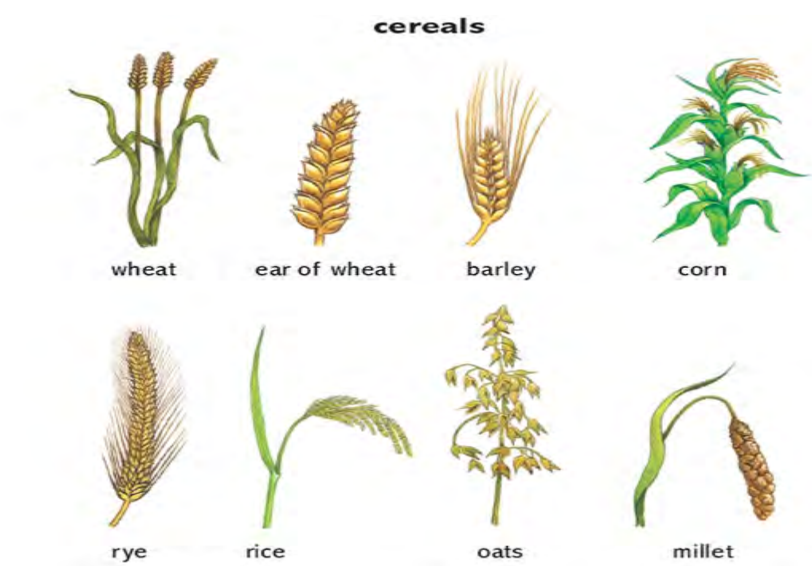
Cereals, Appropriability and Hierarchy

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

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?

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?

Outline of the presentation

1. Existing theories and our explanation

2. The model

3. Empirical evidence on a large cross-section of pre-colonial societies and on a country-level panel dataset.

4. Supportive evidence

Existing literature

- Neolithic Revolution →

  Increased productivity →

  Food surplus → (various mechanisms)

  Hierarchy (an elite that did not produce food) →

  The emergence of the state

Existing literature

- Neolithic Revolution →
  Increased productivity →
  Food surplus → (various mechanisms)
  Hierarchy (an elite that did not produce food) →
  The emergence of the state

- Differences between regions in productivity →
  differences in surplus →
  differences in social institutions

Existing literature recent summaries

Jared Diamond (1997)

"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."

Existing literature recent summaries

Jared Diamond (1997)

"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."

Douglas Price and Ofer Bar-Yosef (2010)

"Cultivation … supported a stable economy with ***surplus*** that resulted in the ***formation of elite groups***…"

Our criticism

We argue that the surplus explanations are flawed:

- Surplus is neither *necessary* nor *sufficient* for appropriation

Our criticism

We argue that the surplus explanations are flawed:

- Surplus is neither *necessary* nor *sufficient* for appropriation

- Surplus is unlikely to emerge following the transition to farming

Our criticism

We argue that the surplus explanations are flawed:

- Surplus is neither ***necessary*** nor *sufficient* for appropriation

Our criticism

We argue that the surplus explanations are flawed:

- Surplus is neither *necessary* nor ***sufficient*** for appropriation

Our criticism

We argue that the surplus explanations are flawed:

- Surplus is neither *necessary* nor *sufficient* for appropriation
- Surplus is unlikely to emerge following the very slow transition to farming

(Population size adjusts to prevent the creation of surplus following the slow rise in productivity, as predicted by Malthus and supported empirically by Ashraf-Galor, 2011, and others)

Our explanation

- Neolithic Revolution →

  Increased appropriability →

  Hierarchy (an elite that did not produce food) →

  The emergence of the state

Our explanation

- Neolithic Revolution →
  - Increased appropriability →
  - Hierarchy (an elite that did not produce food) →
  - The emergence of the state

- Differences between regions in land suitability for cereals vs. roots/tubers →
  - Differences in appropriability →
  - Differences in hierarchical complexity

Our explanation

- Appropriability generates the demand for the state and it allows its existence
  - →Encourages robbery and creates a demand for protection
  - →Facilitated the finance of the elite and the provision of protection

Our explanation

- Appropriability generates the demand for the state and it allows its existence
  - →Encourages robbery and creates a demand for protection
  - →Facilitated the finance of the elite and the provision of protection

- Surplus is an outcome of hierarchy rather than its cause

Additional theories

Carneiro (1970) “circumscription theory”

Conflict → states (when the losers cannot escape)
In the Amazon Basin, “almost unlimited agricultural land,” In Peru, “The mountains, the desert, and the sea … blocked escape in every direction”

Additional theories

Carneiro (1970) “circumscription theory”

Conflict → states (when the losers cannot escape)
In the Amazon Basin, “almost unlimited agricultural land,” In Peru, “The mountains, the desert, and the sea … blocked escape in every direction”

We note that: the environmental theory of Carniero is incompatible with the geographical evidence that motivated Diamond and vice versa.
In both the Amzon Basin and New Guinea cerals are not the staple crop

Additional theories

Acemoglu & Robinson (2012)

Institutions→
Transition to farming & Surplus

Additional theories

Acemoglu & Robinson (2012)

Institutions→
Transition to farming & Surplus

Should we look for one unified theory to explain the transition to farming?

Related Literature

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

- 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

A Model of Anarchy and Hierarchy

- The model illustrates how high productivity of tubers prevents the emergence of hierarchy and a state
- It also shows how a non-benevolent state dominates anarchy efficiency-wise by reducing distortions: higher farming output and less extraction

Agents

- Farmers (measure 1) and Non-Farmers (measure N)
- Non-Farmers employment:
  - Bandits in anarchy/Tax collectors in hierarchy (measure λ)

    or
  - Subsistent foragers (measure $N - \lambda$) with income s
- λ - endogenous ratio of bandits or tax collectors to farmers
- Agents are risk neutral

Production

- Each farmer can grow 1 unit of cereals or $1 - \delta$ units of tubers, or any linear combination
- $\delta \leq 1$ - tubers' productivity loss (we restrict attention to $\delta > 0$)
  - δ is the key difference between regions

Appropriation technology

- Tubers cannot be appropriated
- $\tau \in [0, 1)$ - appropriation rate of cereals (by bandits in anarchy, by the state in hierarchy)

  $\tau = \tau(\lambda)$, $\tau(0) = 0$, $\tau'(\lambda) > 0$, $\tau''(\lambda) < 0$, and $\lim_{\lambda \to 0} \tau'(\lambda) = \infty$

Farmers optimization

- $\beta \in [0,1]$ - the fraction of land allocated to cereals
- Farmers' income:

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

- Farmers choose β to maximize income

Anarchy

A bandit's income:

$$\pi = \frac{\tau(\lambda)\beta}{\lambda}$$

Equilibrium - a pair (β, τ) such that:

1. $\beta = \arg\max I$
2. $\pi = s$

$\rightarrow$

$$s = \frac{\tau\beta}{\lambda(\tau)}$$

where $\lambda(\tau)$ is the inverse function of $\tau(\lambda)$

Define $\hat{\delta}_A$ by:

$$\frac{\hat{\delta}_A}{\lambda(\hat{\delta}_A)} = s$$

Proposition: *Unique equilibrium* (β_A, τ_A)

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

where β_A, τ_A are weakly increasing with δ

→ Farmers welfare is decreasing with δ

Output

$\bar{Y}$ - The maximal level of output

If $\beta = 1$ and $\lambda = 0 \rightarrow Y = \bar{Y}$

$$\bar{Y} = 1 + sN$$

Output and distortions

The equilibrium (β_A, τ_A) introduces two distortions:

1. Farmers growing tubers
2. Forgone output of bandits

→ Equilibrium output (per farmer) is:

$$Y = \bar{Y} - (1 - \beta_A)\delta - \lambda_A s.$$

where $\lambda_A = \lambda(\tau_A)$

Corollary: *Loss of output:*

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

where bandits income $\lambda_A s = \beta_A \tau_A$

Hierarchy

- The state has monopoly over the use of force
- This monopoly comes at a fixed cost $G_0 > 0$
- The state employs λ tax collectors at cost s per collector and the tax rate is a fraction $\tau = \tau(\lambda)$ of cereals
- The state can commit to $\tau \leq \delta \rightarrow \beta = 1$

The state's maximization problem:

$$\max_{\tau} R(\tau) \equiv \tau\beta - \lambda(\tau)s$$

subject to:

$$\beta = \arg\max (1-\tau)\beta + (1-\delta)(1-\beta)$$

→ The optimal tax rate is

$$\tau_H = \min\{\delta, \hat{\delta}_H\}$$

where $\hat{\delta}_H$ is given by

$$s\lambda'\left(\hat{\delta}_H\right) = 1$$

Assumption:

$$R(\hat{\delta}_H) > G_0$$

(otherwise a state cannot exist for any δ)

$\rightarrow$ there exists a unique $\underline{\delta}_H < \hat{\delta}_H$ such that

$$\delta < \underline{\delta}_H \leftrightarrow R(\tau_H) < G_0$$

Anarchy vs. Hierarchy

- The state employs tax collectors such that:
  marginal tax revenue $\geq s$
- In anarchy:
  average theft revenue $= s$
  $\rightarrow$

$$\underline{\delta}_H < \hat{\delta}_H < \hat{\delta}_A$$

- If $\delta < \underline{\delta}_H$

  $\rightarrow$ anarchy, $\beta < 1$ and $\tau = \delta$

- If $\delta \in [\underline{\delta}_H, \hat{\delta}_H]$

  $\rightarrow$ anarchy, $\beta < 1$ and $\tau = \delta$

  or

  $\rightarrow$ hierarchy, $\beta = 1$ and $\tau = \delta$

- If $\delta \in (\hat{\delta}_H, \hat{\delta}_A]$

  → anarchy, $\beta \leq 1$ and $\tau = \delta$

  or

  → hierarchy, $\beta = 1$ and $\tau = \hat{\delta}_H < \delta$

- If $\delta > \hat{\delta}_A$

  → anarchy, $\beta = 1$ and $\tau = \hat{\delta}_A < \delta$

  or

  → hierarchy, $\beta = 1$ and $\tau = \hat{\delta}_H < \hat{\delta}_A$

Hierarchy is Pareto dominant

Farmers' income is (weakly) larger, the state creates a surplus (above G_0), and all others are unaffected

For $\delta > \underline{\delta}_H$

$$Y_H > Y_A$$

Main conclusions

1. A state dominates anarchy efficiency-wise
2. High productivity of tubers prevents the emergence of a state

3. The correlation between efficiency and hierarchy across regions may be negative

→ Additional structure to the model can capture the *long run* effect of hierarchy (state capacity) on growth

Remarks

1. Heterogenous δ among farmers

   $\rightarrow \tau_H < \tau_A$

2. Risk averse farmers

   $\rightarrow \tau_H > \tau_A$

Example

$$\tau = \tau(\lambda) = \rho\lambda^{1/2}; \rho \in (0,1)$$

$$\rightarrow$$

$$\lambda = \lambda(\tau) = (\tau/\rho)^2$$

Anarchy

$$\hat{\delta}_A = \frac{\rho^2}{s}$$

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

Hierarchy

$$\hat{\delta}_H = \frac{\rho^2}{2s} = \frac{\hat{\delta}_A}{2}$$

For $\underline{\delta}_H \leq \delta$ a state can exist and generates a tax revenue, net of the cost of taxation:

$$R(\delta) = \begin{cases} \delta - s\left(\frac{\delta}{\rho}\right)^2 & \delta < \hat{\delta}_H \\ \frac{1}{4s}\rho^2 & \delta \geq \hat{\delta}_H \end{cases}$$

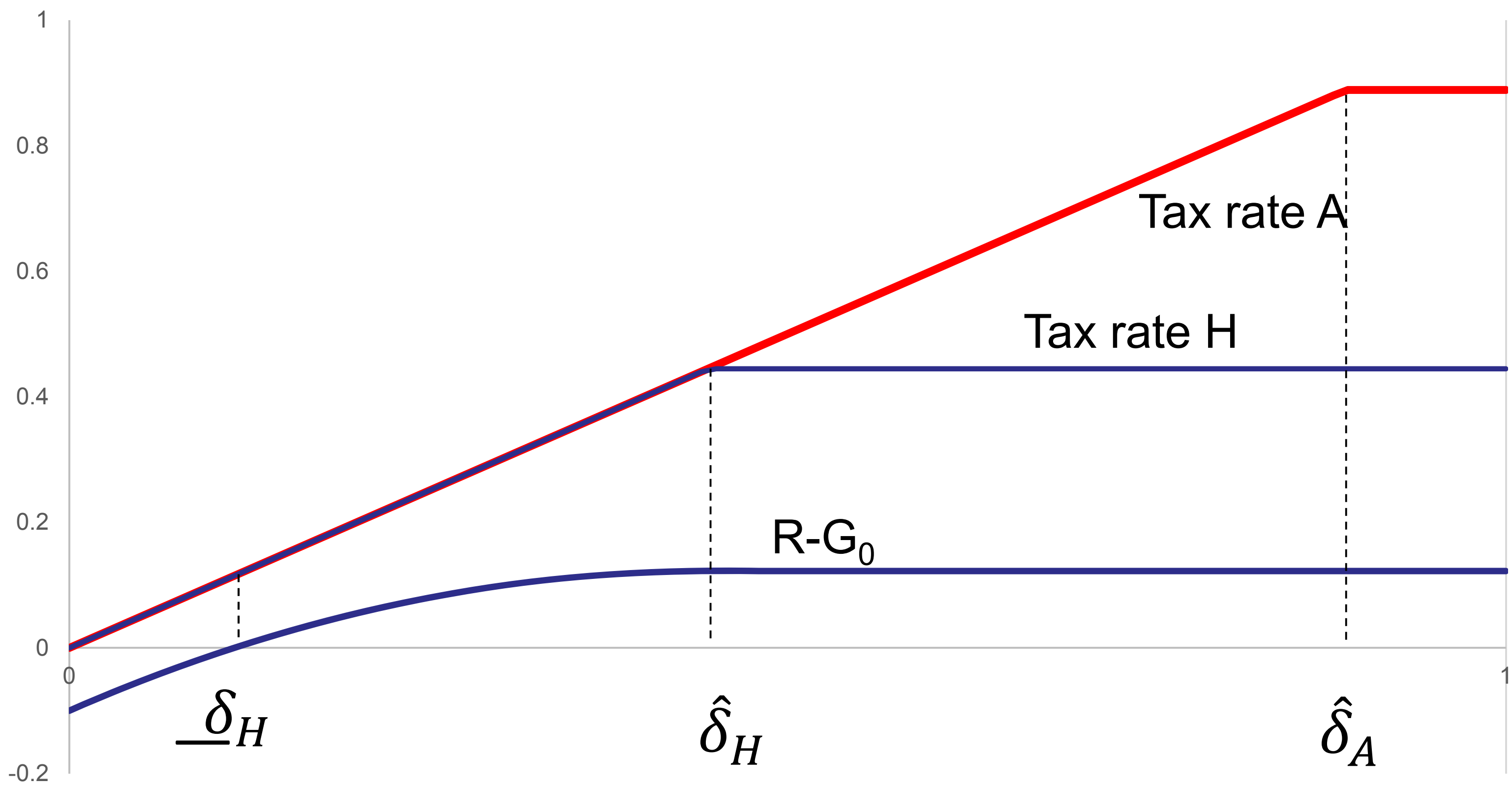
$R'(\delta) > 0$ for $\delta < \hat{\delta}_H$

$\underline{\delta}_H$ is given by $R(\underline{\delta}_H) = G_0$

$$\underline{\delta}_H = \frac{\rho}{2s}\left(\rho - \sqrt{\rho^2 - 4G_0 s}\right)$$

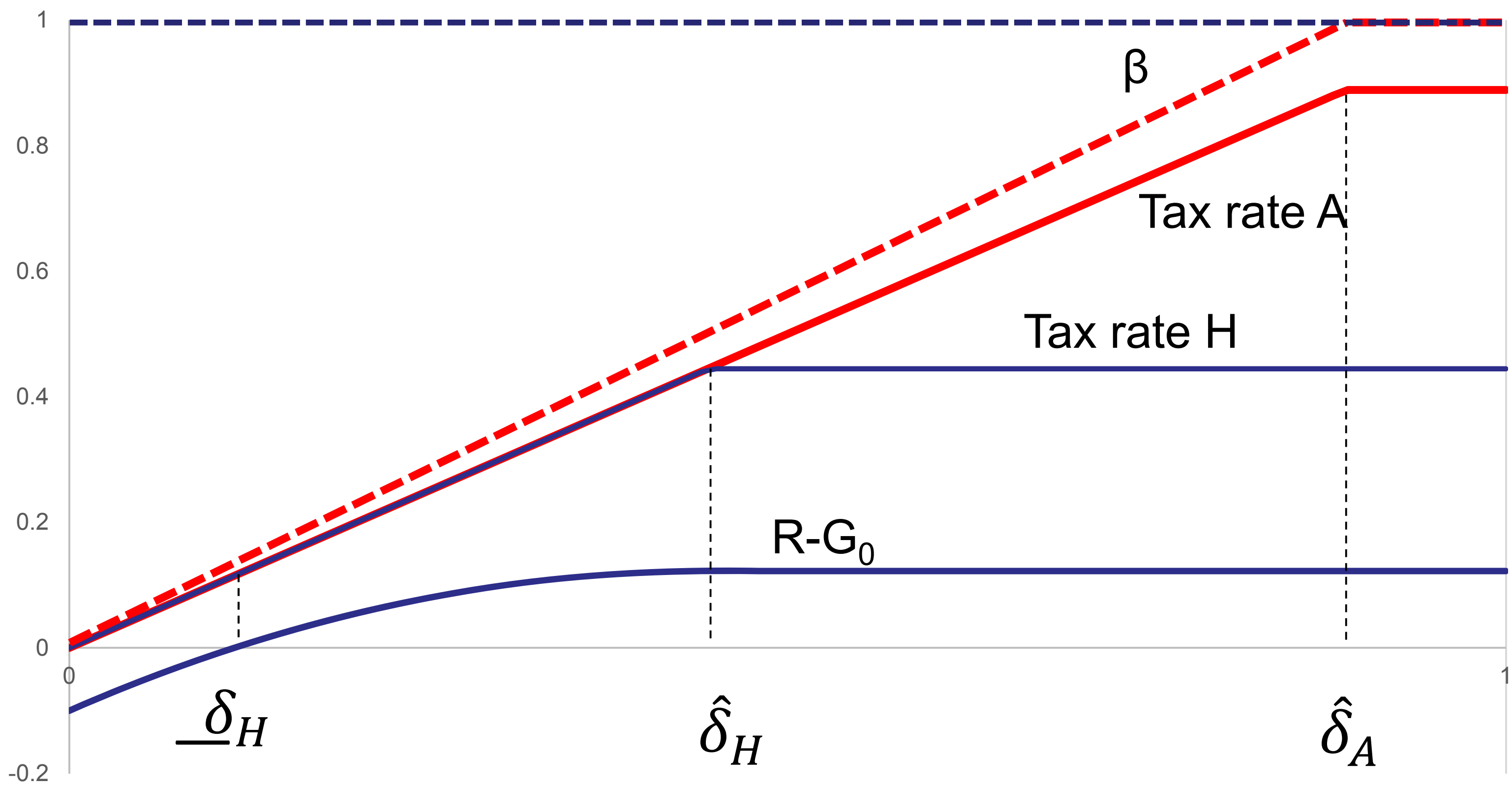
Tax and net revenue: Anarchy vs. Hierarchy

ρ=2/3, s=1/2, G_0=1/10



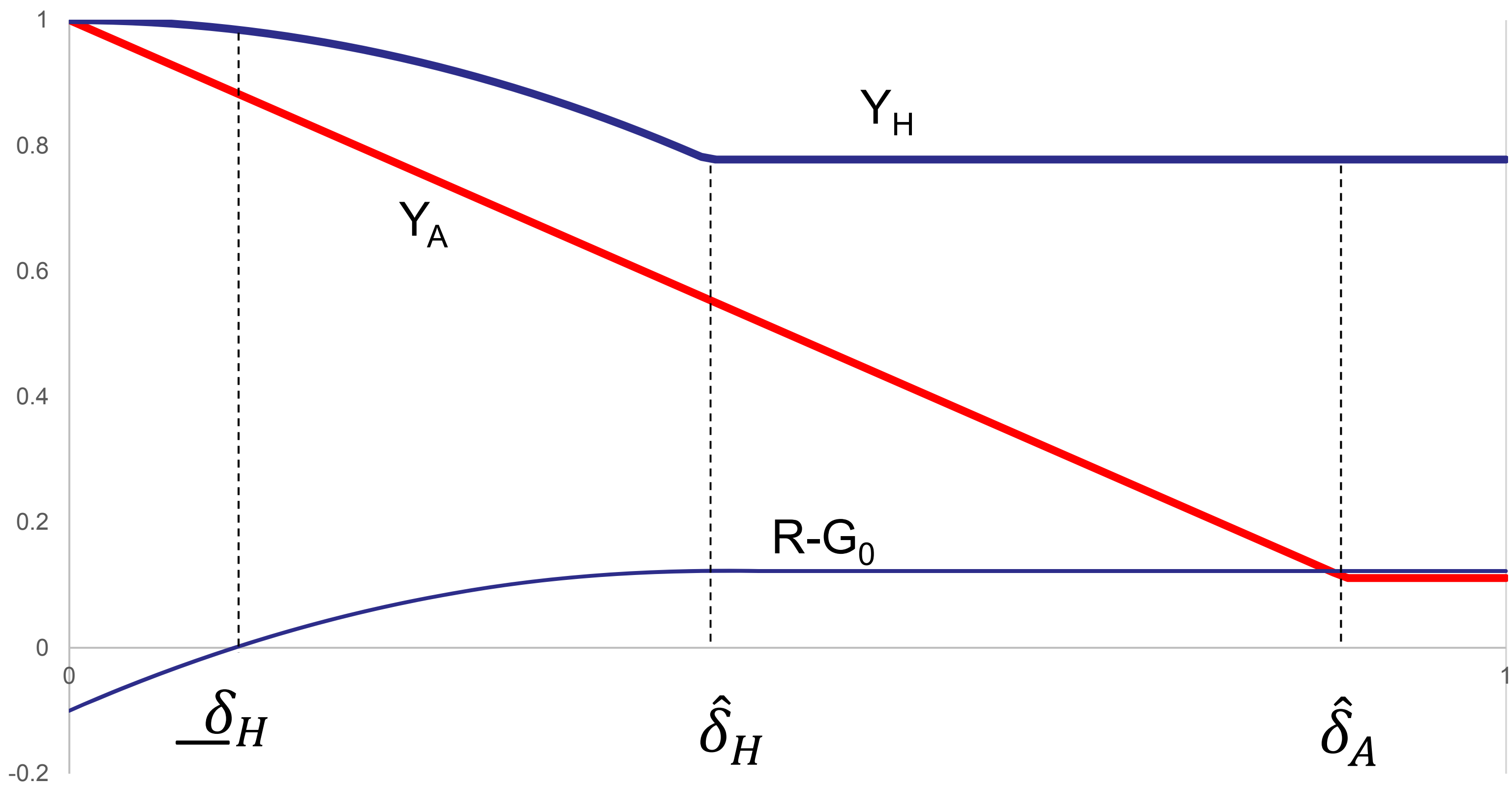
Tax, cereals and net revenue: Anarchy vs. Hierarchy

$\rho=2/3$, $s=1/2$, $G_0=1/10$



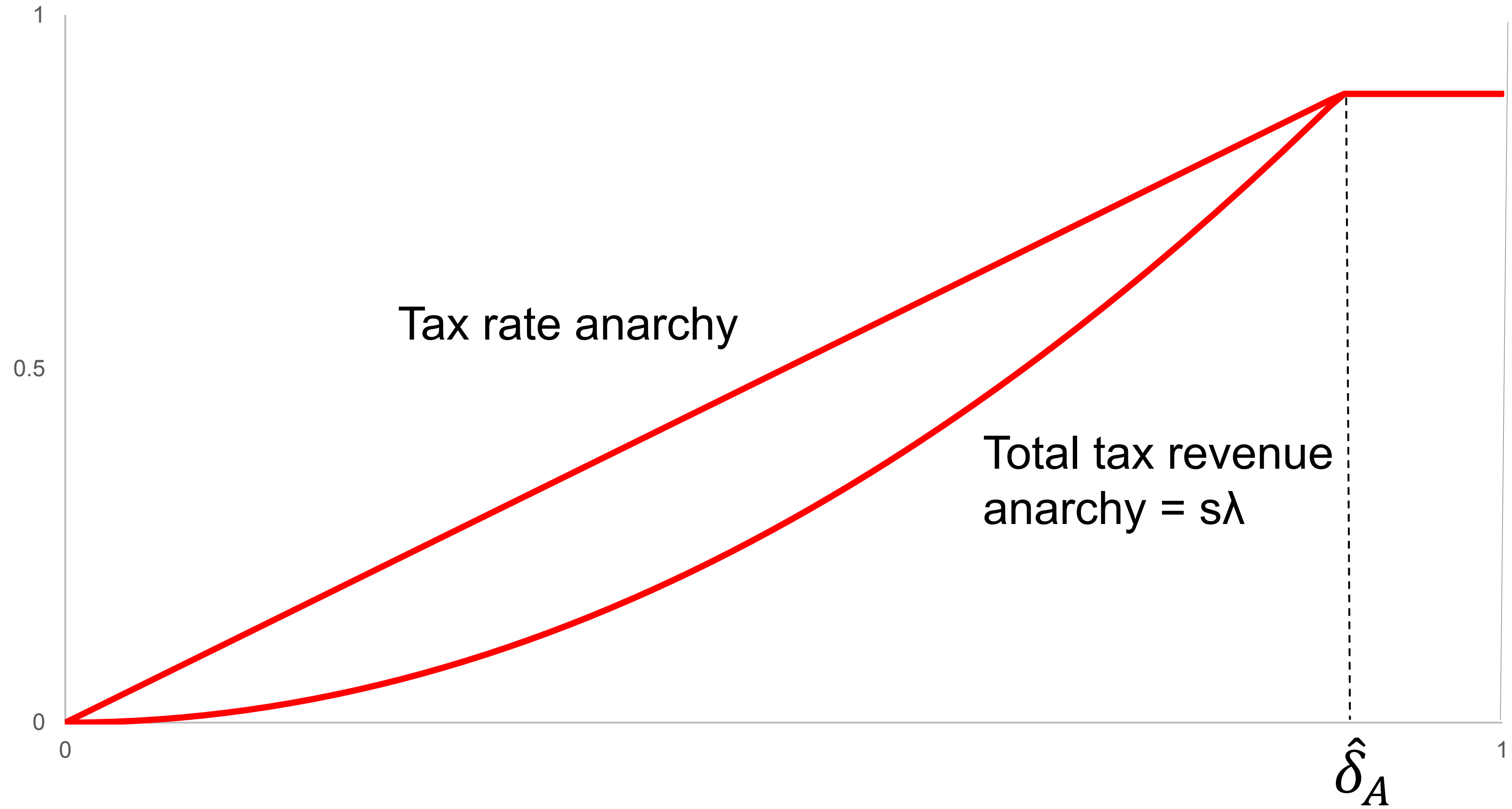
Output:
Anarchy vs. Hierarchy

$\rho=2/3$, $s=1/2$, $G_0=1/10$



Tax rate and revenue: Anarchy

ρ=2/3, s=1/2,



Risk averse farmers

$$u = (1-\tau)\log(\beta + (1-\beta)(1-\delta)) + \tau\log((1-\beta)(1-\delta))$$

Farmers' optimization given $\tau \leq \delta$:

$$\beta_A = \frac{\delta - \tau}{\delta}$$

Tax rate (number of bandits) given β_A:

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

In equilibrium:

$$\beta_A = \frac{s\delta}{\rho^2 + s\delta} < \frac{s\delta}{\rho^2}$$

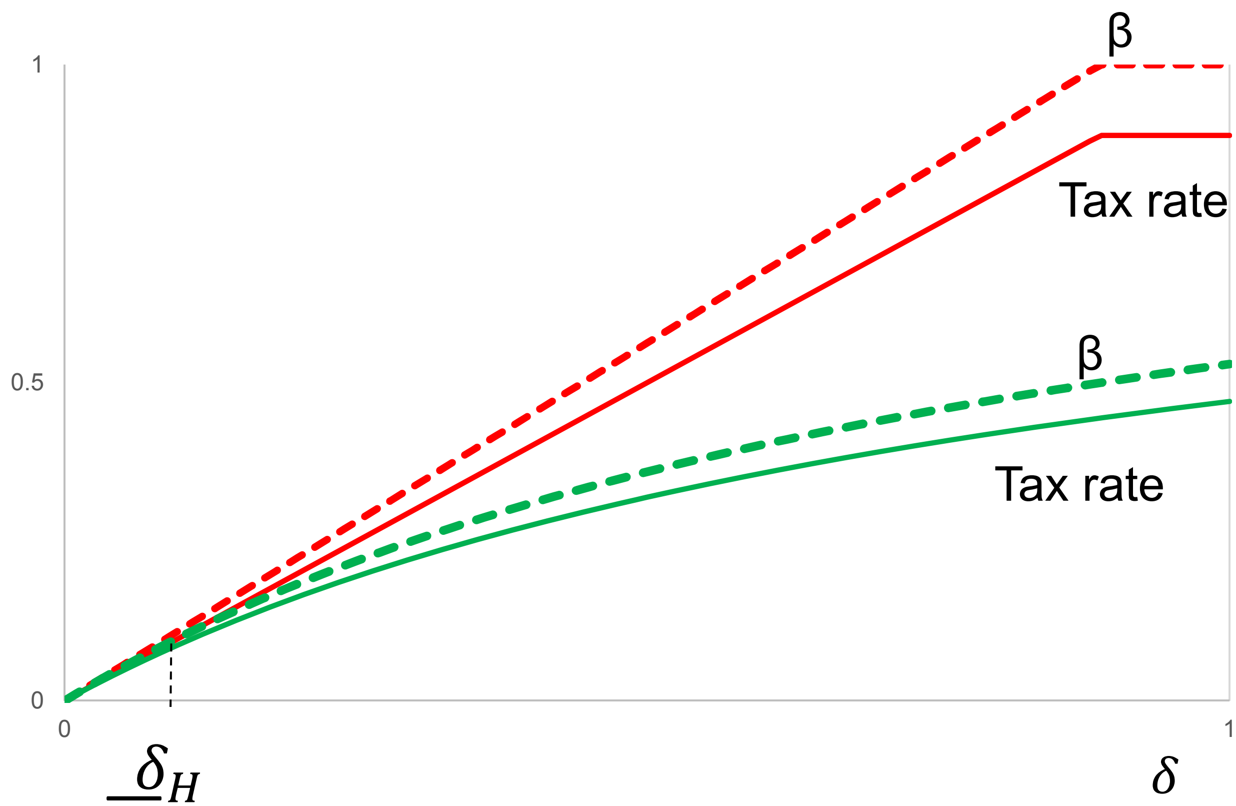
$$\tau_A = \frac{\rho^2\delta}{\rho^2 + s\delta} < \frac{\rho^2}{s}$$

- In comparison with the risk neutral case: β_A and τ_A, are smaller
- Inefficiency $(1-\beta_A)\delta + \lambda_A s$ is also smaller: $\lambda_A s = \tau_A \beta < \delta\beta$
- Total revenue of bandits is smaller

  → transition to hierarchy is less likely

Tax and cereals in anarchy: risk neutral vs. risk averse

ρ=2/3, s=1/2



Comment:

Endogenous population

In a Malthusian setting there is an additional source of inefficiency in anarchy: a smaller population

Data

- **Murdock's Ethnographic Atlas**

Database of 1,267 societies from around the world. Ideally, it should cover societies at an idealized moment of first European contact.

  - 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 50 CE to 2000 CE.

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

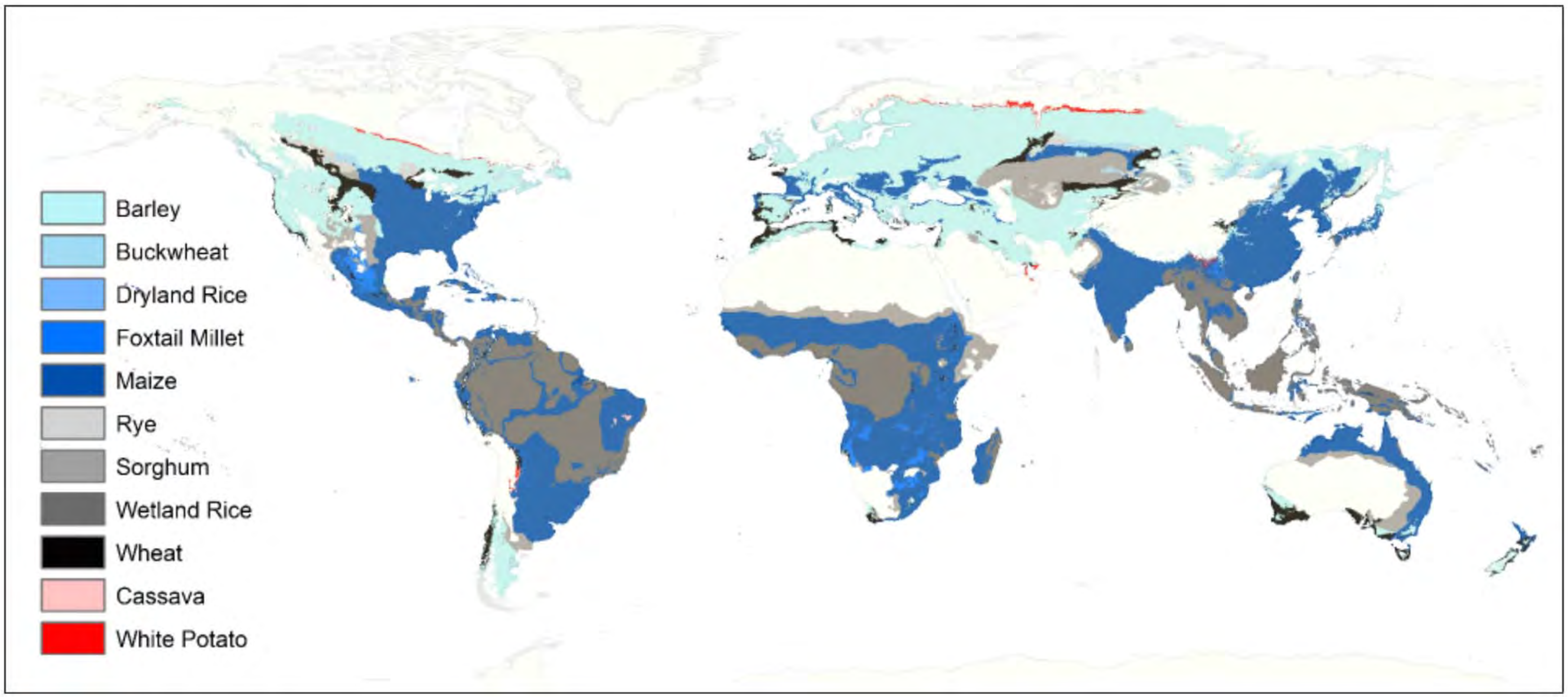
Data

Table 1: Descriptive Statistics

	SOURCE	Mean	p50	SDev	Min	Max	N
PANEL A: Societies in Ethnoatlas							
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
PANEL A: Countries X 50 years							
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	Nunn and Puga (2012)	0.35	0.00	0.43	0.00	1.00	2,959

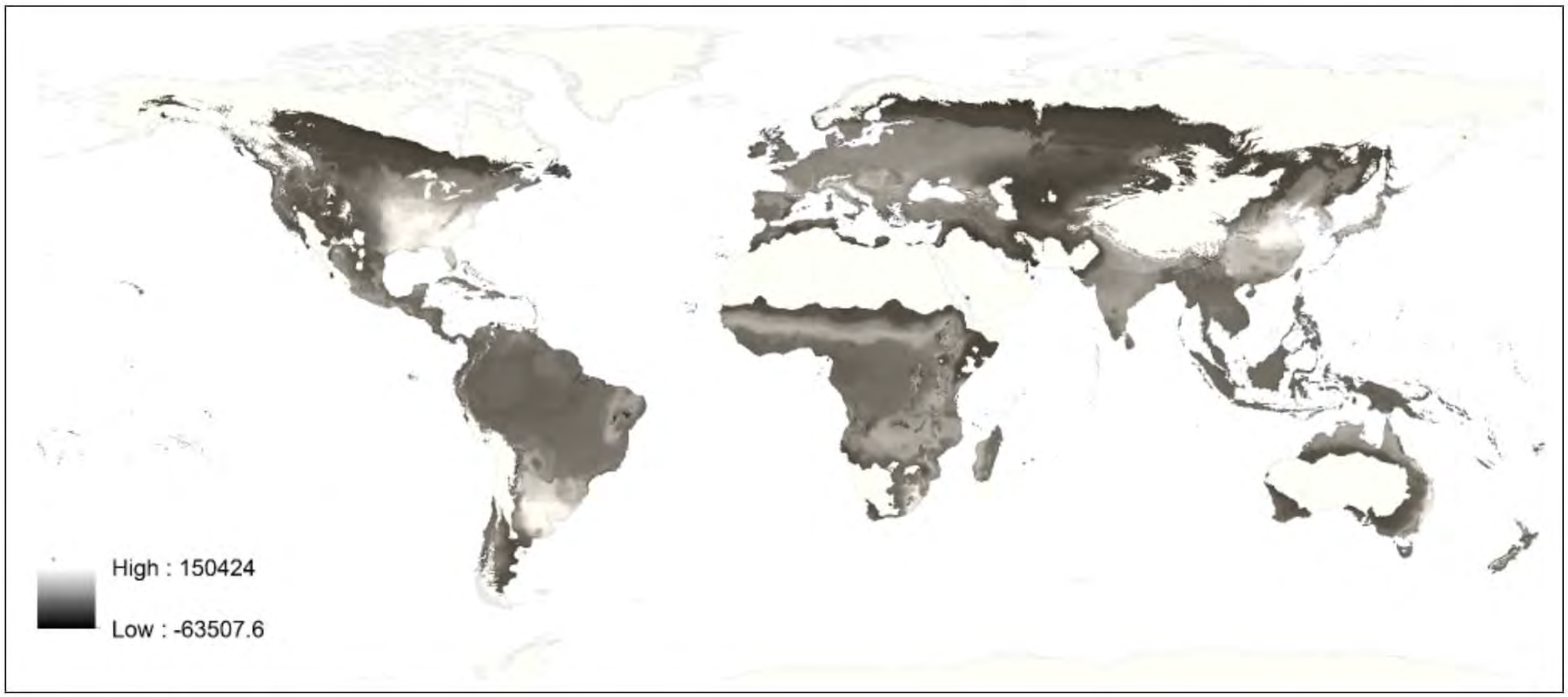
Crop yields, agriculture and main crop

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



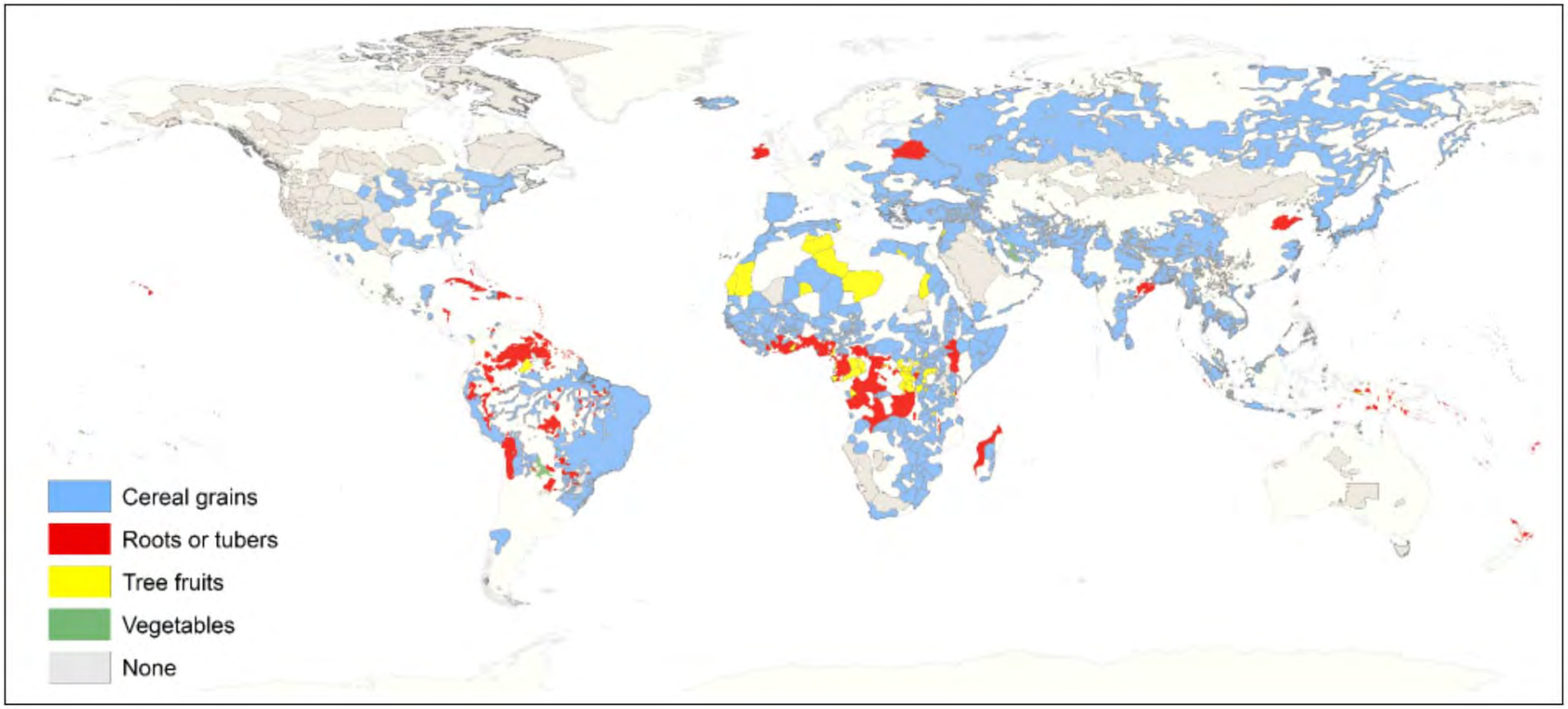
Crop yields, agriculture and main crop

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

	Dependent variable is:					
	Major crop is cereal grains (dummy)			Reliance on agriculture		
	(1)	(2)	(3)	(4)	(5)	(6)
CALORIC DIFF	0.205***	0.210***	0.253***	0.0812***	-0.0978***	-0.0464***
(CER - TUB)	(0.0168)	(0.0310)	(0.0329)	(0.00945)	(0.0134)	(0.0136)
MAX CALORIES		-0.00664	-0.137***		0.230***	0.128***
(ALL CROPS)		(0.0338)	(0.0386)		(0.0153)	(0.0178)
CONTINENT FE	NO	NO	YES	NO	NO	YES
r2	0.132	0.132	0.359	0.0733	0.235	0.387
N	982	982	982	1063	1063	1063

The table reports cross-sectional OLS 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 1-3) or the reliance of the these societies on agriculture (columns 4-6). 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. Robust standard errors in parentheses *** 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
  - POPULATION DENSITY (1995)
  - HISTORICAL POPULATION DENSITY (HYDE)
  - HISTORICAL POPULATION DENSITY (Pryor, 1995)

Cereals, surplus and hierarchy

2SLS estimates

2^{nd} stage:

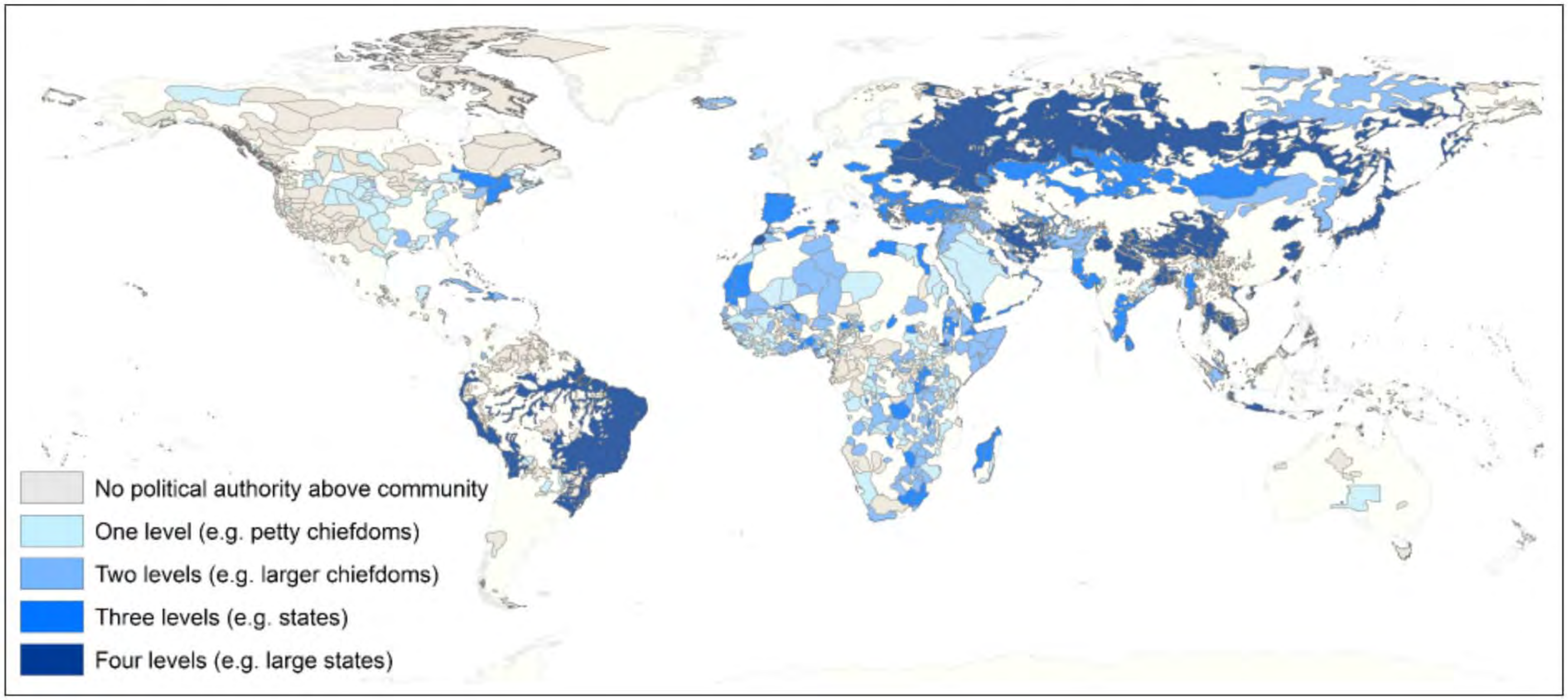
$$Hierarchy_i \,/\, Surplus_i = \alpha\, I(Main\ Crop=Cereals_i) + X'\beta + \varepsilon$$

1^{st} stage:

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

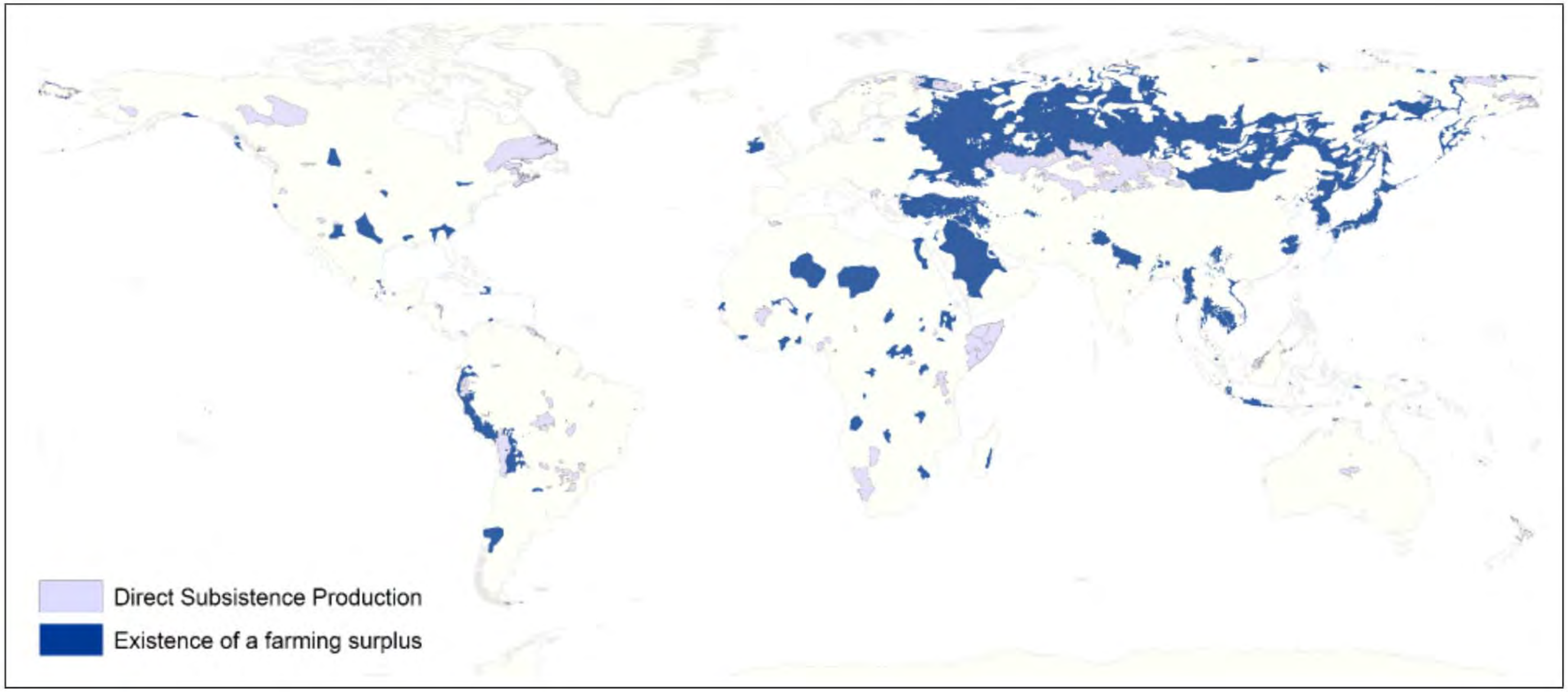
Cereals, surplus and hierarchy

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 3: Cereals, Surplus and Hierarchy - Reduced Form

	Dependent variable is:					
	Jurisdictional Hierarchy Beyond Local Community			Existence of farming surplus		
	(1)	(2)	(3)	(4)	(5)	(6)
CALORIC DIFF	0.244***	0.179**	0.274***	0.141***	0.241***	0.202***
(CER - TUB)	(0.0394)	(0.0732)	(0.0758)	(0.0319)	(0.0681)	(0.0742)
MAX CALORIES		0.0825	-0.188**		-0.132	-0.0985
(ALL CROPS)		(0.0713)	(0.0886)		(0.0870)	(0.0985)
CONTINENT FE	NO	NO	YES	NO	NO	YES
r2	0.0416	0.0429	0.249	0.0757	0.0911	0.157
N	952	952	952	140	140	140

The table reports cross-sectional OLS 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. Robust standard errors in parentheses *** significant at less than 1 percent; ** significant at 5 percent; * significant at 10 percent

Cereals and hierarchy

Table 4: 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	(0.0630)	(0.195)	(0.364)	(0.245)	(0.0762)	(0.261)	(0.332)	(0.277)
MAX CALORIES			0.0811				-0.0368	
(ALL CROPS)			(0.0714)				(0.0564)	
DEPENDENCE ON				0.334				-0.419
AGRICULTURE				(0.298)				(0.644)
CONTINENT FE	NO	NO	NO	NO	YES	YES	YES	YES
N	952	952	952	952	952	952	952	952
F excl instrum.		145.6	42.53	63.39		95.00	58.58	22.37
A-R Test (p-val)		0.000	0.0147	0.000		0.000	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. 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. "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

Cereals and Hierarchy: Robustness checks

- **Results are robust when controlling for:**
  - PRECIPITATION
  - TEMPERATURE
  - ELEVATION
  - RUGGEDNESS
  - ABSOLUTE LATITUDE
  - DISTANCE MAJOR RIVER
  - DISTANCE COAST
  - MALARIA
  - 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 5: 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
A-R Test (p-val)		0.000	0.000	0.000		0.000	0.00878	0.000

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. "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

Cereals and Surpus: Robustness checks

- **Results are robust when controlling for:**
  - PRECIPITATION
  - TEMPERATURE
  - ELEVATION
  - RUGGEDNESS
  - ABSOLUTE LATITUDE
  - DISTANCE MAJOR RIVER
  - DISTANCE COAST
  - MALARIA
  - 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

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

Note:

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

-Variation in $YieldsCereals_{c,t}$ *and* $YieldsTubers_{c,t}$ *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

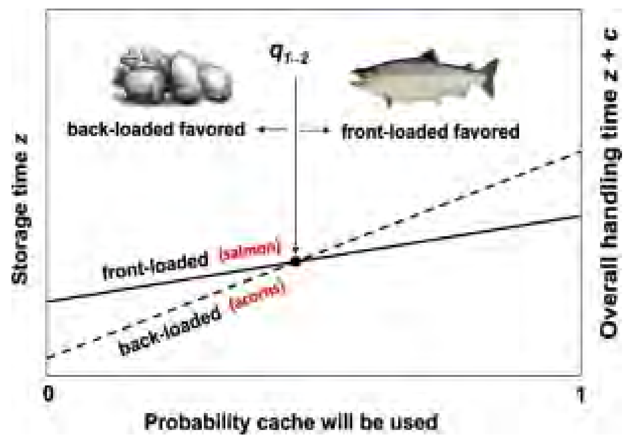
Cereals and Surpus: Robustness checks

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

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)

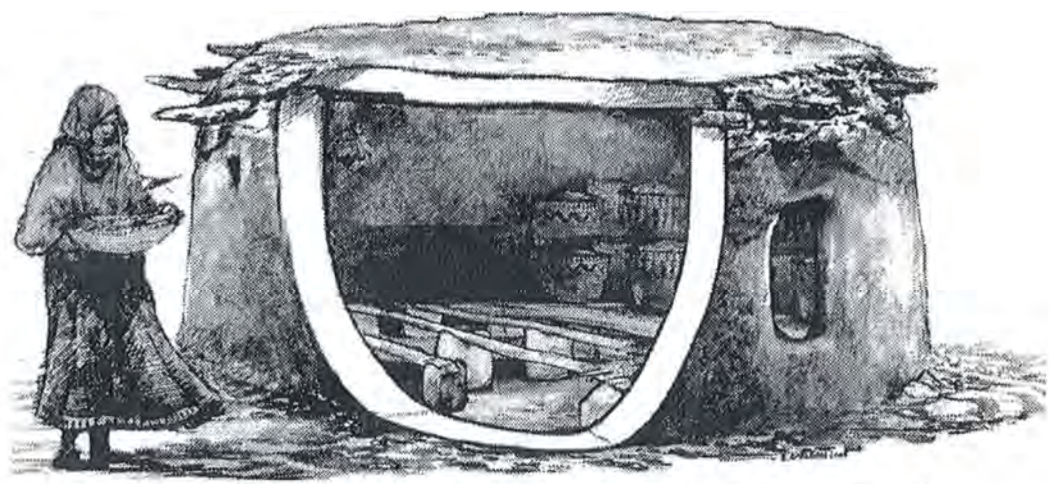
→ it isn't farming that explains the emergence of hierarchy – it is appropriability

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

Conclusions

- Geography, through its effect on appropriability, can explain differences in hierarchy and institutions

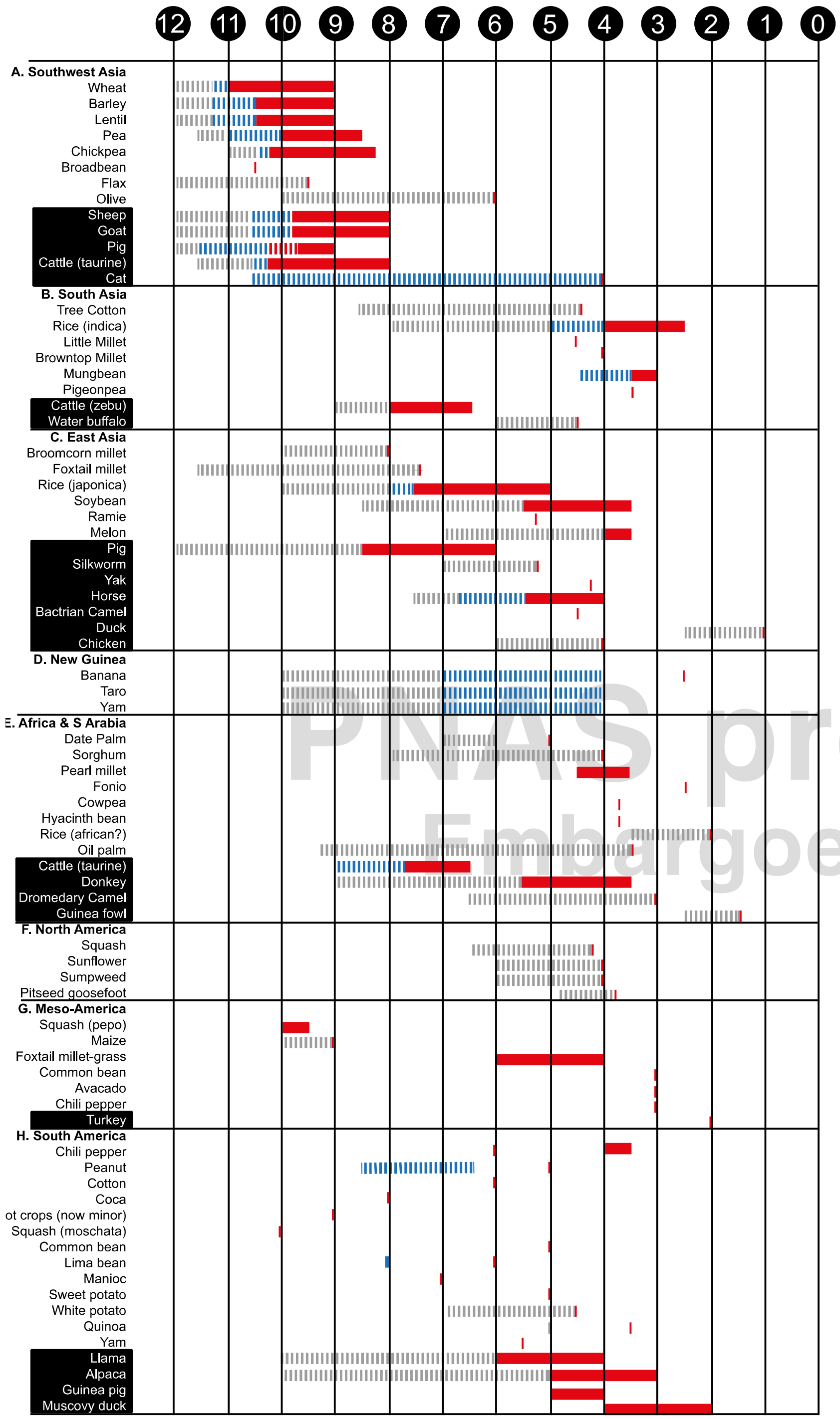
Conclusions

- 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

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



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) •

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 (ALL CROPS)	0.0899	0.0835	0.0631	0.0250	0.0317
	(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 (ALL CROPS)	0.0215	0.0191	0.0132	0.0208	0.0117
	(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)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	2SLS	2SLS	2SLS	OLS	2SLS	2SLS	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)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	2SLS	2SLS	2SLS	OLS	2SLS	2SLS	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