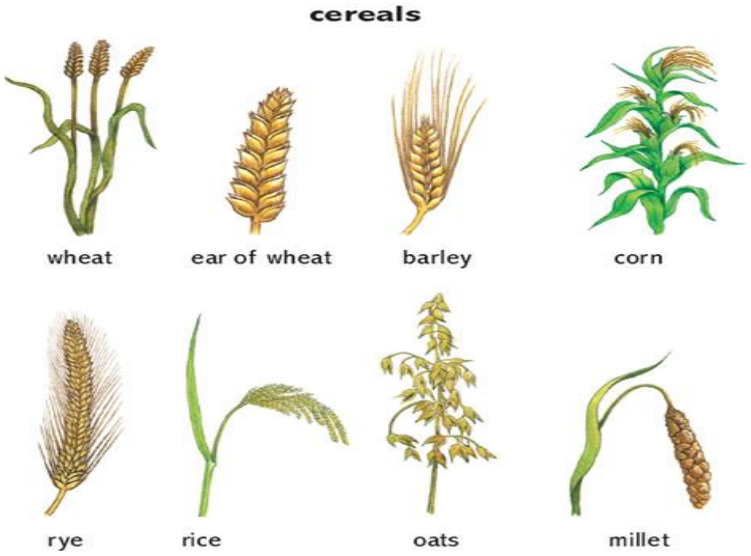
Cereals, Appropriability and Hierarchy

Joram Mayshar	Hebrew University of Jerusalem
Omer Moav	University of Warwick & IDC
Zvika Neeman	Tel-Aviv University
Luigi Pascali	UPF & University of Warwick

Cereals, Appropriability and Hierarchy

Joram Mayshar	Hebrew University of Jerusalem
Omer Moav	University of Warwick & IDC
Zvika Neeman	Tel-Aviv University
Luigi Pascali	UPF & University of Warwick



This stuff, not this

The emergence of hierarchy

Following the Neolithic Revolution some regions of the world developed complex hierarchies, leading to city-states and the great civilizations of antiquity

- How did farming trigger this change?
- Why did some regions remain with only simple hierarchy, in spite of adopting farming?

Existing literature: the emergence of hierarchy

- Neolithic Revolution →

  Increased productivity →

  Food surplus → (various mechanisms)

  An elite that did not produce food (hierarchy) →

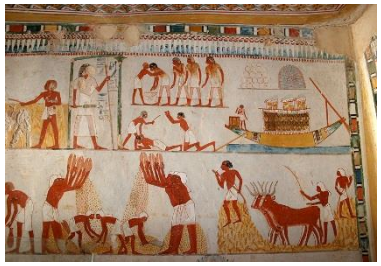
  The emergence of the state

"In short, plant and animal domestication meant much more food … The resulting food ***surpluses*** … were a ***prerequisite*** for the development of settled, ***politically centralized, socially stratified***, economically complex, technologically innovative societies." (Jared Diamond, 1997)

- Differences in agricultural productivity across regions generate differences in surplus and, therefore, in hierarchical complexity.

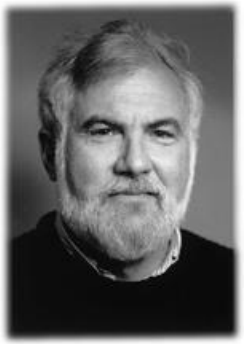
Our criticism

- Surplus is not ***necessary*** for appropriation




- Surplus is not ***sufficient*** for appropriation


- Surplus unlikely to emerge following Neolithic transition

Our explanation

- Neolithic Revolution →

  Increased appropriability (disproportionally more in regions suitable for cereals but not for roots/tubers) →

  Cereals could be taxed or stolen →

  An elite that did not produce food (hierarchy) →

  The emergence of the state

- Differences in land suitability for cereals/roots/tubers across regions generates difference in appropriability and, therefore, in hierarchical complexity.

The model (sketch)

- **Organizations:**
  - Anarchy
    - Roving bandits
  - Hierarchy
    - Monopoly of violence, No bandits
    - Fixed cost of organizing the state (army)
    - The state employs tax collectors

- **Agents**
  - Farmers
    - Choose the percentage of their land to allocate to tubers and cereals.
    - Cereals are more productive but they are appropriable (they can be taxed in hierarchy, stolen in anarchy).
  - Non farmers
    - Choose whether to be foragers (and earn an exogenous income) or bandits/tax collectors

The model (sketch)

- **Expropriation technology:**
  - Anarchy
    - Expropriation rates are an increasing/concave function of the number of bandits
    - Non-farmers will become bandits until the revenues from foraging and banditry are equalized
  - Hierarchy
    - Tax rates are an increasing/concave function of the number of tax collectors.
    - State maximizes net tax revenues (tax revenues-collection costs)

- **Main exogenous parameter:**
  - Relative productivity of cereals vs tubers

- **Definition of an equilibrium:**
  - Percentage of land allocated to cereals <-Farmers' optimization
  - Expropriation rates of cereals (anarchy) <-Non-farmers' optimization
  - Tax rates on cereals (hierarchy) <-State optimization

The model (sketch)

- **Distortions:**
  - Farmers might decide to cultivate the less productive crop
  - Non-famers might decide to be bandits/tax collectors rather than foragers

- **Results:**
  - If the relative productivity of cereals vs tubers is very low a state cannot exists (and cereals are not planted)

  (Intuition: it is difficult to impose decent tax rates, as the the farmers can easily switch to the non-appropriable crop. Therefore, the fixed costs to set-up a state are above the maximum achievable net tax revenues)
  - If cereals are productive enough to support a state, than hierarchy Pareto dominates anarchy.

  (Intuition: Lower expropriation rates under hierarchy. This implies that farmers will always cultivate the more productive crop and there will be less non-farmers that do not engage in foraging.

Data

- **Murdock's Ethnographic Atlas**

Database of 1,267 pre-colonial societies from around the world.

  - Jurisdictional Hierarchy Beyond Local Community
  - Major Crop Type
  - Dependence on agriculture
  - Farming surplus
  - Other controls (e.g. population density)

- **Food and Agriculture Organization – GAEZ**
  - Land productivity
  - Productivity advantage of cereals vs roots and tubers
  - Other controls (e.g. precipitation, temperature, elevation etc.)

- **Hierarchy Index (Borcan et al, 2014)**

Cover 159 modern day countries for every half century from 1000 CE to 2000 CE.

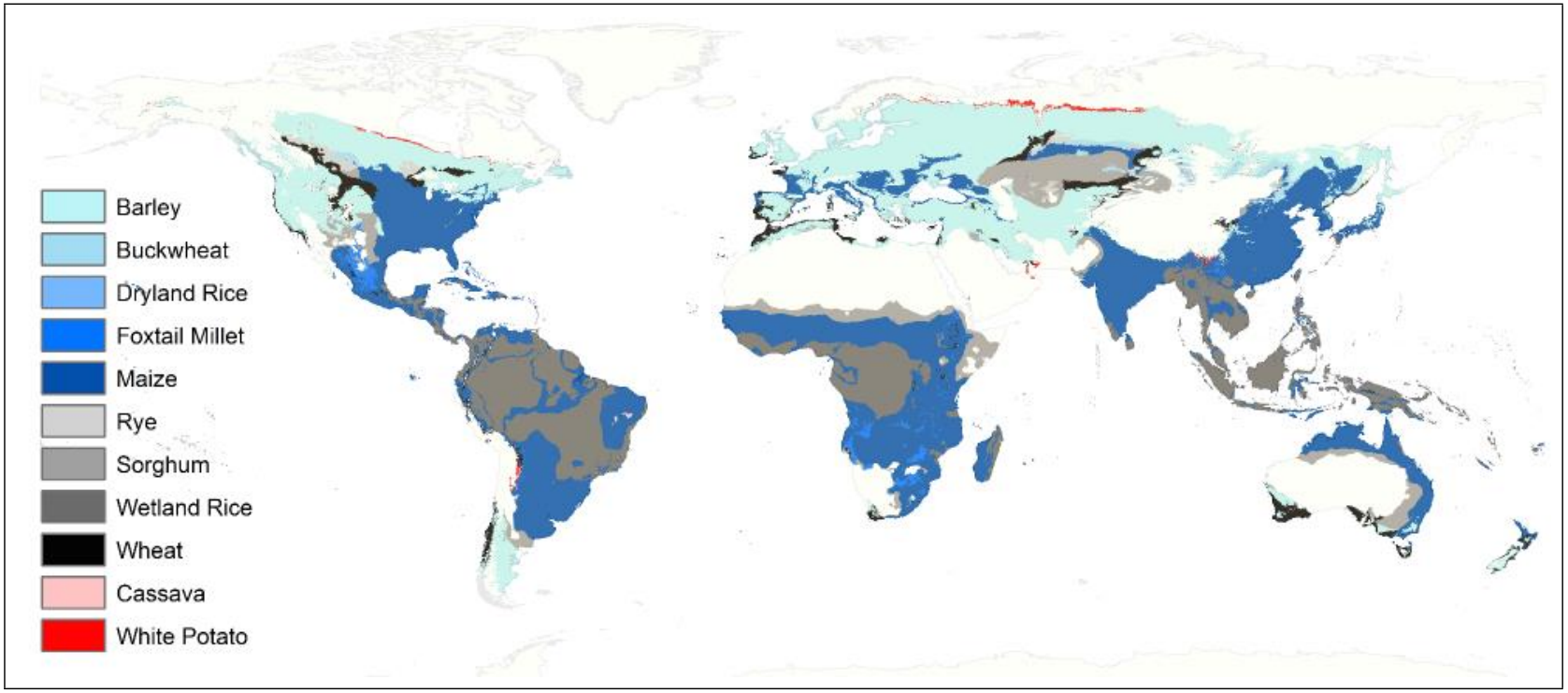
- **Archeological evidence (authors from several sources)**

Cover 1x1 decimal degrees raster points. Data on ancient cities and archaeological ruins.

- **Several other sources**
  - HYDE (Historical population reconstruction), MAP database (Incidence of malaria), Fenske (2013) (several other correlates)

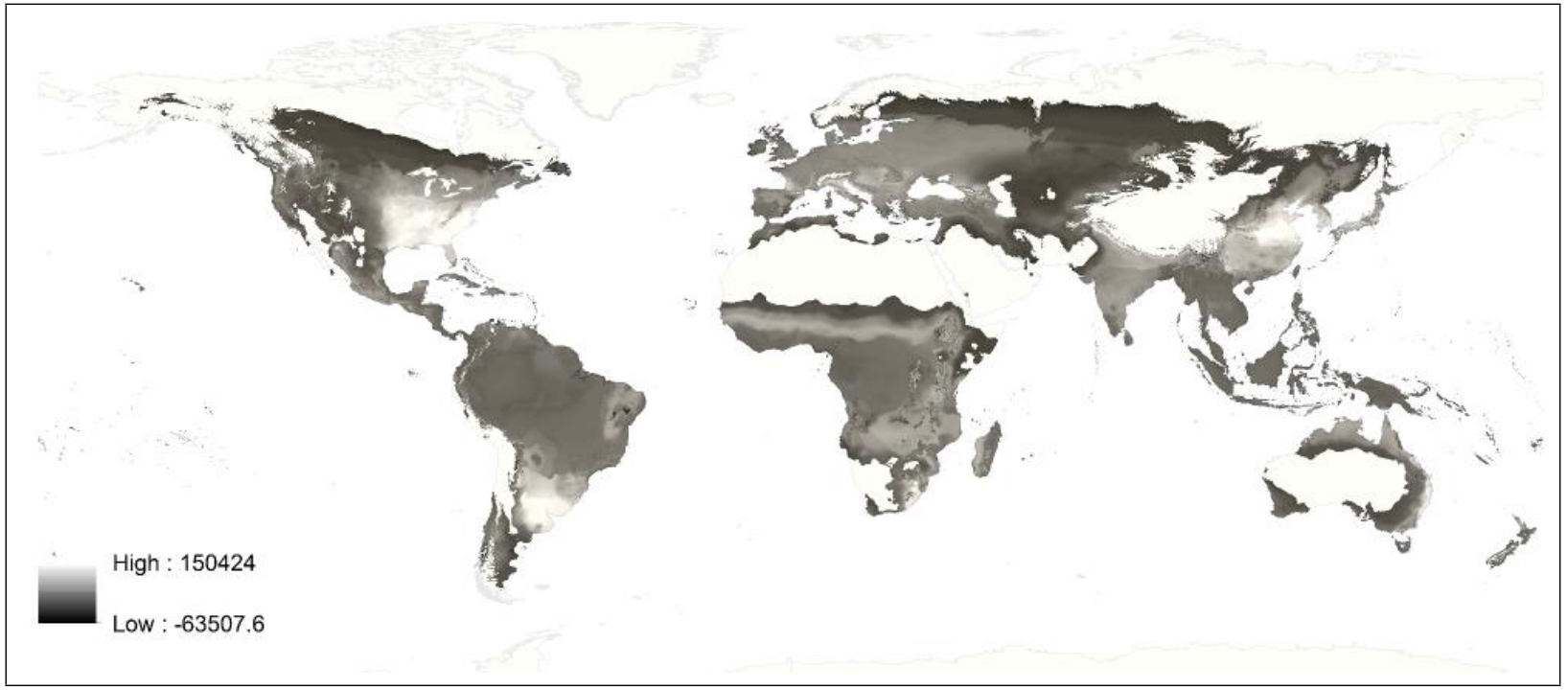
Crop yields, agriculture and main crop

Figure C.3: Optimal crop in terms of caloric yields among cereals, roots and tubers



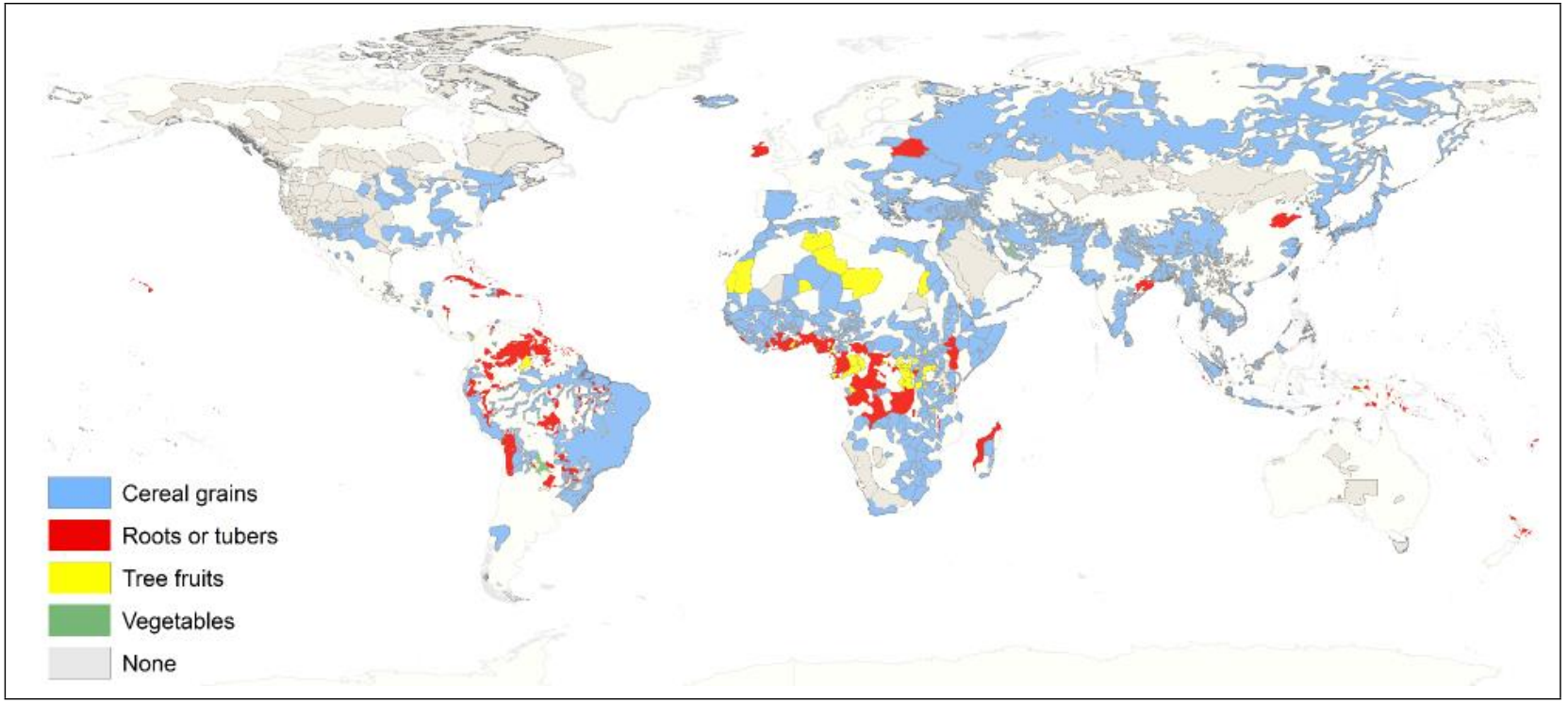
Crop yields, agriculture and main crop

Figure 7: Difference in potential yields (calories per hectare) of cereals versus roots and tubers.



Crop yields, agriculture and main crop

Figure 5: Major crop in pre-colonial societies



Crop yields, agriculture and main crop

Table 1: Potential Crop Yields, Choice of Crops and Reliance on Agriculture

	Dependent variable is:							
	Major crop is cereal grains (dummy)					Reliance on agriculture		
	(1) OLS	(2) OLS	(3) OLS	(4) Logit	(5) Logit	(6) OLS	(7) OLS	(8) OLS
CALORIC DIFF (CER - TUB)	0.205*** (0.029)	0.210*** (0.063)	0.253*** (0.059)	1.150*** (0.339)	1.617*** (0.380)	0.081*** (0.022)	-0.098*** (0.029)	-0.046** (0.022)
MAX CALORIES (ALL CROPS)		-0.007 (0.083)	-0.137** (0.069)	-0.119 (0.384)	-0.896** (0.407)		0.230*** (0.046)	0.128*** (0.035)
CONTINENT FE	NO	NO	YES	NO	YES	NO	NO	YES
Ave marg. effect of CALORIC DIFF				0.282*** (0.081)	0.385*** (0.092)			
r2	0.132	0.132	0.359			0.0733	0.235	0.387
pseudo r2				0.109	0.258			
N	982	982	982	982	982	1063	1063	1063

The table reports cross-sectional OLS and Logit estimates and the unit of observation is the society in Murdock's Ethnoatlas. The dependent variable is either a dummy that identifies societies that cultivate cereal grains as main crop (columns 1-5) or the reliance of these societies on agriculture (columns 6-8). CALORIC DIFF (CER-TUB) is the standardized difference between the maximum potential calorie yield per hectare that can be obtained from cereals versus the one that can be obtained from either roots or tubers. MAX CALORIES (ALL CROPS) is the standardized maximum potential calorie yield per hectare that can be obtained from cultivating the most productive crop among cereal grains, roots and tubers. 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.

Crop yields, agriculture and main crop: Robustness checks

- **Results are robust when controlling for:**
  - PRECIPITATION
  - TEMPERATURE
  - ELEVATION
  - RUGGEDNESS
  - ABSOLUTE LATITUDE
  - DISTANCE MAJOR RIVER
  - DISTANCE COAST
  - MALARIA
  - PLOW
  - POPULATION DENSITY (1995)
  - HISTORICAL POPULATION DENSITY (HYDE)
  - HISTORICAL POPULATION DENSITY (Pryor, 1995)

Cereals, surplus and hierarchy

2SLS estimates

2nd stage:

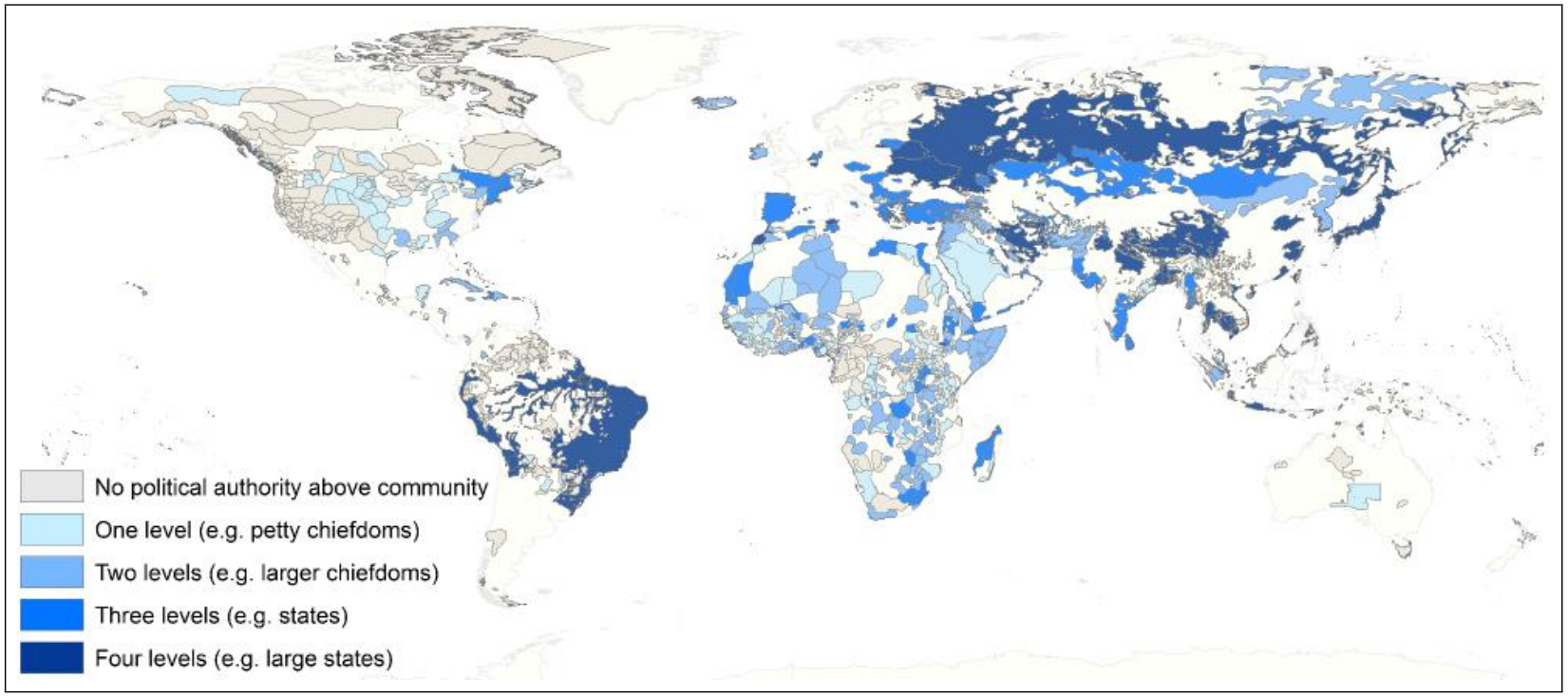
$Hierarchy_i / Surplus_i = \alpha\ I(Main\ Crop=Cereals_i) + X'\beta + \varepsilon$

1st stage:

$I(Main\ Crop=Cereals_i) = \gamma_0(YieldCereals_i - YieldTubers_i) + X'\beta + \varepsilon$

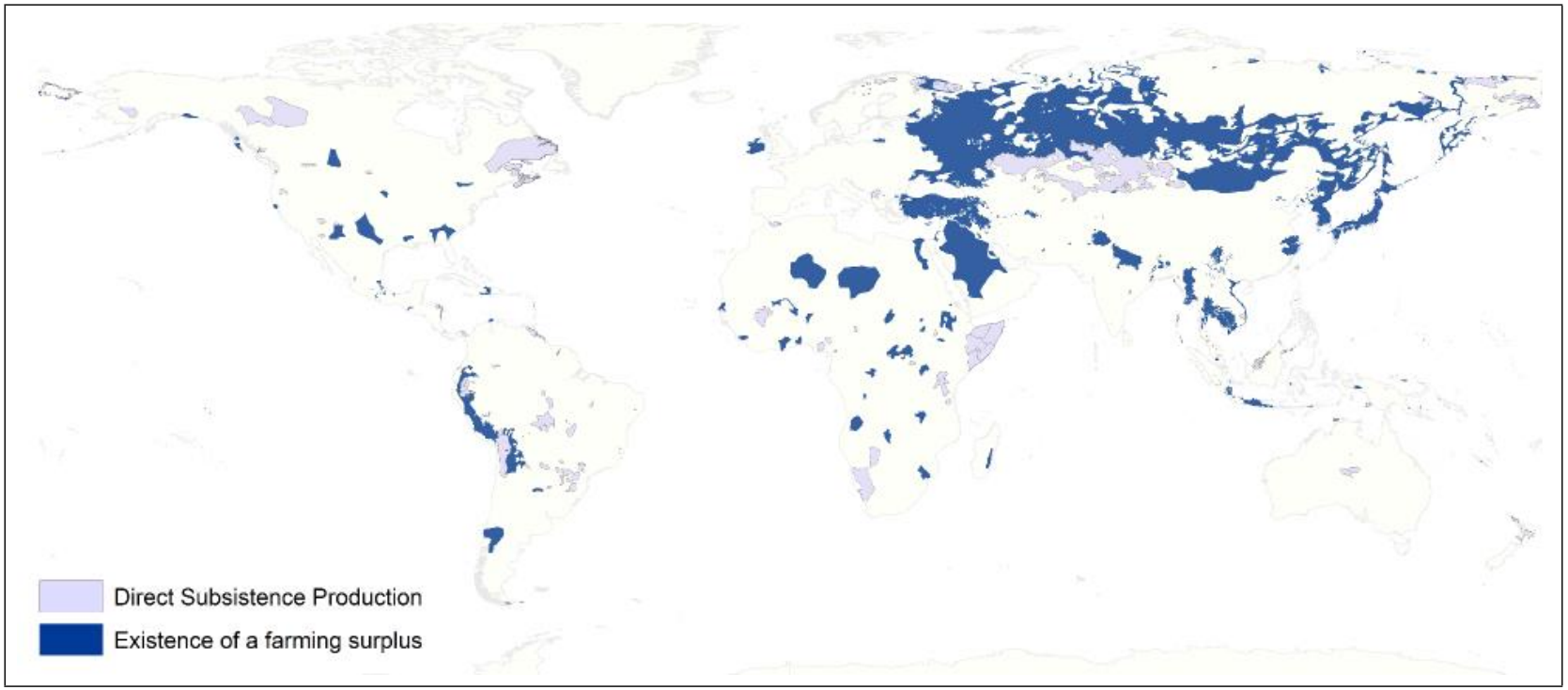
Cereals, surplus and hierarchy

Figure 4: Jurisdictional hierarchy beyond the local community in pre-colonial societies



Cereals, surplus and hierarchy

Figure 6: Farming surplus in pre-colonial societies



Cereals, surplus and hierarchy

Table 2: Cereals, Surplus and Hierarchy - Reduced Form

	Dependent variable is:							
	Jurisdictional Hierarchy Beyond Local Community				Existence of Farming Surplus			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	Ord Logit	OLS	OLS	OLS	Logit
CALORIC DIFF	0.244***	0.179	0.274**	0.495***	0.141***	0.241***	0.202***	0.997***
(CER - TUB)	(0.069)	(0.120)	(0.107)	(0.149)	(0.0319)	(0.0681)	(0.0742)	(0.384)
MAX CALORIES		0.082	-0.188*	-0.224		-0.132	-0.0985	-0.479
(ALL CROPS)		(0.141)	(0.108)	(0.178)		(0.0870)	(0.0985)	(0.463)
CONTINENT FE	NO	NO	YES	YES	NO	NO	YES	YES
Ave marg. effect of CALORIC DIFF								0.249***
								(0.096)
r2	0.0416	0.0429	0.249		0.0757	0.0911	0.157	
pseudo r2				0.121				0.124
N	952	952	952	952	140	140	140	140

The table reports cross-sectional OLS (columns 1-3 and 5-7), Ordered Logit (column 4) and Logit (column 8) estimates and the unit of observation is the society in Murdock's Ethnoatlas. The dependent variable is either a dummy that identifies societies that produce a farming surplus or Murdock's (1967) index of jurisdictional hierarchy beyond the local community and it takes the following values: 1 (no political authority beyond community), 2 (petty chiefdoms), 3 (larger chiefdoms), 4 (states), 5 (large states). CALORIC DIFF (CER-TUB) is the standardized difference between the maximum potential calorie yield per hectare that can be obtained from cereals versus the one that can be obtained from either roots or tubers. MAX CALORIES (ALL CROPS) is the standardized maximum potential calorie yield per hectare that can be obtained from cultivating the most productive crop among cereal grains, roots and tubers. Societies that live on lands that are suitable for neither cereals nor roots and tubers are excluded from the sample. Columns 1-4 report in parentheses Conley standard errors adjusted for spatial correlation, while columns 5-8 report robust standard errors. *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Cereals and hierarchy

Table 3: Cereals and Hierarchy - OLS and 2SLS

	Dependent variable: Jurisdictional Hierarchy Beyond Local Community							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	2SLS	2SLS	2SLS	OLS	2SLS	2SLS	2SLS
MAIN CROP:	0.707***	1.170***	0.863	1.040**	0.304**	0.892**	1.064**	0.993**
CEREALS	(0.131)	(0.359)	(0.596)	(0.414)	(0.120)	(0.420)	(0.538)	(0.463)
MAX CALORIES			0.081				-0.037	
(ALL CROPS)			(0.127)				(0.071)	
DEPENDENCE ON				0.334				-0.419
AGRICULTURE				(0.517)				(0.783)
CONTINENT FE	NO	NO	NO	NO	YES	YES	YES	YES
N	952	952	952	952	952	952	952	952
F excl instrum.		147.7	44.84	65.51		99.87	76.90	33.09

The table reports cross-sectional OLS and 2SLS estimates and the unit of observation is the society in Murdock's Ethnoatlas. The dependent variable is Murdock's (1967) index of jurisdictional hierarchy beyond the local community and it takes the following values: 1 (no political authority beyond community), 2 (petty chiefdoms), 3 (larger chiefdoms), 4 (states), 5 (large states). The main regressor is a dummy that identifies society in which the major crop is a cereal grain. MAX CALORIES (ALL CROPS) is the standardized maximum potential calorie yield per hectare that can be obtained from cultivating the most productive crop among cereal grains, roots and tubers. DEPENDENCE ON AGRICULTURE is the percentage calorie dependence on agriculture for subsistence. 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.

Cereals and hierarchy: robustness checks

- **Results are robust when controlling for:**
  - PRECIPITATION
  - TEMPERATURE
  - ELEVATION
  - RUGGEDNESS
  - ABSOLUTE LATITUDE
  - ALTERNATIVE MEASURES OF LAND PRODUCTIVITY
  - DISTANCE MAJOR RIVER
  - DISTANCE COAST
  - MALARIA
  - PLOW
  - POPULATION DENSITY (1995)
  - HISTORICAL POPULATION DENSITY (HYDE)
  - HISTORICAL POPULATION DENSITY (Pryor, 1995)
  - USING ETHNIC BOUNDARIES AS IN FENSKE (2013)
  - INCLUDING SOCIETIES LIVING IN DESERTIC SOILS

Cereals and surplus

Table E.12: Cereals and Surplus - OLS and 2SLS

	Dependent variable: Existence of a farming surplus							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	2SLS	2SLS	2SLS	OLS	2SLS	2SLS	2SLS
MAIN CROP:	0.359***	0.940***	0.846***	0.846***	0.299***	1.005***	0.797**	0.799**
CEREALS	(0.0791)	(0.260)	(0.273)	(0.275)	(0.0901)	(0.316)	(0.314)	(0.317)
MAX CALORIES			0.0186				0.0361	
(ALL CROPS)			(0.0626)				(0.0611)	
DEPENDENCE ON				0.191				0.438
AGRICULTURE				(0.663)				(0.775)
CONTINENT FE	NO	NO	NO	NO	YES	YES	YES	YES
N	139	139	139	139	139	139	139	139
F excl instrum.		16.08	17.37	5.486		15.35	12.44	4.338

The table reports cross-sectional OLS and 2SLS estimates and the unit of observation is the society in Murdock's Ethnoatlas. The dependent variable is a dummy that identifies societies that produce a farming surplus. The main regressor is a dummy that identifies society in which the major crop is a cereal grain. MAX CALORIES (ALL CROPS) is the standardized maximum potential calorie yield per hectare that can be obtained from cultivating the most productive crop among cereal grains, roots and tubers. DEPENDENCE ON AGRICULTURE is the percentage calorie dependence on agriculture for subsistence. 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.

Cereals and surplus: robustness checks

- **Results are robust when controlling for:**
  - PRECIPITATION
  - TEMPERATURE
  - ELEVATION
  - RUGGEDNESS
  - ABSOLUTE LATITUDE
  - ALTERNATIVE MEASURES OF LAND PRODUCTIVITY
  - DISTANCE MAJOR RIVER
  - DISTANCE COAST
  - MALARIA
  - PLOW
  - POPULATION DENSITY (1995)
  - HISTORICAL POPULATION DENSITY (HYDE)
  - HISTORICAL POPULATION DENSITY (Pryor, 1995)
  - USING ETHNIC BOUNDARIES AS IN FENSKE (2013)
  - INCLUDING SOCIETIES LIVING IN DESERTIC SOILS

Cereals and hierarchy

Panel estimates

$$Hierarchy_{i,t} = \alpha\,(YieldsCereals_{i,t} - YieldsTubers_{i,t}) + \eta_i + \eta_t + X'\beta_t + \varepsilon_{c,t}$$

Note:

-Hierarchy: (=0: Tribe; =0.75: Chiefdom; =1: State)

-Variation in $YieldsCereals_{i,t}$ *and* $YieldsTubers_{i,t}$ *over time are generated by the Columbian exchange.*

- Years 1500-1600 are excluded from the regression.

Cereals and hierarchy

Table 6: Cereals and Hierarchy - Panel Regressions

	Dep. Variable: Hierarchy Index						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CALORIC DIFF	0.189***	0.272***	0.282***	0.240***	0.255***	0.261***	0.197**
(CER - TUB)	(0.0683)	(0.0834)	(0.0760)	(0.0857)	(0.0889)	(0.0839)	(0.0795)
MAX CALORIES		-0.163	-0.193	-0.152	-0.115	-0.148	-0.165
(ALL CROPS)		(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. The dependent variable is an hierarchy index: it equals 0 if there is not a government above tribal level, 0.75 if the political organization can be at best described as a paramount chiefdom and 1 otherwise. CALORIC DIFF (CER-TUB) is the standardized difference between the maximum potential calorie yield per hectare that can be obtained from cereals versus the one that can be obtained from either roots or tubers. MAX CALORIES (ALL CROPS) is the standardized maximum potential calorie yield per hectare that can be obtained from cultivating the most productive crop among cereal grains, roots and tubers. Robust standard errors in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent

Cereals and hierarchy: Robustness checks

- **Results are robust when controlling for:**
  - EXCLUDING YEARS 1500-1750
  - EXCLUDING COLONIES
  - DISTANCE MAJOR RIVER
  - DISTANCE COAST
  - MALARIA
  - TROPICAL LAND
  - POPULATION DENSITY (1500)
  - SETTLERS MORTALITY
  - SLAVE EXPORTS

Cereals and hierarchy

Panel estimates

$$Hier_{it} = \sum_{j=1050}^{1850} \alpha_j (CalDiff_{i,AfterExchange} - CalDiff_{i,BeforeExchange}) + X'_{it}\beta + \eta_i + \eta_t + u_{it}.$$

Note:

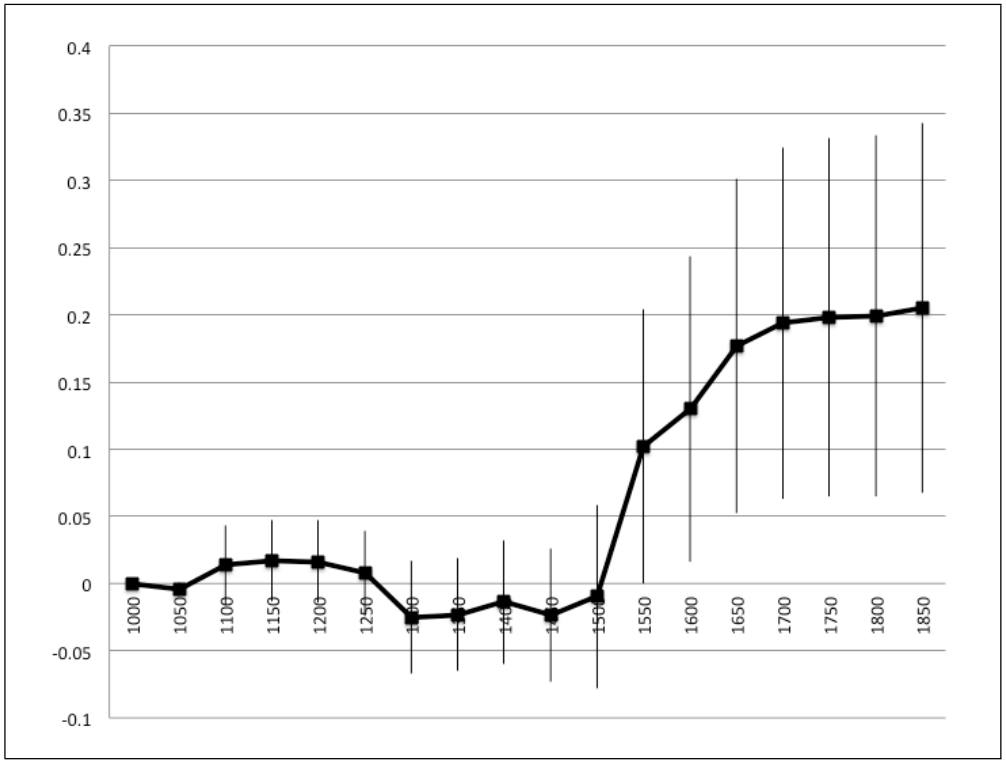
- Hierarchy: (=0: Tribe; =0.75: Chiefdom; =1: State)
- $\text{CalDiff}_{i,t} = \text{YieldsCereals}_{i,t} - \text{YieldsTubers}_{i,t}$

Baseline time-period 1000-1050. -

More Flexible specification: no need to assume in which year the Columbian exchange is completed. -

Cereals and hierarchy

Figure 8: Flexible estimates of the relationship between the change in the caloric advantage of cereals over roots and tubers due to the Columbian exchange and hierarchy.



Cereals and ancient civilizations

OLS estimates

1) $City_i / Archaelogical\ ruin_i = \alpha\ (YieldCereals_i - YieldTubers_i) + X'\beta + \varepsilon$

2) $City_i / Archaelogical\ ruin_i = \alpha\ (Distance\ area\ domestication\ cereals_i) + X'\beta + \varepsilon$

Notes:
-The unit of observation is a 1x1 decimal degree raster point
-The sample covers all area of the world that were
-*Distance area domestication cereals*$_i$ is the distance from the closest area of domestication of a cereal grain

Cereals and ancient civilizations

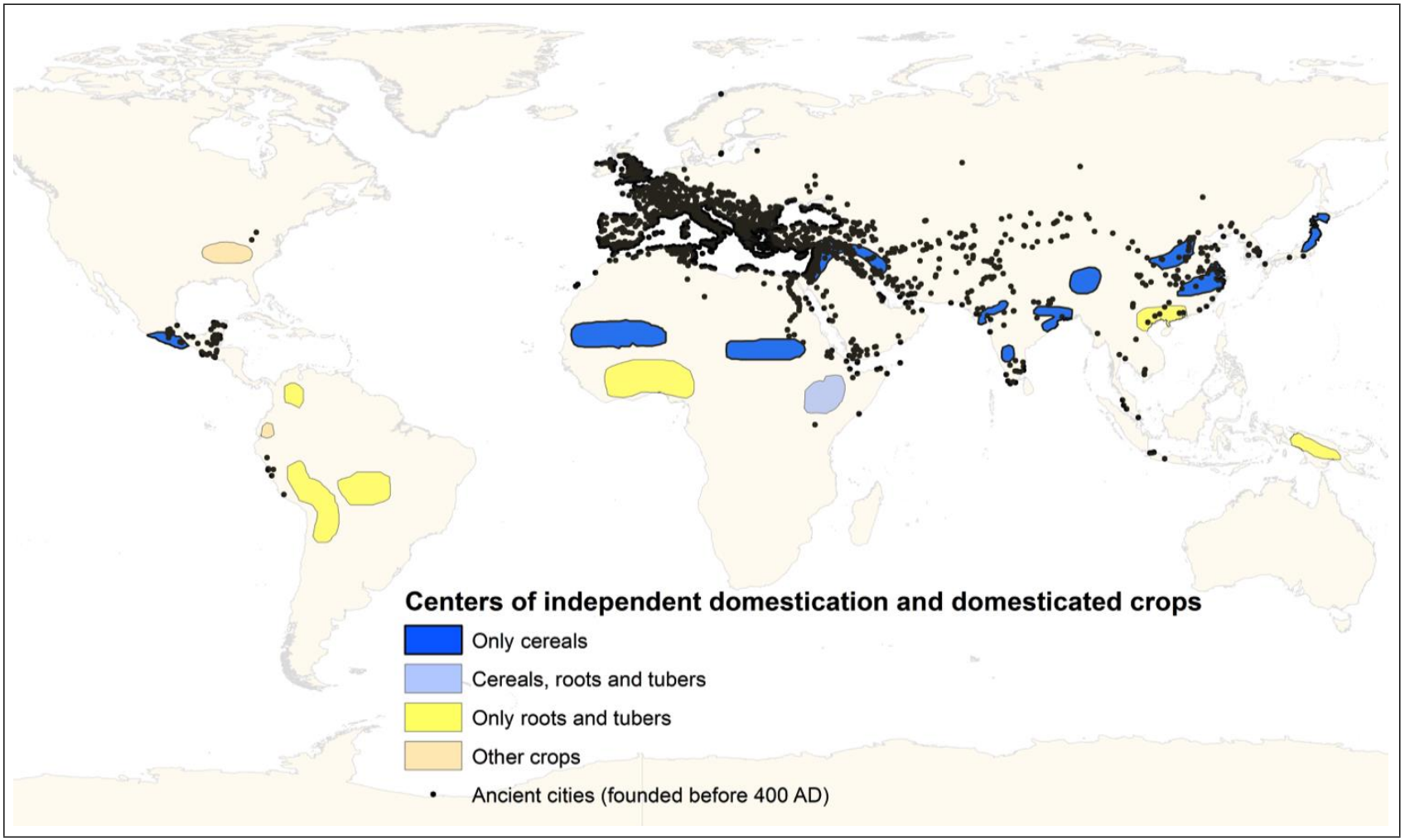
Table 6: Potential Crop Yields and the Location of Ancient Cities.

	Dependent variable is:							
	Presence of an ancient city (dummy)					Log(1+ number ancient cities)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	Logit	OLS	OLS	OLS
CALORIC DIFF	0.0469***	0.145***	0.129***	0.0340**	1.256**	0.186***	0.167***	0.0357**
(CER - TUB)	(0.0143)	(0.0388)	(0.0380)	(0.0162)	(0.603)	(0.0538)	(0.0512)	(0.0180)
MAX CALORIES		-0.0864***	-0.0744***	-0.0126	-0.208	-0.111***	-0.0966***	-0.0139
(ALL CROPS)		(0.0267)	(0.0256)	(0.0128)	(0.542)	(0.0361)	(0.0333)	(0.0138)
CONTINENT FE	NO	NO	YES	NO	NO	NO	YES	NO
COUNTRY FE	NO	NO	NO	YES	YES	NO	NO	YES
Ave marg. effect of					0.0135**			
CALORIC DIFF					0.006			
r2	0.0498	0.0841	0.0986	0.451		0.0773	0.0865	0.574
N	15927	15927	15927	15927	9032	15927	15927	15927

The table reports cross-sectional OLS and Logit estimates and the unit of observation is the 1x1 decimal degree square. In columns (1)-(5), the dependent variable is a dummy that takes the value of one if there is evidence of at least one ancient city in the pixel and zero otherwise. In columns (6)-(8), the dependent variable is log(1+number of ancient cities in the pixel). CALORIC DIFF (CER-TUB) is the standardized difference between the maximum potential calorie yield per hectare that can be obtained from cereals versus the one that can be obtained from either roots or tubers. MAX CALORIES (ALL CROPS) is the standardized maximum potential calorie yield per hectare that can be obtained from cultivating the most productive crop among cereal grains, roots and tubers. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Cereals and ancient civilizations

Figure E.5: Ancient cities and centers of independent domestication



Cereals and ancient civilizations

Table 7: The Origin of the Neolithic Transition and the Location of Ancient Cities.

	Dependent variable is:						
	Presence of an ancient city (dummy)				Log(1+ number ancient cities)		
	(1) OLS	(2) OLS	(3) OLS	(4) Logit	(5) OLS	(6) OLS	(7) OLS
Distance closest adoption cereals		-0.00214***	-0.00143**	-0.187***		-0.00253***	-0.00147**
		(0.000597)	(0.000604)	(0.0333)		(0.000767)	(0.000647)
Distance closest adoption agriculture	-0.00120***	0.000909	0.000253	0.112***	-0.00117***	0.00133	0.0000658
	(0.000343)	(0.000676)	(0.000566)	(0.0379)	(0.000409)	(0.000900)	(0.000680)
CONTINENT FE	NO	NO	YES	YES	NO	NO	YES
Ave marg. effect of "Distance closest adoption cereals"				-0.002***			
				(0.001)			
r2	0.00949	0.0307	0.0495		0.00512	0.0220	0.0376
N	15927	15927	15927	15116	15927	15927	15927

The table reports cross-sectional OLS and Logit estimates and the unit of observation is the 1x1 decimal degree square. In columns (1)-(4), the dependent variable is a dummy that takes the value of one if there is evidence of at leaste one ancient city in the pixel and zero otherwise. In columns (5)-(7), the dependent variable is log(1+number of ancient cities in the pixel). "Distance closest adoption cereals" is the distance (in km) between the pixel and the closest region in which agriculture started independently and cereals were among the domesticated crops. "Distance closest adoption agriculture" is the distance between the pixel and the closest region in which agriculture was independently adopted. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Cereals and ancient civilizations

Table 7: The Origin of the Neolithic Transition and the Location of Ancient Cities.

	Dependent variable is:						
	Presence of an ancient city (dummy)				Log(1+ number ancient cities)		
	(1) OLS	(2) OLS	(3) OLS	(4) Logit	(5) OLS	(6) OLS	(7) OLS
Distance closest adoption cereals		-0.00214***	-0.00143**	-0.187***		-0.00253***	-0.00147**
		(0.000597)	(0.000604)	(0.0333)		(0.000767)	(0.000647)
Distance closest adoption agriculture	-0.00120***	0.000909	0.000253	0.112***	-0.00117***	0.00133	0.0000658
	(0.000343)	(0.000676)	(0.000566)	(0.0379)	(0.000409)	(0.000900)	(0.000680)
CONTINENT FE	NO	NO	YES	YES	NO	NO	YES
Ave marg. effect of "Distance closest adoption cereals"				-0.002***			
				(0.001)			
r2	0.00949	0.0307	0.0495		0.00512	0.0220	0.0376
N	15927	15927	15927	15116	15927	15927	15927

The table reports cross-sectional OLS and Logit estimates and the unit of observation is the 1x1 decimal degree square. In columns (1)-(4), the dependent variable is a dummy that takes the value of one if there is evidence of at leaste one ancient city in the pixel and zero otherwise. In columns (5)-(7), the dependent variable is log(1+number of ancient cities in the pixel). "Distance closest adoption cereals" is the distance (in km) between the pixel and the closest region in which agriculture started independently and cereals were among the domesticated crops. "Distance closest adoption agriculture" is the distance between the pixel and the closest region in which agriculture was independently adopted. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Cereals and ancient civilizations

Table 8: The Origin of the Neolithic Transition and Archeological Ruins.

	Dependent variable is a dummy that identifies evidence of:						
	ancient archeolog. sites	pyramids	ancient temples	ancient mines	ancient palaces	ancient sculptured stones	ancient standing stones
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Distance closest adoption cereals	-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)
Distance closest adoption agriculture	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 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). "Distance closest adoption cereals" is the distance (in km) between the pixel and the closest region in which agriculture started independently and cereals were among the domesticated crops. "Distance closest adoption agriculture" is the distance between the pixel and the closest region in which agriculture was independently adopted. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.

Cereals and ancient civilizations: robustness checks

- **Results are robust when controlling for:**
  - PRECIPITATION
  - TEMPERATURE
  - ELEVATION
  - RUGGEDNESS
  - ABSOLUTE LATITUDE
  - POPULATION DENSITY (1995)
  - EXCLUDING EUROPE
  - EXCLUDING DESERTS

Further supportive evidence

- The trade off between productivity and appropriability.
  - Acorns and salmons in aboriginal California (Tushingham and Bettinger, 2013)
  - Bitter and Sweet cassava in Malawi (Chiwona-Karltun et al., 2002)

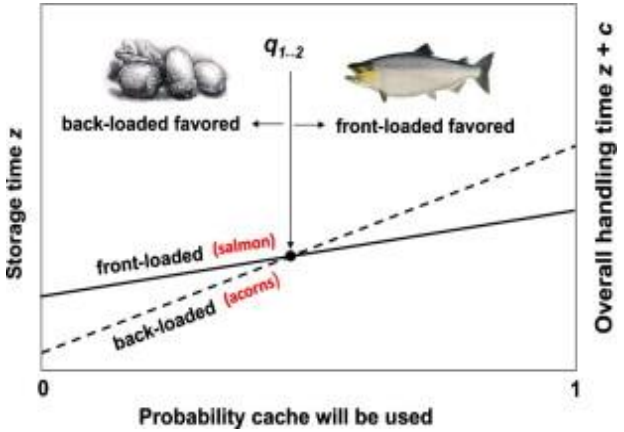
- Storability and social complexity
  - Natufian granaries (Juijt and Finlayson, 2009)
  - Storing vs non-storing hunter-gathers (Testart, 1882)

- Appropriability and stationary bandits
  - Mafia and sulphur mine in Sicily (Buonanno et al, 2012)
  - Rowing and stationary bandits in DRC (De La Sierra, 2013

Supportive evidence: productivity vs appropriability

Native Americans in California (Tushingham and Bettinger 2013)

- Despite the fact that salmon is a better source of nutrition, earlier foragers preferred to rely on acorns
- Unlike salmon, gathering and storage of acorns involves little effort but its subsequent preparation for consumption is costly
- The rapid transition to salmon intensification was possible after a sedentary community was large enough and storage facilities where constructed



→

(1) selection of food sources is affected by their appropriability
(2) appropriable food and complex hierarchy are correlated

Supportive evidence: productivity vs appropriability

Women in Malawi and bitter cassava (Chiwona-Karltun et al. 2002)

- Women in Malawi, particularly single women, prefer to grow bitter and toxic cassava variants that require more processing

- "We **grow bitter, toxic cassava** because it gives a certain level of food security. If we are to grow sweet cassava, look at our neighbors! Their whole field was harvested by **thieves** while they slept and now they have no food. Nobody wants to die from hunger."

→

(1) the extra post-harvest effort provides protection against thievery; thieves prefer the non-bitter variant that requires less processing

(2) Again a correlation between vacuum of state and less appropriable/inefficient crops

Supportive evidence: storage and hierarchy before farming

Native Americans in the northwestern coast
Testart (1982)

- Testart criticizes the idea of that the adoption of an agricultural way of life was a turning point in the organization of human societies. According to Testart, the turning point is the adoption of storing techniques.

In particular, he takes a cross-section of 40 hunter-gatherers societies and shows that storing societies present three characteristics (sedentarism, high population density and socioeconomic inequalities) which have been considered typical of agricultural societies.

- Hunter-gatherers who relied on seasonal and storable resources such as acorns or dried salmon developed complex hierarchical societies similar to the Neolithic farmers that cultivated cereals

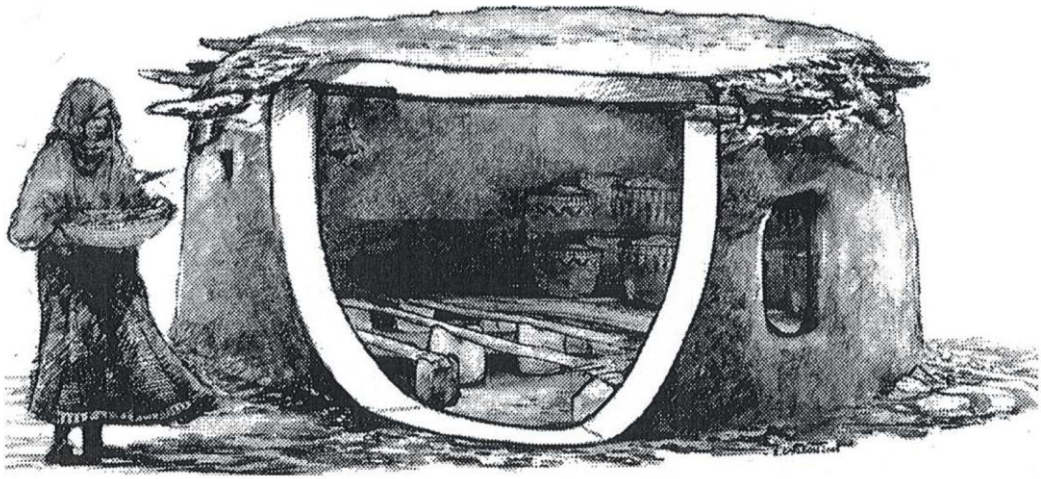
- (Testart refrained from identifying a causal mechanism that relates storage to hierarchy)

→ it isn't farming that explains the emergence of hierarchy – it is appropriability

Supportive evidence: storage and hierarchy before farming

The Natufian age
Kuijt and Finlayson (2009)

Evidence for large-scale storage in sophisticated granaries before the domestication of plants from 11,000 years ago indicate social organization



Strorage structure constructed 11,300-11,200 B.P (Before Present) from the Jordan valley (Dhra' Jordan). (Kuijt and Finlayson, PNAS 2009).

Supportive evidence: appropriability and stationary bandits

Mining in the DRC
De la Sierra (2013)

- A rise in the price of Coltan — produced from a relatively bulky and hence transparent ore — led to the monopolization of violence
- An increase in the price of gold, which is easier to conceal and is hence less transparent, did not

→ it isn't productivity/surplus that explains the emergence of hierarchy – it is appropriability

Supportive evidence: appropriability and stationary bandits

Sulphur mines and the mafia
Buonanno et al. (2012)

- Buonanno et al. support the hypothesis that the mafia in Sicily emerged after the collapse of the Bourbon Kingdom.

- A vacuum of power made it easy for a new hierarchy to emerge, disproportionally more where the local product was more appropriable: the mines and in particular the sulphur mines.

→ it isn't productivity/surplus that explains the emergence of hierarchy – it is appropriability

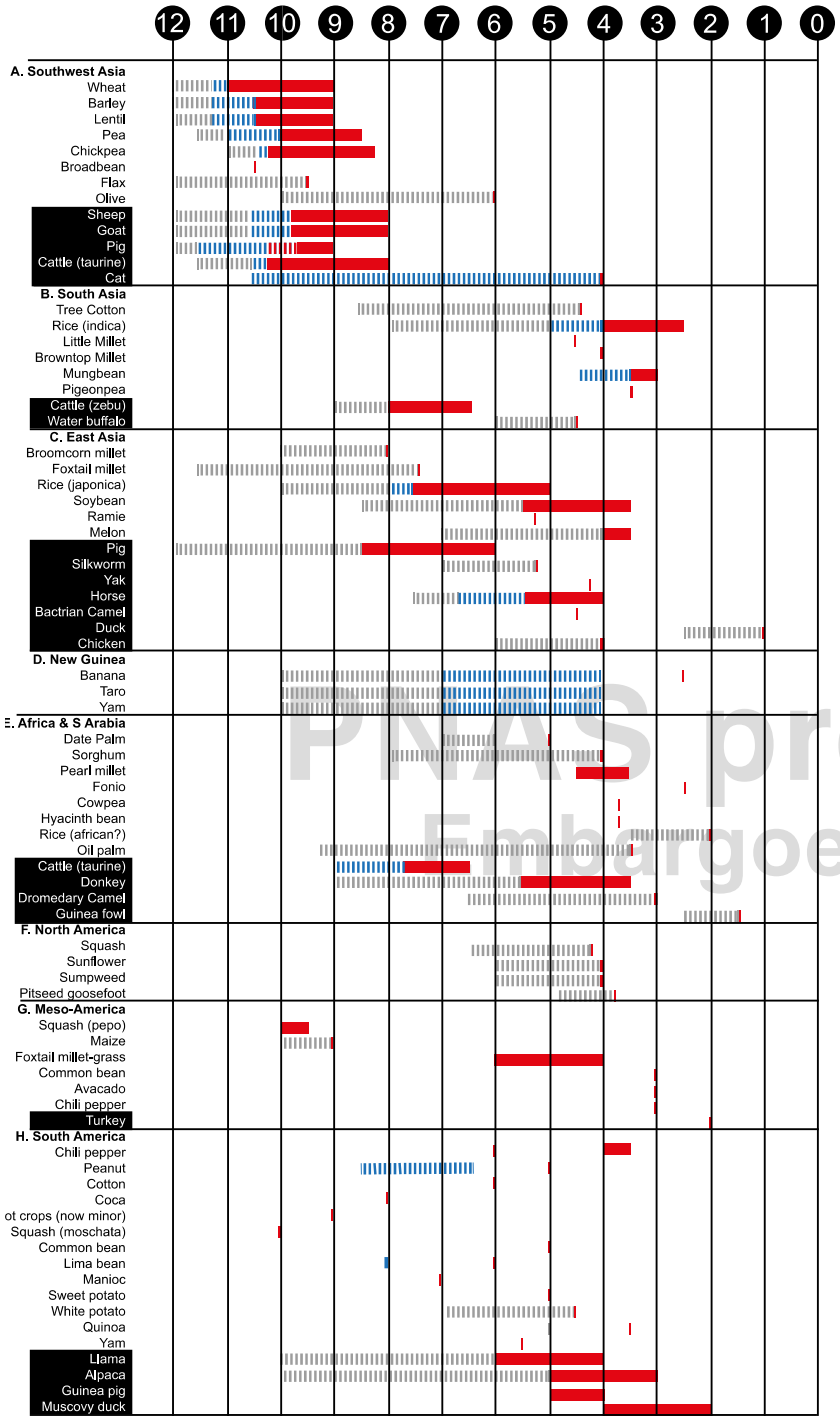
Related Literature:

Geography, Transparency and Institutions
Mayshar, Moav & Neeman (2013)

Second part of the paper I have just presented

- Once a state exist, how environmental factors shape:
  - Land ownership (private vs elite)
  - State concentration (center vs periphery)
  - State capacity

- Application to Ancient Egypt and Mesopotamia



Concluding remarks:

- Two motivating stylized observations:
  - In *Egypt*, state hierarchy evolved rapidly following the adoption of farming in the Nile valley, facilitating the construction of the great pyramids as early as the third millennium BCE
  - Farming was initiated in *New Guinea* at about the same time as in Egypt, but there it did not lead to the emergence of states

More generally, the table reports the centers of crop domestication

- The only regions that did not generate complex hierarchical organizations were those that did not domesticate cereals (but rather roots/tubers/fruits)

Conclusions

- Geography, through its effect on appropriability, can explain differences in hierarchy and institutions
- A key factor that explains low state capacity is *high productivity* of less appropriable crops
- The literature which proposes that productivity and surplus are a precondition for hierarchy is flawed

Descriptive statistics 1

Table E.1: Descriptive Statistics: societies in Ethnoatlas

	SOURCE	Mean	p50	SDev	Min	Max	N
Hierarchy beyond Local Community	Ethnoatlas	1.89	2.00	1.04	1.00	5.00	1,059
Major Crop: Cereals	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
Farming surplus	Tuden and Marshall (1972)	0.49	0.00	0.50	0.00	1.00	162
Population density (categorical)	Pryor (1985)	3.83	4.00	1.57	2.00	7.00	168
Cal/ha Best Crop (std)	authors	0.00	0.23	1.00	-1.92	2.66	1,179
Cal/ha Cereals- Cal/ha Tubers (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)	FAO-GAEZ	0.00	0.17	1.00	-9.24	3.58	1,179
Ruggedness (std)	FAO-GAEZ	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

Descriptive statistics 2

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

	SOURCE	Mean	p50	SDev	Min	Max	N
Hierarchy index	Borcan et al. (2014)	0.72	1.00	0.45	0.00	1.00	2,869
Cal/ha Best Crop (std)	authors	0.00	0.35	1.00	-1.64	2.69	2,959
Cal/ha Cereals- Cal/ha Tubers (std)	authors	0.00	-0.00	1.00	-1.49	3.12	2,959
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)	FAO-GAEZ	0.00	-0.33	1.00	-1.10	4.65	2,845
Ruggedness (std)	Nunn and Puga (2012)	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
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

Descriptive statistics 3

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

	SOURCE	Mean	p50	SDev	Min	Max	N
Cities founded before 400 AD	DeGroff (2009)	0.16	0.00	1.36	0.00	76.00	15,927
Archeological 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
Cal/ha Best Crop (std)	authors	-0.70	-1.28	1.26	-1.78	3.76	15,927
Cal/ha Cereals- Cal/ha Tubers (std)	authors	-0.93	-1.40	1.03	-2.67	2.96	15,927
Distance closest area adoption cereals	authors	28.71	24.72	22.78	0.00	270.26	15,927
Distance closest area adoption agriculture	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)	FAO-GAEZ	-0.00	-0.34	1.00	-0.87	6.01	15,927
Ruggedness (std)	FAO-GAEZ	-0.00	0.35	1.00	-3.38	1.10	15,927
Absolute Latitude (std)	authors	40.52	41.50	22.20	0.50	83.50	15,927
Population density 1995 (std)	FAO-GAEZ	0.00	-0.59	1.00	-0.76	3.58	15,861

Descriptive statistics 4

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

Variables	Hier.	Crop: cereals	Dep. agric.	Farm. surp.	Pop dens.	Cal/ha b. crop	Cer. -Tub.	% Fertile land	Caloric suit. ind.
Hierarchy	1.0								
Main crop: cereals	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				
Cal/ha best crop	0.2	0.3	0.4	0.2	0.3	1.0			
Cereals-Tubers	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

Crop yields, agriculture and main crop

Table C.1: Potential Crop Yields and Choice of Crops - Robustness Checks 1

	Dep. Variable: Major crop is cereal grains (dummy)				
	(1)	(2)	(3)	(4)	(5)
CALORIC DIFF	0.139***	0.268***	0.195***	0.198***	0.271***
(CER - TUB)	(0.0345)	(0.0334)	(0.0307)	(0.0315)	(0.0358)
MAX CALORIES	0.0791**	-0.103**	0.00835	0.0138	-0.0981**
(ALL CROPS)	(0.0374)	(0.0412)	(0.0336)	(0.0353)	(0.0457)
Precipitation	-0.0995***				
	(0.0238)				
Temperature Abs Latitude		0.0781***			
		(0.0183)			
Elevation			0.120***		
			(0.0154)		
Ruggedness				0.0302**	
				(0.0153)	
Abs Latitude					-0.0670***
					(0.0205)
r2	0.161	0.146	0.160	0.136	0.141
N	982	982	982	982	982

Back

Crop yields, agriculture and main crop

Table C.2: Potential Crop Yields and Choice of Crops - Robustness Checks 2

	Dep. Variable: Major crop is cereal grains (dummy)					
	(1)	(2)	(3)	(4)	(5)	(6)
CALORIC DIFF	0.211***	0.209***	0.256***	0.198***	0.207***	0.276***
(CER - TUB)	(0.0308)	(0.0310)	(0.0307)	(0.0313)	(0.0313)	(0.0630)
MAX CALORIES	-0.00949	-0.00947	-0.0804**	-0.0143	-0.00862	-0.235***
(ALL CROPS)	(0.0336)	(0.0338)	(0.0366)	(0.0341)	(0.0338)	(0.0758)
Major River	-0.0359**					
	(0.0144)					
Distance Coast		0.0355**				
		(0.0154)				
Pct. Malaria			0.0711***			
			(0.0152)			
Pop Dens. 1995				0.0668***		
				(0.0154)		
Hist Pop Dens					0.0324	
					(0.0323)	
Pop Dens						0.235***
						(0.0332)
r2	0.138	0.137	0.149	0.148	0.137	0.313
N	982	982	982	966	982	144

Back

Cereals, surplus and hierarchy

Table C.3: Cereals and Hierarchy - 2SLS. Controlling for geography.

	Dependent variable: Jurisdictional Hierarchy Beyond Local Community				
	(1)	(2)	(3)	(4)	(5)
	2SLS	2SLS	2SLS	2SLS	2SLS
MAIN CROP: CEREALS	0.478	0.599**	0.900**	0.887**	0.590**
	(0.570)	(0.298)	(0.394)	(0.396)	(0.300)
MAX CALORIES	0.178	0.172***	0.0731	0.0725	0.167**
(ALL CROPS)	(0.120)	(0.0653)	(0.0771)	(0.0846)	(0.0693)
Precipitation	-0.112				
	(0.0744)				
Temperature		-0.0734*			
		(0.0394)			
Elevation			-0.0631		
			(0.0635)		
Ruggedness				-0.0126	
				(0.0377)	
Abs Latitude					0.0622
					(0.0402)
N	952	952	952	952	952
F excl instrum.	15.39	59.50	37.45	36.76	55.55
A-R Test (p-val)	0.403	0.0458	0.0185	0.0205	0.0502

Back

Cereals, surplus and hierarchy

Table C.4: Cereals and Hierarchy - 2SLS. Controlling for isolation and population density.

	Dependent variable: Jurisdictional Hierarchy Beyond Local Community				
	(1)	(2)	(3)	(4)	(5)
	2SLS	2SLS	2SLS	2SLS	2SLS
MAIN CROP: CEREALS	0.840**	0.870**	0.777**	1.317*	0.730**
	(0.356)	(0.366)	(0.329)	(0.685)	(0.328)
MAX CALORIES	0.0899	0.0835	0.0631	0.0250	0.0317
(ALL CROPS)	(0.0695)	(0.0706)	(0.0659)	(0.103)	(0.0636)
Major River	0.102***				
	(0.0356)				
Distance to Coast		-0.0323			
		(0.0364)			
Pop Density (HYDE)			0.257**		
			(0.125)		
Pop Density (SCSS)				0.415**	
				(0.183)	
Pop Density 1995					0.334***
					(0.0481)
N	952	952	952	142	936
F excl instrum.	43.86	41.93	40.91	17.63	37.13
A-R Test (p-val)	0.0160	0.0149	0.0161	0.0243	0.0223

Back

Cereals, surplus and hierarchy

Table C.5: Cereals and Hierarchy - 2SLS. 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
MAIN CROP: CEREALS	0.707***	1.109***	0.845**	1.040***	0.304***	0.841***	1.080***	0.994***
	(0.0630)	(0.188)	(0.333)	(0.245)	(0.0762)	(0.236)	(0.302)	(0.257)
MAX CALORIES (ALL CROPS)			0.0692				-0.0542	
			(0.0646)				(0.0546)	
DEPENDENCE ON AGRICULTURE				0.334				-0.574
				(0.298)				(0.583)
CONTINENT FE	NO	NO	NO	NO	YES	YES	YES	YES
N	952	942	942	952	952	942	942	942
F excl instrum.		162.7	52.46	63.39		118.7	74.18	28.21
A-R Test (p-val)		0.000	0.00859	0.000		0.000	0.000	0.000

Back

Cereals, surplus and hierarchy

Table C.6: Cereals and Hierarchy - 2SLS. 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
MAIN CROP: CEREALS	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)
MAX CALORIES (ALL CROPS)			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

Back

Cereals, surplus and hierarchy

Table C.7: Cereals and Surplus - 2SLS. Controlling for geography.

	Dependent variable: Existence of a farming surplus				
	(1)	(2)	(3)	(4)	(5)
	2SLS	2SLS	2SLS	2SLS	2SLS
MAIN CROP: CEREALS	0.774**	0.764***	0.921***	0.930***	0.681**
	(0.375)	(0.261)	(0.301)	(0.315)	(0.267)
MAX CALORIES	0.0334	0.0387	0.00222	-0.0215	0.0534
(ALL CROPS)	(0.0793)	(0.0686)	(0.0677)	(0.0811)	(0.0637)
Precipitation	-0.0344				
	(0.0785)				
Temperature		-0.0281			
		(0.0475)			
Elevation			-0.155***		
			(0.0543)		
Ruggedness				-0.109	
				(0.0714)	
Abs Latitude					0.0511
					(0.0468)
N	139	139	139	139	139
F excl instrum.	10.41	19.42	15.50	14.83	15.68
A-R Test (p-val)	0.0162	0.00198	0.000	0.000875	0.00822

Back

Cereals, surplus and hierarchy

Table C.8: Cereals and Surplus - 2SLS. Controlling for isolation and population density.

	Dependent variable: Existence of a farming surplus				
	(1)	(2)	(3)	(4)	(5)
	2SLS	2SLS	2SLS	2SLS	2SLS
MAIN CROP: CEREALS	0.823***	0.851***	0.820***	0.848***	0.916***
	(0.277)	(0.275)	(0.300)	(0.288)	(0.314)
MAX CALORIES	0.0215	0.0191	0.0132	0.0208	0.0117
(ALL CROPS)	(0.0625)	(0.0626)	(0.0589)	(0.0530)	(0.0616)
Major River	0.0363				
	(0.0409)				
Distance to Coast		-0.0150			
		(0.0448)			
Pop Density (HYDE)			0.0291		
			(0.0379)		
Pop Density (SCSS)				-0.00815	
				(0.0847)	
Pop Density 1995					0.00146
					(0.0358)
N	139	139	139	139	137
F excl instrum.	15.86	17.09	13.35	17.91	12.99
A-R Test (p-val)	0.00127	0.000635	0.00353	0.000	0.00111

Back

Cereals, surplus and hierarchy

Table C.9: Cereals and Surplus: Potential calorie yields refer to ethnic boundaries in Fenske (2013).

	Dependent variable: Existence of a farming surplus							
	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) OLS	(6) 2SLS	(7) 2SLS	(8) 2SLS
MAIN CROP: CEREALS	0.359***	0.909***	0.894***	0.846***	0.299***	0.953***	0.845**	0.864***
	(0.0791)	(0.274)	(0.297)	(0.275)	(0.0901)	(0.318)	(0.336)	(0.303)
MAX CALORIES (ALL CROPS)			0.00286				0.0196	
			(0.0657)				(0.0657)	
DEPENDENCE ON AGRICULTURE				0.191				0.210
				(0.663)				(0.723)
CONTINENT FE	NO	NO	NO	NO	YES	YES	YES	YES
N	139	138	138	138	139	138	138	138
F excl instrum.		15.52	17.23	5.486		16.90	13.56	4.786
A-R Test (p-val)		0.0000310	0.000326	0.0000119		0.0000802	0.00548	0.0000920

Back

Cereals, surplus and hierarchy

Table C.10: Cereals and Surplus: OLS and 2SLS. Sample including societies living in desertic soils.

	Dependent variable: Existence of a farming surplus							
	(1) OLS	(2) 2SLS	(3) 2SLS	(4) 2SLS	(5) OLS	(6) 2SLS	(7) 2SLS	(8) 2SLS
MAIN CROP: CEREALS	0.368***	0.630***	0.871***	0.871***	0.294***	0.657**	0.814***	0.821***
	(0.0733)	(0.220)	(0.279)	(0.283)	(0.0849)	(0.260)	(0.300)	(0.316)
MAX CALORIES (ALL CROPS)			-0.0368				-0.0215	
			(0.0501)				(0.0473)	
DEPENDENCE ON AGRICULTURE				-0.362				-0.244
				(0.488)				(0.540)
CONTINENT FE	NO	NO	NO	NO	YES	YES	YES	YES
N	161	161	161	161	161	161	161	161
F excl instrum.		18.58	17.37	14.46		19.68	14.27	7.531
A-R Test (p-val)		0.00711	0.000	0.000		0.0109	0.00391	0.00191

Back

Cereals, surplus and hierarchy

Table 7: Cereals and Hierarchy - Panel Regressions - Robustness Checks

	Dep. Variable: Hierarchy Index							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CALORIC DIFF	0.160*	0.127	0.206*	0.274***	0.245***	0.258***	0.273***	0.254***
(CER - TUB)	(0.0892)	(0.0843)	(0.116)	(0.0833)	(0.0928)	(0.0957)	(0.0840)	(0.0675)
MAX CALORIES	-0.0507	0.0471	-0.261	-0.176	-0.121	-0.133	-0.199	-0.211**
(ALL CROPS)	(0.133)	(0.132)	(0.192)	(0.143)	(0.151)	(0.151)	(0.145)	(0.102)
Controls (x Year FE):								
Legal Origin	YES	NO	NO	NO	NO	NO	NO	NO
Pop Density 1500	NO	YES	NO	NO	NO	NO	NO	NO
Settlers Mortality	NO	NO	YES	NO	NO	NO	NO	NO
Slave Exports	NO	NO	NO	YES	NO	NO	NO	NO
Distance River	NO	NO	NO	NO	YES	NO	NO	NO
Distance Coast	NO	NO	NO	NO	NO	YES	NO	NO
Pct Malaria	NO	NO	NO	NO	NO	NO	YES	NO
Tropical Land	NO	NO	NO	NO	NO	NO	NO	YES
COUNTRY FE	YES	YES	YES	YES	YES	YES	YES	YES
TIME FE	YES	YES	YES	YES	YES	YES	YES	YES
r2	0.699	0.714	0.707	0.683	0.678	0.679	0.681	0.744
N	2869	2869	1501	2869	2755	2755	2793	2869

Back

Cereals, surplus and hierarchy

Table C.11: Cereals and Hierarchy - Panel Regressions

	Dep. Variable: Government above tribal level						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CALORIC DIFF	0.188***	0.270***	0.280***	0.235***	0.252***	0.259***	0.192**
(CER - TUB)	(0.0683)	(0.0835)	(0.0758)	(0.0855)	(0.0890)	(0.0840)	(0.0791)
MAX CALORIES		-0.159	-0.189	-0.150	-0.110	-0.145	-0.161
(ALL CROPS)		(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

Back

Cereals, surplus and hierarchy

Table C.12: Cereals and Hierarchy - Panel Regressions. Robustness Checks: Excluding years 1500-1750

	Dep. Variable: Hierarchy Index						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CALORIC DIFF	0.198***	0.272***	0.282***	0.235***	0.249***	0.260***	0.190**
(CER - TUB)	(0.0720)	(0.0889)	(0.0811)	(0.0912)	(0.0946)	(0.0892)	(0.0846)
MAX CALORIES		-0.145	-0.176	-0.140	-0.0889	-0.130	-0.148
(ALL CROPS)		(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

Back

Cereals and ancient civilizations

Table E.24: Potential Crop Yields and the Location of Ancient Cities. Robustness checks: Controlling for Geography and Population Density.

	Dependent variable: Presence of an ancient city (dummy)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CALORIC DIFF (CER - TUB)	0.124***	0.167***	0.129***	0.129***	0.0946***	0.168***	0.0634***	0.112***
	(0.0367)	(0.0458)	(0.0380)	(0.0386)	(0.0301)	(0.0474)	(0.00546)	(0.0410)
MAX CALORIES (ALL CROPS)	-0.0693***	-0.120***	-0.0751***	-0.0743***	-0.0910***	-0.121***	-0.0405***	-0.0694**
	(0.0253)	(0.0333)	(0.0257)	(0.0261)	(0.0232)	(0.0358)	(0.00440)	(0.0292)
Precipitation	-0.00393							
	(0.00735)							
Temperature		0.0588***						
		(0.0163)						
Elevation			-0.00178					
			(0.00624)					
Ruggedness				-0.00883				
				(0.00747)				
Pop Dens 1995					0.0891***			
					(0.0128)			
Abs Latitude						-0.00257***		
						(0.000908)		
CONTINENT FE	YES	YES	YES	YES	YES	YES	YES	YES
r2	0.0987	0.116	0.0986	0.100	0.172	0.112	0.0705	0.105
N	15862	15833	15927	15927	15861	15927	12052	8942

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 evidence of at least one ancient city in the pixel and zero otherwise. CALORIC DIFF (CER-TUB) is the standardized difference between the maximum potential calorie yield per hectare that can be obtained from cereals versus the one that can be obtained from either roots or tubers. MAX CALORIES (ALL CROPS) is the standardized maximum potential calorie yield per hectare that can be obtained from cultivating the most productive crop among cereal grains, roots and tubers. In column 7 the sample excludes Europe, in column 8 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.

Cereals and ancient civilizations

Table E.26: The Origin of the Neolithic Transition and the Location of Ancient Cities. Robustness checks: Controlling for Geography and Population Density.

	Dependent variable is the presence of an ancient city (dummy)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Distance closest adoption cereals	-0.00141**	-0.000710	-0.00148**	-0.00132**	-0.00168**	-0.000710	-0.00144**	-0.00264***
	(0.000601)	(0.000922)	(0.000679)	(0.000630)	(0.000651)	(0.00112)	(0.000591)	(0.000922)
Distance closest adoption agriculture	0.000250	0.000340	0.000323	0.000101	0.00194***	0.000339	0.000564	0.000369
	(0.000576)	(0.000653)	(0.000609)	(0.000617)	(0.000636)	(0.000662)	(0.000468)	(0.00103)
Precipitation	0.00153							
	(0.00715)							
Temperature		0.0412**						
		(0.0186)						
Elevation			-0.00719					
			(0.00863)					
Ruggedness				-0.00600				
				(0.00666)				
Pop Dens 1995					0.0819***			
					(0.0130)			
Abs Latitude						-0.00159		
						(0.00110)		
CONTINENT FE	YES	YES	YES	YES	YES	YES	YES	YES
r2	0.0497	0.0593	0.0505	0.0501	0.153	0.0548	0.0642	0.0836
N	15862	15833	15927	15927	15861	15927	12052	8942

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 evidence of at least one ancient city in the pixel and zero otherwise. "Distance closest adoption cereals" is the distance (in km) between the pixel and the closest region in which agriculture started independently and cereals were among the domesticated crops. "Distance closest adoption agriculture" is the distance between the pixel and the closest region in which agriculture was independently adopted. In column 7 the sample excludes Europe, in column 8 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.

Cereals and ancient civilizations

Table E.28: 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 sculputured stones	ancient standing stones
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Distance closest adoption cereals	-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)
Distance closest adoption agriculture	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). "Distance closest adoption cereals" is the distance (in km) between the pixel and the closest region in which agriculture started independently and cereals were among the domesticated crops. "Distance closest adoption agriculture" is the distance between the pixel and the closest region in which agriculture was independently adopted. Robust standard errors, clustered at the country-level, in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent.