Yes
Observations	130	130	130	130	130
R-square	0.718	0.405	0.593	0.540	0.756

Summary: This table is exploring the slavery channel. It establishes the significant positive effect of land suitability for agriculture on population density in the year 1 CE, on irrigation potential, on the fraction of irrigated land in 1900, on communication, medium of exchange and transportation in the year 1, while controlling for geography, years since the Neolithic transition, distance from the nearest technological frontier, social stratification and unobserved continental fixed effects. Notes: (i) Land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate and soil suitability for cultivation; (ii) social stratification captures the number of classes within a society. The index is assigned a value of 1 for egalitarian societies, a value of 2 for two social classes and a value of 3 for three or more social classes (slaves or casts); (iii) irrigation potential measures the fraction of land that becomes marginally arable upon the use of irrigation; (iv) the set of continent dummies includes a fixed effect for Africa, the Americas, Australia, Europe and Sub-Saharan Africa. (v) a single continent dummy is used to represent the Americas, which in natural given the historical period examined; (vi) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (vii) robust standard error estimates are reported in parentheses; (viii) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table C.9: Robustness-Slavery in the Modern Era

	(1)	(2)
	Log Per Capita Av. GDP 1990-2000	Trust
Adjusted Land Suitability	-1.876***	-0.355***
	(0.595)	(0.088)
Log Adjusted Social Stratification in 1 CE	1.165**	0.548*
	(0.558)	(0.303)
Continental Dummies	Yes	Yes
Geographical Controls	Yes	Yes
Legal Origin-European Colony-Major Religion Shares	Yes	Yes
Institutional Controls-Education	Yes	Yes
Observations	127	68
R-square	0.812	0.779

Summary: This table explores the slavery channel in the modern era. It establishes the significant adverse effect of adjusted land suitability on income per capita in year 2000 and on the level of generalized trust, while controlling for geography, adjusted years since the Neolithic transition, ethnic fractionalization, quality of institutions, disease environment, social stratification in the year 1 CE and fixed effects for legal origin, European colony, major religion shares and unobserved continental fixed effects.
Notes: (i) Generalized levels of trust captures the fraction of total respondents within a given country, that answer that "most people can be trusted " in the question "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people"; (ii) land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate and soil suitability for cultivation; (iii) social Stratification captures the number of classes within a society. The index is assigned a value of 1 for egalitarian societies, a value of 2 for two social classes and a value of 3 for three or more social classes (slavery or castes); (iv) adjusted land suitability (social stratification) is the cross-country weighted average of the land suitability (social stratification) measure. The weight associated with a given country represents the fraction of the year 2000 population that can trace its ancestral origins to the given country in the year 1500; (v) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (vi) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (vii) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (viii) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (ix) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (x) robust standard error estimates are reported in parentheses; (xi) *** denotes statistical significance at the 1 % ** at the 5%, and * at the 10%, all for two-sided hypothesis tests.

Table C.10: Robustness-Influential Observations in the Malthusian Era

	(1)	(2)	(3)	(4)	(5)
	Log Pop. Dens. in 1 CE	Log. Irrig. Potent.	Med. of Exch. in 1 CE	Comm. in 1 CE	Transp. inr 1 CE
Land Suitability	1.280**	-1.838**	-0.491***	-0.584**	-0.297***
	(0.615)	(0.797)	(0.130)	(0.282)	(0.078)
Continental Dummies	Yes	Yes	Yes	Yes	Yes
Geographical Controls	Yes	Yes	Yes	Yes	Yes
Observations	130	130	130	130	130
Pseudo R-square	0.474	0.239	0.440	0.349	0.551

Summary: This table establishes that the effect of land suitability on population density in 1500, on irrigation potential, on medium of exchange, communication and transportation is robust to outliers using Quantile Regression Analysis. The analysis controls for geography, years since the Neolithic transition, distance from the nearest technological frontier and unobserved continental fixed effects. Notes: (i) Soil suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (ii) irrigation potential measures the fraction of land that becomes marginally arable upon the use of irrigation; (iii) the set of continent dummies includes a fixed effect for Africa, the Americas, Australia, Europe and Sub-Saharan Africa; (iv) a single continent dummy is used to represent the Americas, which in natural given the historical period examined; (v) the set of controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island, years since Neolithic transition and distance from the nearest technological frontier; (vi) robust standard error estimates are reported in parentheses; (vii) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table C.11: Robustness-Influential Observations in the Modern Era

	(1)	(2)
	Log Per Capita Av. GDP 1990-2000.	Trust
Adj. Land Suitability	-0.908***	-0.356***
	(1.69e-14)	(3.07e-15)
Controls	Yes	Yes
Number of Observations	132	70
Pseudo R-square	0.6187	0.545

Summary: This table establishes that the adverse effect of adjusted land suitability on income per capita in 2000 and on the generalized level of trust is robust to outliers using Quantile Regression Analysis. The analysis controls for geography, adjusted years since the Neolithic transition, ethnic fractionalization, quality of institutions, disease environment and fixed effects for legal origin, European colony, major religion shares and unobserved continental fixed effects.
Notes: (i) Generalized levels of trust captures the fraction of total respondents within a given country, that answer that "most people can be trusted " in the question "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people"; (ii) land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate and soil suitability for cultivation; (iii) adjusted land suitability is the cross-country weighted average of the land suitability measure. The weight associated with a given country represents the fraction of the year 2000 population that can trace its ancestral origins to the given country in the year 1500; (iv) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (v) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude,log access to navigable waterways and a fixed effect for landlocked country and island; (vi) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (vii) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (viii) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (ix) robust standard error estimates are reported in parentheses; (x) *** denotes statistical significance at the 1 % ** at the 5%, and * at the 10%, all for two-sided hypothesis tests.

Table C.12: Robustness-Regional Controls in the Malthusian Era

	(1)	(2)	(3)	(4)	(5)
	Log Pop. Dens. in 1 CE	Log. Irrig. Potent.	Med. of Exch. in 1 CE	Comm. in 1 CE	Transp. inr 1 CE
Land Suitability	0.972**	-2.047***	-0.415**	-0.479**	-0.376***
	(0.431)	(0.594)	(0.167)	(0.193)	(0.124)
Continental Dummies	Yes	Yes	Yes	Yes	Yes
Geographical Controls	Yes	Yes	Yes	Yes	Yes
Observations	130	130	130	130	130
R-square	0.710	0.396	0.570	0.408	0.720

Summary: This table explores the robustness of the results to the use of alternative regional controls. It establishes the significant positive effect of land suitability on population density in the year 1500 as well as the adverse effect of land suitability on irrigation potential, medium of exchange, communication and transportation in the year 1 CE, while controlling for geography, years since the Neolithic transition, distance from the nearest technological frontier and unobserved continental fixed effects.

Notes: (i) Land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration, as well as ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (ii) irrigation potential measures the fraction of land that becomes marginally arable upon the use of irrigation; (iii) the set of continent dummies includes a fixed effect for Latin America and the Caribbean, Sub-Saharan Africa, East Asia and Pacific Region, Europe and Central Asia, Middle East and North Africa and South Asia ; (iv) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (v) robust standard error estimates are reported in parentheses; (vi) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table C.13: Robustness-Regional Controls in the Modern Era

	(1)	(2)
	Log Per Capita Av. GDP 1990-2000	Trust
Adjusted Land Suitability	-1.743***	-0.305***
	(0.576)	(0.086)
Continental Dummies	Yes	Yes
Geographical Controls	Yes	Yes
Legal Origin-European Colony-Major Relig. Shares	Yes	Yes
Insitututional Controls-Education	Yes	Yes
Observations	132	70
R-square	0.808	0.748

Summary: This table explores the robustness of the results to alternative regional controls. It establishes the significant adverse effect of adjusted land suitability on income per capita in year 2000 and the level of generalized trust while controlling for geography, adjusted years since the Neolithic transition, ethnic fractionalization, quality of institutions, disease environment, fixed effects for legal origin, European colony, major religion shares and unobserved regional fixed effects. Notes: (i) Generalized levels of trust captures the fraction of total respondents within a given country, that answer that "most people can be trusted " in the question "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people"; (ii) land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate and soil suitability for cultivation; (iii) adjusted land suitability is the cross-country weighted average of the land suitability measure. The weight associated with a given country represents the fraction of the year 2000 population that can trace its ancestral origins to the given country in the year 1500; (iv) the set of continent dummies includes a fixed effect for Latin America and the Caribbean, Sub-Saharan Africa, East Asia and Pacific Region, Europe and Central Asia, Middle East and North Africa and South Asia; (v) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (vi) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (vii) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (viii) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (ix) robust standard error estimates are reported in parentheses; (x) *** denotes statistical significance at the 1 % ** at the 5%, and * at the 10%, all for two-sided hypothesis tests.

Table C.14: Robustness- OPEC and Very Low Productivity Countries

	(1)	(2)	(3)	(4)
	Log Per Cap. Av. GDP 1990-2000	Trust	Log Per Cap. Av. GDP 1990-2000	Trust
Adjusted Land Suitability	-1.453***	-0.196**	-1.370**	-0.365**
	(0.522)	(0.086)	(0.598)	(0.140)
Continental Dummies	Yes	Yes	Yes	Yes
Geographical Controls	Yes	Yes	Yes	Yes
L. Or-Eur. Col.- Relig. Sh.	Yes	Yes	Yes	Yes
Insitutu.l Controls-Ed.	Yes	Yes	Yes	Yes
OPEC	Yes	Yes	No	No
Land Suitability>0.1	No	No	Yes	Yes
Observations	132	70	110	57
R-square	0.821	0.778	0.842	0.728

Summary: This table explores the robustness of the results to the potential of being driven by very low fertility countries. The first two columns control for OPEC countries, whereas the last two columns exclude countries with very low natural land productivity. The table establishes the significant adverse effect of adjusted land suitability on income per capita in year 2000 and the level of generalized trust while controlling for geography, adjusted years since the Neolithic transition, ethnic fractionalization, quality of institutions, disease environment, fixed effects for legal origin, European colony, major religion shares and unobserved continental fixed effects. Notes: (i) Generalized levels of trust captures the fraction of total respondents within a given country, that answer that "most people can be trusted " in the question "Generally speaking, would you say that most people can be trusted or that you can't be too careful in dealing with people"; (ii) land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate and soil suitability for cultivation; (iii) adjusted land suitability is the cross-country weighted average of the land suitability measure. The weight associated with a given country represents the fraction of the year 2000 population that can trace its ancestral origins to the given country in the year 1500; (iv) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America. Sub-Saharan Africa and Oceania; (v) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (vi) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (vii) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (viii) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (ix) OPEC is a dummy for oil producing countries; (x) robust standard error estimates are reported in parentheses; (xi) *** denotes statistical significance at the 1 % ** at the 5%, and * at the 10%, all for two-sided hypothesis tests.

D Robustness-WVS

TABLE D.1: Summary Statistics-WVS

Table: Descriptive Statistics-Reduce Form-WVS

		Summary Statistics				Pairwise Correlations													
		Mean	S.D.	Min.	Max.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1)	Trust	0.252	0.434	0.000	1.000	1.000													
(2)	Land Suitability	0.488	0.215	0.020	0.876	-0.122	1.000												
(3)	Log Years Since Neolithic	8.649	0.390	7.824	9.250	0.144	0.197	1.000											
(4)	Log Average Ruggedness	4.594	0.865	2.450	6.218	0.002	0.214	0.292	1.000										
(5)	Log Average Elevation	6.261	0.763	3.806	7.908	-0.080	-0.041	0.068	0.700	1.000									
(6)	Log Absolute Latitude	3.252	0.706	0.000	4.159	0.118	-0.062	0.297	0.225	-0.065	1.000								
(7)	% Land 100 km of Coas/Riv	0.304	0.206	0.000	0.693	0.028	0.379	0.025	-0.015	-0.579	0.184	1.000							
(8)	Ethnic Fractionalization	0.437	0.242	0.002	0.930	-0.142	-0.195	-0.434	0.006	0.407	-0.456	-0.480	1.000						
(9)	Polity IV	5.262	3.268	0.000	10.000	0.004	0.068	-0.041	0.120	0.008	0.207	0.104	-0.038	1.000					
(10)	Disease Environment	215.044	16.068	186.000	248.000	-0.086	0.020	-0.277	-0.186	0.134	-0.666	-0.358	0.469	-0.005	1.000				
(11)	Religious Group	53.028	13.886	1.000	86.000	-0.015	-0.165	-0.119	-0.160	-0.078	-0.081	0.015	0.172	0.042	-0.086	1.000			
(12)	Gender	1.558	0.497	1.000	2.000	-0.061	-0.059	-0.161	0.008	0.059	0.063	-0.031	0.098	0.075	0.000	-0.010	1.000		
(13)	Age	38.255	15.668	15.000	97.000	0.094	0.070	0.210	0.019	-0.145	0.153	0.155	-0.227	0.076	-0.169	0.060	-0.094	1.000	
(14)	Educational Level	4.774	2.442	1.000	8.000	-0.046	-0.070	-0.298	0.044	0.112	-0.004	-0.071	0.170	0.172	0.096	-0.069	0.060	-0.332	1.000

Note: Number of observations =86498, Number of Countries=54

Table D.2: Robustness of Land Suitability Index-WVS

	(1)	(2)
	Trust	
Adj. Soil Suit	-0.386***	
	(0.142)	
Adj. Clim. Suit		-0.377***
		(0.114)
Regional F.E	Yes	Yes
Cross Country Controls		
Education-Gender-Religion	Yes	Yes
Observations	86498	86498
R-square	0.120	0.120

Summary: This table tests the robustness of the validity of the land suitability index. In particular it establishes the significant adverse effect of ancestry adjusted climatic suitability and ancestry adjusted soil suitability the individual level of trust, while controlling for geography, adjusted years since the Neolithic transition, ethnic fractionalization, quality of institutions, disease environment, schooling, and fixed effects for legal origin, dominant religion shares, European colony, individual control (age, gender, education, religious group) and unobserved continental fixed effects. Notes: (i)The "Trust" index is the response to the question whether most people can be trusted. The index takes values 0-1 with 1 indicating more trust; (ii) climatic suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation such as growing degree days and the ratio of actual to potential evapotranspiration; (iii) soil suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (iv) adjusted climatic (soil) suitability is the cross-country weighted average of climatic (soil) suitability. The weight associated with a given country represents the fraction of the year 2000 population that can trace its ancestral origins to the given country in the year 1500; (v) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (vi) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (vii) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (viii) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (ix) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (x) robust standard error estimates are reported in parentheses; (xi) *** denotes statistical significance at the 1 % ** at the 5%, and * at the 10%, all for two-sided hypothesis tests.

Table D.3: Robustness to Confounding Factors-WVS

	(1)	(2)	(3)	(4)	(5)
			Trust		
Adjusted Land Suitability	-1.424***	-0.418***	-0.380***	-0.208***	-0.332***
	(0.510)	(0.105)	(0.094)	(0.071)	(0.095)
Log Social Stratification in 1 CE		0.223***			
		(0.085)			
Log Land Suitability Diversity.(A)			0.181***		
			(0.056)		
OPEC				0.163***	
				(0.024)	
Continental Dummies	Yes	Yes	Yes	Yes	Yes
Geography-Institutional Controls	Yes	Yes	Yes	Yes	Yes
Education-Gender-Religion	Yes	Yes	Yes	Yes	Yes
Land Suitability>0.1	No	No	No	No	Yes
Logit Model	Yes	No	No	No	No
Marginal Effect	-0.241***	-	-	-	-
Observations	86403	84505	86498	86498	78091
R-square	0.117	0.123	0.122	0.126	0.103

Summary: This table explores the validity of the estimation. In particular Column (1) estimates a logit model. Column (2) explores the slavery channel by controlling for ancestry adjusted stratification in the year 1 CE. Column (3) explores the trade channel by controlling for diversity in land suitability. Column (4) introduces an OPEC dummy in the analysis to capture resource rich countries with very low land productivity. Column (5) is censoring the sample by excluding countries with extremely low natural land productivity. The baseline analysis controls for geography, adjusted years since the Neolithic transition, ethnic fractionalization, quality of institutions, disease environment, schooling, and fixed effects for legal origin, dominant religion shares, European colony, individual control (age, gender, education, religious group) and unobserved continental fixed effects.
Notes: (i) The "Trust" index is the response to the question whether most people can be trusted. The index takes values 0-1 with 1 indicating more trust; (ii) land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration, as well as ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (iii) irrigation potential measures the fraction of land that becomes marginally arable upon the use of irrigation; (iv) adjusted land suitability is the cross-country weighted average of the land suitability measure. The weight associated with a given country represents the fraction of the year 2000 population that can trace its ancestral origins to the given country in the year 1500; (v) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (vi) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (vii) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (viii) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (ix) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (x) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America. Sub-Saharan Africa and Oceania; (xi) robust standard error estimates are reported in parentheses; (xii) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

E Robustness-ESS

Table E.1: Summary Statistics-ESS

Table: Descriptive Statistics-ESS

		Summary Statistics				Pairwise Correlations													
		Mean	S.D.	Min.	Max.	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1)	Trust	0.400	0.490	0.000	1.000	1													
(2)	Land Suitability	0.472	0.255	0.007	0.956	-0.059	1												
(3)	Log Years Since Neolithic	8.678	0.371	5.991	9.259	-0.023	0.423	1											
(4)	Log Average Ruggedness	4.456	0.858	1.282	6.371	-0.040	0.206	0.281	1										
(5)	Log Average Elevation	5.905	0.792	-0.650	7.950	-0.057	-0.077	0.133	0.770	1									
(6)	Log Absolute Latitude	3.656	0.556	0.000	4.159	0.025	0.005	0.279	-0.040	-0.252	1								
(7)	% of Land 100 km Coas/Riv	0.364	0.248	0.000	0.693	0.005	0.639	0.200	-0.101	-0.447	0.144	1							
(8)	Ethnic Fractionalization	0.319	0.188	0.002	0.930	-0.054	-0.096	-0.273	0.033	0.310	-0.571	-0.380	1						
(9)	Polity IV	4.886	3.533	0.000	10.000	0.069	0.186	0.132	0.053	-0.204	0.288	0.332	-0.347	1					
(10)	Disease Environment	208.713	14.757	186.000	248.000	0.025	-0.346	-0.245	0.090	0.233	-0.267	-0.614	0.235	0.009	1				
(11)	Religious Group	4.627	2.334	1.000	11.000	0.027	-0.105	0.036	0.026	0.062	0.008	-0.133	0.074	-0.037	0.077	1			
(12)	Gender	1.559	0.496	1.000	2.000	0.011	-0.023	-0.028	-0.006	-0.013	0.025	-0.028	-0.009	0.009	0.053	-0.093	1		
(13)	Age	46.628	18.308	15.000	97.000	0.006	-0.008	0.072	-0.068	-0.103	0.186	0.046	-0.116	0.093	-0.037	-0.082	0.072	1	
(14)	Educational Level	3.978	1.871	1.000	7.000	0.136	-0.068	-0.053	-0.131	-0.126	0.099	-0.026	-0.032	0.083	0.090	0.060	0.045	-0.035	1

Note: Number of Observations = 5940, Number of Countries=26, Number of Countries (Ancestry)=116

Table E.2: Robustness of the Land Suitability Index-ESS

	(1)	(2)
	Trust	
Soil Suit (A)	-0.045***	
	(0.017)	
Climate Suit. (A)		-0.117***
		(0.014)
Regional F.E	Yes	Yes
Geography-Institutional Controls (A)	Yes	Yes
Age-Gender-Education-Religion	Yes	Yes
Observations	5940	5940
R-square	0.129	0.129

Summary: This table explores the robustness of the results to the soil and the climate component of the land suitability index. It establishes the adverse effect of each component of land suitability on current levels of trust of migrants. Column (1) introduces the soil component whereas Column (2) introduces the climatic component. The analysis controls for geography, adjusted years since the Neolithic transition, ethnic fractionalization, quality of institutions, disease environment, schooling, and fixed effects for legal origin, dominant religion shares, European colony, individual controls (age, gender, education, religious group) and unobserved regional fixed effects. Notes: (i) The "Trust" index is the response to the question whether most people can be trusted. The index takes values 0-1 with 1 indicating more trust; (ii) Climatic suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation such as growing degree days and the ratio of actual to potential evapotranspiration; (iii) soil suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (iv) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (v) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (vi) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (vii) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (viii) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (ix) (A) denotes that the controls are derived from the ancestry of the respondent; (x) the set of regional dummies includes a fixed effect for 251 NUTS 2 regions; (xi) robust standard error estimates are reported in parentheses; (xii) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table E.3: Robustness to Confounding Factors-ESS

	(1)	(2)	(3)	(4)
	Trust			
Land Suit (A)	-0.097***	-0.076***	-0.097***	-0.070***
	(0.016)	(0.014)	(0.015)	(0.017)
Social Stratification in 1 CE	-0.066***			
	(0.013)			
Land Suitability Diversity.(A)		-0.020***		
		(0.007)		
OPEC			-0.025**	
			(0.010)	
Regional F.E	Yes	Yes	Yes	Yes
Geography-Institutional Controls (A)	Yes	Yes	Yes	Yes
Land Suitability>0.1	No	No	No	Yes
Age-Gender-Education-Religion	Yes	Yes	Yes	Yes
Observations	5823	5940	5940	5655
R-square	0.131	0.130	0.130	0.125

Summary: This table tests the robustness of the results in on a number of additional ethnic controls. Column (1) introduces a control for social stratification in the year 1 CE to explore the slavery channel. Column (2) introduces an index of suitability diversity to explore the trade channel. Column (3) introduces a control for OPEC countries. Column (4) excludes very low fertility countries to capture the possibility of corner solutions. The analysis controls for geography, adjusted years since the Neolithic transition, ethnic fractionalization, quality of institutions, disease environment, schooling, and fixed effects for legal origin, dominant religion shares, European colony, individual controls (age, gender, education, religious group) and unobserved regional fixed effects.
Notes: (i) The "Trust" index is the response to the question whether most people can be trusted. The index takes values 0-1 with 1 indicating more trust; (ii) land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration, as well as ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (iii) social stratification captures the number of classes within a society. The index is assigned a value of 1 for egalitarian societies, a value of 2 for two social classes and a value of 3 for three or more social classes (castes or slaves); (iv) land suitability diversity is based on the range of a land suitability index; (v) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (vi) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (vii) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (viii) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (ix) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (x) (A) denotes that the controls are derived from the ancestry of the respondent; (xi) the set of regional dummies includes a fixed effect for 251 NUTS 2 regions; (xii) OPEC is a dummy for oil producing countries; (xiii) robust standard error estimates are reported in parentheses; (xiv) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table E.4: Robustness to Parental and Partner Controls-ESS

	(1)	(2)	(3)
		Trust	
Land Suit (A)	-0.086***	-0.086***	-0.094***
	(0.014)	(0.014)	(0.015)
Regional F.E	Yes	Yes	Yes
Geography-Institutional Controls (A)	Yes	Yes	Yes
Age-Gender-Education-Religion	Yes	Yes	Yes
Paternal Education-Employment	Yes	Yes	Yes
Maternal Education-Employment	No	Yes	Yes
Partner's Education-Employment	No	No	Yes
Observations	5940	5940	5873
R-square			

Summary: This table establishes the robustness of the results to the inclusion of parental and partner's control that could potentially affect trust of the individual. Column (1) introduces controls on the paternal level of education and employment at the age of 14 (of the respondent). Column (2) add the same controls for the mother of the respondent. Finally Column (3) adds a control on the marital status of the respondent and the partner's educational level. The analysis controls for geography, adjusted years since the Neolithic transition, ethnic fractionalization, quality of institutions, disease environment, schooling, and fixed effects for legal origin, dominant religion shares, European colony, individual controls (age, gender, education, religious group) and unobserved regional fixed effects. Notes: (i) The "Trust" index is the response to the question whether most people can be trusted. The index takes values 0-1 with 1 indicating more trust; (ii) land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration, as well as ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (iii) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (iv) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (v) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (vi) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (vii) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (viii) (A) denotes that the controls are derived from the ancestry of the respondent; (ix) the set of regional dummies includes a fixed effect for 251 NUTS 2 regions; (x) robust standard error estimates are reported in parentheses; (xi) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table E.5: Land Suitability and Trust of Second Generation Migrants

	(1)	(2)	(3)
		Trust	
Land Suit (A)	-0.448*	-0.029***	-0.082*
	(0.234)	(0.008)	(0.047)
Regional F.E	Yes	Yes	Yes
Geography-Institutional Controls (A)	Yes	Yes	Yes
Age-Gender-Education-Religion	Yes	Yes	Yes
ESS Four Rounds	No	Yes	Yes
Logit Model	Yes	No	No
Double Clustering	Yes	Yes	No
Marginal Effect	0.442*	-	-
Observations	5771	19794	5940

Summary: This table establishes the validity of the estimation. Column (1) estimates the logit model (since the trust variable is a binary variable). Column (2) expands the analysis to four waves of the ESS for which the country of origin of the father is availble. Column (3) clusters the standard errors only at the dimension of the country of origin. The analysis controls for geography, adjusted years since the Neolithic transition, ethnic fractionalization, quality of institutions, disease environment, schooling, and fixed effects for legal origin, dominant religion shares, European colony, individual controls (age, gender, education, religious group) and unobserved regional fixed effects. Notes: (i) The "Trust" index is the response to the question whether most people can be trusted. The index takes values 0-1 with 1 indicating more trust; (ii) log land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration, as well as ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (iii) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (iv) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (v) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (vi) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (vii) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (viii) (A) denotes that the controls are derived from the ancestry of the respondent; (ix) the set of regional dummies includes a fixed effect for 251 NUTS2 regions; (x) robust standard error estimates are reported in parentheses; (xi) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

Table E.6: Land Suitability and Trust of Second Generation Migrants

	(1)	(2)	(3)
		Trust	
Land Suit (A)	-0.149***	-0.074*	-0.097***
	(0.029)	(0.044)	(0.019)
Country F.E	Yes	Yes	Yes
Geography-Institutional Controls (A)	Yes	Yes	Yes
Age-Gender-Education-Religion	Yes	Yes	Yes
Father Born in Different Country	Yes	Yes	Yes
Both Parents Born in Different Country	No	Yes	Yes
First Generation Migrants	No	No	Yes
Second Generation Migrants	Yes	Yes	No
Observations	2403	1266	3364

Summary: This table establishes the robustness of the results to potential selection issues, by employing only second generation migrants. Column (1) keeps only the sample of the respondents born in an ESS country but whose fathers' have a different ancestry. Column (2) keeps only the sample of migrants whose parents come from a different country. Column (3) keeps only the first generation migrants whose both parents have been born in the host country. The analysis controls for geography, adjusted years since the Neolithic transition, ethnic fractionalization, quality of institutions, disease environment, schooling, and fixed effects for legal origin, dominant religion shares, European colony, individual controls (age, gender, education, religious group) and unobserved regional fixed effects. The results are robust to the sample of second generation migrants, thereby capturing the intergenerational transmission of cultural traits.
Notes: (i) The "Trust" index is the response to the question whether most people can be trusted. The index takes values 0-1 with 1 indicating more trust; (ii) land suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration, as well as ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH; (iii) the set of continent dummies includes a fixed effect for Africa, Asia, Australia, Europe, North America, South America, Oceania and Sub-Saharan Africa; (iv) the set of geographical controls includes log average ruggedness, log average elevation, log absolute latitude, log access to navigable waterways and a fixed effect for landlocked country and island; (v) the set of legal origins dummies includes a fixed effect for British legal origin, French origin, German origin, Scandinavian origin and Socialist origin; (vi) the set of major religion shares dummies includes a fixed effect for Catholic share, Muslim share, Protestant share, and other religious shares; (vii) the set of European colony dummies includes a fixed effect for British colony, French colony, Spanish colony, other European colony and non-colony; (viii) (A) denotes that the controls are derived from the ancestry of the respondent; (ix) the set of country fixed effects includes a fixed effect for 26 ESS countries. The regional dummies are available only for the fifth wave of ESS and thus the analysis employs countries fixed effects instead; (x) robust standard error estimates are reported in parentheses; (xi) *** denotes statistical significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level, all for two-sided hypothesis tests.

F Variable Definitions and Sources

F.1 Cross-Country Variables

Outcome Variables

Population Density in the Year 1, 1000, and 1500. Population density (in persons per square km) for given year is calculated as population in that year, as reported by McEvedy and Jones (1978), divided by total land area as reported by the World Bank's *World Development Indicators*. The cross-sectional unit of observation in McEvedy and Jones' (1978) data set is a region delineated by its international borders in 1975. Historical population estimates are provided for regions corresponding to either individual countries or, in some cases, to sets comprised of 2–3 neighboring countries (e.g., India, Pakistan, and Bangladesh). In the latter case, a set-specific population density figure is calculated based on total land area and the figure is then assigned to each of the component countries in the set. The same methodology is also employed to obtain population density for countries that exist today but were part of a larger political unit (e.g., the former Yugoslavia) in 1975. Historical population estimates are also available from Maddison (2003), albeit for a smaller set of countries than McEvedy and Jones (1978).

Income Per Capita in 2000. Real GDP per capita, in constant 2000 CE international dollars, as reported by Penn World Table.

Years since Industrialization. The timing of industrialization is determined as the year in which the share of the agricultural sector became less than 30% of the aggregate economic activity. The measure employed is provided by O. Galor. The construction of the data is based upon Mitchell (1975) and the threshold is decided using 5-year averages in order to filter out most of the yearly fluctuations around the threshold.

Irrigation in 1900. Data on irrigation are reported by Freydank and Siebert (2008). They have constructed a set of annual values of area equipped for irrigation for all 236 countries during the time period 1900 - 2003. The values are provided in 1000 ha units. The *Irrigation* variable is using the data for the year 1900 and is expressed as the ratio of irrigated land over arable land.

Irrigation Potential. Data on irrigation potential is obtained from AQUASTAT. The index of irrigation potential is calculated as the fraction of land that becomes marginally suitable for cultivation upon the introduction of irrigation divided by the total arable land under rain-fed conditions. The fraction of land suitable for cultivation denotes the extent of very suitable, suitable, moderately suitable or marginally suitable land.

Communication in Year 1, Transportation in Year 1, Medium of Exchange in Year 1. Data on a) Communication in the year 1 CE b) Transportation in the year 1 CE c) Medium of Exchange in the year ,1 CE are constructed from Peregrine's (2003) Atlas of Cultural Evolution, and aggregated at the country level by Ashraf and Galor (2011). Each of these three sectors is reported on a 3-point scale, as evaluated by various anthropological and historical sources. The level of technology in each sector is indexed as follows. In the communications sector, the index is assigned a value of 0 under the absence of both true writing and mnemonic or non-written records, a value of 1 under the presence of only mnemonic or non-written records, and a value of 2 under the presence of both. In the transportation sector, the index is assigned a value of 0 under the absence of both vehicles and pack or draft animals, a value of 1 under the presence of only pack or draft animals, and a value of 2 under the presence of both. In the Medium of Exchange sector, the index is assigned a value of 0 under the absence of domestically used articles and currency, a value of one under the presence of only domestically used articles and the value of 2 under the presence of both. In all cases, the sector-specific indices are normalized to assume values in the [0; 1]-interval. Given that the cross-sectional unit of observation in Peregrine's dataset is an archaeological tradition or culture, specific to a given region on the global map, and since spatial delineations in Peregrine's dataset do not necessarily correspond to contemporary international borders, the culture-specific technology index in a given year is aggregated to the country level by averaging across those cultures from Peregrine's map that appear within the modern borders of a given country.

Mean Generalized Trust. The fraction of World Values Survey (WVS) respondents that agreed with the statement "most people can be trusted."

Distrust in Civil Servants. It is the country average answer to the question: "Do you have a lot of confidence, quite a lot of confidence, not very much confidence, no confidence at all in civil servants?". The variable is equal to 1 if the answer is no confidence, and 0 otherwise. The variable comes from the World Values Survey (WVS).

Geographical Variables

Land Suitability. A geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation, such as growing degree days and the ratio of actual to potential evapotranspiration, as well as ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH. This index was initially reported at a half-degree resolution by Ramankutty et al. (2002). Formally, Ramankutty et al. (2002) calculate the land suitability index (S) as the product of climate suitability (Sclim) and soil suitability (Ssoil), i.e., S = Sclim Ssoil. The climate suitability component is estimated to be a function of growing degree days (GDD) and a moisture index (α) gauging water availability to plants, calculated as the ratio of actual to potential evapotranspiration, i.e., Sclim = f1(GDD)f2(α). The soil suitability component, on the other hand, is estimated to be a function of soil carbon density (Csoil) and soil pH (pHsoil), i.e. Ssoil = g1(Csoil)g2(pHsoil). The functions, f1(GDD), f2(α), g1(Csoil), and g2(pHsoil) are chosen by Ramankutty et al. (2002) by empirically fitting functions to the observed relationships between cropland areas, GDD, α, Csoil, and pHsoil. For more details on the specific functional forms chosen, the interested reader is referred to Ramankutty et al. (2002). Since Ramankutty et al. (2002) report the land suitability index at a half-degree resolution, Michalopoulos (2012) aggregates the index to the country level by averaging land suitability across grid cells within a country. This study employs the country-level aggregate measure reported by Michalopoulos (2012) as the control for land suitability in the baseline regression specifications for both historical population density and contemporary income per capita.

Land Suitability (Adjusted). The cross-country weighted average of the land suitability measure. The weight associated with a given country in the calculation represents the fraction of the year 2000 CE population (of the country for which the measure is being computed) that can trace its ancestral origins to the given country in the year 1500 CE . The ancestry weights are obtained from the World Migration Matrix (1500 CE–2000 CE) of Putterman and Weil (2010).

Land Suitability Diversity. The land suitability diversity measure is based on the range of the land suitability index, reported at a half-degree resolution by Ramankutty et al. (2002), across grid cells within a country. This variable is obtained from the data set of Michalopoulos (2012).

Land Suitability Diversity (Adjusted). The cross-country weighted average of the land suitabilitydiversity measure. The weight associated with a given country in the calculation represents the fraction of the year 2000 CE population (of the country for which the measure is being computed) that can trace its ancestral origins to the given country in the year 1500 CE . The ancestry weights are obtained from the World Migration Matrix (1500 CE–2000 CE) of Putterman and Weil (2010).

Climatic Suitability. Climatic suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of climate suitability for cultivation such as growing degree days and the ratio of actual to potential evapotranspiration. This index was initially reported at a half-degree resolution by Ramankutty et al. (2002) whereas the country-level aggregate measure is obtained by Michalopoulos (2012).

Soil Suitability. Soil suitability is a geospatial index of the suitability of land for agriculture based on ecological indicators of soil suitability for cultivation, such as soil carbon density and soil pH. This index was initially reported at a half-degree resolution by Ramankutty et al. (2002) whereas the country-level aggregate measure is obtained by Michalopoulos (2012).

Absolute Latitude. The absolute value of the latitude of a country's approximate geodesic centroid as reported by the CIA's *World Factbook*.

Percentage of Land within 100 km of Waterway. The percentage of a country's total land area that is located within 100 km of an ice-free coastline or sea-navigable river. This variable was originally constructed by Gallup et al. (1999) and is part of Harvard University's CID Research Datasets on *General Measures of Geography* available online.

Average Elevation. The average elevation of a country in thousands of km above sea level, calculated using geospatial elevation data reported by the G-ECON project (Nordhaus, 2006) at a 1-degree resolution. The measure is thus the average elevation across the grid cells within a country.

Average Ruggedness. The measure is the average degree of ruggedness across the grid cells within a country, calculated using geospatial elevation data reported by the G-ECON project (Nordhaus, 2006) at a 1-degree resolution. This variable is obtained from the data set of Michalopoulos (2012).

Small Island and Landlocked Dummy. 0/1-indicators for whether or not a country is a small island nation, and whether or not it possesses a coastline. These variables are constructed by Ashraf and Galor (2011a) based on information reported by the CIA in The World Factbook online resource.

Disease Environment. The total number of different types of infectious diseases in a country, as reported by Fincher and Thornhill (2008), based on the Global Infectious Disease and Epidemiology Network (GIDEON) online database.

Distance Variables

Distance to Frontier in the Year 1, 1000 and 1500.: The distance, in thousands of kilometers, from a country's modern capital city to the closest regional technological frontier in the year 1500 CE, as reported by Ashraf and Galor (2011a). Specifically, the authors employ historical urbanization estimates from Tertius Chandler (1987) and George Modelski (2003) to identify frontiers based on the size of urban populations, selecting the two largest cities from each continent that belong to different sociopolitical entities.

Years since Neolithic Revolution. The number of thousand years elapsed, until the year 2000 CE, since the majority of the population residing within a country's modern national borders began practicing sedentary agriculture as the primary mode of subsistence. This measure, reported by Putterman (2008), is compiled using a wide variety of both regional and country-specific archaeological studies as well as more general encyclopedic works on the transition from hunting and gathering to agriculture during the Neolithic.

Years since Neolithic Revolution (Adjusted). The cross-country weighted average of the timing of the Neolithic Revolution. The weight associated with a given country in the calculation represents the fraction of the year 2000 CE population (of the country for which the measure is being computed) that can trace its ancestral origins to the given country in the year 1500 CE . The ancestry weights are obtained from the World Migration Matrix, 1500 CE–2000 CE, of Putterman and Weil (2010).

Institutional Variables

Ethnic Fractionalization. A fractionalization index, constructed by Alesina et al. (2003), that captures the probability that two individuals, selected at random from a country's population, will belong to different ethnic groups.

Polity IV. The 1960–2000 CE mean of an index that quantifies the extent of institutionalized democracy, as reported in the Polity IV data set. The Polity IV democracy index for a given year is an 11-point categorical variable (from 0 to 10) that is additively derived from Polity IV codings on the (i) competitiveness of political participation, (ii) openness of executive recruitment, (iii) competitiveness of executive recruitment, and (iv) constraints on the chief executive.

Legal Origins. A set of dummy variables, reported by La Porta et al. (1999), that identifies the legal origin of the Company Law or Commercial Code of a country. The five legal origin possibilities are: (i) English Common Law, (ii) French Commercial Code, (iii) German Commercial Code, (iv) Scandinavian Commercial Code, and (v) Socialist or Communist Laws.

European Colony. An indicator for whether or not a country was colonized by a European nation as coded by Acemoglu et al. (2005a). The variable equals 1 for colonized countries.

Major Religion Shares. A set of variables, from La Porta et al. (1999), that identifies the percentage of a country's population belonging to the three most widely spread religions of the world. The religions identified are: (i) Roman Catholic, (ii) Protestant, (iii) Muslim, and iv) Other.

Percentage of Native Population. The variable of the percentage of native population is constructed by (Ashraf and Galor, 2011), based on the migration matrix of Putterman and Weil (2010).

Schooling. Schooling is the average total enrollment rate for the period 1990-2000. The data are derived from the World Bank.

Social Stratification. Social Stratification is a measure of social complexity and captures the number of classes within a society. It is constructed from Peregrine's (2003) Atlas of Cultural Evolution. The level of stratification is indexed as follows. The index is assigned a value of 1 for egalitarian societies, a value of 2 for two social classes and a value of 3 for three or more social classes. The index is constructed for the year 1 CE.

F.2 WVS Variables

Outcome Variables

Trust. The "Trust" index is the response to the question whether "most people can be trusted" or "one needs to be too careful". The index takes values 0-1 with 1 indicating that most people can be trusted. The index is taken from the four waves (1981-2002) of the WVS sample.

Individual Controls

Age. The age of the respondent. The age is taken from the four waves (1981-2002) of the WVS sample.

Gender. The gender of the respondent. The gender is taken from the four waves (1981-2002) of the WVS sample.

Religious Denomination. The religious group in which the respondent belongs. Respondents are classified in 90 religious groups, The data is taken from the four waves (1981-2002) of the WVS sample.

Level of Education. The higher level of education attained by the respondent. The questionnaire distinguishes seven different levels of education (inadequately completed elementary education, completed (compulsory) elementary education, (compulsory) elementary education and basic vocational qualification, secondary, intermediate vocational qualification, secondary, intermediate general qualification, full secondary, maturity level certificate, higher education - lower-level tertiary certificate, higher education - upper-level tertiary certificate). The data is taken from the four waves (1981-2002) of the WVS sample.

F.3 ESS Variables

Outcome Variables

Trust. Respondents are given the statement "Generally speaking, would you say that most people can be trusted, or that you can't be too careful in dealing with people? Please tell me on a score of 0 to 10, where 0 means you can't be too careful and 10 means that most people can be trusted." In order to keep the symmetry with the "Trust" variable employed in the cross country sample, derived from the WVS, the variable is rescaled on a two-point scale, with the value 0, capturing the values 0-5 of the original variable and the value 1 capturing the values 6-10. Therefore 0 is now reflecting the answer "Strongly Disagree-Disagree" and 1 reflecting the answer "Strongly Agree-Agree".

Individual Controls

Age. The age of the respondent. The age is taken from the fifith wave of the ESS (2010) The robustness section employs data from rounds 2-5 (2004-2010) for which the origin of the migrant is available at the country level.

Gender. The gender of the respondent. The gender is taken from the fifith wave of the ESS (2010) The robustness section employs data from rounds 2-5 (2004-2010) for which the origin of the migrant is available at the country level.

Religious Denomination. The religious group in which the respondent belongs. The questionnaire covers 8 broad categories of religious denominations (Roman Catholic, Protestant, Eastern Orthodox, Other Christian denomination, Jewish, Islamic, Eastern Religions, Other non-Christian Religions) and a category of non-religious people. The data is taken from the fifith wave of the ESS (2010) The robustness section employs data from rounds 2-5 (2004-2010) for which the origin of the migrant is available at the country level.

Level of Education. The higher level of education attained by the respondent. The questionnaire distinguishes seven different levels of education (less than lower secondary, lower secondary, lower tier upper secondary, upper tier upper secondary, advanced vocational, lower tertiary BA level, higher tertiary > MA level). The same classification holds for the father's, mother's and partner's education. The data is taken from the fifith wave of the ESS (2010) The robustness section employs data from rounds 2-5 (2004-2010) for which the origin of the migrant is available at the country level.

Parental Employment Status at Age 14 of the Respondent. The employment status of the father (mother) when the respondent was 14. The questionnaire distinguishes six different levels of education (employee, self employed, not working, father (mother) dead/absent, refusal, don't know). The data is taken from the fifith wave of the ESS (2010) The robustness section employs data from rounds 2-5 (2004-2010) for which the origin of the migrant is available at the country level.