APPENDICES

Appendix A:
Analysis of the Pinhasi et al. (2005) data

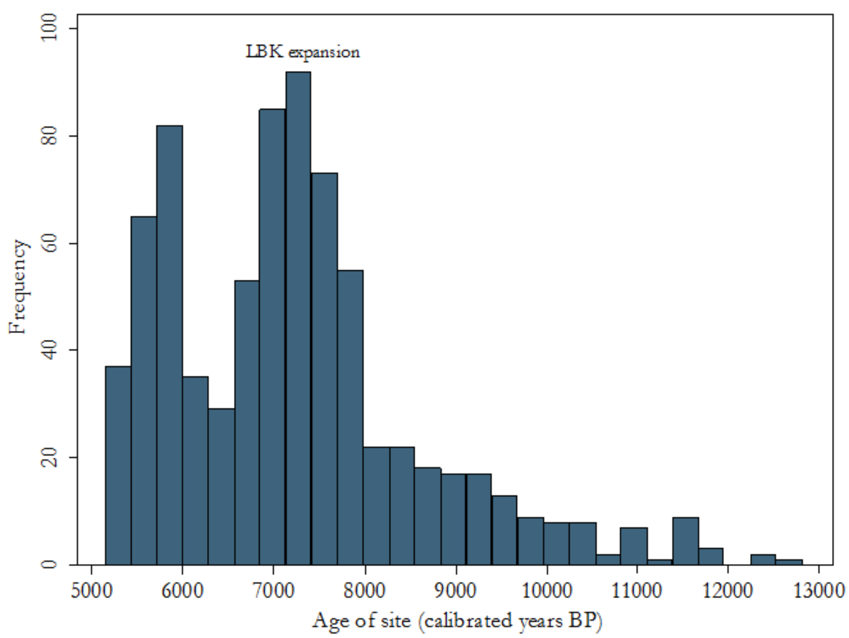
1. Introduction

In this section, we briefly discuss the properties of the Pinhasi et al. (2005) data, which form the basis of our empirical analysis. Section 2 reviews the basic characteristics of the data, section 3 discusses the geographical distribution, whereas section 4, lastly, deals with issues regarding measurement error and potential biases.

2. Basic characteristics

The frequency distribution of the 765 archaeological sites in Pinhasi et al (2005) is shown in the histogram in Figure A1. The distribution has two very distinct peaks; one around 7400 BP and one around 5800 BP. These coincide with two periods of particularly rapid expansions referred to as the Linear Bandkeramik-culture (LBK), in which farmers broke into central Europe and southern Germany after several centuries of standstill, and the later Funnelbeaker-culture (TRB) when most of northern Europe and Scandinavia was settled (Bellwood, 2005).

Figure A1: Frequency distribution of time since agricultural transition among 765 Pinhasi et al (2005) sites



The five oldest and five youngest sites are shown in Table A1. The oldest sites are all in the Fertile Crescent area of the Middle East, comprising areas of current Iraq, Turkey, Jordan, Israel, Syria, and Lebanon. Among the oldest five sites are the very famous Cayönü and Mureybet that are often discussed in the archaeological literature and which are around 12,000 years old. The youngest site in the sample is from 5140 BP at King Barrow Ridge, UK. The standard deviation of the observations range between 28 to 291 years.

Table A1: The five oldest and youngest sites in Pinhasi et al. (2005)

Site	Country	Calibrated date (yrs BP)	St dev
Oldest 5 sites			
M'lefaat	Iraq	12811	75
Hallan Cemi Tepsi	Turkey	12429	268
Cayönü	Turkey	12300	200
Mureybet	Syria	11855	251
Wadi Faynan 16	Jordan	11851	103
Youngest 5 sites			
King Barrow Ridge	UK	5140	170
Normanton Down.	UK	5147	153
Dorchester VIII	UK	5147	150
Flögeln	Germany	5148	117
Szczecin-Ustowo	Poland	5150	130

3. Geographical distribution

As we discuss also in the paper, the distribution of sites across Western countries is not even. The United Kingdom has by far the greatest number of site observations (126) with France the second (108), followed by Italy (78). We would thus expect that the accuracy of dating is greatest in these countries. More than 20 countries have zero observation within their borders. Below, we will return to this issue and perform a statistical analysis on the determinants of why some countries have more observations than others.

4. Measurement issues and potential biases

The data in Pinhasi et al. (2005) have been collected from various different sources. The authors collected the earliest date of Neolithic occupation for each site. Outlier dates that were considered anomalies to the existing literature were excluded. Also the typical culture (LBK, TRB, etc) of each site is specified. The material used for the dating of the site is charcoal, whenever that was available. Comparatively few of the sites were dated by using the best available methodology in the field (accelarator mass spectrometry (AMS)). The authors preferred to include many sites rather than fewer sites with very high quality of measurement and recognize that the choice involves a certain tradeoff. In the paper, Pinhasi et al. (2005) exclude 30 observations with a standard deviation above 200 so that their sample consist of 735 observations. Since we did not see any particular reason for using a standard deviation cut-off of 200 for inclusion, we chose to use also these observations so that our sample has 765 sites as observations in total.

Are the observations biased in some structural way? We have already shown that the geographical distribution across countries is uneven. Table A2 features the logged number of sites within countries as the dependent variable and then studies what determines this number. Not surprisingly, the number of observations increases with the size of country area. Furthermore, it is also clear that richer countries have more observations, all else equal. This presumably reflects the fact that richer countries can spend more resources on archaeological research. Similarly, more sites are available in countries with greater arable land areas. One of the strongest predictors is however the distance to Jericho such that when controlling for other factors, a longer distance to Jericho is associated with fewer sites.

Does this potentially bias our results? The fact that richer countries have more observations implies that the accuracy of regional dating should be higher in such countries. Although this might affect our regional analysis, we do not think that it should bias our cross-country investigation to any greater extent as long as the dating in a country with few observations is as accurate as the dating in a country with many observations.

Table A2: Determinants of the number of sites within countries

	Dependent variable: Log number of sites
Distance to Jericho	-0.501***
	(0.158)
Latitude	-0.141*
	(0.024)
Longitude	-0.007
	(0.010)
Log arable land area	0.428**
	(0.174)
Log distance to coast or river	-0.305
	(0.243)
Log country area	0.452***
	(0.143)
Log GDP per capita	0.669***
	(0.154)
Europe dummy	0.296
	(0.586)
Observations	60
R-squared	0.498

Notes: The figure shows the determinants of log number of Pinhasi archaeological sites within our sample of Western countries. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Appendix B:
Data appendix

B1: Variable definitions, sources, and descriptive statistics for the main cross-country tables

Outcome variables

GDP per capita in 2005. Real GDP per capita in constant 2000 international dollars from *World Development Indicators*, World Bank.

GDP per capita in 1 CE, 1000, 1500, 1820. Real GDP per capita data from Maddison (2013).

Population density in 1 CE, 1000, 1500. Total country population divided by total country area, from Ashraf and Galor (2013).

Variables capturing time since agricultural transition

Average time since agricultural transition. Main explanatory variable showing the date of transition to agriculture for the average region in a country, on the basis of the 765 sites from Pinhasi et al. (2005). For the construction of this variable, we use the location and dating of the individual sites to create a comprehensive map of the date of transition for each grid cell in the Western core. The method that we employ is Inverse Distance Weighted Interpolation (IDW) in ArcGIS. The first step of calculating the average adoption date for a given region is interpolating observed points of archaeological sites. For each cell S_0 on the map, the formula used in interpolation is as follows (Johnston et al, 2003):

$$\hat{Y}(S_0) = \sum_{i=1}^{N} \lambda_i Y(S_i)$$

In this expression, $\hat{Y}(S_0)$ is the predicted adoption date for location S_0, N is the number of measured sample points surrounding the prediction location that will be used in the prediction (in our study, N is set to 15), λ_i are the weights assigned to each measured point, and $Y(S_i)$ is the observed value at the location S_i, one of the known archaeological sites.

The formula to determine the weights is:

$$\lambda_i = d_{i0}^{-p} / \sum_{i=1}^{N} d_{i0}^{-p}$$

Where

$$\sum_{i=1}^{N} \lambda_i = 1$$

The variable d_{i0} is the air distance between location S_0 and archaeological sites, S_i. The power parameter p is determined by minimizing the root-mean-square prediction error (RMSPE) in the Geostatistical Analyst tool of ArcGIS.[1]

In determining the adoption date of a given area, the IDW methodology implicitly assumes that the archaeological site closest to the area gives the best information on the approximate date of agricultural adoption. Given that the IDW method calculates the interpolated adoption date for every cell, the average adoption date for each subnational unit of analysis is simply calculated as the average of all the estimated adoption date of location cells within that subnational unit.[2]

Taking the year 2000 as the benchmark year, the mean date of transition in years before present (BP) in the cross-country sample is 7,611 years, the minimum is 5,608 (Denmark) and the maximum 9,743 (Syria). The mean time since agricultural transition in our cross-regional sample of NUTS2 regions is 7,050 years with a range from 5,598 to 10,290. This translates into a mean adoption date of 5,050 BCE and a first adoption date of 8,290 BCE.

Most cross-country studies that include the time since Neolithic transition as a variable have so far used the cross-country data set in Putterman (2006). For each country, Putterman (2006) determines a date of transition by using the first attested date of Neolithic agriculture within the country's borders as stated by various specialized sources. We believe that our new methodology offers several advantages as compared to Putterman (2006). As far as we know, the data in Pinhasi et al (2005) offer the most recent and most comprehensive compilation of transition dates for the Western region. Furthermore, our methodology provides the average date of transition for a country rather than the first date of transition, as in Putterman (2006).[3]

We believe that this practice will more accurately reflect the transition for the whole country since there may be large discrepancies in dates of transition between regions within countries, as also acknowledged by Putterman (2006). With our methodology, it is further possible to determine transition dates on a much finer geographical level.

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[1] As explained in Johnston et al (2003), each observed point is removed and compared to the predicted value for that location. The RMSPE is the summary statistic of the error of the prediction surface. The Geostatistical Analyst in ArcGIS tries several different powers for IDW to identify the power that produces the minimum RMSPE.

[2] Another class of interpolation techniques, often known as kriging, uses geostatistical properties. Kriging relies on autocorrelation as a function of distance and assumes that the data come from a stationary stochastic process. Given the terrain variation and boundaries, however, the spread of agricultural adoption does not appear to satisfy this assumption. Pinhasi et al. (2005) finds that for Eurasia the agricultural adoption date in an area can be well approximated as a linear function of the distance from the origin in the Fertile Crescent. The correlation between IDW and kriging estimates nevertheless remain very high (0.9729) and the difference has little impact on the final result. Figure A3 in the Appendix shows an example of IDW methodology applied to the 78 Neolithic sites in Italy.

[3] We average over the calculated scores for all the cells within each country to get the country score.

Figure B1: Neolithic sites and the spread of agriculture in Italy

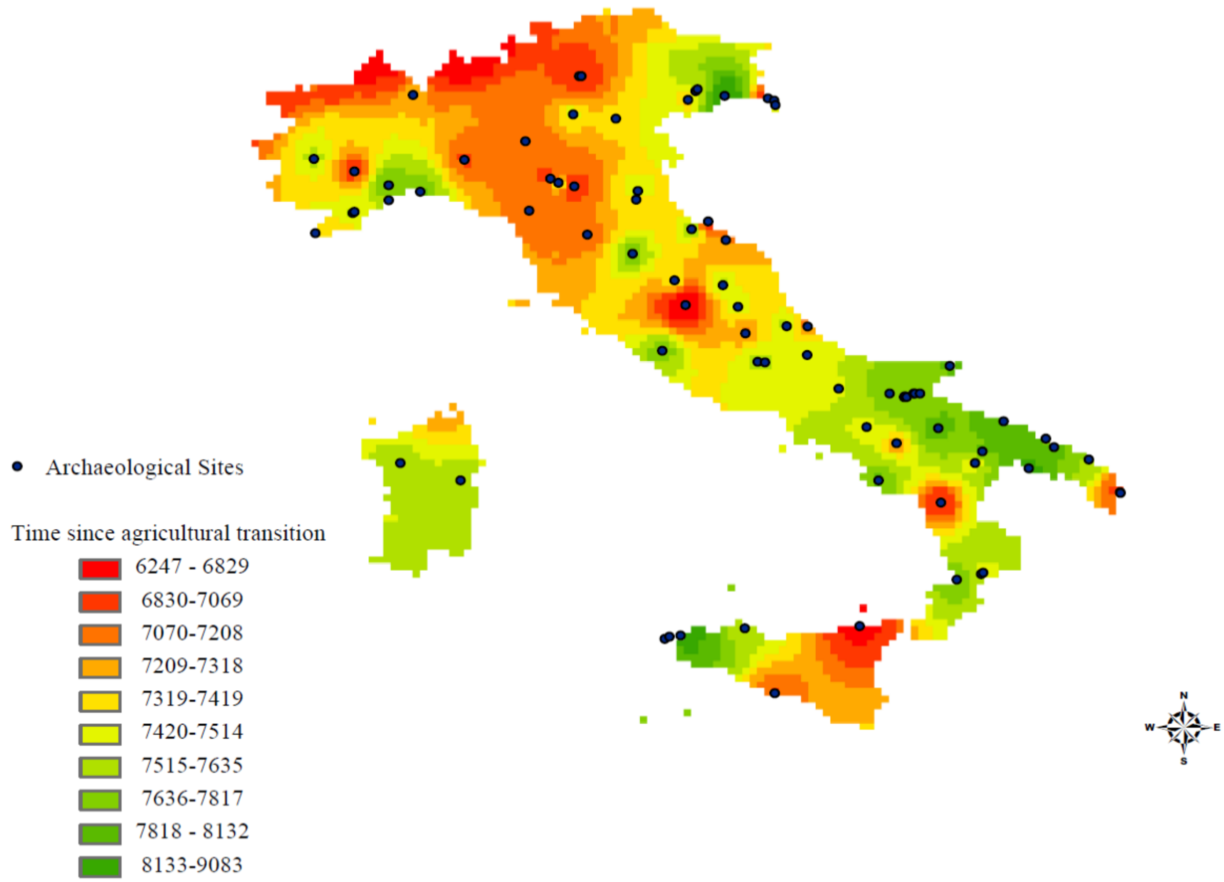


Figure B1 shows the distribution of 78 sites within Italy. The colors have been generated according to the Inverse Distance Weighted Interpolation (IDW) method discussed in 3.2 such that dark green areas made the agricultural transition first and the dark red areas made the transition last. The figure illustrates that there can be quite a bit of variation also within countries.

Predicted time since agricultural transition. An alternative variable created on the basis of the regression equation specified in Figure B2. The latitude and longitude of each country's centroid is used to calculate their approximate *Distance to Jericho*. The distance figure for each country *i* is then imputed into the estimated equation in Figure B2; *Predicted time since agricultural transition (i)* = 9783.8 – 1.01782 x *Distance to Jericho(i).*

The variable is again based on the location and dating of the 765 sites in the Pinhasi et al. (2005) sample and exploits the observed pattern of a fairly stable speed of agricultural diffusion across space from the area of origin in the Fertile Crescent. A similar method is used in the analysis in Pinhasi et al.'s (2005) article.

The construction of this variable first relies on the identification of a center of agricultural origin. In line with the seminal study by Ammerman and Cavalli-Sforza (1984), we use Jericho as the center of diffusion and then calculate the shortest air distance from Jericho to each archaeological site in our sample, using the Great Circle Formula.[4] More specifically, we run a regression of the form

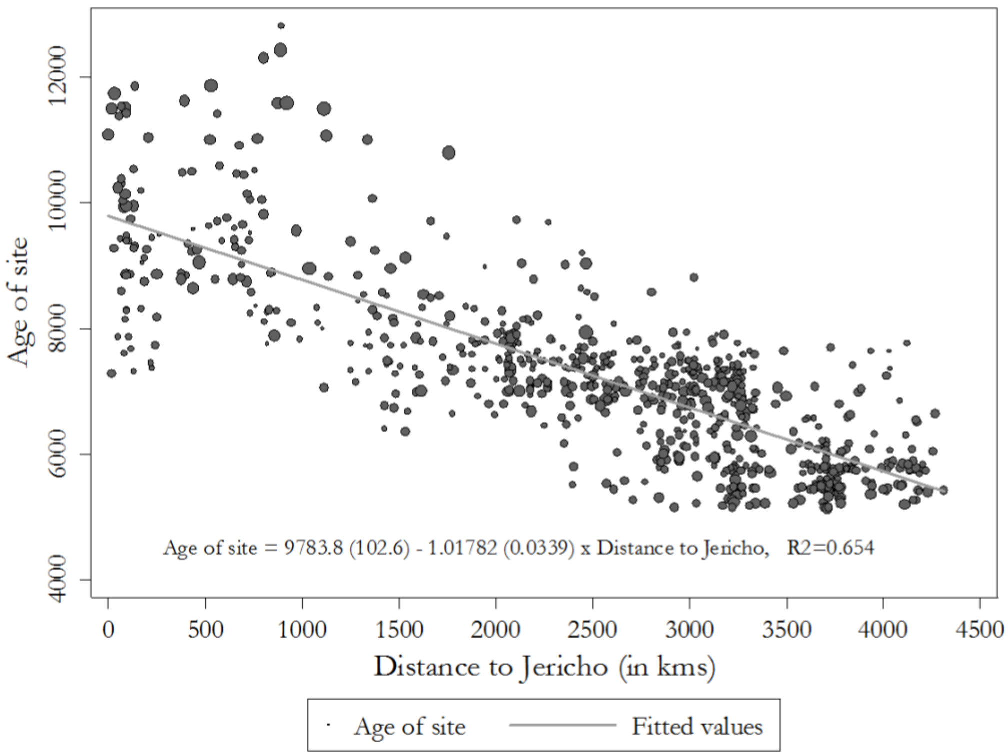
$$T_s = \hat{\alpha}_0 + \hat{\alpha}_1 D_s + \hat{\epsilon}_s$$

where T_s is the observed time since agricultural transition at site s, D_s is air distance in kms from site s to Jericho, $\hat{\epsilon}_s$ is a random error term, $\hat{\alpha}_0$ is a constant and $\hat{\alpha}_1$ is the regression coefficient capturing the marginal effect of distance from Jericho on time since transition. The prediction is $\hat{\alpha}_1 < 0$, i.e. the longer the distance from the origin of agriculture, the shorter the time since transition to agriculture.

Figure B2 shows the relationship between distance from Jericho in kms and the age of the site in calibrated C14 years (or time since agricultural transition) BP (before present) for the 765 sites in our sample. Each observation is a circle and the size of each circle reflects the standard deviation in the calibration of the date such that larger circles have higher standard deviations.

[4] In their investigation of the most likely centers of original domestication, Pinhasi et al. (2005) finds that the sites Abu Madi (in Egypt) and Cayönu (Turkey) are the most likely centers, although Jericho gives a very similar score. See Appendix A for further details.

Figure B2: Relationship between age of site and distance to Jericho among 765 Pinhasi et al. (2005) sites



Note: The figure shows the unconditional relationship between age of site in calibrated radiocarbon years BP and aerial distance to Jericho among 765 archaeological sites in Pinhasi et al. (2005). *Distance to Jericho* is calculated using the Great Circle Formula and takes no account of geographical constraints such as mountains or oceans. Each site observation is represented by a circle. The size of each circle is proportional to the standard deviation of the calibrated dating of the site such that larger circles have larger standard deviations. The fitted curve is a linear OLS regression line with estimated coefficients as displayed in the graph (with robust standard errors in parenthesis).

As the fitted line in Figure B2 shows, there is a strong negative relationship between the age of the site and the distance to Jericho in kilometers. The constant in the regression is $\hat{\alpha}_0$=9783.8 years BP and the slope coefficient is $\hat{\alpha}_1$=-1.018. The interpretation of the coefficient is that agriculture spread on average with a speed of approximately 1 km per year.[5]

We then use the estimated equation in Figure B2 and the geodesic distances of countries and regions to Jericho, to calculate the predicted date of agricultural transition $\overline{T}_i=\hat{\alpha}_0+\hat{\alpha}_1 D_i$ of each geographical unit i in our samples. The correlation of this measure with Average time since agricultural transition is 0.76 at the country level.

[5] There were several periods of more rapid expansion, such as during the LBK culture, as well as periods of standstill. In Appendix A, we discuss the agricultural diffusion process in more detail.

Earliest date of transition. The date of transition to agriculture for the first region in a country to make the transition, using the Inverse Distance Weighted Interpolation, on the basis of the 765 sites from Pinhasi et al. (2005).

Time since agricultural transition (Putterman). The first attested date of agricultural transition within a country. Source: Putterman (2006).

Geographical variables

Distance to Jericho. Using information on the latitude and longitude of the country's and Jericho's approximate centroids, we calculate the aerial distance to Jericho in kilometers by employing the Great Circle Formula. The variable does not take into account geographical obstacles such as water or mountains.

Latitude. Latitude degree of the approximate centroid of the country. Source: CIA World Factbook (2013).

Longitude. Longitude degree of the approximate centroid of the country. Source: CIA World Factbook (2013).

Land suitability for agriculture. Index of the suitability of land for agriculture based on indicators of climate and ecological suitability for cultivation. Source: Michalopoulos (2012)

Arable land area. Arable land in 2001-2005 as a percent of the total land area. Source: World Development Indicators.

Distance to coast or river. Mean distance to an ice-free coastline or a sea-navigable river in kilometers. Source: Harvard CID Research Datasets.

Mean altitude. Mean elevation of country in meters above the sea level. Source: Harvard CID Research Datasets.

Area. Area of country in square kilometers. Source: CIA World Factbook.

Rougness of terrain. Average degree of terrain roughness in a country based on grid cell elevation data. Source: Nordhaus (2006).

Temperature. Average monthly temperature of a country in degrees Celsius. Source: Nordhaus (2006).

Precipitation. Average monthly precipitation of a country in millimeters over the 1960-1990 period. Source: Nordhaus (2006).

Migratory distance to Addis Abeba. Measure of migratory distance from Addis Abeba to the country in question, assuming intermediate geographical stepping-points, as explained in Ashraf and Galor (2013).

Historical variables

Predicted genetic diversity. The expected heterozygosity (genetic diversity) of a given country as predicted by migratory distance from Addis Abeba. Source: Ashraf and Galor (2013)

Ethnic fractionalization. Herfindahl index of ethnic fractionalization. The variable approximates the probability that two random persons within a country *do not* belong to the same ethnic group. Source: Alesina et al (2003).

Protestant population. Variables capturing the percentage of Protestants in a country's population. Source: Ashraf and Galor (2013).

Roman, Byzantine, Carolingian, and Ottoman Empire variables. Own assessment based on digitalized maps from Euratlas (2012).

Mongol invasion in 1300 CE. Dummy=1 if country was strongly affected by Mongol raids around 1300 CE. Own assessment based on various references that are available upon request.

Legal origin variables. Dummy variables capturing the legal origin of countries. Source: La Porta et al (1990).

State history 1-1950 CE. The variable captures the extent of a country's state experience during 1-1950 CE. The variable is normalized to range between 0 and 1 where 1 means maximum state experience during the period. Source: Putterman (2010), http://www.econ.brown.edu/fac/louis_putterman/antiquity%20index.htm.

Executive constraints in 1500. This variable uses information from all available observations in Acemoglu et al (2005) who have coded the variable independently in line with the Polity IV-codebook. The variable ranges between 1-7 where 1 implies no constraints against the executive and 7 implies very strong constraints as in a fully developed democracy. We have added information from countries that belonged to the Ottoman Empire during the period and all of them are coded as 1. This is well in line with the literature, for instance Hourani (2013), where it is emphasized that the Ottoman Empire was strongly autocratic in this era.

Democracy stock 1900-2000. Index capturing average levels of democracy during 1900-2000 according to the Polity2 measure. The score for country *i* is calculated as *Democracy stock 1900-2000* (i) $= \sum_{s=1900}^{2000} 0.99^{2000-s} \cdot Polity2_{i,s}$ where $Polity2_{i,s}$ is the score for country *i* at time *s* and where 0.99 is a time discount factor. Source: Gerring et al (2005).

B2: Variable definitions and sources for the NUTS2 cross-regional analysis

Average GDP per capita 2005. Average level of GDP per capita on NUTS2-region level in 2005 in euros. Source: Eurostat (2012) and Turkish Statistical Institute

Average time since agricultural transition. Constructed in the same way as the equivalent variables on country level.

Distance to coast or river. Mean distance to an ice-free coastline or a sea-navigable river in kilometers. Source: constructed using ESRI 2008 Data and Maps for GIS

Fraction of land suitable for agriculture. Fraction of land suitable for agriculture. Source: Ramankutty et al. (2008)

B3: Variable definitions and sources for the NUTS3 cross-regional analysis

Average GDP per capita 2005. Average level of GDP per capita on NUTS3 in euros
Source: Eurostat (2012) and Turkish Statistical Institute

Average time since agricultural transition. Constructed in the same way as the equivalent variables on country level.

Distance to coast or river. Mean distance to an ice-free coastline or a sea-navigable river in kilometers. Source: constructed using ESRI 2008 Data and Maps for GIS

Fraction of land suitable for agriculture. Fraction of land suitable for agriculture. Source: Ramankutty et al. (2008)

Additional references:

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

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La Porta, R., F. Lopez-de-Silanes, A. Schleifer, and R. Vishny (1999) "The Quality of Government" *Journal of Law, Economics & Organization*, 15(1):222-79.

Ramankutty, N., A.T. Evan, C. Monfreda, and J.A. Foley (2008). "Farming the Planet: Geographic Distribution of Global Agricultural Lands in the Year 2000", in Global Biogeochemical Cycles 22.1.

B4: Descriptive statistics

Table B1: Summary statistics and sources of variables for the cross-country analysis in tables 1-2

Variables	N	Mean	SD	Min	Max
Dependent variables					
Log GDP per capita in 2005 (constant 2000 USD)	64	8.688	1.369	6.224	10.859
Log Population density in 1 CE	54	1.024	1.266	-1.481	3.170
Log Population density in 1000 CE	60	1.318	1.136	-1.258	3.442
Log Population density in 1500 CE	61	1.733	1.296	-1.258	4.135
Log GDP per capita in 1 CE	24	6.144	0.164	5.991	6.696
Log GDP per capita in 1000 CE	21	6.097	0.156	5.991	6.477
Log GDP per capita in 1500 CE	22	6.432	0.231	6.064	7.003
Log GDP per capita in 1820 CE	29	6.693	0.396	6.064	7.516
Independent variables					
Average time since agricultural transition (in 1000 yrs from 2000 CE)	64	7.611	1.100	5.608	9.743
Predicted time since agricultural transition (in 1000 yrs from 2000 CE)	65	7.430	1.122	4.393	9.737
Earliest date of transition (for any region country, in 1000 yrs from 2000 CE)	60	8.446	1.593	5.673	12.408
Time since agricultural transition (Putterman)	62	7.003	1.850	3.5	10.5
Geographical controls					
Log latitude (degrees)	64	-1.117	1.032	-4.198	0.588
Log land suitability for agriculture (index)					
Log arable land area (percent)	64	2.575	1.250	-2.106	4.028
Log area (sq. kms)	64	4.501	2.131	-2.797	8.098
Rougness of terrain	63	0.189	0.145	0.017	0.569
Temperature (degrees Celsius)	63	13.26	7.163	1.026	27.36
Precipitation (mms)	63	50.60	28.91	2.911	109.1
Migratory distance to Addis Abeba (in 1000 kms)	65	4.945	1.050	2.462	7.821
Longitude (degrees)	65	24.71	20.41	-21.97	77.22
Europe, Southwest Asia and Fertile Crescent dummies	64			0	1
Historical variables					
Predicted genetic diversity	65	0.737	0.008	0.715	0.756
Ethnic fractionalization (Herfindahl index)	64	0.346	0.221	0.034	0.792
Protestant population	63	11.87	26.56	0	97.8
Roman empire (fraction of country part of empire in 200 CE)	64	0.469	0.455	0	1
Byzantine empire (fraction of country part of empire in 500 CE)	64	0.174	0.357	0	1
Carolingian empire (fraction of country part of empire in 800 CE)	64	0.163	0.350	0	1
Ottoman empire (fraction of country part of empire in 1600 CE)	64	0.267	0.383	0	1
Mongol empire (dummy=1 if country was overrun by Mongols in 13-14th centuries CE)	64			0	1
Legal origin UK, France, Scandinavia	65			0	1
State history 1-1950 CE (index)	52	0.606	0.151	0.290	0.887
Democracy stock 1900-2000 (index)	65	-7.078	364.75	-604.6	637.6
Executive constraints in 1500 (index)	47	1.34	0.635	1	3

Table B2: Summary statistics and sources of variables used in the regional analysis (NUTS2)

Variables	N	Mean	SD	Min	Max
Dependent variable					
Log Average GDP per capita 2005 (in €)	283	9.760	0.613	7.664	11.26
Independent variables					
Average time since agricultural transition (in 1000 yrs from 2000 CE)	283	7.076	0.960	5.598	10.29
Geographical controls					
Land suitability (as fraction of total land area)	277	0.591	0.225	0.002	0.968
Distance to coast or major river (kilometers)	283	29.97	55.30	0	305.0

Table B3: Summary statistics and sources of variables used in the regional analysis (NUTS3)

Variables	N	Mean	SD	Min	Max
Dependent variable					
Log Average GDP per capita 2005 (in €)	1360	9.664	0.784	7.003	11.91
Independent variables					
Average time since agricultural transition (in 1000 yrs from 2000 CE)	1360	7.066	0.841	5.243	11.32
Geographical controls					
Land suitability (as fraction of total land area)	1349	0.154	0.079	0	0.371
Distance to coast or major river (kilometers)	1360	55.85	72.09	0	377.0

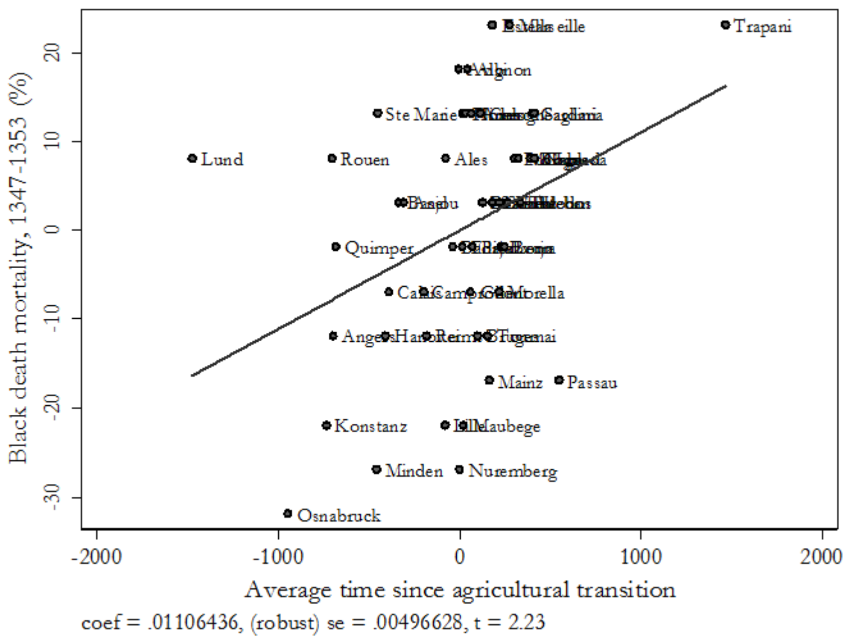
Appendix C: Robustness Checks

Table C1: Within-country relationships between average GDP per capita and time since agricultural transition for NUTS3-regions in five large countries

	OLS point estimate for *Average time since agricultural transition*			
Country	No controls	With controls	Obser-vations	Pinhasi sites
France	-0.184** (0.075) R^2=0.085	-0.201** (0.081) R^2=0.102	96	108
Germany	0.166*** (0.037) R^2=0.040	0.190*** (0.040) R^2=0.320	429	57
Italy	-0.533*** (0.104) R^2=0.196	-0.363*** (0.118) R^2=0.333	107	78
Spain	-0.773*** (0.168) R^2=0.240	-0.654 *** (0.214) R^2=0.375	51	8
Turkey	-0.323*** (0.033) R^2=0.466	-0.292*** (0.040) R^2=0.486	81	30

Note: The table shows estimated coefficients for the within-country relationships between *Average time since agricultural transition* and *Log Average GDP per capita 2005* for the five largest countries with significant regression coefficients. The estimator is OLS in all specifications and each observation is a NUTS3-region. A constant with unreported coefficients has been included in all regressions. The set of control variables includes *Fraction of land suitable for agriculture* and *Log distance to coast or river*. Robust standard errors are in ()-parentheses. *Pinhasi sites* refers to the number of archaeological sites in Pinhasi et al (2005) within each country's borders that are used for assessing the date of transition for each region. *** p<0.01, ** p<0.05, * p<0.1.

Figure C1: Bivariate relationship between Black Death mortality in 1347-1353 and average time since agricultural transition among 53 Western cities



Note: The figure shows the bivariate relationship between Black Death mortality in 1347-1353 and average time since agricultural transition for 53 European cities. The data on Black Death mortality are from Christakos et al (2005), p 141. The data on Average time since agricultural transition for the 53 cities have been obtained with the same method as described in section 3.2.

Appendix D: A Comparative country analysis

Our key variable in the empirical section is a country's or region's time since transition to agriculture, $t-\tau_j$. In a comparative country analysis at time t, it will be evident that the impact of an early transition to agriculture (i.e. a high $t-\tau_j$) will be time varying and imply a development reversal from early to later in history.

To illustrate this, consider two countries, A (which we could think of as Mesopotamia) and B (Sweden), where biogeographic potential for agriculture are such that $F_A > F_B$ so that $\tau_A(F_A) < \tau_B(F_B)$. The countries are identical in all other respects. The rapid productivity development during the take-off stage, in accordance with the process in equation (1), soon kicks in in country A whereas country B at first stays at a pre-agricultural stage where $A_{Bt}=1$. At an early stage in history such as $\tau_A < t < \tau_B$, a comparison of productivity levels between the two countries will then show that

$$A_{At} = \frac{\widetilde{A}_A}{1+(\widetilde{A}_A - A_{A\tau_A})e^{-g(t-\tau_A)}} > A_{Bt} = 1$$

At this early stage, the positive effect of an early transition to agriculture $\tau_j(F_j)$ clearly dominates and implies that country A has a more advanced productivity and a higher population density than country B.

However, at a much later date, close to infinity such that $t \to \infty$, then we will instead have that

$$A_{At} = \widetilde{A}_A + \varepsilon_A < A_{Bt} = \widetilde{A}_B + \varepsilon_B$$

where ε_A and ε_B are infinitesimally small numbers. At this date, a development reversal has been completed so that country B now has a higher productivity. The negative effect of an early transition to agriculture thus dominates in the long run and there should eventually be a negative relationship between total productivity levels and $t-\tau_j$.