*For Online Publication*

**Appendix A: Cereals vs. Roots and Tubers**

In this appendix we seek to provide evidence in support of our various factual claims on the distinction between cereals and roots/tubers: (i) that reliance on roots and tubers is a major phenomenon in tropical regions; (ii) that roots and tubers are highly productive in the tropics; (iii) that their harvesting is in general non-seasonal; (iv) that after harvest they are significantly more perishable than cereals; and (v) that there exist significant climatic and soil variations in the productivity of cereals and of roots and tubers. (vi) that there moisture content is very high, making them bulky to transport.

.

Table A.1: Major staple crops produced in regions of the world in 1961

| | World 1961 | | Sub-Sahara 1961 | | Papua New-Guinea 1961 | |
|---|---|---|---|---|---|---|
| | Average Cal Yield (mil Kcal/ha)* | Total Energy Produced ($10^{12}$ kcal)** | Average Cal Yield (mil Kcal/ha)* | Total Energy Produced ($10^{12}$ kcal)** | Average Cal Yield (mil Kcal/ha)* | Total Energy Produced ($10^{9}$ kcal)** |
| Rice | 6.92 | 798 | 4.57 | 12 | 13.16 | 6 |
| Wheat | 3.78 | 772 | 2.39 | 6 | | |
| Maize | 7.09 | 748 | 3.66 | 53 | 3.34 | 0 |
| Barley | 4.68 | 255 | 2.79 | 3 | | |
| Oats | 3.19 | 122 | 2.86 | 0 | | |
| Sorghum | 3.02 | 139 | 2.53 | 29 | 5.62 | 0 |
| Rye | 3.92 | 119 | 0.60 | 0 | | |
| Millet | 2.24 | 97 | 2.17 | 24 | | |
| Soybean | 1.66 | 40 | 0.55 | 0 | | |
| Potato | 9.41 | 208 | 5.14 | 1 | 5.21 | 0 |
| Cassava | 11.85 | 114 | 9.10 | 50 | 15.94 | 84 |
| Sweet Potato | 6.32 | 84 | 4.44 | 3 | 3.44 | 254 |
| Yam | 8.54 | 10 | 8.65 | 9 | 19.56 | 142 |
| Taro | 6.63 | 5 | 0.54 | 0 | 7.51 | 136 |
| Banana | 9.47 | 19 | 5.21 | 3 | 11.17 | 276 |
| Plantain | 6.37 | 16 | 5.65 | 11 | | |
| Total of above | | 3,545 | | 203 | | 898 |
| Population (mil) | | 3,083 | | 223 | | 2 |

The average caloric content of each crop is based on the figures in table E.4. For Soybeans, Taro, Bananas and Plantains the respective figures are 1.47, 1.12, 0.89, and 1.22, based on http://ndb.nal.usda.gov/ndb/, accessed Feb 2017. * Calculated on the basis of the caloric content of each crop multiplied by the average land yield, as reported by the FAO (http://faostat3.fao.org/download/Q/*/E accessed Feb 2017). ** Calculated on the basis of the average caloric yield multiplied by the crop area, as reported by the FAO (http://faostat3.fao.org/download/Q/*/E accessed Feb 2015).

Table A1 presents summary data on the main staple crops in sub-Saharan Africa, in Papua New Guinea (PNG) and the world in 1961 – the earliest year for which the Food and Agriculture Organization (FAO) provides the information.[46] In relying on relatively recent data, our presumption is that the soil and climatic conditions have not changed significantly since the Neolithic period. Of course, we recognize that the plants that provide most of the calories that humans consume have undergone major modifications since antiquity, and that their availability was greatly impacted by the post-Columbian migration of species between the continents.

(i) The data in Table A1 reveals that roots and tubers provided 37.9 percent of the total calories produced by the main staple crops in sub-Saharan Africa in 1961. We note that cassava alone provided about 45 percent of the total calories produced by these crops in Nigeria in 2013.

(ii) The table reveals further that the average caloric yield of cassava and yam in sub-Saharan Africa (9.10 and 8.65 mil Kcal/Ha) exceeded the comparable world average yield of the three main cereals, rice, maize and wheat (equal to 6.82, 7.09 and 3.56 mil Kcal/Ha, respectively).

(iii) The table reveals that the yield of non-cereals in PNG is generally high.

(iv) The seasonality of cereals is well known. They have to be sown and reaped in a relatively fixed period in the year, and usually once a year. On the other hand, roots and tubers are generally perennial and may be harvested at any time during the year. In fact, cassava can be left intact in the ground for two years. This gives farmers great flexibility around the timing of the harvest, and prevents the need for significant storage. Rees et al. (2012, p. 394) report: "Harvest time [of cassava] ranges from six to 24 months, and roots can be left in the ground until needed, making cassava a very useful food security crop."[47]

(v) Harvested grains are storable with relatively little loss from one harvest to the next, and even over several years. On the other hand, roots and tubers are in general perishable once out of the ground, though to different degrees. In particular, cassava starts to rot at ambient African temperature within 2-3 days of being harvested. The rapid deterioration is often hastened by abrasions caused by uprooting and transportation. Rees et al. (2012, p. 394) summarize the evidence: "Despite their agronomic advantages over grains, which are the other main staple food crops, root crops are far more perishable. Out of the ground, and at ambient temperatures these root crops have shelf lives that range from a couple of days for cassava. . . , two to four weeks for sweet potato, to between four and 18 weeks for the natural dormancy of yams. . . " Cassava's fast rotting upon harvest can be overcome only by freezing or by laborious processing that turns the

[46] Given a rough estimate of 1 million calories required per person per year (2740 kcal per day), the columns on total energy produced provide a crude estimate of the population (in millions) whose energy needs could be supported by each crop (ignoring the feeding of animals, seed requirements and wastage). It is evident that (other than in PNG) the total energy produced by the listed major crops could roughly feed the entire population – but in PNG it could feed less than half the population.

[47] See also Lebot (2009) and Bradshaw (2010).

moist root into dry flour.

(vi) Lebot (2009) lists the optimal annual rainfall for cassava, yams and sweet potato as ranging from 750 to 1500 mm of rain, and the optimal temperature as 20-30 degrees centigrade. This reveals that while these crops are cultivable in the tropics, they cannot be cultivated in temperate climates.

(vii) According to Lebot (pp. vi, 78) the moisture content of cassava is 63% of the weight, and that of sweet potato and yam is 71% and 74% respectively.

By these considerations, even though the potato is biologically a tuber, when it comes to the degree of appropriability, it could be considered a quasi-cereal, since it is cultivable in temperate climates, is seasonal, and is relatively non-perishable upon harvesting.

## References

[1] Bradshaw, J. E. (editor), (2010) *Root and Tuber Crops*, Springer.

[2] Lebot, Vincent (2009) *Tropical Root and Tuber Crops: Cassava, Sweet Potato, Yams and Aroids,* CABI.

[3] Rees, Debbie et al. (2012) "Tropical Root Crops," in *Crop Post-Harvest: Science and Technology – Perishables,* edited by Debbie Rees, Graham Farrell and John Orchard, Blackwell-Wiley, 392-413.

*For Online Publication*

**Appendix B: Surplus and appropriation – the role of population**

We develop here a simple model to illustrate our Malthusian critique of the surplus theory for explaining the rise of hierarchy following the Neolithic Revolution. In this model, when population size is exogenous, both an increase in the degree of appropriability and a rise in productivity (generating surplus) lead to larger net tax revenue as a share of output. However, when the population is endogenous, according to the Malthusian framework, an increase in appropriability raises the share of net taxes, while a rise in productivity does not.

Denote the total size of the farming population by $N$. The production function is assumed to be Cobb-Douglas:

$$Y = (AX)^{\alpha} N^{1-\alpha} = A^{\alpha} N^{1-\alpha},$$

where $A$ denotes the level of technology, $X$ is the constant size of land which we normalize to one, and $0 < \alpha < 1$.

We assume that the cost of taxing a share $\tau$ of total income $Y$ is given by:

$$\frac{Y \cdot C(\tau, m)}{z},$$

where $m$ represents per-capita surplus income. The parameter $z > 0$ represents the degree of appropriability, so that a higher $z$ implies a lower cost of taxation. The function $C(\tau, m)$ is continuous and differentiable, and increasing and convex in the tax rate $\tau$. ($C_1 \geq 0, C_{11} > 0$). In adapting the standard surplus approach, we assume that resistance to tax payment is lower the higher is surplus income. As a result, the cost of taxation is assumed to decrease in surplus income, or $C_2 < 0$. Surplus income is:

$$m = (1-\tau)\left(\frac{A}{N}\right)^{\alpha} - s,$$

where $s$ is subsistence income. The share of total net taxes out of total income, denoted by $\pi$, is:

$$\pi(\tau, m, z) = \tau - \frac{C(\tau, m)}{z}.$$

The government chooses the tax rate $\tau$ to maximize its net revenue $\Pi = \pi Y$. We assume the existence of an interior solution for the tax rate, $\tau^*$, where the first and second order conditions are satisfied. Our aim is to examine how $\pi$ is affected by changes in productivity $A$ and in the degree of appropriability $z$.

**B1. The case of a fixed population**

Given our assumptions, when the population is constant, $Y$ is independent of $\tau$. The optimal tax rate $\tau^*$ thus maximizes $\pi$ and satisfies the first order condition:

$$\frac{1}{z}\frac{dC(\tau,y)}{d\tau}\bigg|_{\tau=\tau^*} = \frac{C_1(\tau^*,m) - C_2(\tau^*,m)\left(\frac{A}{N}\right)^{\alpha}}{z} = 1.$$

Consider the effect of an increase in the appropriability parameter $z$. By the envelope theorem:

$$\frac{d\pi(\tau^*,m,z)}{dz} = \frac{\partial\pi(\tau^*,m,z)}{\partial z} = \frac{C(\tau^*,m)}{z^2} > 0.$$

Consider next the effect of an increase in productivity $A$. By a similar argument:

$$\frac{d\pi(\tau^*,m,z)}{dA} = \frac{\partial\pi(\tau^*,m,z)}{\partial m}\cdot\frac{dm}{dA} = -\frac{C_2(\tau^*,m)}{z}\cdot\frac{\alpha(m+s)}{A} > 0.$$

Thus, we have:

**Proposition B1.** *With a fixed population, both an increase in appropriability $z$ and an increase in productivity $A$ raise the share of taxes out of income $\pi$.*

**B2. The case of Malthusian population**

In a Malthusian setting the population size adjusts to keep agents' per capita surplus income $m$ at zero. Thus:

$$N = \frac{(1-\tau)Y}{s}.$$

This implies:

$$Y = A\left(\frac{1-\tau}{s}\right)^{\frac{1-\alpha}{\alpha}} \equiv Y(\tau,A);\ m \equiv 0.$$

Denote:

$$\pi^*(\tau,z) \equiv \pi(\tau,0,z) = \tau - \frac{C(\tau,0)}{z}.$$

In this case, the tax rate has a negative effect on output through its effect on the size of the farming population $N$.

The optimal tax rate $\tau^* = \tau^*(z,A)$ maximizes $\Pi = \pi^*(\tau,z)Y(\tau,A)$. Our assumptions imply that it is implicitly defined by the first order condition:

$$F(\tau,z,A) \equiv Y(\tau,A)\frac{\partial\pi^*(\tau,z)}{\partial\tau} + \pi^*(\tau,z)\frac{\partial Y(\tau,A)}{\partial\tau} = Y\left(1 - \frac{C_1(\tau,0)}{z}\right) - \pi^*(\tau,z)\,Y\frac{1-\alpha}{\alpha(1-\tau)} = 0.$$

Thus, at the optimum $\tau^*$:

$$\frac{\partial \pi^*(\tau, z)}{\partial \tau} = -\frac{\pi^*(\tau, z)}{Y(\tau, A)} \cdot \frac{\partial Y(\tau, A)}{\partial \tau} = \pi^*(\tau, z) \cdot \frac{1-\alpha}{\alpha(1-\tau)} > 0.$$

In addition,

$$\frac{d\pi^*(\tau^*(z, A), z)}{dz} = \frac{\partial \pi^*(\tau^*(z, A), z)}{\partial \tau} \frac{d\tau^*(z, A)}{dz} + \frac{\partial \pi^*(\tau^*, z)}{\partial z} = \frac{\partial \pi^*(\tau^*, z)}{\partial \tau} \frac{d\tau^*}{dz} + \frac{C(\tau^*, 0)}{z^2}.$$

To prove that this expression is positive, it is sufficient to prove that $\partial \tau^*/\partial z$ is positive. By the Implicit-Function Theorem, for $F(\tau, z, A)$ defined above:

$$\frac{\partial \tau^*}{\partial z} = -\left. \frac{\partial F/\partial z}{\partial F/\partial \tau} \right|,$$

and by the second-order conditions: $\partial F/\partial \tau < 0$. Thus,

$$sign\left[\frac{\partial \tau^*}{\partial z}\right] = sign\left[\left.\frac{\partial F}{\partial z}\right|\right].$$

Now,

$$\frac{\partial F}{\partial z} = Y \cdot \frac{C_1(\tau, 0)}{z^2} + \frac{C(\tau, 0)}{z^2} \cdot Y \cdot \frac{1-\alpha}{\alpha(1-\tau)} > 0.$$

Similarly,

$$\frac{d\pi^*(\tau^*(z, A), z)}{dA} = \frac{\partial \pi^*(\tau^*(z, A), z)}{\partial \tau} \frac{d\tau^*(z, A)}{dA}.$$

Once again by the Implicit Function Theorem: $sign\left[\frac{\partial \tau^*}{\partial A}\right] = sign\left[\left.\frac{\partial F}{\partial A}\right|\right]$. But

$$\frac{\partial F(\tau, z, A)}{\partial A} = \frac{\partial \pi^*(\tau, z)}{\partial \tau} \cdot \frac{\partial Y(\tau, A)}{\partial A} + \pi^*(\tau, z) \cdot \frac{\partial^2 Y(\tau, A)}{\partial \tau \partial A}.$$

Since $\frac{\partial Y(\tau, A)}{\partial A} = \frac{Y(\tau, A)}{A}$ and $\frac{\partial^2 Y(\tau, A)}{\partial \tau \partial A} = \frac{\frac{\partial Y(\tau, A)}{\partial \tau}}{A}$, we have:

$$\frac{\partial F(\tau, z, A)}{\partial A} = \frac{F(\tau, z, A)}{A}.$$

Since the first order conditions require $F(\tau, z, A) = 0$, it follows that $\frac{\partial \tau^*}{\partial A} = 0$ so that

$$\frac{d\pi^*(\tau^*(z, A), z)}{dA} = 0.$$

Thus, we have:

**Proposition B2.** *With Malthusian population, an increase in appropriability $z$ raises the share of taxes in the economy $\pi$, but an increase in productivity $A$ leaves that share intact.*

*For Online Publication*

**Appendix C: Counter-examples in the Ethnographic Atlas**

We checked the Ethnographic Atlas database for possible outliers. Out of the total Atlas sample of 1412 societies, only 1259 had data on hierarchy above the local level (variable 33). Out of these 1259 societies, only 959 are coded as reliant on specified food sources (variable 29): 634 relied mostly on cereal grains, 259 on roots and tubers, 82 on fruit trees and 4 on vegetables. The Atlas defines a "large state" as possessing at least four levels of hierarchy above the local community, and defines those with three levels as "states" (Gray, 1998). The following table provides the distribution of these societies by the major crop type.[48]

| | Total | % Cereal | % Roots & tubers | % Fruit trees | % Other |
|---|---|---|---|---|---|
| All societies | 979 | 64.8 | 26.5 | 8.4 | 0.4 |
| Above hierarchy = 4 | 32 | 90.6 | 9.4 | 0 | 0 |
| Above hierarchy = 3 | 82 | 79.3 | 13.4 | 7.3 | 0 |

It is evident that societies that rely on grain crops form a significantly larger share of those with higher levels of hierarchy than in the total sample. Still, we were intrigued by the three societies (9.4%) that are coded as "large states" that are reliant on roots and tubers. In this appendix we examine the three apparent exceptions to our statement that all pre-modern large states relied on cereals. Our conclusion is that our statement stands.

1. The first case is identified by Murdock (1981, p. 39) as "Shantung Chinese." The anthropological data were based on Yang's (1945) detailed report about the small village of Taitou, apparently pertaining to the 1930s. The province where this village (which no longer exists) was located is now known as Shandong. Shandong, on the eastern edge of China (in between Beijing and Shanghai) is now one of the more prosperous provinces. There is little doubt that the village of Taitou was at the time part of a major state: China. We take issue, however, with the presumption that this state, or even that province, should be classified as based on roots and tubers, as the Ethnographic Atlas has it.

To begin with, Yang reports (1945 p. 16) that the main crops cultivated in the village of Taitou were "wheat, millet, barley, soybean, corn, sweet potatoes, and peanuts." Thus it is not clear why the village was coded as reliant on the intensive cultivation of roots, even though this may not be entirely wrong. According to Yang, the land of the village was multi-cropped, and sweet potatoes

[48] All of the societies with maximal hierarchies had a specified major crop type, and two societies with above hierarchy coded as 3 had unspecified crop type (thus making the total 84, instead of 82).

were the principal crop during the summer months. More precise information can be obtained from the data collected by Buck (1937). Buck provides detailed statistics from another village, Tsimio, located about forty kilometers from Taitou. According to these data (pp. 73, 75), sweet potatoes supplied 43.3 percent of the total calories consumed in Tsimio, and seeds supplied 54.4 percent of the calories. But Tisimio (and presumably also Taitou) was unrepresentative of Shandong as a whole. In the other eleven villages that entered Buck's sample from the province, one listed the percentage of calories supplied by seeds as 76.0 (with sweet potatoes supplying 20.8 percent), and all of the other ten villages listed seeds as supplying at least 91 percent of the calories consumed. We conclude that the coding of the "shantung Chinese" society as reliant on the intensive cultivation of roots is wrong.

But the problem at hand goes beyond coding. The Ethnographic Atlas focuses mostly on cultural issues such as kin relations, with the underlying presumption that the data from one location pertains for the society as a whole. Yet the number of levels of hierarchy presiding over any location depends mostly on the region that encompasses that specific location. Even if Shandong's farming were based solely on roots, it could easily belong to a complex polity whose hierarchy relies on taxing cereals. This is evidently the case for China, whose state relied from the very start on the cultivation of cereals: mostly on wheat in the north (where Shandong is located), and mostly on rice in the south. Furthermore, sweet potatoes reached China only after the Columbian Exchange, while Shandong was already an integral part of the Chinese hierarchical state almost two millennia earlier.

2. The data source for "Byelorussians (White Russian)" society (latitude: 55N, longitude 28E) is identified in Ethnology, (vol. 4, April 1965) as "Unpublished ethnographic notes" by Melvin Ember (1954), pertaining to 1910. We were unable to obtain this source, but employed alternative sources about the Belarus.[49]

Vakar (1956, p. 30) describes the territory as a "low marshy plane, sloping slightly to the south and east. Only in the north and northeast are there elevation of the soil," with the highest point at 345 meters above sea level. "In general ... the soil ... is not very favorable for cultivation. Forest and shallow lakes cover more than one half the whole land. ... Crops are liable to be damaged by humidity rather than droughts. ... fish and potatoes being the staff of life for most Belarusian peasants." This characterization is confirmed by the soil-suitability data according to which the soil suitability for agriculture in Belarus is in the 25th percentile below the average, and

[49] The following summary is based mostly on Vakar (1956), and The Great Soviet Encyclopedia (GSE), vol. 3, 1973.

the productivity of cereals is below average. The fact that potatoes became the main cultivated crop from the 16th century is thus not surprising. In 1913 the land yielded 4.0 million tons of potatoes and only 2.6 million tons of all cereal grains; at the same time, "livestock raising is the leading branch of agriculture in Byelorussia" (GSE, p. 627). Thus, we do not question the Atlas's coding of Belarus as based on roots and tubers (at least since Columbus).

The multiple rivers that cross Belarus provided the main waterway for early trade between the Black Sea in the south and the Baltic Sea in the north. The area was settled between the 6th and the 8th centuries by East Slav tribes, whose economy was apparently based on trade in forest products like furs, game, honey, beeswax and amber and on primitive (cereal) agriculture. As it turns out, almost throughout its history, the territory of Belarus was ruled from outside by its neighboring states, rather than from within. In the 10-12 centuries it was controlled from Kiev (now in the Ukraine) in the south, under the Grand Duke of the Kieven Rus' – but several local feudal vassal principalities existed (all centered in the relatively elevated north).[50] From the 13th until the 18th centuries, the territory was ruled from the north and the west: first by the Grand Duchy of Lithuania, then by the Polish-Lithuanian Commonwealth, and effectively by Poland. Finally, from 1795 until 1990 Byelorussia was ruled from the east, as part of the Russian Empire and later as a Republic within the USSR. Thus we don't question the coding of Belarus society as subjected to full state hierarchy, however, we note that as a dependent territory almost throughout its history, its form of agriculture can hardly be considered to have shaped the degree of complexity of the states that controlled it. Indeed, Borcan et al. (2018) assign Belarus a statehood score of 0.5 from 850 until 1950 – where, in their scoring system "Band/tribe is marked by a rule score of 0, paramount chiefdom is assigned 0.75 and fully-fledged state receives the value 1."

3. The third case concerns the Bubi society on the tropical island of Fernando Po (now called Bioko, and part of the state of Equatorial Guinea). This volcanic island, whose area is about 2,000 square kilometers, is located in the Atlantic Ocean, about 30 kilometers off the coast of present Cameroon. The Bubis' staples were yams and cocoyams (=taro), in addition to fish and game. Thus, also in this case we do not contest the Atlas identification of this society as reliant on roots and tubers. However, we find problematic the characterization of this society (presumably in 1920) as a large state society.[51] Indeed, according to the Atlas, the form of agriculture is not extensive,

[50] Some historians identify the second half of the 11th century as the "first Independent Belorussian State," under the prince ruling in Polock (=Polacak= Polatsk) – see Vakar (1956) and Plokhy (2006 pp. 12, 46-54). If so, Belarus regained independence only with the breakup of the USSR in 1991.

[51] One indication for the problematic identification of the Bubi society as a "large state" is its lack of urban centers. Of the 32 Atlas societies coded as "large states," 27 had cities with population exceeding 50,000 people, 3 more had towns with 5,000 or more people, and one (the Siamese) had towns in the range of 1,000-5,000 people. The Bubi

but rather "extensive or shifting agriculture." Written sources about the island by missionaries and travelers since the 19th century are surprisingly abundant. The Atlas was coded on the basis of several such sources (Ethnology vol. 5, Jan 1966 pp. 132-133). For our purposes of examining mostly the Bubis' political institutions, we find it expedient to rely mostly on Sundiata (1994, 1996, 2011).

The island of Fernando Po was a Spanish colony, but the British set a station in its northern coast from 1827 until 1943. The colonists (including freed slaves that they brought to the island) settled in the coast, while the native Bubis concentrated in the interior hilly slopes of the island where they managed their own affairs. According to Sundiata (1996 p. 7), in 1912 the island's Bubi population numbered only 6,800.[52] The coastal settlers traded with the Bubis by purchasing from them palm oil for export, in exchange for various imported wares (like knifes).

The Bubis were divided in the 19th century into 28 districts, with several villages in each district. The districts often fought with one another over women and over imported objects (Sundiata, 1996 pp. 75-79). According to Sundiata (1996 p. 75), "in spite of their fairly simple material culture, the nineteenth-century Bubi had an elaborate system of socioeconomic stratification." Within chiefdoms, individuals were distinguished as nobles or as commoners, as well as by age groups. The chiefs' role was mostly in settling disputes, imposing and collecting fines, and leading fights.

The long-standing political fragmentation of the Bubis underwent substantial change in the 1840s. Sundiata (1996, p. 80-82) attributes this development to recurring incidents after the British left the island, whereby foreign interlopers from the coasts raided the Bubis inland. As a result, Moka, the chief of one of the southern districts, was able to form a loose confederacy of the various chiefs and was recognized as "Great Chief," (or king) with the task of mediating intra-ethnic strife and containing the incursions.[53] The island under Moka might be considered a hierarchical kingdom.[54] We doubt that this should be considered a case of a stable state society based on the

society is coded as "missing data," but in fact had not had villages exceeding 1,000 people.

[52] An 1837 report by British adventurers states "The native population of Fernando Po may be about five thousand, divided into tribes, that were formerly constantly at war with each other" (Laird and Oldfield, p. 301). That report also notes the Bubis' "free and independent bearing" and adds that "they still go perfectly naked" (p. 302). The missionary Clarke (1848, p. v) estimates the island's total population (including the non-Bubis) at "20,000 souls."

[53] According to Sundiata (1996 p.80-81), Moka "had seventy wives and concubines" and reinforced his position by exercising magical powers. He refused to be seen by any Europeans and "limited his use of European wares to guns and machetes," scorning "the use of European cloth, rum, salt and tobacco."

[54] Baumann (1888), a German traveler, provides a firsthand report of Moka's "kingdom" in 1886. He describes Moka's capital village as consisting of scattered hut complexes, surrounded by fields of yam (p. 103). He also narrates how, on the way there, a Bubi chief asked if he would become their king and resist Moka, telling him how much they resented being subjected to Moka (p. 33).

cultivation of tubers, but rather than an ad hoc confederacy of chiefdoms, motivated primarily by external issues related to warfare and trade (as was the case with several earlier African kingdoms). The fragility of the Bubis' presumed state is evident in that little of it survived into the twentieth century, after cocoa plantations (manned by imported laborers) started to dominate the Island's economy and the Spanish colonial power asserted its rule on the Island.

## References


[1] Baumann, Oscar (1888) Eine Afrikanische Tropen-Insel: Fernando Póo und die Bube, Eduard Hölzel.

[2] Borcan, Oana, Ola Olsson and Louis Putterman, (2018) "State History and Economic Development: Evidence from Six Millennia," Brown University, Department of Economics Working Paper Series.

[3] Buck, John Lossing (1937) Land Utilization in China: Statistics, Shanghai, North-China Daily News.

[4] Clarke, John (1848), Introduction to the Fernandian Tongue.

[5] Gray, J. Patrick (1998), "Ethnographic Atlas Codebook," World Cultures, 10 86-136.

[6] The Great Soviet Encyclopedia (1973) "Byelorussian Soviet Socialist Republic," volume 3, translation of third Edition [1970], New York, Macmillan.

[7] Laird, Macgregor and R.A.K. Oldfield (1837) Narrative of Expedition into the Interior of Africa, London, Richard Bentley.

[8] Plokhy, Serhii (2006) The Origins of the Slavic Nations: Premodern Identities in Russia, Ukraine, and Belarus, Cambridge University Press.

[9] Sundiata, Ibrahim (1994) "State Formation and Trade: The Rise and Fall of the Bubi Polity, c.1840-1910," The International Journal of African Historical Studies, 27, 505-523.

[10] Sundiata, Ibrahim K. (1996) From Slaving to Neoslavery: the Bight of Biafra and Fernando Po in the Era of Abolition, 1827-1930, University of Wisconsin Press.

[11] Sundiata, Ibrahim (2011) “Moka of Bioko (late 1820s-1899): The Chief Who United a Central African Island” in The Human Factor in Modern Africa, edited by Dennis Cordell, Rowman and Littlefield, pp. 47-66.

[12] Yang, Martin C (1945) A Chinese Village, New York, Columbia University Press.

*For Online Publication*

**Appendix D: A Model of Cereals and Hierarchy**

The basic premise of the model is that regions of the world differ in their productivity of tubers relative to that of cereals. For simplicity we postulate that tubers, unlike cereals, cannot be expropriated by bandits or by tax collectors. We model farmers' choice of what crop to grow in two different regimes: anarchy and hierarchy, and derive conclusions on the circumstances that are conducive for the emergence of hierarchy.

The economy is populated by a measure one of farmers and a measure $N$ of non-farmers. Our main exogenous variable, $\delta > 0$, measures the productivity advantage of cereals over tubers.[55] The productivity of cereals is normalized to unity. Thus, farmers can grow one unit of cereals, or $1-\delta$ units of tubers, or any linear combination thereof. Hence, a farmer's output is $\beta + (1-\beta)(1-\delta) = (1-\delta) + \beta\delta$, where $\beta \in [0,1]$ is the fraction of land allocated to cereals. Output is measured in nutritional units independently of their source.

The income of non-farmers who engage in foraging is assumed to be constant and denoted: $s > 0$. In a state of anarchy, non-farmers can chose to be either foragers or bandits who expropriate crops from farmers. In a state of hierarchy, we assume that some non-farmers are hired by the state to serve as tax collectors, and are paid the wage $s$. We denote by $\lambda$ the measure of bandits or tax collectors. $N$ is assumed to be larger than the equilibrium level of $\lambda$. We also assume that in order to be viable and to deter bandits, the state has to possess monopoly over the use of force which entails a cost.

**Anarchy**

Under anarchy, farmers might be raided by bandits. A raided farmer loses his entire cereal crop, but none of his crop of tubers. Farmers are assumed to be risk neutral.[56] A farmer who faces a raid with probability $\tau$, chooses the fraction of land allocated to cereal $\beta$ to maximize his expected income $I$, weighing the productivity advantages of cereals over tubers, $\delta$, against the disadvantage, as measured by the expropriation rate $\tau$:

$$I = (1-\tau)\beta + (1-\delta)(1-\beta) = (1-\delta) + \beta(\delta - \tau). \quad \text{(E.1)}$$

We assume that the rate of expropriation, $\tau$, is a function of the measure of bandits $\lambda$: $\tau = \tau(\lambda)$. The function, $\tau(\lambda)$ is strictly increasing and strictly concave, and satisfies: $\tau(0) = 0$, $\lim_{\lambda \searrow 0} \tau'(\lambda) =$

[55] If $\delta \leq 0$ the analysis is trivial: tubers dominate cereals in providing both protection and higher productivity, so that farmers would only grow tubers in equilibrium, and the economy could only be in a state of anarchy.

[56] In Appendix D we show that our results are robust to the introduction of risk aversion.

$\infty$, $\lim_{\lambda \nearrow \infty} \tau'(\lambda) = 0$ with $\lim_{\lambda \nearrow \infty} \tau(\lambda) = \overline{\tau} \leq 1$, with corresponding properties for the inverse function $\lambda(\tau)$. Bandits are uncoordinated (if they coordinate they become the ruling elite and the equilibrium becomes identical to that under hierarchy). Thus each bandit's expected income $\pi$ is given by the total amount of confiscated cereals divided by the measure of bandits: $\pi = \tau(\lambda)\beta/\lambda$.

**Definition.** *Equilibrium consists of a pair* $(\beta, \tau)$ *such that:*

1. $\beta$ *maximizes farmers' income I, given the confiscation rate* $\tau$*;*
2. *given* $\beta$*, non-farmers are indifferent between being foragers or bandits, so that* $\pi = s$*.*[57]

Using the inverse relation $\lambda(\tau)$, the last condition can be restated as requiring: $\tau\beta/\lambda(\tau) = s$. Define now a threshold rate $\delta_A$ by the implicit relationship:[58]

$$\frac{\delta_A}{\lambda(\delta_A)} = s.$$

**Proposition 1.** *The economy under anarchy has a unique equilibrium* $(\beta_A, \tau_A)$ *that is given by:*

$$(\beta_A, \tau_A) = \begin{cases} \left(\frac{\lambda(\delta)s}{\delta}, \delta\right) & if \quad \delta < \delta_A \\ \\ (1, \delta_A) & if \quad \delta \geq \delta_A \end{cases}.$$

That is, the equilibrium confiscation rate $\tau_A$ equal $\delta$ if tubers are grown, and tubers are not grown if $\delta > \delta_A$.

**Proof.** If $\delta > 0$, an equilibrium with no cereals ($\beta_A = 0$) can be ruled out since in that case $\pi = 0$, leading to $\lambda = 0$ and $\tau = 0$, which would lead to $\beta = 1$, a contradiction. This implies that the equilibrium can either be one with cereals only ($\beta_A = 1$) or mixed ($0 < \beta_A < 1$), where both crops are cultivated.

If $\delta \geq \delta_A$, farmers cultivate only cereals ($\beta_A = 1$), even though this entails a maximal confiscation rate $\tau_A = \delta_A$ and a corresponding maximal number of bandits, $\lambda(\delta_A)$.

Our assumptions on $\tau(\cdot)$ imply that the confiscation rate, $\tau(\lambda)/\lambda$, is monotonically decreasing in $\tau$, from infinity towards zero. Thus, when $\delta < \delta_A$, both cereals and tubers are cultivated and we have: $\delta/\lambda(\delta) > \delta_A/\lambda(\delta_A) = s$. Hence, there exists a unique $\beta_A \in (0, 1]$ such that $\pi_A \equiv \delta\beta_A/\lambda(\delta) =$

[57] Micro-foundation for the shape of $\tau(\lambda)$ can be obtained by assuming that banditry is time consuming and that bandits are not coordinated, so that when their number increase, the probability of raiding the same farmers increases, and the marginal total loot declines.

[58] We use the subscript $A$ to denote parameters and equilibrium values in a regime of anarchy, and similarly use the subscript $H$ in a state of hierarchy.

$s$. The last condition, in conjunction with the condition $\tau_A = \delta$, defines the equilibrium combination $(\beta_A, \tau_A)$. ■

**Income distribution.** It follows from Proposition 1 that if cereals' productivity advantage is low ($\delta < \delta_A$), $\beta_A$, $\tau_A$ and $\lambda_A = \lambda(\tau_A)$ are strictly increasing in $\delta$ and all tend to zero when $\delta$ decreases towards zero. As a result, also the total expected amount of cereals confiscated by bandits, $\tau_A\beta_A$, strictly increase in $\delta$. In that range, farmers' income equals $1 - \delta$, and thus decreases in $\delta$. On the other hand, when the productivity advantage of cereals exceeds the threshold $\delta_A$, all these variables become independent of $\delta$, with farmers income equaling $1 - \delta_A$. In these two ranges combined, proposition 1 thus implies that $\tau_A\beta_A$, $\tau_A$ and $\lambda_A$ all weakly increase in $\delta$. In turn, even though bandits' welfare is equal to $s$ independently of the value of $\delta$, farmers' welfare weakly decreases with $\delta$.

**The effect of the reservation income s.** The smaller is $s$, the larger the incentive for foragers to engage in banditry. This implies a higher threshold $\delta_A$, meaning that farmers will raise tubers in a wider range of $\delta$. Thus, for values of $\delta > \delta_A$, a lower $s$ reduces farmers' income. However, for $\delta < \delta_A$, a smaller $s$ has no effect on farmers income, or on $\tau$ and therefore on $\lambda$; it will reduce however the equilibrium value of $\beta$.

**Two sources of inefficiency**. Denote by $Y_0$ the maximal possible level of output in the economy, when all farmers cultivate only the more productive cereals (assuming $\delta > 0$) and all non-farmers engage in foraging. This maximal output level is: $Y_0 = 1 + Ns$. We can observe that the equilibrium $(\beta_A, \tau_A)$ introduces two deviations from this maximal output level: the first is due to farmers growing tubers (if $\delta < \delta_A$); and the other is due to the forgone output by banditry. Thus, equilibrium output is:

$$Y = Y_0 - (1 - \beta_A)\,\delta - s\lambda(\tau_A).$$

Inspection of the equilibrium values $(\beta_A, \tau_A)$ reveals that for large values of $\delta$, the only distortion is the loss of output due to bandits being unproductive: $s\lambda_A = s\lambda(\tau_A)$, which equals the threshold level $\delta_A$. For small values of $\delta$, tubers are cultivated, $\tau_A = \delta$, and farmers are indifferent between the two crops. From the fact that expected revenue per-bandit is equal to $\tau_A\beta_A/\lambda(\tau_A) = s$ it follows that $s\lambda(\tau_A) = \tau_A\beta_A$. Thus we obtain:

**Corollary 1.** *The output loss $(Y_0 - Y)$ due to an anarchy regime is:*

$$(1-\beta_A)\,\delta+\lambda_A s=\begin{cases}\delta & if \quad \delta<\delta_A\\ \\ \delta_A & if \quad \delta\geq\delta_A\end{cases}.$$

**Hierarchy**

We assume that in a state of hierarchy the elite (the state) chooses its tax policy to maximize the revenue net of the cost of tax collection. In order to facilitate comparison between the two regimes, we assume that the state has access to the same expropriation technology as bandits. Namely, the state cannot tax tubers, and if it employs a measure $\lambda$ of tax collectors (hired from among the potential foragers) at cost $s$ per tax collector, it can generate revenue of $\tau(\lambda)\beta$ from the farming sector. Adopting Weber's definition of the state, we also assume that a state has to have a monopoly power over the use of force, and thus be able to deter bandits. This deterrence power, we assume, entails a fixed cost $G_0>0$.

A key advantage that a state has is that it is farsighted and organized, and can thus commit not to expropriate farmers beyond a certain tax rate.[59] That is, the state selects a tax rate $\tau$, and hires $\lambda(\tau)$ tax-collectors at cost $s\lambda(\tau)$, to maximize its net revenue, subject to the constraint that farmers respond to the tax rate:

$$\max_{\tau\geq 0} R\,(\tau)=\tau\beta-s\lambda\,(\tau)\,,$$

subject to

$$\beta=\arg\max_{\beta'\in[0,1]}\left\{(1-\delta)+\beta'(\delta-\tau)\right\}.$$

It is evident that $\beta=0$ if $\tau>\delta$. This implies that in the optimum $\tau\leq\delta$. In addition $\beta=1$ if $\tau<\delta$. Assuming that $\beta=1$ when $\tau=\delta$, the state's problem becomes:

$$\max_{\tau}[\tau-s\lambda\,(\tau)],\ \text{subject to}\ \tau\leq\delta.$$

The optimal tax rate under hierarchy is therefore: $\tau_H(\delta)=\min\{\delta,\delta_H\}$, where $\delta_H$ is the parameter that solves $s\lambda'\,(\delta_H)=1$. Thus, at the high range of tubers' productivity, where $\delta<\delta_H$, $\tau_H=\delta$, the net revenue is $R\,(\tau_H(\delta))=\delta-s\lambda\,(\delta)$, which is increasing in $\delta$. Our assumption that the state has to sustain deterrence against bandits at a fixed cost $G_0>0$ sets a lower limit on the

[59] Another difference between bandits and the state is that bandits confiscate a farmer's entire cereal crop with probability $\tau$, while an organized hierarchy taxes farmers at the rate $\tau$ with certainty. If farmers are risk neutral, as assumed here, this difference is unimportant.

net revenue for the state to be viable. Clearly if $G_0$ exceeds the maximal revenue $R(\delta_H)$, the state is not viable. We thus assume that $R(\delta_H) > G_0$. Under this assumption we can define a viability threshold $\underline{\delta} < \delta_H$, such that: $R(\underline{\delta}) = G_0$, so that he state is viable when $\delta > \underline{\delta}$.

**Proposition 2.** (i) *If $\delta$ is small ($\delta < \underline{\delta}$), a state cannot exist. (ii) In the intermediate range where $\underline{\delta} \leq \delta < \delta_H$, the optimal tax rate is $\tau_H = \delta$. (iii) If $\delta$ is large ($\delta \geq \delta_H$), then the optimal tax rate is equal to $\delta_H$.*

**Income distribution.** Under hierarchy, farmers grow only cereals. Thus, their income is $1 - \tau_H = 1 - \min\{\delta, \delta_H\}$, which is weakly decreasing in the cereal productivity advantage over tubers $\delta$. Total tax receipts equals $\tau_H$, and the net tax revenue to the elite is: $\tau_H - s\lambda(\tau_H) - G_0$. Both increase in $\delta$ up to the threshold $\delta_H$, after which they remain constant.

**Output Loss.** Analogously to the case of anarchy, we obtain here:

$Y_0 - Y = (1 - \beta_H)\delta + s\lambda(\tau_H) + G_0$ and since $\beta_H = 1$, $Y_0 - Y = s\lambda(\tau_H) + G_0$. Thus:

**Corollary 2.** The output loss due to hierarchy is:

$$Y_0 - Y = \begin{cases} s\lambda(\delta) + G_0 & if \quad \delta < \delta_H \\ \\ s\lambda(\delta_H) + G_0 & if \quad \delta \geq \delta_H \end{cases}.$$

.

**Anarchy vs. Hierarchy**

As explained in the previous sub-section, a state can only exist if tubers are sufficiently unattractive to farmers, that is, if the productivity advantage of cereals, $\delta$, is above the threshold $\underline{\delta}$. The comparison between the regimes of anarchy and hierarchy depends on the relationship between the thresholds $\delta_A$, $\delta_H$ and $\underline{\delta}$.

These threshold levels satisfy: $\delta_A > \delta_H > \underline{\delta}$. Since $\delta_H$ is defined by $\tau'(\lambda(\delta_H)) = s$, and $\delta_A$ is defined by $\delta_A/\lambda(\delta_A) = s$, $\delta_A > \delta_H$ follows from the strict concavity of $\tau(\lambda)$.

**Proposition 3.** *For $\delta > \underline{\delta}$ the state is viable and:*

*(i) Hierarchy weakly Pareto dominates anarchy. (ii) The economy is more productive under hierarchy than under anarchy.*

**Proof.** (i) Because the function $\tau(\cdot)$ is strictly concave, the marginal productivity of tax collectors (or bandits) is lower than the average productivity: $\tau'(\lambda) < \tau(\lambda)/\lambda$ and $\tau'(\lambda(\tau)) < \tau/\lambda(\tau)$.

Recall that, $\lambda(\delta_H)$ is defined by $\tau'(\lambda(\delta_H)) = s$ and $\lambda(\delta_A)$ is defined by $\delta_A/\lambda(\delta_A) = s$. It therefore follows from the concavity of $\tau(\cdot)$ that $\delta_H < \delta_A$ and $\lambda(\delta_H) < \lambda(\delta_A)$.
Non-farmers earn the same income $s$ irrespective of the regime. Suppose that $\delta > \underline{\delta}$. On the other hand, the implied tax rate on farmers under anarchy is larger than or equal than the tax rate under hierarchy. In the range where $\underline{\delta} \leq \delta \leq \delta_H$, the tax rate under both anarchy and hierarchy is $\delta$; in the range $\delta_H \leq \delta < \delta_A$ the tax rate under anarchy $\delta$ is higher than the tax rate under hierarchy $\delta_H$ and in the range $\delta_A \leq \delta$ the tax rate under anarchy is $\delta_A$, whereas under hierarchy it is lower $\delta_H$. Hence, farmers are weakly better off in all cases under hierarchy than under anarchy. Finally, when $\delta > \underline{\delta}$, a hierarchy generates an additional surplus to the elite, since by construction: $\tau - s\lambda(\tau) - G_0 > 0$. ■
(ii) From corollaries 1 and 2 we obtain that the difference between total output under hierarchy to that under anarchy is equal to:

$$Y_H(\delta) - Y_A(\delta) = \begin{cases} \delta - s\lambda(\delta) - G_0 & if \quad \delta \in [\underline{\delta}, \delta_H] \\ \delta - s\lambda(\delta_H) - G_0 & if \quad \delta \in (\delta_H, \delta_A] \\ \delta_A - s\lambda(\delta_H) - G_0 & if \quad \delta > \delta_A \end{cases}.$$

When $\delta = \underline{\delta}$, by the definition of $\underline{\delta}$, $R(\underline{\delta}) = \underline{\delta} - s\lambda(\underline{\delta}) = G_0$, the output gap between the two regimes is zero . When $\underline{\delta} \leq \delta \leq \delta_A$, the output gap equals the rent enjoyed by the elite, which is increasing in $\delta$. ■

The total output under hierarchy is weakly higher for two reasons. (1) Under hierarchy farmers cultivate only cereals. Thus they do not resort to self-protection through the cultivation of the less productive tubers, as they do (when $\delta < \delta_A$) under anarchy. (2) The state employs (weakly) fewer tax collectors than the scale of foragers who engage in banditry under anarchy, since with the state their marginal product is higher or equals their cost $s$, whereas under anarchy it is their average product that equal $s$.

**The main predictions of the analysis**

1. Farmers may choose to grow tubers even when tubers are less productive for the purpose of self-protection against appropriation by bandits or by tax collectors.

2. If the productivity advantage of cereals over tubers is sufficiently small, $\delta < \underline{\delta}$, a state cannot exist. This result illustrates our claim that it isn't low productivity that hinders the development of hierarchy and related institutions, but rather relatively high productivity of

crops that are hard to expropriate. A hierarchy could emerge if the productivity advantage of cereals is sufficiently high: $\delta > \underline{\delta}$.

3. Whenever it exists, even a non-benevolent state hierarchy that monopolizes coercive force dominates anarchy from an efficiency point of view. This follows from our assumption that the state can commit to a tax rate that maximizes its net revenue, and that consequently farmers cultivate only the more efficient cereals.

4. If cereals are sufficiently more productive than tubers, a state of hierarchy is a possible outcome but anarchy can persist. A reasonable interpretation for a transition from anarchy to hierarchy, is that coordination is required, either within the emerging state, by the farmers who seek protection, or by the outsider bandits under the leadership of the would be elite. The coordination problem could explain the lag of several millennia between the adoption of cereal cultivation, for instance in the fertile crescent, and the emergence of early states (Scott, 2017).

**Example**

A simple example helps to illustrate our results diagrammatically. Consider the following specification for the expropriation function: $\tau(\lambda) = \rho\sqrt{\lambda}$, with $\rho \in (0, 1)$.

In this case, $\delta_A = \rho^2/s$ and $\delta_H = \alpha^2/2s$.[60] The equilibrium under anarchy is given by

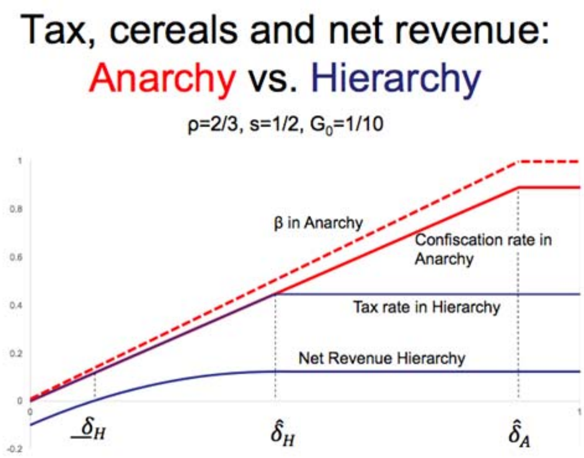
$$(\beta_A, \tau_A) = \begin{cases} \left(\frac{s\delta}{\rho^2}, \delta\right) & if \quad \delta < \delta_A \\ \\ \left(1, \frac{\rho^2}{s}\right) & if \quad \delta \geq \delta_A \end{cases}.$$

For $\underline{\delta} \leq \delta \leq \delta_H$ a state sets a tax rate equal to $\delta$ and generates net tax revenue: $R(\delta) = \delta - s\left(\frac{\delta}{\rho}\right)^2$, which increases in $\delta$ up to the point where $\delta = \delta_H$ after which $R(\delta) = R(\delta_H)$. Figure **??** presents the comparison between anarchy and hierarchy with respect to the tax rate and the production of cereals, as a function of $\delta$. It also presents the net revenue of the elite in a regime of hierarchy.

**Risk averse farmers.** We illustrate here the robustness of the model's qualitative predictions when farmers are risk averse. The results are in a sense even stronger, given that risk-averse farmers under anarchy seek more protection by choosing a smaller share of cereals. Farmers' risk aversion

[60] The lower limit for state existence, $\underline{\delta} > 0$, is implicitly defined by the quadratic equation: $\underline{\delta} - s\left(\frac{\delta}{\rho}\right)^2 = G_0$, where to have any solution we require that : $G_0 \leq \rho^2/4s$.

Figure E.1: Tax, cereals and net revenue: Anarchy vs. Hierarchy




does not affect the analysis of the model under a regime of hierarchy since in this case the tax rate that the state imposes is certain. We chose to illustrate the case of anarchy with risk-averse farmers by examining a case where a simple analytic solution can be obtained. For that purpose, we employ the specification of the expropriation function, $\tau(\lambda) = \rho\sqrt{\lambda}$, as in the model's example, and consider the case where farmers have a log-utility function: $u(I) = \log(I)$. Farmers under anarchy thus chose $\beta \geq 0$ to maximize the expected utility:

$$U(I) = (1-\tau)\log(\beta + (1-\delta)(1-\beta)) + \tau \log(1-\delta)(1-\beta).$$

The solution is

$$\beta_A = \max\left\{\frac{\delta - \tau}{\delta}, 0\right\}.$$

Non-farmers' freedom to enter banditry implies: $s = \tau\beta/\lambda(\tau)$. And thus:

$$\tau_A = \frac{\rho^2 \beta_A}{s}.$$

Solving for the equilibrium values of $(\beta_A, \tau_A)$ yields (when $\beta_A > 0$):

$$\beta_A = \frac{s\delta}{\rho^2 + s\delta}; \ \tau_A = \frac{\rho^2 \delta}{\rho^2 + s\delta}.$$

Inspection of the equilibrium values of $(\beta_A, \tau_A)$ reveals that as $\delta$ tends to zero, both $\beta_A$ and $\tau_A$

tend to zero. As $\delta$ increases towards one, $\tau_A$ approaches $\rho^2/(\rho^2+s)$ and $\beta_A$ approaches $s/(\rho^2+s)$. This implies that even in the limit, when the productivity of tubers approaches zero, they are still grown by farmers.

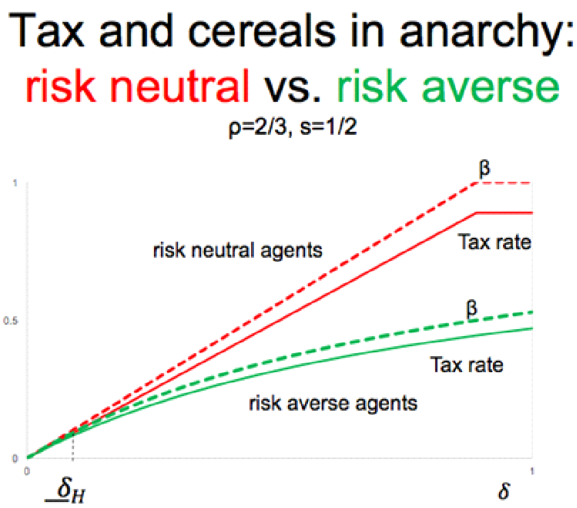
Compared to the model with risk neutrality (in the preceding sub-section), the introduction of risk aversion implies that farmers reduce the cultivation of cereals $\beta_A$, and increase the share of land devoted to tubers as a device for self-insurance. Consequently the confiscation rate $\tau_A$ is lower, and the measure of banditry $\lambda_A$ is smaller as well.

While the former effect tends to increase overall inefficiency, the total efficiency effect of introducing risk aversion in a regime of anarchy is positive. To recall from corollary 1, under risk neutrality the overall inefficiency $(1-\beta_A)\,\delta+s\lambda_A$ is equal to $\delta$. This is smaller than the inefficiency under risk aversion, which under our specification is equal to $(1-\beta_A)\,\delta+\lambda_A s=\delta-\beta_A\,(\delta-\tau_A)<\delta$. Correspondingly, the expected income of each farmer under anarchy is also higher under risk aversion, because

$(1-\tau_A)\,(\beta_A+(1-\delta)\,(1-\beta_A))+\tau_A\,(1-\delta)\,(1-\beta_A)=1-\delta+(\delta-\tau_A)\,\beta_A$ is equal to $1-\delta$ under risk neutrality, but is strictly larger under risk aversion because under risk aversion $\tau_A<\delta$. The reason for this is that under risk neutrality farmers in a mixed equilibrium are indifferent between growing cereals and tubers and so derive an identical income of $1-\delta$. In contrast, under risk aversion, farmers derive a strictly larger expected income from cereals to compensate for the risk associated with cereals, which pushes their expected income higher.[61] The figure illustrates the difference between the two types of equilibrium: the case of risk neutral farmers and risk averse farmers.

[61] This implies that risk neutral farmers would benefit if they could commit to grow less cereals in equilibrium, which we assume they cannot. The problem is that when a farmer decides how much cereal to grow, he ignores the negative externality this imposes on other farmers through contributing to the measure of bandits.

Figure E.2: Output: Anarchy vs. Hierarchy



*For Online Publication*

**Appendix E: Wild relatives of domesticated crops**

In this appendix, we report the list of the wild relatives of domesticated crops. In parenthesis we indicate whether the wild crop is a primary, secondary or tertiary relative.

**Barley**

Hordeum brevisubulatum (3), Hordeum bulbosum (3), Hordeum chilense (3), Hordeum vulgare spontaneum (1)

**Cassava**

Manihot esculenta (1), Manihot pruinosa (1), Manihot aesculifolia (2), Manihot anomala (2), Manihot brachyloba (2), Manihot chlorosticta (2), Manihot dichotoma (2), Manihot espruinosa (2), Manihot garcilis (2), Manihot leptophylla (2), Manihot pilosa (2), Manihot tripartita (2), Manihot esculenta subsp. peruviana (2), Manihot cartaghinensis subsp. glaziovii (2), Manihot angustiloba (2), Manihot caerulescens (2), Manihot cartaghinensis (2), Manihot davisiae (2), Manihot oligantha (2), Manihot rubricaulis (2), Manihot anomala subsp. glabrata (2), Manihot baccata (2), Manihot caerulescens subsp. caerulescens (2), Manihot cecropifoliia (2), Manihot compositifolia (2), Manihot diamantinensis (2), Manihot fruticulosa (2), Manihot gabrielensis (2), Manihot garcilis subsp. garcilis (2), Manihot grahamii (2), Manihot guaranitica (2), Manihot heptaphylla (2), Manihot hunzikeriana (2), Manihot irwinii (2), Manihot jacobinensis (2), Manihot janiphoides (2), Manihot pauciflora (2), ] Manihot peltata (2), Manihot pentaphylla (2), Manihot pentaphylla subsp. pentaphylla (2), Manihot pentaphylla subsp. tenuifolia (2), Manihot pringlei (2), Manihot purpureocostata (2), Manihot quinquepartita (2), Manihot rhomboidea subsp. microcarpa (2), Manihot rhomboidea subsp. rhomboidea (2), Manihot salicifolia (2), Manihot sparsifolia (2), Manihot stricta (2), Manihot tomentosa (2), Manihot violacea (2), Manihot xavantinensis (2)

**Maize**

Zea diploperennis (2), Zea luxurians (2), Zea mays subsp. mexicana (1), Tripsacum dactyloides (3), Tripsacum dactyloides var. dactyloides (3), Tripsacum dactyloides var. hispidum (3),

**Millet, Broom**

Millet Panicum Miliaceum (1), Millet Panicum Bergii (2), Millet Panicum Fauriei (2), Millet Panicum Nephelophilum (2)

**Millet, Foxtail**

Millet Setaria italica (1), Millet Setaria viridis (1), Millet Setaria adhaerans/verticillata (2), Millet Setaria faberi (2)

**Oat**

Avena abyssinica (3), Avena byzantina (1), Avena fatua (1), Avena hybrida (1), Avena insularis (2), Avena maroccana (Avena magna) (2), Avena murphyi (2), Avena sterilis (1), Avena strigosa (3)

**Potato**

Solanum clarum (2), Solanum multiinterruptum (2), Solanum colombianum (2), Solanum oxycarpum (2), Solanum microdontum (2), Solanum candolleanum (1), Solanum longiconicum (2), Solanum chomatophilum (2), Solanum sogarandinum (2), Solanum flahaultii (2), Solanum laxissimum (2), Solanum coelestipetalum (1), Solanum bombycinum (2), Solanum piurae (2), Solanum iopetalum (2), Solanum cajamarquense (2), Solanum chiquidenum (2), Solanum burkartii (2), Solanum hjertingii (2), Solanum contumazaense (2), Solanum bulbocastanum (3), Solanum venturii (2), Solanum gracilifrons (2), Solanum demissum (2), Solanum hintonii (2), Solanum infundibuliforme (1), Solanum hastiforme (2), Solanum albicans (2), Solanum tarnii (3), Solanum okadae (1), Solanum schenckii (2), Solanum palustre (3) , Solanum brevicaule (1), Solanum polyadenium (2), Solanum medians (2), Solanum chacoense (2), Solanum neovavilovii (2), Solanum violaceimarmoratum (2), Solanum kurtzianum (2), Solanum verrucosum (2), Solanum neorossii (2), Solanum gandarillasii (2), Solanum rhomboideilanceolatum (2), Solanum berthaultii (1), Solanum andreanum (2), Solanum garcia-barrigae (2), Solanum stoloniferum (2), Solanum agrimonifolium (2), Solanum acroscopicum (2), Solanum marinasense (1), Solanum cantense (2), Solanum raphanifolium (2), Solanum acaule (1), Solanum hougasii (2), Solanum pillahuatense (2), Solanum buesii (2), Solanum maglia (2), Solanum boliviense (2), Solanum neocardenasii (2), Solanum commersonii (2), Solanum morelliforme (2), Solanum vernei (1)

**Rice**

Oryza alta (2), Oryza australiensis (2), Oryza barthii (1), Oryza glaberrima (1), Oryza glumipatula (1), Oryza grandiglumis (2), Oryza latifolia (2), Oryza longistaminata (1), Oryza meridionalis (1), Oryza minuta (2),Oryza nivara (1), Oryza officinalis (2), Oryza punctata (2), Oryza rhizomatis (2), Oryza ridleyi (3), Oryza rufipogon (1)

**Rice bean**

Vigna acontifolia (3), Vigna angularis (2), Vigna dalzelliana (2), Vigna khandalensis (3), Vigna minima (2), Vigna mungo (3), Vigna radiata (3), Vigna subramaniana (3), Vigna triloba (3), Vigna umbellata (1)

**Rye**

Secale cereale ancestrale (1), Secale cereale segetale (1)

**Sorghum**

Sorghum angustum (3), Sorghum bicolor drummondii (1), Sorghum bicolor verticilliflorum (1), Sorghum ecarinatum (3),Sorghum exstans (3), Sorghum halepense (2), Sorghum interjectum (3), Sorghum intrans (3), Sorghum laxiflorum (3), Sorghum matarankense (3), Sorghum nitidum (3), Sorghum propinquum (3), Sorghum stipoideum (3), Sorghum timorense (3), Sorghum versicolor (3)

**Sweet Potato**

Ipomoea cordatotriloba (3), Ipomoea cynanchifolia (3), Ipomoea grandifolia (3), Ipomoea lacunosa (3), Ipomoea leucantha (3), Ipomoea littoralis (2), Ipomoea ramosissima (3), Ipomoea splendor-sylvae (3), Ipomoea tabascana (2), Ipomoea tenuissima (3), Ipomoea tiliacea (3), Ipomoea trifida (2), Ipomoea triloba (3)

**Wheat**

Aegilops bicornis (2), Aegilops biunicalis (2), Aegilops columnaris (2), Aegilops comosa subventricosa (2), Aegilops crassa (2), Aegilops cylindrica (2), Aegilops geniculata (2), Aegilops juvenalis (2), Aegilops kotschyi (2), Aegilops longissima (2), Aegilops markgrafii (2), Aegilops neglecta (2), Aegilops peregrina (2), Aegilops searsii (2), Aegilops speltoides ligustica (2), Aegilops speltoides speltoides (2), Aegilops speltoides (2), Aegilops tauschii (2), Aegilops triuncialis (2), Aegilops umbellulata (2), Aegilops vavilovii (2), Aegilops ventricosa (2), Amblyopyrum muticum muticum (2), Triticum monococcum aegilopoides (1), Triticum monococcum (1), Triticum timopheevii armeniacum (1), Triticum timopheevii (1), Triticum turgidum dicoccoides (1), Triticum urartu (1)

**Yam, Water**

Dioscorea brevipetiolata (2), Dioscorea hamiltonii (2), Dioscorea nummularia (1), Dioscorea transversa (1), Dioscorea abyssinica (3), Dioscorea cayenensis subsp. rotundata (2)

**Yam, Lagos**

Dioscorea burkilliana (1), Dioscorea minutiflora (1), Dioscorea smilacifolia (1), Dioscorea abyssinica (3), Dioscorea cayenensis subsp. rotundata (1), Dioscorea praehensilis (1)

**Yam, White Guinea**

Dioscorea abyssinica (3), Dioscorea cayenensis subsp. rotundata (1), Dioscorea praehensilis (1)

*For Online Publication*

## Appendix F: Additional data tables and figures

Table F.1: Descriptive Statistics: societies in Ethnoatlas

| | SOURCE | Mean | p50 | SDev | Min | Max | N |
|---|---|---|---|---|---|---|---|
| *Hierarchy* | Ethnoatlas | 1.89 | 2.00 | 1.04 | 1.00 | 5.00 | 1,059 |
| *CerMain* | Ethnoatlas | 0.54 | 1.00 | 0.50 | 0.00 | 1.00 | 1,092 |
| Dependence on agriculture | Ethnoatlas | 0.45 | 0.50 | 0.27 | 0.03 | 0.93 | 1,178 |
| Intensive irrigation | Ethnoatlas | 0.14 | 0.00 | 0.35 | 0.00 | 1.00 | 862 |
| Dependence on herding $\leq 25\%$ | Ethnoatlas | 0.77 | 1.00 | 0.42 | 0.00 | 1.00 | 1,178 |
| Dependence on herding $> 26\%$ and $\leq 50\%$ | Ethnoatlas | 0.18 | 0.00 | 0.39 | 0.00 | 1.00 | 1,178 |
| Dependence on herding $> 26\%$ and $\leq 50\%$ | Ethnoatlas | 0.02 | 0.00 | 0.14 | 0.00 | 1.00 | 1,178 |
| Dependence on herding $> 76\%$ | Ethnoatlas | 0.02 | 0.00 | 0.15 | 0.00 | 1.00 | 1,178 |
| Herding main animals: pigs | Ethnoatlas | 0.07 | 0.00 | 0.26 | 0.00 | 1.00 | 1,086 |
| Herding main animals: sheep | Ethnoatlas | 0.16 | 0.00 | 0.37 | 0.00 | 1.00 | 1,086 |
| Herding main animals: equine anim. | Ethnoatlas | 0.06 | 0.00 | 0.24 | 0.00 | 1.00 | 1,086 |
| Herding main animals: camels, llama | Ethnoatlas | 0.02 | 0.00 | 0.15 | 0.00 | 1.00 | 1,086 |
| Herding main animals: bovine | Ethnoatlas | 0.40 | 0.00 | 0.49 | 0.00 | 1.00 | 1,086 |
| Animals in cultivation | Ethnoatlas | 0.14 | 0.00 | 0.35 | 0.00 | 1.00 | 1,086 |
| Farming surplus | Tuden and Marshall (1972) | 0.49 | 0.00 | 0.50 | 0.00 | 1.00 | 162 |
| Tax burden | Ross (1983) | 1.11 | 1.00 | 0.90 | 0.00 | 2.00 | 66 |
| Population density (categorical) | Pryor (1985) | 3.83 | 4.00 | 1.57 | 2.00 | 7.00 | 168 |
| *LandProd* (std) | authors | 0.00 | 0.23 | 1.00 | -1.92 | 2.66 | 1,179 |
| *CerAdv* (std) | authors | 0.00 | -0.13 | 1.00 | -1.73 | 4.16 | 1,179 |
| Precipitation (std) | FAO-GAEZ | 0.00 | -0.13 | 1.00 | -1.39 | 10.65 | 1,179 |
| Temperature (std) | FAO-GAEZ | 0.00 | 0.37 | 1.00 | -2.57 | 1.32 | 1,179 |
| Elevation (std) | GDEM | 0.00 | 0.17 | 1.00 | -9.24 | 3.58 | 1,179 |
| Ruggedness (std) | GDEMs | 0.00 | -0.35 | 1.00 | -0.90 | 6.41 | 1,179 |
| Absolute Latitude (std) | Ethnoatlas | 0.00 | -0.43 | 1.00 | -1.21 | 3.36 | 1,179 |
| Distance to major river (std) | Fenske (2013) | 0.00 | -0.63 | 1.00 | -0.63 | 1.58 | 1,179 |
| Distance to coast (std) | Fenske (2013) | 0.00 | -0.30 | 1.00 | -1.11 | 3.14 | 1,179 |
| Pct malaria | MAP | 0.17 | 0.06 | 0.21 | 0.00 | 0.69 | 1,179 |
| Population density 1995 (std) | FAO-GAEZ | 0.00 | -0.38 | 1.00 | -0.62 | 7.23 | 1,161 |
| Historical population density (std) | HYDE | 0.00 | -0.23 | 1.00 | -0.30 | 25.85 | 1,179 |
| Plow Advantage (std) | FAO-GAEZ | -0.00 | 0.31 | 1.00 | -2.83 | 2.61 | 1,179 |
| % Fertile land | Ramankutty et al (2002) | -0.00 | -0.03 | 1.00 | -1.43 | 2.53 | 1,134 |
| Caloric Suitability Index (std) | Galor and Ozak (2015) | 0.00 | 0.28 | 1.00 | -1.95 | 2.63 | 1,179 |

FAO GAEZ v3 database downloaded on 15/01/2016. std - a standardized variable that has been rescaled to have a mean of zero and a standard deviation of one.

Table F.2: Descriptive Statistics: Countries X 50 years

| | **SOURCE** | **Mean** | **p50** | **SDev** | **Min** | **Max** | **N** |
|---|---|---|---|---|---|---|---|
| *Hierarchy* | Borcan et al. (2018) | 0.72 | 1.00 | 0.45 | 0.00 | 1.00 | 2,869 |
| *LandProd* (std) | authors | 0.00 | 0.35 | 1.00 | -1.64 | 2.69 | 2,959 |
| *CerAdv* (std) | authors | 0.00 | -0.00 | 1.00 | -1.49 | 3.12 | 2,959 |
| WR of cereals | authors | 0.49 | 0.00 | 0.50 | 0.00 | 1.00 | 2,959.00 |
| WR of roots and tubers | authors | 0.05 | 0.00 | 0.22 | 0.00 | 1.00 | 2,959.00 |
| WR of cereals, roots and tubers | authors | 0.34 | 0.00 | 0.47 | 0.00 | 1.00 | 2,959.00 |
| Precipitation (std) | FAO-GAEZ | 0.00 | -0.29 | 1.00 | -1.38 | 2.89 | 2,940 |
| Temperature (std) | FAO-GAEZ | 0.00 | 0.20 | 1.00 | -2.68 | 1.52 | 2,884 |
| Elevation (std) | GDEM | 0.00 | -0.33 | 1.00 | -1.10 | 4.65 | 2,845 |
| Ruggedness (std) | GDEM | 0.00 | -0.31 | 1.00 | -1.12 | 4.25 | 2,959 |
| Absolute latitude (std) | Nunn and Puga (2012) | 0.00 | -0.17 | 1.00 | -1.51 | 2.18 | 2,959 |
| Legal origin: English common law | La Porta et al. (1999) | 0.27 | 0.00 | 0.44 | 0.00 | 1.00 | 2,959 |
| Legal origin: French civil law | La Porta et al. (1999) | 0.45 | 0.00 | 0.50 | 0.00 | 1.00 | 2,959 |
| Legal origin: Socialist law | La Porta et al. (1999) | 0.22 | 0.00 | 0.41 | 0.00 | 1.00 | 2,959 |
| Legal origin: German civil law | La Porta et al. (1999) | 0.03 | 0.00 | 0.18 | 0.00 | 1.00 | 2,959 |
| Legal origin: Scandinavian law | La Porta et al. (1999) | 0.03 | 0.00 | 0.18 | 0.00 | 1.00 | 2,959 |
| Population density 1500 (std) | Acemoglu et al. (2002) | 0.00 | -0.05 | 1.00 | -2.96 | 2.78 | 2,959 |
| Mortality of early settlers (std) | Acemoglu et al. (2002) | 0.00 | -0.11 | 1.00 | -2.91 | 2.56 | 1,519 |
| Slaves exported (std) | Nunn (2008) | 0.00 | -0.26 | 1.00 | -0.26 | 9.01 | 2,959 |
| Genetic diversity (std) | Ashraf and Galor (2013) | 0.00 | 0.24 | 1.00 | -3.66 | 1.74 | 2,675 |
| Hist. domesticable animals/area | Ashraf and Galor (2011) | 2.58 | 0.01 | 17.72 | 0.00 | 168.00 | 2,032 |
| Distance to major river (std) | www.pdx.edu/econ/ | 0.00 | -0.29 | 1.00 | -0.89 | 7.63 | 2,845 |
| Distance to coast (std) | www.pdx.edu/econ/ | 0.00 | -0.41 | 1.00 | -0.75 | 4.48 | 2,845 |
| Pct malaria | MAP | 0.65 | 0.94 | 0.41 | 0.00 | 1.00 | 2,883 |
| % country with tropical climate (std) | Nunn and Puga (2012) | 0.35 | 0.00 | 0.43 | 0.00 | 1.00 | 2,959 |
| Caloric suitability index (std) | Galor and Ozak (2015) | 0.00 | 0.29 | 1.00 | -1.82 | 2.93 | 2,959 |

FAO GAEZ v3 database downloaded on 15/01/2016. std - a standardized variable that has been rescaled to have a mean of zero and a standard deviation of one.

Table F.3: Descriptive Statistics: 1x1 decimal degree pixel

| | SOURCE | Mean | p50 | SDev | Min | Max | N |
|---|---|---|---|---|---|---|---|
| **Panel A**: *cross-sectional data-15,927 raster points* | | | | | | | |
| City founded <AD 450 (dummy) | Reba et al. (2016) | 0.01 | 0.00 | 0.08 | 0.00 | 1.00 | 15,927 |
| City founded <500 BC (dummy) | Reba et al. (2016) | 0.00 | 0.00 | 0.06 | 0.00 | 1.00 | 15,927 |
| City founded <AD 400 (dummy) | DeGroff (2009) | 0.05 | 0.00 | 0.22 | 0.00 | 1.00 | 15,927 |
| Archaeological sites | ANCIENTLOCATIONS.NET | 0.24 | 0.00 | 2.58 | 0.00 | 138.00 | 15,927 |
| Pyramids or Mastaba | MEGALITHIC.CO.UK | 0.01 | 0.00 | 0.75 | 0.00 | 87.00 | 15,927 |
| Temples | MEGALITHIC.CO.UK | 0.04 | 0.00 | 0.64 | 0.00 | 46.00 | 15,927 |
| Mines | MEGALITHIC.CO.UK | 0.01 | 0.00 | 0.21 | 0.00 | 22.00 | 15,927 |
| Palaces | MEGALITHIC.CO.UK | 0.00 | 0.00 | 0.06 | 0.00 | 5.00 | 15,927 |
| Sculptured Stones | MEGALITHIC.CO.UK | 0.02 | 0.00 | 0.83 | 0.00 | 101.00 | 15,927 |
| Standing Stones | MEGALITHIC.CO.UK | 0.04 | 0.00 | 0.71 | 0.00 | 45.00 | 15,927 |
| *LandProd* (std) | authors | -0.70 | -1.28 | 1.26 | -1.78 | 3.76 | 15,927 |
| *CerAdv* (std) | authors | -0.93 | -1.40 | 1.03 | -2.67 | 2.96 | 15,927 |
| WR of cereals | authors | 0.19 | 0.00 | 0.39 | 0.00 | 1.00 | 15,927 |
| WR of roots and tubers | authors | 0.08 | 0.00 | 0.27 | 0.00 | 1.00 | 15,927 |
| WR of cereals, roots and tubers | authors | 0.05 | 0.00 | 0.23 | 0.00 | 1.00 | 15,927 |
| *DistanceCer* | authors | 28.71 | 24.72 | 22.78 | 0.00 | 270.26 | 15,927 |
| *DistanceAgr* | authors | 19.02 | 15.51 | 17.57 | 0.00 | 234.51 | 15,927 |
| Precipitation (std) | FAO-GAEZ | 0.00 | -0.32 | 1.00 | -1.06 | 9.24 | 15,862 |
| Temperature (std) | FAO-GAEZ | 0.00 | -0.32 | 1.00 | -1.33 | 1.81 | 15,833 |
| Elevation (std) | GDEM | -0.00 | -0.34 | 1.00 | -0.87 | 6.01 | 15,927 |
| Ruggedness (std) | GDEM | -0.00 | 0.35 | 1.00 | -3.38 | 1.10 | 15,927 |
| Absolute Latitude | authors | 40.52 | 41.50 | 22.20 | 0.50 | 83.50 | 15,927 |
| Irrigation Potential (std) | authors | 0.00 | 0.67 | 1.00 | 0.67 | 1.74 | 8,214 |
| Plow Advantage (std) | authors | 0.00 | 0.05 | 1.00 | -3.00 | 3.44 | 15,927 |
| Population density 1995 (std) | FAO-GAEZ | 0.00 | -0.59 | 1.00 | -0.76 | 3.58 | 15,861 |
| **Panel B**: *panel data-15,927 raster points with observations either before or after Neolithic transition* | | | | | | | |
| Prehistoric archaelogical sites | D. and R. Whitehouse (1975) | 0.11 | 0.00 | 0.71 | 0.00 | 23.00 | 31,854 |
| Prehistoric settlements | D. and R. Whitehouse (1975) | 0.08 | 0.00 | 0.59 | 0.00 | 21.00 | 31,854 |

FAO GAEZ v3 database downloaded on 15/01/2016. std - a standardized variable that has been rescaled to have a mean of zero and a standard deviation of one.

Table F.4: Caloric content of cereals, roots and tubers

| Crop | Energy | Crop | Energy |
|---|---|---|---|
| Barley | 3.52 | Sorghum | 3.39 |
| Buckwheat | 3.43 | Sweet Potato | 0.86 |
| Cassava | 1.6 | Wetland Rice | 3.7 |
| Foxtail Millet | 3.78 | Wheat | 3.47 |
| Indigo Rice | 3.7 | White Potato | 0.77 |
| Maize | 3.65 | Yams | 1.18 |
| Oat | 2.46 | Sorghum | 3.39 |
| Rye | 3.38 | | |

Values are in kilo calories per 100g. Source: Galor and Ozak (2015) and USDA Nutrient Database for Standard Reference (R25). The data source in table A1 is different, and therefore the caloric content reported there is slightly different as well.

Table F.5: Pairwise correlations of the main variables used in the empirical analysis on the societies in the Ethnoatlas

| Variables | $Hier.$ | $CerMain$ | Dep. agric. | Farm. surp. | H. Pop dens. | $LandProd$ | $CerAdv$ | % Fertile land | Caloric suit. ind. |
|---|---|---|---|---|---|---|---|---|---|
| $Hierarchy$ | 1.0 | | | | | | | | |
| $CerMain$ | 0.3 | 1.0 | | | | | | | |
| Dependence agriculture | 0.4 | 0.5 | 1.0 | | | | | | |
| Farming surplus | 0.6 | 0.4 | 0.3 | 1.0 | | | | | |
| Hist Pop density (Pryor) | 0.6 | 0.5 | 0.7 | 0.4 | 1.0 | | | | |
| $LandProd$ | 0.2 | 0.3 | 0.4 | 0.2 | 0.3 | 1.0 | | | |
| $CerAdv$ | 0.2 | 0.4 | 0.3 | 0.3 | 0.2 | 0.8 | 1.0 | | |
| % Fertile land | 0.2 | 0.2 | 0.3 | 0.2 | 0.3 | 0.4 | 0.5 | 1.0 | |
| Caloric suitability index | 0.2 | 0.3 | 0.5 | 0.2 | 0.3 | 1.0 | 0.8 | 0.5 | 1.0 |

Table F.6: Potential Crop Yields and Choice of Crops. Robustness checks: Controlling for Geography.

| | Dep. Variable: Major crop is a cereal grain (dummy) | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *CerAdv* | 0.214*** | 0.274*** | 0.248*** | 0.250*** |
| | (0.057) | (0.054) | (0.059) | (0.059) |
| *LandProd* | -0.088 | -0.174*** | -0.132* | -0.133* |
| | (0.067) | (0.064) | (0.069) | (0.070) |
| Precipitation | -0.058* | | | |
| | (0.031) | | | |
| Temperature | | 0.066** | | |
| | | (0.033) | | |
| Elevation | | | 0.030* | |
| | | | (0.017) | |
| Ruggedness | | | | 0.012 |
| | | | | (0.026) |
| CONTINENT FE | YES | YES | YES | YES |
| r2 | 0.367 | 0.364 | 0.362 | 0.359 |
| N | 982 | 982 | 982 | 982 |

The table reports cross-sectional OLS estimates and the unit of observation is the society in Murdock's Ethnoatlas. Societies that live on lands that are suitable for neither cereals nor roots and tubers are excluded from the sample. Standard errors (in parentheses) are adjusted for spatial correlation using Conley's (1999) method. *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.7: Potential Crop Yields and Choice of Crops. Robustness checks: Controlling for Isolation, Population Density and the Plow.

| | Dep. Variable: Major crop is a cereal grain (dummy) | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (5) | (6) | | (7) | (8)) |
| *CerAdv* | 0.252*** | 0.250*** | 0.253*** | 0.261*** | 0.254*** | 0.253*** | 0.257*** |
| | (0.058) | (0.060) | (0.059) | (0.071) | (0.059) | (0.058) | (0.049) |
| *LandProd* | -0.137** | -0.135* | -0.136** | -0.222*** | -0.139** | -0.204*** | -0.205*** |
| | (0.067) | (0.069) | (0.069) | (0.086) | (0.069) | (0.060) | (0.061) |
| Major River | -0.028* | | | | | | |
| | (0.017) | | | | | | |
| Distance Coast | | 0.016 | | | | | |
| | | (0.035) | | | | | |
| Hist Pop Dens (HYDE) | | | -0.015 | | | | |
| | | | (0.016) | | | | |
| Hist Pop Dens (PRYOR) | | | | 0.206*** | | | |
| | | | | (0.038) | | | |
| Pop Dens 1995 | | | | | -0.004 | | |
| | | | | | (0.025) | | |
| Irrigation | | | | | | 0.191*** | |
| | | | | | | (0.049) | |
| Plow Advantage | | | | | | | -0.148*** |
| | | | | | | | (0.033) |
| CONTINENT FE | YES | YES | YES | YES | YES | YES | YES |
| r2 | 0.362 | 0.360 | 0.360 | 0.383 | 0.348 | 0.396 | 0.398 |
| N | 982 | 982 | 982 | 144 | 966 | 800 | 982 |

The table reports cross-sectional 2SLS estimates and the unit of observation is the society in Murdock's Ethnoatlas. Societies that live on lands that are suitable for neither cereals nor roots and tubers are excluded from the sample. Standard errors (in parentheses) are adjusted for spatial correlation using Conley's (1999) method. *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.8: Cereals and Hierarchy - Reduced Form using generalized ordered logit

| | Dependent variable: Jurisdictional Hierarchy Beyond Local Community | | | |
|---|---|---|---|---|
| | Hierarchy<=1 vs Hierarchy>1 | H<=2 vs H>2 | H<=3 vs H>3 | H<=4 vs H>4 |
| *CerAdv* | 0.327* | 0.542*** | 0.674*** | 0.841** |
| | (0.173) | (0.172) | (0.230) | (0.407) |
| *LandProd* | 0.0596 | -0.392** | -0.485* | -0.597 |
| | (0.198) | (0.199) | (0.281) | (0.515) |

The table reports the estimates from a generalized ordered logit. The unit of observation is the society in Murdock's Ethnoatlas. Societies that live on lands that are suitable for neither cereals nor roots and tubers are excluded from the sample. Robust standard errors in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.9: Cereals and Hierarchy - 2SLS. Robustness checks: Controlling for Geography.

| | Dependent variable: Jurisdictional Hierarchy Beyond Local Community | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | 2SLS | 2SLS | 2SLS | 2SLS |
| *CerMain* | 0.911 | 0.750* | 1.102** | 1.071** |
| | (0.624) | (0.407) | (0.553) | (0.545) |
| *LandProd* | -0.008 | 0.051 | -0.045 | -0.039 |
| | (0.081) | (0.062) | (0.074) | (0.075) |
| Precipitation | -0.001 | | | |
| | (0.001) | | | |
| Temperature | | -0.248*** | | |
| | | (0.072) | | |
| Elevation | | | -0.069* | |
| | | | (0.039) | |
| Ruggedness | | | | -0.008 |
| | | | | (0.050) |
| CONTINENT FE | YES | YES | YES | YES |
| N | 952 | 952 | 952 | 952 |
| F excl instrum. | 49.13 | 83.83 | 74.16 | 74.51 |

The table reports cross-sectional 2SLS estimates and the unit of observation is the society in Murdock's Ethnoatlas. Societies that live on lands that are suitable for neither cereals nor roots and tubers are excluded from the sample. Standard errors (in parentheses) are adjusted for spatial correlation using Conley's (1999) method. *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.10: Cereals and Hierarchy - 2SLS. Robustness checks: Controlling for Isolation, Population Density and the Plow.

| | Dependent variable: Jurisdictional Hierarchy Beyond Local Community | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS |
| *CerMain* | 1.073** | 1.078** | 1.021** | 1.471* | 0.992** | 0.933* | 1.029** |
| | (0.519) | (0.545) | (0.504) | (0.811) | (0.472) | (0.555) | (0.453) |
| *LandProd* | -0.040 | -0.038 | -0.056 | 0.006 | -0.085 | 0.012 | 0.080 |
| | (0.070) | (0.071) | (0.071) | (0.119) | (0.072) | (0.078) | (0.066) |
| Major River | 0.122*** | | | | | | |
| | (0.038) | | | | | | |
| Distance to Coast | | -0.024 | | | | | |
| | | (0.058) | | | | | |
| Hist Pop Dens (HYDE) | | | 0.211** | | | | |
| | | | (0.102) | | | | |
| Hist Pop Dens (PRYOR) | | | | 0.276 | | | |
| | | | | (0.192) | | | |
| Pop Dens 1995 | | | | | 0.290*** | | |
| | | | | | (0.048) | | |
| Irrigation | | | | | | 0.445* | |
| | | | | | | (0.242) | |
| Plow Advantage | | | | | | | 0.259*** |
| | | | | | | | (0.093) |
| CONTINENT FE | YES | YES | YES | YES | YES | YES | YES |
| N | 952 | 952 | 952 | 142 | 936 | 770 | 952 |
| F excl instrum. | 76.84 | 74.70 | 77.41 | 14.22 | 76.15 | 84.42 | 85 |

The table reports cross-sectional OLS and 2SLS estimates and the unit of observation is the society in Murdock's Ethnoatlas. Societies that live on lands that are suitable for neither cereals nor roots and tubers are excluded from the sample. Standard errors (in parentheses) are adjusted for spatial correlation using Conley's (1999) method. *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.11: Cereals and Hierarchy - 2SLS. Robustness checks: Sample Including Societies Living in Desertic Soils.

| | Dependent variable: Jurisdictional Hierarchy Beyond Local Community | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | OLS | 2SLS | 2SLS | 2SLS | OLS | 2SLS | 2SLS | 2SLS |
| *CerMain* | 0.712*** | 1.200*** | 0.831** | 0.999*** | 0.313*** | 0.839*** | 1.180*** | 1.092*** |
| | (0.0596) | (0.206) | (0.360) | (0.262) | (0.0703) | (0.273) | (0.322) | (0.284) |
| *LandProd* | | | 0.0667 | | | | -0.0489 | |
| | | | (0.0520) | | | | (0.0418) | |
| DEPENDENCE ON AGRICULTURE | | | | 0.327 | | | | -0.513 |
| | | | | (0.257) | | | | (0.434) |
| CONTINENT FE | NO | NO | NO | NO | YES | YES | YES | YES |
| N | 1059 | 1059 | 1059 | 1059 | 1059 | 1059 | 1059 | 1059 |
| F excl instrum. | | 130.2 | 44.59 | 56.16 | | 81.93 | 64.09 | 51.98 |
| A-R Test (p-val) | | 0.000 | 0.0183 | 0.000 | | 0.00163 | 0.000 | 0.000 |

The table reports cross-sectional OLS and 2SLS estimates and the unit of observation is the society in Murdock's Ethnoatlas. All societies included in the Ethnoatlas, for which the relevant data are available, are included in the sample. "A-R Test" is the Anderson-Rubin test: the null hypothesis that the endogenous regressor is equal to zero. Robust standard errors in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.12: Cereals and Hierarchy - 2SLS. Robustness checks: Potential Calorie Yields Refer to Ethnic Boundaries in Fenske (2013)

| | Dependent variable: Jurisdictional Hierarchy Beyond Local Community | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | OLS | 2SLS | 2SLS | 2SLS | OLS | 2SLS | 2SLS | 2SLS |
| *CerMain* | 0.707*** | 1.104*** | 0.752 | 0.872** | 0.304** | 0.839** | 0.897** | 0.898** |
| | (0.131) | (0.364) | (0.483) | (0.414) | (0.120) | (0.395) | (0.436) | (0.440) |
| *LandProd* | | | 0.104 | | | | -0.015 | |
| | | | (0.099) | | | | (0.060) | |
| DEPENDENCE ON AGRICULTURE | | | | 0.569 | | | | -0.225 |
| | | | | (0.520) | | | | (0.892) |
| CONTINENT FE | NO | NO | NO | NO | YES | YES | YES | YES |
| N | 952 | 942 | 942 | 952 | 952 | 942 | 942 | 942 |
| F excl instrum. | | 156.3 | 55.98 | 52.60 | | 120.1 | 88.82 | 20.90 |

The table reports cross-sectional OLS and 2SLS estimates and the unit of observation is the society in Murdock's Ethnoatlas. Societies that live on lands that are suitable for neither cereals nor roots and tubers are excluded from the sample. Standard errors (in parentheses) are adjusted for spatial correlation using Conley's (1999) method. *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.13: Cereals and Hierarchy - 2SLS. Robustness checks: Controlling for Alternative Measures of Land Suitability for Agriculture

| | Dependent variable: Jurisdictional Hierarchy Beyond Local Community | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| | 2SLS | 2SLS | 2SLS | 2SLS |
| *CerMain* | 1.009*** | 0.723 | 0.867 | 1.121* |
| | (0.372) | (0.478) | (0.636) | (0.585) |
| % fertile land | 0.073 | 0.057 | | |
| (Ramankutty et al. 2002) | (0.061) | (0.054) | | |
| Caloric Suitability Index | | | 0.081 | -0.049 |
| (Galor and Ozak, 2016) | | | (0.138) | (0.078) |
| CONTINENT FE | NO | YES | NO | YES |
| N | 952 | 952 | 952 | 952 |
| F excl instrum. | 106.3 | 70.49 | 38.25 | 65.04 |

The table reports cross-sectional 2SLS estimates and the unit of observation is the society in Murdock's Ethnoatlas. All societies included in the Ethnoatlas, for which the relevant data are available, are included in the sample. Standard errors (in parentheses) are adjusted for spatial correlation using Conley's (1999) method. *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.14: Cereals and Hierarchy - 2SLS. Robustness checks: the role of domesticated animals

| | Dependent variable: Jurisdictional Hierarchy Beyond Local Community | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS |
| *CerMain* | 0.820* | 1.092*** | 0.921** | 0.782 | 0.839* | 1.037*** | 0.774** |
| | (0.440) | (0.383) | (0.447) | (0.511) | (0.472) | (0.313) | (0.390) |
| America | -0.200 | | | | | | |
| | (0.194) | | | | | | |
| Eurasia and Africa | 0.367 | | | | | | |
| | (0.325) | | | | | | |
| Hearding 25-50% | | 0.363* | 0.187 | | | | |
| | | (0.199) | (0.168) | | | | |
| Hearding 51-75% | | 0.411 | 0.277 | | | | |
| | | (0.349) | (0.325) | | | | |
| Hearding 76-100% | | 0.851*** | 0.679* | | | | |
| | | (0.254) | (0.271) | | | | |
| Pigs | | | | 0.112 | -0.143 | | |
| | | | | (0.107) | (0.175) | | |
| Sheeps | | | | 0.470** | 0.414 | | |
| | | | | (0.229) | (0.253) | | |
| Equine animals | | | | 0.207 | 0.253 | | |
| | | | | (0.191) | (0.159) | | |
| Camels, Llamas | | | | 1.526*** | 1.437*** | | |
| | | | | (0.467) | (0.479) | | |
| Bovine animals | | | | 0.696** | 0.520* | | |
| | | | | (0.319) | (0.311) | | |
| Animals Cultivation | | | | | | 1.001*** | 1.043*** |
| | | | | | | (0.207) | (0.215) |
| CONTINENT FE | NO | NO | YES | NO | YES | NO | YES |
| N | 952 | 952 | 952 | 949 | 949 | 949 | 949 |
| F excl instrum. | 89.85 | 124.2 | 93.21 | 75.62 | 88.77 | 145.8 | 98.57 |

The table reports cross-sectional 2SLS estimates and the unit of observation is the society in Murdock's Ethnoatlas. Societies that live on lands that are suitable for neither cereals nor roots and tubers are excluded from the sample. Standard errors (in parentheses) are adjusted for spatial correlation using Conley's (1999) method. *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.15: Cereals, Surplus, and Taxation -Reduced Form

| | Dependent variable is: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Existence of a farming surplus | | | | Tax burden | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | OLS | OLS | OLS | Logit | OLS | OLS | OLS | Ord Logit |
| *CerAdv* | 0.141*** | 0.241*** | 0.202*** | 1.128*** | 0.223* | 0.433** | 0.257 | 1.038** |
| | (0.0319) | (0.0681) | (0.0742) | (0.363) | (0.116) | (0.183) | (0.175) | (0.494) |
| *LandProd* | | -0.132 | -0.0985 | -0.601 | | -0.293 | -0.206 | -0.654 |
| | | (0.0870) | (0.0985) | (0.392) | | (0.238) | (0.231) | (0.536) |
| CONTINENT FE | NO | NO | YES | NO | NO | NO | YES | NO |
| N | 140 | 140 | 140 | 140 | 56 | 56 | 56 | 56 |
| r2 | | 0.0757 | 0.0911 | 0.157 | | 0.0533 | 0.0781 | 0.341 |

The table reports cross-sectional OLS (columns 1-3 and 5-7), Logit (column 4) and ordered logit (column 8) estimates and the unit of observation is the society in Murdock's Ethnoatlas. Societies that live on lands that are suitable for neither cereals nor roots and tubers are excluded from the sample. Robust standard errors in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.16: Cereals, Surplus, and Taxation - OLS and 2SLS

| | Dependent variable is: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Existence of a farming surplus | | | | Tax burden | | | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | OLS | 2SLS | 2SLS | 2SLS | OLS | 2SLS | 2SLS | 2SLS |
| *CerMain* | 0.359*** | 0.940*** | 0.846*** | 0.846*** | 0.853*** | 0.846** | 1.018** | 1.173 |
| | (0.0791) | (0.260) | (0.273) | (0.275) | (0.209) | (0.406) | (0.471) | (0.850) |
| *LandProd* | | | 0.0186 | | | | -0.0634 | |
| | | | (0.0626) | | | | (0.158) | |
| DEPENDENCE ON AGRICULTURE | | | | 0.191 | | | | -0.584 |
| | | | | (0.663) | | | | (1.574) |
| CONTINENT FE | NO | NO | YES | NO | NO | NO | YES | NO |
| N | 139 | 139 | 139 | 139 | 56 | 56 | 56 | 56 |
| F excl instrum. | | 16.08 | 17.37 | 5.486 | | 22.58 | 15.11 | 3.184 |
| r2 | 0.128 | | | | 0.233 | | | |

The table reports cross-sectional OLS and 2SLS estimates and the unit of observation is the society in Murdock's Ethnoatlas. Societies that live on lands that are suitable for neither cereals nor roots and tubers are excluded from the sample. Robust standard errors in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.17: Cereals and Surplus - 2SLS. Robustness checks: Controlling for Geography.

| | Dependent variable: Existence of a farming surplus | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS |
| *CerMain* | 0.774** | 0.764*** | 0.921*** | 0.930*** | 0.681** |
| | (0.375) | (0.261) | (0.301) | (0.315) | (0.267) |
| *LandProd* | 0.0334 | 0.0387 | 0.00222 | -0.0215 | 0.0534 |
| | (0.0793) | (0.0686) | (0.0677) | (0.0811) | (0.0637) |
| Precipitation | -0.0334 | | | | |
| | (0.0762) | | | | |
| Temperature | | -0.0283 | | | |
| | | (0.0479) | | | |
| Elevation | | | -0.106*** | | |
| | | | (0.0372) | | |
| Ruggedness | | | | -0.111 | |
| | | | | (0.0723) | |
| Abs Latitude | | | | | 0.0516 |
| | | | | | (0.0472) |
| N | 139 | 139 | 139 | 139 | 139 |
| F excl instrum. | 10.41 | 19.42 | 15.50 | 14.83 | 15.68 |

The table reports cross-sectional 2SLS estimates and the unit of observation is the society in Murdock's Ethnoatlas. Robust standard errors in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.18: Cereals and Surplus - 2SLS. Robustness checks: Controlling for Isolation, Population Density, Potential for Irrigation, and the Plow.

| | Dependent variable: Existence of a farming surplus | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS |
| *CerMain* | 0.823*** | 0.851*** | 0.820*** | 0.848*** | 0.916*** | 0.646*** | 0.822*** |
| | (0.277) | (0.275) | (0.300) | (0.288) | (0.314) | (0.245) | (0.237) |
| *LandProd* | 0.0215 | 0.0191 | 0.0132 | 0.0208 | 0.0117 | 0.101* | 0.0265 |
| | (0.0625) | (0.0626) | (0.0589) | (0.0530) | (0.0616) | (0.0540) | (0.0574) |
| Major River | 0.0368 | | | | | | |
| | (0.0414) | | | | | | |
| Distance to Coast | | -0.0149 | | | | | |
| | | (0.0447) | | | | | |
| Hist Pop Dens (HYDE) | | | 0.0291 | | | | |
| | | | (0.0379) | | | | |
| Hist Pop Dens (PRYOR) | | | | -0.00808 | | | |
| | | | | (0.0840) | | | |
| Pop Density 1995 | | | | | 0.00145 | | |
| | | | | | (0.0357) | | |
| Irrigation | | | | | | 0.0291 | |
| | | | | | | (0.128) | |
| Plow Advantage | | | | | | | 0.0129 |
| | | | | | | | (0.0489) |
| N | 139 | 139 | 139 | 139 | 137 | 111 | 139 |
| F excl instrum. | 15.86 | 17.09 | 13.35 | 17.91 | 12.99 | 23.25 | 22.07 |

The table reports cross-sectional 2SLS estimates and the unit of observation is the society in Murdock's Ethnoatlas. Societies that live on lands that are suitable for neither cereals nor roots and tubers are excluded from the sample. Robust standard errors in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.19: Cereals and Taxation- 2SLS. Robustness checks: Controlling for Geography.

| | Dependent variable: Tax Burden | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS |
| *CerMain* | 0.808 | 1.056** | 1.019** | 1.014** | 1.132** |
| | (0.577) | (0.495) | (0.473) | (0.501) | (0.571) |
| *LandProd* | 0.0487 | -0.0814 | -0.0667 | -0.0603 | -0.112 |
| | (0.214) | (0.190) | (0.164) | (0.178) | (0.205) |
| Precipitation | -0.180 | | | | |
| | (0.167) | | | | |
| Temperature | | 0.0232 | | | |
| | | (0.128) | | | |
| Elevation | | | -0.0488 | | |
| | | | (0.250) | | |
| Ruggedness | | | | 0.00906 | |
| | | | | (0.116) | |
| Abs Latitude | | | | | -0.0593 |
| | | | | | (0.150) |
| N | 56 | 56 | 56 | 56 | 56 |
| F excl instrum. | 10.10 | 14.75 | 15.43 | 13.08 | 8.491 |

The table reports cross-sectional 2SLS estimates and the unit of observation is the society in Murdock's Ethnoatlas. Robust standard errors in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.20: Cereals and Taxation - 2SLS. Robustness checks: Controlling for Isolation, Population Density, Potential for Irrigation, and the Plow.

| | Dependent variable: Tax Burden | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS |
| *CerMain* | 0.999** | 0.993** | 0.380 | 0.00327 | 0.627 | 0.689 | 1.102** |
| | (0.470) | (0.438) | (0.591) | (0.536) | (0.492) | (0.659) | (0.483) |
| *LandProd* | -0.0530 | -0.0573 | -0.0998 | -0.174 | -0.158 | -0.0175 | -0.108 |
| | (0.158) | (0.152) | (0.154) | (0.138) | (0.151) | (0.163) | (0.160) |
| Major River | 0.101 | | | | | | |
| | (0.122) | | | | | | |
| Distance to Coast | | -0.0310 | | | | | |
| | | (0.0998) | | | | | |
| Hist Pop Dens (HYDE) | | | 0.291** | | | | |
| | | | (0.119) | | | | |
| Hist Pop Dens (PRYOR) | | | | 0.641*** | | | |
| | | | | (0.166) | | | |
| Pop Density 1995 | | | | | 0.227*** | | |
| | | | | | (0.0852) | | |
| Irrigation | | | | | | 0.329 | |
| | | | | | | (0.328) | |
| Plow Advantage | | | | | | | -0.0601 |
| | | | | | | | (0.0974) |
| N | 56 | 56 | 56 | 56 | 56 | 42 | 56 |
| F excl instrum. | 13.15 | 18.51 | 9.980 | 4.693 | 11.48 | 8.747 | 14.18 |

The table reports cross-sectional 2SLS estimates and the unit of observation is the society in Murdock's Ethnoatlas. Societies that live on lands that are suitable for neither cereals nor roots and tubers are excluded from the sample. Robust standard errors in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.21: Cereals and Hierarchy in Classical Antiquity - Cross-sectional regressions. Robustness Checks: Excluding Continents one-by-one

| | Dep. Variable: Hierarchy Index in AD 450 | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| *WR Cer* | 0.481*** | 0.398*** | 0.493*** | 0.510*** | 0.465*** |
| | (0.143) | (0.133) | (0.140) | (0.168) | (0.124) |
| *WR RT* | 0.179 | 0.170 | 0.174 | 0 | 0.182 |
| | (0.175) | (0.172) | (0.174) | (.) | (0.173) |
| *WR Cer and RT* | 0.0429 | 0.0573 | 0.0164 | 0.141 | 0.0623 |
| | (0.133) | (0.104) | (0.120) | (0.180) | (0.114) |
| CONTINENT FE | YES | YES | YES | YES | YES |
| Sample excludes | Africa | Asia | Europe | America | Oceania |
| r2 | 0.371 | 0.206 | 0.538 | 0.410 | 0.401 |
| N | 103 | 113 | 116 | 124 | 148 |

The table reports cross-sectional OLS estimates and the unit of observation is the territory delimited by modern-country borders. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.22: Cereals and Hierarchy in Classical Antiquity - Cross-sectional regressions. Further robustness checks

| | Dep. Variable: Hierarchy Index in AD 450 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| *WR Cer* | 0.460*** | 0.414*** | 0.500** | 0.467*** | 0.417*** | 0.449*** | 0.457*** | 0.412*** | 0.499*** | 0.500*** |
| | (0.104) | (0.104) | (0.195) | (0.124) | (0.135) | (0.117) | (0.132) | (0.130) | (0.125) | (0.163) |
| *WR RT* | 0.0887 | 0.197 | 0.152 | 0.181 | 0.148 | 0.172 | 0.204 | 0.117 | 0.123 | 0.153 |
| | (0.175) | (0.164) | (0.186) | (0.173) | (0.176) | (0.180) | (0.177) | (0.188) | (0.174) | (0.194) |
| *WR Cer and RT* | 0.0586 | 0.0569 | -0.0283 | 0.0573 | 0.0265 | 0.0534 | 0.0440 | 0.0787 | 0.0806 | 0.170 |
| | (0.101) | (0.0983) | (0.152) | (0.113) | (0.124) | (0.112) | (0.127) | (0.114) | (0.118) | (0.159) |
| Controls: | | | | | | | | | | |
| Legal Origin | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Pop. Dens. 1500 | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO |
| Settlers Mortality | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO |
| Slave Exports | NO | NO | NO | YES | NO | NO | NO | NO | NO | NO |
| Genetic Diversity | NO | NO | NO | NO | YES | NO | NO | NO | NO | NO |
| Distance River | NO | NO | NO | NO | NO | YES | NO | NO | NO | NO |
| Distance Coast | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO |
| Pct Malaria | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO |
| Tropical Land | NO | NO | NO | NO | NO | NO | NO | NO | YES | NO |
| Dom. Animals | NO | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| CONTINENT FE | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| N | 151 | 151 | 79 | 151 | 145 | 145 | 147 | 151 | 137 | 106 |
| r2 | 0.509 | 0.467 | 0.568 | 0.409 | 0.396 | 0.429 | 0.412 | 0.417 | 0.418 | 0.380 |

The table reports cross-sectional OLS estimates and the unit of observation is the territory delimited by modern-country borders. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.23: Cereals and Hierarchy in Classical Antiquity - Cross-sectional regressions

| | Dep. Variable: Hierarchy Index in AD 450 | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| *CerAdv* | 0.245** | 0.355*** | 0.160 | 0.278** | 0.198* | 0.187* |
| | (0.0993) | (0.118) | (0.102) | (0.108) | (0.111) | (0.101) |
| *LandProd* | -0.262*** | -0.400*** | -0.154 | -0.312*** | -0.214* | -0.210** |
| | (0.0986) | (0.123) | (0.104) | (0.107) | (0.112) | (0.0984) |
| Controls: | | | | | | |
| Abs Latitude | NO | YES | NO | NO | NO | NO |
| Precipitation | NO | NO | YES | NO | NO | NO |
| Temperature | NO | NO | NO | YES | NO | NO |
| Elevation | NO | NO | NO | NO | YES | NO |
| Ruggedness | NO | NO | NO | NO | NO | YES |
| CONTINENT FE | YES | YES | YES | YES | YES | YES |
| r2 | 0.328 | 0.343 | 0.336 | 0.350 | 0.326 | 0.353 |
| N | 151 | 151 | 150 | 148 | 145 | 151 |

The table reports cross-sectional OLS estimates and the unit of observation is the territory delimited by modern-country borders. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.24: Cereals and Hierarchy - Panel Regressions - Robustness Checks

| | Dep. Variable: Hierarchy Index | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| *CerAdv* | 0.160* | 0.127 | 0.206* | 0.274*** | 0.162* | 0.245*** | 0.258*** | 0.273*** | 0.254*** | 0.252** |
| | (0.0892) | (0.0843) | (0.116) | (0.0833) | (0.0831) | (0.0928) | (0.0957) | (0.0840) | (0.0675) | (0.101) |
| *LandProd* | -0.0507 | 0.0471 | -0.261 | -0.176 | -0.00456 | -0.121 | -0.133 | -0.199 | -0.211** | -0.186 |
| | (0.133) | (0.132) | (0.192) | (0.143) | (0.148) | (0.151) | (0.151) | (0.145) | (0.102) | (0.159) |
| Controls (xYear): | | | | | | | | | | |
| Legal Origin | YES | NO | NO | NO | NO | NO | NO | NO | NO | NO |
| Pop. Dens. 1500 | NO | YES | NO | NO | NO | NO | NO | NO | NO | NO |
| Settlers Mortality | NO | NO | YES | NO | NO | NO | NO | NO | NO | NO |
| Slave Exports | NO | NO | NO | YES | NO | NO | NO | NO | NO | NO |
| Genetic Diversity | NO | NO | NO | NO | YES | NO | NO | NO | NO | NO |
| Distance River | NO | NO | NO | NO | NO | YES | NO | NO | NO | NO |
| Distance Coast | NO | NO | NO | NO | NO | NO | YES | NO | NO | NO |
| Pct Malaria | NO | NO | NO | NO | NO | NO | NO | YES | NO | NO |
| Tropical Land | NO | YES | NO | NO | NO | NO | NO | NO | YES | NO |
| Dom. Animals | NO | NO | NO | NO | NO | NO | NO | NO | NO | YES |
| COUNTRY FE | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| TIME FE | YES | YES | YES | YES | YES | YES | YES | YES | YES | YES |
| r2 | 0.699 | 0.714 | 0.707 | 0.683 | 0.682 | 0.678 | 0.679 | 0.681 | 0.744 | 0.696 |
| N | 2869 | 2869 | 1501 | 2869 | 2603 | 2755 | 2755 | 2793 | 2869 | 2014 |

The table reports panel OLS estimates and the unit of observation is the territory delimited by modern-country borders every 50 years. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.25: Cereals and Hierarchy - Panel Regressions. Robustness checks: Excluding Colonies

| | Dep. Variable: Hierarchy Index | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| *CerAdv* | 0.128* | 0.186** | 0.230*** | 0.162** | 0.182** | 0.178** | 0.135* |
| | (0.0660) | (0.0786) | (0.0735) | (0.0816) | (0.0857) | (0.0788) | (0.0772) |
| *LandProd* | | -0.111 | -0.179 | -0.0997 | -0.0884 | -0.0879 | -0.115 |
| | | (0.136) | (0.131) | (0.136) | (0.138) | (0.134) | (0.119) |
| Controls (x Year FE): | | | | | | | |
| Precipitation | NO | NO | YES | NO | NO | NO | NO |
| Temperature | NO | NO | NO | YES | NO | NO | NO |
| Elevation | NO | NO | NO | NO | YES | NO | NO |
| Ruggedness | NO | NO | NO | NO | NO | YES | NO |
| Abs Latitude | NO | NO | NO | NO | NO | NO | YES |
| COUNTRY FE | YES | YES | YES | YES | YES | YES | YES |
| YEAR FE | YES | YES | YES | YES | YES | YES | YES |
| r2 | 0.773 | 0.774 | 0.789 | 0.774 | 0.770 | 0.777 | 0.786 |
| N | 2414 | 2414 | 2398 | 2365 | 2329 | 2414 | 2414 |

The table reports panel OLS estimates and the unit of observation is the territory delimited by modern-country borders every 50 years. The sample excludes those cells 50yearsXcountry in which countries were either colonies or protectorates. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.26: Cereals and Hierarchy - Panel Regressions. Robustness checks: a Different Measure of Hierarchy

| | Dep. Variable: Government above tribal level | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| *CerAdv* | 0.188*** | 0.270*** | 0.280*** | 0.235*** | 0.252*** | 0.259*** | 0.192** |
| | (0.0683) | (0.0835) | (0.0758) | (0.0855) | (0.0890) | (0.0840) | (0.0791) |
| *LandProd* | | -0.159 | -0.189 | -0.150 | -0.110 | -0.145 | -0.161 |
| | | (0.140) | (0.131) | (0.138) | (0.142) | (0.138) | (0.122) |
| Controls (x Year FE): | | | | | | | |
| Precipitation | NO | NO | YES | NO | NO | NO | NO |
| Temperature | NO | NO | NO | YES | NO | NO | NO |
| Elevation | NO | NO | NO | NO | YES | NO | NO |
| Ruggedness | NO | NO | NO | NO | NO | YES | NO |
| Abs Latitude | NO | NO | NO | NO | NO | NO | YES |
| COUNTRY FE | YES | YES | YES | YES | YES | YES | YES |
| YEAR FE | YES | YES | YES | YES | YES | YES | YES |
| r2 | 0.672 | 0.674 | 0.707 | 0.677 | 0.673 | 0.677 | 0.699 |
| N | 2869 | 2869 | 2850 | 2812 | 2755 | 2869 | 2869 |

The table reports panel OLS estimates and the unit of observation is the territory delimited by modern-country borders every 50 years. The dependent variable is a dummy that identifies those territories characterized by a supra-tribal government. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.27: Cereals and Hierarchy - Panel Regressions. Robustness checks: a Different Measure of Soil Suitability for Agriculture

| | Dep. Variable: Hierarchy Index | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| *CerAdv* | 0.189*** | 0.272*** | 0.282*** | 0.240*** | 0.255*** | 0.261*** | 0.197** |
| | (0.0683) | (0.0834) | (0.0760) | (0.0857) | (0.0889) | (0.0839) | (0.0795) |
| Caloric Suitability Index | | -0.163 | -0.193 | -0.152 | -0.115 | -0.148 | -0.165 |
| | | (0.141) | (0.131) | (0.139) | (0.142) | (0.138) | (0.123) |
| Controls (x Year FE): | | | | | | | |
| Precipitation | NO | NO | YES | NO | NO | NO | NO |
| Temperature | NO | NO | NO | YES | NO | NO | NO |
| Elevation | NO | NO | NO | NO | YES | NO | NO |
| Ruggedness | NO | NO | NO | NO | NO | YES | NO |
| Abs Latitude | NO | NO | NO | NO | NO | NO | YES |
| COUNTRY FE | YES | YES | YES | YES | YES | YES | YES |
| TIME FE | YES | YES | YES | YES | YES | YES | YES |
| r2 | 0.680 | 0.682 | 0.716 | 0.684 | 0.681 | 0.686 | 0.705 |
| N | 2869 | 2869 | 2850 | 2812 | 2755 | 2869 | 2869 |

The table reports panel OLS estimates and the unit of observation is the territory delimited by modern-country borders every 50 years. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.28: Cereals and Hierarchy - Panel Regressions. Robustness Checks: Excluding Years 1500-1750

| | Dep. Variable: Hierarchy Index | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| *CerAdv* | 0.198*** | 0.272*** | 0.282*** | 0.235*** | 0.249*** | 0.260*** | 0.190** |
| | (0.0720) | (0.0889) | (0.0811) | (0.0912) | (0.0946) | (0.0892) | (0.0846) |
| *LandProd* | | -0.145 | -0.176 | -0.140 | -0.0889 | -0.130 | -0.148 |
| | | (0.149) | (0.140) | (0.146) | (0.150) | (0.146) | (0.129) |
| Controls (x Year FE): | | | | | | | |
| Precipitation | NO | NO | YES | NO | NO | NO | NO |
| Temperature | NO | NO | NO | YES | NO | NO | NO |
| Elevation | NO | NO | NO | NO | YES | NO | NO |
| Ruggedness | NO | NO | NO | NO | NO | YES | NO |
| Abs Latitude | NO | NO | NO | NO | NO | NO | YES |
| COUNTRY FE | YES | YES | YES | YES | YES | YES | YES |
| YEAR FE | YES | YES | YES | YES | YES | YES | YES |
| r2 | 0.711 | 0.712 | 0.743 | 0.715 | 0.711 | 0.716 | 0.735 |
| N | 2416 | 2416 | 2400 | 2368 | 2320 | 2416 | 2416 |

The table reports panel OLS estimates and the unit of observation is the territory delimited by modern-country borders every 50 years. The years 1500-1750 are excluded from the regression. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.29: Cereals and Hierarchy - Panel Regressions. Robustness Checks: Excluding Years 1500-1750

| | Dep. Variable: Hierarchy Index | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| *Change CerAdv ∗ LinearTrend* | -0.0000601 | -0.000138 | -0.000145 | -0.000153 | -0.000169 | -0.000138 | -0.000138 |
| | (0.0000691) | (0.000135) | (0.000137) | (0.000138) | (0.000134) | (0.000135) | (0.000135) |
| *Change LandProd ∗ LinearTrend* | | 0.000142 | 0.000152 | 0.000164 | 0.000196 | 0.000142 | 0.000142 |
| | | (0.000191) | (0.000193) | (0.000194) | (0.000187) | (0.000191) | (0.000191) |
| Controls (x Year FE): | | | | | | | |
| Precipitation | NO | NO | YES | NO | NO | NO | NO |
| Temperature | NO | NO | NO | YES | NO | NO | NO |
| Elevation | NO | NO | NO | NO | YES | NO | NO |
| Ruggedness | NO | NO | NO | NO | NO | YES | NO |
| Abs Latitude | NO | NO | NO | NO | NO | NO | YES |
| COUNTRY FE | YES | YES | YES | YES | YES | YES | YES |
| YEAR FE | YES | YES | YES | YES | YES | YES | YES |
| r2 | 0.887 | 0.887 | 0.887 | 0.885 | 0.888 | 0.887 | 0.887 |
| N | 1661 | 1661 | 1650 | 1628 | 1595 | 1661 | 1661 |

The table reports panel OLS estimates and the unit of observation is the territory delimited by modern-country borders every 50 years. The years 1500-1750 are excluded from the regression. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.30: Cereals and Hierarchy - Panel Regressions 2

| | Dep. Variable: Hierarchy Index | | | | | | |
|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| *Change CerAdv∗* 1050 | -0.00422 | -0.00799 | -0.00811 | -0.00825 | -0.00810 | -0.00799 | -0.00799 |
| | (0.00332) | (0.00573) | (0.00581) | (0.00592) | (0.00581) | (0.00573) | (0.00573) |
| *Change CerAdv∗* 1100 | 0.0135 | 0.0119 | 0.0118 | 0.0117 | 0.0131 | 0.0119 | 0.0119 |
| | (0.0180) | (0.0205) | (0.0205) | (0.0206) | (0.0218) | (0.0205) | (0.0205) |
| *Change CerAdv∗* 1150 | 0.0172 | 0.0305 | 0.0303 | 0.0302 | 0.0334 | 0.0305 | 0.0305 |
| | (0.0185) | (0.0278) | (0.0278) | (0.0279) | (0.0300) | (0.0278) | (0.0278) |
| *Change CerAdv∗* 1200 | 0.0164 | 0.0298 | 0.0294 | 0.0292 | 0.0334 | 0.0298 | 0.0298 |
| | (0.0186) | (0.0281) | (0.0281) | (0.0281) | (0.0303) | (0.0281) | (0.0281) |
| *Change CerAdv∗* 1250 | 0.00759 | 0.0200 | 0.0191 | 0.0182 | 0.0252 | 0.0200 | 0.0200 |
| | (0.0194) | (0.0299) | (0.0299) | (0.0300) | (0.0323) | (0.0299) | (0.0299) |
| *Change CerAdv∗* 1300 | -0.0253 | -0.0404 | -0.0425 | -0.0448 | -0.0350 | -0.0404 | -0.0404 |
| | (0.0254) | (0.0440) | (0.0443) | (0.0448) | (0.0462) | (0.0440) | (0.0440) |
| *Change CerAdv∗* 1350 | -0.0234 | -0.0388 | -0.0409 | -0.0431 | -0.0333 | -0.0388 | -0.0388 |
| | (0.0254) | (0.0440) | (0.0443) | (0.0448) | (0.0462) | (0.0440) | (0.0440) |
| *Change CerAdv∗* 1400 | -0.0139 | -0.0460 | -0.0485 | -0.0511 | -0.0598 | -0.0460 | -0.0460 |
| | (0.0280) | (0.0509) | (0.0513) | (0.0518) | (0.0496) | (0.0509) | (0.0509) |
| *Change CerAdv∗* 1450 | -0.0235 | -0.0451 | -0.0479 | -0.0509 | -0.0573 | -0.0451 | -0.0451 |
| | (0.0303) | (0.0619) | (0.0624) | (0.0628) | (0.0622) | (0.0619) | (0.0619) |
| *Change CerAdv∗* 1500 | -0.00977 | -0.0452 | -0.0488 | -0.0524 | -0.0629 | -0.0452 | -0.0452 |
| | (0.0414) | (0.0688) | (0.0692) | (0.0698) | (0.0686) | (0.0688) | (0.0688) |
| *Change CerAdv∗* 1550 | 0.102* | 0.221** | 0.128 | 0.193* | 0.225** | 0.207* | 0.128 |
| | (0.0618) | (0.108) | (0.111) | (0.110) | (0.112) | (0.110) | (0.107) |
| *Change CerAdv∗* 1600 | 0.130* | 0.379*** | 0.286** | 0.350*** | 0.397*** | 0.364*** | 0.286** |
| | (0.0690) | (0.125) | (0.124) | (0.128) | (0.130) | (0.127) | (0.121) |
| *Change CerAdv∗* 1650 | 0.177** | 0.505*** | 0.412*** | 0.477*** | 0.514*** | 0.491*** | 0.412*** |
| | (0.0756) | (0.123) | (0.122) | (0.124) | (0.128) | (0.124) | (0.121) |
| *Change CerAdv∗* 1700 | 0.194** | 0.511*** | 0.418*** | 0.482*** | 0.459*** | 0.497*** | 0.418*** |
| | (0.0794) | (0.129) | (0.126) | (0.131) | (0.134) | (0.131) | (0.125) |
| *Change CerAdv∗* 1750 | 0.198** | 0.578*** | 0.485*** | 0.549*** | 0.532*** | 0.563*** | 0.485*** |
| | (0.0807) | (0.109) | (0.109) | (0.111) | (0.114) | (0.110) | (0.108) |
| *Change CerAdv∗* 1800 | 0.199** | 0.544*** | 0.450*** | 0.516*** | 0.496*** | 0.529*** | 0.450*** |
| | (0.0813) | (0.110) | (0.110) | (0.112) | (0.115) | (0.111) | (0.109) |
| *Change CerAdv∗* 1850 | 0.205** | 0.504*** | 0.409*** | 0.476*** | 0.455*** | 0.490*** | 0.411*** |
| | (0.0834) | (0.112) | (0.111) | (0.114) | (0.118) | (0.114) | (0.110) |
| Controls (x Year FE): | | | | | | | |
| *Change LandProd* | NO | YES | YES | YES | YES | YES | YES |
| Precipitation | NO | NO | YES | NO | NO | NO | NO |
| Temperature | NO | NO | NO | YES | NO | NO | NO |
| Elevation | NO | NO | NO | NO | YES | NO | NO |
| Ruggedness | NO | NO | NO | NO | NO | YES | NO |
| Abs Latitude | NO | NO | NO | NO | NO | NO | YES |
| COUNTRY FE | YES | YES | YES | YES | YES | YES | YES |
| TIME FE | YES | YES | YES | YES | YES | YES | YES |
| r2 | 0.717 | 0.733 | 0.750 | 0.732 | 0.730 | 0.736 | 0.745 |
| N | 2718 | 2718 | 2700 | 2664 | 2610 | 2718 | 2718 |

The table reports panel OLS estimates and the unit of observation is the territory delimited by modern-country borders every 50 years. Robust standard errors, clustered at the country-level, in parentheses. *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.31: Wild Relatives of Domesticated Crops and the Location of Ancient Cities. Robustness Checks: Excluding Continents one-by-one

| Dep. variable: presence of cities/large settlements founded by AD 400 | | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| *WR Cer* | 0.239*** | 0.220*** | 0.102*** | 0.224*** | 0.199*** |
| | (0.0495) | (0.0503) | (0.0292) | (0.0392) | (0.0385) |
| *WR RT* | 0.00373 | 0.0160 | -0.0224 | 0.0100 | 0.00537 |
| | (0.0138) | (0.0173) | (0.0142) | (0.0197) | (0.0157) |
| *WR Cer and RT* | -0.00320 | 0.0386 | -0.0117 | 0.0392* | 0.0267 |
| | (0.0178) | (0.0256) | (0.0141) | (0.0236) | (0.0217) |
| CONTINENT FE | YES | YES | YES | YES | YES |
| Sample excludes | Africa | Asia | Europe | America | Oceania |
| r2 | 0.176 | 0.182 | 0.0953 | 0.144 | 0.144 |
| N | 14487 | 13902 | 13201 | 11598 | 16265 |

The table reports cross-sectional OLS estimates and the unit of observation is the 1x1 decimal degree square. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.32: Wild Relatives of Domesticated Crops and the Location of Ancient Cities. Robustness Checks: Logit regressions

| Dep. variable: presence of cities/large settlements founded by AD 400 | | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| *WR Cer* | 2.963*** | 2.852*** | 2.877*** | 1.698*** |
| | (0.391) | (0.438) | (0.616) | (0.324) |
| *WR RT* | | -0.771 | -0.0138 | -1.331*** |
| | | (0.650) | (0.686) | (0.429) |
| *WR Cer and RT* | | -0.912 | -0.191 | -0.759 |
| | | (0.676) | (0.868) | (0.823) |
| CONTINENT FE | YES | YES | YES | YES |
| N | 17076 | 17076 | 17076 | 17076 |

The table reports cross-sectional Logistic estimates and the unit of observation is the 1x1 decimal degree square. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.33: Wild Relatives of Domesticated Crops and the Location of Ancient Cities. Robustness Checks: Controlling for Geography.

| Dependent variable is the presence of cities/large settlements founded by AD 400 | | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| *WR Cer* | 0.210*** | 0.189*** | 0.195*** | 0.196*** | 0.198*** |
| | (0.0388) | (0.0397) | (0.0380) | (0.0376) | (0.0371) |
| *WR RT* | 0.0423*** | 0.00105 | 0.00451 | 0.00559 | 0.0102 |
| | (0.0161) | (0.0141) | (0.0149) | (0.0151) | (0.0114) |
| *WR Cer and RT* | 0.0638*** | 0.0208 | 0.0229 | 0.0250 | 0.0301* |
| | (0.0204) | (0.0192) | (0.0204) | (0.0204) | (0.0162) |
| Precipitation | -0.0244*** | | | | |
| | (0.00850) | | | | |
| Temperature | | 0.00996 | | | |
| | | (0.0127) | | | |
| Elevation | | | -0.00696 | | |
| | | | (0.00535) | | |
| Ruggedness | | | | 0.00173 | |
| | | | | (0.00691) | |
| Abs Latitude | | | | | 0.000277 |
| | | | | | (0.000713) |
| CONTINENT FE | YES | YES | YES | YES | YES |
| r2 | 0.153 | 0.148 | 0.145 | 0.145 | 0.145 |
| N | 16850 | 16267 | 17076 | 17076 | 17076 |

The table reports cross-sectional OLS estimates and the unit of observation is the 1x1 decimal degree square. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.34: Wild Relatives of Domesticated Crops and the Location of Ancient Cities. Robustness Checks: Controlling for Irrigation Potential, the Plow, Population Density, Excluding Europe and Deserts.

| Dependent variable is the presence of cities/large settlements founded by AD 400 | | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| *WR Cer* | 0.207*** | 0.194*** | 0.122*** | 0.102*** | 0.222*** |
| | (0.0429) | (0.0352) | (0.0335) | (0.00468) | (0.0430) |
| *WR RT* | 0.0286 | 0.0181 | -0.0307** | -0.0224*** | 0.0251 |
| | (0.0213) | (0.0174) | (0.0123) | (0.00659) | (0.0207) |
| *WR RT and Cer* | 0.0585** | 0.0565** | -0.0384** | -0.0117 | 0.0657** |
| | (0.0282) | (0.0230) | (0.0194) | (0.00728) | (0.0303) |
| Irrigation Potential | 0.0277*** | | | | |
| | (0.0103) | | | | |
| Plow Advantage | | 0.0383*** | | | |
| | | (0.00824) | | | |
| Pop Dens 1995 | | | 0.0608*** | | |
| | | | (0.00884) | | |
| CONTINENT FE | YES | YES | YES | YES | YES |
| r2 | 0.171 | 0.165 | 0.185 | 0.0953 | 0.178 |
| N | 9086 | 17076 | 16848 | 13201 | 10091 |

The table reports cross-sectional OLS estimates and the unit of observation is the 1x1 decimal degree square. In column 4 the sample excludes Europe, in column 5 the sample excludes deserts. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.35: The Origin of the Neolithic Transition and the Location of Ancient Cities. Robustness checks: Controlling for Geography.

| Dependent variable is the presence of cities/large settlements founded by AD 400 | | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| *DistanceCer* | -0.00141** | -0.000710 | -0.00148** | -0.00132** | -0.000710 |
| | (0.000601) | (0.000922) | (0.000679) | (0.000630) | (0.00112) |
| *DistanceAgr* | 0.000250 | 0.000340 | 0.000323 | 0.000101 | 0.000339 |
| | (0.000576) | (0.000653) | (0.000609) | (0.000617) | (0.000662) |
| Precipitation | 0.00166 | | | | |
| | (0.00772) | | | | |
| Temperature | | 0.0413** | | | |
| | | (0.0186) | | | |
| Elevation | | | -0.00706 | | |
| | | | (0.00848) | | |
| Ruggedness | | | | -0.00597 | |
| | | | | (0.00662) | |
| Abs Latitude | | | | | -0.00159 |
| | | | | | (0.00110) |
| CONTINENT FE | YES | YES | YES | YES | YES |
| r2 | 0.0497 | 0.0593 | 0.0505 | 0.0501 | 0.0548 |
| N | 15862 | 15833 | 15927 | 15927 | 15927 |

The table reports cross-sectional OLS estimates and the unit of observation is the 1x1 decimal degree square. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.36: The Origin of the Neolithic Transition and the Location of Ancient Cities. Robustness checks: controlling for irrigation potential, the plow, population density, excluding Europe and deserts.

| Dependent variable is the presence of cities/large settlements founded by AD 400 | | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| *DistanceCer* | -0.00294*** | -0.00136* | -0.00168** | -0.00144*** | -0.00264*** |
| | (0.00103) | (0.000710) | (0.000651) | (0.000245) | (0.000922) |
| *DistanceAgr* | 0.000528 | 0.000271 | 0.00194*** | 0.000564** | 0.000369 |
| | (0.00125) | (0.000664) | (0.000636) | (0.000276) | (0.00103) |
| Irrigation Potential | 0.00527 | | | | |
| | (0.0104) | | | | |
| Plow Advantage | | 0.0358*** | | | |
| | | (0.0100) | | | |
| Pop Density 1995 | | | 0.0859*** | | |
| | | | (0.0137) | | |
| CONTINENT FE | YES | YES | YES | YES | YES |
| r2 | 0.105 | 0.0689 | 0.153 | 0.0642 | 0.0836 |
| N | 8214 | 15927 | 15861 | 12052 | 8942 |

The table reports cross-sectional OLS estimates and the unit of observation is the 1x1 decimal degree square. In column 4 the sample includes only Asia and Africa, in column 5 the sample excludes deserts. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.37: The Origin of the Neolithic Transition and Archeological Ruins.

| | Dependent variable is a dummy that identifies evidence of: | | | | | | |
|---|---|---|---|---|---|---|---|
| | ancient archaeolog. sites | pyramids | ancient temples | ancient mines | ancient palaces | ancient sculptured stones | ancient standing stones |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| *DistanceCer* | -0.00279*** | -0.000282 | -0.000636** | -0.000210** | -0.000132** | -0.000232** | -0.0000152 |
| | (0.000824) | (0.000187) | (0.000311) | (0.000106) | (0.0000550) | (0.000108) | (0.0000706) |
| *DistanceAgr* | 0.000864 | 0.000105 | 0.000316 | 0.0000109 | 0.0000689 | 0.000166 | 0.00000243 |
| | (0.000753) | (0.000146) | (0.000330) | (0.000144) | (0.0000487) | (0.000105) | (0.000119) |
| CONTINENT FE | YES | YES | YES | YES | YES | YES | YES |
| r2 | 0.0328 | 0.00451 | 0.0105 | 0.00294 | 0.00189 | 0.00930 | 0.0187 |
| N | 15927 | 15927 | 15927 | 15927 | 15927 | 15927 | 15927 |

The table reports cross-sectional OLS estimates and the unit of observation is the 1x1 decimal degree square. The dependent variable is a dummy that takes the value of one if there is archaeological evidence of either ancient sites from the Stone Age (column 1), or ancient pyramids or mastaba (column 2), or ancient temples (column 3), or ancient mines or quarries (column 4), or ancient palaces (column 5), or ancient sculptured stones (column 6). or ancient standing stones (column 7). Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.38: The Origin of the Neolithic Transition and Archaeological Ruins.

| | Dependent variable is the log (1+ number of archaeological ruin) | | | | | | |
|---|---|---|---|---|---|---|---|
| | ancient archaeolog. sites | pyramids | ancient temples | ancient mines | ancient palaces | ancient sculptured stones | ancient standing stones |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| *DistanceCer* | -0.00359*** | -0.000264 | -0.000556* | -0.000153** | -0.000109** | -0.000193** | -0.0000245 |
| | (0.00114) | (0.000170) | (0.000306) | (0.0000740) | (0.0000446) | (0.0000932) | (0.0000652) |
| *DistanceAgr* | 0.00120 | 0.0000880 | 0.000167 | 0.0000140 | 0.0000581 | 0.000152 | 0.0000752 |
| | (0.000981) | (0.000133) | (0.000332) | (0.000101) | (0.0000382) | (0.0000977) | (0.000157) |
| CONTINENT FE | YES | YES | YES | YES | YES | YES | YES |
| r2 | 0.0266 | 0.00256 | 0.00784 | 0.00260 | 0.00159 | 0.00800 | 0.0176 |
| N | 15927 | 15927 | 15927 | 15927 | 15927 | 15927 | 15927 |

The table reports cross-sectional OLS estimates and the unit of observation is the 1x1 decimal degree square. The dependent variable is log of one plus the number of either ancient sites from the Stone Age (column 1), or ancient pyramids or mastaba (column 2), or ancient temples (column 3), or ancient mines or quarries (column 4), or ancient palaces (column 5), or ancient sculptured stones (column 6), or ancient standing stones (column 7). Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.39: The Origin of the Neolithic Transition and Archaeological Ruins. Robustness Checks: Excluding Europe

| | Dependent variable is a dummy that identifies evidence of | | | | | | |
|---|---|---|---|---|---|---|---|
| | ancient archaeolog. sites | pyramids | ancient temples | ancient mines | ancient palaces | ancient sculptured stones | ancient standing stones |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| *DistanceCer* | -0.00279*** | -0.000281 | -0.000637** | -0.000208* | -0.000132** | -0.000231** | -0.0000128 |
| | (0.000826) | (0.000181) | (0.000311) | (0.000122) | (0.0000558) | (0.000104) | (0.0000637) |
| *DistanceAgr* | 0.000776 | 0.0000616 | 0.000362 | -0.0000761 | 0.0000597 | 0.000124 | -0.0000923 |
| | (0.000528) | (0.000109) | (0.000328) | (0.000141) | (0.0000476) | (0.0000768) | (0.0000663) |
| CONTINENT FE | YES | YES | YES | YES | YES | YES | YES |
| r2 | 0.0410 | 0.00524 | 0.0135 | 0.00405 | 0.00265 | 0.00520 | 0.00416 |
| N | 12052 | 12052 | 12052 | 12052 | 12052 | 12052 | 12052 |

The table reports cross-sectional OLS estimates and the unit of observation is the 1x1 decimal degree square. The sample excludes Europe. The dependent variable is a dummy that takes the value of one if there is archeological evidence of either ancient sites from the Stone Age (column 1), or ancient pyramids or mastaba (column 2), or ancient temples (column 3), or ancient mines or quarries (column 4), or ancient palaces (column 5), or ancient sculptured stones (column 6), or ancient standing stones (column 7). Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.40: Potential Crop Yields and the Location of Ancient Cities.

| | Dependent variable is the presence of cities founded by: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | classical antiquity | | | | AD 450 | | 500 BC | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| *CerAdv* | 0.0469*** | 0.145*** | 0.129*** | 0.0340** | 0.0174*** | 0.0161** | 0.00882*** | 0.00875** |
| | (0.0143) | (0.0388) | (0.0380) | (0.0162) | (0.00621) | (0.00635) | (0.00335) | (0.00350) |
| *LandProd* | | -0.0864*** | -0.0744*** | -0.0126 | -0.0108** | -0.0106** | -0.00579** | -0.00640** |
| | | (0.0267) | (0.0256) | (0.0128) | (0.00427) | (0.00462) | (0.00242) | (0.00278) |
| CONTINENT FE | NO | NO | YES | NO | NO | YES | NO | YES |
| COUNTRY FE | NO | NO | NO | YES | NO | NO | NO | NO |
| r2 | 0.0498 | 0.0841 | 0.0986 | 0.451 | 0.00758 | 0.0159 | 0.00316 | 0.0103 |
| N | 15927 | 15927 | 15927 | 15927 | 15927 | 15927 | 15927 | 15927 |

The table reports cross-sectional OLS estimates and the unit of observation is the 1x1 decimal degree square. Robust standard errors, clustered at the country-level, in parentheses. *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Table F.41: Potential Crop Yields and the Location of Ancient Cities. Difference-in-difference analysis

| | Dependent variable is: | | | |
|---|---|---|---|---|
| | archaeol. site (dummy) | Log(1+ # archaeol. site) | ancient settlem. (dummy) | Log(1+ # ancient settlem.) |
| | (1) | (2) | (3) | (4) |
| *Post X CerAdv* | 0.0683** | 0.117*** | 0.0668** | 0.101*** |
| | (0.0293) | (0.0417) | (0.0283) | (0.0365) |
| *Post X LandProd* | -0.0266 | -0.0581** | -0.0226 | -0.0456* |
| | (0.0208) | (0.0281) | (0.0203) | (0.0247) |
| CELL FE | YES | YES | YES | YES |
| TIME FE | YES | YES | YES | YES |
| r2 | 0.0710 | 0.0800 | 0.0738 | 0.0765 |
| N | 31854 | 31854 | 31854 | 31854 |

The table reports difference-in-difference OLS regressions. The unit of observation is the 1x1 decimal degree square either before or after the Neolithic transition. Robust standard errors, clustered at the country-level, in parentheses. *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Figure F.1: Density plot of the focal year for societies in Murdock's Ethnographic Atlas.

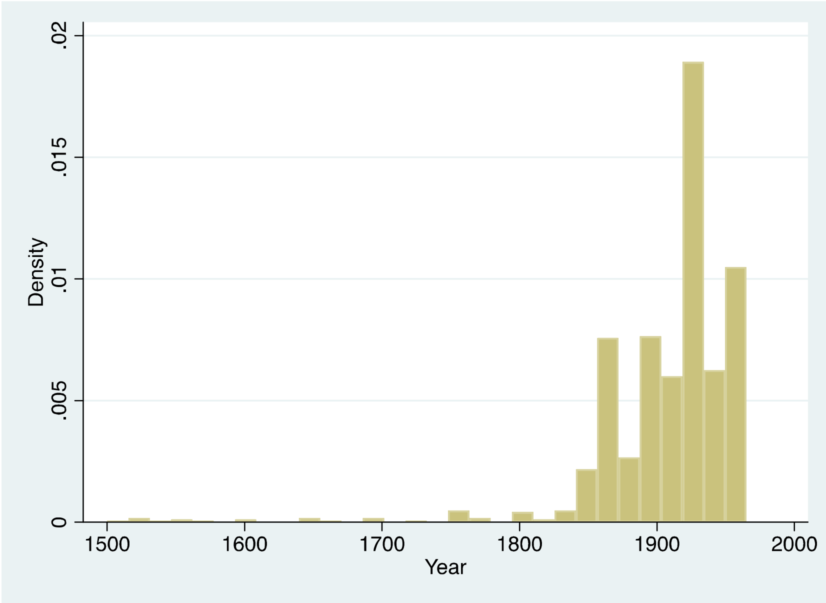



Figure F.2: Farming surplus in pre-industrial societies

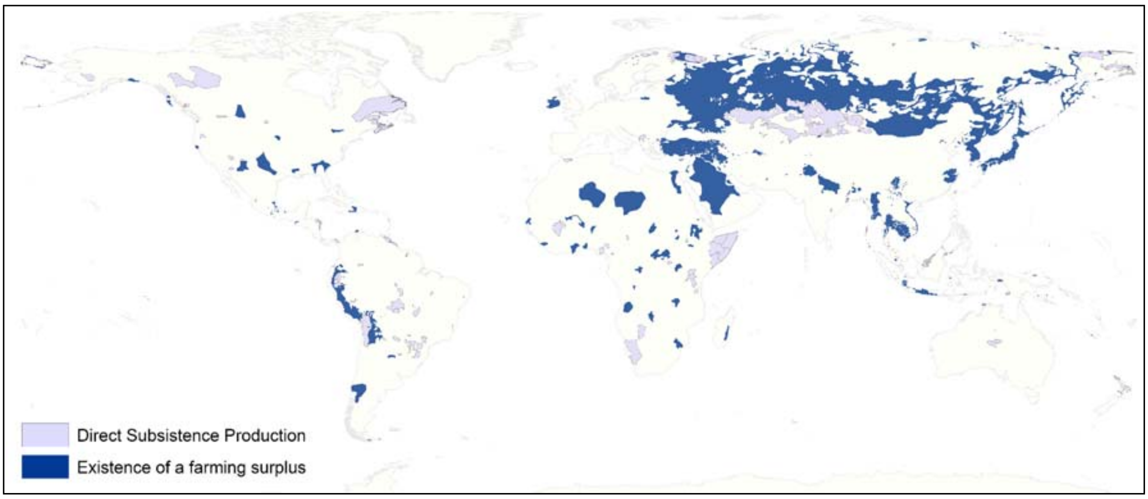


Figure F.3: Years of colonization

Figure F.4: Cities founded before 450 AD

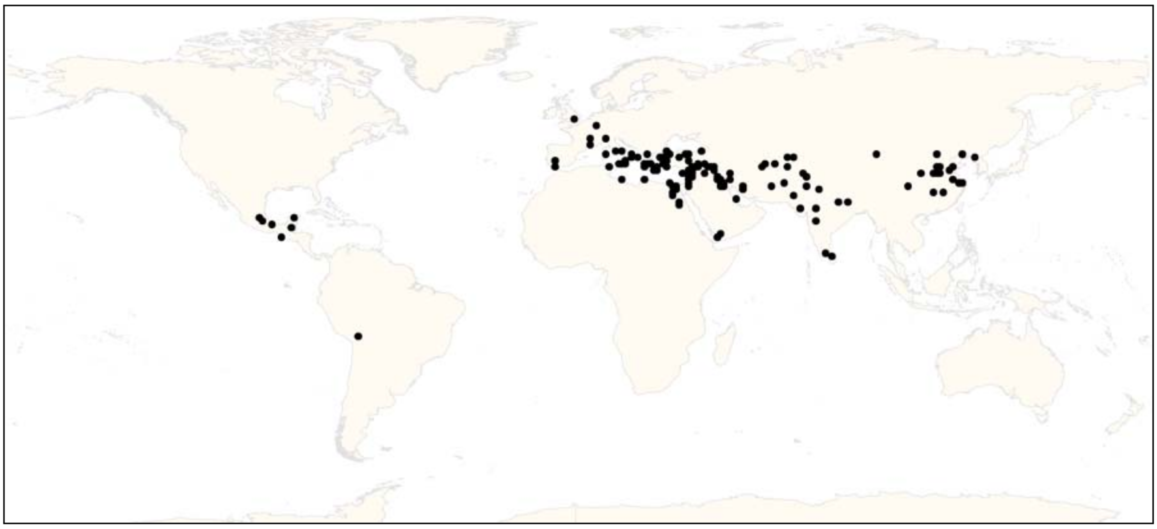


Figure F.5

Figure F.6: Cities founded before 500 BC

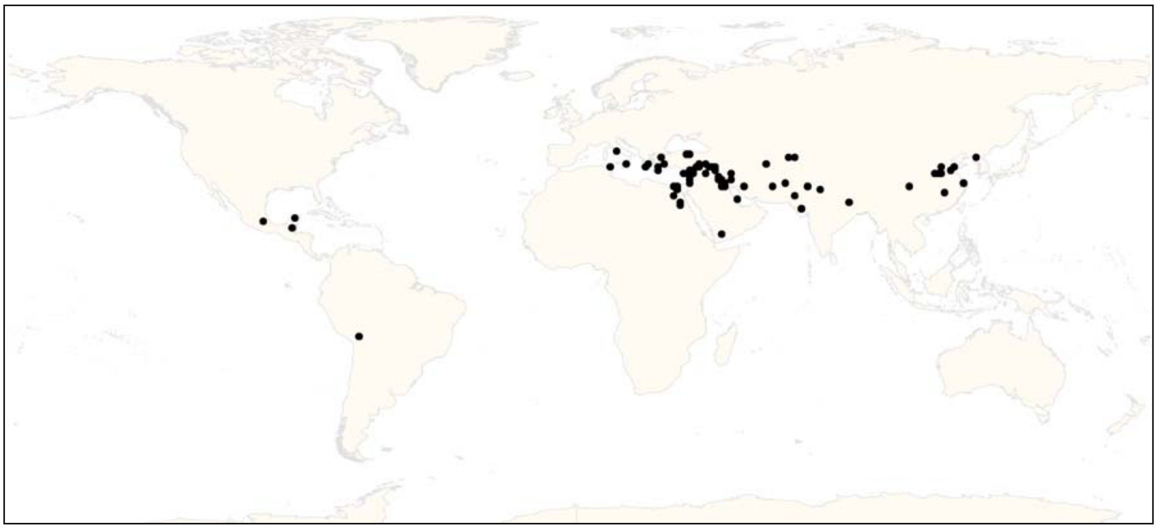


Figure F.7: Potential yields (calories per hectare) from cereal grains.

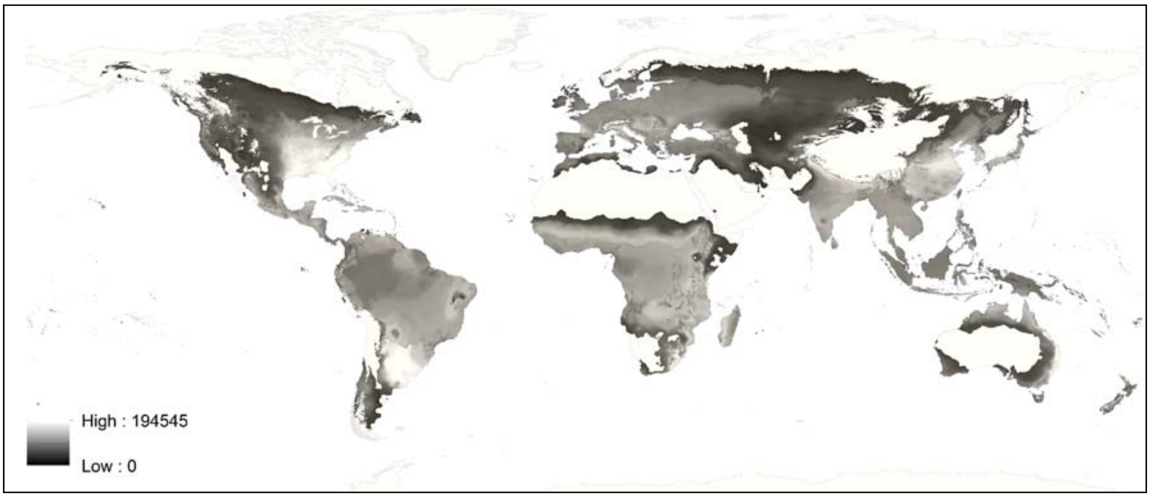



Figure F.8: Potential yields (calories per hectare) from roots and tubers

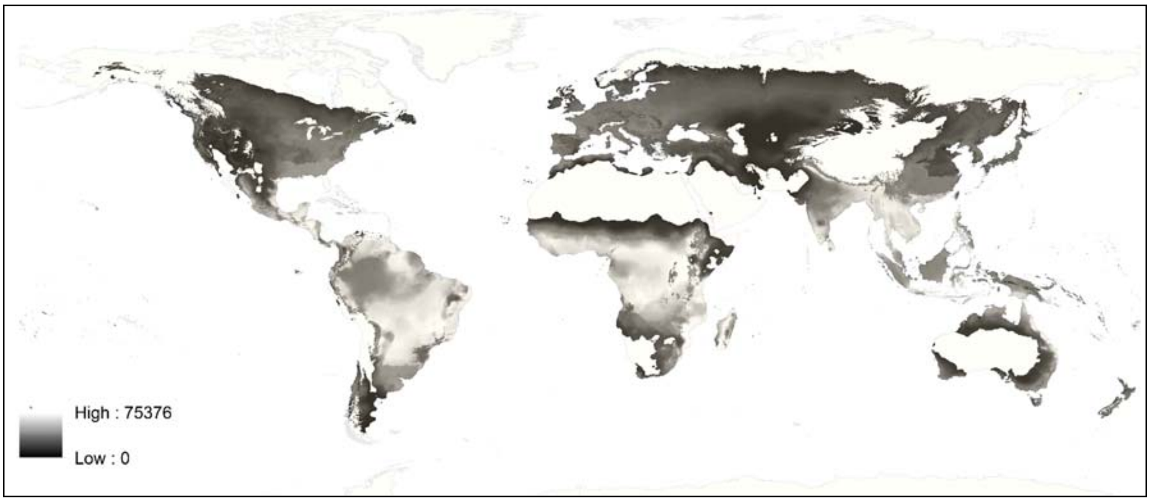


Figure F.9: Optimal crop in terms of caloric yields among cereals, roots and tubers

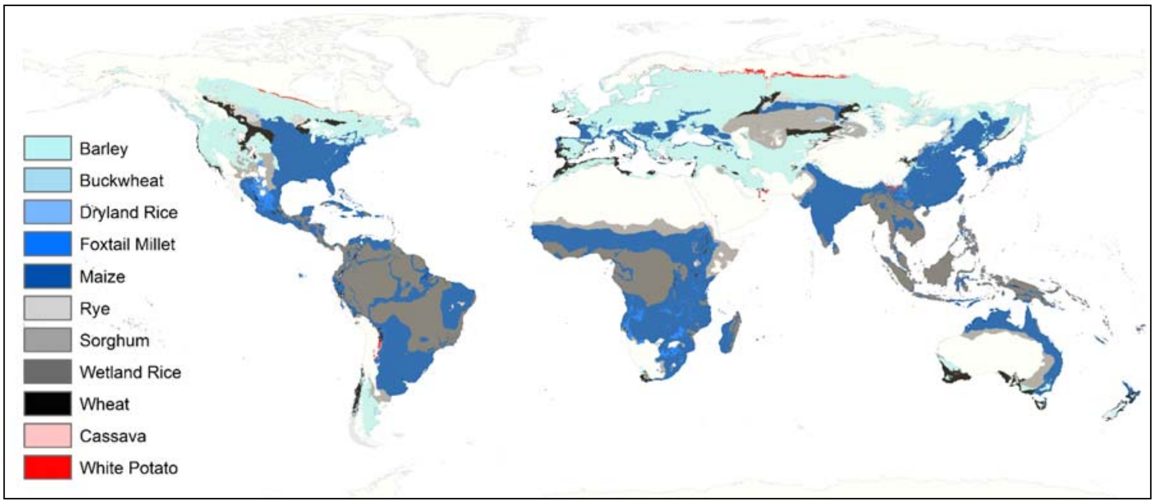



Figure F.10:

Figure F.11: Box plot: productivity advantage of cereals and hierarchy in pre-industrial societies

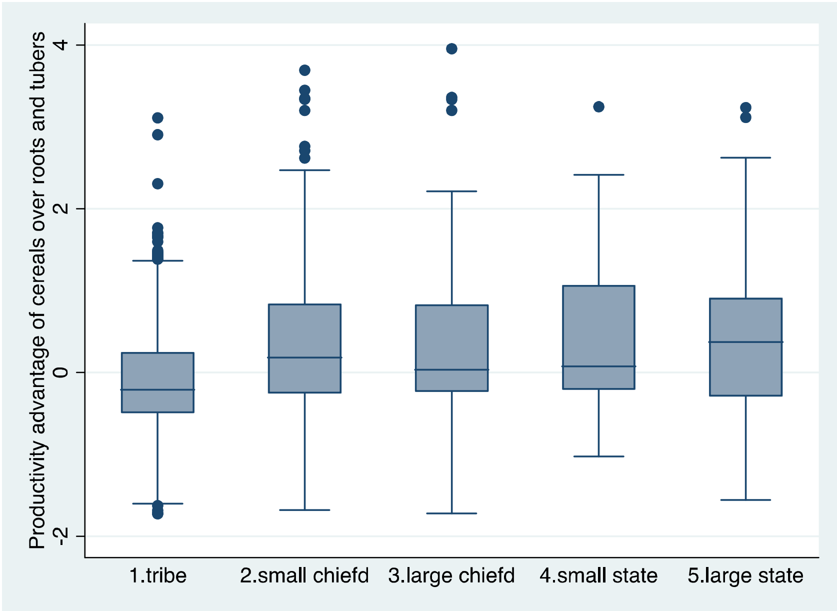



Figure F.12: Box plot: cereals and hierarchy in classical antiquity

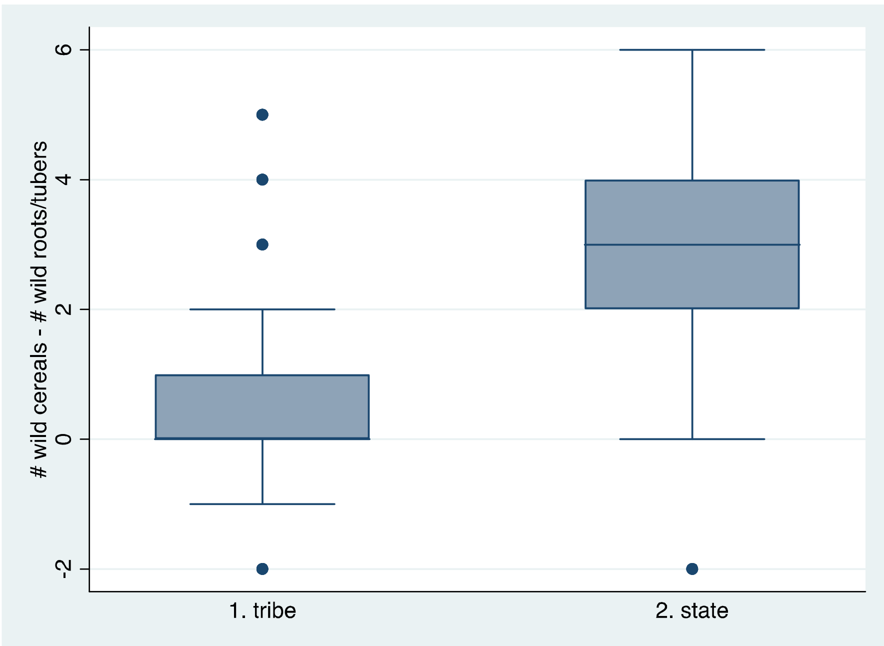


Figure F.13: Box plot: distance from areas of origin of agriculture and large human settlements founded before 400AD

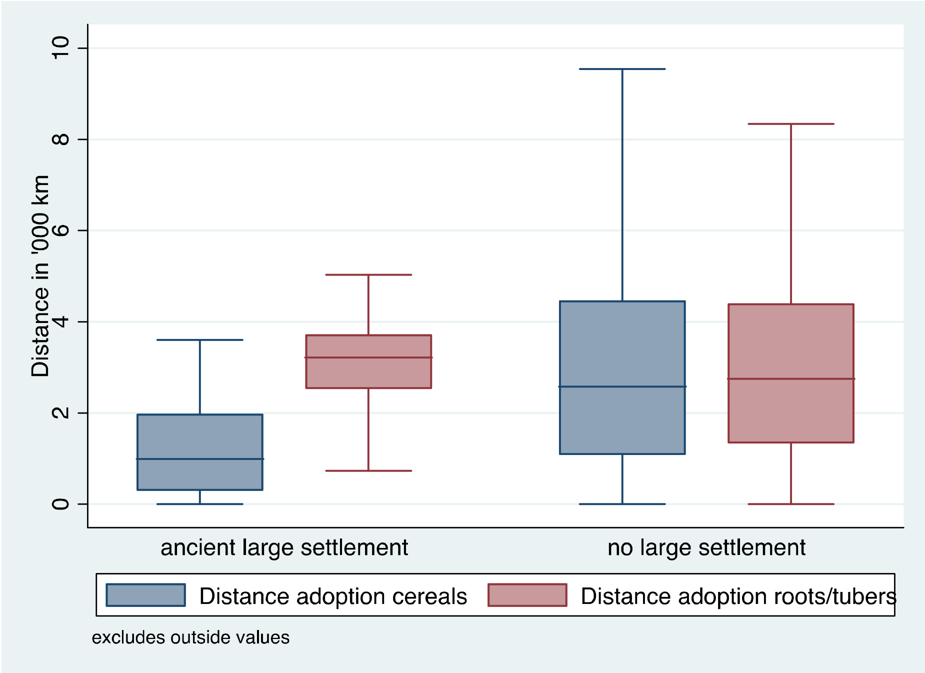



Figure F.14: Cities founded before 500 BC and centers of independent domestication