

Global Economic History

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What Is Economic History?

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Does the past have useful economics?

Does the Past Have Useful Economics?

- A classical approach. [McCloskey \(1976\)](#)
- From classical to modern approach. [Arrow \(1985\)](#) [Solow \(1985\)](#)
- A modern approach. [Abramitzky \(2015\)](#) [Cantoni](#) [Yuchtman \(2021\)](#)
- Methodological issues in economic history. [Blum and Colvin \(2018\)](#)

A Classical Approach

McCloskey (1976)

- Economic history for itself.
- More and better economic facts.
- Better economic theory.
- Better economic policy.

“Disinterested intellectual curiosity is the lifeblood of real civilization. [...] There is nothing that more divides civilized from semi-savage man [sic] than to be conscious of our forefathers as they really were, and bit by bit to reconstruct the mosaic of the long-forgotten past. To weigh the stars, or to make ships sail in the air or below the sea, is not a more astonishing and ennobling performance on the part of the human race in these latter days, than to know the course of events that had long been forgotten, and the true nature of men and women who were here before us.”
Trevelyan (1942)

Economic History for Itself

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“Every economy and every society has an interesting story to tell.”
Mokyr (2003)

⇒ Economic history much alike mathematical economics.

More and Better Economic Facts

- Inductive or deductive approach: facts are necessary.

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- Inductive or deductive approach: facts are necessary.
- History simply provides more facts.
- Whenever institutions are present, statistics are present.
- Even before: archaeology provides facts about the economy.

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 - IPUMS NAPP: full count censuses North Atlantic starting 1703.

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- More facts about populations:
 - IPUMS USA: full count censuses 1850–1950.
 - IPUMS NAPP: full count censuses North Atlantic starting 1703.
- Other facts:
 - Macrohistory: macro-finance indicators, 17 countries since 1870.
 - World Inequality Database: inequality indices since 1875.

Aside: IPUMS

- Greatest accomplishment for empirical economics and economic history.
- IPUMS: 98 countries, 443 censuses, > 1Bn individuals.
- Historical samples:
 - USA: full count censuses 1850–1950.
 - UK: 1851–1911.
 - Canada: 1852–1911.
 - Norway: 1801–1910.
 - Sweden: 1880–1910.
 - Iceland: 1703–1910.
- Data management:
 - Data preservation and reformatting.
 - Metadata integration: harmonized documentation.
 - Variable integration, e.g., marital status.
 - Dissemination: free, accessible, formats.

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 - USA: linked samples across censuses (IPUMS).
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- Populations: no anonymity rule.
 - USA: linked samples across censuses (IPUMS).
 - France: linked samples across vital records (TRA).
- Access dramatically improved recently.

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 - Inaccuracies and measurement errors.

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- Main limits to more and better facts:
 - Existence of historical data.
 - Inaccuracies and measurement errors.
- On existence.
 - True.
 - But be creative and knowledgeable about the data production process.
- On inaccuracies.
 - Less true.
 - Much more cautious approach to data as constructed objects.

“Much of the problem, I think, arises because of the separation in economics between data producers and data analyzers. By and large, we do not produce our own data and, hence, do not feel responsible for it.” Griliches (1974)

More and Better Economic Facts

- History provides better facts through natural experiments.
 - Can we learn from these experiments?
 - People were the same hundred years ago.
 - Structures were different and changed: we can learn a lot from that.
- ⇒ More on that later.

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In analogous discussions concerning the role of theory in historical research the argument is frequently made (perhaps because it is valid) that the historian will inevitably be guided by some [theory]. [...] Much the same can be said for the use of history by theorists. Even the most scornful ahistorical economist makes some use of history: his own experience, the experience of his generation, or the loose historical generalizations which abound in the folklore of even highly sophisticated societies.

Cameron (1965)

- Theorists routinely use history (although some get facts wrong):
 - Kaldor stylized facts and neoclassical growth theory.
 - Ricardo and rising land rents.
 - Rostow and the stages of growth.
 - Marx and the impoverishment of the working class.

Better Economic Theory

- Economic history to test economic theory.

Better Economic Theory

- Economic history to test economic theory.
- More helpful than contemporaneous economy.
- Enables to test theories in their pure form, as structures sometimes less complex in the past.
- E.g., Koudijs (2015) on information and stock prices volatility.

“Have a very healthy respect for the study of economic history, because that’s the raw material out of which any of your conjectures or testings will come.” Samuelson (2009)

One purpose of history is to broaden our conception of the possible.

Rockoff (1975)

- Learn from historical crises to inform policy.
- Bernanke is among the best examples.

Better Economists?

- Smith, Marshall, Schumpeter, Keynes, Friedman. . .
- The great economists were all deeply historical in their thinking.
- Even if not object of study, the long view helps finding important research questions.

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From the Classical to the Modern Approach

Arrow (1985) Solow (1985)

- The (caricatured) classical approach might be a naive view of history.
- History is not just a repository of facts for testing economic theory.

The aim of historical study as such was not simply to serve as a source of data from which to infer and to test social science generalizations.

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- Economic history would just be applied economics with old data.
In this dispensation an economic historian is merely an economist with a high tolerance for dust or a working knowledge of a foreign language.

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- By its general statements, economic theory generates new questions for economic history.
- But economic theory emphasizes generality at the expense of particularity.
- Economic history helps the development of economic analysis by defining its historical conditioning.

⇒ Economic history is crucial to assess “external validity.”

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A Modern Approach

Abramitzky (2015)

- Test economic theory.
- Improve economic policy.
- Learn about mechanisms.
- Answer the big questions.

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 - Impact of supply shocks on technological change: Hanlon (2015) uses drop in cotton from US South after Civil War.
 - Effect of ↓ agricultural labor availability on agricultural development: Hornbeck and Naidu (2014) use Great Mississippi Flood of 1927.

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Better Economic Policy

- Economic history to improve economic policy.
- Historical settings allow counterfactual worlds, or repetition of episodes.
- Again, past financial crises deeply inform current policy.

- Economic history to learn about mechanisms.
 - Typically, economists learn about mechanisms indirectly, e.g. by interactions or heterogeneity across subgroups.
 - Deep knowledge of historical setting and direct (qualitative) historical evidence can be much more convincing.
 - Analytic narratives approach using game theory (see Avner Greif's work).

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 - Why are some countries rich and other poor?
 - Why did the Industrial Revolution happen in Europe and not elsewhere?
 - What factors caused the demographic transition?
 - How and why did inequality evolve over time?
 - What is the process of cultural change?

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- These are too big to nail. But...

Economic history seems to collectively agree to not limit ourselves to answer only those questions with random variation, of which there are not as many.

Natural Experiments of History

Cantoni Yuchtman (2021)

- Economic history is especially popular in mainstream economics for natural experiments.
- Enable to answer important questions that require historical perspective while keeping applied micro approach and credible causal identification.
- Especially popular in economic growth and development.

⇒ Bridge between economic history and all other disciplines.

Natural Experiments of History

- Taxonomy of three primary motives for examining historical natural experiments:
 - Natural experiments to learn about historical episodes (cat. 1).
 - Natural experiments yielding general economic insights (cat. 2).
 - Natural experiments to understand contemporary development (cat. 3).

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 - Natural experiments to understand contemporary development (cat. 3).
- Not mutually exclusive: most research overlaps categories.
- No one motive is better or worse.

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⇒ At the confluence: AJR's *Colonial Origins*

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 - Impact of WWI of female labor force participation: variations from cohort-drafting rules (Boehnke and Gay 2022).

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- Critique of “looking under the lamppost.”
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 - Miss many important historical aspects.
- Sometimes, amounts to argue for inexplicability of historical variation of interest.
- But understanding source of variation is valuable (even beyond LATE).

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 - Causal effect of input relative abundance on technical change: use decline in US South cotton imports to Britain during US Civil War as a source of variation in input availability (Hanlon 2015).

Yield General Economic Insight: Challenges

- Usually nice “existence” results.
- Sometimes lack of insight on mechanisms.
- Go beyond estimating single parameter.
- Critiques of reduced form à la Heckman (2005) and Deaton (2010).

Understand Contemporary Development

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 - Long-run effects of disease environment: Alsan (2014) uses suitability for Tze Tze fly as IV for disease environment.

Understand Contemporary Development: Challenges

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 - Especially salient when little data around the experiment: challenges to the exclusion restriction.
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- Reproducibility is challenging, as well as the risk of multiple hypothesis testing.
- Bias toward persistence. When and why does history not persist?

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Methodological issues in economic history

- Economics versus history
- Measurement and historical data
- Econometric identification
- Geographic Information Systems (GIS)

Economics versus history

Colvin and Wagenaar (2018)

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- Traditional history:
 - Focus on the particular, explain individual events, outliers.
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- Traditional history:
 - Focus on the particular, explain individual events, outliers.
 - No counterfactual thinking.
 - Attributes cause and effect through timing.
- Economics:
 - Focus on generalizations, explain trends, means and variances.
 - Counterfactual approach: reality is a draw from distribution.
 - Disentangle causes from effects.

Economics versus history

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- Bad history is purely inductive.
 - Use observation to draw arguments based on evidence.
 - Might select those archival evidence to confirm theory
- Good economic history uses abduction:
 - Surprising observation (against prior).
 - Build hypothesis.
 - Test hypothesis and reject it.

⇒ Back and forth between theory and empirics.

Blum (2018)

- Measurement and source criticism is fundamental:
 - Right measure and level of aggregation.
 - Data generated how, by whom, for what, with which representation system?
 - Inputting data enables knowledge of hidden regularities.
 - Measurement error invalidates any identification strategy.

Measurement and historical data

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 - Data generated how, by whom, for what, with which representation system?
 - Inputting data enables knowledge of hidden regularities.
 - Measurement error invalidates any identification strategy.
- Mismeasurement and bias can be exploited:
 - Difficult to measure populations' numeric skills.
 - “Age heaping” method.
 - Frequency of rounding (0 or 5) age when self-reporting.

Econometric identification

Blum and Dimicio (2018)

- Economic history uses standard tools of econometrics.
- Identifying correlation:
 - Controlling for observables.
 - Multivariate OLS regressions.
 - But measurement error, reverse causality, omitted variable bias.

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- Economic history uses standard tools of econometrics.
- Identifying correlation:
 - Controlling for observables.
 - Multivariate OLS regressions.
 - But measurement error, reverse causality, omitted variable bias.
- Identifying causality:
 - Empirical design: exogenous variation in treatment variable.
 - Difference-in-differences.
 - Instrumental variables (included in the narrative). Caicedo (2020)
 - Regression discontinuity designs.

Econometric identification

- Deep institutional knowledge essential for credibility of identification.
- External validity issues: LATEs.
- Trade-off between validity and importance.
- Ask questions first, look for identification after.

Johnson (2018)

- GIS as a tool for new historical data:
 - Matching modern datasets with historical units.
 - Suitable for time-invariant characteristics: topography, agricultural potential, climate. Nunn and Puga (2012)
 - Spatially disaggregated modern data (for persistence studies): night light intensity. Michalopoulos and Papaioannou (2018)

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- GIS as a tool for matching historical data:
 - Match heterogeneous geolocated datasets. Dittmar (2011)
 - Georeferencing historical maps.

Geographic Information Systems (GIS)

- GIS as a tool for new analyzes:
 - Spatial regression discontinuity designs.
 - Spatial networks: optimal paths and market access.

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- GIS as a tool for new analyzes:
 - Spatial regression discontinuity designs.
 - Spatial networks: optimal paths and market access.
- Using GIS methods:
 - Softwares: QGIS (free) and ArcGIS (pay).
 - Coding: python.

When and how is economic history valuable to better understand the present?

Modern Economic Growth in Historical Perspective

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Toulouse
School of
Economics

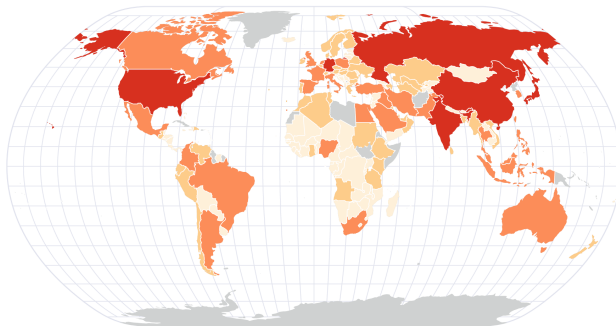
Why are some countries so much richer than others?

- Current cross-country differences in income
- GDP and welfare
- Economic growth and income differences

Current cross-country differences in income

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2017 PPP-adjusted GDP in bil. 2011 US \$



USA = 18,200. CHN = 18,400. FRA = 2,600. NGA = 835.

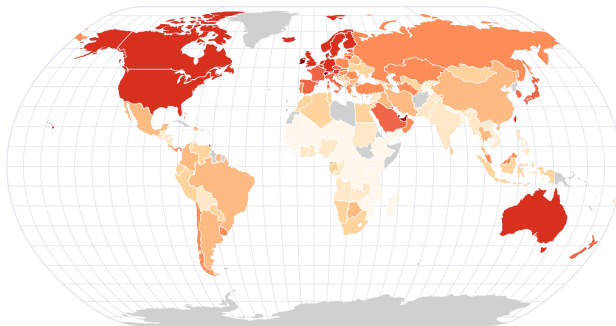
basemap from Natural Earth (CC0) - Penn World Table



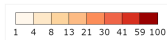
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Current cross-country differences in income

2017 PPP-adjusted GDP per Capita in thous. 2011 US \$



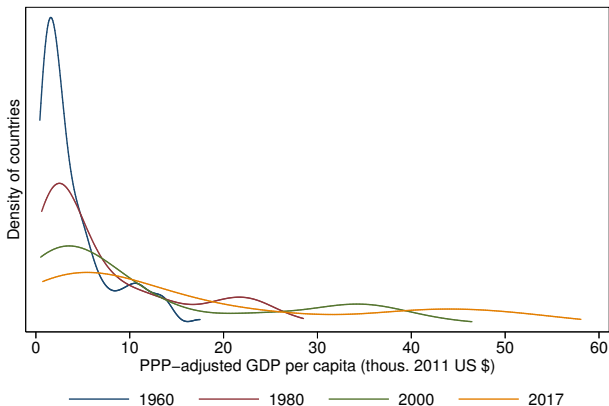
USA = 56, CHN = 13, FRA = 41, NGA = 4.
basemap from Natural Earth (CCO) - Penn World Table 9.1



Made with Khartis

Evolution of cross-country differences in income

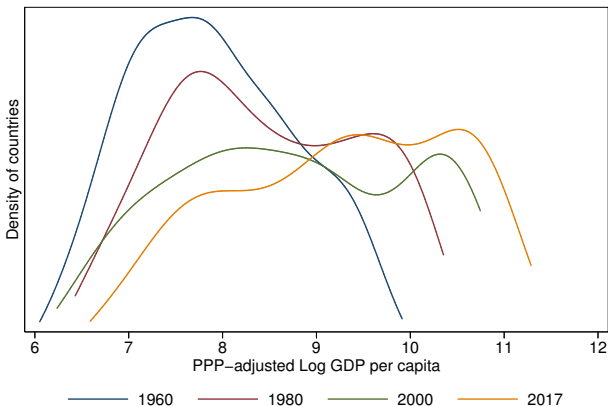
Distribution of Countries: GDP per Capita



Source: Penn World Table 9.1, 110 countries.

Evolution of cross-country differences in income

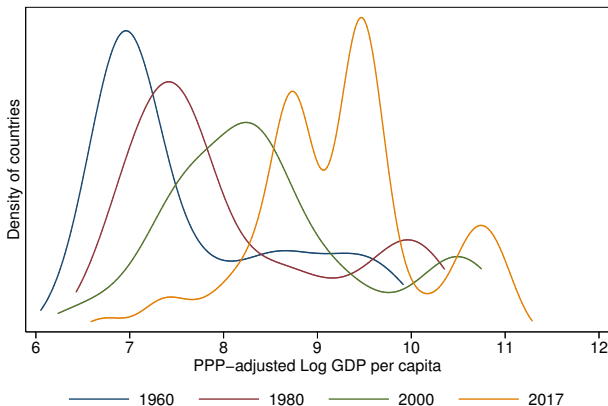
Distribution of Countries: Log GDP per Capita



Source: Penn World Table 9.1, 110 countries.

Evolution of cross-country differences in income

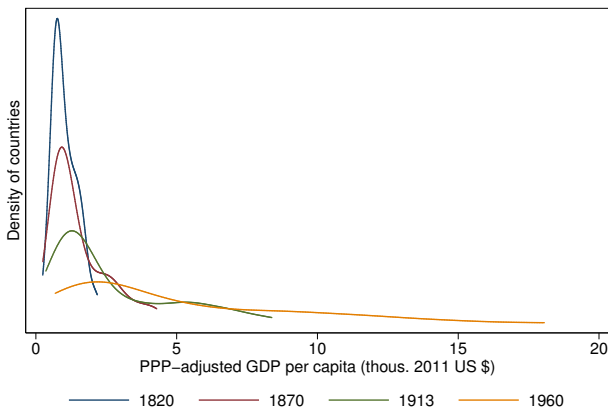
Population-Weighted Distribution of Countries: Log GDP per Capita



Source: Penn World Table 9.1, 110 countries.

Evolution of cross-country differences in income

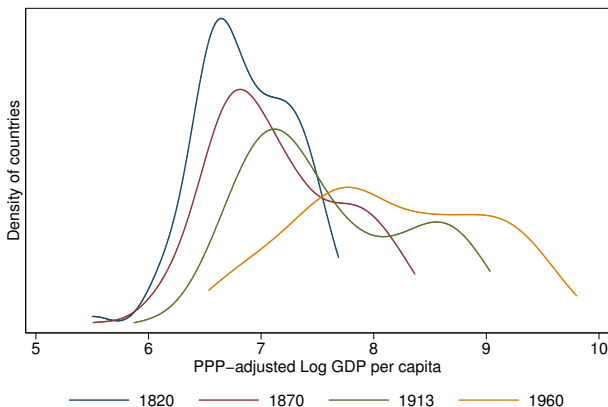
Distribution of Countries: GDP per Capita



Source: Maddison Project Database 2018, 86 countries.

Evolution of cross-country differences in income

Distribution of Countries: Log GDP per Capita



Source: Maddison Project Database 2018, 86 countries.

Data Source: Penn World Table

- Best cross-country GDP modern data: [Penn World Tables 10.0](#).
- Reference paper: [Feenstra, Inklaar and Timmer \(2015\)](#).
- GDP, consumption, TFP measures.
- PPP-adjusted, constant prices (2011 US \$) \implies comparability.
- 183 countries, 1950–2019, yearly.

Data Source: Maddison Project Database

- Best cross-country pre-1950 GDP data source: [Maddison Project](#).
- Reference paper: [Bolt, Inklaar, de Jong and van Zanden \(2018\)](#).
- New version: GDP per capita based on PWT methodology.
- 80 countries pre-1950, starting 1800s (even before).
- Lower data availability than PWT.

GDP and welfare

Definition

Definition (Gross Domestic Product)

GDP is the market value of final goods and services newly produced in a country during a given period of time

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- GDP is the most commonly used indicator of economic activity.
- GDP is measured in a currency at **current** prices.
- GDP measures **final** goods and services.
- GDP measures goods newly **produced** during the period considered.

Three equivalent approaches

① Product approach

- Highlights **value-added** of domestic output.
- Most common definition, used in economic history.

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- Highlights **income** earned by factors operating domestically.

⇒ Production = Expenditure = Income.

Components

$$\underbrace{Y}_{\text{Final Product}} = \underbrace{C + I + G + (X - M)}_{\text{Expenditure on Final Goods and Services}}$$

- Y : final product (or total income earned by domestic factors).
- C : consumption spendings on goods and services.
- I : investment spendings on capital (and changes in inventories)
- G : government expenditures on goods and services.
- $X - M$: net exports of goods and services.

A distorted picture of reality

A distorted picture of reality

- 1 GDP per capita matters.

A distorted picture of reality

- ① GDP per capita matters.
- ② GDP is a constructed measure, subject to revisions.

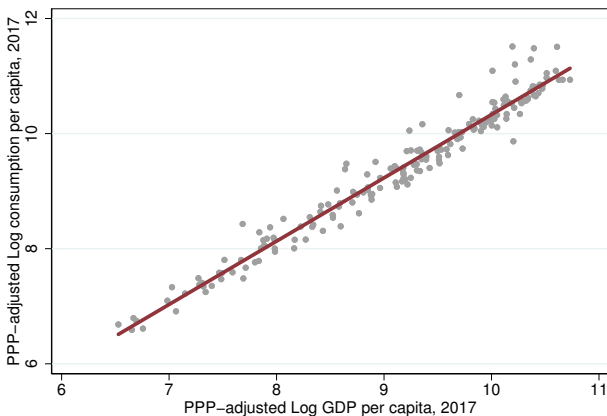
A distorted picture of reality

- ① GDP per capita matters.
- ② GDP is a constructed measure, subject to revisions.
- ③ Many things that contribute to wealth are not measured:

A distorted picture of reality

- ① GDP per capita matters.
- ② GDP is a constructed measure, subject to revisions.
- ③ Many things that contribute to wealth are not measured:
 - Goods and services not sold on a market: e.g. home production, child care, clean air.
 - Illegal activities: e.g. drugs, prostitution.
 - Natural resource depletion.
 - Welfare: e.g. leisure, health, inequality, happiness.
 - Digital goods.
 - Changes in quality.

Income per Capita and Consumption per Capita, 2017



Source: Penn World Table 9.1, 182 countries.

Income and welfare

Jones and Klenow (2016)

- Compute a new welfare measure that combines consumption, leisure, inequality and mortality.

Jones and Klenow (2016)

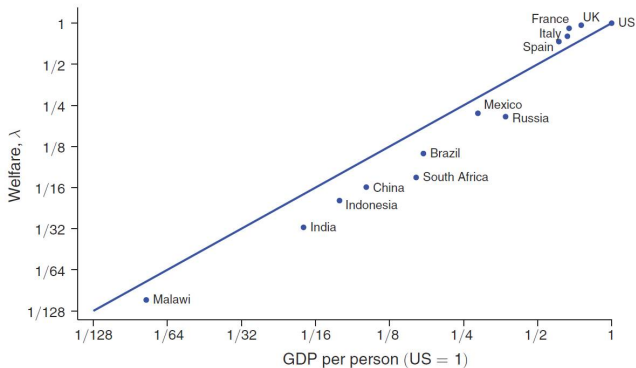
- Compute a new welfare measure that combines consumption, leisure, inequality and mortality.

France vs USA in 2005

Indicator	France	USA
GDP per Capita	67	100
Consumption per Capita	60	100
Life Expectancy	80	77
Leisure (h. work)	535	877
Inequality (Gini)	0.261	0.369
Welfare	92	100

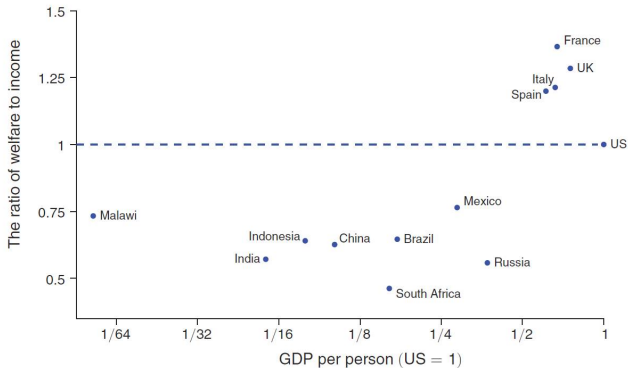
Income and welfare

Welfare and income are correlated at 98%



Income and welfare

Welfare differs from income by about 35%



Adhami et al. (2023)

- Social welfare perspective: total population matters too!
 - Japan 1960–2019: consumption per capita $\times 6$, population $\times 1.3$.
 - Mexico 1960–2019: consumption per capita $\times 3$, population $\times 3$.
- Reconsider growth using a consumption-equivalent metric based on total utilitarian social welfare.

\implies Put “humans” into a Human Development Index.

Population and welfare

- Total welfare is $W(N_t, c_t) = N_t \cdot u(c_t)$.
 - N_t : number of (identical) people.
 - c_t : (representative) consumption per capita.
 - $u(\cdot)$: flow utility function.
- $u(\cdot)$ is positive with diminishing returns ($u > 0$, $u' > 0$, $u'' < 0$).

Population and welfare

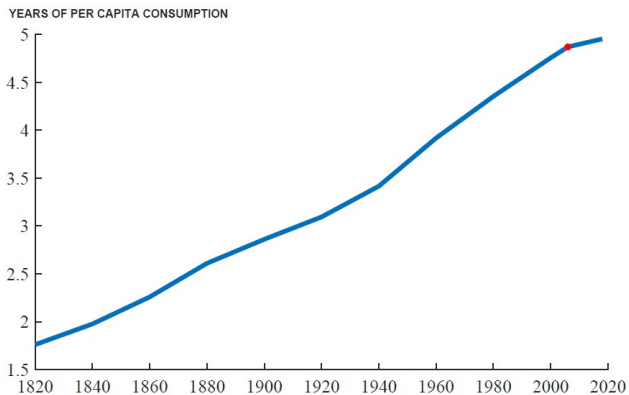
- Calculate a consumption-equivalent of welfare growth based on slope of social indifference curve.
- Get $v(c)$, value of having one more person alive for one period, i.e., 1pp population growth is worth $v(c)$ pp of consumption growth.
- $v(c) > 1$ because of “consumer surplus” associated with diminishing marginal utility.
- Weight $v(c)$ is the “value of a year of life” in consumption per person.

⇒ As living standards increase, “life” becomes increasingly valuable.

- Example in U.S. 2006:
 - Value of statistical life = \$7.4m.
 - Consumption per capita per year = \$38k.
 - Given life expectancy and assuming lof utility: $v(c_{US,2006}) \simeq 4.87$.
 - A year of life in US 2006 is valued at 5 years worth of consumption per person.

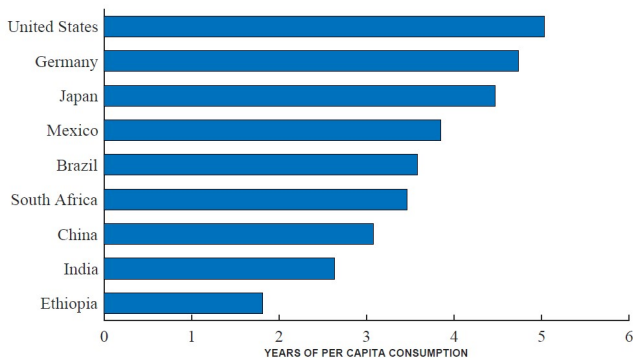
Population and welfare

$v(c)$ over time in the US



Population and welfare

$v(c)$ across countries in 2019



Population and welfare

$$CE = v(c_t) \cdot g_{Nt} + g_{ct}$$

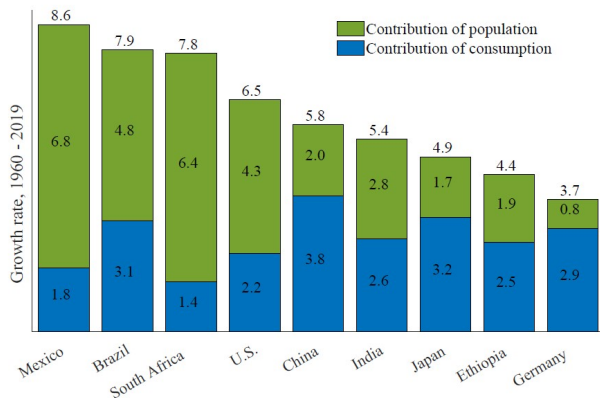
- CE: consumption equivalent.
- g_N : population growth.
- g_c : consumption growth.
- $v(c)$: weight on population growth or value of a year of life measured in years of per capita consumption.

Overview of results from 1960 to 2019

	Unweighted	Pop Weighted
CE-welfare growth, g_λ	6.2%	5.9%
Population term, $v(c)g_N$	4.1%	3.1%
Consumption term, g_c	2.1%	2.8%
Population growth, g_N	1.8%	1.6%
Value of life, $v(c)$	2.7	2.3
Pop share of CE-welfare growth	66%	51%

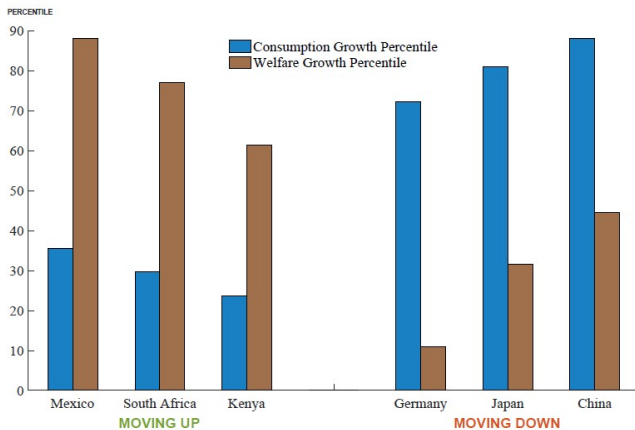
Population and welfare

Welfare growth in selected countries, 1960–2019

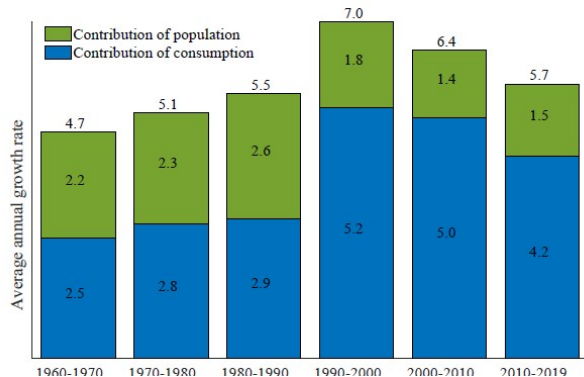


Population and welfare

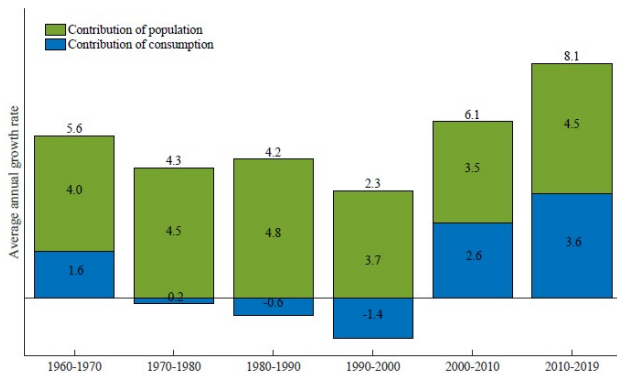
Changing perspectives on who is growing rapidly



Growth in China by decade

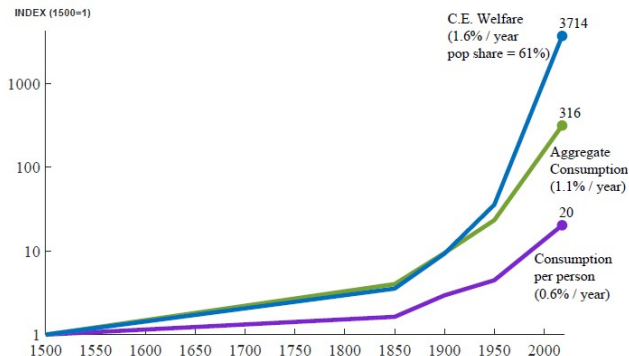


Growth in Sub-saharan Africa by decade



Population and welfare

Cumulative growth in “the world”, 1500–2018



- Consumption per capita $\times 20$ ($g_c = 0.6\%$ per year).
- Welfare $\times 3,700$ ($g_{CE} = 1.6\%$ per year).

Economic growth and income differences

Economic growth and income differences

- Growth rates explain large income differences.

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- Let g : growth rate, T = time, $GDP_0 = 1$. Then

$$GDP_T = (1 + g)^T$$

- Suppose $g_A = 2\%$ and $g_B = 0\%$.
 - After 100 years, A 7 times richer than B.
 - After 200 years, A 52 times richer than B.

Economic growth and income differences

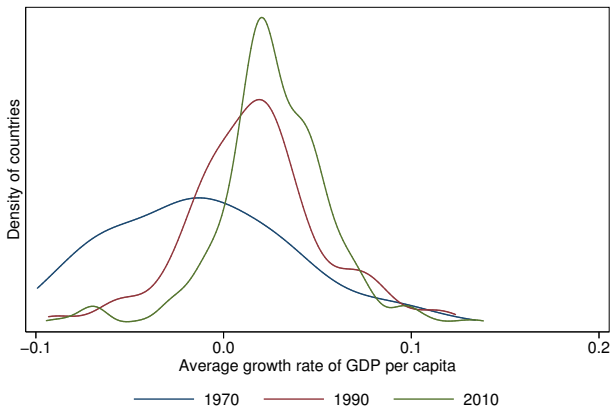
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- Suppose $g_A = 2\%$ and $g_B = 0\%$.
 - After 100 years, A 7 times richer than B.
 - After 200 years, A 52 times richer than B.
- How long to:
 - double GDP? $\log 2 / \log(1 + g)$. If $g = 2\%$, then 35 years.
 - decuple GDP? $\log 10 / \log(1 + g)$. If $g = 2\%$, then 116 years.

Economic growth and income differences

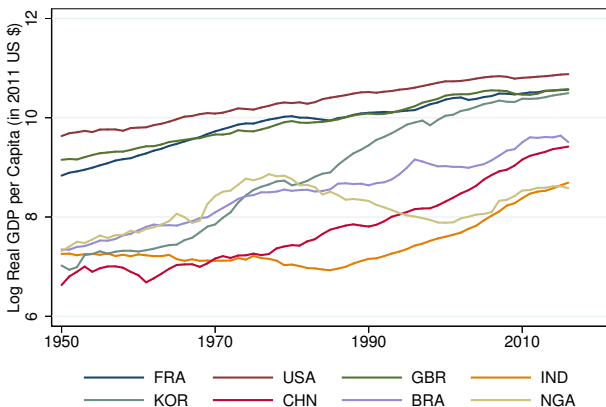
Distribution of GDP per Capita Growth Rates



Source: Penn World Table 9.1

Economic growth and income differences

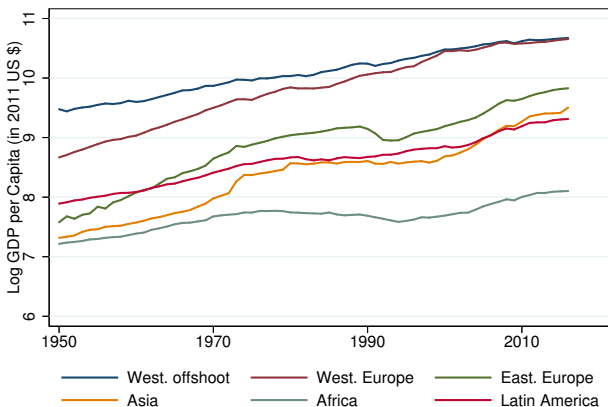
Evolution of Income per Capita across Countries



Source: Maddison Project Database 2018.

Economic growth and income differences

Evolution of Income per Capita across Continents



Source: Maddison Project Database 2018.

Historical Growth Accounting

Victor Gay

Visiting professor at University of Michigan

Toulouse School of Economics

Institute for Advanced Study in Toulouse

Winter 2024



How can we measure historical GDP?

Historical national accounting

- Potential value of growth accounting in economic history:
 - Benchmarking growth performance over the long run.
 - Quantification of contributions to growth of particular sectors or new technology.
 - Understand nature of TFP growth.
- Potential weaknesses of growth accounting in economic history :
 - Highly sensitive to methodology and data quality.
 - Does not tell anything about causality from factor input growth to TFP growth.

⇒ Prerequisite to testing hypotheses about factors of long-run growth.

Historical national accounting

- Central question: relationship between inputs and outputs.
- Typically, Cobb-Douglas production function:

$$Y = AL^{1-\alpha}K^\alpha$$

- α and $1 - \alpha$: output elasticities of capital and labor.
- A : total factor productivity (TFP).
- Diminishing returns to factor accumulation.

- Basic growth accounting equation in growth rates:

$$\Delta \log (Y/L) = \alpha \Delta \log (K/L) + \Delta \log A$$

- Factor share α constant $\simeq 1/3$.
- Issues measuring L and K , but feasible.
- Once estimate Y , get estimate of A .

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-
- For comparisons across time and space: proper price levels.

⇒ How to estimate Y and convert into PPP?

- Maddison's (2001) *The World Economy: A Millennial Perspective*.
- Result of 50 years of research.
- Maddison (2010) Online database.
- Maddison Project: extends Maddison work. [Bolt et al. \(2018\)](#)

Four types of GDP data

- Official estimates by national statistical offices (1870–1950).
- Historical estimates based on same methods (pre-1870).
- Historical estimates based on proxy variables (pre-1870).
- “Guesstimates.”

Methods for data-abundant nations

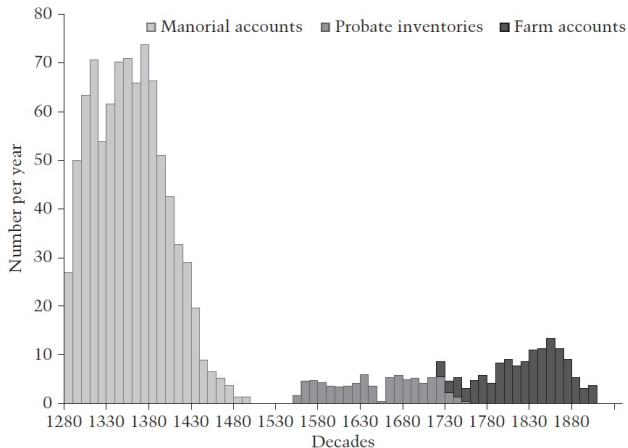
- Most common for pre-1870: output approach.
- Broadberry et al. (2015) *British Economic Growth, 1270–1870*
- Sectors estimated separately with auxiliary data for 1270–1700:
 - Agricultural output.
 - Industrial output.
 - Service sector output.

Britain's agricultural output

- Three databases across different periods:
 - 1250–1500: Medieval Accounts Database. Manorial accounts for land use, crops, animals, livestock products. [Campbell \(2000, 2007\)](#)
 - 1550–1750: Early Modern Probate Inventories Database. Animal stocking densities and indirect estimates of arable yields. [Overton \(1991, 2000\)](#) [Overton et al. \(2004\)](#)
 - 1700–1800: Modern Farm Accounts Database. Sample of farmers accounts. [Turner et al. \(2001\)](#)

Britain's agricultural output

Number of sampled farm enterprises per year



Source: Broadberry et al. (2015)

Manorial accounts (1250–1550)

- Seigniorial domain accounts: crops, animals, livestock products, capital equipment.
- Biases in manorial accounts:
 - Bias toward large ecclesiastical estates.
 - Uneven geographical coverage: bias to the south and east.
 - Non-seigniorial sector large (75%) and not represented.
- Solutions:
 - Weighting scheme for regional imbalances.
 - Auxiliary information for non-seigniorial sector (tax and tithe returns from peasant holdings) showing strong correlation in crop yields across sectors.

Probate inventories (1550–1750)

- Comparable information to manorial accounts.
- Available at death of farmer, with quantities and values of crops stored on farm and livestock.
- Biases in the Probate Inventories Database:
 - Omissions of large parts of northern, midland, southern England (8 of 43 counties, most in the east).
 - One-off observation occasioned by deaths of farmers.
 - Crop acreages available but not grain yield, so assumptions needed.
 - Under representation of very large and very small farms.

Farmers accounts (1700–1800)

- Paradoxically, least well-documented period.
- Sample of farms accounts starting in the 1720s.
- Biases in farmers accounts:
 - Less standardized than late-medieval period.
 - No information on land acreage or crops sown and harvested, not always animals.
 - Uneven coverage over time and space (though more even than other sources).
 - Selection of farmers who keep proper accounts.

Britain's agricultural output

- Agricultural output = acreage per crop \times yield per acre.
- Deduce grain used as seed and as fodder for working animals.

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- Agricultural land use:
 - Start with survey of farmland in 1871: 43% of land for agriculture.
 - Account for population changes and density, changes in potential arable land through drainage of wetland, deserted medieval villages.
 - Get 39% of land area for agriculture in 1290.
 - Interpolate in between.

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 - Get 39% of land area for agriculture in 1290.
 - Interpolate in between.
- Then allocate arable land between crops from the three databases (wheat, rye, barley, oats, potatoes).

Britain's agricultural output

Changes in the distribution of arable land (1290–1871)

Region	Estimated arable acreage, 1290	Arable as % total area, 1290	Recorded arable acreage, 1871	Arable as % total area, 1871	Net change in arable area, 1290–1871	Net change in % arable, 1290–1871
Eastern counties	2,810,950	58.8	3,056,568	63.0	245,618	4.2
NE midlands	1,200,070	49.0	952,758	39.2	-247,312	-9.8
Northeast	1,622,420	27.6	1,950,640	34.1	328,220	6.5
Northwest	708,220	17.4	1,016,285	24.5	308,065	7.1
Southeast	3,268,150	48.4	3,516,531	51.2	248,381	2.8
Southwest	639,370	25.0	1,031,253	40.6	391,883	15.6
SW midlands	1,506,550	44.9	1,311,922	39.0	-194,628	-5.9
West midlands	994,270	40.2	1,007,413	41.9	13,143	1.7
ENGLAND	12,750,000	39.4	13,843,370	42.8	1,093,370	3.4

Source: Broadberry et al. (2015)

Britain's agricultural output

Composition of arable land use (1290–1871, millions of acres)

Year	Wheat	Rye/maslin	Barley/dredge	Oats	Pulses	Potatoes	Other crops	Total sown	Fallow arable	Total arable
1270	2.21	0.72	1.23	2.94	0.29	0.00	0.00	7.40	5.13	12.52
1300	2.68	0.60	1.27	3.16	0.45	0.00	0.00	8.16	4.56	12.72
1380	1.83	0.36	1.22	1.87	0.47	0.00	0.00	5.75	3.89	9.64
1420	1.61	0.32	1.17	1.66	0.45	0.00	0.00	5.21	3.53	8.75
1450	1.53	0.31	1.15	1.59	0.44	0.00	0.00	5.03	3.41	8.44
1500	1.58	0.37	1.19	1.56	0.47	0.00	0.10	5.26	3.24	8.50
1600	1.85	0.77	1.44	1.32	0.61	0.00	0.72	6.72	2.16	8.87
1650	2.00	0.39	1.86	1.13	1.02	0.00	1.36	7.74	1.88	9.63
1700	1.99	0.42	1.82	1.15	0.98	0.00	1.30	7.64	1.91	9.56
1750	1.95	0.06	1.50	1.82	0.98	0.08	2.53	8.92	1.59	10.51
1800	2.51	0.06	1.46	1.97	0.83	0.17	2.90	9.91	1.28	11.19
1830	2.12	0.06	1.81	1.27	0.63	0.26	4.46	10.62	1.30	11.91
1871	3.31	0.06	1.96	1.45	0.90	0.39	5.28	13.35	0.48	13.84

Source: Broadberry et al. (2015)

Britain's agricultural output

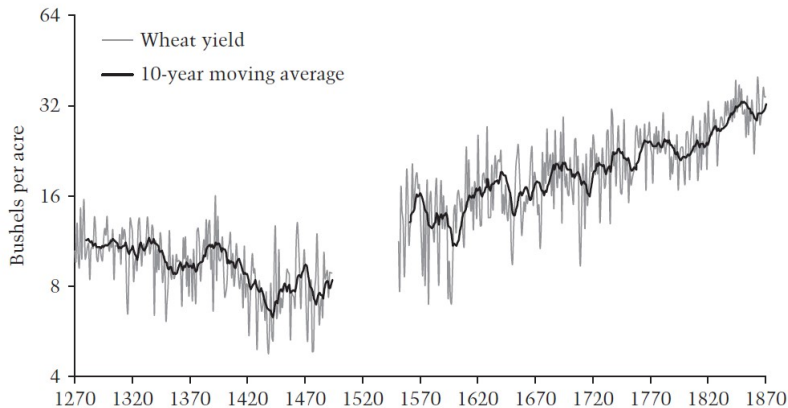
- Grain yield per acre and crop, net of seed sown.
- Use regression analysis:

$$\ln(\text{Yield}_{it}) = \alpha + \beta_i + \gamma_j + \delta_t + \varepsilon_{it}$$

- Yield_{it} : yield of farm i in year t .
 - β_i : location fixed effect.
 - γ_j : region fixed effect.
 - δ_t : year fixed effect.
- Get index of national trend.
 - Absolute levels obtained by using regional shares of sown areas for each crop.

Britain's agricultural output

English weighted national average gross crop yields per acre (bushels, log scale)



Source: Broadberry et al. (2015)

Britain's agricultural output

Total arable output net of seed and animal consumption (million bushels)

Decade	Wheat (m. bus.)	Rye (m. bus.)	Barley (m. bus.)	Oats (m. bus.)	Pulses (m. bus.)	Potatoes (m. bus.)
1270s	18.85	8.94	14.44	20.45	0.44	
1300s	20.88	5.95	14.91	19.12	1.43	
1350s	12.02	2.72	10.91	8.93	0.95	
1400s	10.35	2.02	12.56	7.29	0.98	
1450s	7.69	2.80	9.69	8.58	0.82	
1500s	ND	ND	ND	ND	ND	
1550s	17.08	3.83	11.82	8.14	1.74	ND
1600s	20.70	7.85	18.59	8.44	4.01	ND
1650s	27.01	3.70	33.50	6.14	6.53	ND
1700s	27.94	6.70	35.20	5.70	8.25	1.27
1750s	31.48	1.51	39.67	13.03	9.03	13.56
1800s	46.32	1.36	42.67	14.06	11.07	26.70
1850s	73.69	1.09	58.23	15.93	9.57	44.79
1860s	86.07	0.98	57.00	16.33	11.42	47.72

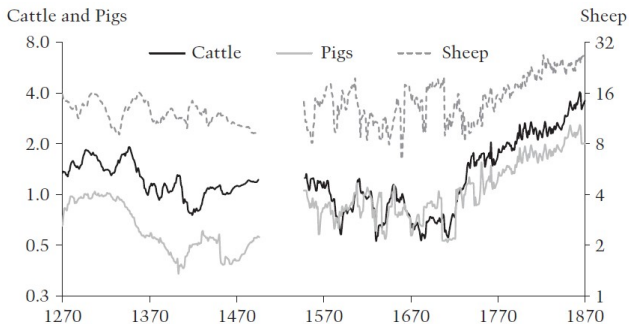
Source: Broadberry et al. (2015)

Britain's agricultural output

- Livestock farming is a function of:
 - Number of non-working livestock.
 - Proportion producing milk, meat, hides, skins, wool, and tallow.
 - Respective yields per animal.
- Derived from databases and applying regional weighting scheme.
- Same method: regression to get aggregate trend, then weighting per region.

Britain's agricultural output

Number of non-working livestock (millions, log scale)



Source: Broadberry et al. (2015)

Britain's agricultural output

Percentages of the animal stock producing specific livestock products

Year	<i>% of animals producing</i>					
	<i>Milk</i>	<i>Beef</i>	<i>Veal</i>	<i>Mutton</i>	<i>Pork</i>	<i>Wool</i>
1300	90	15	14.1	26	49	90
1700	90	25	21.1	26	49	90
1850	90	33	25.0	40	100	80

Source: Broadberry et al. (2015)

Britain's agricultural output

Milk, meat, and wool yields per animal

Decade	Milk (gals)	Beef (lbs)	Veal (lbs)	Mutton (lbs)	Pork (lbs)	Wool (lbs)
1270s	100.00	168.00	29.00	22.00	64.00	1.63
1300s	100.96	169.26	29.22	22.14	64.11	1.48
1350s	112.27	183.91	31.79	23.81	65.36	1.81
1400s	124.83	199.82	34.59	25.60	66.64	1.49
1450s	138.81	217.11	37.63	27.52	67.94	1.24
1500s	ND	ND	ND	ND	ND	ND
1550s	172.35	257.50	44.74	31.96	70.62	1.64
1600s	200.66	294.44	51.22	36.18	72.00	1.88
1650s	233.63	336.68	58.63	40.97	75.85	2.17
1700s	272.01	384.98	67.12	46.39	86.56	2.51
1750s	316.69	440.22	76.84	52.53	98.78	2.91
1800s	368.72	503.37	87.96	59.49	112.72	3.38
1850s	429.29	575.59	100.69	67.36	128.63	3.92
1860s	443.90	592.82	103.73	69.22	132.42	4.05

Source: Broadberry et al. (2015)

Britain's agricultural output

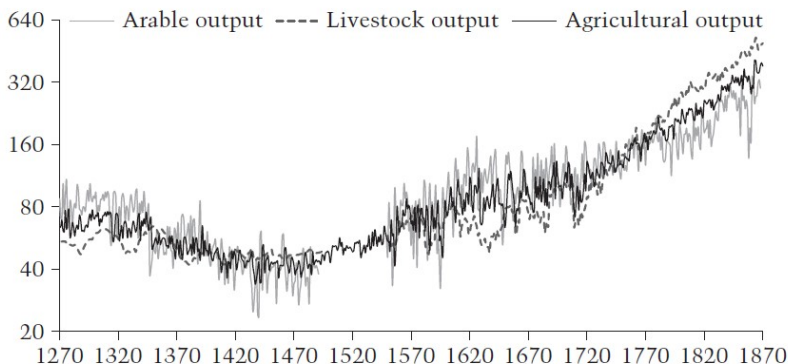
Total outputs of milk, meat, wool, hides, and hay

Decade	Milk (m. gals)	Beef (m. lbs)	Veal (m. lbs)	Mutton (m. lbs)	Pork (m. lbs)	Wool (m. lbs)	Hides (m. lbs)	Hay (m. tons)
1270s	42.09	10.57	1.98	81.33	26.13	20.84	6.29	0.12
1300s	54.45	13.72	2.63	90.49	30.82	20.89	7.34	0.11
1350s	51.46	13.52	2.56	94.49	21.33	24.82	7.36	0.12
1400s	45.25	12.39	2.32	75.11	12.38	15.13	6.32	0.10
1450s	44.92	12.83	2.37	83.90	14.06	13.11	6.59	0.09
1500s	ND	ND	ND	ND	ND	ND	ND	ND
1550s	63.94	19.85	3.58	79.32	31.39	14.08	7.54	0.15
1600s	58.56	19.06	3.40	157.49	33.51	28.34	9.90	0.24
1650s	72.52	24.83	4.35	130.85	31.14	23.95	10.51	0.29
1700s	59.10	21.16	3.67	211.92	39.93	39.09	13.12	0.34
1750s	163.19	62.94	10.50	217.12	84.40	34.12	21.73	0.55
1800s	279.75	115.99	18.54	422.49	170.63	56.62	38.50	1.37
1850s	434.05	192.64	28.28	616.27	297.43	71.66	53.08	1.93
1860s	492.79	217.85	31.99	713.12	293.05	83.36	58.34	1.94

Source: Broadberry et al. (2015)

Britain's agricultural output

Total arable, livestock, and agricultural output (log scale, 1700=100)



Source: Broadberry et al. (2015)

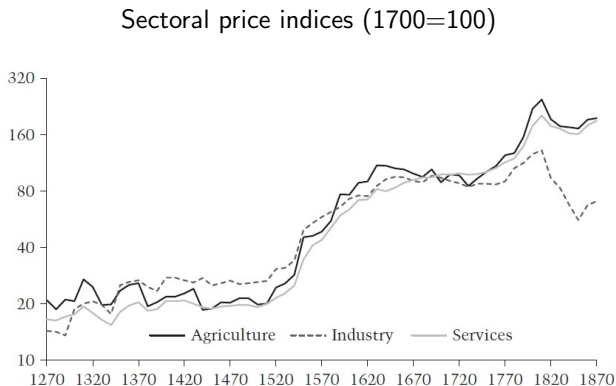
Britain's agricultural output

- Total value of net agricultural output is the product of volumes and respective prices.
- First, need to construct a (constant) price series of each output.
- Second, compute the share of each output in total value.
- Third, shares are used as weights in the construction of the agricultural real output index.
- Fourth, divide by population to get per capita output.

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- See later for predictions on data scarce periods.

Britain's agricultural output



Source: Broadberry et al. (2015)

Britain's agricultural output

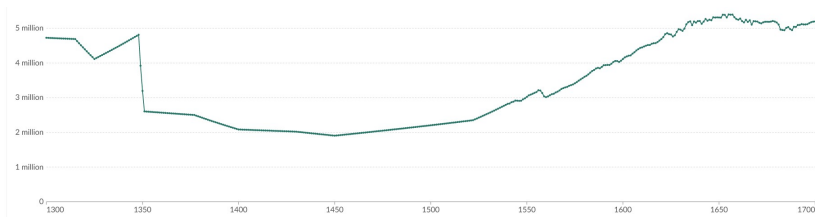
Current and constant-price shares of outputs in agriculture

Decade	Current prices		Constant 1700 prices		
	<i>Arable</i> (%)	<i>Livestock</i> (%)	<i>Arable</i> (%)	<i>Livestock</i> (%)	Total agricultural output (1700 = 100)
1270s	60.1	39.9	69.2	30.8	62
1300s	51.2	48.8	66.4	33.6	67
1350s	48.8	51.2	53.3	46.7	51
1400s	46.3	53.7	57.5	42.5	45
1450s	38.4	61.6	53.1	46.9	47
1500s	ND	ND	ND	ND	52
1550s	58.1	41.9	60.5	39.5	56
1600s	58.1	41.9	58.8	41.2	83
1650s	64.5	35.5	64.0	36.0	103
1700s	59.7	40.3	61.5	38.5	112
1750s	57.8	42.2	54.6	45.4	138
1800s	48.5	51.5	45.3	54.7	225
1850s	44.8	55.2	44.2	55.8	341
1860s	40.0	60.0	44.3	55.7	375

Source: Broadberry et al. (2015)

Britain's agricultural output

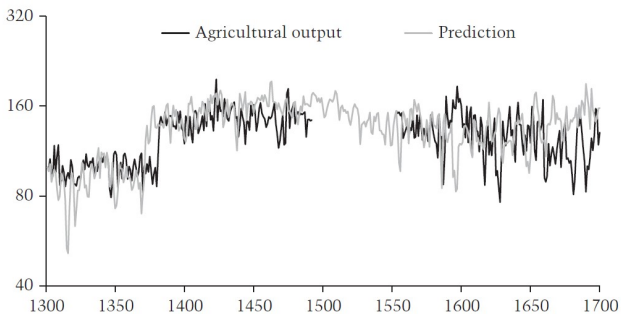
Population of England



Source: Our World in Data, Bank of England (2014)

Britain's agricultural output

Agricultural output per head (log scale, 1300=100)



Source: Broadberry et al. (2015)

Britain's industrial output

- Methodology similar to agricultural output:
 - Output in volumes for each sector.
 - Construct (constant) price series for each sector.
 - Compute share of each output in total value.
 - Use shares as weights in the construction of output index.
 - Divide by population.

Britain's industrial output

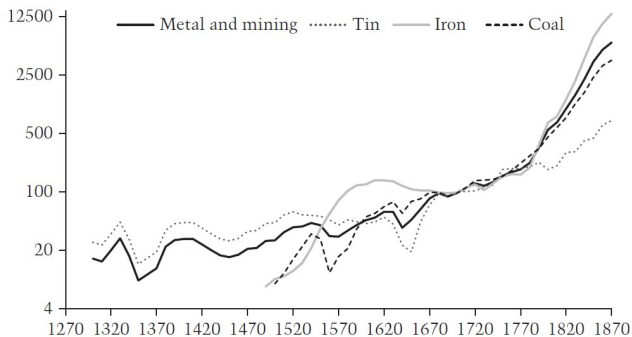
- Methodology similar to agricultural output:
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 - Compute share of each output in total value.
 - Use shares as weights in the construction of output index.
 - Divide by population.
- Additional issue: value added and double-counting.
 - Project back value added weights in specific benchmark year.
 - When possible, distinguish between degree of processing (pig iron vs bar iron).

Britain's industrial output

- Many databases for the main industrial sectors up to 1700:
 - Metals and mining:
 - Iron: capacity of blast furnaces and periods of activity. [King \(2005\)](#)
 - Tin: receipts of coinage dues. [Hatcher \(1973\)](#)
 - Textiles and leather:
 - Wool and woolen cloth: detailed export records. [Carus-Wilson and Coleman \(1963\)](#)
 - Leather and food processing: reconstruction of agricultural sector. [Broadberry et al. \(2015\)](#)
 - Other sectors:
 - Food processing: reconstruction of agricultural sector. [Broadberry et al. \(2015\)](#)
 - Construction: cathedral building, house building (urban population).
 - Book production: titles listed by British Library.

Britain's industrial output

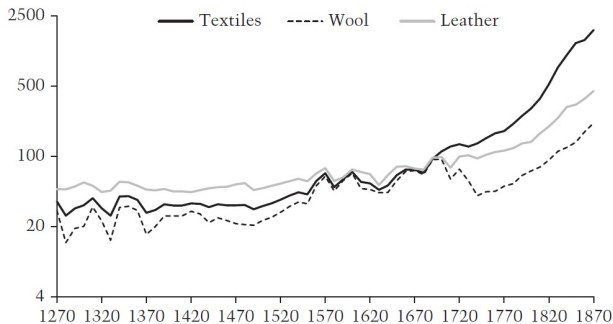
Output of metals and mining industries (log scale, 1700=100)



Source: Broadberry et al. (2015)

Britain's industrial output

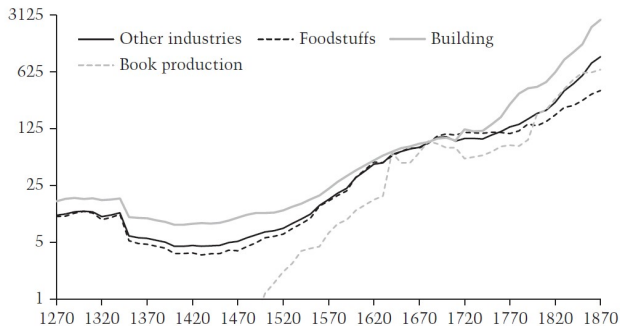
Output of textile and leather industries (log scale, 1700=100)



Source: Broadberry et al. (2015)

Britain's industrial output

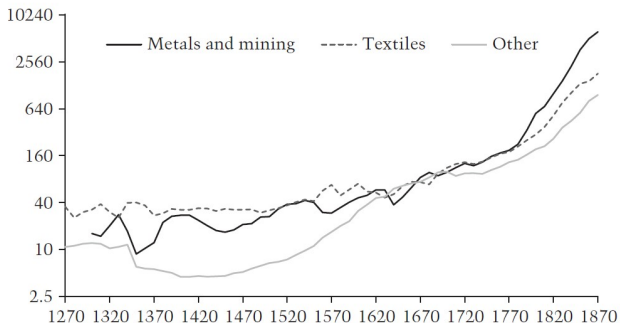
Output of other industries (log scale, 1700=100)



Source: Broadberry et al. (2015)

Britain's industrial output

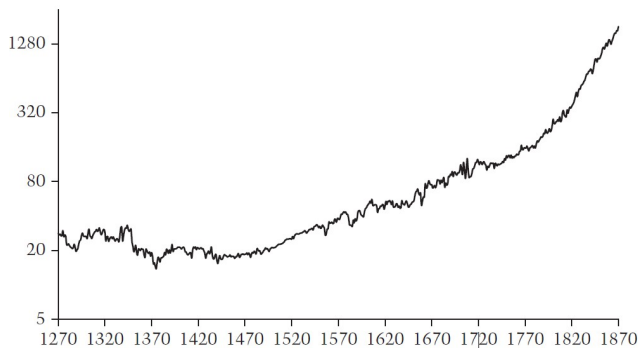
Industrial output by major sub-sectors (log scale, 1700=100)



Source: Broadberry et al. (2015)

Britain's industrial output

Industrial output (log scale, 1700=100)



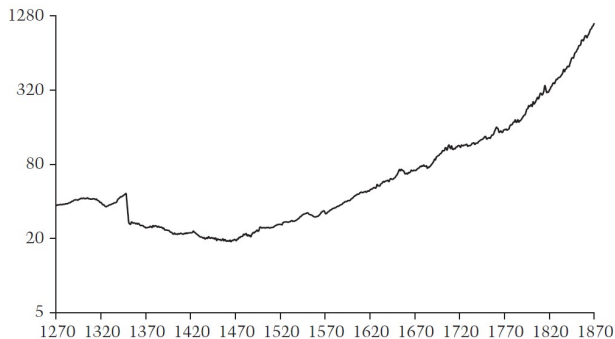
Source: Broadberry et al. (2015)

Britain's services sector output

- Method from [Deane and Cole \(1962\)](#).
- Broken down into subsectors:
 - Commerce: trade, freight transport, financial services.
 - Housing and domestic services: rate of population growth.
 - Government: revenues. [O'Brien and Hunt \(1999\)](#)

Britain's services sector output

Service-sector output (log scale, 1700=100)

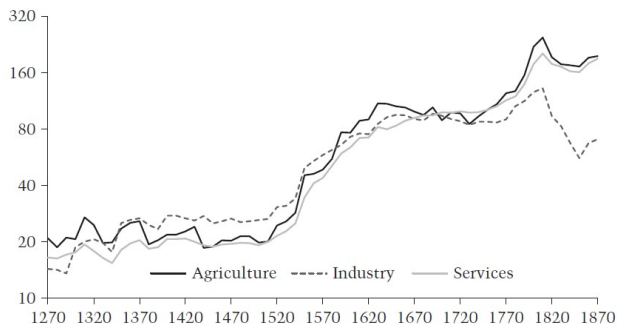


Source: Broadberry et al. (2015)

- Putting things together:
 - Combine output series with sectoral weights based on input-output tables for 1841 to adjust for double accounting. [Horrell et al. \(1994\)](#)
 - Use price series to convert into nominal series. [Clark \(2004, 2005, 2006\)](#) [Beveridge \(1939\)](#)
 - Create a chained index of GDP.
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- Attempts from income side, but changes in working hours (“industrious revolution” 1700–1820).

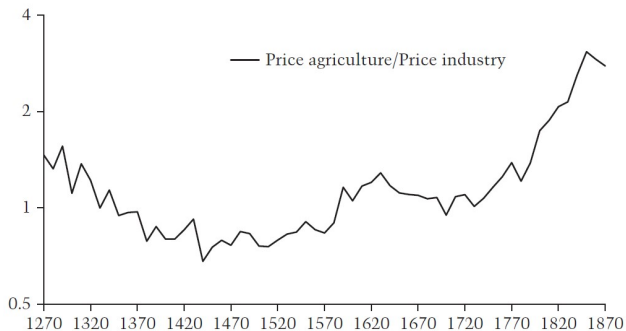
Sectoral price indices (1700=100)



Source: Broadberry et al. (2015)

Britain's GDP

Inter-sectoral terms of trade (log scale, 1700=100)



Source: Broadberry et al. (2015)

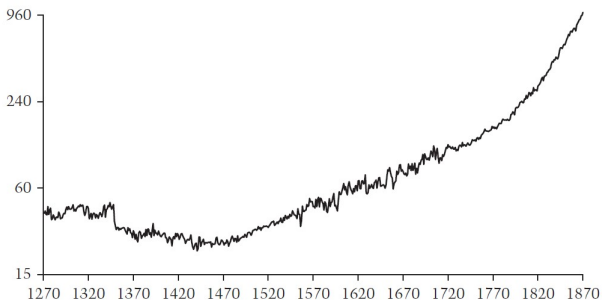
Sectoral shares in nominal GDP

Year	Territory	<i>Agriculture (%)</i>	<i>Industry (%)</i>	<i>Services (%)</i>	<i>Total (%)</i>
1381	England	45.5	28.8	25.7	100.0
1522	England	39.7	38.7	21.6	100.0
1600	England	41.1	36.2	22.7	100.0
1700	England	26.7	41.3	32.0	100.0
	and Britain				
1759	Britain	29.7	35.2	35.1	100.0
1801	Britain	31.3	32.7	36.0	100.0
1841	Britain	22.1	36.4	41.5	100.0

Source: Broadberry et al. (2015)

Britain's GDP

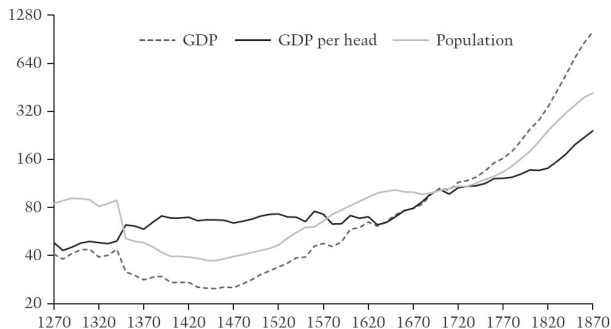
Real GDP (log scale, 1700=100)



Source: Broadberry et al. (2015)

Britain's GDP

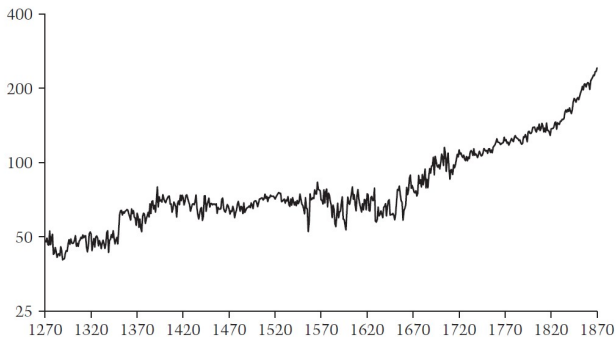
Real GDP, population, and real GDP per capita (log scale, 1700=100)



Source: Broadberry et al. (2015)

Britain's GDP

Real GDP per capita (log scale, 1700=100)



Source: Broadberry et al. (2015)

Methods for data-scarce nations

- Rely on modelling and proxies.

Methods for data-scarce nations

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- Instead of measuring agricultural output, derive it from demand for food. [Allen \(2000\)](#)

$$Q^A = rcN$$

- Q^A : real agricultural output.
- r : ratio of production to consumption (often $r = 1$).
- c : per capita consumption.
- N : population.

Methods for data-scarce nations

- Real consumption per capita assumed to be a function of its own real price (P^A/P), real prices of other goods (P^{NA}/P) and real income per capita (y).

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- Real consumption per capita assumed to be a function of its own real price (P^A/P), real prices of other goods (P^{NA}/P) and real income per capita (y).
- In log-linear form:

$$\ln c = \alpha_0 + \alpha_1 \ln \left(P^A/P \right) + \alpha_2 \ln \left(P^{NA}/P \right) + \beta \ln y$$

- P^A/P : agricultural product prices in real terms.
- P^{NA}/P : non-agricultural product prices in real terms.
- y : real income per capita.
- α_0 : constant.
- α_1 : own-price elasticity of demand.
- α_2 : cross-price elasticity of demand.
- β : income elasticity of demand.

- Adding-up property of linear demand:

$$\alpha_1 + \alpha_2 + \beta = 0$$

Methods for data-scarce nations

- Adding-up property of linear demand:

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- Values from developing countries:
 - $\alpha_1 = -0.6$.
 - $\alpha_2 = 0.1$.
 - $\implies \beta = 0.5$.
- With price and wage series, get agricultural output from income side.

- Estimate non-agricultural output Q^{NA} :

$$Q = Q^A + Q^{NA} \iff Q = \frac{Q^A}{1 - (Q^{NA}/Q)}$$

- Q^{NA}/Q : share non-agricultural output.

\implies Proxied by urbanization rate, e.g., Bairoch (1988).

- Many use long-run estimate inappropriately.
- Careful to distinguish direct and indirect approaches.
- Same series can mix both e.g. Netherlands pre-1510 vs 1510–1807.
van Zanden and van Leeuwen (2012)

Data reliability grades

A. Data reliability grades		
Reliability grade	Margin of error	Average margin of error
A. Firm figures	\pm less than 5%	\pm 2.5%
B. Good figures	\pm 5% to 15%	\pm 10%
C. Rough estimates	\pm 15% to 25%	\pm 20%
D. Conjectures	\pm more than 25%	\pm 40%

Source: Broadberry (2021) based on Feinstein (1972)

Data reliability grades

B. Reliability assessments for GDP in the Netherlands, China, and Japan	
	Grade
<i>Netherlands</i>	
1347-1510	C
1510-1650	B
1650-1750	A
1750-1807	B
<i>China</i>	
Northern Song (980-1120)	B
Ming (1400-1620)	B
Qing (1690-1840)	A
<i>Japan</i>	
Ancient (730-1150)	D
Medieval (1250-1450)	C
Tokugawa (1600-1846)	B

Source: Broadberry (2021) based on van Zanden and van Leeuwen (2012) and Broadberry, Guan and Li (2018)

Comparisons over time and space

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- Benchmark: 1990 GKI\$ 400 \simeq subsistence level.

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- Main point of HGDP is not precision but order of magnitude.
- Still: need reliable comparative picture of living standards.

⇒ Don't take Maddison at face value, check underlying sources.

The Great Divergence

Victor Gay

Visiting professor at University of Michigan

Toulouse School of Economics

Institute for Advanced Study in Toulouse

Winter 2024



Toulouse
School of
Economics

When did countries first start to diverge?

Broadberry (2021) Goldstone (2021)

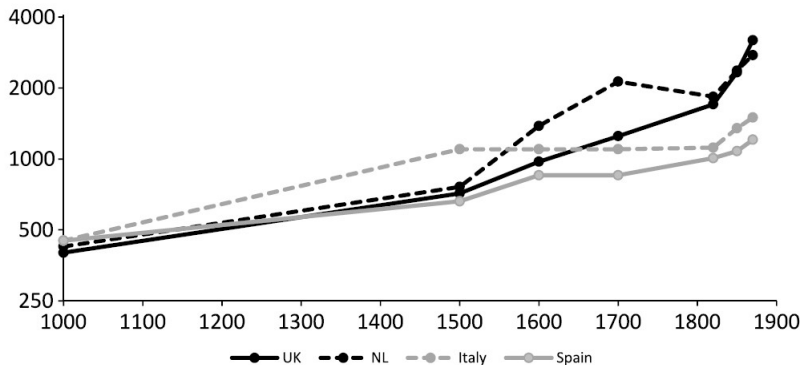
- Europe's Little Divergence
- Asia's Little Divergence
- The Great Divergence
- Reconsidering the Great Divergence

Revising past views

- First global historical estimates by Maddison (2001) *The World Economy: A Millennial Perspective*.
- Traditional view: gap in living standards between Europe and Asia starting in 1500, perhaps 1300.
- Revising traditional view: Pomeranz (2000) argues gap emerged after 1800.
- Latest estimates: Great Divergence around 1700.
- Careful re-examination of recent data sources: probably later, in the late 1700s.

Europe's Little Divergence

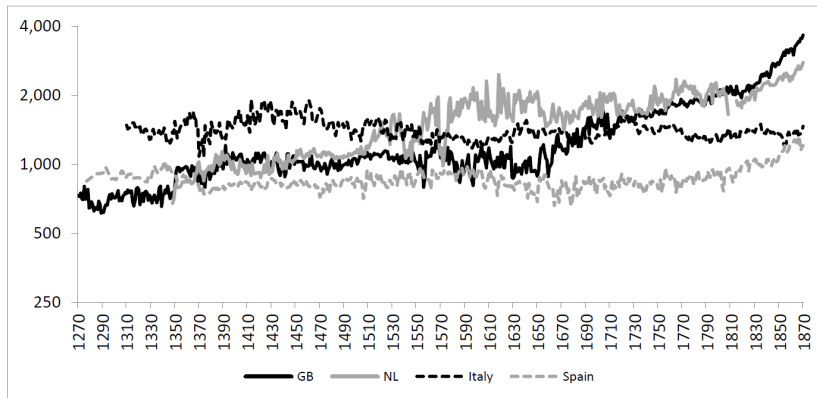
GDP per Capita in Europe, 1270–1870 (1990 GK\$, Log scale)



Source: Broadberry (2021) based on Maddison (2010).

Europe's Little Divergence

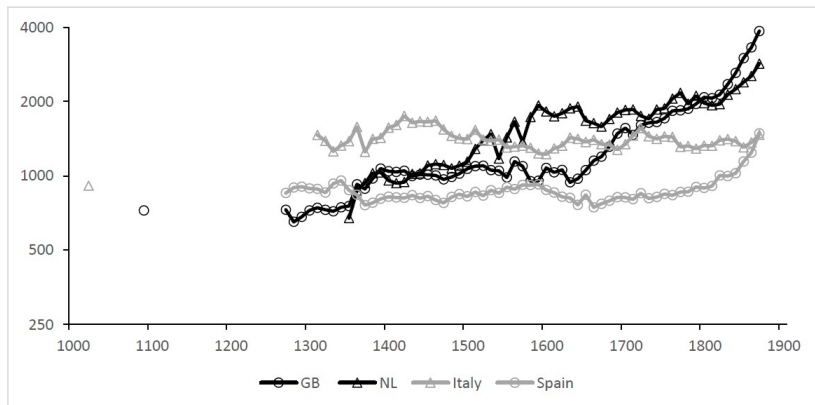
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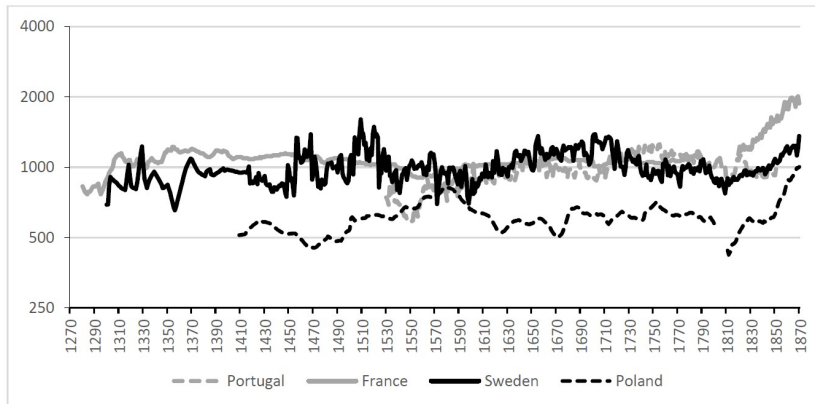
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Source: Broadberry (2020) based on Palma and Reis (2019), Ridolfi (2016), Krantz (2017), Schon and Krantz (2012), Malinowski and van Zanden (2017).

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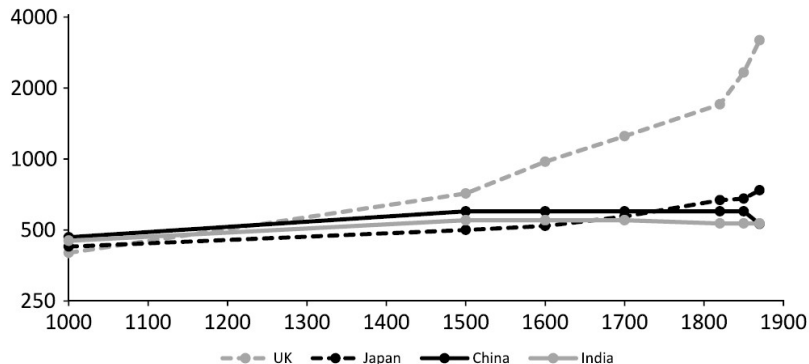
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⇒ Europe's Little Divergence (North-West vs rest) circa 1500

Asia's Little Divergence

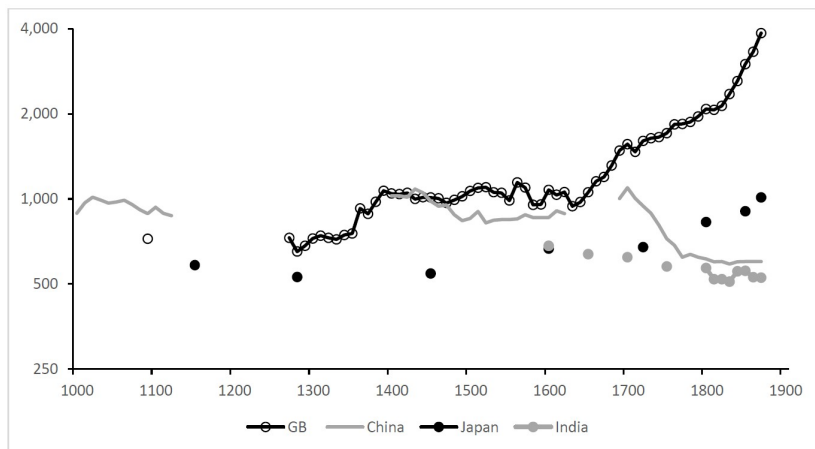
GDP per Capita in Asia, 1000–1870 (1990 GK\$, Log scale)



Source: Broadberry (2021) based on Maddison (2010).

Asia's Little Divergence

GDP per Capita in Asia, 1000–1870 (1990 GKIS\$, Log scale)



Source: Broadberry (2021) based on Broadberry et al. (2015), Broadberry, Guan and Li (2018), Bassino, Broadberry, Fukao, Gupta and Takashima (2015), Broadberry, Custodis and Gupta (2015)

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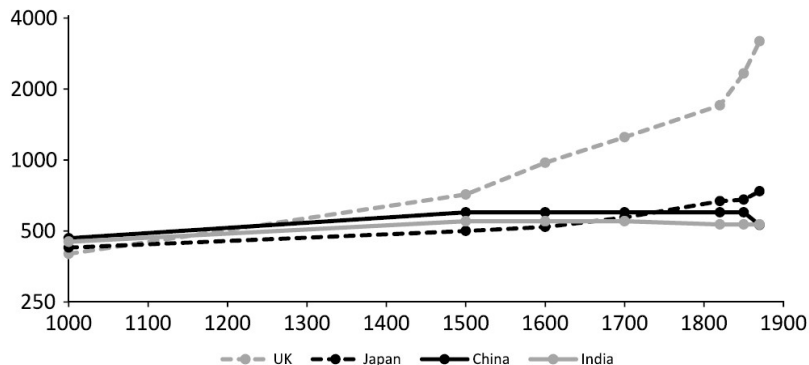
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⇒ Asia's Little Divergence (Japan vs China) circa 1700

The Great Divergence

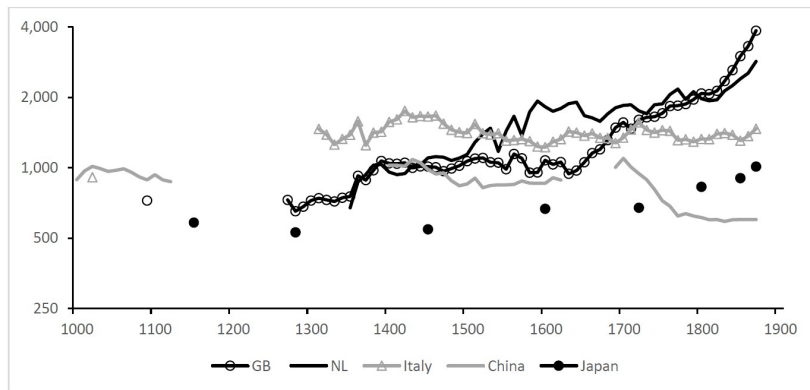
GDP per Capita in Asia, 1000–1870 (1990 GK\$, Log scale)



Source: Broadberry (2021) based on Maddison (2010).

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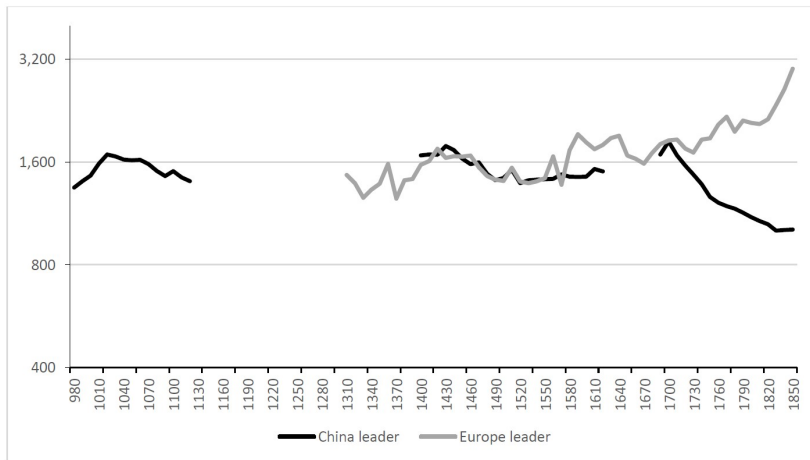
GDP per Capita in Europe and Asia, 1000–1870 (1990 GK\$, Log scale)



Source: Broadberry (2020) based on Broadberry et al. (2015), van Zanden and van Leeuwen (2012), Malanima (2011), Broadberry, Guan and Li (2018), Bassino, Broadberry, Fukao, Gupta and Takashima (2015).

The Great Divergence

GDP per Capita in Leading Regions of China and Europe, 980–1850 (1990 GK\$, Log scale)



Source: Broadberry (2020) based on Broadberry, Guan and Li (2018).

The Great Divergence

- Year 1000:
 - Leadership of China at \$1,000.
 - Italy \simeq \$ 911; Britain \simeq \$ 723.

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- Year 1000:
 - Leadership of China at \$1,000.
 - Italy \simeq \$ 911; Britain \simeq \$ 723.
- Did Great Divergence start 13–14th?
 - China much larger than any European country (160M vs 19M France in 1600).
 - Compare leading regions (Yangzi Delta vs Italy, NL, UK)

The Great Divergence

- Year 1000:
 - Leadership of China at \$1,000.
 - Italy \simeq \$ 911; Britain \simeq \$ 723.
- Did Great Divergence start 13–14th?
 - China much larger than any European country (160M vs 19M France in 1600).
 - Compare leading regions (Yangzi Delta vs Italy, NL, UK)

⇒ The Great Divergence (Europe vs Asia) circa 1700

Reconsidering the Great Divergence

Goldstone (2021)

- Modern economic growth is sustained growth in income per capita *together* with population growth.
- Might be later than 1700, probably late 1700s:
 - Holland: no gain in per capita income for 200 years after 1600.
 - Britain: no sustained simultaneous growth of per capita income and population during same half-century prior to 1750.
 - Global comparisons: gains in Britain and Holland in 1750–1800 not unprecedented.

Reconsidering the Great Divergence: Holland

- The Malthusian trap was broken by Schumpeterian growth several times before industrialization, though for only a few decades.
- In Europe: Renaissance Italy or Golden Age Holland.
- Holland's Golden Age in 15–16th century:
 - Cluster of innovations in ship design, construction, commercial farming, use of wind power and hydraulics.
 - Collapse of Antwerp mid-16th: dominance of Holland over Baltic and north Atlantic trade.
 - But surging population halted gains early 17th, leading to long stagnation.

Reconsidering the Great Divergence: Holland

GDP and GDP per capita in Holland (1510–1800, constant 1800 guilders)



Source: Goldstone (2021).

Reconsidering the Great Divergence: Holland

Growth in Holland (1510s–1800s, 1500 levels = 100)

	GDP	GDP growth since prior date	Pop	Population growth since prior date	GDP/cap	GDP/cap growth since prior date
1510s	100		100		100	
1540s	111.1	.35	121.4	.64%	91.4	−.30%
1590s	241.0	1.56%	166.4	.63%	144.7	.92%
1640s	389.0	.96%	271.4	.98%	143.3	−.02%
1700s	418.5	.12%	301.6	.18%	138.8	−.05%
1800s	407.9	−.03%	269.9	−.11%	151.2	.08%

Source: Goldstone (2021).

Reconsidering the Great Divergence: Holland

- 1540s–1560s: strong growth until Dutch war for Independence with Spain and structural change (stable hereafter).
 - Share of agriculture: 22%→13%→11% (1750s).
 - Share of industry: 30%→22%→30% (1750s).
 - Share of services: 48%→65%→59% (1750s).
- Stagnation after the 1640s:
 - 1540–1640: growth of GDP by 300%.
 - 1640–1750: growth of GDP by 5%.
 - 1750–1790: growth of GDP by 10%.

Reconsidering the Great Divergence: Holland

- The break of Malthusian trap was short-lived.
 - 1540s–1590s: GDP per capital growth of 56% (0.9% per year), with population growth of 37%.
 - 1590s–1670s: population growth $>$ GDP growth.
 - 1670s–1800s: population decline.
- GDP per capita of 1590s not reached until 1760s.
- Holland did not achieve modern economic growth until after 1800s.

Reconsidering the Great Divergence: Britain

- Clear break with Malthusian patterns by 1700 or 1800, after industrialization?

Growth in Britain (1270s–1860s)

	Population	Real GDP per head
England		
1270s–1300s	.23	−.02
1300s–1340s	−.06	.07
1340s–1400s	<u>−1.32</u>	<u>.57</u>
1400s–1450s	−.14	−.07
1450s–1500s	.29	.11
1500s–1550s	.66	−.16
1550s–1600s	.64	.18
1600s–1650s	.45	−.05
1650s–1700s	<u>−.06</u>	<u>.79</u>
Great Britain		
1700s–1750s	.31	.18
1750s–1800s	.82	.39
1800s–1830s	1.43	.41
1830s–1860s	1.17	1.15

Source: Goldstone (2021).

Reconsidering the Great Divergence: Britain

- Only two periods see rapid gains in GDP per capita in 1270s–1750s.
 - 1340s–1400s: 0.57% per year.
 - 1650s–1700s: 0.79% per year.
 - Average for other periods pre-1750s: 0.0003% per year (12% overall).

Reconsidering the Great Divergence: Britain

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 - 1340s–1400s: 0.57% per year.
 - 1650s–1700s: 0.79% per year.
 - Average for other periods pre-1750s: 0.0003% per year (12% overall).
- Two episodes due to population decline:
 - 1340s–1400s: Black Death (reaching Spain of 1250s, far behind Italy).
 - 1650s–1700s: also slight population decline (-0.6% per year), with little structural change.

Reconsidering the Great Divergence: Britain

- Is 1700s–1750s modern economic growth?
 - GDP per capita growth of 0.18% per year.
 - Weak population growth (lower than any half-century of growth since 1450s).
 - Similar patterns as those before, e.g., 1550s.
- Onset in modern economic growth no earlier than 1750s.

Reconsidering the Great Divergence: Britain

- Break from prior trends after 1750? According to Broadberry et al. (2015), yes: strong population and GDP per capita growth.
- But doubts about validity of estimates for agricultural output of Broadberry et al. (2015) for 1700–1800.
 - Broadberry et al. (2015) claim GDP per capita growth in agriculture of 0.55% per year 1700s–1750s and 0.93% per year 1750s–1800s.
 - Using a demand-side approach, Nuvolari and Ricci (2013) find decline in 1750s–1800s. Allen (2000) also.
 - Clark (2018) finds similar results (overall decline of 35% rather than growth of 5%).

Reconsidering the Great Divergence: Britain

Estimates for agricultural output in Britain (1500s–1800s)

	Allen	Nuvolari/Ricci	Clark	Broadberry et al.
1500/22	131.2	126.4	140.3	117.1
1550s	102.9	119.5	81.3	97.5
1600s	84.3	93.0	95.0	100.9
1650s	90.7	93.2	91.3	88.9
1700s	100	100	100	100
1750s	110.9	114.6	102.6	117.9
1800s	83.5	86.0	65.2	124.4

Source: Goldstone (2021).

Reconsidering the Great Divergence: Britain

- The devil is in the details.
 - Difference not in arable output but in livestock products output.
 - Broadberry: “Calculating the output of the livestock sector is more speculative than equivalent calculations for the arable sector”.
 - Broadberry: “Paradoxically, the least well-documented period is that nearest the present”.
 - Farm animals sparsely documented in farms accounts, which are already sparse.
 - Their numbers: 84 lb of meat per year per capita in 1800, compared to 110 in US and 81 in China today. Plausible?

Reconsidering the Great Divergence: Britain

- Trends in wages, consumption, and heights to assess Broadberry's findings.
 - Real wages: 0.28% annual gains in 1700s–1750s vs 0.18% in 1750s–1800s (Humphries and Weisdorf 2019).
 - Consumption: Decline in kilocalories consumed from 3,100 per day and person in 1700s to 2,800 in 1800s (Wrigley 2010).
 - Height: rise until the 1770s but decline to 1800s (Meredith and Oxley 2014).

Reconsidering the Great Divergence: Britain

Sensitivity of Broadberry et al.'s estimates

	Agricultural output	GDP	GDP/capita
(a) Broadberry et. al.			
1270s–1700s (England)	.10	.22	.18
1650s–1700s (England)	.20	.78	.79
1700s–1750s (Britain)	.55	.49	.18
1750s–1800s (Britain)	.93	1.21	.39
1700s–1800s (Britain)	.74	.85	.29
(b) Consensus of other scholars: 25% decline in average output/capita 1750–1800			
1270s–1700s (England)	.10	.22	.18
1650s–1700s (England)	.20	.78	.79
1700s–1750s (Britain)	.55	.49	.18
1750s–1800s (Britain)	.24	1.02	.20
1700s–1800s (Britain)	.40	.75	.19

Source: Goldstone (2021).

⇒ No break in patterns before 1780 besides 1650–1700 (<0.2% per year)

Reconsidering the Great Divergence

- Reconsidering the Great Divergence:
 - The Great Divergence was sudden and perhaps later than previously thought.
 - Identifying exactly when a departure from typical patterns of pre-modern growth in GDP per capita occurred is crucial for explaining that departure.
 - Still, “Rather than viewing the changes in the English economy which took place before the mid-18th century as part of a lengthy but unitary process which culminated as the Industrial Revolution, therefore, they should perhaps be regarded differently. Such changes may have been a necessary but were not a sufficient condition for the later transformation which took place” (Shaw-Taylor and Wrigley 2013).

Wages and Living Standards

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Winter 2024



Beyond historical GDP?

- Methodology
- Global estimates
- Challenges
- Real wages vs GDP per capita

Beyond historical GDP

- Alternative ways to measure historical living standards:
 - GDP per capita
 - Anthropometrics (height)
 - Life expectancy
 - Real wages

Wages and living standards

Arroyo and Gary (2023) De Zwart (2023)

- Real wages as a measure of living standards.
 - Tells what people earned and could afford at a time and place.
 - Wages and prices are relatively easy to collect.
 - Allow comparisons between regions and periods.
 - Captures short-term variation across time and short-distance variation across space.

Wages and living standards

Arroyo and Gary (2023) De Zwart (2023)

- Potential answers to many questions about underlying mechanisms of long-run development.
 - Skill-biased wage premia.
 - Integration of labor markets.
 - Demand for skills following technical and political changes.
 - Changes in inequality.

- Data sources for wages and prices in accounting books (Europe and Americas):
 - Public institutions (hospitals, churches, charities, municipal governments, the military).
 - Private businesses, plantations, manorial estates.
 - Households.

- Methodological issues:
 - Composition and weights of consumption basket.
 - Representativeness of occupation used.
 - Number of working days in a year.
 - Value of in-kind payments.
 - Nature of labor regime (labor market, home production, coercion).

- Solution: relate male wages to consumer basket based on caloric needs near subsistence level. [Allen \(2001\)](#)
 - Bare-bones basket = necessary nutrients + fuel (heating + lighting).
 - Initially: 1940 calories per day. Re-evaluated at 2100 calories per day. [Humphries \(2013\)](#) [Allen \(2015\)](#)
 - Income of male laborer relative to cost-of-living of household $\implies \times 3$ (wife + 2 children consuming half basket). Re-evaluated to $\times 4$.
 - Re-evaluations pushed down real wage levels, but same trends over time and space.
 - Normalize to subsistence level to get a “subsistence ratio”.

BB-baskets for Britain

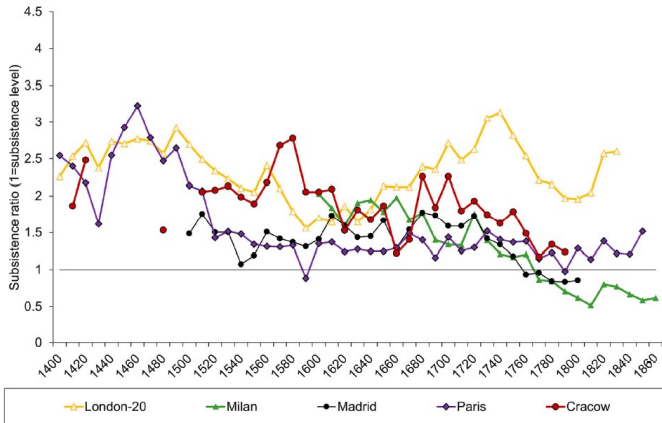
Item	Unit/Year	Allen et al., 2011	Allen, 2015
Energy Target per person	kcal	1940	2100
Main staple (Rye)	kg	180	197
Beans or peas	kg		20
Meat	kg		5
Butter	kg		3
Linen	m		3
Lamp oil	liter		1.3
Soap	kg		1.3
Candles	kg		1.3
Fuel	mBTU		3
Household multiplier	x	x 3	x 4
Household energy	kcal	5820	8400

Source: De Zwart (2023) based on Allen et al. (2011) and Allen (2015).

- The Little Divergence across Europe
- The Great Divergence between Europe and Asia
- The Americas

The Little Divergence across Europe

Men's real wages across Europe, computed using subsistence baskets



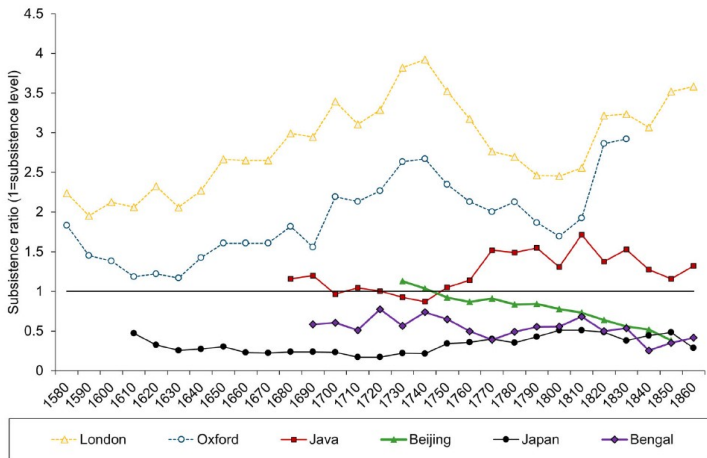
Source: De Zwart (2023) based on Allen (2001), Malanima (2013), Lopez Losa and Piquero (2021), Ridolfi (2019), and Malinowski (2016).

The Little Divergence across Europe

- Using historical GDP estimates, Little Divergence circa 1500 for Netherlands, and 1650 for Britain.
- Using standards of living, seems later: between 1700 and 1720.
- Downward long-run trend, except for Britain.

The Great Divergence between Europe and Asia

Men's real wages across Europe and Asia, computed using subsistence baskets



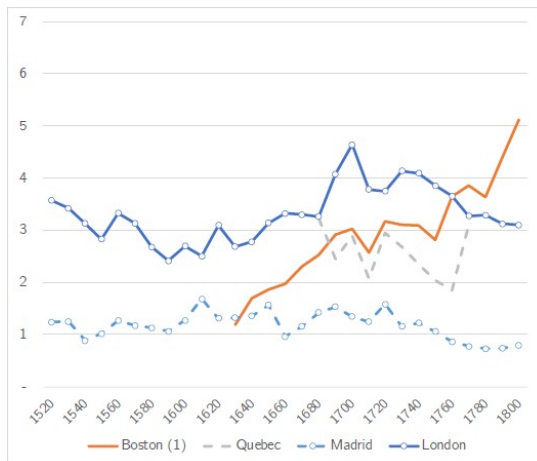
Source: De Zwart (2023) based on Allen et al. (2011), De Zwart and Van Zanden (2015), and Kumon (2022).

The Great Divergence between Europe and Asia

- Wages in China were relatively low and declining, as in India.
- Wages in Japan were extremely low, among the poorest in the world.
- Using historical GDP estimates, Great Divergence circo 1700.
- Using standards of living, seems earlier: perhaps before 1600s.

The Americas

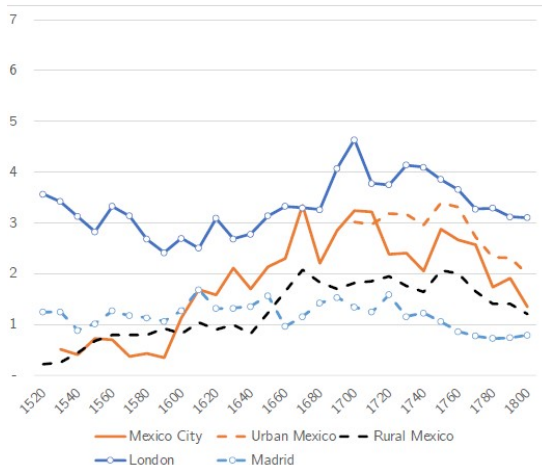
Men's real wages across Europe and the Americas, computed using subsistence baskets



Source: Arroyo and Gary (2023) based on Allen (2001), Losa and Zarauz (2021), and Geloso (2019).

The Americas

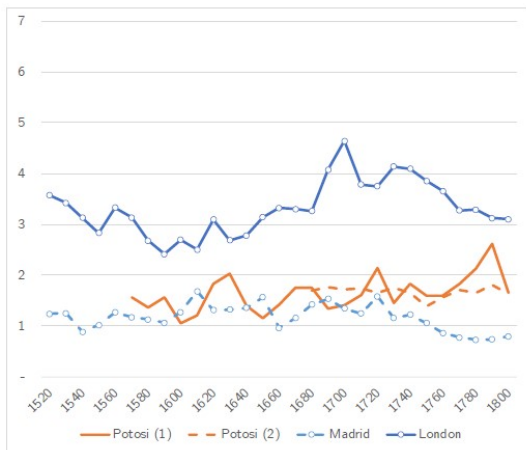
Men's real wages across Europe and the Americas, computed using subsistence baskets



Source: Arroyo and Gary (2023) based on Allen (2001), Allen et al. (2012), and Abad et al. (2012).

The Americas

Men's real wages across Europe and the Americas, computed using subsistence baskets



Source: Arroyo and Gary (2023) based on Allen (2001), Allen et al. (2012), and Abad et al. (2012).

- Welfare ratios in Latin America above subsistence levels after colonization, even rising somewhat after the end of forced labor.
- Despite colonization, wages not out of line with much of Europe.
- Exceptionalism in the United States since the 18th century.

- Challenges and issues when using this approach:
 - Numerator: wages and labor markets.
 - Denominator: prices and baskets.

Wages and labor markets

- Who's wages are compared?
- Are these wages representative for the population at large?
- How do real wages of urban workers compare to rural workers?
- How did systems of labor coercion affect real wages?
- Role of labor contracts and labor organizers for wages?

Wages and labor markets

- Main source of wage for historical comparisons: urban wages of construction workers.
 - Wage is main source of income, so indicates standard of living.
 - Technology for building stable across time and space.
 - Very good records, especially church construction.
- Are these representative?

Wages and labor markets

- Can be representative of broader wages if competitive local labor markets:
 - If wages $<$ standard in agriculture, then movement to agriculture \implies labor scarcity in urban areas \implies wage increases and vice-versa.
 - True if free movement from urban to rural areas.
 - Many instances of labor market systems of coercion (slavery, corvée).
 - Complicated by coexistence of “free” and “unfree” labor in the same area (e.g., Potosi).
- Still, rural and urban wages follow broadly similar long-run patterns, despite some short periods of divergence.

Wages and labor markets

- Often use daily wages to estimate annual real wages.
 - Assumptions on the length of the working year.
 - Typically 250 work days, but wide variation over space and time (e.g., 150 in Sweden).
 - Seasonality compounds these issues.

Wages and labor markets

- Often use daily wages to estimate annual real wages.
 - Assumptions on the length of the working year.
 - Typically 250 work days, but wide variation over space and time (e.g., 150 in Sweden).
 - Seasonality compounds these issues.
- One solution: annual wages based on annual work contracts.
 - Compare with daily wages trends if convergence or divergence.
[Humphries and Weisdorf \(2015, 2019\)](#)
 - Still issue of representativeness of annual contracts in share of all contracts and characteristics of workers (Britain: minority and declining share of contracts + younger unmarried).

Wages and labor markets

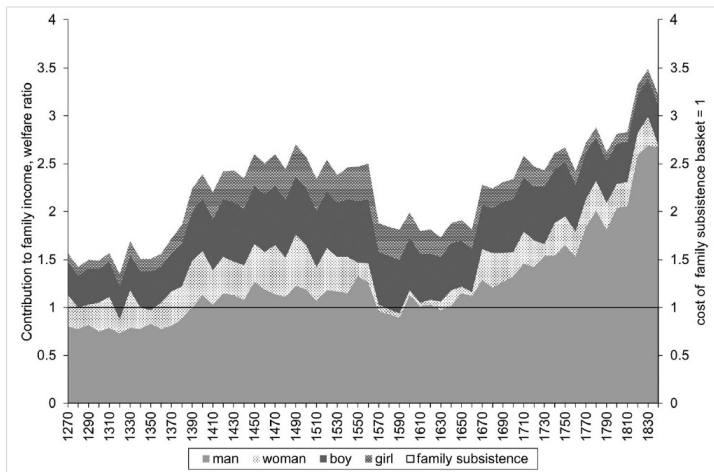
- Observed wages paid to laborers or contractors?
 - Building contractors commission in early modern London: 20–30%.
 - Similar in Paris or Italy, but unclear throughout the world.
- Wages in books of large institutions not representative of regular labor market.
- Cash wages fail to capture payments in kind (lodging, food). Use confidence intervals adding the value of in-kind transfers.

Wages and labor markets

- Focus on male wages, but male breadwinner is not the norm throughout history.
 - Should also include women and children's earnings (though substantial fluctuations over time and space).
 - Broader picture of family incomes over time, e.g., women and children might contribute more than 50% of total or drive long-run trends.
 - Same issues as with male wages, need to account for changes in demographic patterns and labor force participation rates.

Wages and labor markets

Real wages in England



Source: De Zwart (2023) based on Horrell et al. (2021).

- Issues in estimating the denominator: the cost of living.
 - Laspeyers index.
 - Housing costs.
 - Global temperature variation.

- Subsistence basket methodology: Laspeyres index.
 - Fixed set of goods, fluctuates only with changes in prices.
 - But baskets of consumption change over time.
 - Establish benchmarks and create chained-Laspeyres index. [Horrell \(2023\)](#)
 - Good for comparisons within a country over time but not for comparisons over space, where a bare-bone basket might be more appropriate.

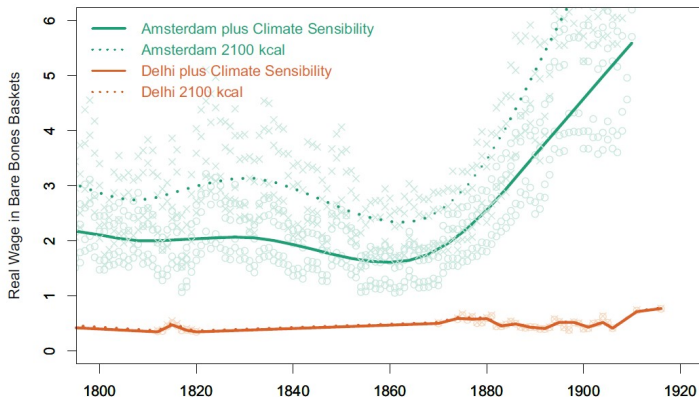
- Housing costs:
 - General assumption: before industrialization, housing about 5% of households total expenses per family member.
 - Very little information, but generally might be higher.
- Climate adjustments: fuel needs are different across climates.

Clothing and energy requirements

		Bombay	St. Petersburg	St P./Bombay
Clothing	Meter eq.	23	63	3 times more
Footware	Meter eq.	1	31	31 times more
Bedding	Meter eq.	3	21	7 times more
Fuel	mBTU	3	25	8 times more
Light	mBTU	.4	.9	2 times more

Source: De Zwart (2023) based on Allen (2017).

Real wages in Amsterdam and Delhi with adjustments for climate differences



Source: De Zwart (2023) based on Allen (2007) and Moatsos (2020).

Real wages vs GDP per capita

Angeles (2008)

- Why are trends in real wages and GDP per capita so different?

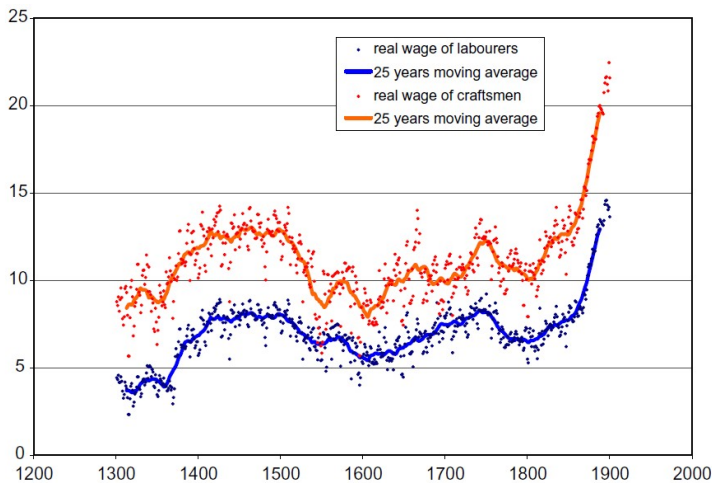
Real wages vs GDP per capita

Angeles (2008)

- Why are trends in real wages and GDP per capita so different?
- Differences can arise with any of three factors:
 - Changes in share of national income allocated to labor.
 - Changes in labor supply per capita.
 - Changes in relative prices.

Real wages vs GDP per capita

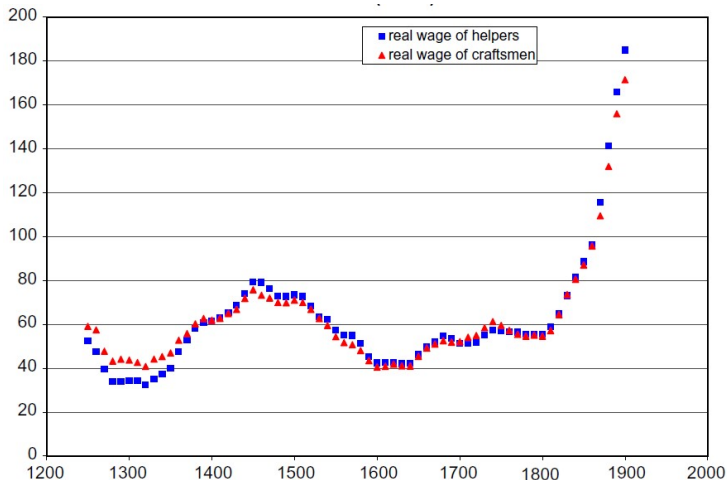
Real wages in England



Source: Angeles (2008) based on Allen (2001).

Real wages vs GDP per capita

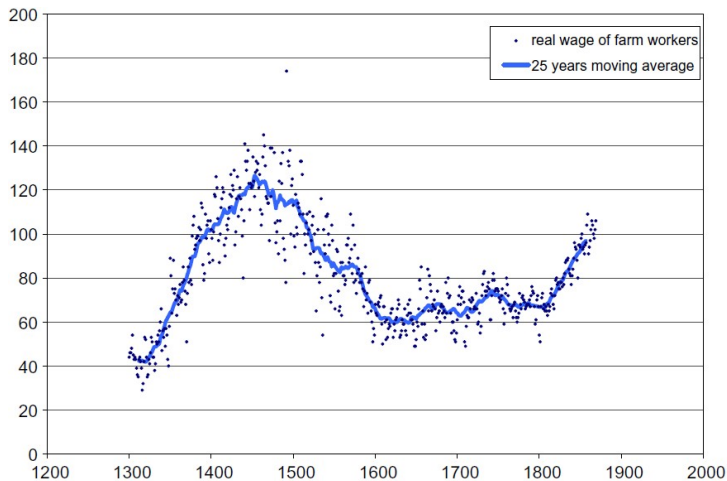
Real wages in England



Source: Angeles (2008) based on Clark (2005).

Real wages vs GDP per capita

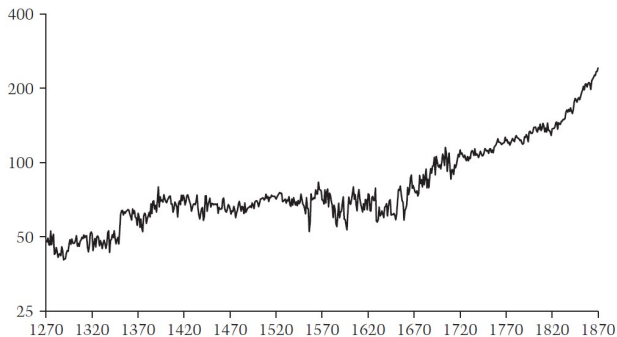
Real wages in England



Source: Angeles (2008) based on Clark (2007).

Real wages vs GDP per capita

Real GDP per capita (log scale, 1700=100)



Source: Broadberry et al. (2015)

Real wages vs GDP per capita

- Construction methodology:
 - GDP per capita: output of each sector weighted by sector share, divided by population.
 - Real wages: nominal wages deflated with appropriate price index reflecting consumption patterns of typical worker.
- Link between the two: fraction of aggregate output corresponds to total of nominal wages (accounting identity).
- Assume competitive labor market, so that wages across sectors are equalized.

Real wages vs GDP per capita

- Changes in share of national income allocated to labor.
 - Higher share \implies growth rate of real wage $>$ growth rate of GDP per capita.
 - Highlights changes in distribution of income between labor and other factors of production.

Real wages vs GDP per capita

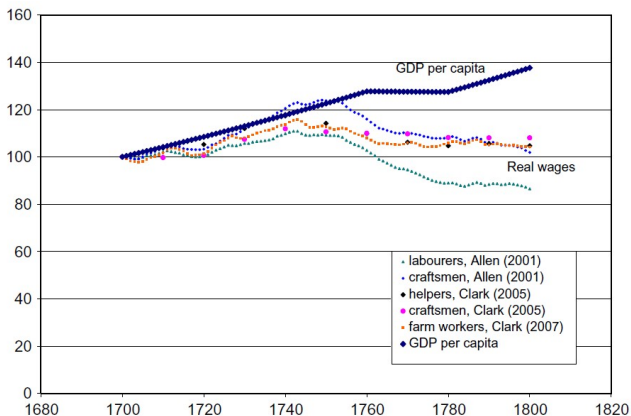
- Changes in share of national income allocated to labor.
 - Higher share \implies growth rate of real wage $>$ growth rate of GDP per capita.
 - Highlights changes in distribution of income between labor and other factors of production.
- Changes in labor supply per capita.
 - Higher labor supply per capita \implies growth rate $<$ growth rate of GDP per capita.
 - Highlights changes in supply of labor per capita (c.f. the “industrious revolution” and the rising number of hours worked in 17–18 century England).

Real wages vs GDP per capita

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- Changes in relative prices.
 - Ambiguous effects depending on how large and pace of growth of sector with appreciation.

Real wages vs GDP per capita

Real wage and GDP per capita (1700=100)



Source: Angeles (2008) based on Craft and Harley (1992), Wrigley et al. (1997), Allen (2001), and Clark (2005, 2007)

Real wages vs GDP per capita

- Application to 18th century England
 - All wage series follow similar patterns: growth in 1700–50, decline in 1750–60, stagnation in 1760–1800.
 - Most series show real wages in 1800 are 5% higher than in 1700.
 - Relative to GDP, no divergence until 1750–60.
 - In these data, GDP growth of 37% over the century.

Real wages vs GDP per capita

- Data needed to test the theory:
 - Population: every 5 years. [Wrigley et al. \(1997\)](#)
 - Changes in income distribution: share of labor vs non-labor income based on share of income in top 10%. [Lindert and Williamson \(1983\)](#).
 - Labor supply per capita: hours worked per year from court proceedings. [Voth \(2000, 2001\)](#)
 - Price information on all sectors: only 7 agriculture and 5 industry. [Clark \(2005\)](#)

Real wages vs GDP per capita

Data sources

(a) Crafts (1983) and Crafts and Harley (1992)
Annual growth rate of output per sector, in percentage

	1700–1760	1760–1780	1780–1800
Agriculture	0.6	0.13	0.75
Industry	0.71	1.29	1.96
Commerce	0.69	0.64	1.38
Rent and services	0.38	0.69	0.97
Government	1.91	1.29	2.11

Share of sector in GDP

	1700–1760	1760–1780	1780–1800
Agriculture	0.37	0.37	0.32
Industry	0.20	0.20	0.25
Commerce	0.16	0.16	0.16
Rent and services	0.20	0.20	0.20
Government	0.07	0.07	0.07

(b) Wrigley et al. (1997)
Population of England, in thousands

	1701	1761	1781	1801
Population	5210	6310	7206	8671

(c) Lindert and Williamson (1983)
Share of income to the top 10% of the population (calculations with paupers)

	1688	1759	1801
Share of top 10%	44.0	44.4	47.9

(d) Voith (2001)

	1760	1800
Working hours per year	2576	3328
Total labour supply	100	172.3

(e) Clark (2005)
Prices for 7 categories of agricultural goods and 5 categories of industrial goods, available for each decade of the 18th century

Source: Angeles (2008). Assume constant hours worked for 1700 (2,576 hours per year).

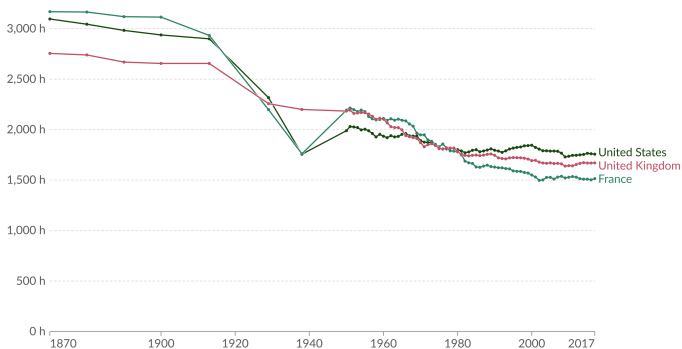
Real wages vs GDP per capita

Annual working hours per worker (1870–2017)

Annual working hours per worker

Average working hours per worker over an entire year. Before 1950 the data corresponds only to full-time production workers (non-agricultural activities). Starting in 1950 estimates cover total hours worked in the economy as measured primarily from National Accounts data.

Our World
in Data



Data source: Huberman & Minns (2007) and PWT 9.1 (2019)

OurWorldInData.org/working-hours | CC BY

Note: We plot the data from Huberman & Minns (2007) and extend coverage using an updated vintage of PWT, which uses the same underlying source. Comparisons between countries are limited due to differences in measurement.

Real wages vs GDP per capita

Explaining the divergence between GDP per capita and real wages

Variable	Percentage change over the period (%)			
	1700–1760	1760–1780	1780–1800	1700–1800
Agriculture	43.2	2.6	16.1	70.6
Industry	52.9	29.2	47.4	191.3
Commerce	51.1	13.6	31.5	125.7
Rent and services	25.5	14.7	21.3	74.7
Government	211.2	29.2	51.8	510.5
GDP	54.6	14.0	29.9	129.0
Population	21.1	14.2	20.3	66.4
GDP per capita	27.7	-0.2	8.0	37.6
Share of labour (z)	-0.7	-3.2	-3.2	-7.0
Labour supply per capita (L/N)	0	12.0	12.0	25.4
Real wage	26.8	-13.7	-6.7	2.1

Source: Angeles (2008).

Real wages vs GDP per capita

- GDP per capita growth over century: 38%.
- Real wage growth over century: 2%.
- Calculation of growth of real wages if only one factor present:
 - If only changes in income distribution, wage growth of 28%.
 - If only changes in labor supply per capita, wage growth of 10%.
 - If only changes in prices, wage growth of 35%.

⇒ 3/4 of the divergence is explained by increased working hours.

Patterns of Long-Run Growth in Global Perspective

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Winter 2024



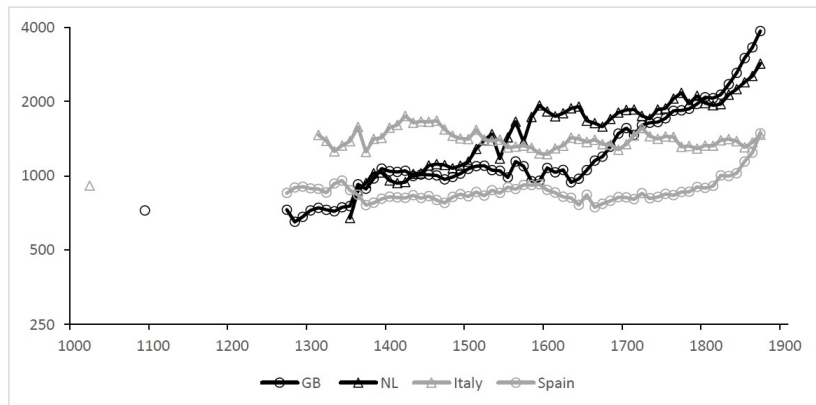
Toulouse
School of
Economics

- Britain
- Continental Europe
 - Spain
 - Italy
 - France
- East Asia
 - China
 - Japan

Britain

Europe's Little Divergence

GDP per Capita in Europe, 1270–1870 (1990 GK\$, Log scale)



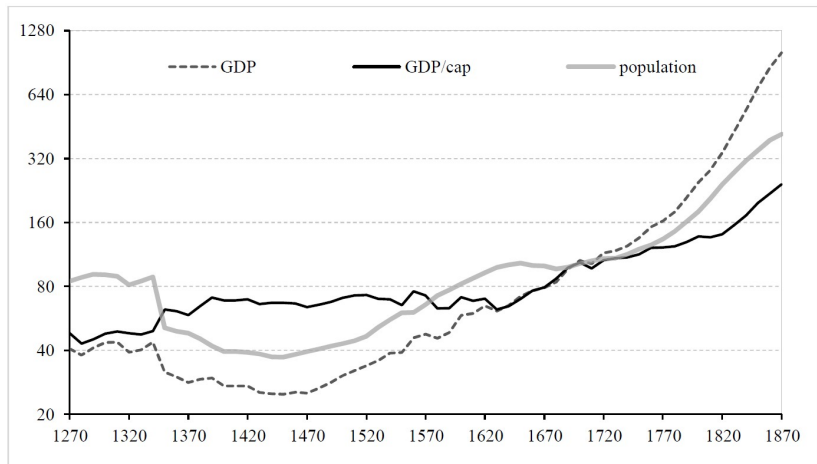
Source: Broadberry (2021) based on Broadberry et al. (2015), van Zanden and van Leeuwen (2012), Malanima (2011), and Alvarez-Nogal and Prados de la Escosura (2013).

Broadberry et al (2013, 2015, 2017) Broadberry (2021)
Humphries and Weidsorf (2019)

- British economic growth in long-run perspective
- Characteristics of modern economic growth
- Structural change
- Wages and standards of living

British economic growth in long-run perspective

Real GDP, Population, and Real GDP per Capita in England (1270–1700) and Great Britain (1700–1870), Averages per Decade, Log Scale, 1700 = 100



Source: Broadberry (2021) based on Broadberry, Guan and Li (2018).

British economic growth in long-run perspective

Annual growth rates in (1270–1700) and Great Britain (1700–1870)

Period	Annual growth rate (%)					Real GDP per head
	Population	Agriculture	Industry	Services	Real GDP	
A. England						
1270s–1300s	0.27	0.24	0.05	0.39	-0.02	-0.29
1300s–1350s	-0.52	-0.52	-0.59	-0.87	-0.64	-0.12
1350s–1400s	-1.06	-0.43	-0.01	-0.44	-0.30	0.76
1400s–1450s	-0.21	-0.10	-0.27	-0.22	-0.06	0.15
1450s–1500s	0.25	0.35	0.43	0.45	0.40	0.15
1500s–1550s	0.65	0.31	0.68	0.48	0.51	-0.14
1550s–1600s	0.62	0.69	1.00	0.74	0.81	0.19
1600s–1650s	0.51	0.21	0.35	0.90	0.41	-0.10
1650s–1700	-0.04	0.20	1.01	0.71	0.78	0.82
1270s–1700	0.04	0.10	0.31	0.23	0.22	0.18
B. Great Britain						
1700–1750s	0.30	0.63	0.56	0.61	0.49	0.19
1750s–1800s	0.77	0.93	1.45	1.32	1.21	0.44
1800s–1850s	1.34	0.78	2.95	2.15	2.08	0.74
1850s–1870	1.54	0.99	3.01	1.96	0.12	0.58
1700–1870	0.84	0.79	1.72	1.43	1.31	0.48

Source: Broadberry et al. (2015).

British economic growth in long-run perspective

- Pre-Black Death (1270–1348): stagnation at low levels despite shocks.
 - Harvest crisis of 1316–18.
 - International credit crunch of 1339–40.
 - Outbreak of Hundred Years War in 1336.

British economic growth in long-run perspective

- Black Death Era (1348–1400s): dramatic demographic shock.
 - Black Death ↓ population by 46% in 1348–9.
 - Immediate GDP ↓ while GDP per K ↑.
 - ↑ in holding sizes, real wages, income.

British economic growth in long-run perspective

- Post-Black Death (1400s–1650s): GDP per K plateaus.
 - Population shrinks until 1450s to its lowest level (2M).
 - Population recovers 1450s–1650s (5.3M) but GDP growth at same rate.
 - Still, restructuring from agriculture to industry.
 - One can see GDP per capita as resilient to population growth.

British economic growth in long-run perspective

- Post-Civil War (1650s–1700): a slow “take-off”.
 - Population stagnation.
 - Strong GDP and GDP per K growth (0.8%).
 - GDP per K double in 1690s vs 1290s.
 - Still not modern economic growth.

British economic growth in long-run perspective

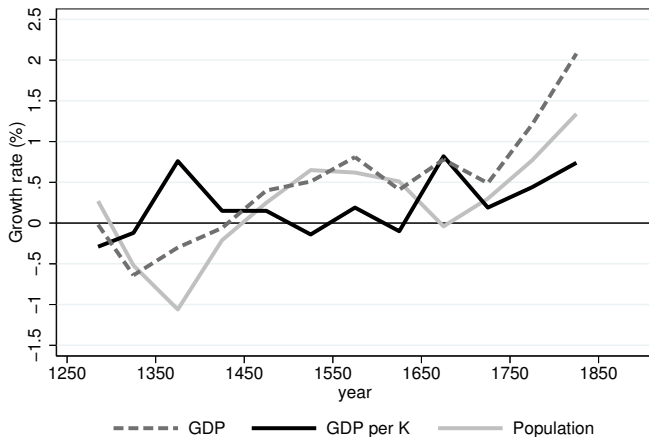
- The “Industrial Revolution” (1700–1850s):
 - Population growth resumes.
 - GDP per K growth positive.
 - Growth positive, stable, no shrinking.
 - Relatively slow rates until 19th century.

British economic growth in long-run perspective

- The “Industrial Revolution” (1700–1850s):
 - Population growth resumes.
 - GDP per K growth positive.
 - Growth positive, stable, no shrinking.
 - Relatively slow rates until 19th century.
- Revision of past views:
 - Britain entered the Industrial Revolution richer than assumed.
 - Britain grew less during the Industrial Revolution than assumed.

Characteristics of modern economic growth

Real GDP, Population, and Real GDP per Capita Growth in England (1270–1700) and Great Britain (1700–1870), Averages per 50-Years



Source: Broadberry (2020) based on Broadberry et al. (2015).

Characteristics of modern economic growth

- Pre-industrial growth:
 - GDP per K growth fast after Black Death and Civil War.
 - Population declines (land/labor $\uparrow \implies$ output/capita \uparrow)
 - Unstable growth with shrinkages.

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- Modern economic growth:
 - GDP per K growth together with population.
 - All rates are positive, stable, no shrinkage.
 - Structural change: shift from agriculture to industry and services.

Structural change in Britain

- Output shares per sector: derived from output approach.
- Labor-force shares per sector: derived from benchmark years.
- Output per worker per sector: ratio of output to labor-force.

- Benchmark years:
 - 1381 poll tax returns.
 - 1522 muster rolls.
 - 1688, 1759, and 1801 social tables.
 - 1813–20 parish registers.
 - 1851–71 population censuses.

- Poll tax return of 1381.
 - Earliest document to estimate occupational structure of England.
 - 30k individuals (2% of adults) across 892 towns.
 - Attribute the 15% of “laborers” to each sector in proportion of known occupations.
 - Weighting procedure for national representativeness of rural (80%), urban (10%), semi-rural populations (10%).
 - Weight women market participation 30% relative to men (based on census 1851).

Sectoral distribution of English labor-force in 1381

Sector	Weighted number of workers with known occupations		Allocated labourers with no stated occupations		Total workers		
	Males (no.)	Females (no.)	Males (no.)	Females (no.)	Males (no.)	Females (no.)	Males and females (no.)
Agriculture	14,351	1,467	2,526	288	16,877	1,755	
Industry	2,602	899	1,244	547	3,846	1,446	
Services	4,480	1,888	0	0	4,480	1,888	
Total	21,433	4,254	3,770	835	25,203	5,089	
	%	%	%	%	%	%	%
Agriculture	67.0	34.5	67.0	34.5	67.0	34.5	57.2
Industry	12.1	21.1	33.0	65.5	15.2	28.4	19.2
Services	20.9	44.4	0.0	0.0	17.8	37.1	23.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Broadberry et al. (2015).

- Muster rolls or military surveys of 1522.
 - Only 3 counties with occupations (one rural, one urban, one semi-rural).
 - Only men.
 - Attribute the 26% of “laborers” to each sector in proportion of known occupations.
 - Weighting procedure for national representativeness of rural (80%), urban (10%), semi-rural populations (10%).
 - Assume women participate 30% relative to men and across sectors as in 1381.

Late-medieval labor-force shares

Sectoral distribution of English labor-force in 1522

Sector	Coventry (Urban) (10%)	Babergh (Semi-rural) (10%)	Rutland (rural) (80%)	Weighted number of male workers with known occupations				
A.	No.	No.	No.	No	%			
Agriculture	12	273	868	1,848	64.7			
Industry	594	577	38	471	16.5			
Services	143	133	218	537	18.8			
TOTAL	749	983	1,124	2,856	100.0			
	Weighted number of male workers with known occupations (from A)		Allocated male labourers with no stated occupations:		Total male workers	Total female workers	Weighted total workers	
B.	No.	%	No.	%	No.	%	%	
Agriculture	1,848	64.7	644	64.7	2,492	64.7	34.5	55.6
Industry	471	16.5	352	35.3	823	21.4	28.4	23.5
Services	537	18.8	0	0	537	13.9	37.1	20.9
TOTAL	2,856	100.0	996	100.0	3,852	100.0	100.0	100.0

Source: Broadberry et al. (2015).

Labor-force shares in social tables 1688–1801

- Use social tables by contemporaries analyzed by Lindert and Williamson (1982).
 - 1688 by Gregory King (1696).
 - 1759 by Joseph Massie (1760).
 - 1801 by Patrick Colquhoun (1806).
- Produced to estimate tax base in wartime across “social classes”.
- Based on parish registers and specific tax revenues, improved with various local censuses.

Labor-force shares in social tables 1688–1801

Sectoral distribution of English labor-force in 1688

Sectors	Occupations	'Family' numbers (i.e. males)			Labour-force shares (2, 3 and 4 as % of 7)		
		According to King ^a	Adjusted for labourers and servants ^a	Occupied	Males	Females ^e	Total ^f
1. Unoccupied	High titles and gentlemen	19,626	43,115				
	Vagrants	23,489					
2. Agriculture	Agriculture	227,440	227,440	635,399	46.0	22.3	38.9
	Agricultural labourers ^b	Included in 5	407,959				
3. Industry	Industry and building	256,866	256,866	447,087	32.3	37.8	34.0
	Industrial labourers ^c	Included in 5	190,221				
4. Services	Commerce	128,025	128,025	299,750	21.7	39.9	27.2
	Professions	42,960	42,960				
	Military and maritime	94,000	94,000				
5. Labourers, Cottagers and Paupers		598,180					
6. TOTAL (1–5)		1,390,586	1,425,351				
7. TOTAL OCCUPIED (2–4)				1,382,236	100.0	100.0	100.0

Source: Broadberry et al. (2015).

Labor-force shares in social tables 1688–1801

Sectoral distribution of English labor-force in 1759

Sectors	Occupations	'Family' numbers (i.e. males)		Labour-force shares (2, 3 and 4 as % of 7)			
		According to Massie ^a	Adjusted for labourers and servants ^a	Occupied	Males	Females ^e	Total ^f
1. Unoccupied	High titles and gentlemen	18,070	31,488				
	Vagrants	13,418					
2. Agriculture	Agriculture	379,008	379,008	664,692	43.0	22.3	36.8
	Agricultural labourers ^b	Included in 5	285,684				
3. Industry	Industry and building	366,252	366,252	499,460	32.3	37.8	33.9
	Industrial labourers ^c	Included in 5	133,208				
4. Services	Commerce	200,500	200,500	381,979	24.7	39.9	29.3
	Professions	57,000	57,000				
	Military and maritime	86,000	86,000				
	Domestic servants ^d	Omitted	38,479				
5. Labourers, cottagers and paupers		418,892					
6. TOTAL (1–5)		1,539,140	1,577,619				
7. TOTAL OCCUPIED (2–4)				1,546,131	100.0	100.0	100.0

Source: Broadberry et al. (2015).

Labor-force shares in social tables 1688–1801

Sectoral distribution of English labor-force in 1801

Sectors	Occupations	'Family' numbers (i.e. males)			<i>Labour-force shares</i> (2, 3 and 4 as % of 7)		
		According to Colquhoun ^a	Adjusted for labourers and servants ^a	Occupied	Males	Females ^e	Total ^f
1. Unoccupied	High titles and gentlemen	27,203	206,921				
	Vagrants	179,718					
2. Agriculture	Agriculture	320,000	320,000	729,322	35.7	22.3	31.7
	Agricultural labourers ^b	Included in 5	409,322				
3. Industry	Industry and building	541,026	541,026	731,883	35.9	37.8	36.4
	Industrial labourers ^c	Included in 5	190,857				
4. Services	Commerce	205,800	205,800	579,816	28.4	39.9	31.9
	Professions	74,840	74,840				
	Military and maritime	244,348	244,348				
	Domestic servants ^d	Omitted	54,828				
5. Labourers, cottagers and paupers		600,179					
6. TOTAL (1–5)		2,193,114					
7. TOTAL OCCUPIED (2–4)			2,247,942	2,041,021	100.0	100.0	100.0

Labor-force shares in 1813–71

- Labor-force shares in 1813–71 from Shaw-Taylor (2009).
 - Parish registers (1813–1820).
 - Population censuses (1851–1871).

Labor-force shares in 1813–71

Sectoral distribution of English labor-force in 1813–71

Sector	1813–20 (%)			1851 (%)			1861 (%)			1871 (%)		
	Males	Females	Total	Males	Females	Total	Males	Females	Total	Males	Females	Total
Agriculture	35.4	22.3	31.4	27.2	15.6	23.5	24.4	12.6	20.6	19.8	11.2	16.9
Industry	47.4	37.8	44.5	50.1	36.4	45.7	49.6	38.3	45.9	52.6	35.8	47.1
Services	17.2	39.9	24.1	22.7	48.0	30.9	26.0	49.1	33.5	27.6	53.0	36.0
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Broadberry et al. (2015).

Structural change in Britain

Sectoral Shares in England (1381–1700) and Great Britain (1700–1870)

Sector	1381	1522	1700	1759	1801	1851
A. Output shares (%)						
Agriculture	45.5	39.7	26.7	29.7	31.3	18.7
Industry	28.8	38.7	41.3	35.2	32.7	32.1
Services	25.7	21.6	32.0	35.1	36.0	49.2
GDP	100.0	100.0	100.0	100.0	100.0	100.0
B. Labour-force shares (%)						
Agriculture	57.2	55.6	38.9	36.8	31.7	23.5
Industry	19.2	23.5	34.0	33.9	36.4	45.6
Services	23.6	20.9	27.2	29.3	31.9	30.9
GDP	100.0	100.0	100.0	100.0	100.0	100.0
C. Output per worker						
Agriculture	79.5	71.4	68.7	80.8	98.9	79.6
Industry	150.1	164.5	121.5	103.8	89.7	70.3
Services	109.1	103.8	117.9	119.9	112.9	159.3
GDP	100.0	100.0	100.0	100.0	100.0	100.0

Source: Broadberry et al. (2015).

Structural change in Britain

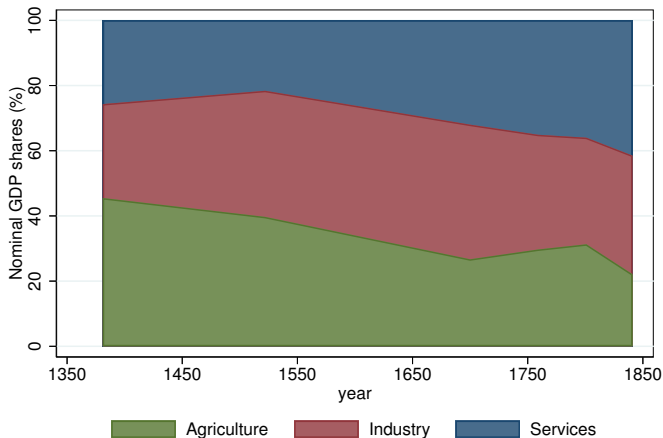
Sectoral annual growth rates in England (1381–1700) and Great Britain (1700–1870)

Period	Annual % growth											
	Agriculture			Industry			Services			GDP		
	Output	Labour- force	Labour productivity	Output	Labour- force	Labour productivity	Output	Labour- force	Labour productivity	Output	Labour- force	Labour productivity
1381–1522	0.01	-0.01	0.02	0.27	0.10	0.17	0.06	-0.16	0.23	0.11	-0.02	0.14
1522–1700	0.38	0.25	0.13	0.73	0.66	0.07	0.74	0.60	0.14	0.60	0.45	0.16
1700–1759	0.79	0.22	0.57	0.63	0.31	0.32	0.70	0.44	0.26	0.69	0.32	0.38
1759–1801	0.85	0.44	0.41	1.54	0.97	0.57	1.36	1.00	0.36	1.23	0.79	0.44
1801–1851	0.74	0.64	0.10	3.00	1.74	1.23	2.16	1.45	0.71	2.10	1.35	0.74
1381–1759	0.30	0.13	0.17	0.54	0.40	0.14	0.48	0.31	0.17	0.43	0.25	0.18
1759–1851	0.79	0.54	0.24	2.33	1.39	0.93	1.80	1.24	0.55	1.70	1.09	0.60

Source: Broadberry et al. (2015).

Structural change in Britain

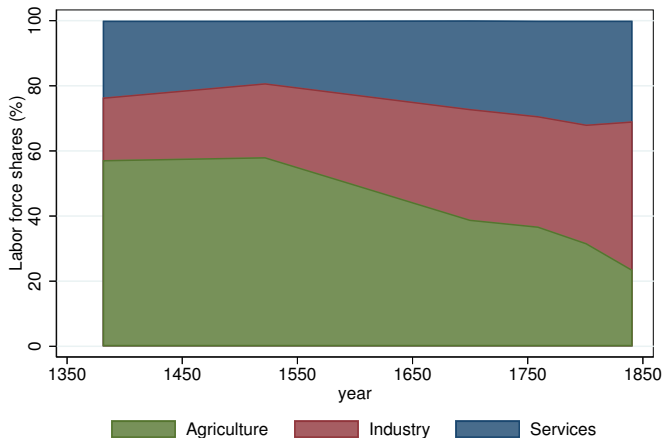
Sectoral Shares in Nominal GDP in England (1381–1700) and Great Britain (1700–1870)



Source: Broadberry (2020) based on Broadberry et al. (2015).

Structural change in Britain

Sectoral Shares in Labor Force in England (1381–1700) and Great Britain (1700–1870)



Source: Broadberry (2020) based on Broadberry et al. (2015).

Structural change in Britain

- As early as 1381, agriculture $< 60\%$ of GDP and labor, and 30% in 1801.
- 1500s–1700, productivity growth slows down in industry due to labor-intensive character of industry.
- 1700–1759: agriculture productivity grows (agricultural revolution) and in industry.
- During IR, industry productivity grows due to labor-saving technologies and division of labor.
- Shift of labor from agriculture to industry occurred before 1759 due to increased productivity in agriculture.

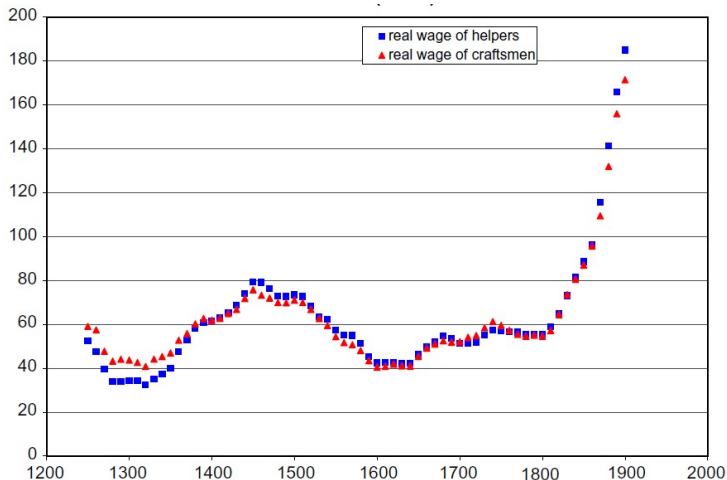
⇒ Labor-intensive (proto) industrialization in 1522–1759 without industrial productivity growth.

Wages and standards of living

- Real wages offer a complementary view of long-run changes in living standards.
- Usually focus on day wages, with assumptions on yearly days of work.
 - “Golden Age of Labor” after the Black Death.
 - Decline then stagnation from 1650s to the 1800s (“Engels’ Pause”).
- Puzzle: why divergence with respect to GDP per capita trends from Broadberry et al. (2015) (besides changes in labor supply in 18th century)?

Wages and standards of living

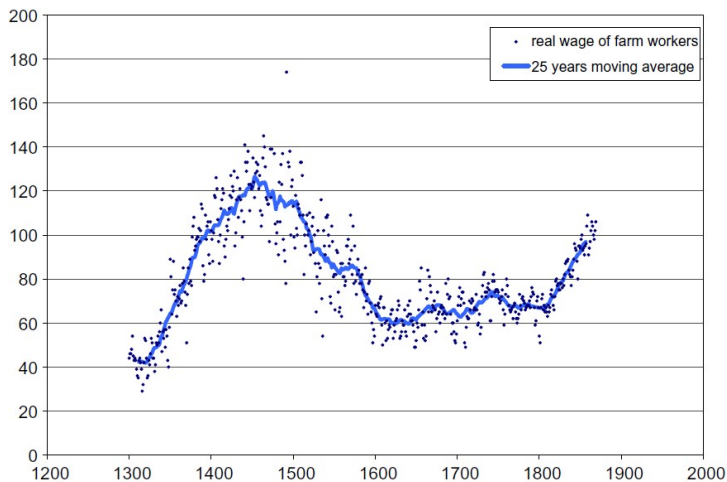
Real wages in England



Source: Angeles (2008) based on Clark (2005).

Wages and standards of living

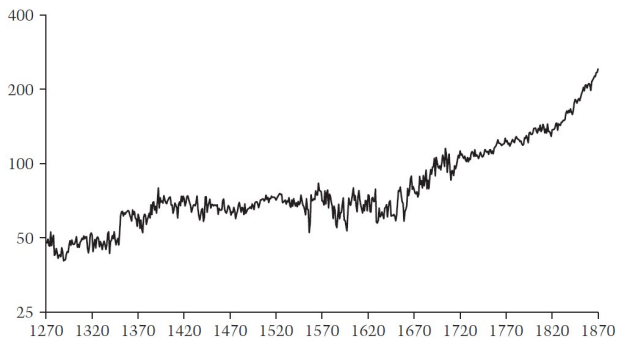
Real wages in England



Source: Angeles (2008) based on Clark (2007).

Wages and standards of living

Real GDP per capita (log scale, 1700=100)



Source: Broadberry et al. (2015)

Humphries and Weisdorf (2019)

- Revisit stylized facts with annual wages.
 - Downscale the “Golden Age of Labor” .
 - Push the take-off 200 years, to late 1500s.
 - Main reason: the “Industrious Revolution” was much earlier than thought based on Voth (2000, 2001).
 - The assumption of 250 working days was wrong: labor input on the intensive margin varied widely in the past.

Wages and standards of living

- Annual wage contracts were common, especially in agriculture.
- If workers are homogeneous and mobile (non-segmented labor market), then yearly contracts in agriculture relevant to workers on daily contracts in all sectors.

Wages and standards of living

- Data sources: 13 primary and secondary sources for unskilled annual male workers in agriculture.
- Data points: 6,800 annual payments, with good temporal and geographical coverage (1260s–1850s) across various occupations.
- In-kind transfers: common, so assume provision of “respectability” basket based on Allen (2009) for 2,500 calories per day.

Wages and standards of living

Allen's Consumption Baskets for One Adult Person

Respectability		Bare bones subsistence	
Good	Quantities per year	Good	Quantities per year
Bread	234 kg	Oatmeal	170 kg
Beans/peas	52 L	Beans/peas	34 kg
Meat	26 kg	Meat	5 kg
Butter	5.2 kg	Butter	3 kg
Cheese	5.2 kg	Cheese	
Eggs	52 each	Eggs	
Beer	182 L	Beer	
Soap	2.6 kg	Soap	1.3 kg
Linen	5 m	Linen	3 m
Candles	2.6 kg	Candles	1.3 kg
Lamp oil	2.6 L	Lamp oil	1.3 kg
Fuel	5.0 M BTU	Fuel	2.0 M BTU
Rent	5% allowance	Rent	5% allowance
Total	2,500 cal/day	Total	2,100 cal/day

Source: Humphries and Weisdorf (2019) based on Allen (2009, 2015)

Number of Annual Payments by Region and Occupational Category

Occupation	Frequency	Per cent	Cum.	Region	Frequency	Per cent	Cum.
Men/Helpers	2,730	40	40	South	2,334	34	34
Servants	865	13	53	Midlands	3,516	52	86
Labourers	559	8	61	North	950	14	100
Unknown	2,646	39	100				
All	6,800	100		All	6,800	100	

Source: Humphries and Weisdorf (2019)

Wages and standards of living

- Account for occupational and spatial heterogeneity in data sources by demeaning through OLS regressions by periods of 50 and 100 years:

$$\ln(\text{Wage}_{it}) = \alpha_i + \sum_j \gamma_j \text{Work}_j + \sum_k \eta_k \text{Region}_k + \sum_l \theta_l \text{Decade}_l + \varepsilon_{it}$$

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Wages and standards of living

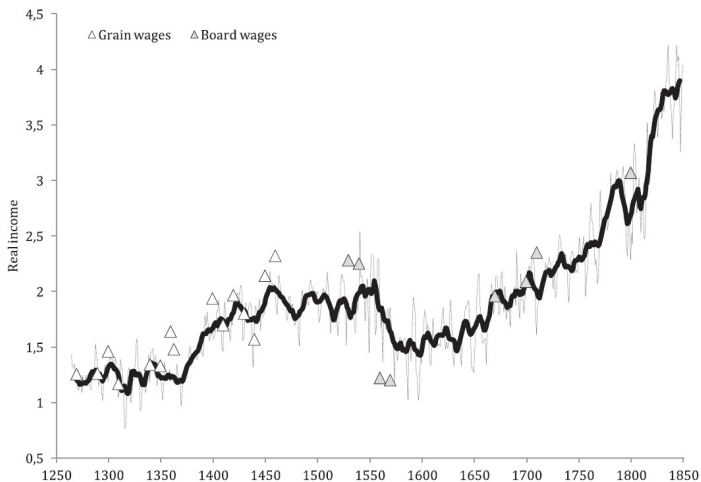
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- Predict payments using regression coefficients and applying weights by share of observations within each occupational category and region population shares.
- Then deflate the series using a standard historic consumer price index.
- Normalize the series to “welfare ratios” (number of respectability baskets that income can buy).

Wages and standards of living

National Real Annual Incomes, 1260–1850



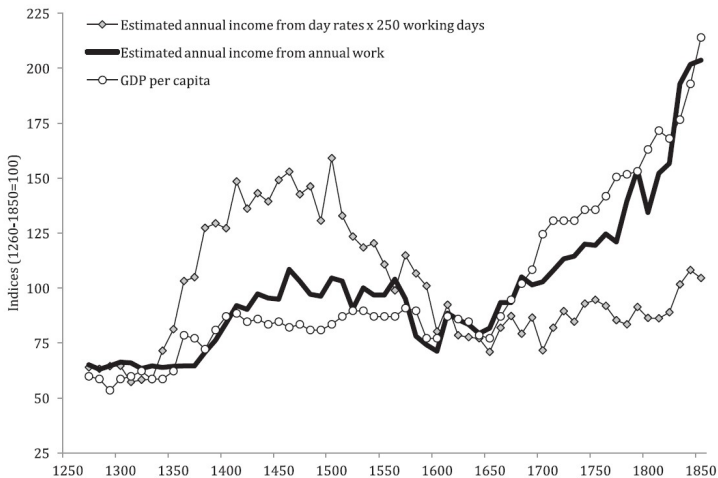
Source: Humphries and Weisdorf (2019)

Wages and standards of living

- New stylized facts:
 - “Golden Age of Labor” after the Black Death is downscaled.
 - Post-Golden Age downturn later, in 1550s rather than 1450s.
 - Gains after 1600s (no “Engel’s Pause”).
 - Only after 1700s that reach 2 baskets.
 - Only after 1800s that can support a family of 4 \implies the male breadwinner model was irrelevant before then.

Wages and standards of living

Indices of GDP per Capita and Real Annual Income, 1260–1850



Source: Humphries and Weisdorf (2019)

Wages and standards of living

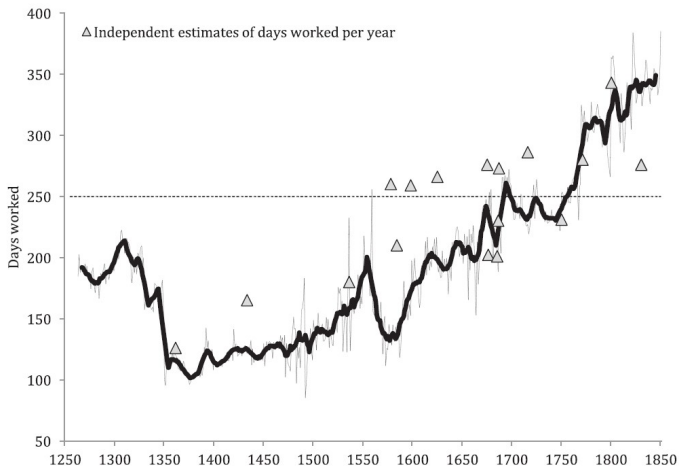
- Puzzle resolved: annual wages track GDP per capita quite well.
- Constant labor supply with daily wage series is misguided.

Wages and standards of living

- Puzzle resolved: annual wages track GDP per capita quite well.
- Constant labor supply with daily wage series is misguided.
- Other discrepancies can be due to changes in labor share (ratio income to GDP per capita).

Wages and standards of living

Length of Working Year, 1260–1850



Source: Humphries and Weisdorf (2019)

Wages and standards of living

Labor Share (income / GDP per capita), 1260–1850



Source: Humphries and Weisdorf (2019)

Wages and standards of living

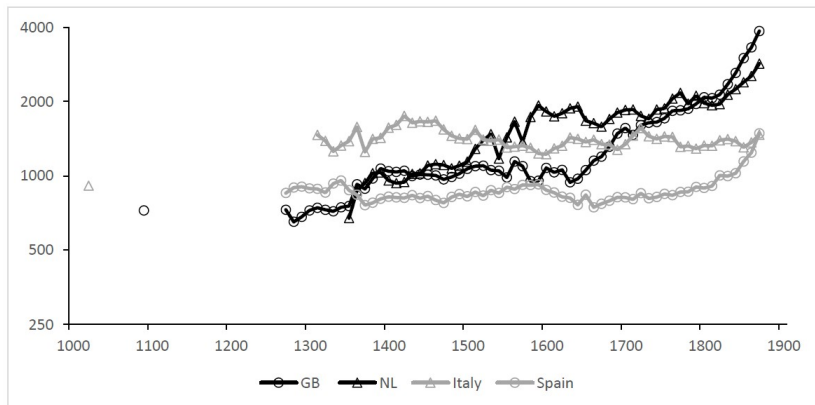
- The puzzle of the divergence between wage data and GDP per capita
 - Very strong variation in length of working days per year.
 - Assumption of 250 days worked is unwarranted.
 - People worked much less post-Black Death.
 - Industrious Revolution started much earlier than 18th century.
 - Explanation by Angeles (2007) holds.

⇒ Puzzle solved!

Continental Europe

Europe's Little Divergence

GDP per Capita in Europe, 1270–1870 (1990 GK\$, Log scale)



Source: Broadberry (2021) based on Broadberry et al. (2015), van Zanden and van Leeuwen (2012), Malanima (2011), and Alvarez-Nogal and Prados de la Escosura (2013).

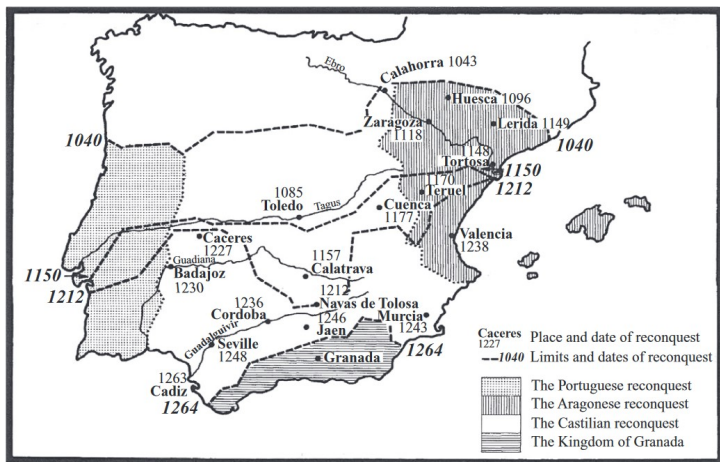
Alvarez-Nogla and Prados de la Escosura (2013)

- Two regimes in pre-industrial Spain:
 - 1270s–1590s: high land-labor ratio frontier and pastoral economy.
 - 1270s–1340s: sustained growth interrupted by Black Death (1348) and Spanish phase of Hundred Years War (1365–89).
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 - 1600s–1810s: low-wage, densely populated, lower path economy.
- Estimates of agricultural output from indirect demand approach, the rest through changes in urban population.

The Reconquest in Spain



Source: Alvarez-Nogal and Prados de la Escosura (2013) based on Mackay (1977).

- Indirect estimation of agricultural output through demand function approach. [Allen \(2000\)](#)

$$Q^A = rcN$$

- Q^A : real agricultural output.
- $r = Q^A/C^A$: ratio of production to consumption (often $r = 1$).
- c : per capita consumption.
- N : population.

- Real consumption per capita:

$$C = \left(P^A/P\right)^{\alpha_1} \left(P^{NA}/P\right)^{\alpha_2} y^\beta$$

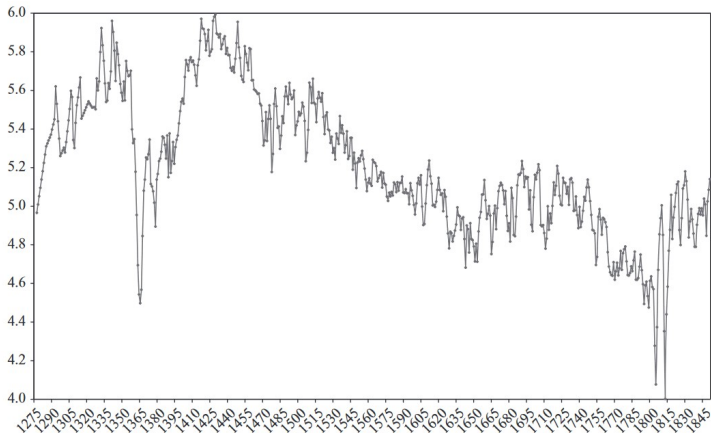
$$\ln c = \alpha_0 + \alpha_1 \ln \left(P^A/P\right) + \alpha_2 \ln \left(P^{NA}/P\right) + \beta \ln y$$

- P^A/P : agricultural product prices in real terms.
- P^{NA}/P : non-agricultural product prices in real terms.
- y : real income per capita.
- α_0 : constant.
- α_1 : own-price elasticity of demand.
- α_2 : cross-price elasticity of demand.
- β : income elasticity of demand.

- Prices are known.
- Income is unknown \implies use real wage w as a proxy (for workers in construction: masons, bricklayers, tilers, carpenters).
 - Other sources of income, especially in rural areas?
 - Share of labor in national income?
 - Wage rates are available \implies working days per year?

- Prices are known.
- Income is unknown \implies use real wage w as a proxy (for workers in construction: masons, bricklayers, tilers, carpenters).
 - Other sources of income, especially in rural areas?
 - Share of labor in national income?
 - Wage rates are available \implies working days per year?
- Price and income elasticities from current developing countries (adapted to case of Spain).
 - $\alpha_1 = -0.4$.
 - $\alpha_2 = 0.1$.
 - $\implies \beta = 0.3$.

Real wage rates, 1277–1850 (1790–9=100) (logs)

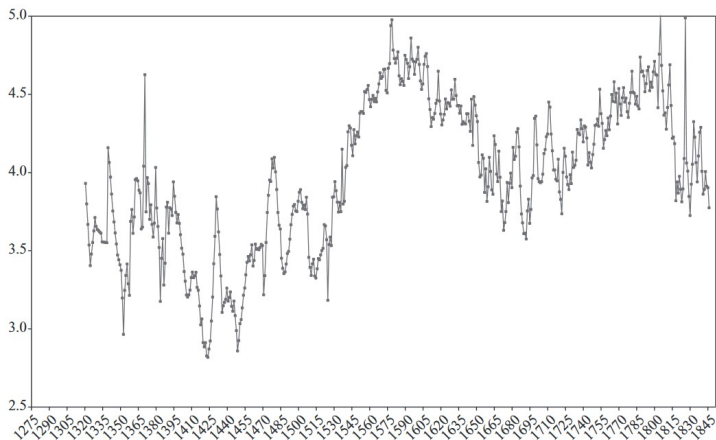


Source: Alvarez-Nogal and Prados de la Escosura (2013).

- Trends in real wage rates:
 - 1290s–1340s: rise.
 - 1350s–1390s: sharp decline following Black Death and Hundred Years War.
 - 1400s–1450s: recovery and millennium peak.
 - 1460s—1650s: long-term decline (below pre-plague levels).
 - 1660s–1790s: flat and declining trend.

- Is real wage a good proxy for real income per capita?
 - Probably 120 working days per hour initially, rising to 150 at the end.
 - Share of labor in national income fluctuated according to land rent to wage rate ratio.
 - Generally high inequality: 10% richest were 15 times richer than 40% poorest (close to England and France).

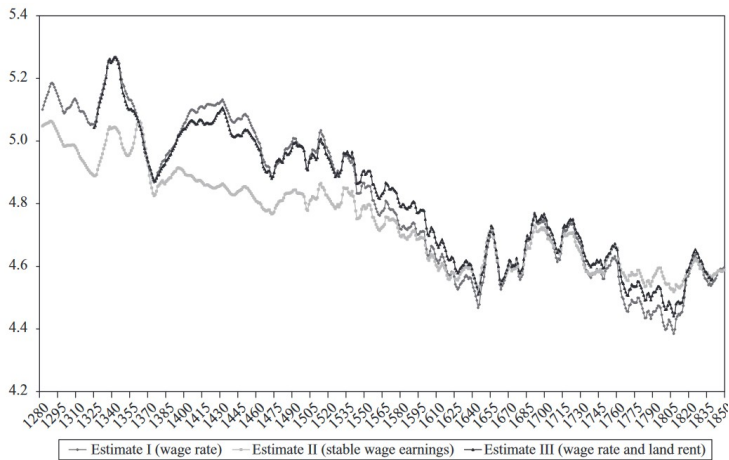
Land rent-wage rate ratio (1790-9=100) (logs)



Source: Alvarez-Nogal and Prados de la Escosura (2013).

- Uncertainty in estimation, so three possibilities:
 - Keep equation as is.
 - Assume response of labor supply to change in wages so returns to labor stable over time (drop the income elasticity term).
 - Use weighted average of real wage rates and real land rents for income proxy.

Real consumption per capita of agricultural goods (1850=100) (logs)



Source: Alvarez-Nogal and Prados de la Escosura (2013).

- Choice of series:
 - Series II: convergence post-1550s but implies lower labor supply before given high wage rates, which seems implausible.
 - Series I and III: convergence throughout, suggesting important roles of relative prices.
 - Use series III for 1320–1845, and series I for 1230–1320 (no rent data).

- Long-run trends:
 - 1230s–1340s: high pre-plague consumption and peak (due to Reconquest of land without demographic expansion).
 - 1340s–1370s: fall post-plague.
 - 1370s–1450s: recovery.
 - 1450s–1650s: long-trend decline.
 - 1650s–1800s: stable with slight recovery and decline.

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 - 1650s–1800s: stable with slight recovery and decline.
- Get agricultural output by multiplying by population (given agricultural export close to 0).

- For industry and services: proxy with urbanization rate (share of population in urban centers).
- Estimate non-agricultural output Q^{NA} :

$$Q = Q^A + Q^{NA} \iff Q = \frac{Q^A}{1 - (Q^{NA}/Q)}$$

- Q^{NA}/Q : share non-agricultural output.
- Use a 5,000 inhabitants threshold (consistent with Bairoch's (1988) estimates).
- Exclude known “agro-towns” in the frontier economy of southern Spain.

Adjusted rate of urbanization (%)

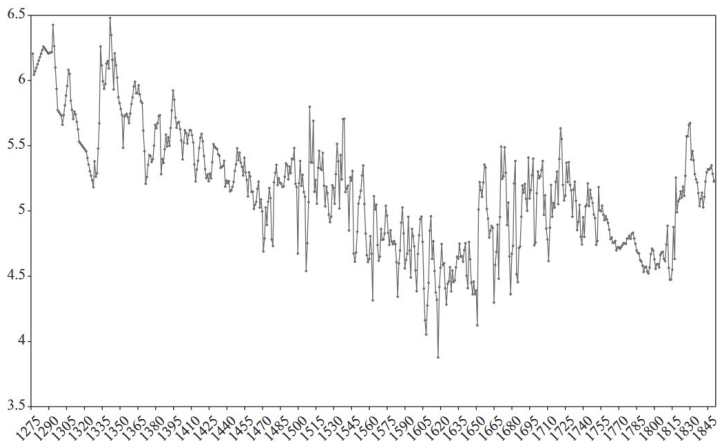
1000	8.0
1300	8.8
1400	7.8
1530	9.9
1591	14.5
1700	11.1
1750	13.5
1787	17.4
1857	23.2

Note: * Share of population in towns of 5,000 and over, excluding those living on agriculture.

Source: Alvarez-Nogal and Prados de la Escosura (2013).

- Are the fall in consumption per capita and increase urbanization contradictory?
- Hypothesis: non-agriculture consumption increased at expense of food staples, due to increased opportunity cost of food.
- Confirmed by decline of price of industrial goods relative to agricultural goods.

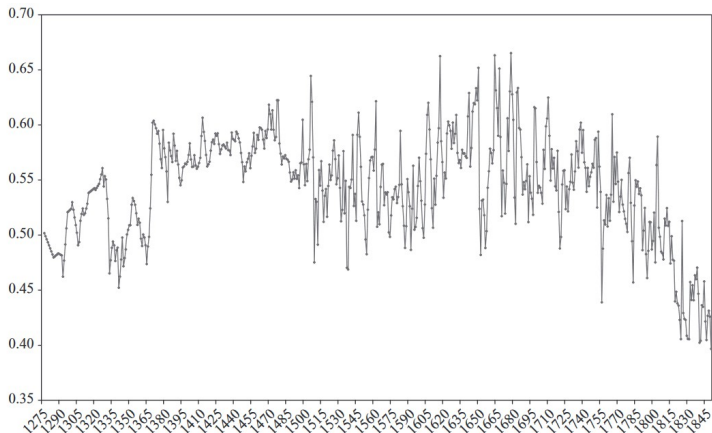
Ratio of industrial to agricultural prices (logs)



Source: Alvarez-Nogal and Prados de la Escosura (2013).

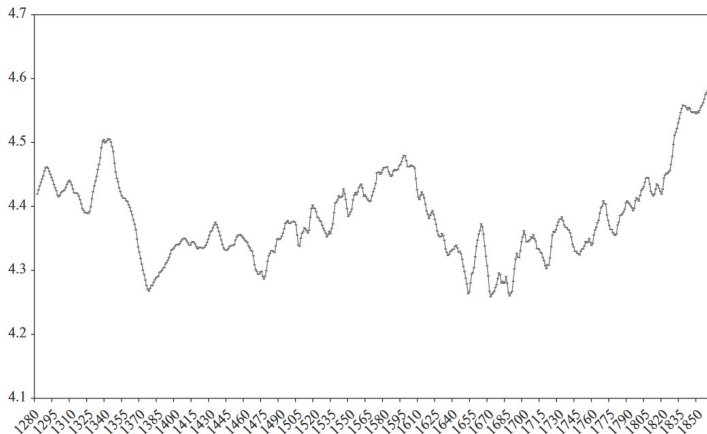
- Final step: compute GDP per capita by weighting agricultural and non-agricultural output.
- Use relative price indexes in both sectors.

Share of agriculture in GDP (current prices) (%)



Source: Alvarez-Nogal and Prados de la Escosura (2013).

Real output per capita (1850-9=100) (logs)

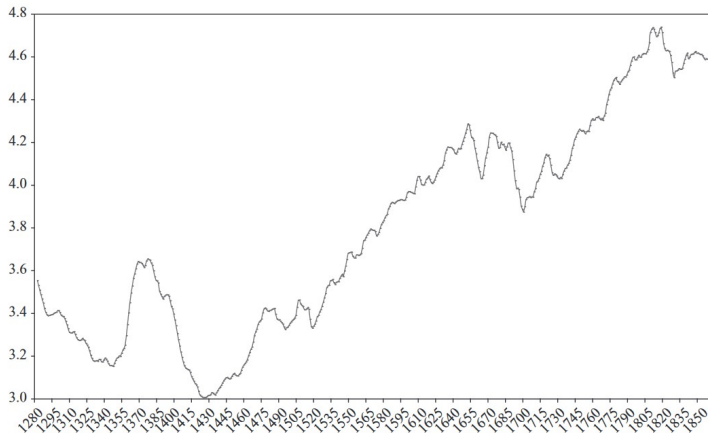


Source: Alvarez-Nogal and Prados de la Escosura (2013).

- Two regimes in pre-industrial Spain:
 - 1270s–1590s: high land-labor ratio frontier and pastoral economy.
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- Differences in well-being as indicated by inequality (ratio of output per capita to nominal wages)?

Inequality (1850-9=100) (logs)



Source: Alvarez-Nogal and Prados de la Escosura (2013).

Output per capita in western Europe (UK in 1850 = 100)

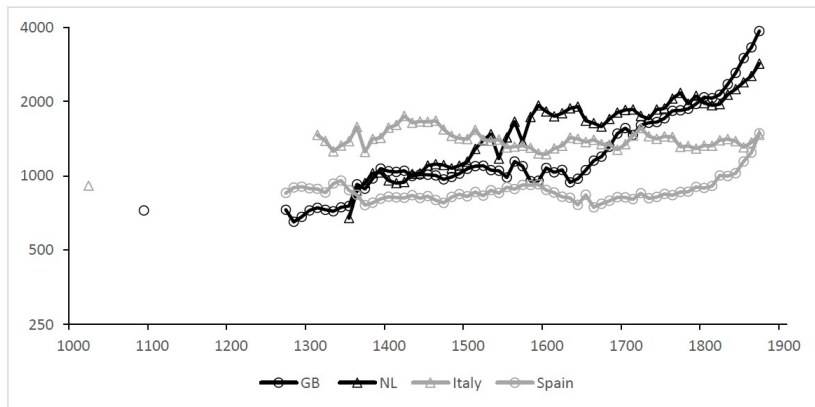
	<i>UK</i>	<i>Netherlands</i>	<i>Germany</i>	<i>France</i>	<i>Italy</i>	<i>Spain</i>	<i>Sweden</i>
<i>Panel A. Relative per capita GDP in 1850 at current US relative prices (PPP) (UK = 100)</i>							
1300	25				72	51	
1348	26	22			67	54	
1400	38	31		52	78	48	
1500	39	37	49	50	68	50	
1570	39	37			64	54	35
1600	37	68	34	50	60	53	
1650	34	69			62	41	
1700	55	54	40	54	65	48	
1750	61	60	45	55	68	46	
1800	75	67	42	56	60	54	41
1850	100	79	61	78	66	64	52
<i>Panel B. Relative per capita GDP in 1850 at 1990 international prices (PPP) (UK = 100)</i>							
1300	25				66	37	
1348	26	29			62	39	
1400	38	39		46	72	35	
1500	39	48	49	44	63	36	
1570	39	47			60	39	29
1600	37	88	35	44	56	38	
1650	34	89			57	29	
1700	55	69	40	47	60	35	
1750	61	78	45	48	63	34	
1800	75	86	42	49	56	39	34
1850	100	102	61	69	61	46	44

Source: Alvarez-Nogal and Prados de la Escosura (2013).

- Other estimates:
 - France, Italy, Germany: demand approach for agriculture + urbanization for the rest.
 - Holland, Britain: output approach based on van Zanden and van Leuwen (2012) and Broadberry et al (2011).
- Prefer estimates using 1990 international (GKI) dollars from Maddison for PPP conversions.

Europe's Little Divergence

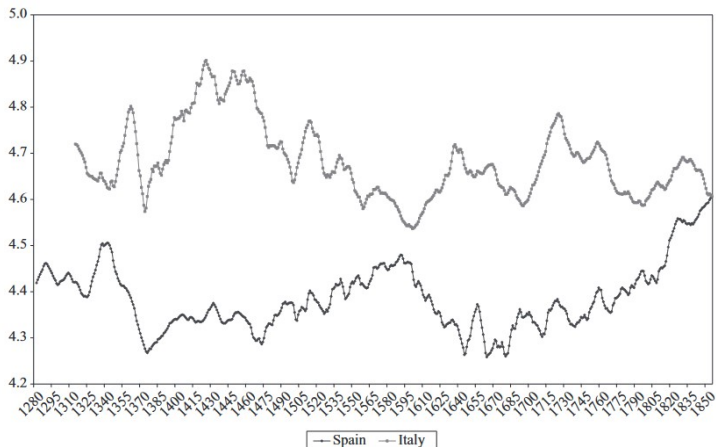
GDP per Capita in Europe, 1270–1870 (1990 GK\$, Log scale)



Source: Broadberry (2021) based on Broadberry et al. (2015), van Zanden and van Leeuwen (2012), Malanima (2011), and Alvarez-Nogal and Prados de la Escosura (2013).

- Turning points:
 - Black Death: downturn due to characteristics of frontier economy with low baseline demographic dynamics.
 - 1600s decline: drop from UK and trends down relative to Europe.
- Generally, Spain doesn't face the Malthusian trap because of low population density: population expansion associated with positive per capita growth.
- Italy is the polar opposite case.

Real output per capita in Spain and Italy (1850–9 = 100) (logs)



Source: Alvarez-Nogal and Prados de la Escosura (2013).

Alvarez-Nogla and Prados de la Escosura (2023, WP)

- Very large decline in 1570s–1650s.
- Impact on people's welfare?

Alvarez-Nogla and Prados de la Escosura (2023, WP)

- Very large decline in 1570s–1650s.
- Impact on people's welfare?
- Measure well-being through people's "spiritual satisfaction" in a country where religion had central role.
 - Use the Bulls of the Crusade: alms collected by Spanish Monarchy after 1574 for 2 silver Reales (and 8 for the wealthy).
 - Spiritual benefit: plenary indulgencies that erased the penance for guilt after sinning, reducing days of Purgatory.
 - Measure of spiritual subjective well-being: number of bulls sold relative to population.
 - Focus on the effect of acquiring bulls rather than motive.

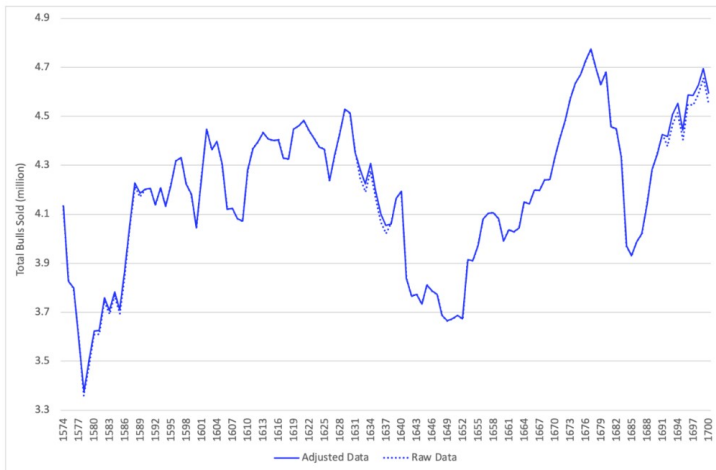
A Bull of the Crusade



Source: Alvarez-Nogal and Prados de la Escosura (2023).

- Archival sources:
 - Number of bulls sold yearly 1574–1704.
 - Based on accounting books on the Crusade across various regional archives.
 - Broad temporal and geographical coverage: Crown of Castile, Aragon and Navarre.
 - Compile individual bulls printed for each bishopric and subtract unsold bulls.

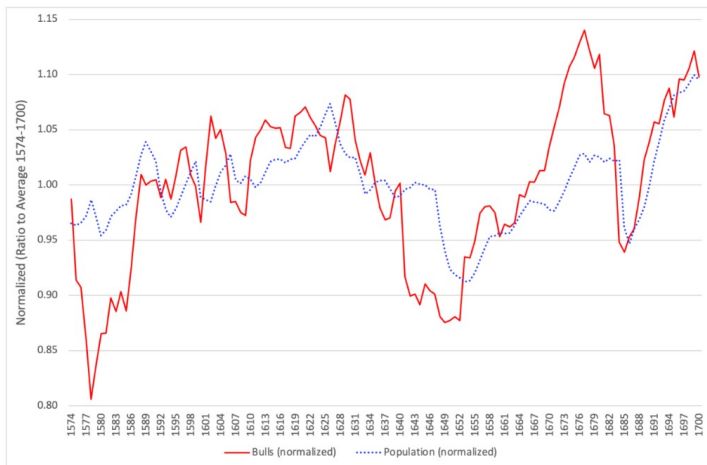
Total bulls sold



Source: Alvarez-Nogal and Prados de la Escosura (2023).

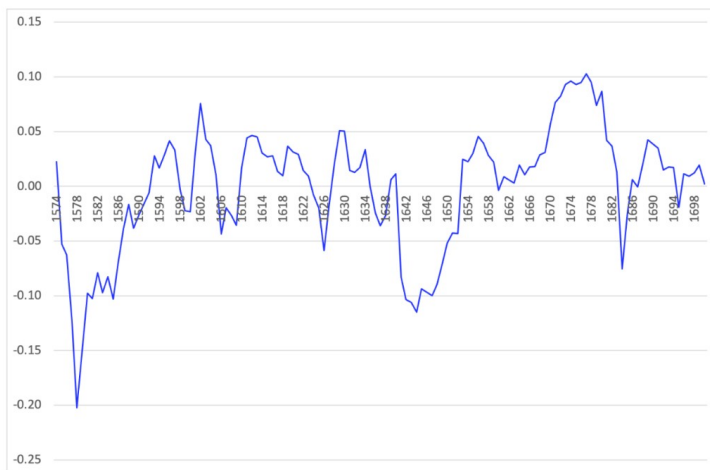
- Main issue: though cheap, depends on purchasing power.
 - Argue that link between bulls sold and economic hardship is uninformative of individuals' subjective welfare.
 - Purchase was cheap and provided spiritual comfort by removing all guilt.
 - Deviation of bulls sold (per capita) and population is informative.

Annual total bulls and population (normalized)



Source: Alvarez-Nogal and Prados de la Escosura (2023).

Subjective well-being: ratio total bulls to population (normalized, logs)



Source: Alvarez-Nogal and Prados de la Escosura (2023).

- Major shocks correlate only slightly with bull movements:
 - Famine episodes: 1606, 1647–50, 1684.
 - Internal political turmoil and wars.
- Cannot explain contractions of 1575–86 and 1626.
- Some potential explanations:
 - 1575–86: credit crisis, when monarchy stopped payment of debt.
 - 1626: alterations to monetary policy, when monarchy substituted copper for silver coinage, leading to scarcity of silver (needed to pay bulls).

- Potential explanations for episodes of improvements:
 - 1602: recovery from plague in Castile.
 - 1670–82: period of expansion resulting from the end of war with Catalonia (1652) and Portugal (1668).

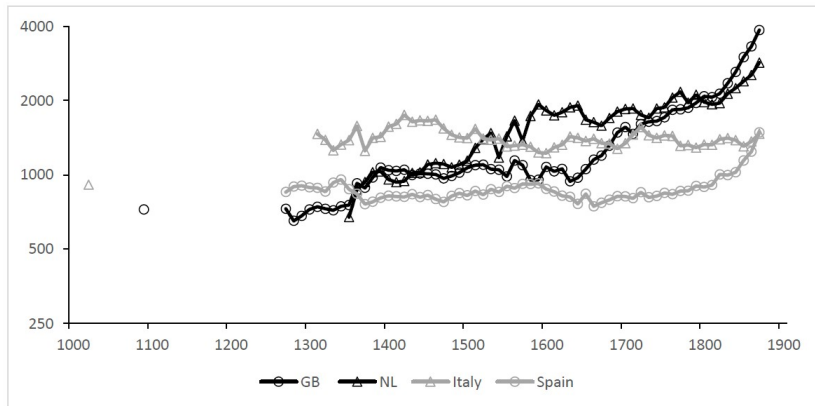
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⇒ Not great measure, but interesting and innovative way to think about subjective well-being in historical setting.

Italy

Europe's Little Divergence

GDP per Capita in Europe, 1270–1870 (1990 GK\$, Log scale)



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Malanima (2011)

- GDP estimates for Italy: Center and North.
- Italy not unified until 1861, little data in South.
- Use indirect method through demand side for agricultural output.
- For other output, urbanization proxy method.

- Indirect estimation of agricultural output through demand function approach. [Allen \(2000\)](#)

$$Q^A = rcN$$

- Q^A : real agricultural output.
- $r = Q^A/C^A$: ratio of production to consumption (often $r = 1$).
- c : per capita consumption.
- N : population.

- Real consumption per capita:

$$C = \left(P^A/P\right)^{\alpha_1} \left(P^{NA}/P\right)^{\alpha_2} y^\beta$$

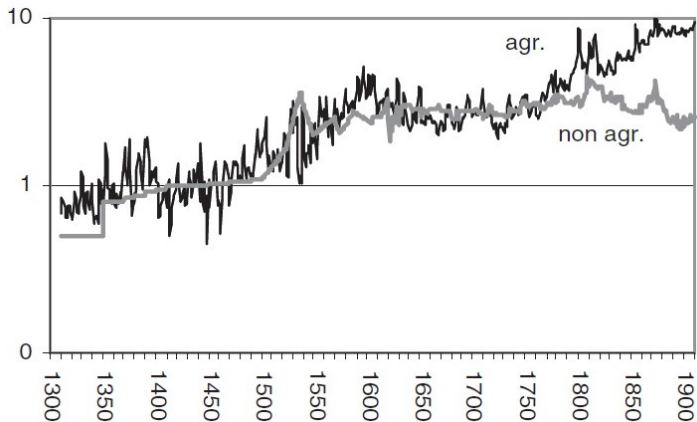
$$\ln c = \alpha_0 + \alpha_1 \ln \left(P^A/P\right) + \alpha_2 \ln \left(P^{NA}/P\right) + \beta \ln y$$

- P^A/P : agricultural product prices in real terms.
- P^{NA}/P : non-agricultural product prices in real terms.
- y : real income per capita.
- α_0 : constant.
- α_1 : own-price elasticity of demand.
- α_2 : cross-price elasticity of demand.
- β : income elasticity of demand.

- Prices are known (Tuscany and Lombardy, argued representative).
- Population is known.
- Income is unknown \implies use real wage w as a proxy (laborers for rural wages, masons for urban wages).
 - Other sources of income, especially in rural areas? Assume competition, so equalization.
 - Share of labor in national income? Assume constant 70% (based on mid-19th century data)
 - Wage rates are available \implies working days per year? Calculate on assumptions in labor supply curve.

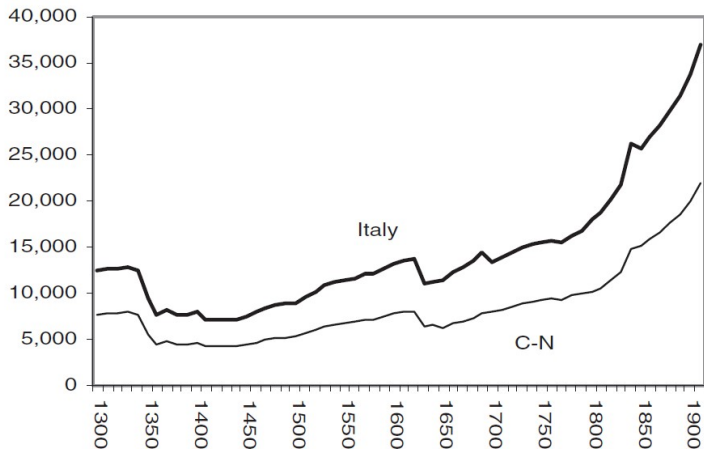
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 - Wage rates are available \implies working days per year? Calculate on assumptions in labor supply curve.
- Same price and income elasticities from current developing countries (adapted to case of Italy).

Price indices of agricultural and non-agricultural goods (1420=40=1, logs)



Source: Malanima (2011).

Population in Italy and central-northern Italy (C-N)



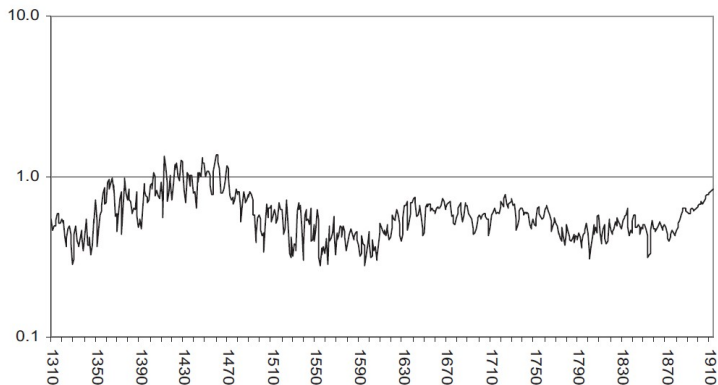
Source: Malanima (2011).

Implicit working days per year

	Days of work
I350–I400	161
I400–50	120
I450–I500	136
I500–50	206
I550–I600	250
I600–50	204
I650–I700	169
I700–50	165
I750–I800	200
I800–20	210

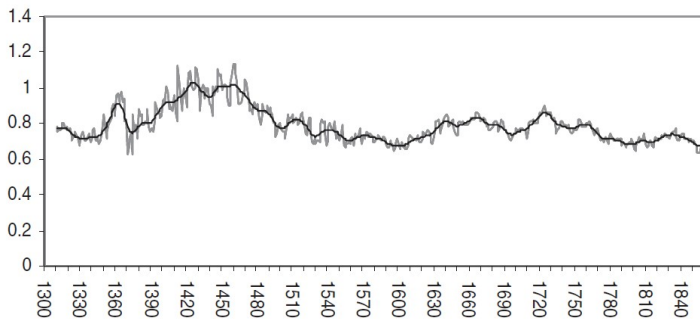
Source: Malanima (2011).

Index of real wage rates (1420–40=1, logs)



Source: Malanima (2011).

Index of per capita agricultural GDP (1420–40=1, logs)



Source: Malanima (2011).

- For industry and services: proxy with urbanization rate (share of population in urban centers).
- Estimate non-agricultural output Q^{NA} :

$$Q = Q^A + Q^{NA} \iff Q = \frac{Q^A}{1 - (Q^{NA}/Q)}$$

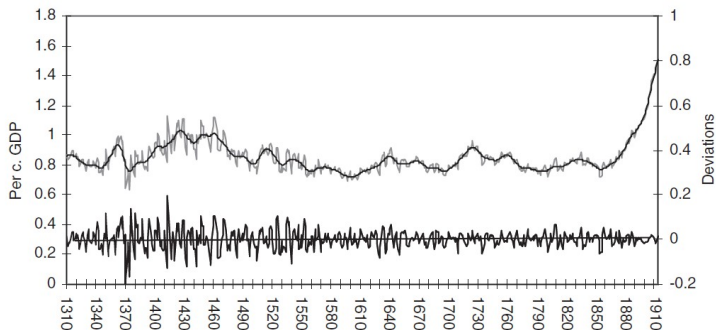
- Q^{NA}/Q : share non-agricultural output.
- Use a 5,000 inhabitants threshold (consistent with Bairoch's (1988) estimates).

Urbanization (%)

	Urbanisation (>5,000)
1300	21.4
1350	17.7
1400	17.6
1450	17.0
1500	21.0
1550	20.0
1600	18.4
1650	15.2
1700	16.9
1750	17.7
1800	17.5
1850-61	16.2

Source: Malanima (2011).

Per capita GDP in central and northern Italy (1420–40=1)



Source: Malanima (2011).

- Three epoch of Italy's pre-industrial growth:
 - 1300s–1550s: Italian Renaissance. Millennium high GDP per capita, Europe's leader (with NL).
 - 1550s–1880s: Italian decline.
 - After 1880s: beginning of modern growth in Italy.

Chilosi and Ciccarelli (2023)

- Two criticism of Malanima's (2011) series:
 - No estimate for South Italy (44% of area and 36% of population).
 - Demand-approach based on daily wages, not representative (misses industrious revolution).
- New estimates (incl. South) independent of wages:

Chilosi and Ciccarelli (2023)

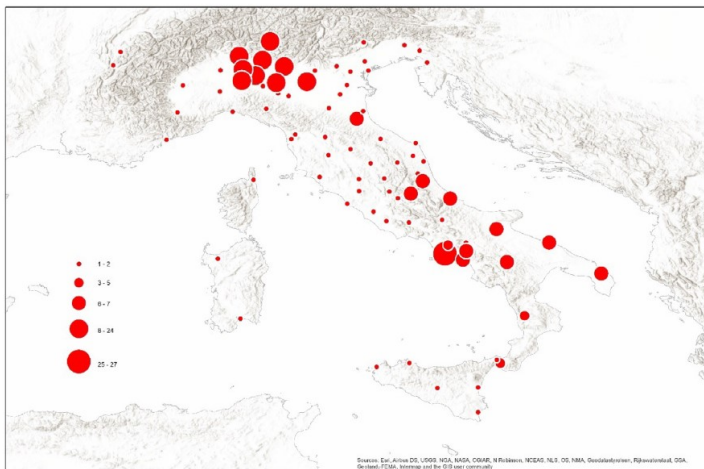
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 - Infer GDP per capita from occupational structure.
 - Approach used in England, showing predictions close to Broadberry et al. (2015).

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 - Approach used in England, showing predictions close to Broadberry et al. (2015).
- Findings: downward upwards for C-N Italy and positive growth for S Italy.

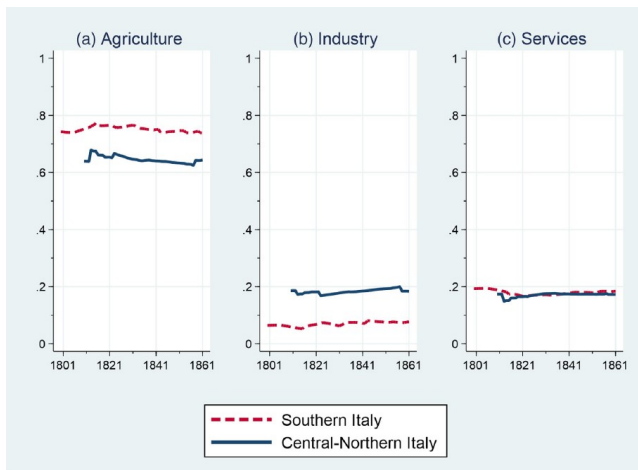
- Method exploits Engel's law to reconstruct GDP per capita trends consistent with agricultural employment shares. [Groth and Persson \(2016\)](#)
- Develop a general equilibrium model linking labor income in agriculture to labor share in agriculture.
- Data from 354 regional censuses between 1800 and 1859. [Chilosi and Ciccarelli \(2022\)](#)

Number of censuses with occupations per province (1800–61)



Source: Chilosi and Ciccarelli (2022).

Sectoral employment shares in Italy (1800–61)



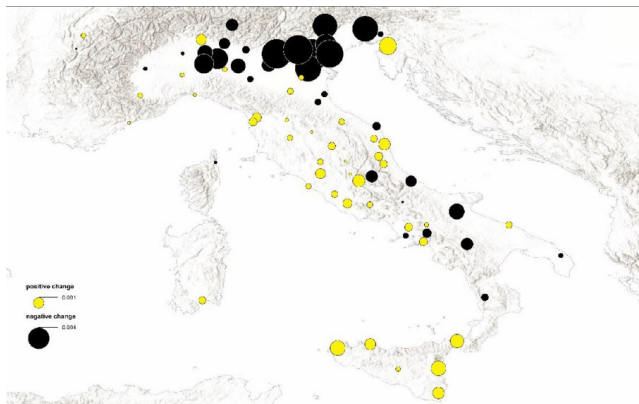
Source: Chilosi and Ciccarelli (2022).

Agricultural employment shares by province in Italy (1848)



Source: Chilosi and Ciccarelli (2022).

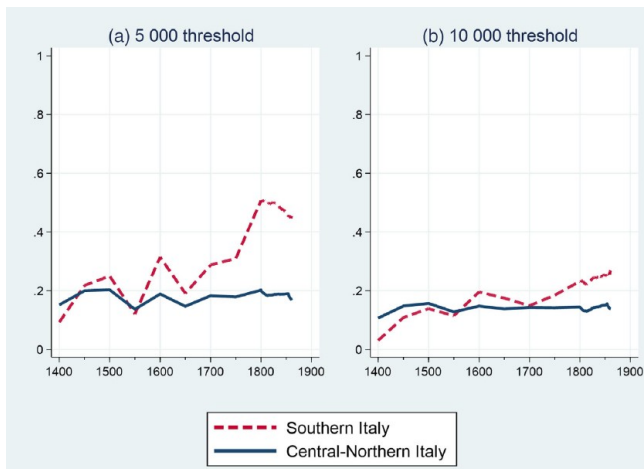
Yearly changes in agricultural employment shares by province in Italy (1800–61)



Source: Chilosi and Ciccarelli (2022).

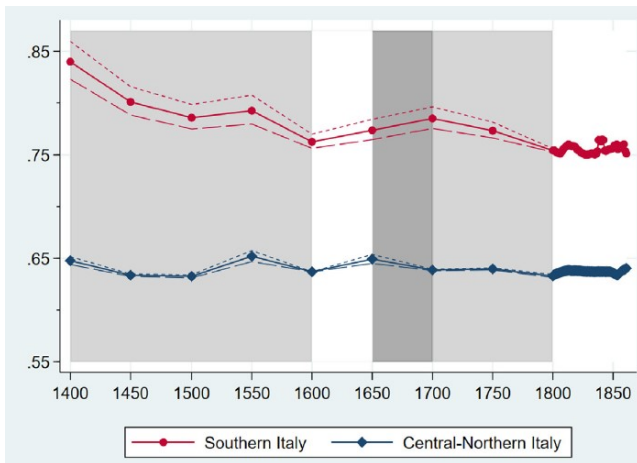
- Sectoral shares before 1800:
 - Extrapolate agricultural employment share backwards relying on trends in urbanization rates.
 - Assume distribution of agricultural workers across cities and countryside did not change.
 - Little proto-industrialization in Italy.
 - Account for agro-towns by focusing on 10,000 threshold

Trends in urbanization rates in Italy (1400–61)



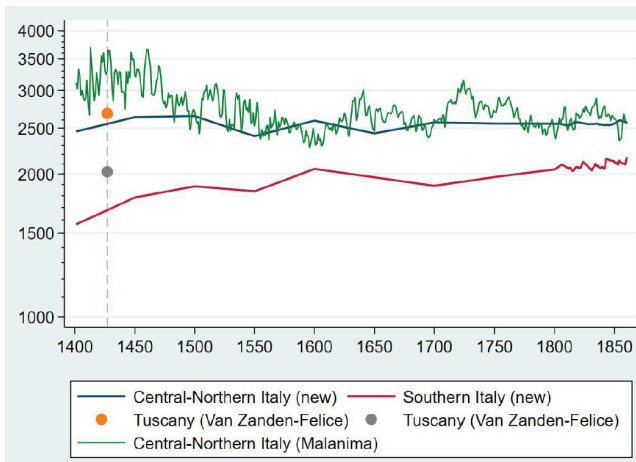
Source: Chilosi and Ciccarelli (2022).

Trends in agricultural employment shares in Italy (1400–61)



Source: Chilosi and Ciccarelli (2022).

GDP per capita in Italy (2011 PPP IGK \$, log scale)

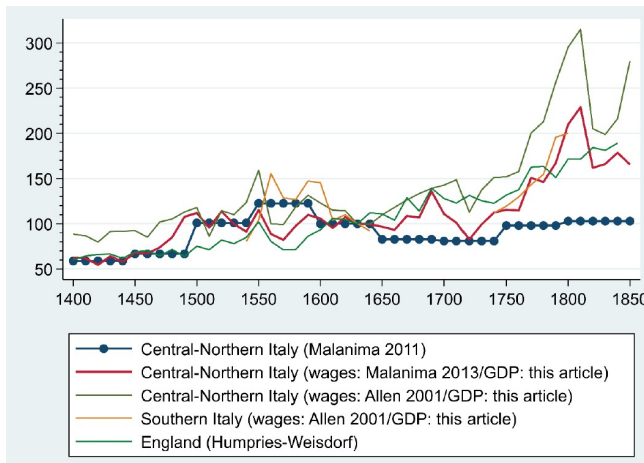


Source: Chilosì and Ciccarelli (2023).

- New information for the South:
 - 1400–1600: strong growth (+33%) during Renaissance
 - 1600–1700: century-long contraction (−10%).
 - 1700–1861: slow growth (+.01%) during Long Risorgimento.

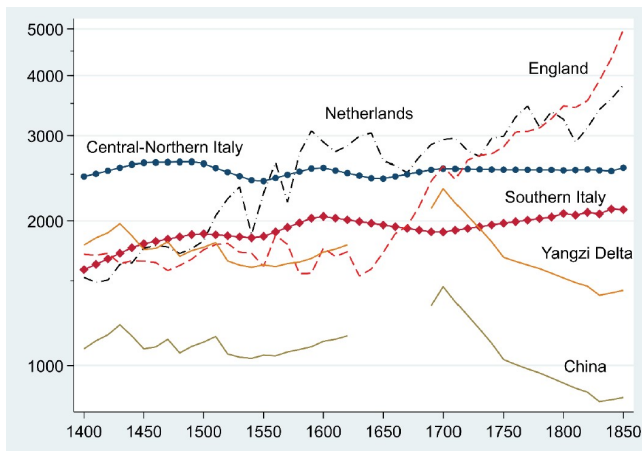
- New information for the South:
 - 1400–1600: strong growth (+33%) during Renaissance
 - 1600–1700: century-long contraction (−10%).
 - 1700–1861: slow growth (+.01%) during Long Risorgimento.
- Comparison with Malanima's (2011) series:
 - Similar: long stagnation for C-N Italy from 1500 to 1861.
 - Lower levels in 1400–1500: unclear but ↓ agricultural shares incompatible with 15th-century decline.
 - Higher levels in 1700–1770: discounts changes in working days.
 - Overall, long-run stagnation of C-N of Italy.

Labor participation index (1630s=100)



Source: Chilosi and Ciccarelli (2023).

GDP per capita (2011 PPP IGK\$, log scale)

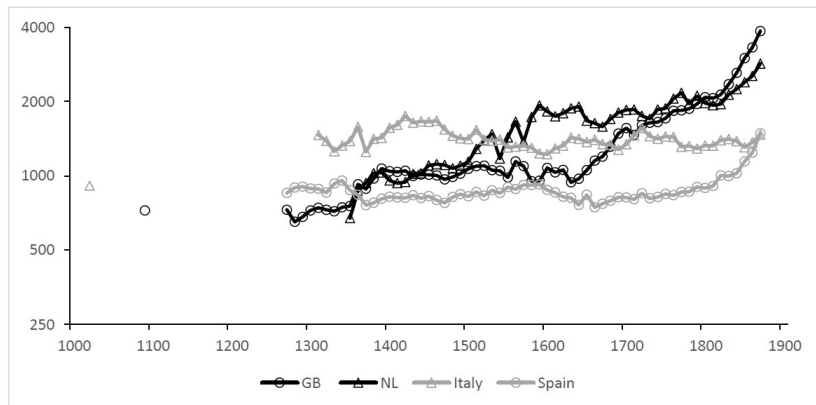


Source: Chilosi and Ciccarelli (2023).

France

Europe's Little Divergence

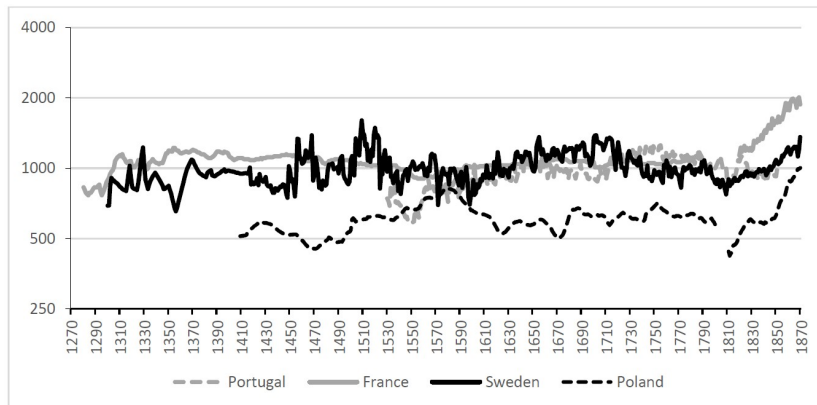
GDP per Capita in Europe, 1270–1870 (1990 GK\$, Log scale)



Source: Broadberry (2021) based on Broadberry et al. (2015), van Zanden and van Leeuwen (2012), Malanima (2011), and Alvarez-Nogal and Prados de la Escosura (2013).

Europe's Little Divergence

GDP per Capita in Europe, 1270–1870 (1990 GK\$, Log scale)



Source: Broadberry (2020) based on Palma and Reis (2019), Ridolfi (2016), Krantz (2017), Schon and Krantz (2012), Malinowski and van Zanden (2017).

Ridolfi and Nuvolari (2021)

- Interesting features of the French case:
 - Typical case of stagnant economy dominated by Malthusian checks (*histoire immobile?*).
 - Intermediate position between North and South in the Little Divergence?

Ridolfi and Nuvolari (2021)

- Interesting features of the French case:
 - Typical case of stagnant economy dominated by Malthusian checks (*histoire immobile?*).
 - Intermediate position between North and South in the Little Divergence?
- No “new generation” estimates for France.
- Broadberry’s series relies on Ridolfi’s (2016) dissertation draft.
- Ridolfi and Nuvolari (2021) update these estimates.

- Indirect estimation of agricultural output through demand function approach. [Allen \(2000\)](#)

$$Q^A = rcN$$

- Q^A : real agricultural output.
- $r = Q^A/C^A$: ratio of production to consumption (often $r = 1$).
- c : per capita consumption.
- N : population.

- Real consumption per capita:

$$C = \left(P^A/P\right)^{\alpha_1} \left(P^{NA}/P\right)^{\alpha_2} y^\beta$$

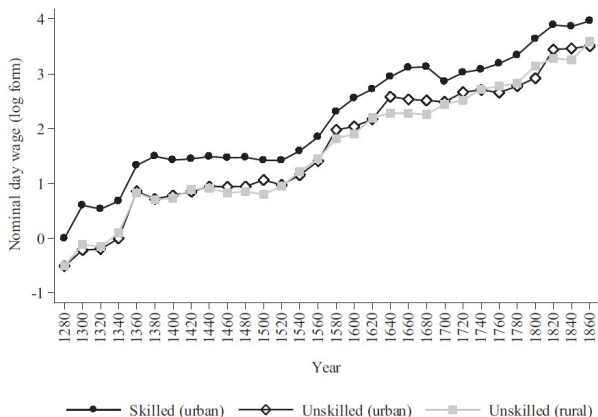
$$\ln c = \alpha_0 + \alpha_1 \ln \left(P^A/P\right) + \alpha_2 \ln \left(P^{NA}/P\right) + \beta \ln y$$

- P^A/P : agricultural product prices in real terms.
- P^{NA}/P : non-agricultural product prices in real terms.
- y : real income per capita.
- α_0 : constant.
- α_1 : own-price elasticity of demand.
- α_2 : cross-price elasticity of demand.
- β : income elasticity of demand.

- Prices are known (47k quotes for 12 commodities). [Ridolfi \(2019\)](#)
- Population is known. [Dupâquier \(1988\)](#)
- Income is unknown \implies use real wage w as a proxy (laborers for rural wages, building's craftsmen for urban wages). [Ridolfi \(2019\)](#)
 - Representative? Apply labor share weights.
 - In-kind transfers: classify wages depending on in-kind payments, keeping only non-nourished workers.
 - Deflate nominal wages by cost of living index based on respectability basket with time-varying weights.
 - Wage rates are available \implies working days per year? Convert to annual income assuming 250 days per year (accurate for construction workers, assumed for laborers).

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 - Wage rates are available \implies working days per year? Convert to annual income assuming 250 days per year (accurate for construction workers, assumed for laborers).
- Same price and income elasticities from current developing countries (adapted to case of France).

French nominal wages (Sous tournois per day, log scale)



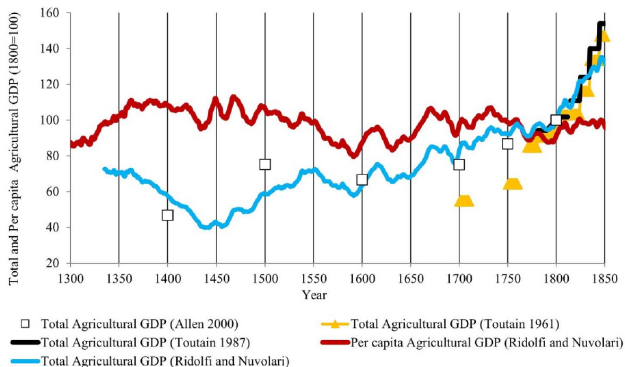
Source: Ridolfi (2019).

Structure of consumer price index

Good	Quantity per person per year	Unit	1300– 1400	1400– 1500	1500– 1600	1600– 1700	1700– 1800	1800– 1850
Bread	182	kg	0.340	0.322	0.365	0.362	0.354	0.360
Legumes	52	l	0.047	0.057	0.085	0.073	0.066	0.066
Beef	26	kg	0.095	0.095	0.103	0.115	0.121	0.151
Butter	5.2	kg	0.060	0.059	0.055	0.060	0.057	0.056
Cheese	5.2	kg	0.039	0.039	0.036	0.040	0.035	0.037
Eggs	52	unit	0.016	0.010	0.014	0.018	0.018	0.013
Wine	182	l	0.152	0.179	0.119	0.104	0.104	0.095
Soap	2.6	kg	0.037	0.034	0.036	0.034	0.032	0.023
Linen	5	m	0.095	0.078	0.056	0.066	0.075	0.054
Candles	2.6	kg	0.034	0.034	0.035	0.033	0.032	0.033
Lamp oil	2.6	l	0.025	0.027	0.029	0.025	0.030	0.023
Firewood	5	Millions BTU	0.013	0.017	0.019	0.021	0.029	0.042
Rent	5	% of total cost	0.048	0.048	0.048	0.048	0.048	0.048
Total			1.000	1.000	1.000	1.000	1.000	1.000

Source: Ridolfi and Nivolari (2021).

Agricultural output (1800=100)



Source: Ridolfi and Nuvolari (2021).

- Three stages for total agricultural output:
 - 1280–1580: typical U shape reflecting demographic trends, Malthusian phase.
 - 1600–1780: steady increase in agricultural output from 60 to 100.
 - 1790–1850: further acceleration with increase of 50 percent.
- Long-run stagnation of per capita agricultural output.

France

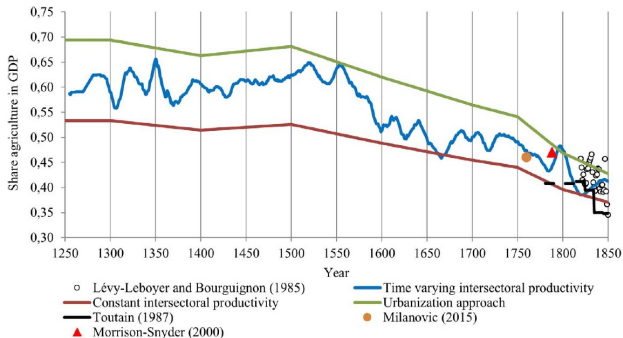
- For industry and services: don't proxy with urbanization rate directly (share of population in urban centers).
- Instead, labor share in agriculture vs rest of economy combined with wage ratios.

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- Instead, labor share in agriculture vs rest of economy combined with wage ratios.
- Estimate share of agricultural output Q^A/Q :

$$\frac{Q^A}{Q} = \frac{\pi_A L_A}{\pi L} \simeq \frac{W_A L_A}{W L}$$

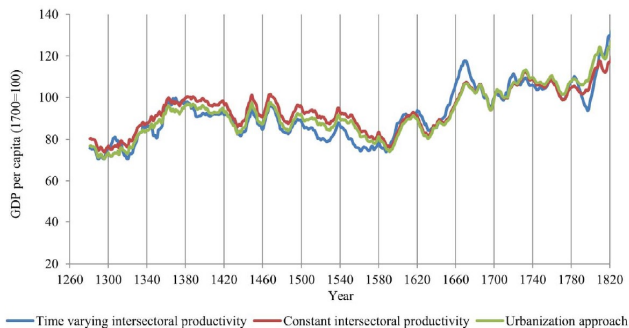
- L_A/L : labor share in agriculture (based on urbanization data).
 - π_A/π : output per worker in agriculture vs rest of economy.
 - W_A/W : real wage ratios in agriculture vs rest of economy.
- Assuming competitive labor markets, real wages approximate productivity.

Agricultural output share



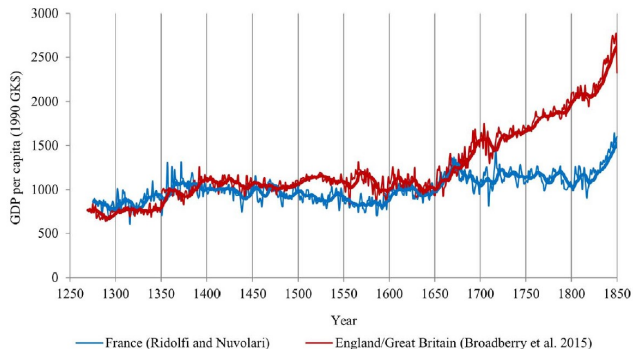
Source: Ridolfi and Nivolari (2021). Constant productivity gap in agriculture at 0.72 based on data from 19th century.

GDP per capita (1700=100)



Source: Ridolfi and Nivolari (2021).

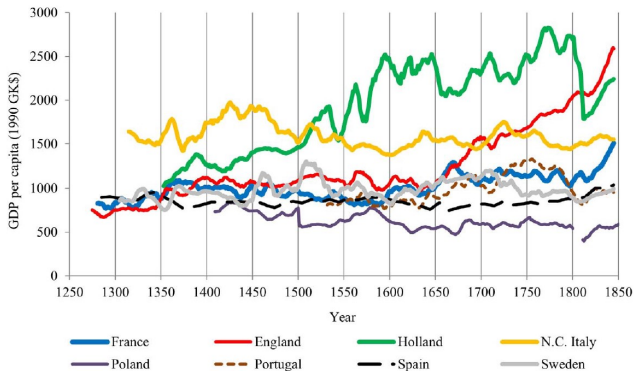
GDP per capita (1990 IGK\$)



Source: Ridolfi and Nuvolari (2021).

- Three stages relative to England:
 - 1250s–1400s: French GDP per capita higher with England converging.
 - 1400s–1680s: similar performances, with France back to pre-Black Death levels in 1600s (due to Wars of Religion).
 - Post-1680s: divergence with England growing.
- Notion of early divergence with England not confirmed by new estimates.

GDP per capita (1990 IGK\$)



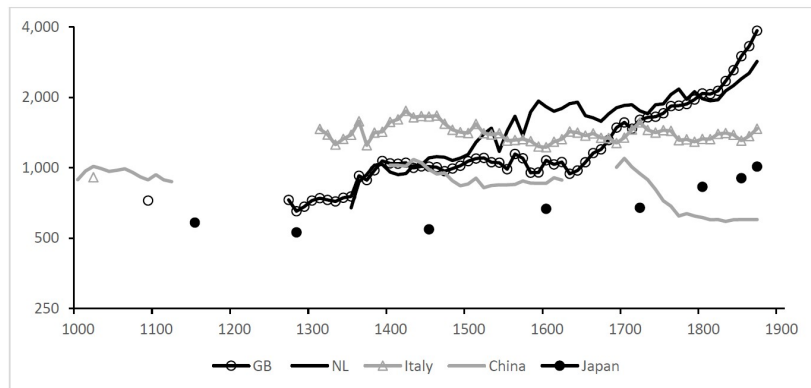
Source: Ridolfi and Nivolari (2021).

- France is intermediate between South and North-West:
 - No sustained growth like Holland early 16th and Britain mid 17th.
 - No large fluctuations like Spain or Italy (though new estimates for Italy signal stagnation).
 - France stable above the pre-Black Death level after 1660s.

China

The Great Divergence

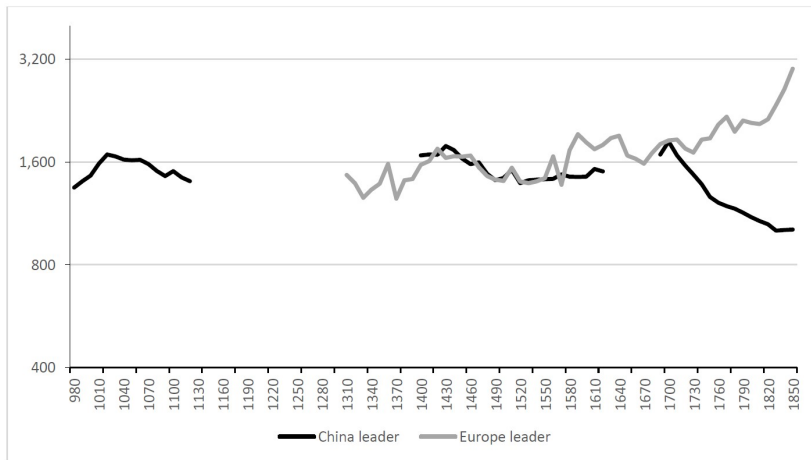
GDP per Capita in Europe and Asia, 1000–1870 (1990 GKI\$, Log scale)



Source: Broadberry (2020) based on Broadberry et al. (2015), van Zanden and van Leeuwen (2012), Malanima (2011), Broadberry, Guan and Li (2018), Bassino, Broadberry, Fukao, Gupta and Takashima (2015).

The Great Divergence

GDP per Capita in Leading Regions of China and Europe, 980–1850 (1990 GK\$, Log scale)



Source: Broadberry (2020) based on Broadberry, Guan and Li (2018).

Broadberry et al. (2018, 2021) Solar (2021)

- Measuring China's GDP per capita is key to the Great Divergence debate.
- But no estimates for China until Broadberry et al. (2018).

Broadberry et al. (2018, 2021) Solar (2021)

- Measuring China's GDP per capita is key to the Great Divergence debate.
- But no estimates for China until Broadberry et al. (2018).
- Data scarce context:
 - 960–1127: Northern Song dynasty, data for 980–1120.
 - 1368–1644: Ming dynasty, data for 1400–1620.
 - 1644–1911: Qing dynasty, data for 1690–1840.

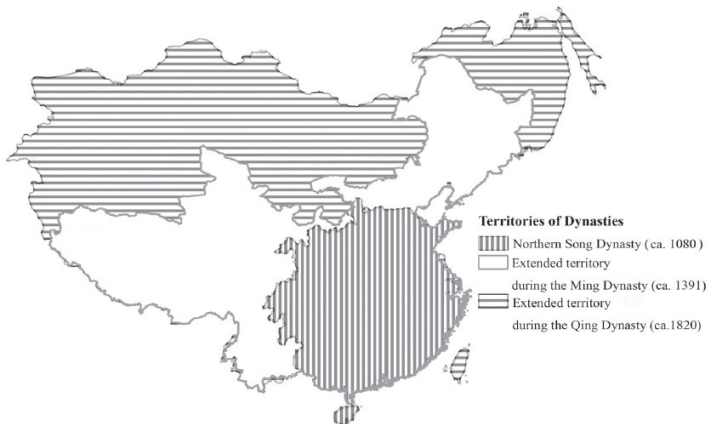
- Results:
 - Fluctuations at high levels during Song and Ming, downward trend during Qing.
 - China richer than Britain circa 1090.
 - Britain catches up by 1400.
 - China richest in Asia in 1600s but behind Europe leaders.
 - Great Divergence under way among areas' leaders by 1700.

- Methods:
 - Patchy wage data \implies can't estimate agricultural output from demand side.
 - Estimate agricultural output from supply side using information on output by sector as for Britain.
 - For non-agriculture, both urbanization and output data available.

- Sources:
 - Rich official sources: systematic, national coverage, but doubtful accuracy.
 - *Shihuo zhi* (treatise on food and money) for each dynasty since 202 BC. Reports from regional authorities to central government on arable land, population, fiscal revenue, output of salt and iron.
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 - Private historical literature, mainly contemporary historians for comprehensive examination to access empire's bureaucracy, but less systematic and complete.
 - *Difang zhi* (regional gazetteers): encyclopedia of province, prefecture, county. Important sources for information on industry but sub-national level.
 - Extensive secondary literature on quantitative economic history of China.

Territories of the Northern Song, Ming, and Qing Dynasties

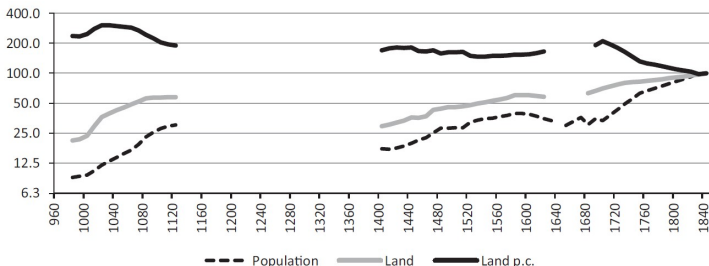


Source: Broadberry et al. (2018).

- Population:
 - Northern Song (980–1120): official data on number of households, multiplied by family size of 5.4 (based on local gazetteers and other sources). 9 benchmark years with decadal interpolation. [Wu \(2000\)](#)
 - Ming (1400–1644): official data on population. 5 benchmark years with decadal interpolation. [Maddison \(1998\)](#) based on [Perkins \(1969\)](#) [Liu and Hwang \(1979\)](#)
 - Qing (1690–1840): official data on population. 3 benchmark years with decadal interpolation. [Maddison \(1998\)](#) based on [Perkins \(1969\)](#) [Liu and Hwang \(1979\)](#)

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 - Qing (1690–1840): official data on population. 3 benchmark years with decadal interpolation. [Maddison \(1998\)](#) based on [Perkins \(1969\)](#) [Liu and Hwang \(1979\)](#)
- Range of error: $\pm 10\%$ initially to $\pm 5\%$ in 18th century.
- Rapid growth during Song, decline during Mongol interlude, then continuous increase during Ming and Qing.

Chinese population and agriculture (1840=100, log scale)



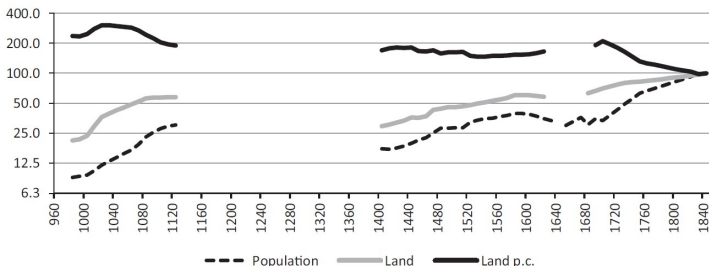
Source: Broadberry et al. (2018).

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- Area of cultivated land:
 - Use official data, but adjusted since relate to tax units rather than arable land.
 - Two potential biases:
 - Tax evasion, although limited as registration needed for retaining ownership.
 - Non-consistent standard measure for unit of land area (*mu*), which varied over regions and time.
 - Data for benchmark years with decadal interpolation from many secondary sources based on official data.

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 - Non-consistent standard measure for unit of land area (*mu*), which varied over regions and time.
 - Data for benchmark years with decadal interpolation from many secondary sources based on official data.
- Range of error: $\pm 20\%$ initially to $\pm 10\%$ in 18th century.
- Growth over time but did not keep up with population during Qing.

Chinese population and agriculture (1840=100, log scale)



Source: Broadberry et al. (2018).

- Crop yields:
 - Northern Song (980–1120): 3 benchmark years based on 286 local observations. [Wi \(1985\)](#) [Qi \(2009\)](#)
 - Ming (1400–1644): derived from land rent, with consensus that rent was about half grain output. 4 benchmark years based on 179 local observations. [Gui \(2000\)](#)
 - Qing (1690–1840): 6 benchmark years based on 3,000 local observations. [Shi \(2015\)](#)
- Yields per crops averaged and weighted by distribution of cultivated land area between crops.
- Distribution of crops from official sources.

Distribution of cultivated land area by major crops

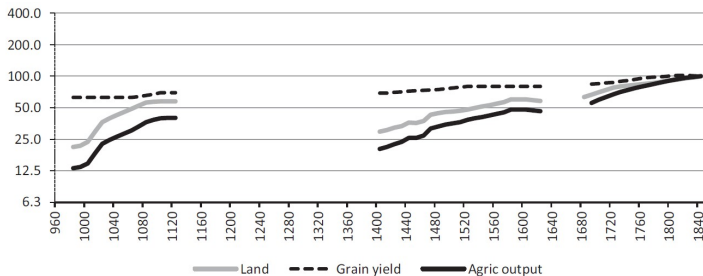
	1000	1400	1700	1750	1800	1850
Rice	60.0	50.2	33.0	31.0	29.0	27.0
Wheat			23.0	22.0	21.0	20.0
Barley			7.0	7.2	7.3	7.2
Millet			8.0	8.2	8.4	8.2
Corn			0.0	1.2	2.3	3.5
Potatoes			0.5	0.5	0.8	1.2
Sorghum			8.1	8.3	8.4	8.3
Other crops	34.0	42.1	9.4	9.7	9.8	9.6
Cash crops	6.0	7.7	11.0	12.0	13.0	15.0
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Broadberry et al. (2018) based on Wu (1985), Guo (2000), and Lui (2009).

- Use 1880s data to derive remaining details. [Zhang \(1987\)](#)
 - Agricultural inputs set to 15% of gross output, based on ratio from 1880s data.
 - Net output of livestock and fishing set at 10% of net output of grain crops, based on ratio from 1880s data.
 - Net output of cash crops (sugarcane, cotton, tobacco, peanuts, hemp) set to 25% of net output of grain crops, based on ratio from 1880s data.

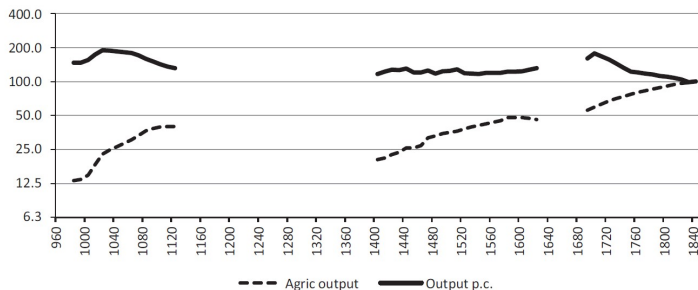
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- Rising yields over time, with introduction of higher-yield rice type. But insufficient to compensate for decline in cultivated land per capita.

Chinese population and agriculture (1840=100, log scale)



Source: Broadberry et al. (2018).

Chinese population and agriculture (1840=100, log scale)



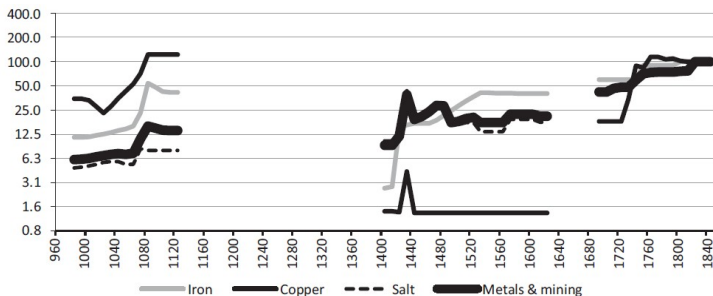
Source: Broadberry et al. (2018).

- Industrial output across 4 main sectors:
 - Metals and mining.
 - Food processing.
 - Textiles and other manufacturing.
 - Building.
- Set of benchmark years and decadal interpolation.
- Get output from each sector and aggregate into index using value-added weights from benchmark year of 1880. [Zhang \(1987\)](#)

- Metals and mining: iron, copper, salt. Liu (1993), Huang (1989), Wang (1995, 2005), Guo (1997), Zeyi (1962), Li (1979), Xu and Wu (1985).
 - Northern Song (980–1120): iron used for coining and government purchases, copper used for minting, salt tax data.
 - Ming (1400–1644): state-run iron and copper industry, private iron and copper tax revenues, salt consumption per head multiplied by population.
 - Qing (1690–1840): iron output from Guangdong industrial center and other provinces, copper output for Yunnan industrial center and other provinces.

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- Volatility with a boom during Song, decline during Ming (decline in weapons production and minting of coins), and rebound during Qing (end of state monopolies).

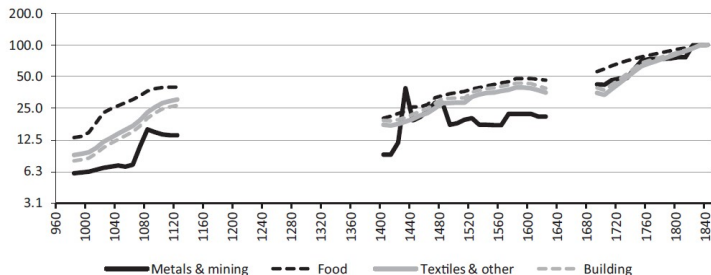
Chinese industry (1840=100, log scale)



Source: Broadberry et al. (2018).

- Food processing: assumed to grow following agricultural output (as for England).
- Building: assumed to grow following population and urbanization (Great Wall completed before 1400). [Rozman \(1973\)](#) [Maddison \(1998\)](#)
- Textile: assumed to grow following population.

Chinese industry (1840=100, log scale)

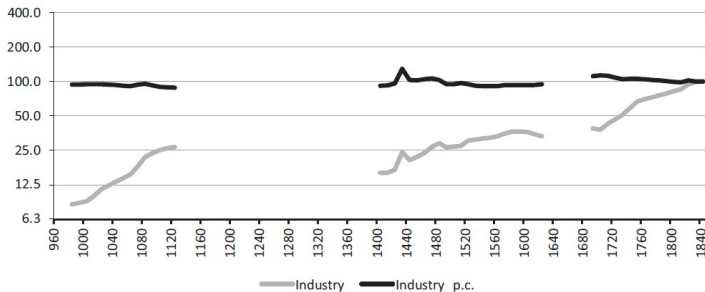


Source: Broadberry et al. (2018).

- Industry output index:
 - Convert output into values using prices and deflate.
 - Aggregate using added-value weights of each sector from benchmark year 1880. [Zhang \(1987\)](#)

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 - Convert output into values using prices and deflate.
 - Aggregate using added-value weights of each sector from benchmark year 1880. [Zhang \(1987\)](#)
- Industrial output grows at same rate as population (also, partly based on population trends).
- 1400s “boom” due to metals and mining.

Chinese industry (1840=100, log scale)

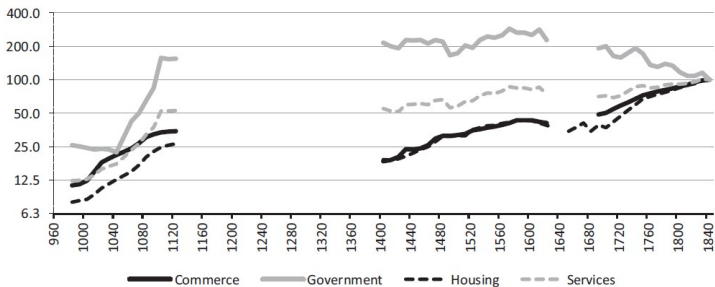


Source: Broadberry et al. (2018).

- Service sector output:
 - Commerce: volume of agricultural and industrial goods distributed based on 1840 weights (58% and 42%) and commercialization rates (17% for agriculture and 100% for industry). [Wu \(1998\)](#)
 - Government: derived from number and civil servants and soldiers multiplied by salaries, deflated with GDP deflator. [Li \(1998\)](#) [Wang \(1995\)](#) [Chen \(2008\)](#) [Shi and Xu \(2008\)](#)
 - Housing and domestic services: assumed to follow population and urbanization, as building industry. [Rozman \(1973\)](#)

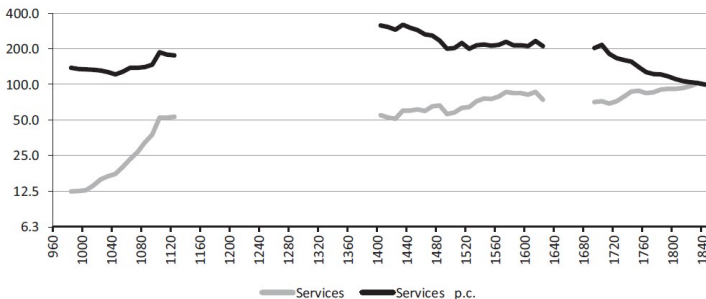
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 - Housing and domestic services: assumed to follow population and urbanization, as building industry. [Rozman \(1973\)](#)
- Sharp rise in size of government sector during Song, maintained during Ming, decline during Qing.
- Convert output into values using prices.
- Aggregate using value-added weights of each sector in benchmark year 1880. [Zhang \(1987\)](#)

Chinese services (1840=100, log scale)



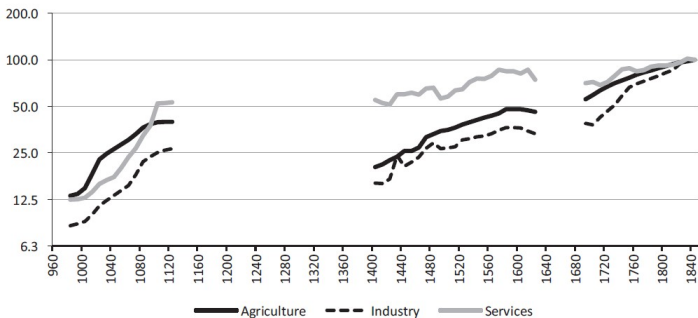
Source: Broadberry et al. (2018).

Chinese services (1840=100, log scale)



Source: Broadberry et al. (2018).

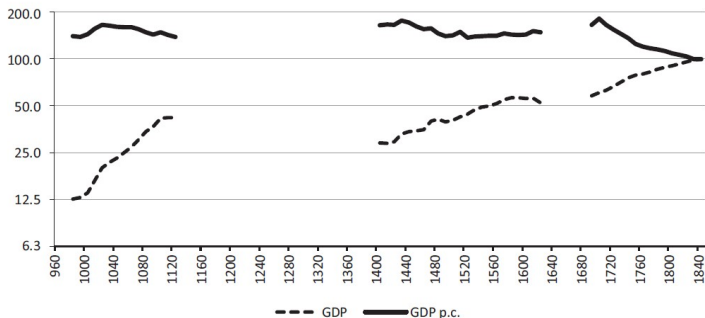
Chinese agricultural, industrial, and service sector output (1840=100, log scale)



Source: Broadberry et al. (2018).

- Combine output indices to produce real GDP.
- Need value added weights of each sector \implies use benchmark year of 1880. Zhang (1987)
- Take absolute level of GDP in 1840 to calculate nominal value of GDP of each sector, assuming stability of output shares between 1840 and 1880.
- To calculate GDP in real terms, use a general price index to construct a GDP deflator based on grain and cloth price index weighted 67% and 33% (based on output shares in 1840).

Chinese constant price GDP and GDP per capita (1840=100, log scale)



Source: Broadberry et al. (2018).

Data reliability grades

Reliability Grade	Margin of Error (in Percent)	Average Margin of Error (in Percent)
A. Firm figures	± less than 5	± 2.5
B. Good figures	± 5 to 15	± 10
C. Rough estimates	± 15 to 25	± 20
D. Conjectures	± more than 25	± 40

Source: Broadberry et al. (2018).

Reliability assessments for Chinese data

	Northern Song	Ming	Qing
<i>Agriculture</i>			
Cultivated land	C	B	A
Crop yields	B	B	A
<i>Industry</i>			
Iron	B	C	B
Copper	B	C	B
Salt	B	B	B
Food processing	C	B	A
Textiles	B	B	A
Building	B	B	A
<i>Services</i>			
Commerce	B	B	A
Government	B	B	B
Housing and domestic service	B	B	A
<i>Real aggregates</i>			
GDP	B	B	A
Population	B	B	A
GDP per capita	B	B	A
<i>Nominal aggregates</i>			
GDP deflator	D	C	B
Nominal GDP	C	C	B

Source: Broadberry et al. (2018).

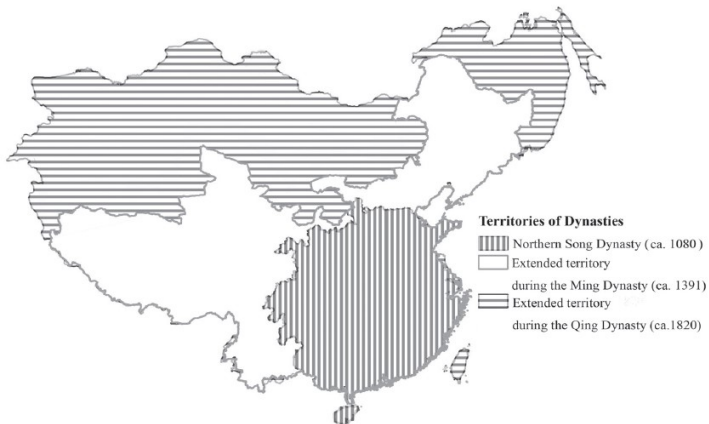
Sensitivity analysis for Chinese GDP

	Northern Song (in Percent)	Ming (in Percent)	Qing (in Percent)
Cultivated land	± 13.7	± 5.2	± 1.6
Crop yields	± 6.8	± 5.2	± 1.6
Iron	± 0.02	± 0.04	± 0.03
Copper	± 0.0039	± 0.0001	± 0.0016
Salt	± 0.04	± 0.07	± 0.13
Food processing	± 0.12	± 0.05	± 0.01
Textiles	± 0.29	± 0.29	± 0.09
Building	± 0.07	± 0.09	± 0.03
Commerce	± 0.80	± 0.68	± 0.22
Government	± 1.20	± 2.73	± 0.85
Housing and domestic service	± 0.67	± 0.84	± 0.25

Source: Broadberry et al. (2018).

- Comparisons across dynasties:
 - Territorial expansion with limited effects, since sparsely populated.
 - GDP expansion in all three dynasties:
 - Northern Song (980–1120): 0.87% growth per year.
 - Ming (1400–1644): 0.27% growth per year.
 - Qing (1690–1840): 0.36% growth per year.
 - But GDP per capita stagnant at high level, with downward trend during Qing (-0.34% per year).
 - Same GDP per capita in 1620 and 980, but 70% of 980 level in 1840.

Territories of the Northern Song, Ming, and Qing Dynasties



Source: Broadberry et al. (2018).

- Early developments with high levels of agricultural productivity, but stuck in high-level equilibrium.
- Decline during Qing due to rapid population expansion leading to division of land holdings without productivity growth, not compensated with expansion of industrial and service sector output.
- One hypothesis is sclerosis due to oversized bureaucracy.

- Comparing China and Britain:
 - Need to compare in common currency: 1990 international \$.
 - Use 1840 benchmark year for which enough price data available.
 - Also use currency exchange rates and basket weights to construct PPP values.
- In PPP, China GDP per capita is 24% of Britain in 1840.
- Converting to international \$ \implies \$600 vs \$2,500 in 1840.

China vs Britain PPP for 1840

	China Tael/lb	GB £ per lb	PPP Tael per £	Chinese Weights	British Weights
Rice	0.01407	0.02500	0.56	0.201	0.000
Wheat	0.00900	0.00691	1.30	0.134	0.335
Sugar	0.04900	0.02191	2.24	0.134	0.134
Tea	0.09347	0.13021	0.72	0.134	0.134
Salt	0.00544	0.00134	4.07	0.067	0.067
Iron	0.04195	0.00402	10.44	0.046	0.046
Cotton cloth	0.20690	0.11301	1.83	0.284	0.284
FOOD			1.53		
OTHER			3.04		
TOTAL			2.03		

Source: Broadberry et al. (2018).

Benchmark estimate of China vs Britain GDP per capita in 1840

<i>China</i>	
Nominal GDP (million tael)	5,379
Population (million)	412
GDP per capita (tael)	13.05
<i>England</i>	
Nominal GDP (£ million)	496.30
Population (million)	18.332
GDP per capita (£)	27.07
<i>Exchange rates</i>	
Silver exchange rate (tael per £)	3.20
PPP (tael per £)	2.03
<i>Comparative China/GB GDP per capita (percent)</i>	
At silver exchange rate	15.04
At PPP	23.76
<i>GDP in 1990 international dollars</i>	
GB	2,521
China	599

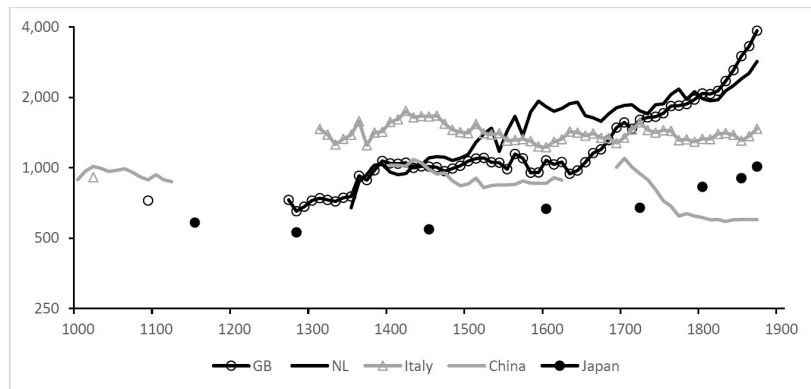
Source: Broadberry et al. (2018).

GDP per capita levels in China and Britain in 1990 IGK\$

	China (\$1990)	GB (\$1990)	China/GB (GB = 100)
980	840		
1020	997		
1060	962		
1090	862	723	119.2
1120	833		
1270		728	
1300		724	
1400	991	1,045	94.8
1450	970	1,011	95.9
1500	852	1,068	79.8
1570	873	1,096	79.7
1600	859	1,077	79.8
1650		1,055	
1700	1,089	1,563	69.7
1750	749	1,710	43.8
1800	654	2,080	31.4
1840	599	2,521	23.8
1850	600	2,997	20.0

Source: Broadberry et al. (2018).

GDP per Capita in Europe and Asia, 1000–1870 (1990 GKI\$, Log scale)



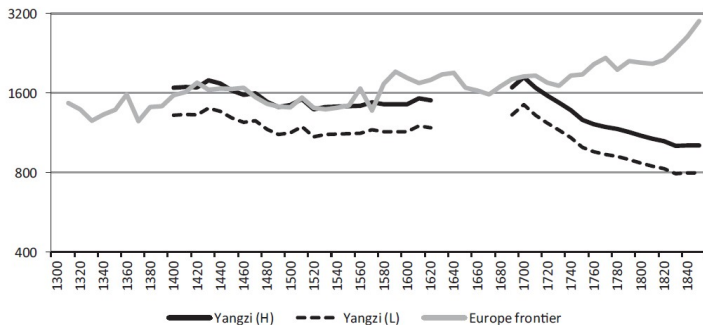
Source: Broadberry (2020) based on Broadberry et al. (2015), van Zanden and van Leeuwen (2012), Malanima (2011), Broadberry, Guan and Li (2018), Bassino, Broadberry, Fukao, Gupta and Takashima (2015).

- Comparison with Europe:
 - China richest country in the world during Northern Song (980–1120).
 - Italy ahead of China by 1300, probably earlier.
 - Britain catches up with China by 1400.
 - Netherlands, Britain, Italy substantially above China by 1500.

- Comparison with Europe leading regions:
 - But compare large economy with smaller ones.
 - More meaningful to use richer region of China: Yangzi Delta region.
 - In benchmark year 1820, Yangzi Delta 54% of Netherlands. [Bozhong and van Zanden \(2012\)](#)
- ⇒ Yangzi Delta region is \$1,050 so 75% higher than China whole.

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- ⇒ Yangzi Delta region is \$1,050 so 75% higher than China whole.
- Apply this ratio to China to get Yangzi series (high hypothesis).
- Compare to Europe leader.
- Build lower series based on alternative estimates in 1850, based on retroprojecting Maddison's figure for 1933. [Xu et al. \(2017\)](#)

GDP per capita in leading regions of Europe and China in 1990 IGS\$

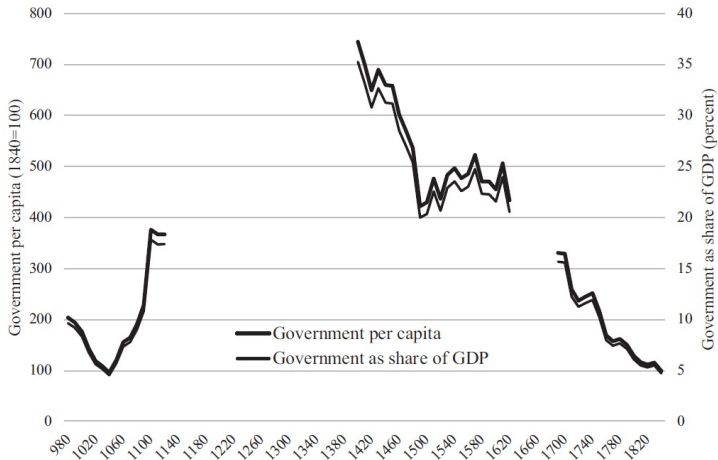


Source: Broadberry et al. (2018).

Solar (2021)

- Issues with Broadberry et al.'s (2018) estimates of government size.
 - Government spending per capita $7\times$ higher in early Ming than in 19th century.
 - Government share is 35% in early Ming and 15% in late Song to early Qing.
 - In Europe, never above 10%.
 - Historical evidence on China points to a sector never above 10%.

Government per capita and as share of GDP



Source: Solar (2021).

- Estimating the government sector:
 - Number employed in civil service and military, multiplied by salaries, deflated within index based on grain and cloth prices.
 - But army in Ming is 1.3–1.8M with population of 70M so male labor force of 14M.
 - Soldier's wages close to day laborers.
 - So government share less than 10–15%.

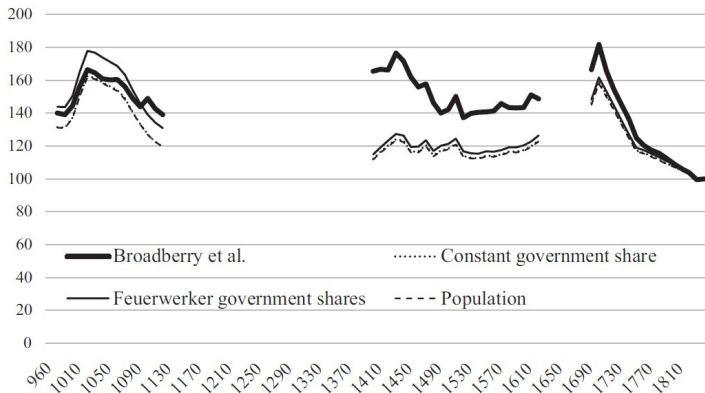
- Double accounting by Broadberry et al. (2018)?
 - Much of soldiers' time spent growing food, transporting grain.
 - Military land accounted for 3–5% of all cultivated land.
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- Also, many civil servants participate in corvée labor for handicraft production, so need to net this out since already in industrial output.

- Three alternative estimates of China's government sector:
 - Assume grew in line with population.
 - Assume constant share of GDP based on benchmark year of 1840.
 - Assume GDP share of alternative source (Song: 13%; Ming: 7%; Qing: 6%). [Feuerwerker \(1984\)](#)

- Three alternative estimates of China's government sector:
 - Assume grew in line with population.
 - Assume constant share of GDP based on benchmark year of 1840.
 - Assume GDP share of alternative source (Song: 13%; Ming: 7%; Qing: 6%). [Feuerwerker \(1984\)](#)
- Song and Qing somewhat unchanged, but Ming largely overestimated (25% lower).

GDP per capita: original and revised government sector



Source: Solar (2021).

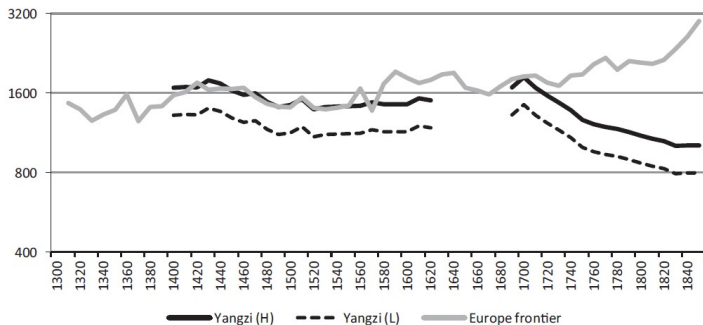
- Other issue: Broadberry et al.'s (2018) benchmark year for nominal GDP:
 - Use 1840 benchmark year for GDP level, using 1880 GDP for value-added shares.
 - More direct estimate of GDP for 1850. [Xu et al. \(2015, 2017\)](#) [Ma and de Jong \(2019\)](#)
 - Prefer benchmark of \$532 in 1850 instead of \$599 in 1840.
- Revised estimates show China much behind by 1400.
- Even looking at leading regions, Great Divergence might have occurred as early as 1400s.

GDP per capita levels in Europe and Asia (1990 IGK\$)

	China	Italy	Netherlands	Great Britain
1020	902			
1090	733			723
1300		1466		724
1400	600	1570	958	1045
1500	637	1408	1141	1068
1600	632	1224	1825	1077
1700	874	1344	1849	1563
1800	576	1327	1974	2080
1850	535	1306	2397	2997

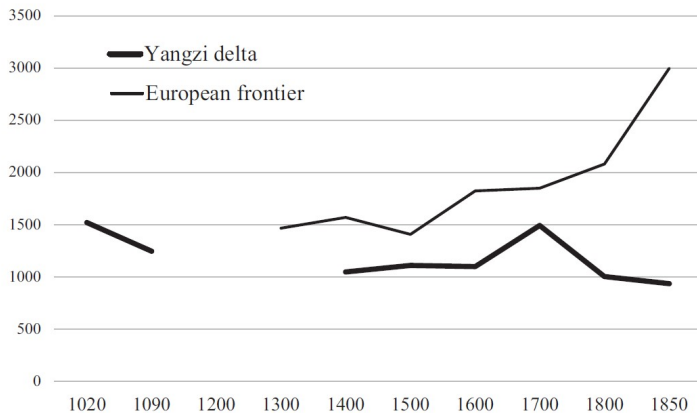
Source: Solar (2021).

GDP per capita in leading regions of Europe and China in 1990 IGK\$



Source: Broadberry et al. (2018).

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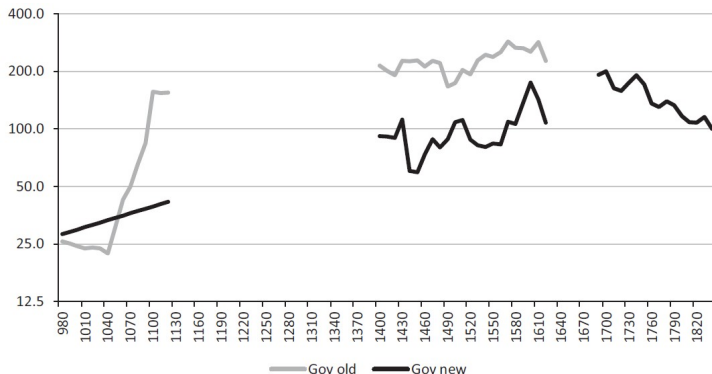
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- Response of Broadberry et al. (2021):
 - Broadly agree on government sector and revise their estimates.
 - Disagree with revision of weight in benchmark year of 1840.
 - Keep their original weighting scheme, decreasing a little the size of government based on auxiliary literature.
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- The debate continues, further issues pointed out in Solar (2021, WP).

Real government services in China (1840=100)



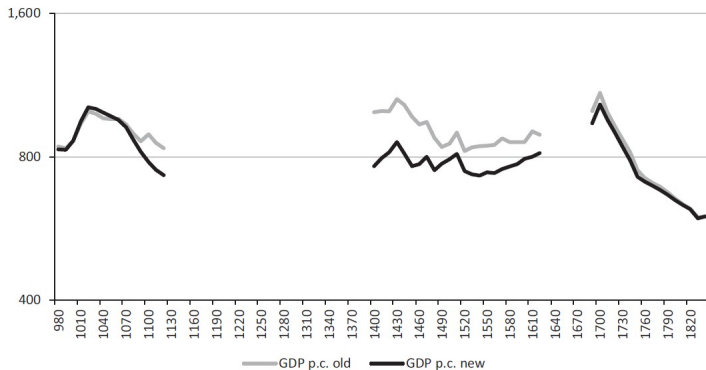
Source: Broadberry et al. (2021).

Revised sectoral shares of GDP at constant 1840 prices (%)

	Agriculture	Industry	Services (Including Government)	Government
980	70.1	5.5	24.4	4.8
1120	71.1	5.8	23.0	2.4
1400	65.7	5.8	28.5	8.6
1620	69.7	5.6	24.7	4.7
1690	67.1	5.7	27.2	7.4
1840	66.1	8.1	25.8	2.1

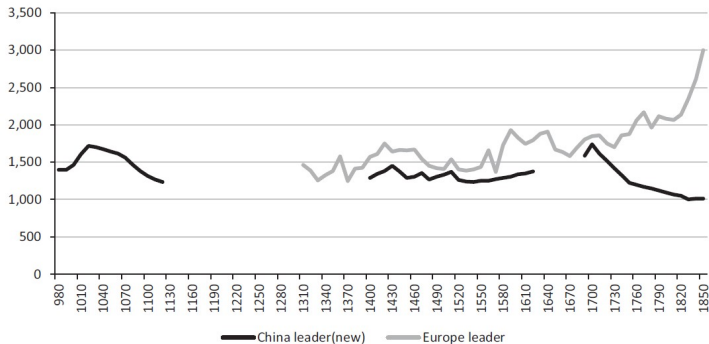
Source: Broadberry et al. (2021).

Real GDP per capita in China in 1990 IGK\$



Source: Broadberry et al. (2021).

GDP per capita in leading regions of Europe and China in 1990 IGK\$

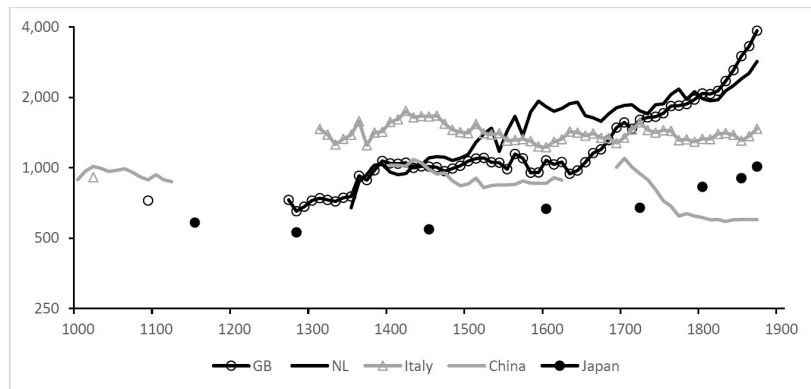


Source: Broadberry et al. (2018).

Japan

The Great Divergence

GDP per Capita in Europe and Asia, 1000–1870 (1990 GK\$, Log scale)



Source: Broadberry (2020) based on Broadberry et al. (2015), van Zanden and van Leeuwen (2012), Malanima (2011), Broadberry, Guan and Li (2018), Bassino, Broadberry, Fukao, Gupta and Takashima (2015).

Bassino et al. (2019)

- Interesting features of the Japanese case:
 - Some historians argued that Japan was on par with Europe until the 19th century. [Hanley \(1983, 1986\)](#)
 - First Asian country to catch up Europe in the 20th century after the Meiji Restoration of 1868, while China and India fell behind.
- No “new generation” estimates for Japan until Bassino et al. (2019) for 710–1874.
- Broadberry’s series relies on Bassino et al.’s working paper.

- Data scarcity \implies only benchmark years, no annual time series.
 - Ancient period (710–1192): 730, 950, 1150.
 - Medieval period (1192–1600): 1280, 1450.
 - Tokugawa period (1600–1868): 1600, 1721, 1804, 1846
 - Meiji period (1868–1912): 1874.

- Methods:
 - Agriculture:
 - From supply side: land use and crops harvested \times crop yields.
 - Combined with indirect demand approach based on population, wages, and prices.
 - Outside agriculture: indirect approach with urbanization proxies.

- Results:
 - Ancient period (710–1192): Malthusian fluctuations, income per capita and population moving in opposite directions.
 - Medieval period (1192–1600): positive growth trend in 1450–1600 (uncertain).
 - Tokugawa period (1600–1868): positive growth trend in 1721–1868 but less than in Europe.
 - Meiji period (1868–1912): take-off and modern economic growth.

- Population:
 - Ancient period (710–1192):
 - 730: number and average size of administrative villages (assuming 1,250–400 inhabitants) and adding 10% of slaves and 150k urban dwellers. [Sawada \(1927\)](#), [Kamata \(1984\)](#), [Farris \(2009\)](#)
 - 950: land area combined with land requirement per person, adding 15% of infants, 150k urban dwellers, 500k slaves. Alternative: number of administrative villages. [Yokoyama \(1879\)](#), [Kito \(1983\)](#), [Farris \(2009\)](#)
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 - Tokugawa (1600–1868) and Meiji periods (1868–1912):
 - 1600: projection from census of 1721. [Saito and Takashima \(2017\)](#)
 - 1804, 1846, 1874: national surveys. [Fukao et al. \(2015\)](#)

Total population of Japan

A. Level in millions				
Year	Average population	Minimum	Maximum	Alternative estimates
730	6.1	5.8	6.4	4.5
950	5.0	4.4	5.6	6.4
1150	5.9	5.5	6.3	6.8
1280	6.0	5.7	6.2	
1450	10.1	9.6	10.5	
1600	17.0	16.2	17.8	
1721	31.3	29.7	32.9	
1804	30.7	29.2	32.2	
1846	32.2	30.6	33.8	
1874	34.5	32.8	36.2	

Source: Bassino, Broadberry, Fukao, Gupta and Takashima (2019).

Annual growth rates (% per year)

B. Annual growth rates (% per year)

Years	Average population	Alternative estimates
730-950	-0.09	0.16
950-1150	0.08	0.03
1150-1280	0.01	-0.10
1280-1450	0.31	
1450-1600	0.35	
1600-1721	0.51	
1721-1804	-0.02	
1804-1846	0.12	
1846-1874	0.25	
730-1280	0.00	0.05
1280-1721	0.38	0.38
1721-1874	0.06	0.06
730-1874	0.15	0.18

Source: Bassino, Broadberry, Fukao, Gupta and Takashima (2019).

- Modest annual rate over period 730–1874: 0.15%.
- No Black Death or Mongol invasion.

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- No Black Death or Mongol invasion.
- 730–1280: stagnation (0%) due to frequent famines (1 every 3 years).
- 1280–1721: growth (0.38%) due to decline in frequency of famines (1 every 4 years, then 8 years after 1450).
- 1721–1846: decline (-0.02%) and slow growth (0.12%) with major famines in 1780s and 1830s.
- 1846–1874: recovery (0.25%), with proto-industrialization.

- Agriculture output from supply side.
 - Ancient (710–1192) and medieval (1192–1600) periods: amount of arable land in use \times estimates of productivity of land.
 - Tokugawa (1600–1868) and early Meiji (1874) periods: direct estimation.
- High uncertainty, hence necessary to cross-validate with demand approach.

- Ancient period (under unified government):
 - Labor restriction (*Ritsuryo*) system, where farmers cultivate allotted fields depending on family characteristics and paying land tax in rice and other poll taxes. Allotment of land revised every 6 years.
 - Arable land from number of administrative villages (50 households) and paddy area per village. For non-paddy fields, area from temples landholdings.
 - Productivity of land for paddy fields based on legal and land-related documents. For non-paddy fields, use ratio of land values.

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 - Productivity of land for paddy fields based on legal and land-related documents. For non-paddy fields, use ratio of land values.
- Medieval period (no unified government): arable land and productivity from secondary literature based on (patchy) primary sources. [Farris \(2006\)](#) [Nishitani \(2015\)](#)

- Tokugawa (1600–1868) and early Meiji (1874) periods: direct estimation.
 - Tokugawa: total agricultural output and land use from taxation system (*kokudaka*).
 - Land area from census 1874 and cadastral survey for 1721.
- Procedures to make benchmark year measurements comparable.

Japanese agricultural production

A. Levels					
	Arable land (1000 chō)	Land productivity (koku/chō)	Agricultural output (1000 koku)	Agricultural output per head (koku)	Agricultural output per head (1874 = 100)
730	640	9.58	6130	1.00	54.0
950	1028	8.30	8527	1.71	91.6
1150	1109	8.31	9211	1.56	83.9
1280	1276	6.49	8278	1.39	74.7
1450	1621	8.60	13,938	1.39	74.5
1600	2497	10.36	25,879	1.52	81.8
1721	3249	12.67	41,173	1.32	70.7
1804	3892	12.74	49,604	1.62	86.8
1846	4265	13.26	56,571	1.76	94.3
1874	4533	14.31	64,861	1.86	100.0

Source: Bassino, Broadberry, Fukao, Gupta and Takashima (2019).

Japanese agricultural production

B. Annual growth rates (% per year)

	Arable land	Land productivity	Agricultural output	Agricultural output per head
730–950	0.22	−0.07	0.15	0.24
950–1150	0.04	0.00	0.04	−0.04
1150–1280	0.11	−0.19	−0.08	−0.09
1280–1450	0.14	0.17	0.31	0.00
1450–1600	0.29	0.12	0.41	0.06
1600–1721	0.22	0.17	0.38	−0.12
1721–1804	0.22	0.01	0.22	0.25
1804–1846	0.22	0.10	0.31	0.20
1846–1874	0.22	0.27	0.49	0.21
730–1280	0.13	−0.07	0.05	0.06
1280–1721	0.21	0.15	0.36	−0.01
1721–1874	0.22	0.08	0.30	0.23
730–1874	0.17	0.04	0.21	0.05

Source: Bassino, Broadberry, Fukao, Gupta and Takashima (2019).

- Overall growth (730–1874): 0.21% per year with 4/5 from extension of arable area and 1/5 from rising land productivity.
- Most growth to keep up with population growth, esp. 730–1721 (Malthusian period).
- 1721–1874: escape Malthusian trap with per capita growth of 0.23%.

- Agriculture output from demand side.
- Indirect estimation of agricultural output through demand function approach. [Allen \(2000\)](#)

$$Q^A = rcN$$

- Q^A : real agricultural output.
- $r = Q^A/C^A$: ratio of production to consumption (often $r = 1$).
- c : per capita consumption.
- N : population.

- Real consumption per capita:

$$C = \left(P^A/P\right)^{\alpha_1} \left(P^{NA}/P\right)^{\alpha_2} y^\beta$$

$$\ln c = \alpha_0 + \alpha_1 \ln \left(P^A/P\right) + \alpha_2 \ln \left(P^{NA}/P\right) + \beta \ln y$$

- P^A/P : agricultural product prices in real terms.
- P^{NA}/P : non-agricultural product prices in real terms.
- y : real income per capita.
- α_0 : constant.
- α_1 : own-price elasticity of demand.
- α_2 : cross-price elasticity of demand.
- β : income elasticity of demand.

- Adapt this framework for Japan, where no prices other than for rice.
- Assume cross-price elasticity is 0 (instead of 0.1) $\implies \alpha_1 = -\beta$.

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$$\ln c = \alpha_0 + \alpha_1 \ln(P^A/P) + \beta \ln(W/P)$$

$$\ln c = \alpha_0 - \beta \ln(P^A/P) + \beta \ln(W/P)$$

$$\ln c = \alpha_0 + \beta \ln(W/P^A)$$

- W/P^A : “rice wages” i.e. daily wage / price of rice.

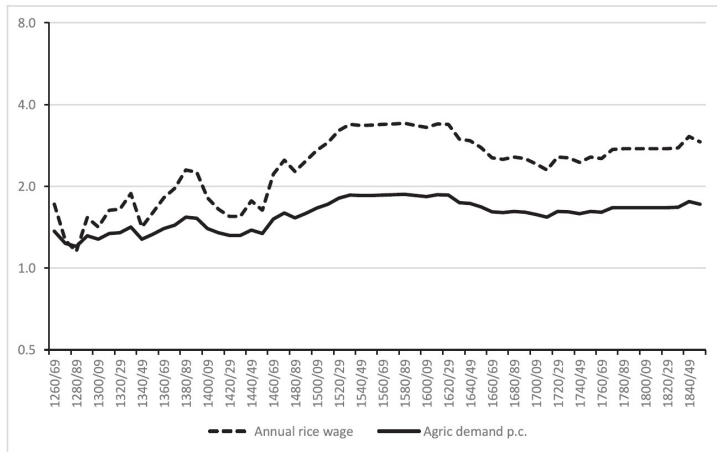
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- Constructed from nominal unskilled wages and price of rice, or from wages paid directly in rice.

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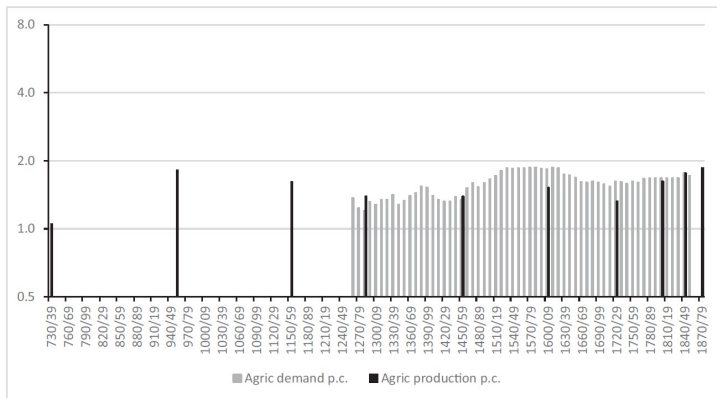
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- Convert into levels using supply side estimates of 1840s of 1.76 koku.
- Alternative sources of income (land rent): stable over time.

Japanese unskilled rice wage and agricultural demand per capita (log scale)



Source: Bassino, Broadberry, Fukao, Gupta and Takashima (2019).

Per capita supply and demand for agricultural products (log scale)



Source: Bassino, Broadberry, Fukao, Gupta and Takashima (2019).

- Supply-side: long time span but low frequency.
- Demand-side: short time span but high frequency.
- Similar increase in output from late-13th to mid-19th.
- Similar fluctuations.

- For industry and services: proxy with urbanization rate (share of population in urban centers).
- Estimate non-agricultural output Q^{NA} :

$$Q = Q^A + Q^{NA} \iff Q = \frac{Q^A}{1 - (Q^{NA}/Q)}$$

- Q^{NA}/Q : share non-agricultural output.
- Use a 10,000 inhabitants threshold because of proto-industrialization.
- (Proto-industrialization implies increased productivity in non-agricultural sector outside cities, creating bias)

Urban population and population density in Japan

	Urban population (1000)	Total population (millions)	Urban share (%)	Population density (persons per chō)
730	124	6.1	2.0	0.21
950	135	5.0	2.7	0.17
1150	120	5.9	2.0	0.20
1280	208	6.0	3.5	0.21
1450	259	10.1	2.6	0.35
1600	1088	17.0	6.4	0.59
1721	3956	31.3	12.6	1.09
1804	3936	30.7	12.8	1.06
1846	3961	32.2	12.3	1.12
1874	3588	34.5	10.4	1.20

Source: Bassino, Broadberry, Fukao, Gupta and Takashima (2019).

- Sharp increase in urbanization in Tokugawa period due to *Bakuhau* system separating peasants in country side and warriors in towns (and to some extent merchants and artisans).
- Account for proto-industrialization by including population density to affect non-agricultural output.
- Divide between secondary and tertiary based on relative weights derived in 1874, 1890, and 1909.

- Sharp increase in urbanization in Tokugawa period due to *Bakuhau* system separating peasants in country side and warriors in towns (and to some extent merchants and artisans).
- Account for proto-industrialization by including population density to affect non-agricultural output.
- Divide between secondary and tertiary based on relative weights derived in 1874, 1890, and 1909.
- Final adjustment: add 18.5% to agriculture to account for forestry and fishery based on benchmark in 1874.

B. Sectoral shares of GDP (%)

	Primary output	Secondary output	Tertiary output
730	86.3	5.5	8.2
950	86.7	5.3	8.1
1150	86.5	5.5	8.1
1280	84.8	5.8	9.4
1450	82.2	6.8	11.0
1600	73.7	8.8	17.5
1721	62.9	10.9	26.2
1804	63.0	10.8	26.2
1846	62.7	10.9	26.3
1874	59.6	12.3	28.1

Source: Bassino, Broadberry, Fukao, Gupta and Takashima (2019).

A. Level of GDP per capita

	GDP (1000 koku)	Population (million)	GDP per capita (koku)	GDP per capita (1874 = 100)
730	8422	6.1	1.38	37.2
950	11,664	5.0	2.33	62.8
1150	12,626	5.9	2.14	57.6
1280	11,571	6.0	1.94	52.4
1450	20,106	10.1	2.00	53.9
1600	41,635	17.0	2.45	66.0
1721	77,603	31.3	2.48	66.8
1804	93,296	30.7	3.04	81.9
1846	106,900	32.2	3.32	89.4
1874	128,176	34.8	3.71	100.0

Source: Bassino, Broadberry, Fukao, Gupta and Takashima (2019).

B. Annual growth rates of GDP per capita
Growth rate (% per year)

730–950	0.24
950–1150	–0.04
1150–1280	–0.07
1280–1450	0.02
1450–1600	0.13
1600–1721	0.01
1721–1804	0.25
1804–1846	0.21
1846–1874	0.40
730–1280	0.06
1280–1721	0.06
1721–1874	0.26
730–1874	0.09

Source: Bassino, Broadberry, Fukao, Gupta and Takashima (2019).

- Ancient period (710–1192): Malthusian economy, with rising living standards when population declines and vice-versa.
- Medieval period (1192–1600): stagnation then growth after 1450.
- Tokugawa period (1600–1868): stagnation then strong growth after 1721.
- Meiji period (1868–1912): take-off in early Meiji.

⇒ Transition to modern economic growth following Meiji builds upon the late Tokugawa period (post-1721).

- Medieval period (1192–1600):
 - 1280–1450: stagnation, but high population growth with development of commerce, transportation, larger cities, along with institutional changes in manorial system.
 - 1450–1600: acceleration with development of direct control of land by feudal lords, leading to improvements in agricultural productivity. Rapid growth in commercial activity overseas.

- Tokugawa period (1600–1868):
 - 1600–1721: stagnation, but high population growth, driven by new castle towns and the reconfiguration of the Japanese geography.
 - 1721–1868: strong growth with little population growth and proto-industrialization. Final period laying the foundations for modern economic growth achieved after Meiji restoration.

B. Reliability assessments for Japanese data

	Ancient	Medieval	Tokugawa
Primary output			
Arable land	C	C	A
Land productivity	D	C	B
Rice wage		C	B
Agricultural output	D	C	B
Secondary and tertiary output			
Secondary output	C	C	B
Tertiary output	C	C	B
Aggregates			
GDP	D	C	B
Population	C	B	A
GDP per capita	D	C	B

Source: Bassino, Broadberry, Fukao, Gupta and Takashima (2019).

C. Sensitivity analysis for Japanese GDP

	Ancient	Medieval	Tokugawa
Arable land	$\pm 17.3\%$	$\pm 16.7\%$	$\pm 1.6\%$
Land productivity	$\pm 35.2\%$	$\pm 16.7\%$	$\pm 6.5\%$
Secondary output	$\pm 5.8\%$	$\pm 1.3\%$	$\pm 1.2\%$
Tertiary output	$\pm 6.4\%$	$\pm 2.0\%$	$\pm 2.6\%$

Source: Bassino, Broadberry, Fukao, Gupta and Takashima (2019).

Different scenarios for Japanese GDP per capita (\$1990).

	Benchmark estimates	High estimates	Low estimates	Alternative estimates
730	376	526	(300)	438
950	635	889	381	757
1150	583	816	350	680
1280	529	635	423	629
1450	545	654	436	614
1600	667	734	600	667
1721	675	743	608	675
1804	828	911	745	828
1846	903	993	813	903
1874	1,011	1,112	910	1,011

Source: Bassino, Broadberry, Fukao, Gupta and Takashima (2019).

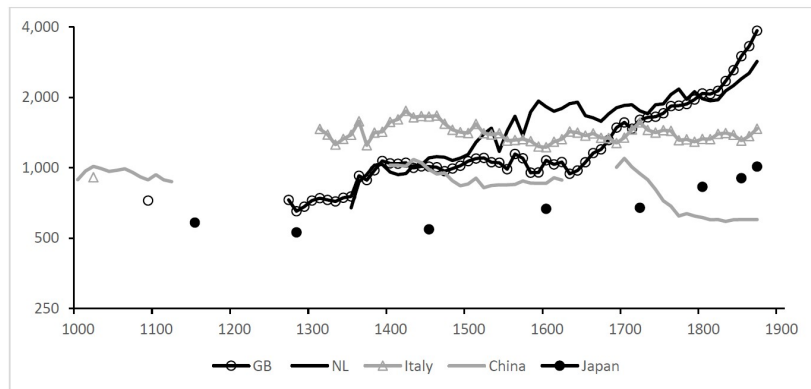
An Anglo-Japanese comparison of per capita GDP, 730–1874.

	Japan p.c. GDP, benchmark estimates (\$1990)	GB p.c. GDP (\$1990)	Japan/GB p.c. GDP, benchmark estimates (GB = 100)	Range for Japan/GB p.c. GDP (GB = 100)
730	376			
950	635			
1150	583			
1280	529	651	81.3	65.0–97.6
1450	545	1011	53.9	43.1–64.7
1600	667	1077	61.9	55.7–68.1
1721	675	1605	42.1	37.9–46.3
1804	828	2080	39.8	35.8–43.8
1846	903	2997	30.1	27.1–33.1
1874	1,011	4191	24.1	21.7–26.5

Source: Bassino, Broadberry, Fukao, Gupta and Takashima (2019).

The Great Divergence

GDP per Capita in Europe and Asia, 1000–1870 (1990 GK\$, Log scale)



Source: Broadberry (2020) based on Broadberry et al. (2015), van Zanden and van Leeuwen (2012), Malanima (2011), Broadberry, Guan and Li (2018), Bassino, Broadberry, Fukao, Gupta and Takashima (2015).

- Comparison Japan and Britain:
 - Before Black Death (1280): Japan at 81% of Britain (65–98).
 - No Black Death in Japan \implies decline to half of Britain in 1450.
 - 1450–1600: gap narrows to 62%.
 - 1600–1874: gap widens with British take-off to 24% despite Japanese take-off late 19th-century.

\implies Despite long-run positive growth, divergence with Britain since 1280, and esp. after 1600.

GDP per capita levels in Europe and Asia

	GB	NL	Italy	Spain	Japan	China	India
730					376		
950					635		
980						853	
1020						1006	
1050						967	
1086	723					878	
1120						863	
1150					583		
1280	651			897	529		
1300	724		1466	889			
1348	745	674	1327	957			
1400	1045	958	1570	822		1032	
1450	1011	1102	1657	827	545	990	
1500	1068	1141	1408	826		858	
1570	1096	1372	1325	919		885	
1600	1077	1825	1224	876	667	865	682
1650	1055	1671	1372	838			638
1700	1563	1849	1344	817		1103	622
1720	1605	1751	1564	850	675	950	
1750	1710	1877	1446	845		727	573
1800	2080	1974	1327	893	828	614	569
1850	2997	2397	1306	1144	903	600	556
1870	3856	2849	1470	1486	1011	618	526

Source: Bassino, Broadberry, Fukao, Gupta and Takashima (2019).

- Japan and the Little Divergence:
 - Japan was relatively poor in Asia in around 1000.
 - Remained poor and stagnant until growth in 1700s.
 - No experience of a decline in 18th-century.
 - Transition to modern growth in 19th-century.

⇒ Little Divergence with China circa 1700.

Ancient Economic History

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Toulouse School of Economics

Institute for Advanced Study in Toulouse

Winter 2024



How to study economic history when written records are scarce?

Matranga and Pascali (2021)

- Alternative sources of data besides written records:
 - Paleoclimatic data
 - Skeletons
 - Structures
 - Inscriptions

Paleoclimatic data

- Ice cores
- Pollen records
- Tree rings

- Ice cores
 - Ice contains tiny air bubbles \implies chemistry of Earth's atmosphere when formed.
 - Vostok Ice Core in Antarctica: data on temperature and CO₂ concentration going back 400k years at 2k years intervals.
 - But reflect average conditions across world (no regional variation).

- Paleopalynology: study of ancient pollen.
 - Conifers and 12% of flowering plants are wind pollinated: preserved, e.g., at bottom of lakes.
 - Date stratified samples through radiocarbon dating.
 - Allows to reconstruct types of plants present, and therefore climate and cultivation in a location and time.
 - Pollen stratigraphy enables to reconstruct panel data across regions.

Izbebski et al. (2020)

- Evidence of changes in structure of agricultural production and market integration in Ancient Greece based on pollen data.

- Periodization:
 - 1000 BCE to 700 BCE: early Iron Age. Small-scale village systems engaged in subsistence farming.
 - 700 BCE to 480 BCE: Archaic period. Expanding settlements and more expansive land-use systems in South; urbanization and autonomous city-states in East and North.
 - 480 BCE to 323 BCE: Classical period. Growing urbanization with citizen farmers in South; Macedonian kingdom in North.
 - 323 BCE to 31 BCE: Hellenistic period. Roman political and military influence.
 - 31 BCE to 330 CE: imperial Roman period. Consolidation of imperial political and economic structures.

- Data of pollen records:
 - European Pollen Database.
 - Focus on sites from southern Greece.
 - Include sites with at least one radiocarbon date for the last 3.5 millennia.
 - 115 samples from 6 sites from 1219 BCE to 730 CE.
 - Each sample documents the whole structure of vegetation around a given site at a particular point in time.
 - Focus on pre-Roman market integration: Iron Age, Archaic, Classical, and Hellenistic periods (1000 BCE to 31 BCE).

Pollen sites in Southern Greece



Source: Izdebski et al. (2020)

Pollen sites in Southern Greece

ID	Site name	No. of samples	Available dates
1	Vravron	19	1069, 971, 872, 774, 676, 578, 479, 381, 283, 185, 86, 37 BCE, 61, 110, 209, 307, 405, 503, 730 CE
2	Elefsina	23	1078, 1040, 984, 946, 889, 852, 795, 672, 597, 484, 380, 276, 201, 87, 12 BCE, 101, 167, 262, 347, 460, 535, 564, 630 CE
3	Lerna	14	1045, 863, 688, 346, 265, 117 BCE, 15, 118, 209, 269, 374, 472, 555, 613 CE
4	Kotychi	11	1072, 525, 451, 378, 231, 157, 10 BCE, 63, 137, 210, 504 CE
5	Voulkaria	41	554, 535, 517, 498, 489, 472, 454, 437, 420, 402, 385, 368, 351, 334, 317, 299, 281, 263, 245, 226, 186, 166, 145, 124, 101, 78, 55, 30, 5 BCE, 21, 48, 76, 104, 165, 229, 262, 332, 406, 484, 565, 649 CE
6	Halos	7	1219, 833, 239 BCE, 155, 400, 542, 630 CE

Source: Izdebski et al. (2020)

- Aggregation of pollen data at regional level:
 - Interpolation of missing eachs for each site and plant taxon using linear splines.
 - Use panel data to predict prevalence of a given plant taxon at a time and place with flexible polynomial in time:

$$\log(y_{it} + 1) = \sum_k \tau_k t^k + c_i + u_{it}$$

- y_{it} : raw percentage of pollen grains for given plant taxon at site i in year t .
- t^k : polynomial in time of degree k .
- c_i : site fixed effect.
- u_{it} : idiosyncratic error term.

Plant taxa (1/2)

Primary anthropogenic indicators	
Cerealia-type	cereals
<i>Olea</i>	olive
<i>Vitis</i>	vine
<i>Castanea</i>	chestnut
<i>Juglans</i>	walnut
Secondary anthropogenic indicators	
Cichorieae	a plant tribe incl. lettuce, chicory, dandelion, and salsify
<i>Plantago lanceolata</i> type	ribwort plantain
<i>Rumex acetosa</i> type	sorrel
<i>Sanguisorba minor</i>	salad burnet

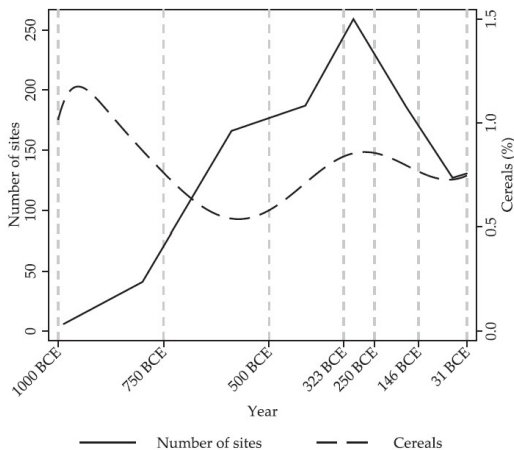
Source: Izdebski et al. (2020)

Plant taxa (2/2)

Open vegetation	
<i>Artemisia</i>	a plant genus incl. mugwort, wormwood, and sagebrush
Chenopodiaceae	a plant family, also called the goosefoot family
Cyperaceae	sedges
Poaceae	grasses
Deciduous trees	
<i>Alnus</i>	alder
<i>Carpinus betulus</i>	common hornbeam
<i>Corylus</i>	hazel
<i>Fagus</i>	beech
<i>Fraxinus ornus</i>	manna ash
<i>Quercus robur</i> type	deciduous oak
Evergreen trees	
<i>Abies</i>	fir
<i>Juniperus</i>	juniper
<i>Pinus</i>	pine
<i>Quercus ilex</i> type	evergreen oak

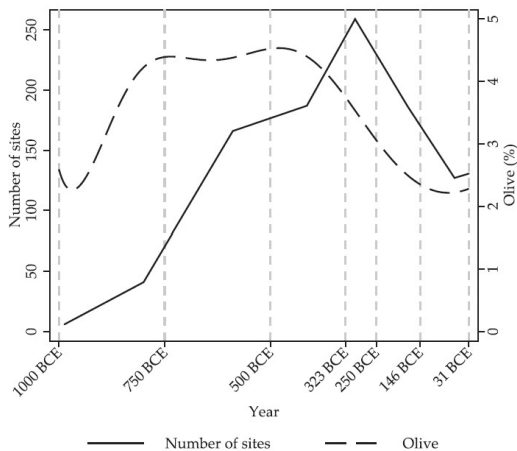
Source: Izdebski et al. (2020)

Cereals in Southern Greece



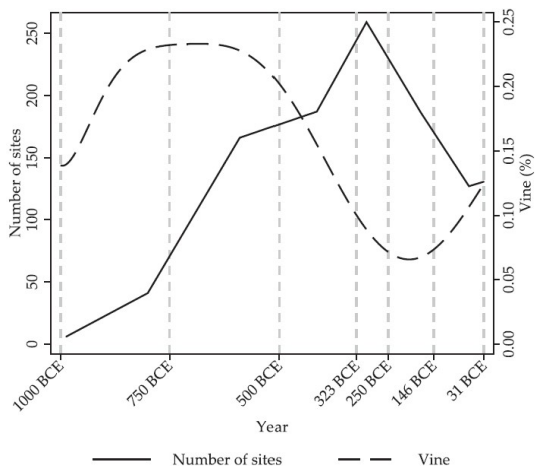
Source: Izdebski et al. (2020)

Olives in Southern Greece



Source: Izdebski et al. (2020)

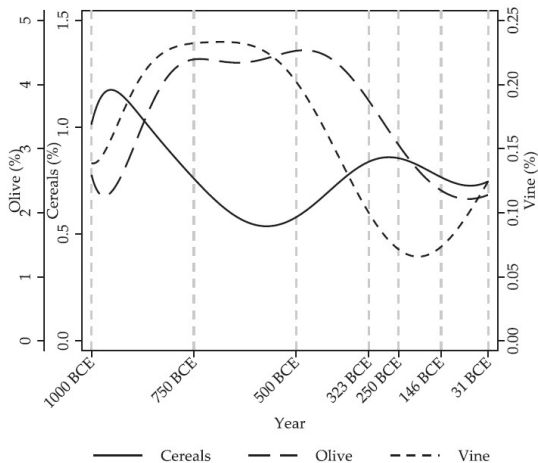
Vines in Southern Greece



Source: Izdebski et al. (2020)

Pollen records

Cereals, olives, and vines in Southern Greece



Source: Izdebski et al. (2020)

- If number of sites approximate demographic change:
 - Demographic growth in southern Greece during early Iron Age, Archaic and Classical periods.
 - Demographic decline in southern Greece during Hellenistic period.

- If number of sites approximate demographic change:
 - Demographic growth in southern Greece during early Iron Age, Archaic and Classical periods.
 - Demographic decline in southern Greece during Hellenistic period.
- Patterns of cultivation:
 - Olive and vine increased in early Iron Age, Archaic, and Classical periods, but declined in Hellenistic period.
 - Cereals decreased in early Iron age and Archaic period, then increased in Classical and Hellenistic periods.

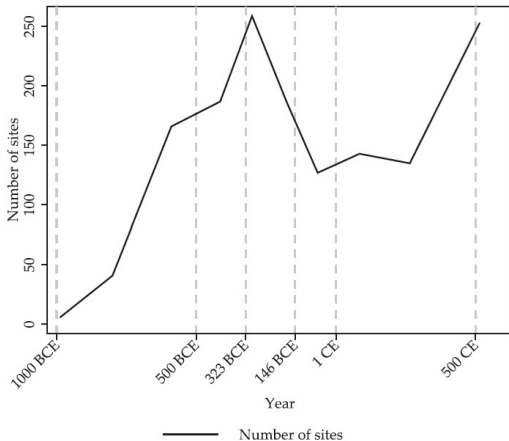
- Evidence of trade expansion before Roman empire:
 - Despite demographic growth, cereal cultivation declines while olive and vine cultivation increase.
 - Evidence of southern Greece developing an export economy based on cash cropping through olive and vine cultivation.
 - Consistent with comparative advantage of this region.

- Validity of pollen-based trends.
 - Number of sites from archaeological survey projects in Peloponnese (proxy for number of settlements): negatively correlated with pollen data from uncultivated plants.

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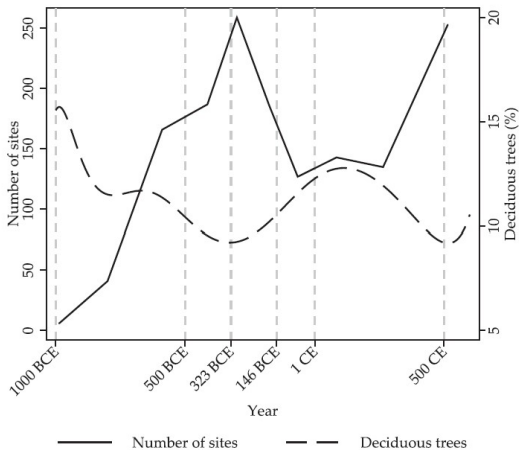
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 - Mediterranean shipwrecks (proxy for maritime trade): positively correlated with trends in cash crops in Roman period. Before: light ships so less preservation.
 - Large-scale oil and wine presses (proxy for capital investment): positively correlated with trends in cash crops in Roman period.

Demography in Southern Greece



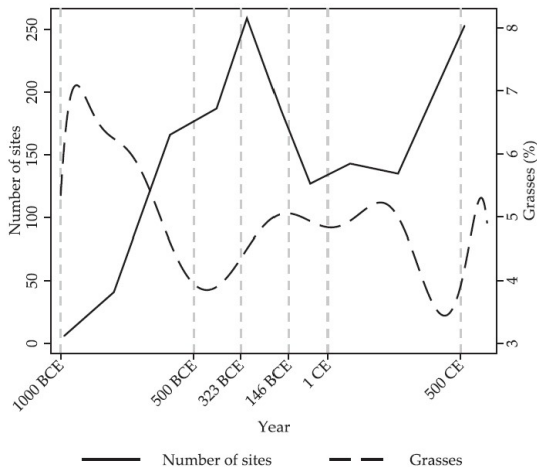
Source: Izdebski et al. (2020)

Demography and deciduous forest trees in Southern Greece



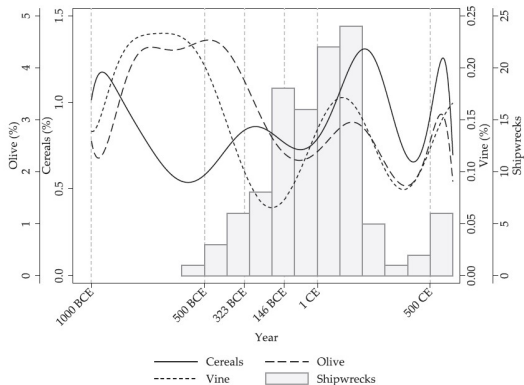
Source: Izdebski et al. (2020)

Demography and grasses in Southern Greece



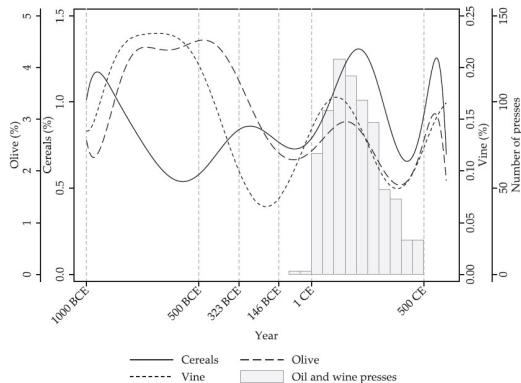
Source: Izdebski et al. (2020)

Pollen data versus shipwrecks in Southern Greece



Source: Izdebski et al. (2020)

Pollen data versus oil and wine presses in Southern Greece

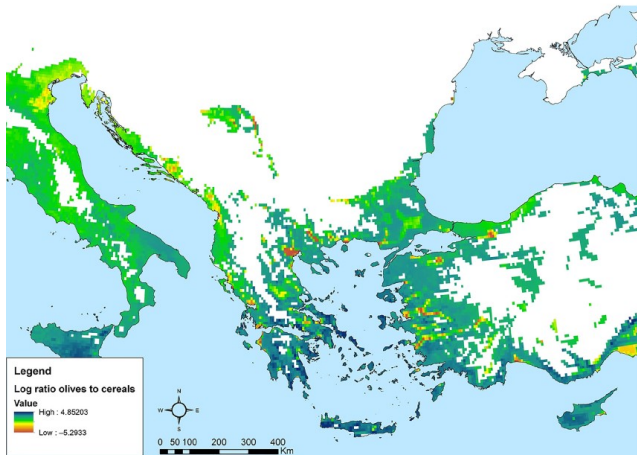


Source: Izdebski et al. (2020)

- Corroborating evidence:
 - Historiography on the Archaic and Classical periods.

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 - Historiography on the Archaic and Classical periods.
 - Comparative advantage in olive cultivation from crop suitability data (ratio of total production capacity in t/ha of olive vs cereals).

Crop suitability in the Northeastern Mediterranean



Source: Izdebski et al. (2020)

- Corroborating evidence:
 - Differential trends in agricultural production associated with trade costs and distance to Black Sea colonies (major potential trade partner).

$$\log(y_{ih} + 1) = \alpha_h + c_i + \delta_{\text{post}_h} \cdot \log(d_i) + u_{ih}$$

- y_{ih} : percentage of pollen grains from given plant taxon at site i in half century h .
- α_h : half century fixed effect.
- c_i : site fixed effect.
- post_h : indicator for Archaic and Classical periods.
- d_i measure of trade cost between site i and Sigeion (ancient Greek city-state at Aegean entrance to Dardanelles).

Pollen records

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 - post_h : indicator for Archaic and Classical periods.
 - d_i measure of trade cost between site i and Sigeion (ancient Greek city-state at Aegean entrance to Dardanelles).
- Costs of trade influenced site-specific cultivation choices in Archaic and Classical periods: when trade cost (distance) increases, more cultivation of cereals and less cash crops.

Difference-in-differences estimates

	log(Cereals+1)	log(Olive+1)	log(Vine+1)
<i>ORBIS model</i>			
log(Trade costs)	2.483** (0.725)	-2.956** (0.669)	-0.505** (0.082)
Observations	37	37	37
G	6	6	6
\hat{G}^*	2.698	2.698	2.698
R^2	0.539	0.617	0.347

Source: Izdebski et al. (2020)

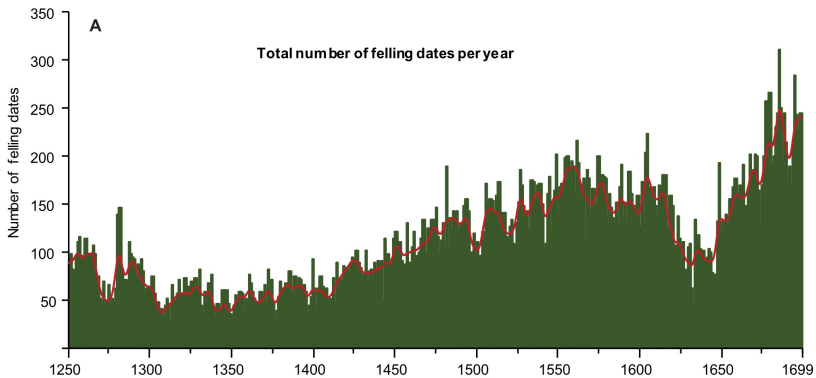
- Tree rings (dendrochronological dating):
 - Width of each ring indicates growth conditions in year when formed: proxy for temperature or rainfall.
 - International Tree Ring Data Bank: data for 4,000 sites on six continents.
 - Also timbers from historical buildings can be used to date them.

Ljungqvist et al. (2018)

- How do plagues affect economic activity? Focus on 1250–1699 Europe.
 - Written records exist, but not well preserved and spatially biased.
 - Analyze link between construction activity (proxied by tree felling dates) and plague outbreaks.

- Dendroarcheological data:
 - 49,640 data points in Austria, Belgium, Czech Republic, France, Germany, Switzerland.
 - Focus on tree-ring sequences where terminal ring of last year of tree growth (waney edge) is present \implies get exact felling year of tree.
 - Wood in dry conditions in buildings' roofs, ceilings, and basement pillars.

Tree rings



Source: Ljungqvist et al. (2018)

Tree rings

Examples of constructions in dendroarcheological dataset

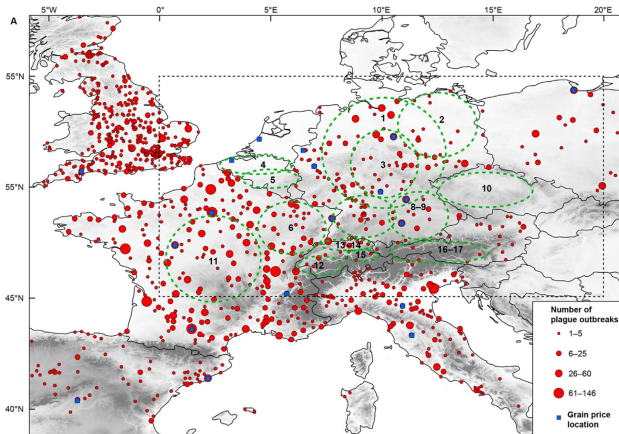


Source: Ljungqvist et al. (2018)

- Plague outbreaks:
 - 9,772 plague outbreaks with year and location information in 1346–1699. [Biraben \(1975\)](#) [Bütgen et al. \(2012\)](#)
 - Issues of overlap between plagues and tree felling dates.
- Normalize data by netting out 10-year averages and standardizing values to focus on deviations from trends.

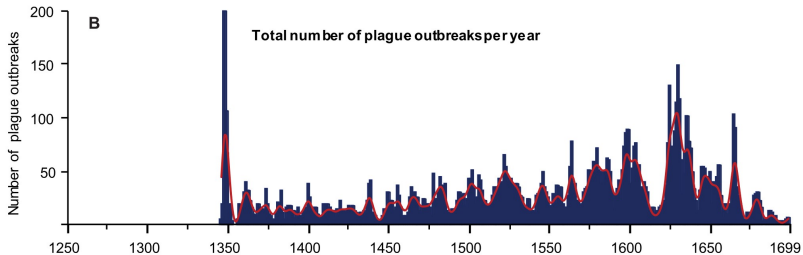
Tree rings

Locations of felling dates and plague outbreaks



Source: Ljungqvist et al. (2018)

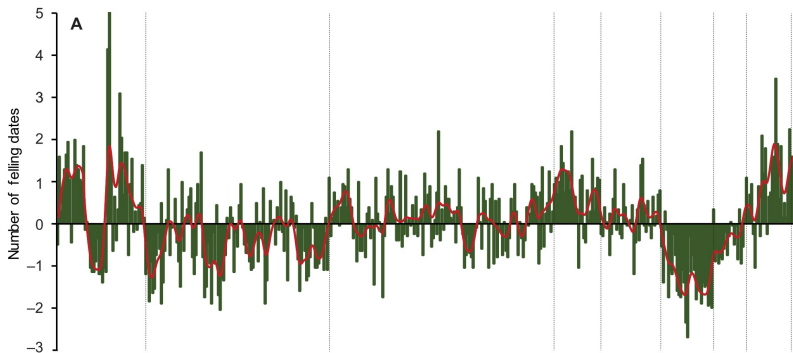
Tree rings



Source: Ljungqvist et al. (2018)

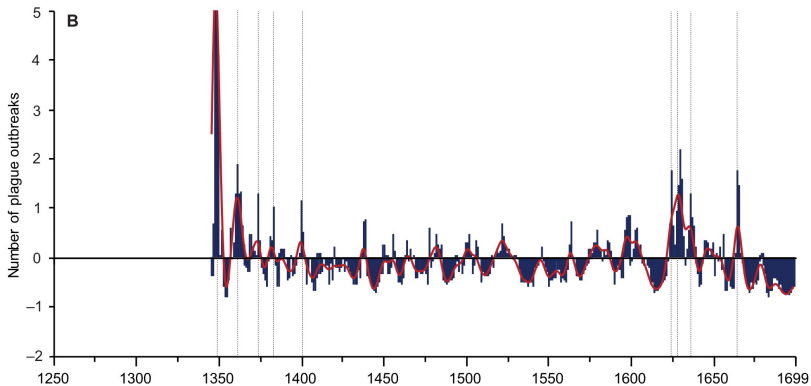
Tree rings

Standardized number of felling dates



Source: Ljungqvist et al. (2018)

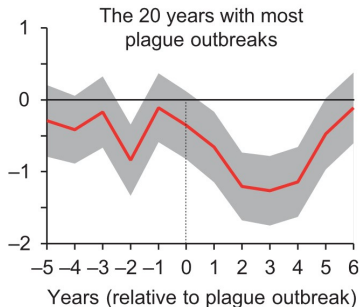
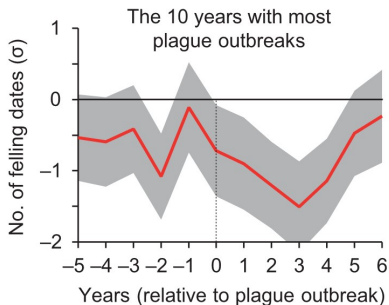
Standardized number of plague outbreaks



Source: Ljungqvist et al. (2018)

Tree rings

Plague outbreaks and felling dates



Source: Ljungqvist et al. (2018)

Skeletal data

- Bones are easily preserved and data can be extracted from them:
 - Height, even with incomplete skeleton.
 - Age at death before 20, especially if skull preserved (using patterns of dentition).
 - Gender with various methodologies.
 - Presence of specific diseases, starvation, violent death.
- Important dataset for North America: the Western Hemisphere Project, with 12k observations across 65 sites for over 8k years.

Stock et al. (2023)

- Was the Neolithic Revolution detrimental to health conditions?
 - Neolithic Revolution: transition from hunting and gathering to agriculture subsistence 8–10 kya (kilo years ago).
 - Surprisingly, associated with worse general health (systematic evidence).
 - Lower height and body mass from skeletal data.
 - Main reasons: initial increase in food availability dominated by higher population density, sedentism, infectious diseases, and zoonotic diseases associated with domestic animals.

Skeletal data

- But transition less rapid and dichotomous than thought:
 - Mixed strategies of plant domestication and foraging lasted for hundred years.
 - Evidence of declines in stature before transition.
 - Evidence of recoveries in some regions.

- But transition less rapid and dichotomous than thought:
 - Mixed strategies of plant domestication and foraging lasted for hundred years.
 - Evidence of declines in stature before transition.
 - Evidence of recoveries in some regions.
- Concomitant Secondary Products Revolution:
 - Use of domestic animals for byproducts (milk, wool, labor).
 - Barrier to milk consumption: inability to digest milk sugar lactose after childhood.
 - Some populations exhibit adaptive response to cultural shift toward dairying (Europe and East Africa).
 - Evidence that milk consumption promote skeletal growth.

- Why interesting for economic history?
 - Starting point of settlements, institutions, and States.
 - Agriculture invented independently multiple times, so causal inference possible.
 - Places that transitioned earlier are wealthier today: deep roots of comparative development (evidence in Topic 2.6).

- Most recent and comprehensive evidence based on skeletal data:
 - Explore association of reduction in body size and transition to agriculture.
 - Heterogeneity across regions depending on domestication.
 - Recovery where selection for lactose persistence?

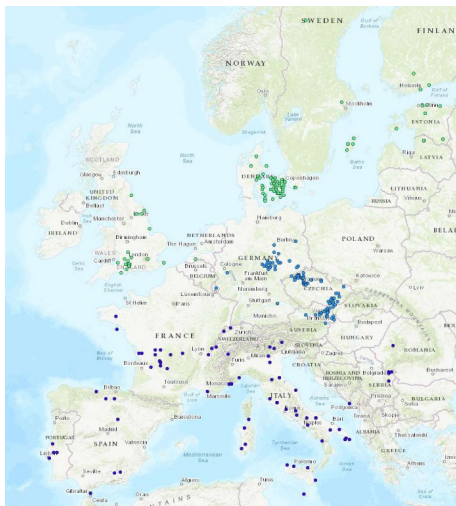
Skeletal data

- Agriculture and domestication of animals originated independently in different regions at different times throughout first half of Holocene.
- Could occur through two factors: cultural change and/or demic diffusion (migration of farmers in new territories).
 - Levant region: signs of transition 14.5–11.5 kya, full swing by 9 kya.
 - Southern Europe: rapid transition 8–7.5 kya driven by demic diffusion and cultural change by hunter-gatherer populations.
 - Central Europe: more gradual, driven by demic diffusion from Balkans.
 - Northern Europe: adoption limited by climatic factors and limited contacts 7.4–4 kya, through cultural change.
 - Britain: also late adoption, but through demic diffusion from continental farmers.

- Similarly heterogeneous diffusion of dairying patterns:
 - Data: lipid residues in Neolithic pottery and genetic variation.
 - Earliest evidence from Northern Europe 5 kya.
 - Evidence of genetic variants in Central and Northern Europe associated with demic diffusion.
 - Potentially due to challenges of establishing crop species at higher latitudes and increased prevalence of zoonotic diseases.

- Skeletal data:
 - 3,507 individual skeletons from 366 archaeological sites in Levant, Europe, Nile Valley, South Asia, China from 34 kya to present.
 - Stature derived from maximum femur and tibial length.
 - Body mass derived from femoral head diameters and maximum breadth of tibial plateau.
 - Date skeletons by radiocarbon, grouped into millennial cohorts.

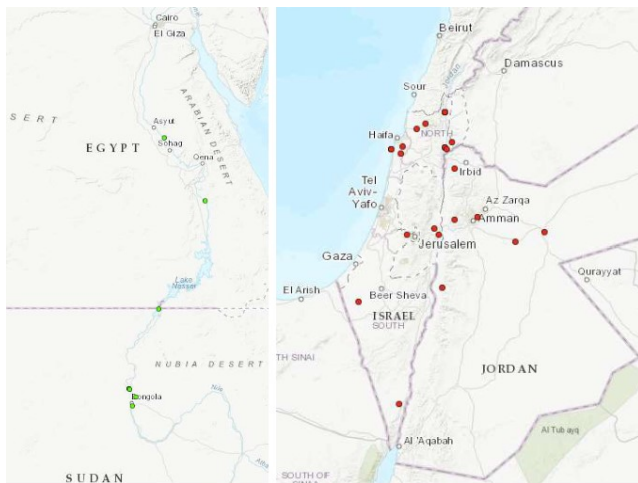
Location of archaeological sites



Source: Stock et al. (2023)

Skeletal data

Location of archaeological sites



Source: Stock et al. (2023)

Location of archaeological sites



Source: Stock et al. (2023)

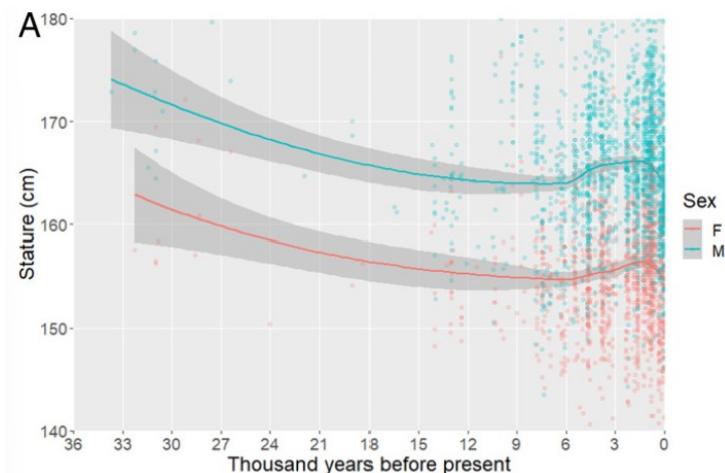
Location of archaeological sites



Source: Stock et al. (2023)

Skeletal data

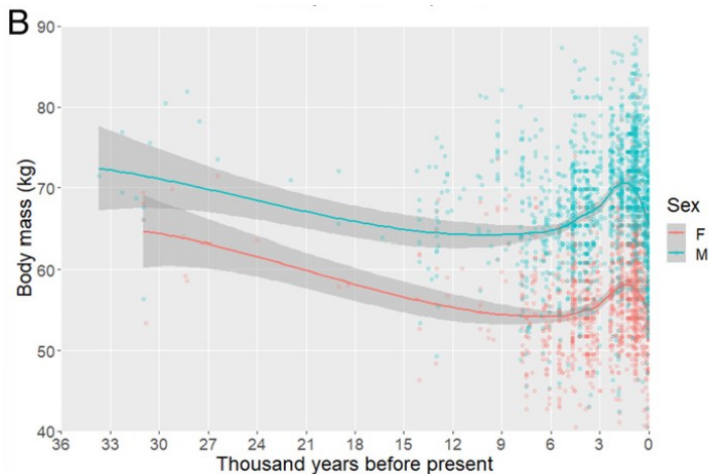
Stature (cm) variation worldwide



Source: Stock et al. (2023)

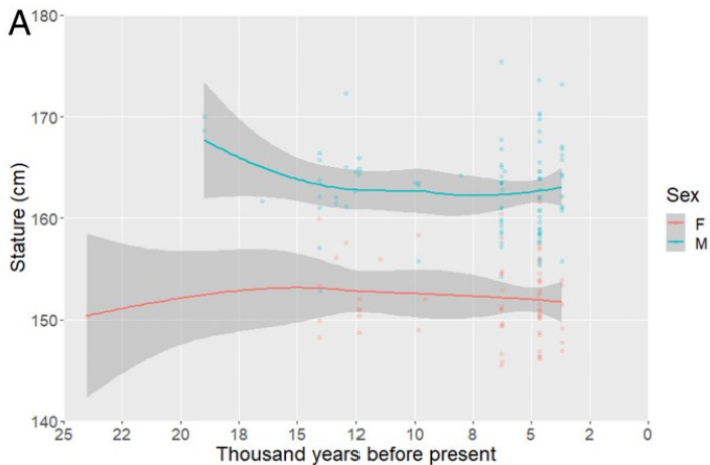
Skeletal data

Body mass (kg) variation worldwide



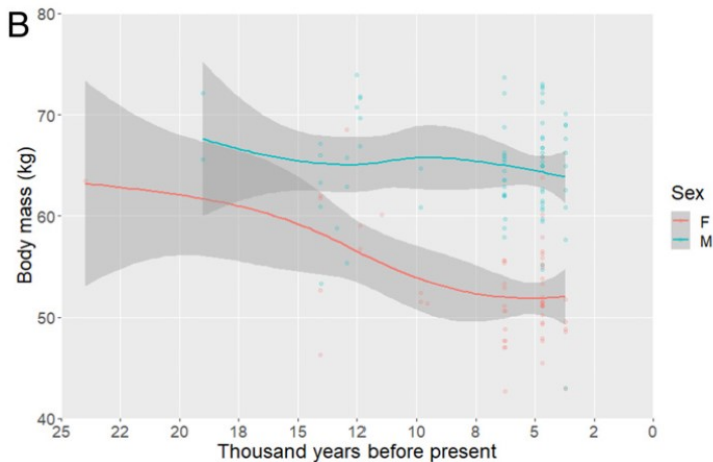
Source: Stock et al. (2023)

Stature (cm) variation in the Levant



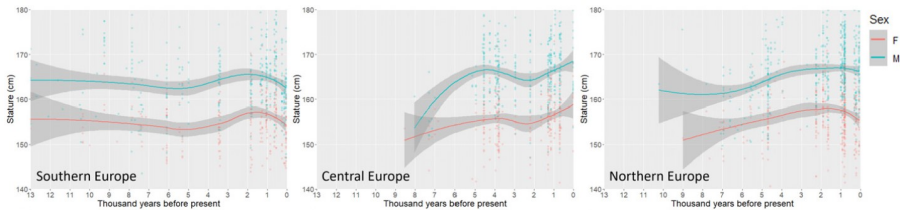
Source: Stock et al. (2023)

Body mass (kg) variation in the Levant



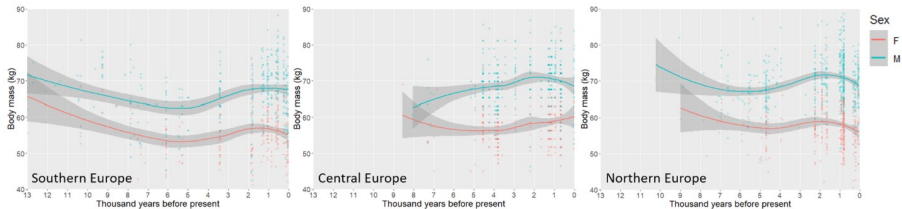
Source: Stock et al. (2023)

Stature (cm) variation in Europe



Source: Stock et al. (2023)

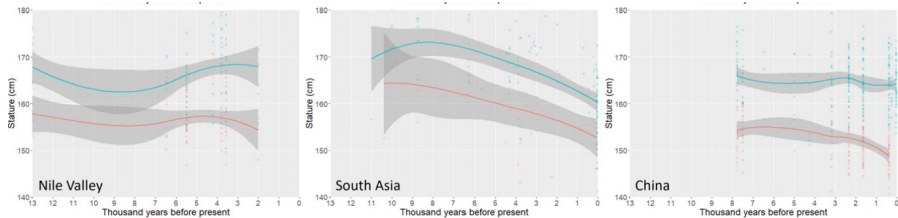
Body mass (kg) variation in Europe



Source: Stock et al. (2023)

Skeletal data

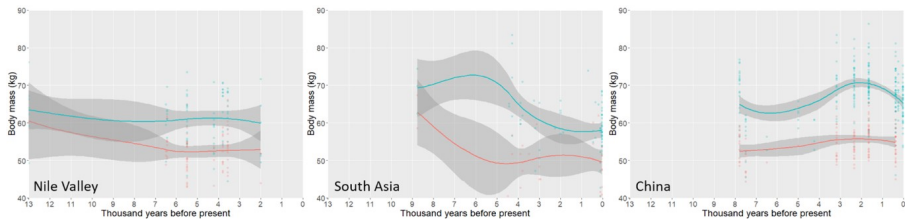
Stature (cm) variation in Nile, South Asia, China



Source: Stock et al. (2023)

Skeletal data

Body mass (kg) variation in Nile, South Asia, China



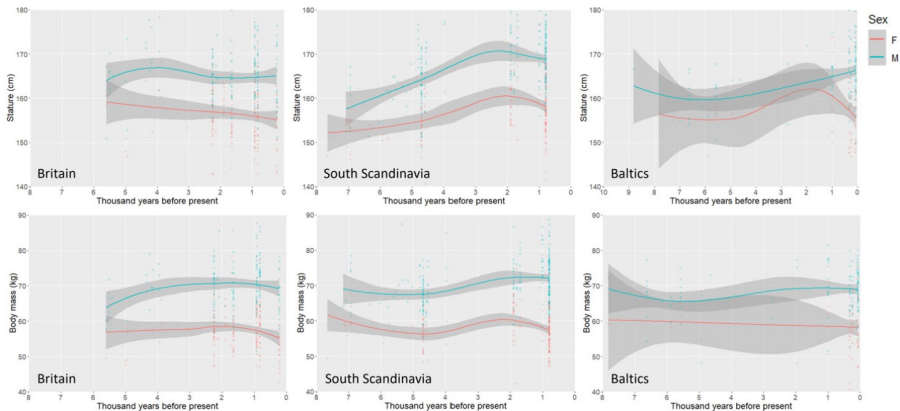
Source: Stock et al. (2023)

Skeletal data

- Results from pooled data: statures reach minimum 8–6 kya, followed by rebounds.
- Heterogeneous trends on regional scales.
 - Levant, where earliest evidence of transition to agriculture: declines in male stature 20–9 kya, and general stability until 3 kya.
 - Southern Europe: decline 10–6 kya then rebound.
 - Central Europe: increase 8–5 kya.
 - Northern Europe: increase in stature from 7 kya and decline in body mass until 5 kya and rebound.
 - Heterogeneous trends in other regions.
- Most significant long-term increases in Central and Northern Europe where evidence for selection on lactose persistence.

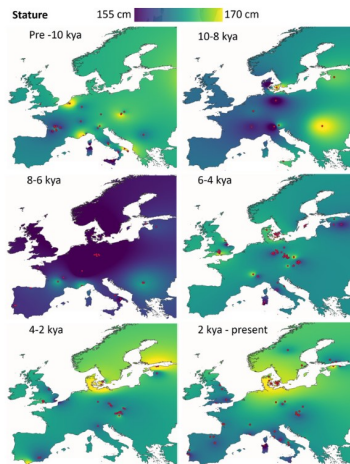
Skeletal data

Stature (cm) and body mass (kg) variation in Europe



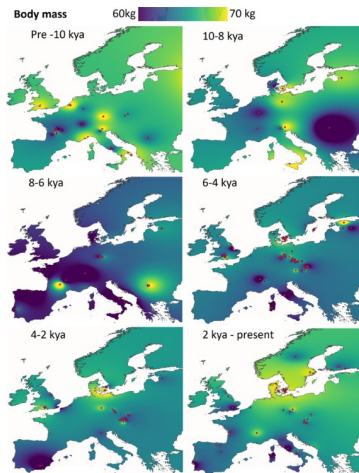
Source: Stock et al. (2023)

Stature (cm) variation in Europe



Source: Stock et al. (2023)

Body mass (kg) variation in Europe



Source: Stock et al. (2023)

- Buildings are generally well preserved and are indicators of historical human activity.
 - Archaeological sites of settlement remains.
 - Ancient road networks connecting urban networks.

Bakker et al. (2021)

- How did trading opportunities affect economic development in the Bronze and Iron Age?
 - Focus on the first massive expansion in maritime trade: the crossing of the Mediterranean at the time of the Phoenicians from 900 BC.
 - Capture trading opportunities by connectedness of points along the coast.
 - Relate connectedness to early development, measured by presence of archaeological sites.
 - Find that locational advantages for sea trade helped development of the Mediterranean region through 1 AD.

- The geography of the Mediterranean:
 - Mediterranean: large inland sea protected from open oceans by Strait of Gibraltar.
 - Favorable climatic conditions for agriculture in the North.
 - Uneven distribution of natural resources and climate \implies opportunities for trade to exploit comparative advantage.

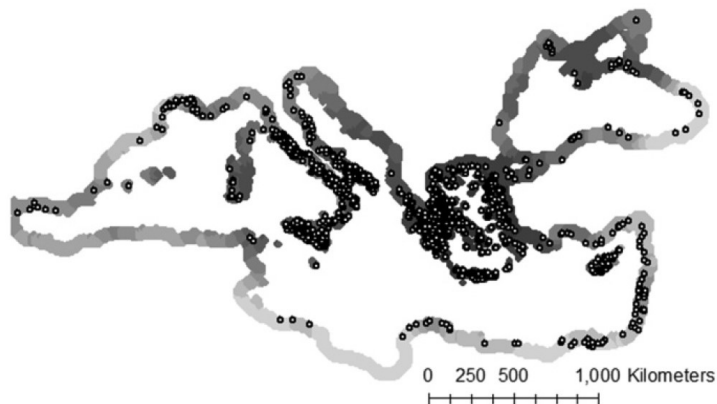
- Ancient seafaring in the Mediterranean:
 - Spread of agriculture from 9500–8000 BC in the Levant to the rest of the region (Iberia in 5500 BC).
 - First archaeological evidence of boats from 5500 BC.
 - From 1000 BC, evidence of prosperous Phoenician city-states spreading from the Levant throughout the coasts of the Mediterranean.
 - Prosperity thanks to trade, with ships crossing 300–700 km of open sea.
 - Zone of intense trade and seafaring by Greek, Etruscan, and Phoenician vessels during Classical Antiquity.

- Units of observation:
 - Divide Mediterranean and Black sea coastline into 10×10 km grid.
 - Grid cell is “coastal” if within 5 km of coastline.
 - Dataset: coast (3,352) and land (8,661) cells within 50 km of coast cell.

- Connectedness:
 - d_{ij} : distance between coastal point i and coastal point j .
 - c_{di} : number of other coastal cells that can be reached within shipping distance d from cell i (e.g., 500 km).
 - c_d is connectivity, capturing trade *opportunities*.

- Economic development:
 - Proxy by number of archaeological sites of settlements in given cell.
 - Data from Pleiades Project, providing location, start and end dates of each place.
 - Only keep places that started before 500 AD and categorized as urban or as settlement.

Connectedness for 500 km distance and Pleiades Narrow Sites, 750 BC



Source: Bakker et al. (2021). Shares indicate deciles of connectedness. Darker points show better-connected cells.

- Estimate OLS regressions of the form:

$$u_{it} = \beta_{dt}c_{di} + X_i\gamma_t + e_{it}$$

- u_{it} : urbanization for grid point i (archaeological sites) in year t .
 - c_{di} : log connectivity for distance d of grid point i (closest coastal cell if inland cells).
 - X_i : vector of grid point control variables.
 - Cluster standard errors at grid level 200×200 km.
- Controls:
 - Latitude and longitude: captures climatic conditions.
 - Indicator variable for type of cell (coast or inland).
 - Distance from Fertile Crescent (origin of spread of agriculture through Mediterranean).

Structures

- Estimate OLS regressions of the form:

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 - Cluster standard errors at grid level 200×200 km.
- Controls:
 - Latitude and longitude: captures climatic conditions.
 - Indicator variable for type of cell (coast or inland).
 - Distance from Fertile Crescent (origin of spread of agriculture through Mediterranean).
 - Potential outliers: Greek islands (best-connected areas), North Africa (lack of archaeological exploration).

Balancing checks

Dependent Variable	(1)	(2)	(3)	(4)	(5)	(6)
Agricultural productivity	0.46	0.00	0.54	0.07	0.16	-0.17
(following Galor & Özak, 2016)	(0.08)	(0.10)	(0.14)	(0.16)	(0.11)	(0.09)
Ruggedness	0.19	0.14	0.06	-0.05	-0.29	-0.13
(following Nunn & Puga, 2012)	(0.14)	(0.19)	(0.29)	(0.28)	(0.16)	(0.16)
River proximity	-3.00	-2.90	-4.32	-3.82	-2.45	-2.99
	(1.72)	(2.14)	(2.96)	(3.33)	(2.09)	(2.19)
Mines proximity	-0.37	0.10	-0.14	0.40	-1.96	-0.04
	(0.37)	(0.74)	(1.22)	(1.48)	(0.74)	(0.67)
Wind	0.31	1.05	-0.53	0.24	0.67	1.20
	(0.16)	(0.23)	(0.30)	(0.34)	(0.17)	(0.22)
Land connectedness	-0.43	-0.30	-0.30	-0.04	-0.24	-0.24
	(0.22)	(0.24)	(0.15)	(0.16)	(0.24)	(0.24)
Observations	12,013	12,013	10,064	10,064	9,464	9,464
Controls						
Longitude and latitude	X	X	X	X	X	X
Distance to coast and Fertile Crescent		X		X		X
Dropping Aegean			X	X		
Dropping North Africa					X	X

Source: Bakker et al. (2021). Each coefficient is from a different regression. The regressor is log connectedness.

Main result (in 750 BC)

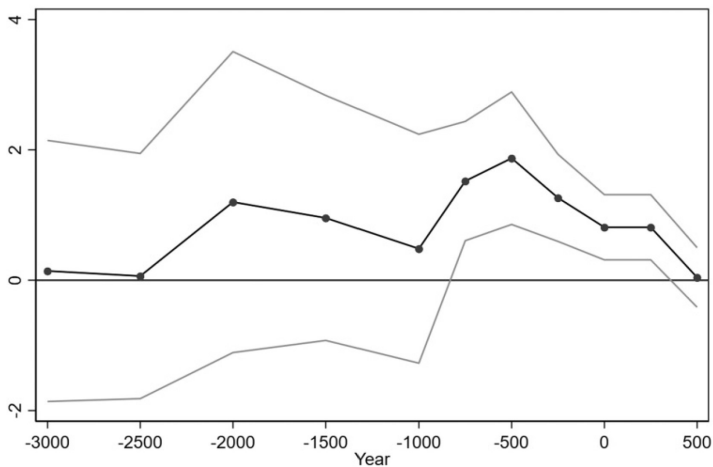
Dependent Variable	Dependent Variable Mean	(1)	(2)	(3)
A. Basic results				
Pleiades wide 750 BC	0.130	0.208 (0.056)	0.103 (0.044)	0.204 (0.056)
Pleiades narrow 750 BC	0.103	0.156 (0.048)	0.075 (0.035)	0.156 (0.048)
Observations	12,013	12,013	10,064	9,464
B. Results excluding coastal cells from outcome definition				
Pleiades wide 750 BC	0.100	0.176 (0.063)	0.095 (0.048)	0.184 (0.062)
Pleiades narrow 750 BC	0.081	0.131 (0.053)	0.073 (0.041)	0.140 (0.053)
Observations	8,661	7,567	6,647	
C. Results excluding short connections				
Pleiades wide 750 BC	0.130	0.201 (0.052)	0.103 (0.042)	0.197 (0.053)
Pleiades narrow 750 BC	0.103	0.152 (0.045)	0.076 (0.034)	0.152 (0.045)
Observations	12,013	10,064	9,464	
Controls		X	X	X
Dropping Aegean			X	
Dropping North Africa				X

Coefficients from regressions of the number of sites on 500 km log connectedness and controls. Controls include longitude, latitude, distance to the coast, and distance to the Fertile Crescent. The dependent variable counts the number of sites in a cell based on either the wide or the narrow Pleiades measure. Panel B excludes coastal cells from the sample, and panel C uses log connectedness from 100 to 500 km as main regressor. Standard errors are clustered at the level of 200×200 km cells, in parentheses.

Source: Bakker et al. (2021).

- Evidence that trade opportunities \implies early development in 750 BC.
 - \uparrow connectedness by 10% \implies \uparrow archaeological sites by 0.02 (compared to mean of 0.130). So elasticity above 1.
 - Dropping Greek islands decreases magnitude.
 - Dropping coastal cells (hence, harbors) does not change results.
 - Dropping short connections (100 km) does not change results, hence long-distance trade matters.

Scaled coefficients for different years



Source: Bakker et al. (2021). Outcome is scaled by dividing by average number of sites in each year, turning it into elasticity.

- Results from 500 year-specific coefficients:
 - Relationship between settlements and connections emerges during middle Bronze Age (2000 BC), though not precise.
 - Most intense relationship during Phoenician trade period from 1000 BC to end of Roman Empire

Delgaard et al. (2022)

- What is the effect of historical transport infrastructures on long-term economic development?
 - Focus on Roman roads network as of the 2nd century.
 - Initially built with military purpose, in straight lines, when little roads present.
 - Persistence of road infrastructure: higher Roman roads density during antiquity \implies higher road density today.
 - Strong vector of economic development in the past and today.

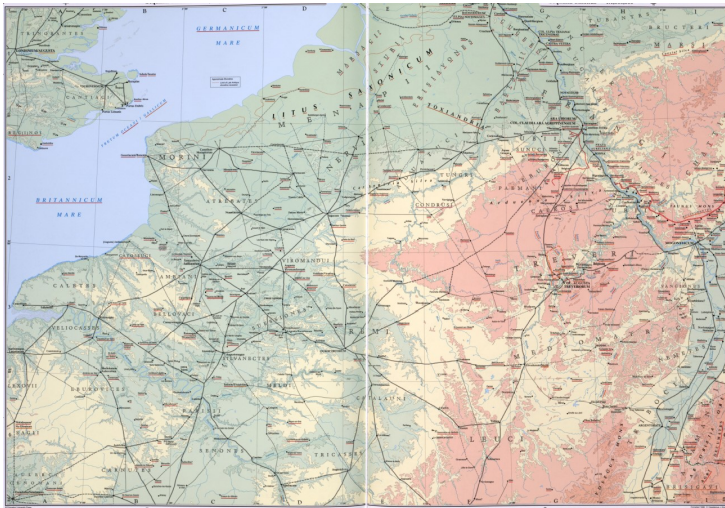
- Units of observation:
 - Area within the border of the Roman Empire in 117 CE (maximum territorial expansion).
 - Divide Empire into cells of 1×1 degrees of latitude by longitude (a little more than 100×100 km).
 - Keep only cells treated by at least one Roman road.

- Units of observation:
 - Area within the border of the Roman Empire in 117 CE (maximum territorial expansion).
 - Divide Empire into cells of 1×1 degrees of latitude by longitude (a little more than 100×100 km).
 - Keep only cells treated by at least one Roman road.
- Roman roads:
 - Based on the Barrington Atlas of the Greek and Roman World, itself based on archaeological remains.
 - Draw 5 km buffer around each road and compute percentage of area within a grid cell.

- Outcome 1: modern roads in 2021 from ESRI.
- Outcome 2: roman settlements in 500 CE from the Digital Atlas of the Roman Empire.
- Outcome 3: average intensity of lights at night 2013–20 from the Earth Observation Group.
- Outcome 4: “gridded” population density in 2010 from the UN.

Structures

Extract from the Barrington Atlas



Source: Barrington Atlas.

Victor Gay (TSE, IAST)

ECON 494 – Part 1 – Topic 5

Winter 2024

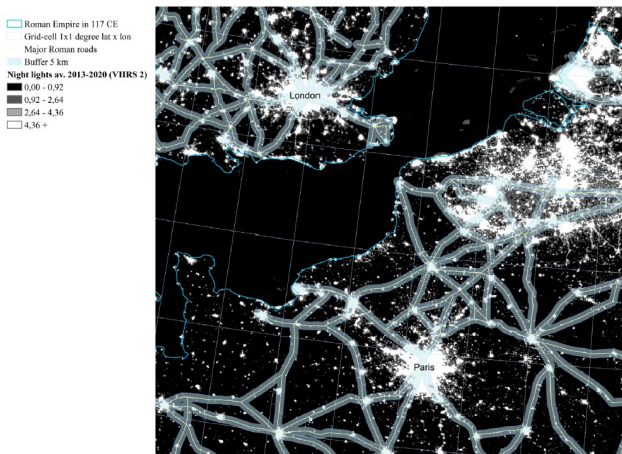
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Roman roads and contemporary night light intensity



Source: Delgaard et al. (2022).

Roman roads and contemporary night light intensity



Source: Delgaard et al. (2022).

- Estimate OLS regressions of the form:

$$\log(y_{grc}) = \delta_c + \delta_r + \beta \cdot \text{RDD}_{grc} + X'_{grc}\gamma + \varepsilon_{grc}$$

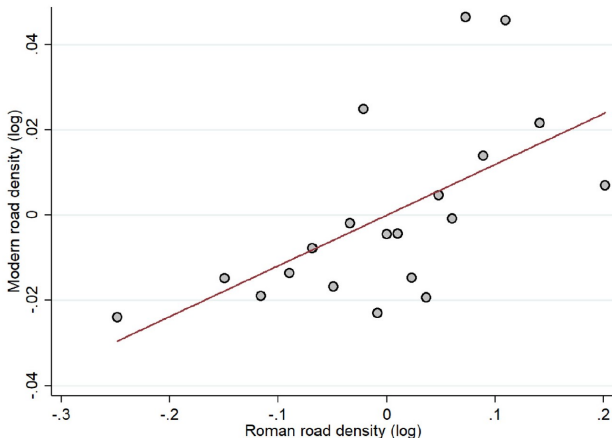
- y_{grc} : outcome of grid cell g in language region r and country c .
 - δ_c and δ_r : language region and country fixed effects to control for cross-country and cultural variation that might affect economic activity.
 - RDD_{grc} : log of roman roads density.
 - X'_{grc} : vector of cell control variables.
 - Adjust standard errors for spatial autocorrelation up to 5 grid cells (361 km).
- Controls:
 - Geographic controls: latitude, longitude, ruggedness, elevation, soil quality.
 - Proximity to water bodies (coast, rivers, natural harbors).
 - Distances to border of empire and current capital.

Structures

	Dependent variable: Modern roads						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln (1+) Roman roads	0.331*** (0.055)	0.240*** (0.058)	0.222*** (0.062)	0.115* (0.063)	0.203*** (0.062)	0.214*** (0.063)	0.119* (0.065)
ln Area	-0.003 (0.006)	0.006 (0.007)	0.005 (0.009)	0.009 (0.008)	0.008 (0.009)	0.005 (0.009)	0.008 (0.009)
ln Latitude	0.322*** (0.043)						
ln (10+) Longitude	-0.013 (0.039)						
ln Longitude squared	0.002 (0.008)						
ln (50+) Elevation				-0.051*** (0.011)			-0.049*** (0.012)
ln Post-1500 caloric suitability				0.012** (0.005)			0.011** (0.005)
ln Distance to coast					-0.010 (0.008)		0.001 (0.008)
ln Distance to major river					-0.006 (0.006)		0.002 (0.006)
ln Distance to natural harbor					-0.011** (0.005)		-0.012** (0.006)
ln Distance to Roman Empire border						-0.007 (0.013)	-0.004 (0.013)
ln (1+) Number of mines						-0.003 (0.008)	-0.001 (0.008)
ln Distance to capital						-0.013 (0.010)	-0.009 (0.010)
ln (1+) Distance to coal						0.003 (0.005)	-0.003 (0.005)
ln Distance to university						-0.008 (0.011)	0.000 (0.011)
ln Distance to Wittenberg						-0.026 (0.054)	-0.044 (0.051)
Country FE	No	Yes	Yes	Yes	Yes	Yes	Yes
Country-language FE	No	No	Yes	Yes	Yes	Yes	Yes
Observations	693	693	693	693	693	693	693
R ²	0.232	0.391	0.475	0.515	0.488	0.481	0.524

Source: Delgaard et al. (2022).

Conditional relationship between modern roads and Roman roads



Source: Delgaard et al. (2022).

Structures

	Dependent variable: Roman settlements in 500 CE						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
In (1+) Roman roads	1.096*** (0.169) [0.178]	0.811*** (0.178) [0.215]	0.832*** (0.189) [0.184]	0.577*** (0.203) [0.176]	0.728*** (0.195) [0.176]	0.778*** (0.187) [0.189]	0.499** (0.205) [0.188]
In Area	0.168*** (0.019)	0.171*** (0.021)	0.199*** (0.017)	0.205*** (0.018)	0.218*** (0.019)	0.186*** (0.017)	0.200*** (0.020)
In Latitude	-0.813*** (0.174)						
In (10+) Longitude	-0.118 (0.126)						
In Longitude squared	0.037 (0.027)						
In (50+) Elevation				-0.107*** (0.041)			-0.069 (0.045)
In Pre-1500 caloric suitability				0.037*** (0.018)			0.039** (0.017)
In Distance to coast					-0.062*** (0.023)		-0.039 (0.026)
In Distance to major river					-0.027 (0.026)		-0.018 (0.027)
In Distance to natural harbor					-0.053** (0.024)		-0.058** (0.024)
In Distance to Roman Empire border						0.014 (0.028)	-0.004 (0.030)
In (1+) Number of mines						0.115** (0.046)	0.123*** (0.046)
Country FE	No	Yes	Yes	Yes	Yes	Yes	Yes
Country-language FE	No	No	Yes	Yes	Yes	Yes	Yes
Observations	693	693	693	693	693	693	693
R ²	0.189	0.324	0.394	0.407	0.416	0.401	0.430

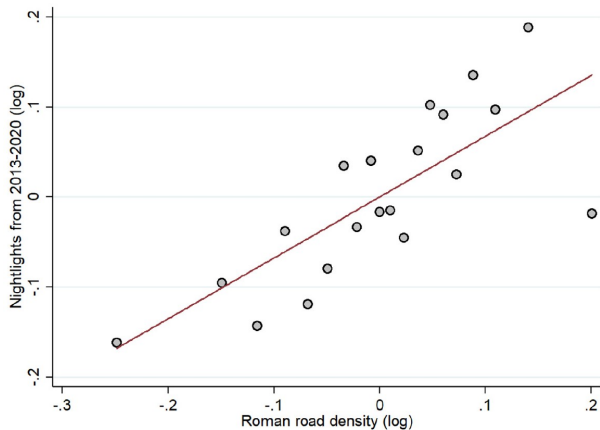
Source: Delgaard et al. (2022).

Structures

	Dependent variable: Nightlights from 2013–2020						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln (1+) Roman roads	1.509*** (0.193) [0.213]	1.346*** (0.178) [0.208]	1.199*** (0.166) [0.200]	0.714*** (0.164) [0.157]	1.037*** (0.162) [0.171]	1.094*** (0.163) [0.187]	0.675*** (0.158) [0.123]
ln Area	-0.040 (0.029)	-0.011 (0.025)	-0.010 (0.023)	0.026 (0.023)	0.023 (0.023)	-0.025 (0.028)	0.029 (0.026)
ln Latitude	-0.412** (0.195)						
ln (10+) Longitude	-0.099 (0.214)						
ln Longitude squared	-0.010 (0.041)						
ln (50+) Elevation				-0.290*** (0.034)			-0.232*** (0.038)
ln Post-1500 caloric suitability				0.017 (0.016)			-0.003 (0.016)
ln Distance to coast					-0.101*** (0.025)		-0.067** (0.028)
ln Distance to major river					-0.041** (0.021)		-0.001 (0.020)
ln Distance to natural harbor					-0.046** (0.020)		-0.043** (0.019)
ln Distance to Roman Empire border						-0.006 (0.042)	-0.017 (0.041)
ln (1+) Number of mines						-0.004 (0.031)	0.006 (0.029)
ln Distance to capital						-0.191*** (0.047)	-0.197*** (0.048)
ln (1+) Distance to coal						-0.002 (0.017)	-0.030* (0.016)
ln Distance to university						-0.052 (0.043)	-0.018 (0.041)
ln Distance to Wittenberg						-0.127 (0.184)	-0.302* (0.167)
Country FE	No	Yes	Yes	Yes	Yes	Yes	Yes
Country-language FE	No	No	Yes	Yes	Yes	Yes	Yes
Observations	691	691	691	691	691	691	691
R ²	0.179	0.465	0.562	0.621	0.598	0.597	0.668

Source: Delgaard et al. (2022).

Conditional relationship between modern nightlights and Roman roads



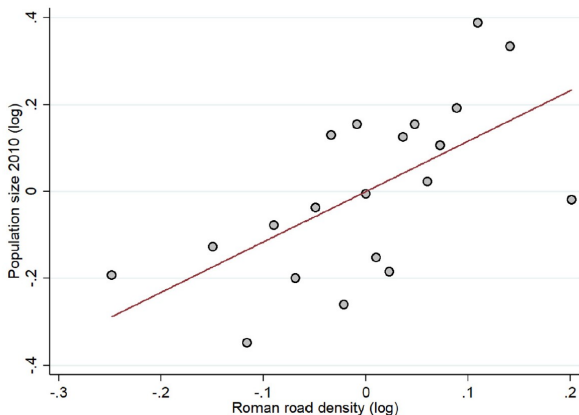
Source: Delgaard et al. (2022).

Structures

	Dependent variable: Population in 2010						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln (1+) Roman roads	3.017*** (0.414) [0.487]	2.638*** (0.426) [0.584]	2.624*** (0.396) [0.503]	1.215*** (0.345) [0.378]	2.246*** (0.375) [0.392]	2.464*** (0.376) [0.484]	1.160*** (0.326) [0.326]
ln Area	1.002*** (0.064)	1.029*** (0.069)	1.099*** (0.039)	1.115*** (0.039)	1.171*** (0.037)	1.060*** (0.040)	1.115*** (0.038)
ln Latitude	2.292*** (0.507)						
ln (10+) Longitude	-0.395 (0.347)						
ln Longitude squared	0.055 (0.070)						
ln (50+) Elevation				-0.510*** (0.076)			-0.431*** (0.082)
ln Post-1500 caloric suitability				0.246*** (0.056)			0.214*** (0.053)
ln Distance to coast					-0.224*** (0.055)		-0.117*** (0.054)
ln Distance to major river					-0.113** (0.048)		-0.036 (0.049)
ln Distance to natural harbor					-0.078* (0.046)		-0.088** (0.040)
ln Distance to Roman Empire border						0.075 (0.079)	0.077 (0.072)
ln (1+) Number of mines						-0.062 (0.061)	-0.046 (0.055)
ln Distance to capital						-0.461*** (0.079)	-0.390*** (0.075)
ln (1+) Distance to coal						-0.032 (0.033)	-0.094*** (0.030)
ln Distance to university						-0.058 (0.075)	0.042 (0.079)
ln Distance to Wittenberg						-0.483 (0.324)	-0.726** (0.316)
Country FE	No	Yes	Yes	Yes	Yes	Yes	Yes
Country-language FE	No	No	Yes	Yes	Yes	Yes	Yes
Observations	693	693	693	693	693	693	693
R ²	0.593	0.701	0.769	0.812	0.784	0.787	0.829

Source: Delgaard et al. (2022).

Conditional relationship between modern population and Roman roads



Source: Delgaard et al. (2022).

- Main findings: strong persistence of Roman road network and past and modern economic development.

- Main findings: strong persistence of Roman road network and past and modern economic development.
- Causal? Use abandonment of wheeled transport in MENA region after 500 BCE.
 - Substitution from wheel transport with camel caravans as more efficient in the region.
 - Roman roads fell into disrepair compared to Europe, where continued use.
 - When automobile arrived in MENA, road planning differed from Roman roads (which had disappeared).
 - Absence of relation in MENA after abandonment of wheel supports causal interpretation.

Structures

Dependent variable:	Settlements in 500 CE		Modern roads		Nightlights from 2010–2013		Population in 2010	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sample:	Europe	MENA	Europe	MENA	Europe	MENA	Europe	MENA
In (1+) Roman roads	0.470* (0.255) [0.171]	0.599* (0.358) [0.371]	0.208*** (0.072) [0.084]	-0.115 (0.091) [0.071]	0.783*** (0.191) [0.155]	0.405 (0.282) [0.269]	1.405*** (0.390) [0.410]	0.717 (0.630) [0.637]
In Area	0.204*** (0.023)	0.235*** (0.050)	0.026*** (0.009)	-0.052*** (0.013)	0.071** (0.029)	-0.069* (0.039)	1.180*** (0.035)	1.045*** (0.096)
In (50+) Elevation	-0.090* (0.054)	-0.060 (0.096)	-0.061*** (0.015)	-0.011 (0.021)	-0.226*** (0.046)	-0.300*** (0.078)	-0.456*** (0.089)	-0.587*** (0.206)
In Pre-1500 caloric suitability	-0.012 (0.018)	0.051** (0.020)						
In Distance to coast	-0.013 (0.030)	-0.095* (0.057)	0.010 (0.011)	0.006 (0.011)	-0.081** (0.038)	-0.021 (0.047)	-0.103* (0.054)	-0.101 (0.125)
In Distance to major river	-0.000 (0.027)	-0.034 (0.068)	0.010 (0.007)	0.005 (0.010)	0.034 (0.023)	-0.058 (0.042)	0.073 (0.048)	-0.306*** (0.111)
In Distance to natural harbor	-0.030 (0.031)	-0.071* (0.040)	-0.014* (0.009)	-0.018** (0.007)	-0.028 (0.027)	-0.104*** (0.030)	-0.060 (0.051)	-0.146* (0.081)
In Distance to Roman Empire border	0.011 (0.031)	0.077 (0.292)	-0.008 (0.013)	-0.141 (0.099)	-0.042 (0.044)	-0.494 (0.403)	0.033 (0.076)	0.195 (0.940)
In (1+) Number of mines	0.071 (0.045)	0.394** (0.167)	-0.008 (0.008)	0.027 (0.022)	-0.021 (0.031)	0.148 (0.095)	-0.095* (0.056)	0.143 (0.182)
In Post-1500 caloric suitability			0.011* (0.006)	0.017*** (0.006)	-0.005 (0.023)	0.013 (0.019)	0.115*** (0.039)	0.240*** (0.080)
In Distance to capital			-0.013 (0.012)	-0.003 (0.014)	-0.178*** (0.063)	-0.316*** (0.068)	-0.335*** (0.099)	-0.667*** (0.162)
In (1+) Distance to coal			-0.002 (0.005)	-0.002 (0.010)	-0.025 (0.016)	-0.046 (0.045)	-0.085*** (0.029)	-0.012 (0.119)
In Distance to university			0.006 (0.011)	-0.168* (0.098)	-0.035 (0.041)	0.610* (0.310)	-0.011 (0.074)	1.041 (0.968)
In Distance to Wittenberg			-0.073 (0.055)	0.671** (0.280)	-0.470** (0.188)	1.483 (1.047)	-0.862*** (0.329)	-0.996 (2.360)
Country-language FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	468	225	468	225	466	225	468	225
R ²	0.428	0.409	0.519	0.562	0.700	0.677	0.896	0.729

Source: Delgaard et al. (2022).

- Most sources are written records on paper.
- But archaeological excavations provide written records on other media:
 - Coins.
 - Tablets.
 - Stones with family names.
- Many can be used to study the economic history of the past.

Explaining the Great Divergence

Victor Gay

Visiting professor at University of Michigan

Toulouse School of Economics

Institute for Advanced Study in Toulouse

Winter 2024

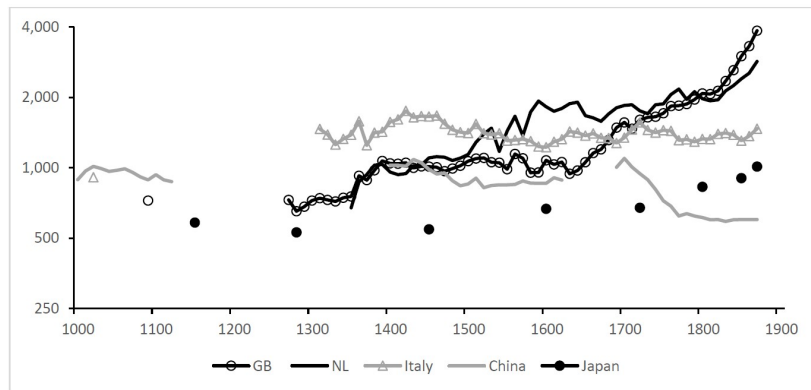


Toulouse
School of
Economics

What factors can explain the Great Divergence?

The Great Divergence

GDP per Capita in Europe and Asia, 1000–1870 (1990 GK\$, Log scale)



Source: Broadberry (2020) based on Broadberry et al. (2015), van Zanden and van Leeuwen (2012), Malanima (2011), Broadberry, Guan and Li (2018), Bassino, Broadberry, Fukao, Gupta and Takashima (2015).

- Neoclassical growth theory.
- Correlates of economic growth.
- Fundamental causes of long-run growth.
- Why did Britain industrialize first?

Neoclassical growth theory

- Based on the Solow growth model. [Solow \(1956\)](#)
- Micro foundations: neoclassical production function.
- Dynamic general equilibrium model:
 - Growth is achieved on path to steady-state.
 - Modern growth theory extends to endogenous steady-state growth with technological progress.
- Simple and abstract representation of complex reality.

Households and production

- Closed economy, unique final good, infinite horizon.
- Many identical households, saving $s \in [0, 1]$ of disposable income.

Households and production

- Closed economy, unique final good, infinite horizon.
- Many identical households, saving $s \in [0, 1]$ of disposable income.
- Many identical firms with representative production function:

$$Y = F(K, L, A) \quad \text{e.g.} \quad Y = AK^\alpha L^{1-\alpha}, \quad \alpha \in (0, 1)$$

- Y : production. K : capital. L : labor. A : technology.
- $F_K, F_L > 0, F_{KK}, F_{LL} < 0$. Decreasing returns to scale.
- A is free: nonexcludable and nonrival.

Endowments, market structure, market clearing

- Competitive markets:
 - Households and firms are price-takers.
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Endowments, market structure, market clearing

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- Firms rent labor at rate w and capital at rate R .
- Market clearing conditions (demand = supply): $L = \bar{L}$ and $K = \bar{K}$.
- Capital depreciates at rate $\delta \in (0, 1)$.

Firm optimization and equilibrium

- Firms solve this optimization problem:

$$\max_{K,L} F(K, L, A) - RK - wL$$

Firm optimization and equilibrium

- Firms solve this optimization problem:

$$\max_{K,L} F(K, L, A) - RK - wL$$

- In equilibrium:
 - Markets clear.
 - Marginal products equal marginal costs: $w = F_L$ and $R = F_K$.
 - Firms make zero profits: $Y = wL + RK$

Fundamental law of motion of capital

- Because of depreciation: $K(t + 1) = (1 - \delta)K(t) + I(t)$.

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- Closed economy: $S(t) = I(t) = Y(t) - C(t)$.
- Household save a fraction of income: $S(t) = sY(t)$.
- Fundamental law of motion of the Solow growth model:

$$K(t + 1) = sF(K(t), L(t), A(t)) + (1 - \delta)K(t)$$

Definition

An equilibrium is a sequence of allocations and prices such that:

$$\{K(t), Y(t), C(t), w(t), R(t)\}_{t=0}^{\infty}$$

- Markets clear.
- Marginal products equal marginal costs.
- The law of motion of capital holds.

Output per capita

- No population growth: $L(t) = L$.
- No technological progress: $A(t) = A$.
- Define capital-labor ratio: $k(t) = K(t)/L$.

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$$y(t) = \frac{Y(t)}{L} = F\left(\frac{K(t)}{L}, 1, A\right) = f(k(t))$$

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- Law of motion becomes: $k(t+1) = sf(k(t)) + (1 - \delta)k(t)$.

Steady-state equilibrium

Definition

A steady-state equilibrium without technological progress and population growth is an equilibrium path in which

$$k(t) = k^*, \quad \forall t$$

Steady-state equilibrium

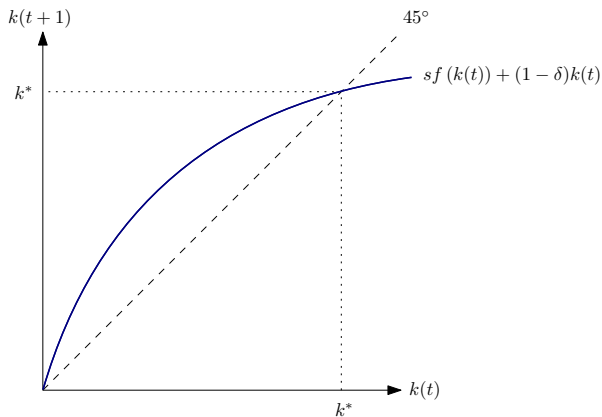
Definition

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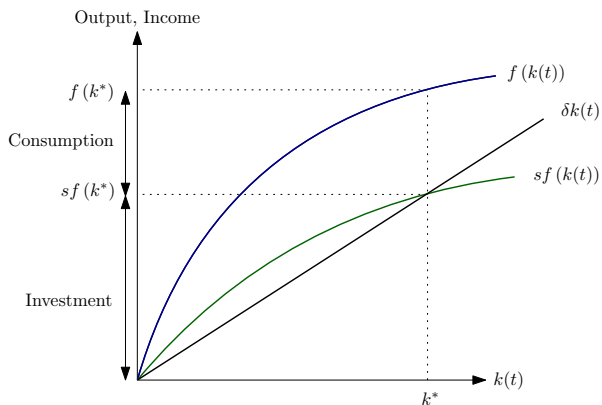
$$k(t) = k^*, \quad \forall t$$

- With the law of motion: $sf(k^*) = \delta k^*$.
- In equilibrium, investment per capita replenishes depreciated capital.

Steady-state equilibrium



Steady-state equilibrium



Economic growth in a Solow world

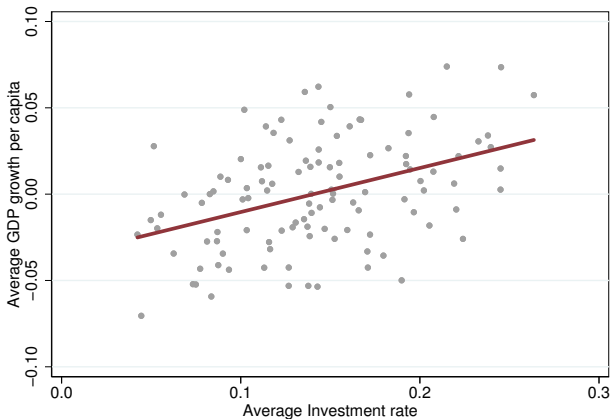
- Once steady-state is reached, no growth.
- Additional growth achieved by shifting steady-state:
 - More investment: $\uparrow s$.
 - Improved technology: $\uparrow A$ (exogenous).
 - Larger population: $\uparrow L$ (exogenous).
- Straightforward to include human capital (H).

Correlates of economic growth

- Empirically, correlates of economic growth:
 - Physical capital accumulation proxied by capital investment rates.
 - Human capital accumulation proxied by schooling.
 - Technological change proxied by total factor productivity (TFP).
 - (Less interested in population since per capita measure)

Correlates of Economic Growth

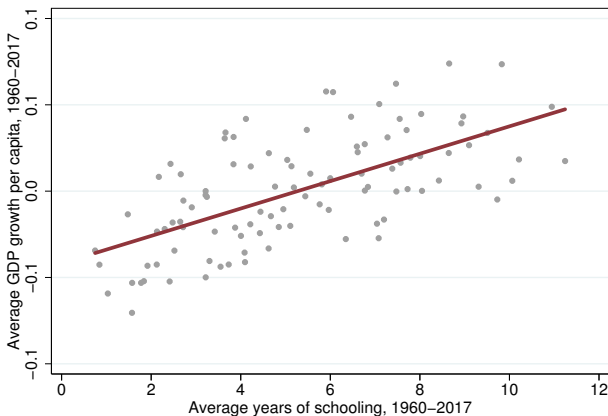
Average GDP per Capita Growth and Capital Investment, 1960–2017



Source: Penn World Table 9.1, 111 countries.

Correlates of Economic Growth

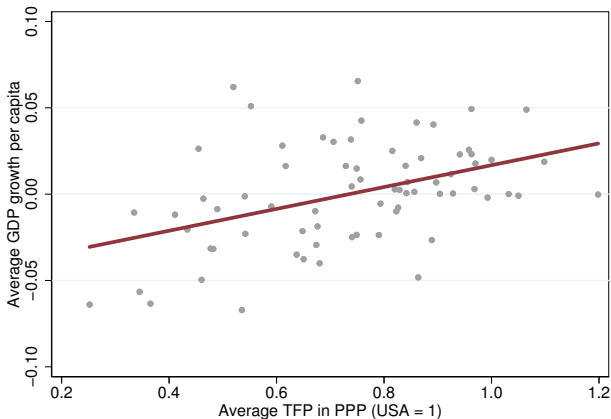
Average GDP per Capita Growth and Human Capital, 1960–2017



Source: Maddison Project Database 2018, Barro–Lee Dataset, 100 countries.

Correlates of Economic Growth

Average GDP per Capita Growth and TFP, 1960–2017



Data Source: Barro-Lee Dataset

- Great cross-country Educational Attainment data source: [Barro-Lee](#).
- Reference paper: [Barro and Lee \(2013\)](#).
- Educational attainment measures by sex and age.
- 146 countries, 1950–2010, 5-year intervals.

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- Other data from Penn World Tables.

Correlates of Economic Growth

- Factors accumulation are *proximate causes* of economic growth.
“The factors we have listed (innovation, economies of scale, education, capital accumulation, etc.) are not causes of growth; they are growth.” North and Thomas (1973)

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- Factors accumulation are *proximate causes* of economic growth.
“The factors we have listed (innovation, economies of scale, education, capital accumulation, etc.) are not causes of growth; they are growth.” North and Thomas (1973)
- Correlation \neq causality.
- Why different choices of investment?
- What are the *fundamental* causes of economic growth?

Fundamental causes of growth

- Four common hypotheses:
 - Luck: multiple equilibria and path dependence.
 - Institutions.
 - Culture.
 - Geography.

Fundamental causes of growth

- Four common hypotheses:
 - Luck: multiple equilibria and path dependence.
 - Institutions.
 - Culture.
 - Geography.
- Technological change (and K , H) is a consequence of these fundamental causes.
- These causes often interact so challenging to take them separately.
- Institutions seem key condition.

Luck: multiple equilibria

- Roots: coordination failures, credit market imperfections, etc.

Luck: multiple equilibria

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- Prisoner's dilemma type game (e.g. technological complementarities)

		Everybody else	
		High investment	Low investment
Individual	High investment	y^H, y^H	$y^L - \varepsilon, y^L$
	Low investment	$y^L, y^L - \varepsilon'$	y^L, y^L

- $y^H > y^L$ and $\varepsilon, \varepsilon' > 0$.

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		High investment	Low investment
Individual	High investment	y^H, y^H	$y^L - \varepsilon, y^L$
	Low investment	$y^L, y^L - \varepsilon'$	y^L, y^L

- Two symmetric (pure-strategy) equilibria.

Luck: Multiple Equilibria and Path Dependence

- Path dependence: remain stuck in inferior equilibrium.
- Institutions as coordination device for equilibrium selection.
Myerson (2009)

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- Path dependence: remain stuck in inferior equilibrium.
- Institutions as coordination device for equilibrium selection.
[Myerson \(2009\)](#)
- Luck cannot explain:
 - Hundred years of cumulative processes.
 - Hundred years of divergence.
 - Why some countries can have very rapid growth.

“Institutions are the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction. In consequence [institutions] structure incentives in human exchange, whether political, social, or economic.” North (1990)

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- Key elements:
 - Humanly devised.
 - Place constraints on individual behavior.
 - Shape human interaction and affect incentives.
- Institutions influence economic, political and social relations among households, individuals and firms.

- Political institutions:
 - Inclusive political institutions, e.g., parliaments with equal participation.
 - Extractive political institutions, e.g., slavery and exploitation by the few.

- Economic institutions (requiring inclusive political institutions):
 - Property rights.
 - Functioning markets.
 - Contractual opportunities.

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 - Property rights.
 - Functioning markets.
 - Contractual opportunities.
- What economic institutions do:
 - Shape the structure of economic incentives.
 - Ensure allocation of resources to efficient uses.
 - Determine distribution of economic revenues.

- “Good” economic institutions stimulate proximate causes of growth:
 - Physical capital accumulation.
 - Human capital accumulation.
 - Development of better technologies.
- Usually: enforcement of property rights and equality of opportunity.

- Why societies not adopt all “good” economic institutions?
 - Coordination failures and multiple equilibria (luck, culture).
 - Conflicts of interest within society (Schumpeterian creative destruction).
- Distribution and conflict shape institutions.

- Values, preferences, beliefs matter for economic performance.

- Values, preferences, beliefs matter for economic performance.
- Culture hypothesis version 1: religion, i.e., protestant origins of capitalism. [Weber 1930](#)

“Montesquieu says of the English that they ‘had progressed the farthest of all peoples in the world in three important things: in piety, in commerce, and in freedom.’ Is it not possible that their commercial superiority and their adaptation to the free political institutions are connected in some ways with that record of piety which Montesquieu ascribes to them?”

- Protestant origins of capitalism:
 - Protestantism: hard work, thrift, saving.
 - Economic success interpreted as chosen by God.

- Culture hypothesis version 2: a culture of (non-)cooperation.
 - Culture as a coordination mechanism for equilibrium selection.
 - Ethno-linguistic fractionalization plays a role.

- Culture hypothesis version 2: a culture of (non-)cooperation.
 - Culture as a coordination mechanism for equilibrium selection.
 - Ethno-linguistic fractionalization plays a role.
- Difficult to explain growth miracle. How fast is cultural change?

- Culture hypothesis version 3: a culture of growth and useful knowledge.
- Joel Mokyr's (and McCloskey's) view:
 - “Scientific Revolution” (17th century) \implies “Industrial Enlightenment”
 - Large supply of useful knowledge and mechanical skills.
 - Knowledge and belief in practical innovation.

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 - Large supply of useful knowledge and mechanical skills.
 - Knowledge and belief in practical innovation.
- Large complementarities with institutions (e.g., contracting and functioning markets).

- Geography hypothesis 1: [Montesquieu \(1748\)](#).
- Climate (heat) shape efforts and attitudes:

“The heat of the climate can be so excessive that the body there will be absolutely without strength. So, prostration will pass even to the spirit; no curiosity, no noble enterprise, no generous sentiment; inclinations will all be passive there; laziness there will be happiness. People are [...] more vigorous in cold climates. The inhabitants of warm countries are like old men, timourous; the people in cold countries are like young men, brave.” [sic]

- Some racist underpinnings. . .
- Some serious economists were still convinced in late 19th century:

“[V]igor depends partly on race qualities: but these, so far as they can be explained at all, seem to be chiefly due to climate.”

Marshall (1890)

- Non-credible hypothesis.

- Geography hypothesis 2: impact of geography on agriculture and technology.

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“[S]erious study of the problems of underdevelopment [. . .] should take into account the climate and its impacts on soil, vegetation, animals, humans and physical assets—in short, on living conditions in economic development.” Myrdal (1968)

- Geographical differences \implies timing and nature of neolithic revolution \implies social organization and development. [Diamond \(1997\)](#)

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- Comparative advantage.
 - Low agricultural productivity \implies comparative advantage in industry.
 - Unfavorable geography provides incentives to industrialize earlier.
- Necessary threshold in agricultural productivity?
 - Many failed to industrialize, although ahead in agricultural productivity.

- Geography hypothesis 3: natural endowments.
 - Endowments of raw energy material (e.g., coal) to power industrialization.
 - True but functioning markets and invention of steam engine preconditions.
 - Hence, dependent on institutions.

- Geography hypothesis 4: territorial fragmentation and state building.
 - States make wars, wars make states (Tilly).
 - Inter-polity conflict generates political institutions.
 - Conflict is more prevalent when fragmented geography.
 - Political geography is key to explain institutions.

Why did Britain industrialize first?

Why did Britain industrialize first?

⇒ The “Holy Grail” of economic history

- Overview of main answers for British exceptionalism (1700–1850).
[Allen \(2009\)](#) [Blum and Colvin \(2018\) chap 24](#), [Hoffman \(2020\)](#),
[Court \(2020\)](#)
 - 1 Institutions
 - 2 A culture of growth and useful knowledge
 - 3 Factor prices and technological change
 - 4 Demography and the European Marriage Pattern
 - 5 Trade and colonialism
 - 6 Geography and coal

- North and Weingast's long-standing argument.
 - Balance of power between sovereign and society through Parliament, solving fundamental commitment problem.
 - Secured property rights.
 - Enables much higher per capita tax revenues (fiscal capacity).

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 - Balance of power between sovereign and society through Parliament, solving fundamental commitment problem.
 - Secured property rights.
 - Enables much higher per capita tax revenues (fiscal capacity).
- Enables efficient warfare, gains from trade, merchant marine.
- Develop of transportation network (natural monopoly).
- Representative institutions enable urbanization and agglomeration effects.

A culture of growth and useful knowledge

- Joel Mokyr's (and McCloskey's) view:
 - “Scientific Revolution” (17th century) \implies “Industrial Enlightenment”
 - Large supply of useful knowledge and mechanical skills.
 - Knowledge and belief in innovation.
- Abundant supply of useful skills.
 - Widespread practice of apprenticeship in Britain.
 - Migration patterns of skilled artisans from Britain to continental Europe.
- Inherited protestant culture as well?

Factor prices and technological change

- Robert Allen's view:
 - High wages, cheap capital and resources (coal).
 - Relative factor prices \implies High demand for innovation.
 - Profitable to mechanize and substitute machines for labor.

Factor prices and technological change

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 - Profitable to mechanize and substitute machines for labor.
- But recent debates on measurement problem:
 - Wage data mostly for daily wage.
 - Working hours very different across country, season, region, sector.
 - New series show British wages not as high as estimated.

Demography and the European Marriage Pattern

- Unified growth theory links economic growth to demographic changes.
- European Marriage Pattern:
 - High female celibacy.
 - Late marriage.
 - Nuclear families.
- Incentives for human capital investment.

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- But very little evidence of link between EMP and growth.

Trade and colonialism

- British colonies supplied:
 - Food: sugar mostly, tea and coffee.
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- Was it an essential factor?
 - Assumes only colonies could supply food and materials.
 - Assumes imported food was essential.
 - Assumes British farmers would have faced diminishing returns in agriculture.
- Little evidence (from Britain perspective):
 - Abundant worldwide supply (slightly higher prices).
 - Little share of caloric intake (14% in 1840s).
 - British agriculture highly productive.

- Potential advantages of Britain's abundant coal deposits:
 - Increasingly important source of heat.
 - Mine floods \implies incentives for steam engines.
 - Main power for textile mines nearby production centers (e.g., Lancashire).

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 - Increasingly important source of heat.
 - Mine floods \implies incentives for steam engines.
 - Main power for textile mines nearby production centers (e.g., Lancashire).
- But prevalent in many European locations.
- Ability to exploit and transport coal matters (institutions).

What can explain the Great Divergence?

Blum and Colvin (2018) chap 23

- Explanations for “Why Britain” slightly different than for “Why Europe.”

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 - Culture of growth.

What can explain the Great Divergence?

Blum and Colvin (2018) chap 23

- Explanations for “Why Britain” slightly different than for “Why Europe.”
- Applies to both the Little and Great Divergence:
 - Institutions and the rules of the game.
 - Culture of growth.
- Applies to the Great Divergence:
 - Warfare and inter-state competition due to land and political fragmentation.

Directed Technical Change

Victor Gay

Visiting professor at University of Michigan

Toulouse School of Economics

Institute for Advanced Study in Toulouse

Winter 2024

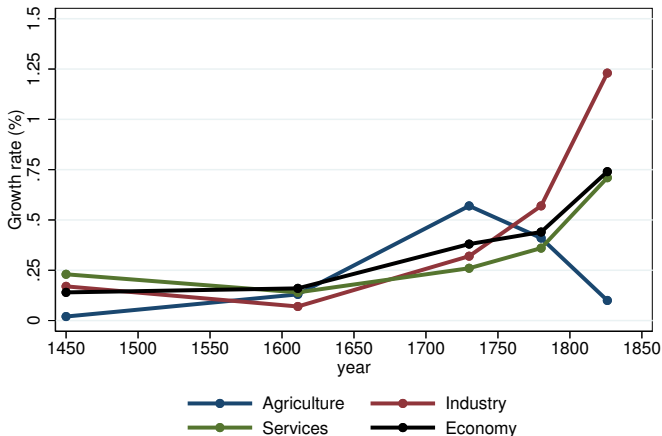


Toulouse
School of
Economics

What was the nature of technical change in Britain and its direct determinants?

Sectoral productivity in Britain

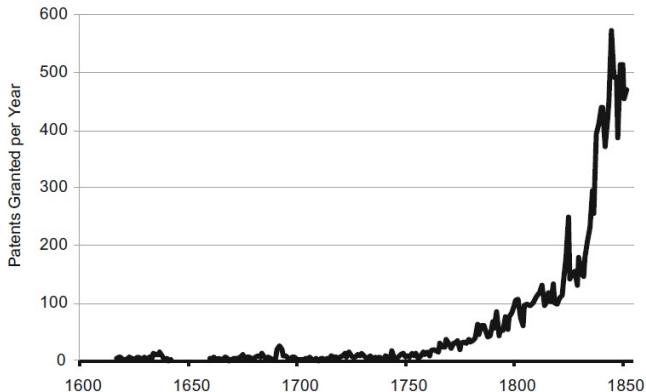
Sectoral Annual Average Productivity Growth Rates in Britain



Source: Broadberry (2020) based on Broadberry et al. (2015).

Patenting in Britain

Patents per year in England (1660–1851)



Source: Clark (2014) based on Mitchell (1988).

Innovations in the textile industry

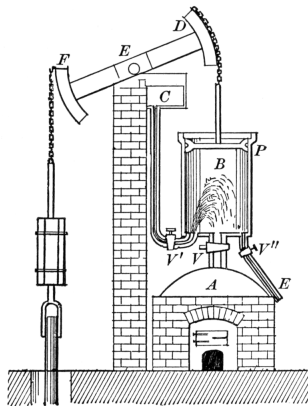
“A wave of gadgets swept over England.” Ashton (1948)

- Textile sector:
 - Hargreaves spinning jenny (mid-1760s)
 - Arkwright water frame (late 1760s)
 - Crompton mule jenny (late 1770s)
- Steam powered these new machines:
 - Newcomen engine (1710s)
 - Watt steam engine (1760s)

⇒ Wave of simultaneous innovations that primarily affected the textile (cotton) industry.

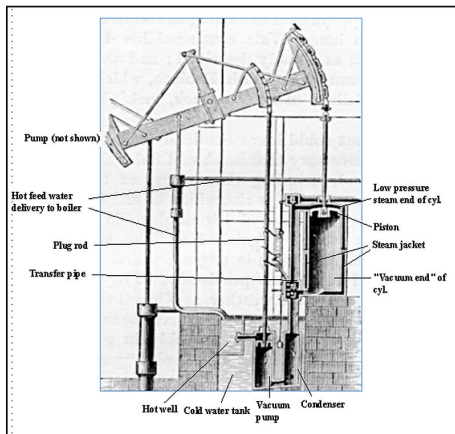
Steam power innovations

Newcomen engine (1710s)



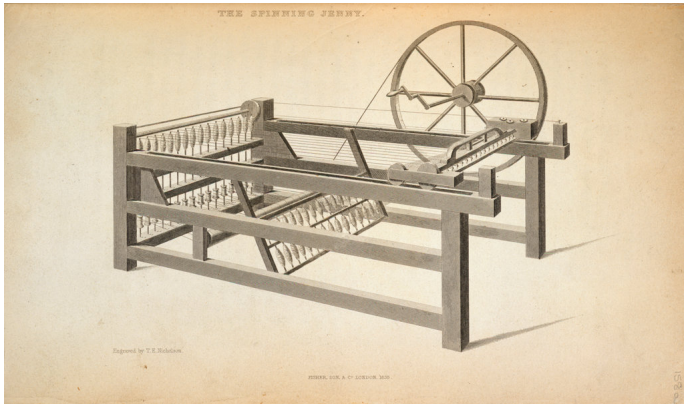
Steam power innovations

Watt steam engine (1760s)



Innovations in the textile industry

Hargreave's spinning jenny of 1770



Source: Allen (2009).

The cotton industry

Hargreave's spinning jenny of 1770



Source: Allen (2009).

The cotton industry

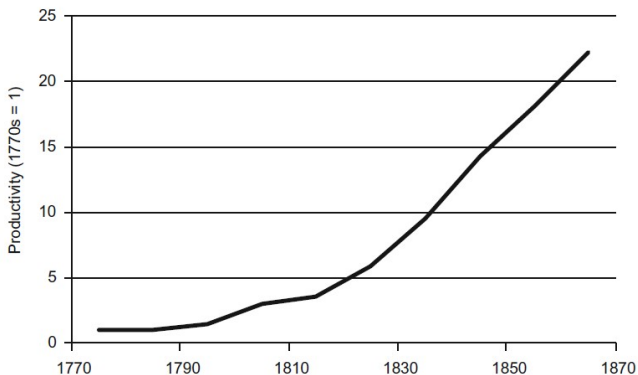
Arkwright's water frame of 1775



Source: Allen (2009).

Important innovations

Cotton spinning and weaving productivity (1770–1869)



Source: Clark (2014) based on Harley (1998).

The cotton industry

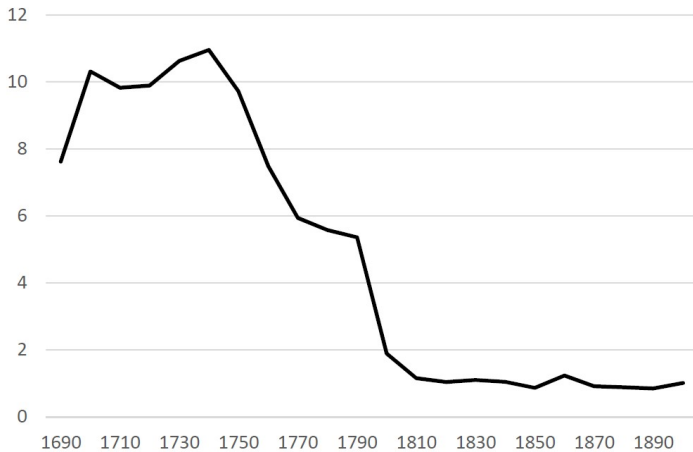
- The cotton industry epitomizes the IR in Britain.
 - Production growth: 7% per year 1770–1815.
 - Total factor productivity growth: 2.6% per year 1780–1860.
 - Accounted for 25% of British productivity growth 1780–1860.
 - Reduction in output price by factor 10 1750–1820.

The cotton industry

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 - Total factor productivity growth: 2.6% per year 1780–1860.
 - Accounted for 25% of British productivity growth 1780–1860.
 - Reduction in output price by factor 10 1750–1820.
- Most intensively mechanized sector.
 - Large decline in share of labor in value added.
 - Many inventions: Hargreave's, spinning jenny, Arkwright water frame, Cartwright loom, Withney cotton gin. . .
 - Biased technical change: save labor.

The cotton industry

Prices of cotton cloth relative to bread in England



Source: Steinssen (2020) based on Allen (2009).

The cotton industry

Real cost of cotton (16 count) in 1784 prices

	Hand Method 1760	24-Spindle Jenny 1775	Arkwright Mill 1784	Glasgow Mill 1836
Labor:				
Cleaning and Carding	7.00	7.00	2.69	0.16
Spinning	7.00	2.33	2.57	0.34
Reeling, bundling, etc.	0.47	0.47	2.19	0
Administrative	2.72	2.72	0.41	0.02
Total Labor	17.19	12.52	7.86	0.52
Materials:				
Raw Cotton	16.88	16.88	16.88	16.70
Other	0	0	1.20	0.53
Capital	0.93	1.88	2.00	0.47
Total Cost	35.00	31.28	27.94	18.22
Labor Share of Value Added	95%	87%	80%	53%

Source: Steinssen (2020) based on Allen (2009).

- Measuring innovation:
 - Macro and microinventions
 - Technical change in cotton spinning
- Directed technical change

Measuring innovation

Macro and microinventions

Mokyr (1990)

- Effective characterization of patterns of technical change:
 - Microinventions: “small, incremental steps that improve, adapt and streamline existing techniques.”
 - Macroinventions: “inventions in which a radical new idea, without a clear precedent, emerges more or less ab nihilo.”

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Mokyr (1990)

- Effective characterization of patterns of technical change:
 - Microinventions: “small, incremental steps that improve, adapt and streamline existing techniques.”
 - Macroinventions: “inventions in which a radical new idea, without a clear precedent, emerges more or less ab nihilo.”
- Traditional measurement of innovations:
 - Raw patent counts.
 - But do not take into account relative importance of underlying inventions.

⇒ “Patent statistics [in the IR period] do not permit to distinguish between radical and minor inventions”

Nuvolari et al. (2021)

- Composite indicator of quality of the 13,070 English patents 1700–1850.

Nuvolari et al. (2021)

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- Sources of the “Bibliographic Composite Index of patent quality”
 - Woodcroft’s *Reference Index* of 1855 on patents 1617–1852: counts number of times each patent mentioned in specialized publications, adjusted for time effects. [Nuvolari and Tartari \(2011\)](#)
⇒ Captures visibility of patents in contemporary engineering and legal literature.

- Sources of the “Bibliographic Composite Index of patent quality”
 - Number of times patent mentioned in Schookler’s (1966) list of “important inventions.”
 \implies Captures visibility of patents in modern reference books of history of science and technology.

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 - Number of times patent mentioned in Schookler’s (1966) list of “important inventions.”
 - ⇒ Captures visibility of patents in modern reference books of history of science and technology.
 - Number of times patentee mentioned in large set of biographical dictionaries.
 - ⇒ Captures relative visibility of patentee in biographical dictionaries.

Macro and microinventions

Patents and inventors coverage of the sources used to construct patent eminence and inventor eminence

Patent eminence			Inventor eminence		
Source	Inventors	Patents	Source	Inventors	Patents
Baker (1976)	123	150	Oxford DNB	291	893
Carter (1978)	201	266	Allen (2009)	76	234
Desmond (1987)	128	157	Day and McNeil (1996)	240	708
Inkster (1991)	27	44	Abbott (1985)	57	246
Dudley (2012)	33	55	Murray (2003)	54	199
Challoner (2009)	41	49	De Galiana (1996)	102	333
Bridgman (2002)	33	38	Meisenzahl and Mokyr (2012)	536	1519
Bunch and Hellemans (2004)	71	93	Benson (2012)	59	206
Ochoa and Corey (1997)	23	24	Gergaud et al (2016)	179	595
Lilley (1948)	28	33			

Source: Nuvolari et al. (2021).

- Properties of the quality indicators:
 - Three indicators correlated, but in limited way.
 - Capture complementary dimensions of patent quality.
 - WRI: captures incremental innovations.
 - Two others: capture breakthrough innovations.

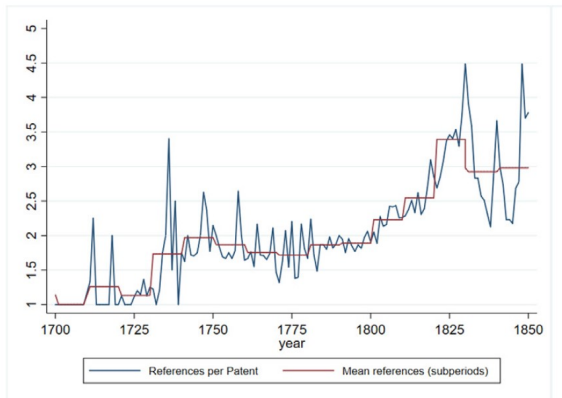
Quality indicators for selected patents

Patent no.	Year	Inventor	Invention	Woodcroft references	Patent eminence	Inventor eminence
542	1733	John Kay	Flying shuttle	1	10	8
556	1736	Jonathan Hulls	Steam-propelled ship	9	0	5
931	1769	Richard Arkwright	Water frame	3	10	9
1111	1775	Richard Arkwright	Carding machine	15	3	9

Source: Nuvolari et al. (2021).

Macro and microinventions

Average number of references per patents over time

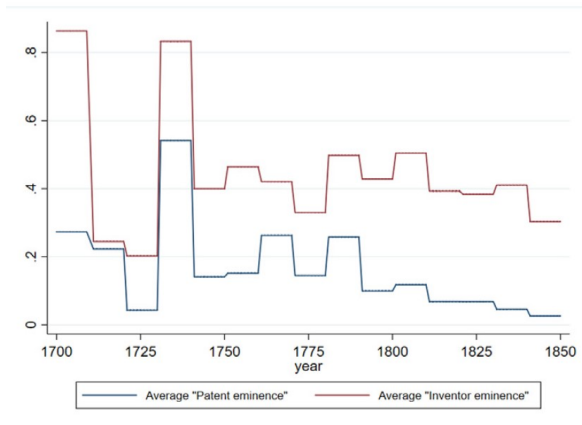


(a) Average number of references per patents in Woodcroft (1862), yearly and by decade.

Source: Nuvolari et al. (2021).

Macro and microinventions

Average number of references per patents over time



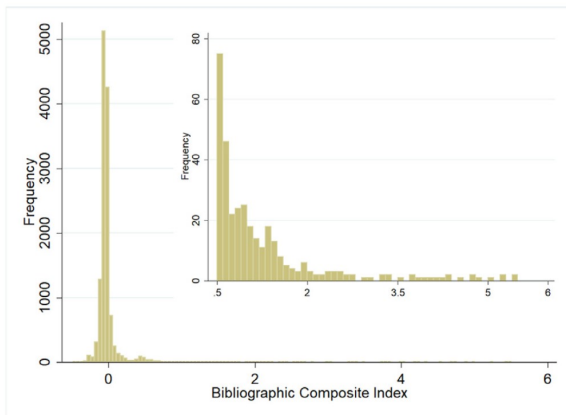
(b) Average number of references per patents by decade.

Source: Nuvolari et al. (2021).

- Building the Bibliographic Composite Index (BCI):
 - Take into account time and sector correlated patterns.
 - Regress each indicator on time and sectoral indicators, extracting residuals.
 - Residuals capture share of variance due to intrinsic quality of patents.
 - Extract latent common factor for each patent.

Macro and microinventions

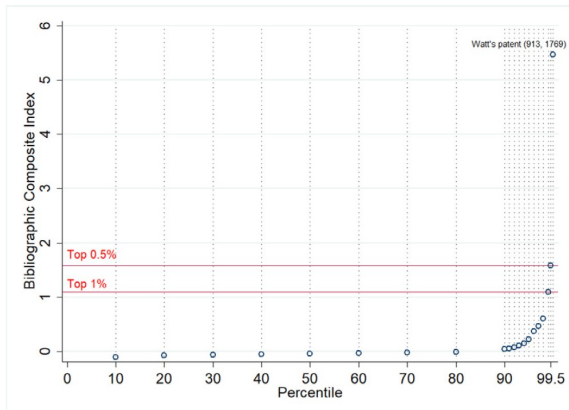
Empirical distribution of the BCI



Source: Nuvolari et al. (2021).

Macro and microinventions

Percentile plot of the BCI



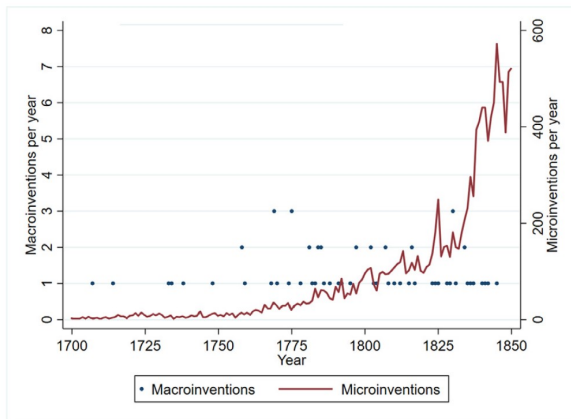
Source: Nuvolari et al. (2021).

- Hypothesis of Mokyr (1990):
 - Macroinventions are generated by a serendipitous search process.
 - Microinventions result of continuous and cumulative improvements, displaying temporal persistence.

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 - Macroinventions are generated by a serendipitous search process.
 - Microinventions result of continuous and cumulative improvements, displaying temporal persistence.
- Results confirm the hypothesis:
 - No time clustering of macroinventions (top 0.5% BCI).
 - Strong time clustering of microinventions (bottom 99.5% BCI).

Macro and microinventions

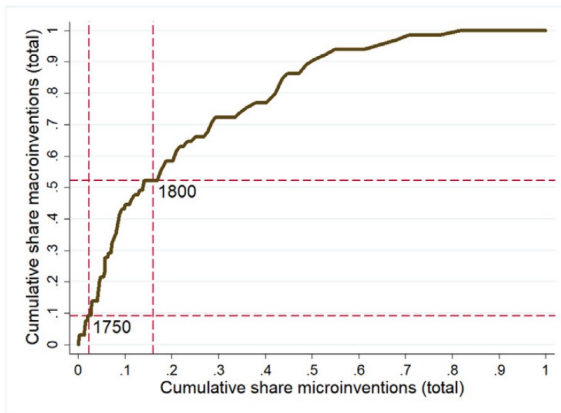
Number of inventions per year



Source: Nuvolari et al. (2021).

Macro and microinventions

Relative cumulative distribution of macro vs micro inventions

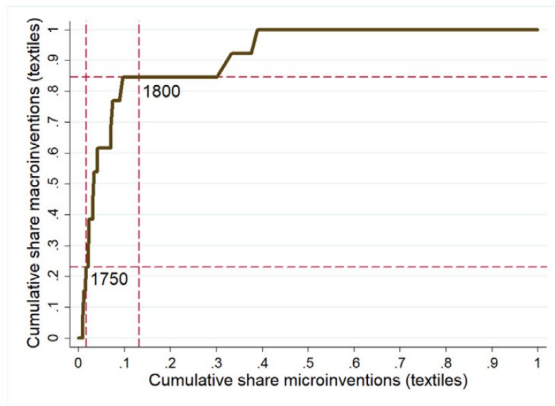


(a) All patents

Source: Nuvolari et al. (2021).

Macro and microinventions

Relative cumulative distribution of macro vs micro inventions

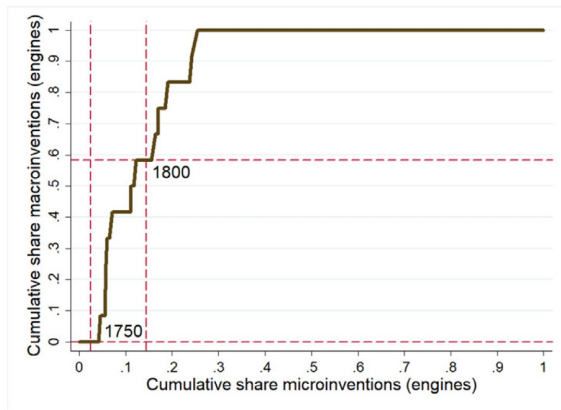


(b) Textile sector

Source: Nuvolari et al. (2021).

Macro and microinventions

Relative cumulative distribution of macro vs micro inventions

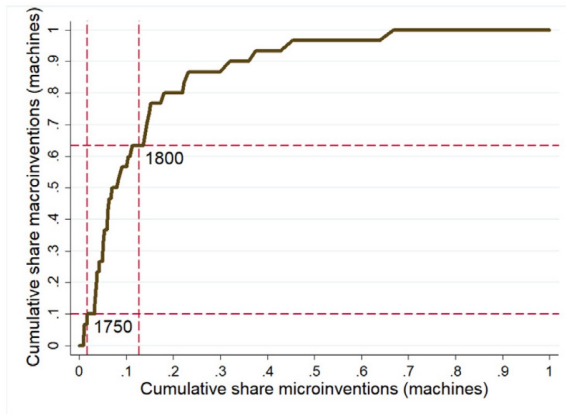


(c) Engine sector

Source: Nuvolari et al. (2021).

Macro and microinventions

Relative cumulative distribution of macro vs micro inventions



(d) Machines

Source: Nuvolari et al. (2021).

Exemples of stated aims of invention for three macroinventions

Patent no.	Year	Inventor	Invention	Excerpt from Woodcroft (1854)	Stated aims
962	1770	James Hargreaves	Spinning jenny	"[...] making an engine [...] to be managed by one person only, which will spin, draw, and twist 16 or more threads at a time by a motion of one hand and a draw of the other"	Save labor; save time
1420	1784	Henry Cort	Puddling process	"[...] manufacturing iron and steel into bars [...] of purer quality, in larger quantity, by a more effectual application of fire and machinery, and with greater yield"	Save capital and raw materials; improve quality
1645	1788	Andrew Meikle	Threshing machine	"[...] the corn is thereby separated from the straw in less time, and in more effectual manner than by threshing or any other manner"	Save time; improve quality

Source: Nuvolari et al. (2021).

Patentees' stated aims of invention, 1700–1799

Stated aim	Top 0.5%	Top 1%	Top 2%	All patents
Create employment	0	1.7	1.2	1.9
Improve working conditions	0	0	2.3	1.4
Save labor	2.9	3.4	4.7	4.2
Save time	11.8	8.5	7	5.2
Save capital and raw materials	8.8	5.1	7	30.8
Reduce consumer price	5.9	5.1	3.5	3.7
Improve quality	32.4	27.1	25.6	29.3
Import substitution	0	1.7	1.2	3.6
Government revenue	0	0	0	1
Other government benefits	5.9	3.4	2.3	2.1

Source: Nuvolari et al. (2021).

Patents for inventions intended to save labor, 1700–1799

Patent aim	Top 0.5%	Top 1%	Top 2%	All patents
Labor-saving stated	2.9	3.4	4.7	3.9
Effectively labor-saving	38.2	38.9	38.4	15.3

Source: Nuvolari et al. (2021).

Technical change in cotton spinning

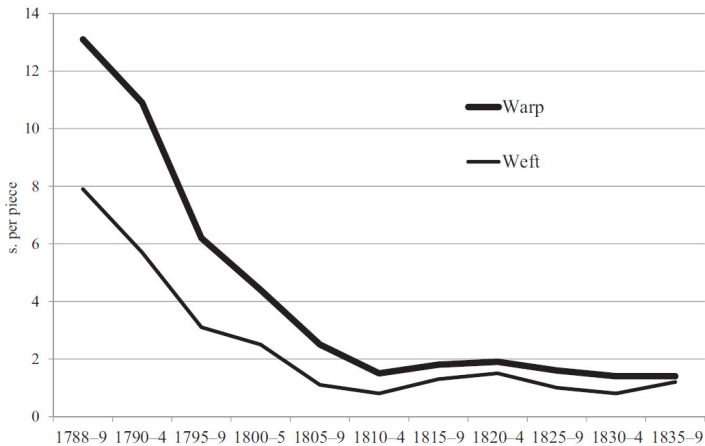
Technical change in cotton spinning

Maw et al. (2022)

- Textile and especially spinning: leading sector in IR.
- Early macro-inventions:
 - Hargreaves' spinning jenny mid-1760s.
 - Arkwright's water-frame late-1760s.
 - Crompton's mule in late-1770s.
- Initial productivity gains from macro-inventions have been overstated.
- Larger gains made in the micro-inventions phase from the 1780s to 1830s.
- Explore nature of improvements made to early macro-inventions in cotton spinning.

Technical change in cotton spinning

Yarn added-value, 1788–1839



Source: Harley (1998).

Technical change in cotton spinning

Contemporary estimates of machine spindleage in the UK cotton industry (spindles, 000)

	<i>Jenny</i>		<i>Mule</i>		<i>Water-frame</i>		<i>Throstle</i>	<i>Total</i>
1784	283	(82%)	4	(1%)	60	(17%)	0	347
1787	1,605	(83%)	50	(3%)	286	(15%)	0	1,941
1789	1,400	(58%)	700	(29%)	310	(13%)	0	2,410
1811	156	(3%)	4,200	(90%)		311 (7%)		4,667
1845	0		13,000	(74%)	0		4,500 (26%)	17,500

Source: Maw et al. (2022).

Technical change in cotton spinning

- Use newspaper advertisements 1780–1835 for information on early cotton-spinning machinery.
- Locations: Manchester, Blackburn, Leeds, Glasgow, Belfast, Derby, Nottingham, Preston.
- Total of 1,465 advertisements.
- Most common: public auctions (63%).
- Contains type of machine, average size, location.

Technical change in cotton spinning

Example of advertisement for cotton-spinning machinery

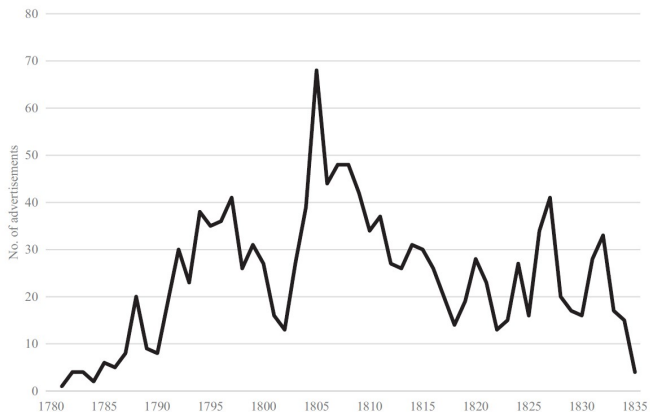
b) *Manchester Mercury*, 8 Apr. 1788

A COTTON MILL.
To be SOLD by AUCTION,
By Order of the Assignees of SALISBURY, BARROW, CARR,
and Co. Bankrupts,
At Spencer's Tavern, in Manchester, in the County of Lan-
caster, on Tuesday the 15th Day of April, 1788, at Five
o'Clock in the Afternoon,
ALL that valuable COTTON MILL, situate at CHIR-
PINGTON, in the County of Lancaster, about 3 Miles from
Preston, in a populous Manufacturing Country, with the
Machinery in and belonging to the same, and the Messuage,
Cottages, Buildings, and about fourteen Acres of Land ad-
jacent thereto.
The Mill containing 23 Yards in Length, by 9 in Breadth,
with the Stream of Water, is held by Lease for a Term of
99 Years, (of which but few are expired) under the yearly
Rent of 4l.
The other Premises consisting of a Building adjoining to
the Mill, a Messuage in the Occupation of Mr. William
Carr, a Smithy, Barn, three Cottages inhabited, one other
Cottage nearly finished, four more Cottages built to the full
Floor, a Garden, and the fourteen Acres of Land, are held
by Lease for a Term of 99 Years, whereof three only are
expired, under the yearly Rent of 21l.
The Water-shaft is twenty-four Inches square, the Wheel
thirteen Feet and a half in Diameter, and five and a half in
Breadth on the Face; there are twenty Spinning Frames,
containing 1032 Spindles at work, and Machinery for six
more Frames, of forty-eight Spindles each; there are also
a proportionable Number of Carding, Roving, Drawing, and
other Machines, and the Mill and Machinery are in full
Work and good Condition.
For further Particulars enquire of Mr. John Whittenbury,
and Mr. Samuel Jackson, of Manchester aforesaid, the As-
signees of the said Bankrupt's Estate; or of Mr. Jones, of
the same Place, Attorney at Law.

Source: Maw et al. (2022).

Technical change in cotton spinning

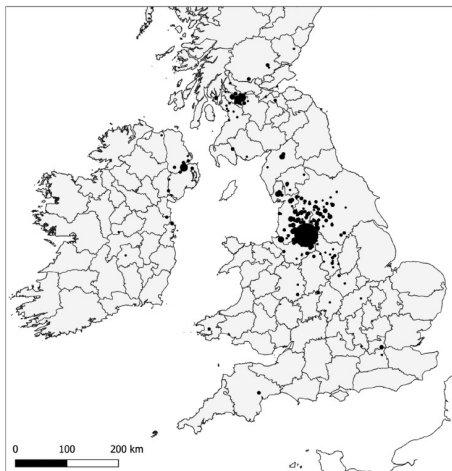
Cotton spinning machinery advertisements, 1780–1835



Source: Maw et al. (2022).

Technical change in cotton spinning

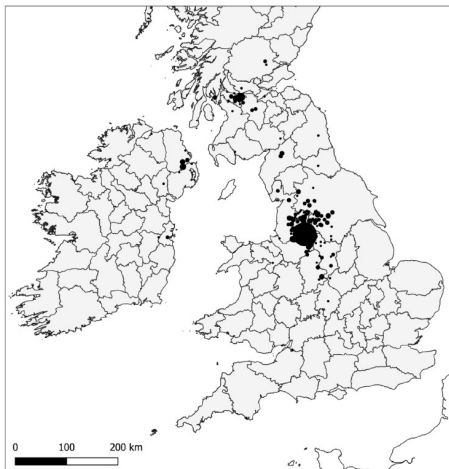
Advertisements for UK cotton-spinning machinery, by location, 1780—1811



Source: Maw et al. (2022).

Technical change in cotton spinning

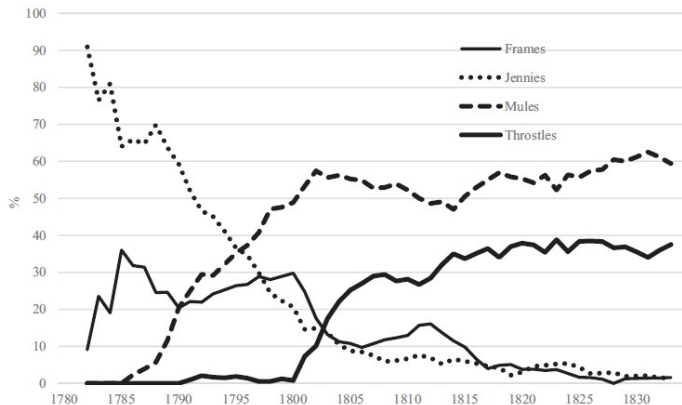
Advertisements for UK cotton-spinning machinery, by location, 1812—1835



Source: Maw et al. (2022).

Technical change in cotton spinning

Machinery advertisements by type of machine

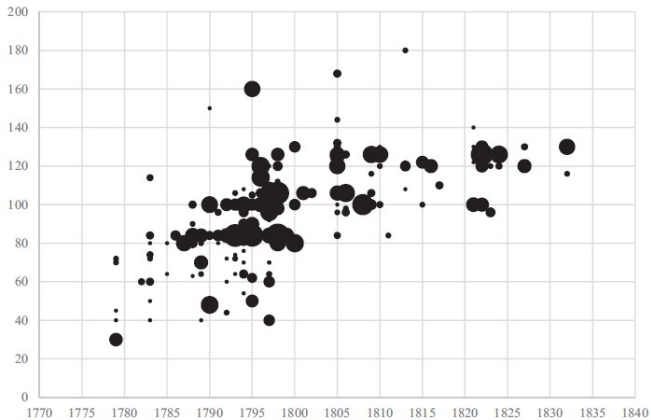


Source: Maw et al. (2022).

Technical change in cotton spinning

Size of advertised spinning machines (spindles)

a) Spinning jennies

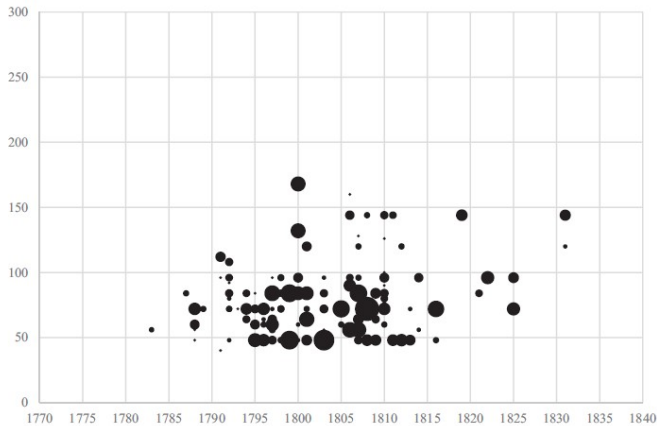


Source: Maw et al. (2022).

Technical change in cotton spinning

Size of advertised spinning machines (spindles)

b) Water-frames

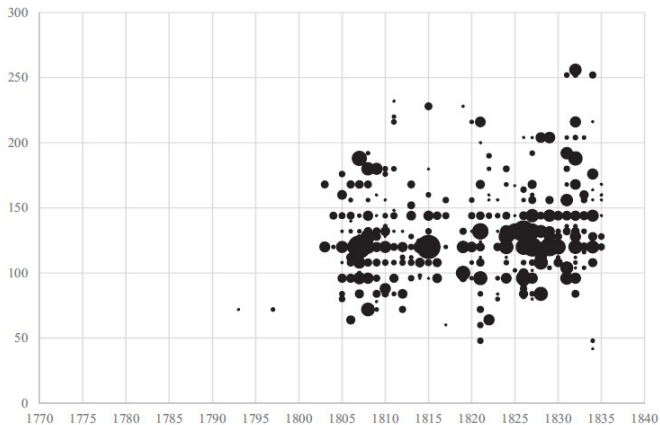


Source: Maw et al. (2022).

Technical change in cotton spinning

Size of advertised spinning machines (spindles)

c) Throstles

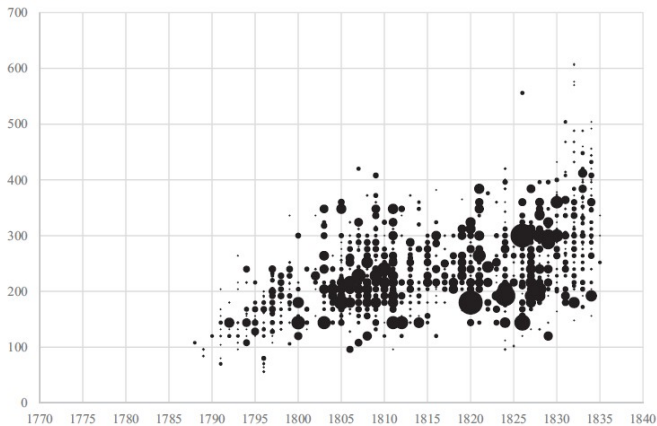


Source: Maw et al. (2022).

Technical change in cotton spinning

Size of advertised spinning machines (spindles)

d) Mules



Source: Maw et al. (2022).

Technical change in cotton spinning

Productivity indicators in cotton spinning, c. 1760—c. 1835

	<i>Spindles per machine</i>	<i>Spinners per machine</i>	<i>Spindles per spinner</i>	<i>Operatives per machine</i>	<i>Hanks spun per spindle, per day (and 'count')</i>		<i>Daily output per spinning machine (hanks)</i>	<i>Daily output per spinning machine (lbs)</i>	<i>Daily output per operative (hanks)</i>	<i>Change factor since 1760</i>
Hand spinning, 1760s	1	1	1	1	8	(16s)	8	0.5	8	
Spinning jenny, 1770s	16	1	16	1	1.6	(16s)	25.6	1.6	25.6	3.2
Water-frame, 1770s	48	1	48	1.5	1.6	(24s)	76.8	3.2	51.2	6.4
Hand mule, 1770s	48	1	48	1.5	1.25	(40s)	60	1.5	40	5
Spinning jenny, 1790s	93	1	93	1.5	1.2	(16s)	111.6	7	74.4	9.3
Water-frame, 1790s	69	1	69	1.5	2	(24s)	138	5.8	92	11.5
Hand mule, 1790s	169	1	169	1.5	1.25	(40s)	211.25	5.3	140.8	17.6
Throstle, early 1830s	142	0.67	213	0.84	4.5	(24s)	639	26.6	760.7	95.1
Power-assisted mule, early 1830s	298	0.5	596	1.08	3	(40s)	894	22.4	827.8	103.5

Source: Maw et al. (2022).

Directed technical change

Directed technical change

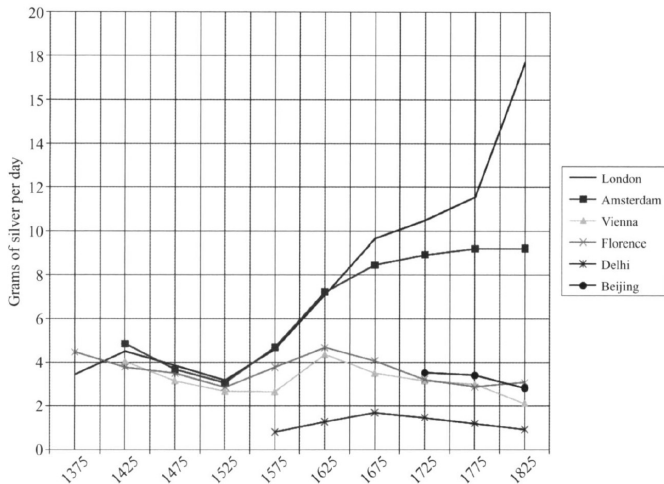
Allen (2011)

- Why were macro-inventions invented in 18th-century Britain?
- Different input factor prices there and then:
 - Wages higher in Britain than elsewhere (high-wage argument).
 - Capital and energy prices lower in Britain than elsewhere (cheap-energy argument).
- Argument about supply and demand of innovation:
 - Demand innovations that substitute capital and energy for labor, e.g., spinning jenny.
 - Supply of practical skills (Mokyr's industrial enlightenment).

“The Industrial Revolution, in short, was invented in Britain in the XVIIIth century because it paid to invent it there, while it would not have been profitable to invent in other times and places.”
Allen (2009)

The high-wage argument

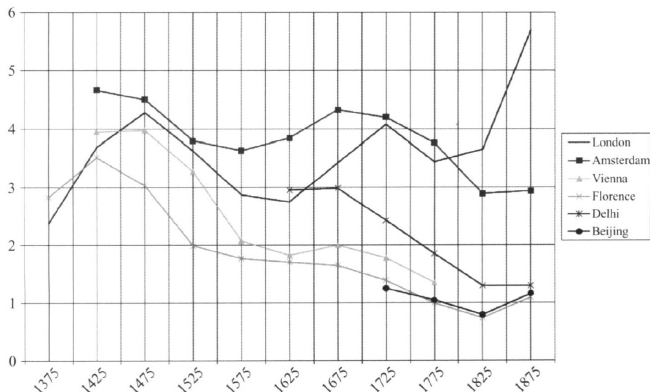
Building laborers' wages around the world, grams of silver per day



Source: Allen (2011).

The high-wage argument

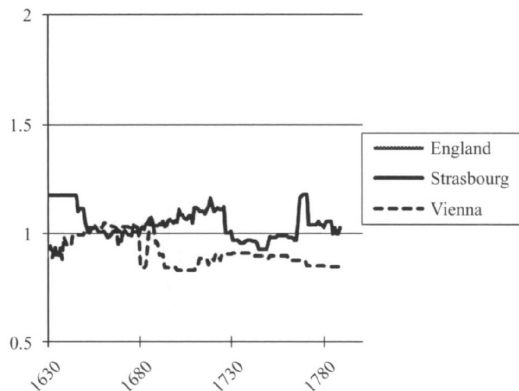
Subsistence ratio for building laborers: income relative to cost of subsistence basket



Source: Allen (2011).

The high-wage argument

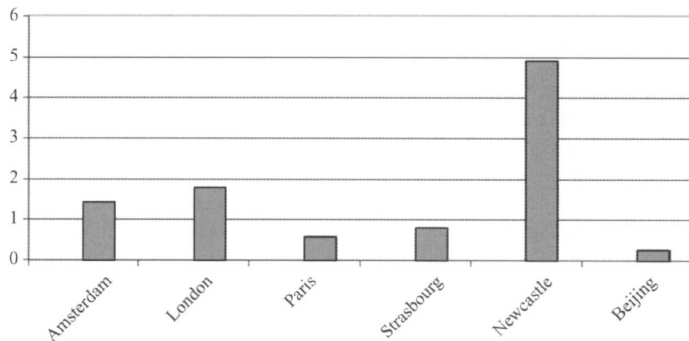
Wage rate relative to price of capital



Source: Allen (2011). Rental price of capital: average price indices for iron, metals, wood, brick multiplied by interest rate plus depreciation rate.

The high-wage argument

Wage rate relative to price of energy



Source: Allen (2011). Price of energy: price of a kilogram of fuel divided by energy content (in grams of silver per million BTUs (British Thermal Units)).

The high wages argument

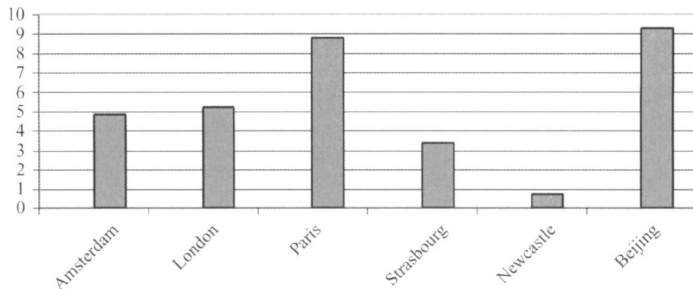
- Why was Britain price and wage structure like this?
 - Britain's success in the global economy: labor demand from international trade, despite growing population and urbanization.

The high wages argument

- Why was Britain price and wage structure like this?
 - Britain's success in the global economy: labor demand from international trade, despite growing population and urbanization.
 - Geography: available coal deposits and cheap to extract.
 - Raise ratio of price of labor to energy \implies demand for energy-using technology.
 - Energy important input in production of metals and bricks (important component of price of capital) \implies fall in capital prices relative to wage \implies demand for capital-using technology.

The high-wage argument

Price of energy, early 1700s



Source: Allen (2011). Price of energy: price of a kilogram of fuel divided by energy content (in grams of silver per million BTUs (British Thermal Units)).

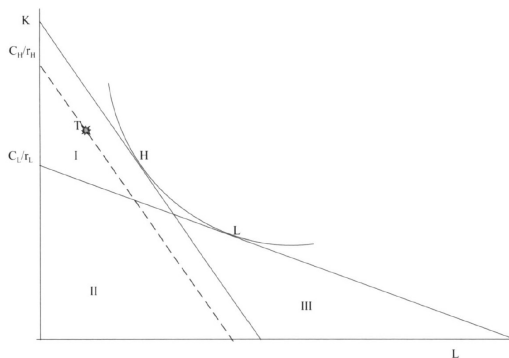
The high wages argument

- Why would high cost of labor induce labor-saving innovations?
 - Innovators innovate if returns to innovation higher than money spent.
 - Returns in terms of royalty: depends on adoption (need patent system).

The high wages argument

- Why would high cost of labor induce labor-saving innovations?
 - Innovators innovate if returns to innovation higher than money spent.
 - Returns in terms of royalty: depends on adoption (need patent system).
- Standard isoquant model:
 - Isoquant curve holds output constant at 1 unit showing combinations of two inputs.
 - Firm has cost $C = rK + wN \iff K = C/r + (w/r)L$
 - r : rental rate of capital K .
 - w : wage rate of labor L .
 - Cost combination of K and L to produce 1 unit.
 - w/r is wage relative to price of capital.

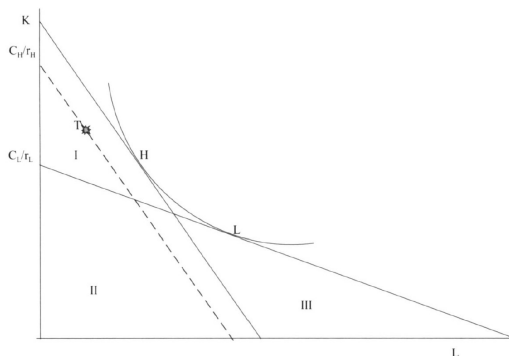
The high-wage argument



- w/r : slope of isocost (constant cost) lines.
- Steeper slope = high-wage firm.
- Intercept C/r is unit cost of firm (intercept with K axis).

Source: Allen (2011).

The high-wage argument

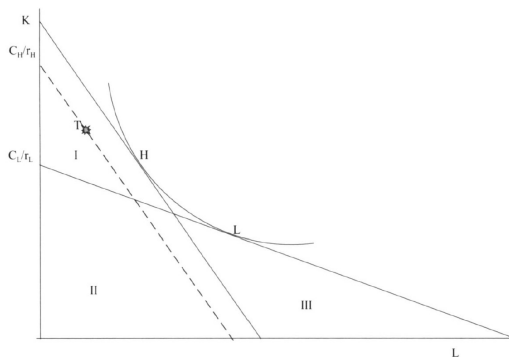


- Equilibrium when isoquant and isocost are tangent.
- At H : combination of K and L for high-wage firm.
- At L : combination of K and L for low-wage firm.

Source: Allen (2011).

The high-wage argument

Biased technical change

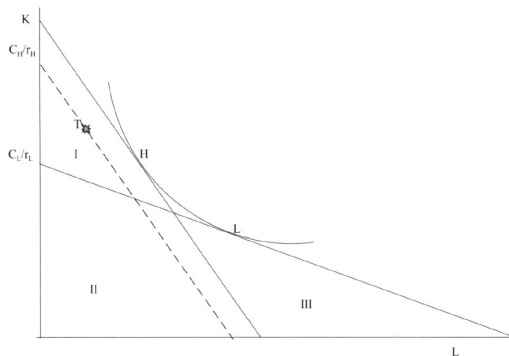


- New technology T with new combination of K and L to produce 1.
- At T , firm uses less K and L than at H and L .
- Adoption only if lower cost, which is true only for high-wage firm.

Source: Allen (2011).

The high-wage argument

Biased technical change



- Technology in zone I: adoption by high-wage firm.
- Technology in zone III: adoption by low-wage firm.
- Technology in zone II: adoption by both firms.

Source: Allen (2011).

The high wages argument

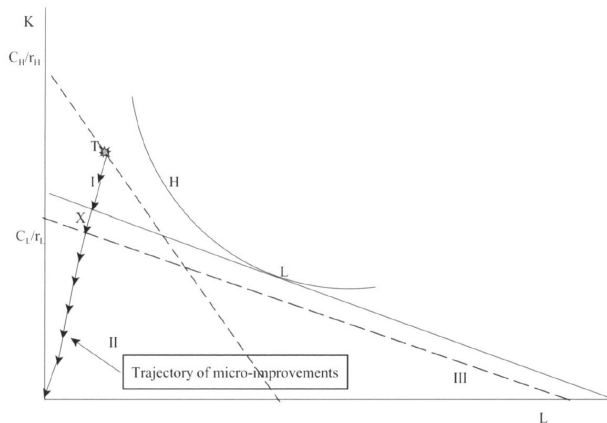
- High-wage and low-wage firms have opposite incentives to invent technology T .
 - Technology in zone I might be invented in high-wage economy, but depends on cost-benefits from R&D investment.
 - Proper patent system helps benefits.
 - Size of market helps, with increasing returns to scale.

The high wages argument

- High-wage and low-wage firms have opposite incentives to invent technology T .
 - Technology in zone I might be invented in high-wage economy, but depends on cost-benefits from R&D investment.
 - Proper patent system helps benefits.
 - Size of market helps, with increasing returns to scale.
- Patterns of innovation consistent:
 - Inventions in machines were capital and energy using (cheap-energy and capital argument).
 - Inventions in textile sector were strongly labor-saving (high-wage argument).
- Micro-inventions helped broader adoption.

The trajectory of micro-improvements

Biased technical change



Source: Allen (2011).

The high wages argument

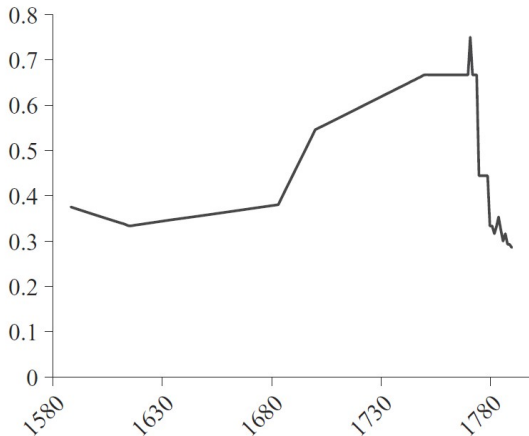
- Was Britain a high wage economy before industrialization?
- Allen highlights innovations in spinning, leading sector in IR:

“[I]t would not have paid to use spinning machines before the eighteenth century: hence, they were not invented earlier. The analysis of profitability turns on the history of women’s wages relative to the cost of spinning machinery’.” Allen (2009)

- Spinners’ high wages prompted innovations in textile industry.

The high wages argument

Earnings of a spinner relative to a building laborer



Source: Allen (2015).

The high wages argument

- Humphries and Scheinder (2018) “Spinning the Industrial Revolution” re-examine this thesis.
 - Essential labor input: hand spinners.
 - Necessary for Allen’s argument: costs of hand spinning rose late 17th–early 18th.
 - Measurement issues:
 - Mostly women and children: seldom appear in statistics.
 - Fragmented sources.
 - Nature of remuneration: piece rates.
- ⇒ Earnings estimates require productivity estimates.

The high wages argument

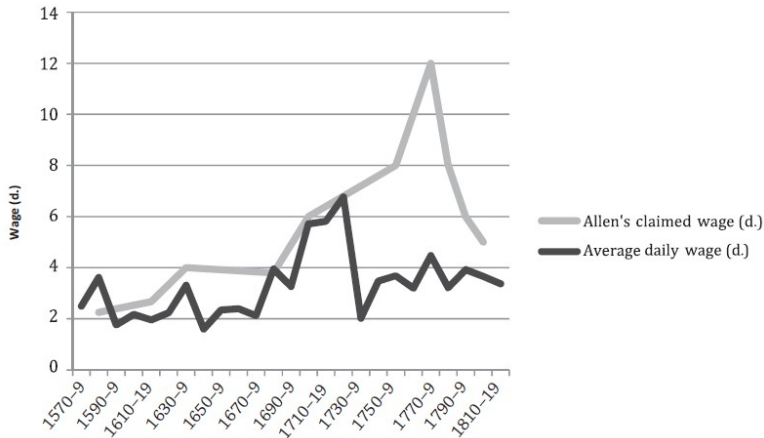
- [Humphries and Scheinder \(2018\)](#) criticize Allen's sources.
 - Allen's productivity estimates rely on one source. [Muldrew \(2012\)](#)
 - [Muldrew \(2012\)](#) based on biased observers (social commentators) and overestimate wages.

The high wages argument

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 - [Muldrew \(2012\)](#) based on biased observers (social commentators) and overestimate wages.
 - [Humphries and Scheinder \(2018\)](#) improve measurement.
 - New data sources: records of putting-out networks, records of poor laws, spinning schools, farms accounts, diaries.
 - Suggests spinners did not have high or strongly growing wages.
 - Exception: 1720s, but too early to explain innovations of 1760s.
- ⇒ "The motivation for mechanization must be sought elsewhere"

The high wages argument

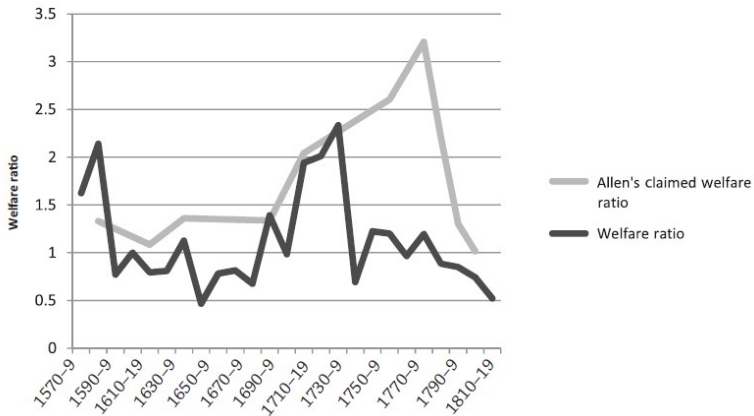
Nominal daily wages, decadal averages



Source: Humphries and Schneider (2018).

The high wages argument

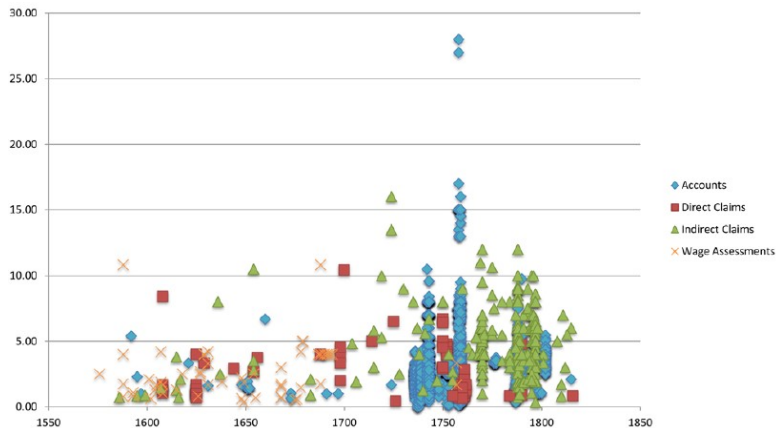
Welfare ratios, decadal averages



Source: Humphries and Schneider (2018).

The high wages argument

Daily wages by source type, nominal daily



Source: Humphries and Schneider (2018).

The high wages argument

- Allen (2019) “Spinning their wheels” re-examine the criticism.

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- Criticism of Humphries-Schneider data:
 - Selection of spinning schools and poor laws data: individuals selected because of low productivity.
 - ⇒ Bias toward low productivity and low wages of spinners.

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- Allen’s data comparable to other series produced with wider coverage, showing wage growth.

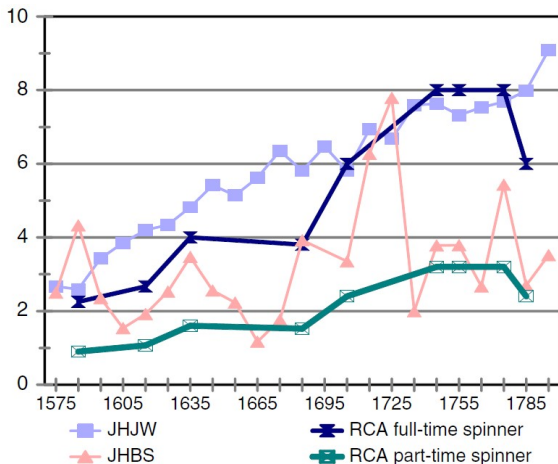
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- Allen’s data comparable to other series produced with wider coverage, showing wage growth.

⇒ “The data presented by Humphries and Schneider fail to sustain their critique of the ‘high wage’ explanation of the industrial revolution.”

The high wages argument

Spinners' earnings (pence per day)



Source: JHJW: Humphries and Weidsorf (2019); JHBS: Humphries and Schneider (2018); RCA: Allen (2015).

The high wages argument

- [Humphries and Schneider \(2020\)](#) “Losing the thread” respond to the rebuttal to the criticism of the original thesis.

The high wages argument

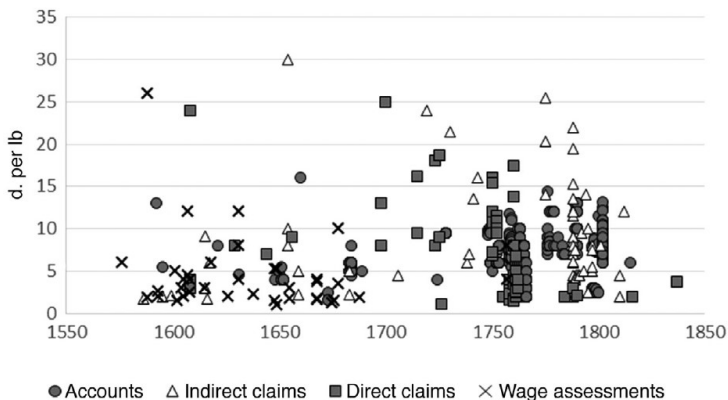
- [Humphries and Schneider \(2020\)](#) “Losing the thread” respond to the rebuttal to the criticism of the original thesis.
- Criticism of wage data used by Allen (low quality, small sample).
- Add 16 data sources, 1,700 observations less subject to biases. Find same results.

⇒ “Allen, rather than us, is spinning his wheels.”

⇒ “Allen has lost the thread of empirical evidence that connects economic historians to the subjects of their study.”

The high wages argument

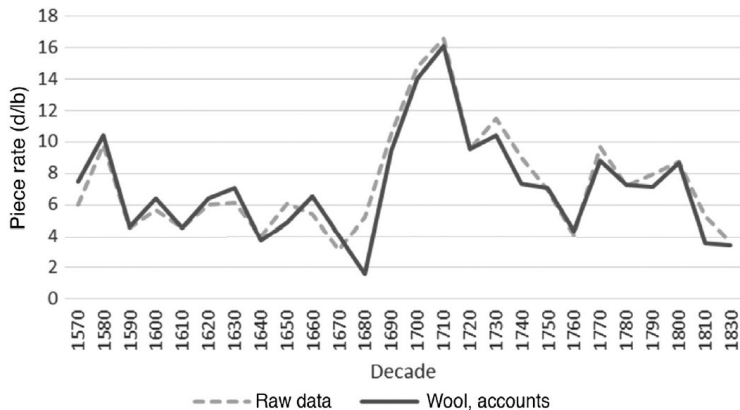
Piece rates by source type, nominal daily



Source: Humphries and Schneider (2020).

The high wages argument

Nominal piece rates from regression analysis



Source: Humphries and Schneider (2020).

The high wages argument

- Conversely, wages outside of Britain were perhaps not as low as claimed by Allen.
- Many evidence that wages relative to energy in France were high.
- E.g., Strasbourg wages. [Geloso \(2019\)](#)
 - Allen: London wages \gg Paris wages 1650–1786.
 - Allen: gap with rest of France even bigger.
 - Geloso: rest of France was not much poorer.
 - Geloso: wages in France were not that low.

The high wages argument

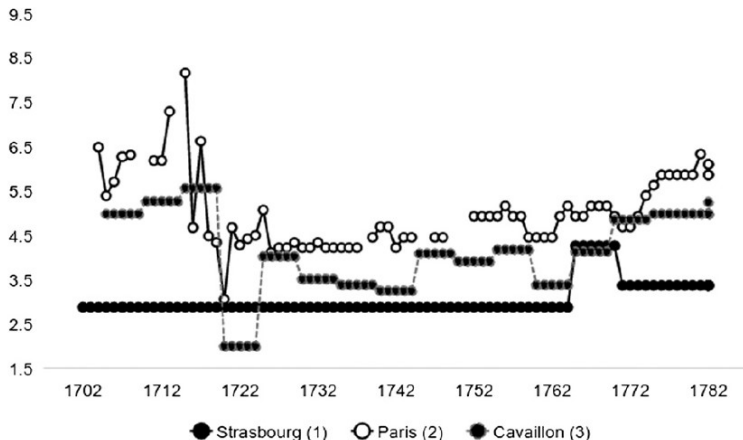
Real wages of Paris workers as a share of real wages of London workers

	UNADJUSTED FIGURES (1)	STEPHENSON ADJUSTMENT (2)
1650–1675	70.88%	88.60%
1675–1700	59.03%	73.78%
1700–1725	56.87%	71.08%
1725–1750	44.81%	56.01%
1750–1775	49.78%	62.22%
1775–1786	57.16%	71.45%

Source: Geloso (2019) based on Allen (2001) and Stephenson (2015).

The high wages argument

Wages in Paris, Strasbourg and Cavailon (grams of silver) 1702–1786



Source: Geloso (2019).

The high wages argument

Wages in Alsace for workers per day by season (grams of silver)

SEASON	OUVRIER	MOISSONNEUR	FAUCHEUR	JOURNALIER	JOURNALIER	BATTEUR EN GRANGE	JOURNALIER	ALLEN'S DATA
	SUMMER	SUMMER	SUMMER	SUMMER	WINTER	WINTER	ANNUAL	SUMMER
1476-1500	4.95	4.89	4.64	3.96	3.51	2.89 ^a	3.74	3.96
1501-1525	4.50	3.60	5.22	3.74	2.52 ^a	2.55 ^a	3.13	3.67
1526-1550	4.05	5.08	4.95	5.09	3.24	3.33	4.17	3.82
1551-1575	5.63	4.46	3.82 ^a	4.59	2.61 ^a	2.39	3.60	3.47
1576-1600	5.54	4.29	3.67 ^a	3.87	2.51 ^a	2.54 ^a	3.19	3.40
1601-1625	6.17	4.19	3.85 ^a	4.37	2.63 ^a	2.48	3.50	4.49
1626-1650	9.32	8.15	6.98	8.46	4.77	4.82	6.62	4.78
1651-1675	8.78	6.30	5.63	5.31	3.51	3.65	4.41	-
1676-1700	6.06 ^a	5.27	4.54 ^a	5.27	3.10 ^a	3.29	4.19	-
1701-1725	6.91 ^a	5.99	5.17 ^a	6.27 ^a	3.53 ^a	3.60	4.90	2.88
1726-1750	4.50	4.83	3.6	5.01 ^a	3.06	3.51	4.03	2.88
1751-1775	4.50	5.09	4.36 ^a	4.50	3.60	3.51	4.05	3.31

^aInterpolated years.

Source: Geloso (2019).

Institutions

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Visiting professor at University of Michigan

Toulouse School of Economics

Institute for Advanced Study in Toulouse

Winter 2024



Toulouse
School of
Economics

What is the role of institutions in the emergence of modern economic growth?

- Defining institutions
- Constitutions and commitment
- Long-run empirical evidence
- State capacity

Defining institutions

Defining institutions

“Institutions are the rules of the game in a society or, more formally, are the humanly devised constraints that shape human interaction. In consequence [institutions] structure incentives in human exchange, whether political, social, or economic.” North (1990)

Defining institutions

- Key elements:
 - Humanly devised.
 - Place constraints on individual behavior.
 - Shape human interaction and affect incentives.
- Institutions influence economic, political and social relations among households, individuals and firms.

Defining institutions

- Key elements:
 - Humanly devised.
 - Place constraints on individual behavior.
 - Shape human interaction and affect incentives.
- Institutions influence economic, political and social relations among households, individuals and firms.
- Rational-theoretic approach:
 - Importance of theory of selection of institutions.
 - Selection through centralized (bargaining) or decentralized (evolutionary competition) process.

Defining institutions

- Political institutions:
 - Inclusive political institutions, e.g., parliaments with equal participation.
 - Extractive political institutions, e.g., slavery and exploitation by the few.

Defining institutions

- Economic institutions (requiring inclusive political institutions):
 - Property rights.
 - Functioning markets.
 - Contractual opportunities.

Defining institutions

- Economic institutions (requiring inclusive political institutions):
 - Property rights.
 - Functioning markets.
 - Contractual opportunities.
- What economic institutions do:
 - Shape the structure of economic incentives.
 - Ensure allocation of resources to efficient uses.
 - Determine distribution of economic revenues.

Defining institutions

- “Good” economic institutions stimulate proximate causes of growth:
 - Physical capital accumulation.
 - Human capital accumulation.
 - Development of better technologies.
- Usually: enforcement of property rights and equality of opportunity.

Defining institutions

Greif and Kingston (2011)

- Some disagree with rational-choice approach to institutions.
- Complementary view: institutions as equilibria.
 - Emphasize theory of motivation and expectations.
 - Institutions emerge as equilibrium in a game of multiple equilibria.
 - Helps explain why “bad” institutions might persist.

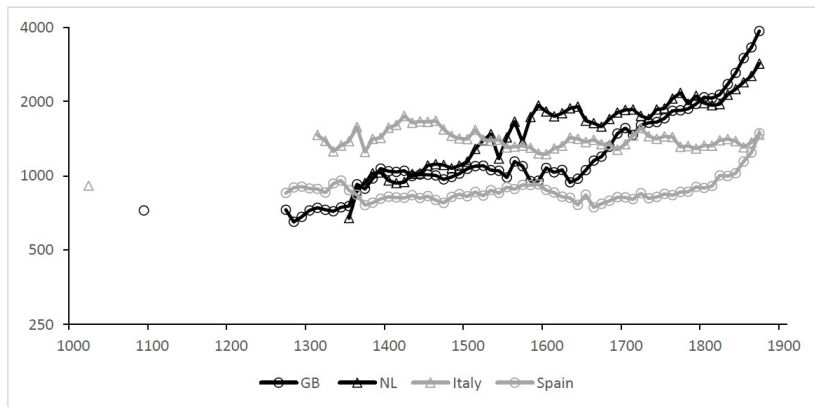
Constitutions and commitment

Constitutions and commitment

- Historical context
- Constitutions and commitment
- Criticism

Historical context: Industrial Revolution in Britain

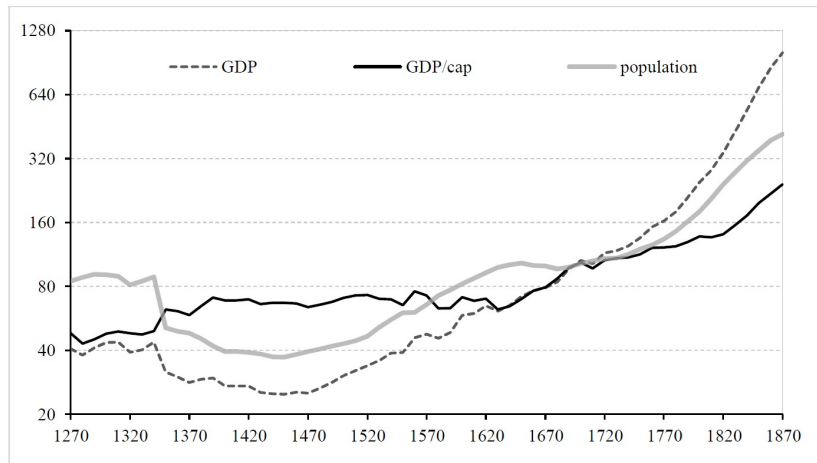
GDP per Capita in Europe, 1270–1870 (1990 GK\$, Log scale)



Source: Broadberry (2020) based on Broadberry et al. (2015), van Zanden and van Leeuwen (2012), Malanima (2011), and Alvarez-Nogal and Prados de la Escosura (2013).

Historical context: Industrial Revolution in Britain

Real GDP, Population, and Real GDP per Capita in England (1270–1700) and Great Britain (1700–1870), Averages per Decade, Log Scale, 1700 = 100



Source: Broadberry (2020) based on Broadberry, Guan and Li (2018).

Historical context: political revolution in Britain

- English Civil War (1642–1651).
 - Conflict between monarchy (Charles I) and Parliamentarians over expropriations.
 - Parliament prevailed, setting up Commonwealth (Cromwell).

Historical context: political revolution in Britain

- English Civil War (1642–1651).
 - Conflict between monarchy (Charles I) and Parliamentarians over expropriations.
 - Parliament prevailed, setting up Commonwealth (Cromwell).
- Instability \implies Charles II restored by Parliament 1660.
- 1680s: James II reestablish Crown supremacy over Parliament.
- Glorious Revolution of 1688.
 - Parliament overthrows James II.
 - Revolutionary Settlement and Declaration of Rights.
 \implies Parliamentary supremacy.

Constitutions and commitment

North and Weingast (1989)

- Strong states and expropriation risk.
 - First goal of a state: national defense, protection against invasion.
 - Achieving this goal \implies strong state.
 - But this implies risk of predation by the state.

Constitutions and commitment

North and Weingast (1989)

- Strong states and expropriation risk.
 - First goal of a state: national defense, protection against invasion.
 - Achieving this goal \implies strong state.
 - But this implies risk of predation by the state.
- High expropriation risk \implies Smaller expected returns to investment
 \implies Smaller incentives for effort, investment, innovation.
- Affects people, but also the state (through tax base).

\implies States face trade-off between expropriation or not.

Constitutions and commitment

- Suppose trade-off in favor of no expropriation.
 - Sovereign wants to establish property rights.
 - Promise to enforce these today and in the future.

Constitutions and commitment

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 - Subjects must believe enforce property rights in the future for reaping returns of current investments.
 - But as returns grow, so do incentives to renege and expropriate.
 - Private citizens understand this, so don't invest today.

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 - But as returns grow, so do incentives to renege and expropriate.
 - Private citizens understand this, so don't invest today.
- ⇒ Sovereign must make credible commitment not to revise property rights.

Constitutions and commitment

- Two ways to solve commitment problem.

Constitutions and commitment

- Two ways to solve commitment problem.
- Reputation when repeated interactions.
 - Reneging on earlier promises tarnishes reputation.
 - Long-run costs decrease incentives for short-run expropriation.
 - But requires valuation of future revenues (so little turnover).
 - Unconstrained rulers cannot use reputation alone.

Constitutions and commitment

- Two ways to solve commitment problem.

Constitutions and commitment

- Two ways to solve commitment problem.
- Create credible commitment devices.
 - Voluntarily restrict ability to expropriate in future.
 - Constitutions (checks and balances) play this role today.
 - Glorious revolution 1688 created such device.

- Before the Glorious Revolution: Crown expropriated wealth.
 - Forced loans, not repaid on time or in full.
 - Sale of monopolies in settled industries.
 - Sale of public offices (reducing value of other offices).
 - Seizure of property.

Constitutions and commitment

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 - Forced loans, not repaid on time or in full.
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 - Sale of public offices (reducing value of other offices).
 - Seizure of property.
- House of Commons composed by wealthy class (targets).

- Institutional changes after the Revolution:
 - Legal disputes over property tried in common law courts.
 - Statute of Monopolies: prohibition of creation of monopolies by sale of patents to existing businesses.
 - Changes in rules of labor mobility and land tenure (enclosures).
- ⇒ Legislative and judiciary independent from monarchy.

- Why no tyranny of Parliament?
 - Balance of power between Crown, Parliament, courts.
 - Fractionalized elites with diverse interests (merchants vs landowners).

Constitutions and commitment

- Constitution and commitment \implies secure property rights
- Many benefits

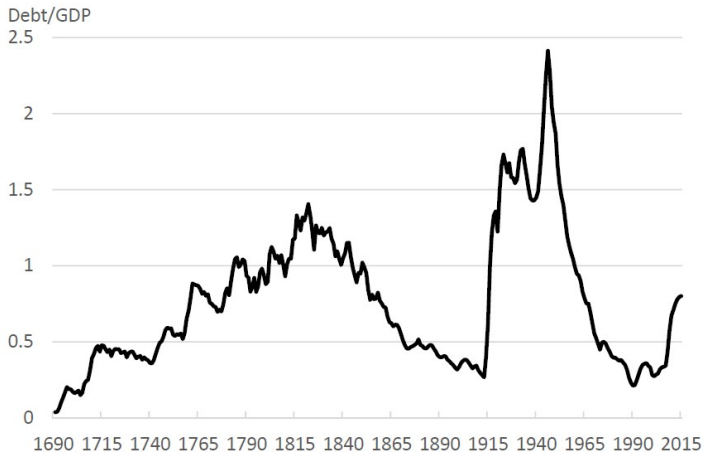
Constitutions and commitment

- Constitution and commitment \implies secure property rights
- Many benefits
 - \uparrow borrowing capacity of government.
 - Major advantage for warfare, leading to gains from trade.
 - Development of private capital markets.
 - Less rent-seeking activities by special-interest groups.
 - Incentives for investment and innovation.

\implies Inclusive institutions were crucial to secure property rights and spur modern economic growth.

Constitutions and commitment

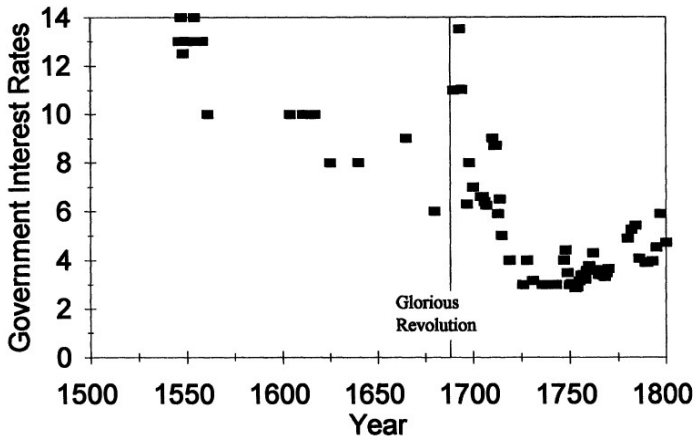
Government Debt to GDP for Britain (1691–2015)



Source: Steinsson (2020) based on Barro (1987) and Thomas and Dimsale (2017).

Constitutions and commitment

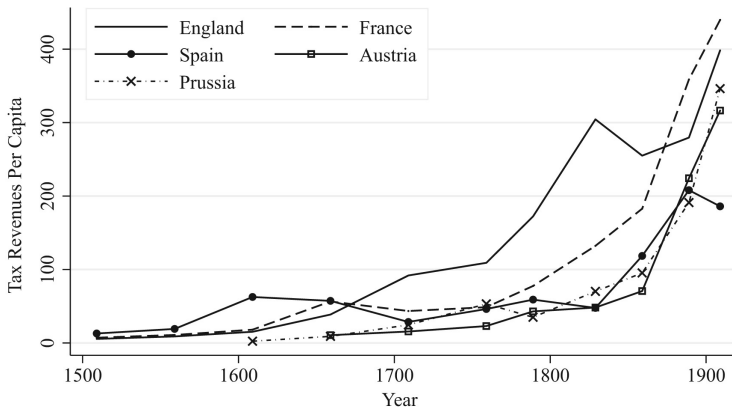
Interest Rates on Government Debt in England



Source: Steinsson (2020) based on Clark (1996).

Constitutions and commitment

Log Tax revenues per capita for five European powers



Source: Johnson and Koyama (2017) based on Karaman and Pamuk (2013).

Ogilvie and Carus (2014)

- No reason why wealth holders seek policies beneficial to the whole economy.
- Other key institutional features matter.

Strong parliaments and growth

- Many examples of strong parliaments which created institutions not beneficial to economic growth.

Strong parliaments and growth

- Many examples of strong parliaments which created institutions not beneficial to economic growth.
- Poland.
 - Strong Parliament, controlled by large landowners.
 - Enforced legal privilege and second serfdom (16th–19th centuries).
 - Prevented policies to allocate resources efficiently and undertake productive investments.

⇒ Concentration of power in homogeneous parliamentary representation impede growth.

Strong parliaments and growth

- Many examples of strong parliaments which created institutions not beneficial to economic growth.

Strong parliaments and growth

- Many examples of strong parliaments which created institutions not beneficial to economic growth.
- German state of Württemberg.
 - Strong Parliament with representatives from diverse commercial and industrial communities (16th–19th centuries).
 - Granted legal monopolies to special-interest groups (guilds, merchant companies. . .)
 - Prevented policies beneficial to whole economy, generating stagnation through monopolistic competition.

⇒ Promotion of particularized institutions rather than generalized institutions matter for growth.

Strong parliaments and growth

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- Even in Britain: mercantilism, slavery, colonialism, protectionism (Corn Laws) created rents economies with ambiguous effects on growth.

⇒ Parliaments do not guarantee diversity of views and growth-enhancing policies.

Other institutional features

Ogilvie and Carus (2014)

- Key distinction: generalized vs particularized institutions.
 - Generalized institutions: rules apply uniformly to all. Good.
 - Particularized institutions: rules apply by group membership (gender, religion, race, parentage, guilds). Bad.

Other institutional features

Ogilvie and Carus (2014)

- Key distinction: generalized vs particularized institutions.
 - Generalized institutions: rules apply uniformly to all. Good.
 - Particularized institutions: rules apply by group membership (gender, religion, race, parentage, guilds). Bad.
- Need simultaneously two types of institutions:
 - Guaranteeing private property.
 - Enforcing contracts (enables resource allocation to best use).

Long-run empirical evidence

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- Do institutions matter for long-run development?
- Extremely difficult question due to endogeneity.

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- Extremely difficult question due to endogeneity.
- Long-run empirical evidence from AJR's "Colonial origins":
 - Contemporaneous correlations. [AJR \(2005\)](#)
 - Reversal of fortune. [AJR \(2002\)](#)
 - Colonial origins. [AJR \(2001\)](#)
 - Unbundling institutions. [AJ \(2005\)](#)

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 - Polity IV.
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- Best current source: V-Dem.
- Some measures of quality of formal institutions (see codebook):
 - Access to justice.
 - Property rights.
 - Rule of law.

Data source: Varieties of Democracy

- Best cross-country institutions data source: [V-Dem](#).
- 450+ indicators, 81 indices, 202 countries, 1789–2020.
- Consistent coding, extremely complete.
- Vastly superior to alternatives.

Data source: Varieties of Democracy

- Property rights (v2xcl_prpty).
 - Question: Do citizens enjoy the right to private property?
 - Scale: Ordinal, converted to interval by the measurement model, from low to high 0–1.

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 - Question: Do citizens enjoy secure and effective access to justice?
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Data source: Varieties of Democracy

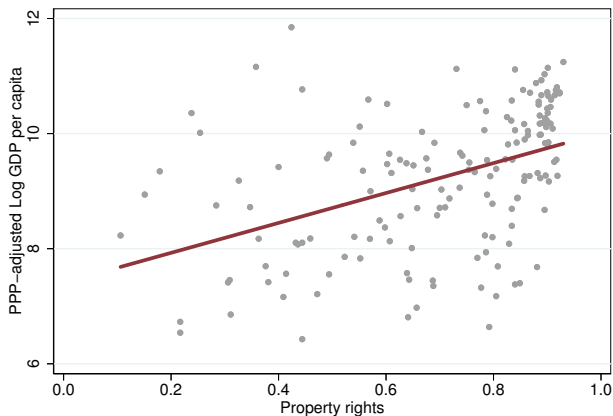
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- Rule of Law (v2x_rule).
 - Question: To what extent are laws transparently, independently, predictably, impartially, and equally enforced, and to what extent do the actions of government officials comply with the law?
 - Scale: Interval, from low to high (0–1). Index combining 15 indicators.

Data source: other institutions datasets

- Polity IV Project (1800–2015).
- Freedom House (1973–2020).
- Political Regimes (1800–2015). Boix et al. (2012)
- Word bank governance indicators (1996–2020). Kaufmann et al. (2010)
- Lexical Index of Electoral Democracy (1800–2013). Skaaning et al. (2015)
- Unified Democracy Score (1946–2012). Penstein et al. (2010)
- Political Institutions and Events (1917–2013). Przeworski et al. (2013)

Contemporaneous correlations

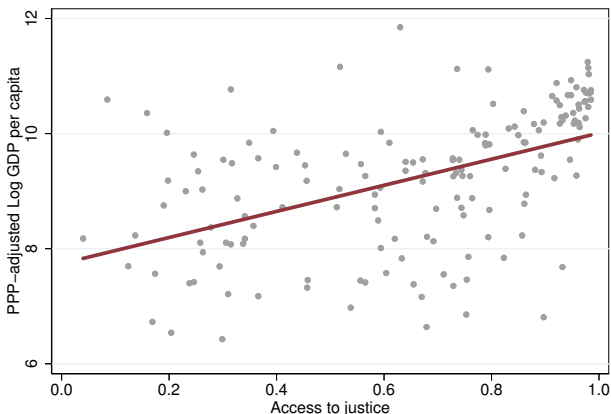
Log GDP per Capita and Property Rights, 2020



Source: V-Dem 9, Maddison Project Database 2018, 160 countries.

Contemporaneous correlations

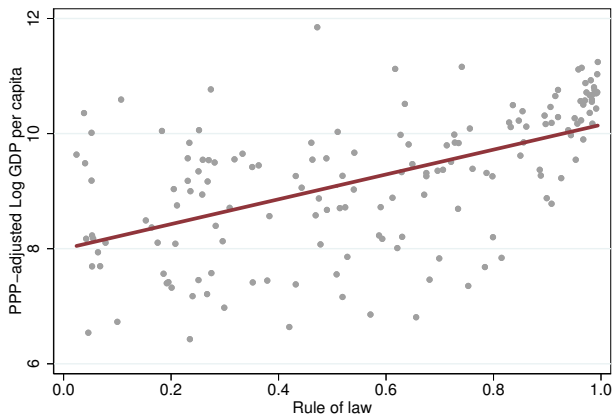
Log GDP per Capita and Access to Justice, 2020



Source: V-Dem 9, Maddison Project Database 2018, 160 countries.

Contemporaneous correlations

Log GDP per Capita and Rule of Law, 2020



Source: V-Dem 9, Maddison Project Database 2018, 160 countries.

Contemporaneous correlations

$$Y_{cy} = \alpha + \beta X_{cy} + \varepsilon_{cy}$$

Year	Property	Justice	Law	Countries
1960	1.64***	1.73***	1.78***	133
1980	1.84***	1.81***	1.83***	140
2000	2.78***	2.77***	2.66***	162
2020	2.60***	2.27***	2.16***	160

Source: V-Dem 9, Maddison Project Database 2018.

Dependent variable: *log* GDP per capita.

*** Significant at the 1 percent level.

Identification issues

- Can we interpret these relationships as causal?

Identification issues

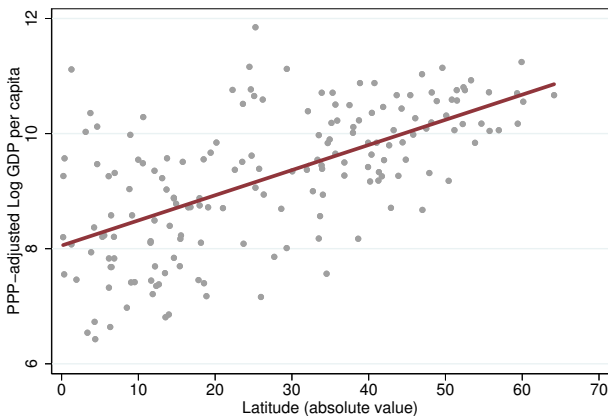
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- Can we interpret these relationships as causal?
- Identification issues:
 - Reverse causality: wealthy countries could afford better institutions.
 - Omitted variable bias: Z causes both institutions and development such as geography or culture.
- General solution: find exogenous source of variation.

Identification issues: geography as a source of OVB

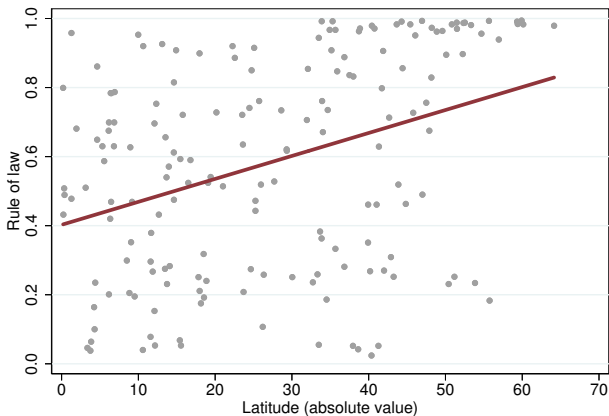
Log GDP per Capita and Latitude, 2020



Source: Maddison Project Database 2018, CEPII GeoDist, 172 countries.

Identification issues: geography as a source of OVB

Rule of Law and Latitude, 2020



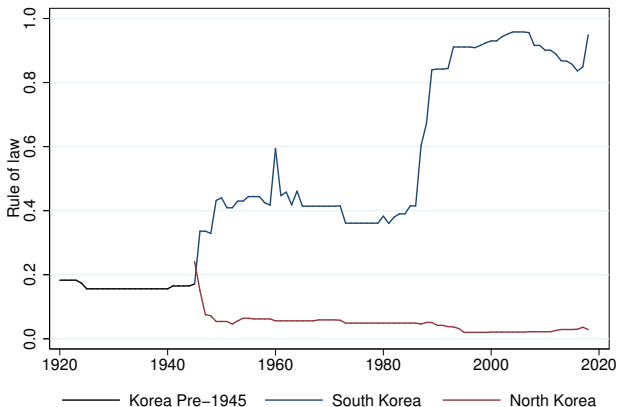
Source: V-Dem 9, CEPII GeoDist, 172 countries.

Data source: geography

- Best cross-country geographical data source: [CEPII-GeoDist](#).
- Geographical variables: continent, landlocked, official language, area, latitude, longitude, identity of colonizers.
- Diadic dataset: bilateral distance.
- Reference paper: [Mayer and Zigago \(2011\)](#)

The Korean experiment

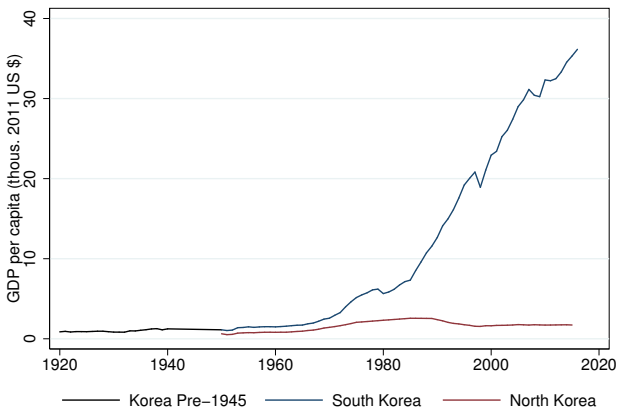
Rule of Law in the Koreas



Source: V-Dem 9.

The Korean experiment

GDP per Capita in the Koreas



Source: Maddison Project Database 2018.

Reversal of fortune

- Acemoglu, Johnson and Robinson (2002)
- Use colonization as a natural experiment to assess the causal impact of institutions on economic development.

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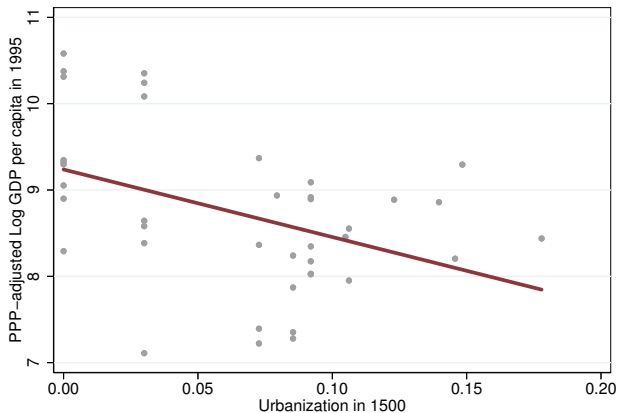
- Acemoglu, Johnson and Robinson (2002)
- Use colonization as a natural experiment to assess the causal impact of institutions on economic development.
- Question: richest ancient civilizations are today among poorest nations. Why?
- Document reversal of relative income among former colonies.
- Evidence that institutions matter for long-run economic development.
- Geography, culture, luck cannot account for the reversal.

Reversal of fortune

- Which countries in this experiment?
 - Colonized by Europeans between 15th and 19th centuries.
 - Excludes Ireland, Russia, Middle East.
- How to capture prosperity before colonization (1500)?
 - Maddison data: too little sample size.
 - Urbanization: captures high agricultural productivity. [Bairoch \(1998\)](#)
 - Population density (measurement issues).
 - Sample sizes small when paper written.

Reversal of fortune

Urbanization in 1500 and Log GDP per Capita in 1995 Former European Colonies



Source: Penn World Table 9, CEPII GeoDist, AJR (2002), 40 countries.

Reversal of fortune

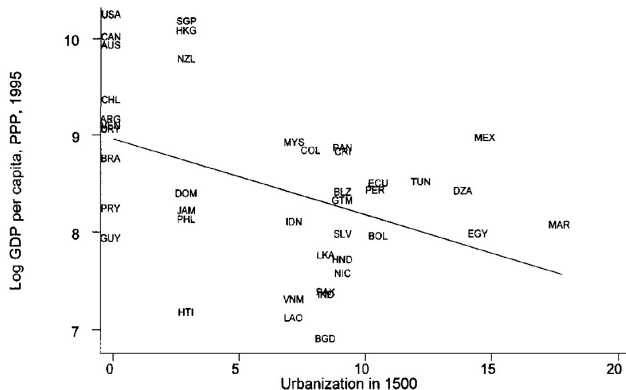


FIGURE I

Log GDP per Capita (PPP) in 1995 against Urbanization Rate in 1500

Note. GDP per capita is from the World Bank [1999]; urbanization in 1500 is people living in towns with more than 5000 inhabitants divided by total population, from Bairoch [1988] and Eggimann [1999]. Details are in Appendices 1 and 2.

Reversal of fortune: robustness

- Potential confounding factors:
 - Geography: continent, latitude, landlocked, island, temperature.
 - Natural resources: gold, iron, silver, zinc, oil, coal.
 - Colonizer: French, Spanish, British.
 - Religion: Catholicism, Islam.

Reversal of fortune: robustness

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 - Natural resources: gold, iron, silver, zinc, oil, coal.
 - Colonizer: French, Spanish, British.
 - Religion: Catholicism, Islam.
- Robust relationship:
 - Higher urbanization in 1500 \implies lower income in 1995.
 - In former European colonies.

Reversal of fortune

Dependent variable:	log GDP per capita (PPP) in 1995			
	(1)	(2)	(3)	(4)
Urbanization 1500	-8.56*** [2.35]	-11.79** [4.74]	-8.41*** [3.04]	-10.59** [4.71]
Geography	No	Yes	No	Yes
Natural resources	No	Yes	No	Yes
Colonizer	No	No	Yes	Yes
Religion	No	No	Yes	Yes
R2	0.22	0.70	0.31	0.79
Countries	40	40	40	40

*** Significant at the 1 percent level. ** Significant at the 5 percent level.

Reversal of fortune: interpretation

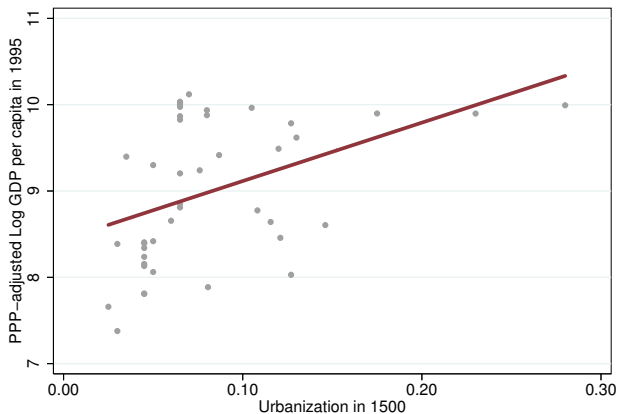
- Interpreting a coefficient of -10.
 - 10 pp lower urbanization 1500 \implies 1 log higher income 1995.
 - Taking exp, means 2-3 times richer.

Reversal of fortune: interpretation

- Interpreting a coefficient of -10.
 - 10 pp lower urbanization 1500 \implies 1 log higher income 1995.
 - Taking exp, means 2-3 times richer.
- Not reversion to mean: specific to former colonies.

Reversal of fortune: non-colonies

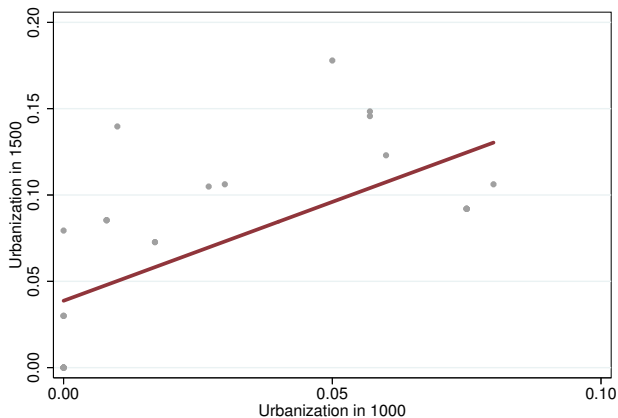
Urbanization in 1500 and Log GDP per Capita in 1995
Non-Colonies



Source: AJR (2002), 43 countries.

Reversal of fortune: timing

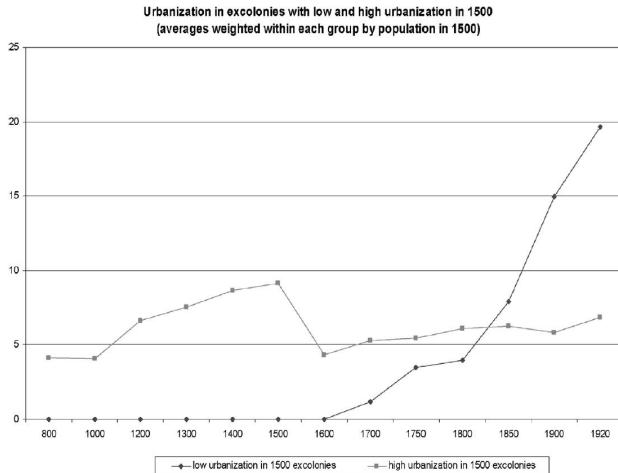
Urbanization in 1500 and 1000
Former European Colonies



Source: AJR (2002), 30 countries.

Reversal of fortune: timing

Evolution of Urbanization in Former European Colonies



Reversal of fortune: interpretation

- Facts compatible with which theory?

Reversal of fortune: interpretation

- Facts compatible with which theory?
 - Geography hypotheses.
 - Culture.
 - Institutions.

Reversal of fortune: geography

- Simple geography hypothesis.
 - Permanent effects of geography (α_1) \implies prosperity.

$$Y_{it} = \alpha_0 + \alpha_1 \cdot G_i + \nu_t + \varepsilon_{it}$$

Reversal of fortune: geography

- Simple geography hypothesis.
 - Permanent effects of geography (α_1) \implies prosperity.

$$Y_{it} = \alpha_0 + \alpha_1 \cdot G_i + \nu_t + \varepsilon_{it}$$

- Inconsistent: rich countries in 1500 are poor today.

Reversal of fortune: geography

- Sophisticated geography hypothesis.
 - Time-varying effects of geography (α_{2t}) \implies prosperity.

$$Y_{it} = \alpha_0 + \alpha_1 \cdot G_i + \sum_t \alpha_{2t} \cdot \nu_t \cdot G_i + \nu_t + \varepsilon_{it}$$

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- “Latitude-specific” agricultural technologies: reversal is industry based.

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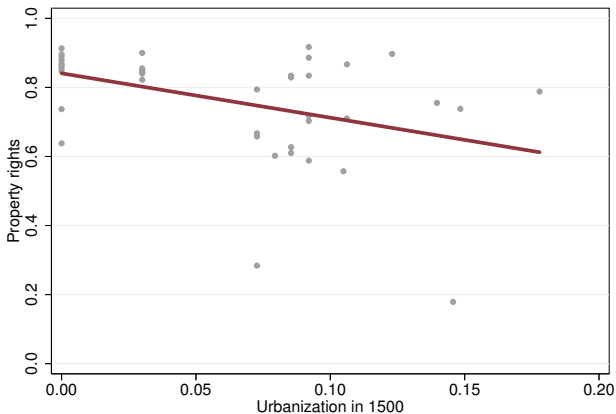
- “Latitude-specific” agricultural technologies: reversal is industry based.
- Lack resources endowment for industrialization: not correlated.

Reversal of fortune: culture

- Culture hypothesis.
 - Colonialism might have changed culture, created new ones.
 - But has nothing to say about timing.

Reversal of fortune: institutions

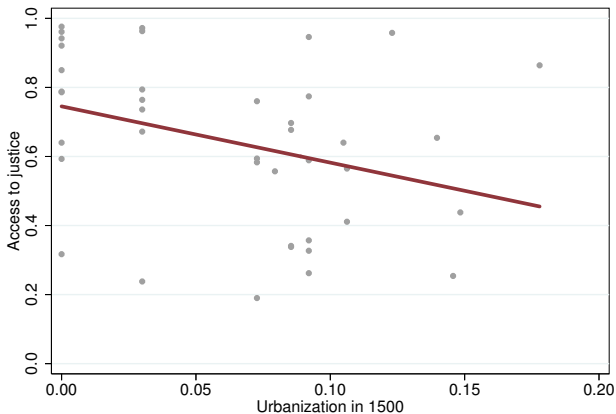
Urbanization in 1500 and Property Rights in 2020
Former European Colonies



Source: V-Dem 9, AJR (2002), 40 countries.

Reversal of fortune: institutions

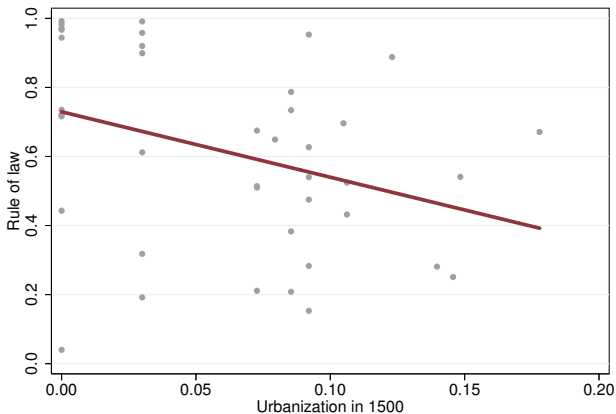
Urbanization in 1500 and Access to Justice in 2020
Former European Colonies



Source: V-Dem 9, AJR (2002), 40 countries.

Reversal of fortune: institutions

Urbanization in 1500 and Rule of Law in 2020
Former European Colonies



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Reversal of fortune: institutions

- Evidence of institutional reversal.
 - High urbanization in 1500 \implies “extractive institutions.”
 - Low urbanization in 1500 \implies “inclusive institutions.”

Reversal of fortune: institutions

- Evidence of institutional reversal.
 - High urbanization in 1500 \implies “extractive institutions.”
 - Low urbanization in 1500 \implies “inclusive institutions.”
- Explains also the timing:
 - Good institutions \implies incentives for K and HK accumulation.
 - Institutions are more important when opportunity to industrialize.

Reversal of fortune: institutions

- Factors for choice of colonial institutions:

Reversal of fortune: institutions

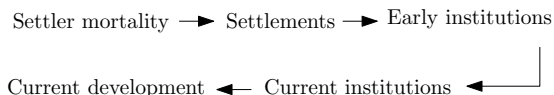
- Factors for choice of colonial institutions:
 - Economic profitability of extractive institutions.
 - Dense population \implies large supply of labor.
 - Pre-existing system of tax administration \implies continue.

Reversal of fortune: institutions

- Factors for choice of colonial institutions:
 - Economic profitability of extractive institutions.
 - Dense population \implies large supply of labor.
 - Pre-existing system of tax administration \implies continue.
 - Whether Europeans could settle.
 - Low density \implies Europeans settle \implies protect their property.
 - Same institutions as home \implies incentives for Europeans to settle.

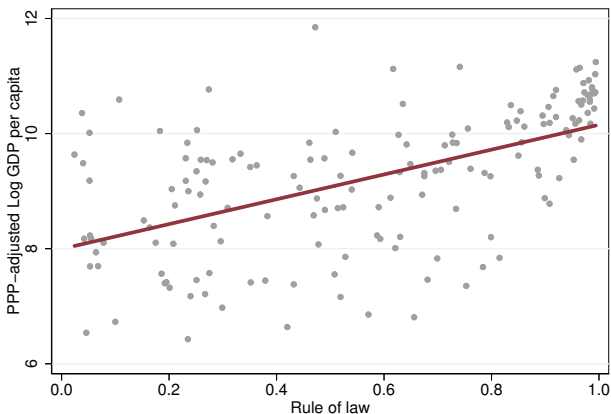
Acemoglu, Johnson and Robinson (2001)

- Show that disease environment shaped incentives to settle.
- Use settler mortality as an IV for current institutions.
- Show causal impact of current institutions on current development.



Colonial origins

Log GDP per Capita and Rule of Law, 2020. Causal?



Source: V-Dem 9, Maddison Project Database 2018, 160 countries.

Colonial Origins

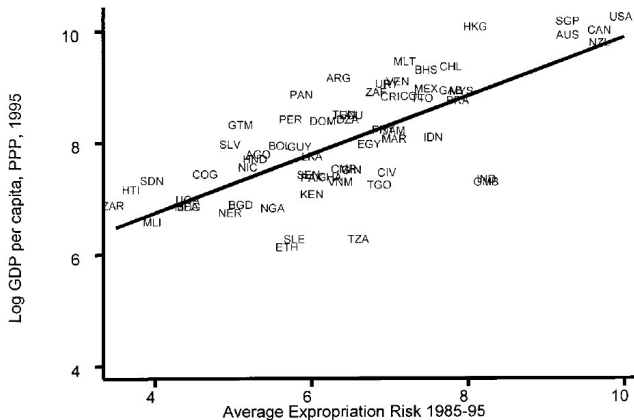


FIGURE 2. OLS RELATIONSHIP BETWEEN EXPROPRIATION RISK AND INCOME

Colonial origins

- Impact of current institutions on current economic performance:

$$\log y_i = \mu + \alpha R_i + \mathbf{X}'_i \gamma + \varepsilon_i$$

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- First stage: impact of settler mortality on current institutions.

$$R_i = \zeta + \beta \log M_i + \mathbf{X}'_i \delta + \nu_i$$

- y : income per capita.
- R : measure of institutions.
- \mathbf{X} : controls.
- M : settler mortality rate.

Colonial origins

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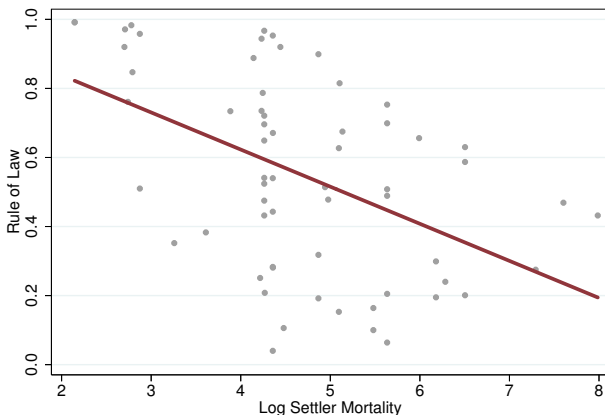
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$$R_i = \zeta + \beta \log M_i + \mathbf{X}'_i \delta + \nu_i$$

- y : income per capita.
 - R : measure of institutions.
 - \mathbf{X} : controls.
 - M : settler mortality rate.
- Exclusion restriction: settler mortality only affect development through institutions.

Colonial origins: first stage

Settler Mortality and Rule of Law, 2020 Former European Colonies



Source: V-Dem 9, AJR (2001), 62 countries.

Colonial origins: first stage

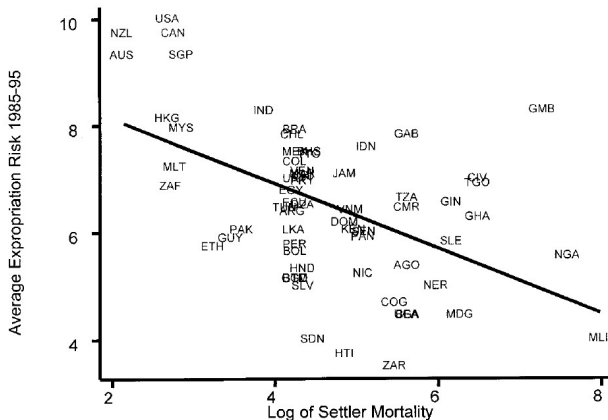


FIGURE 3. FIRST-STAGE RELATIONSHIP BETWEEN SETTLER MORTALITY AND EXPROPRIATION RISK

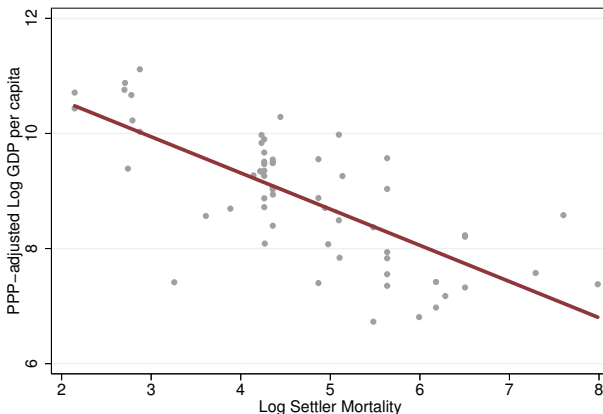
Colonial origins: first stage

Dependent variable:	Rule of Law in 2020			
	(1)	(2)	(3)	(4)
Log settler mortality	-0.11*** [0.02]	-0.05* [0.03]	-0.10*** [0.02]	-0.05* [0.03]
Geography	No	Yes	No	Yes
Colonizer	No	No	Yes	Yes
R2	0.23	0.29	0.28	0.35
Countries	62	62	62	62

*** Significant at the 1 percent level. * Significant at the 1 percent level.

Colonial origins: reduced form

Settler Mortality and Log GDP per Capita, 2020
Former European Colonies



Source: Maddison Project Database 2018, AJR (2001), 62 countries.

Colonial origins: reduced form

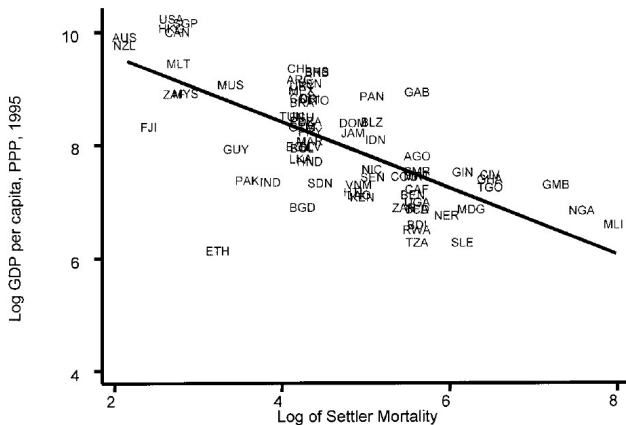


FIGURE 1. REDUCED-FORM RELATIONSHIP BETWEEN INCOME AND SETTLER MORTALITY

Colonial origins: reduced form

Dependent variable:	Log GDP per Capita in 2020			
	(1)	(2)	(3)	(4)
Log settler mortality	-0.63*** [0.08]	-0.42* [0.13]	-0.58*** [0.09]	-0.44*** [0.13]
Geography	No	Yes	No	Yes
Colonizer	No	No	Yes	Yes
R2	0.52	0.64	0.57	0.67
Countries	61	61	61	61

*** Significant at the 1 percent level. * Significant at the 1 percent level.

Colonial origins: IV regressions

Dependent variable:	Log GDP per Capita in 2020			
	(1)	(2)	(3)	(4)
Rule of Law in 2020	5.80*** [0.84]	6.88* [2.28]	5.84*** [0.92]	7.17*** [2.57]
Geography	No	Yes	No	Yes
Colonizer	No	No	Yes	Yes
Countries	61	61	61	61

*** Significant at the 1 percent level. * Significant at the 1 percent level.

Colonial origins: interpretation

- Once institutions purged, little role of geography.
- Rationale for raw correlation between development and geography:
 - Europeans had little immunity to tropical diseases.
 - They tended to settle in temperate latitudes.
 - Explains how geography partly shaped historical institutions.
 - Geography matters only through institutions.

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 - Europeans had little immunity to tropical diseases.
 - They tended to settle in temperate latitudes.
 - Explains how geography partly shaped historical institutions.
 - Geography matters only through institutions.
- Colonial culture? No effect of identity of colonizer.

Colonial origins: criticisms

- Large literature resulting from these two papers.
- Criticisms, e.g. [Albouy \(2012\)](#) (after 5 unpublished comments).
 - Reliability and comparability of European settler mortality rates.
 - Procedure of clustering standard errors.
 - Weak instrument problem.
- Responses in [AJR \(2012\)](#) (after 3 unpublished replies).
- Big picture is robust.

Contract vs predatory theory

- North (1981) distinguishes:
 - Contract theory of the state: legal framework \implies private contracts.
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- Empirical importance of each institutional feature?

Property rights and contracting institutions

- Contracting institutions (horizontal).
 - Rules governing contracting between ordinary citizens.
 - Main component: functioning of legal system.
 - Affects cost of enforcing contracts.
 - Implications for equilibrium contracts and transactions.

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 - Rules governing contracting between ordinary citizens.
 - Main component: functioning of legal system.
 - Affects cost of enforcing contracts.
 - Implications for equilibrium contracts and transactions.
- Property rights institutions (vertical).
 - Rules protecting citizens against government and elites power.
 - Relate to interactions between state and society.
 - Affects returns to investment.
 - Implications for equilibrium capital accumulation.

Measurement: outcomes

- Log GDP per capita. [PWT](#)
- Investment to GDP. [PWT](#)
- Private credit to GDP. [WB](#)
- Stock market capitalization to GDP. [Beck et al. \(2001\)](#)

Measurement: contracting institutions

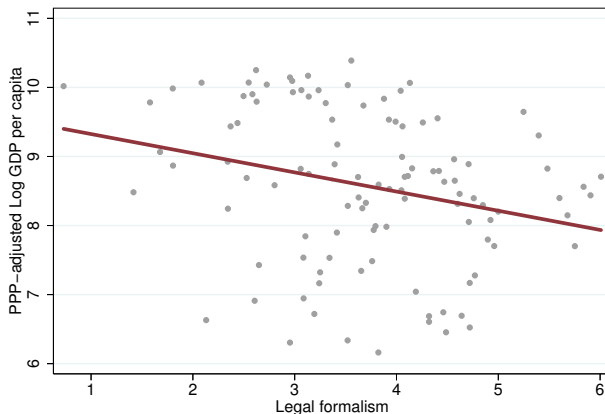
- Index of legal formalism (1–7). [Djankov et al. \(2003\)](#)
- Overall procedural complexity of resolving court case (0–10). [WB](#)
- Number of procedures for resolving court case. [WB](#)

Measurement: property rights institutions

- Constraint on executive (1–7). [Polity IV](#)
- Protection against expropriation (1–10). [Political Risk Services](#)
- Private property index (1–5). [Heritage Foundation](#)
- Property rights (0–1). [V-Dem](#)

Correlations: income and contracting

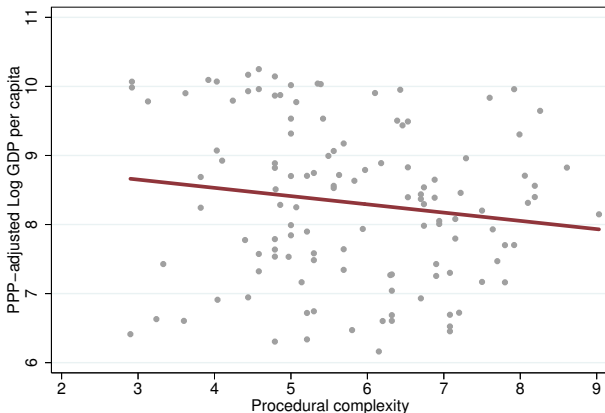
Log GDP per Capita and Contracting, 1990s
All Countries



Source: AJ (2005), 108 countries.

Correlations: income and contracting

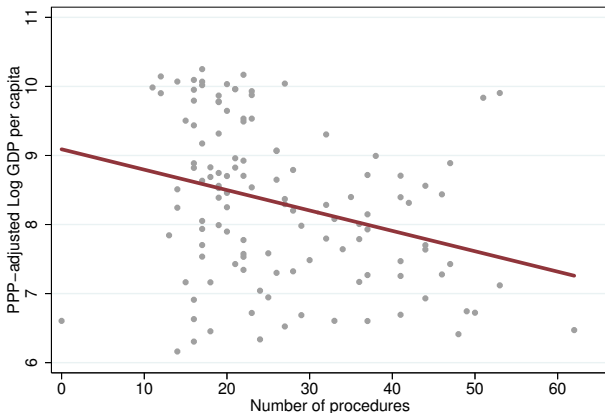
Log GDP per Capita and Contracting, 1990s
All Countries



Source: AJ (2005), 121 countries.

Correlations: income and contracting

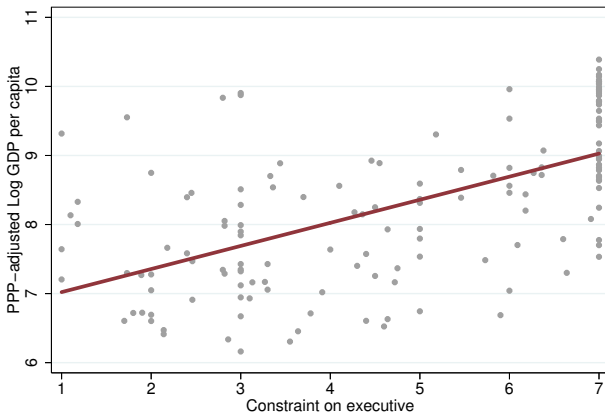
Log GDP per Capita and Contracting, 1990s
All Countries



Source: AJ (2005), 122 countries.

Correlations: income and property rights

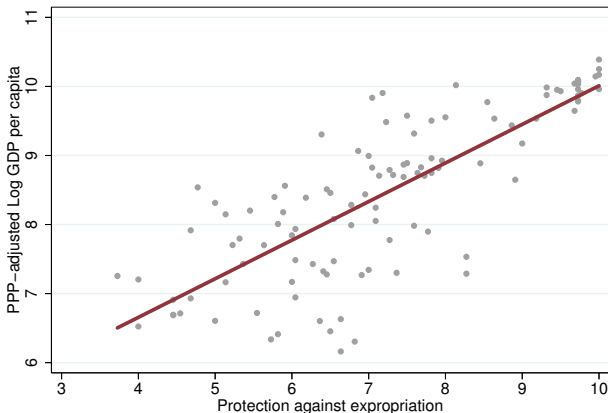
Log GDP per Capita and Property Rights, 1990s
All Countries



Source: AJ (2005), 145 countries.

Correlations: income and property rights

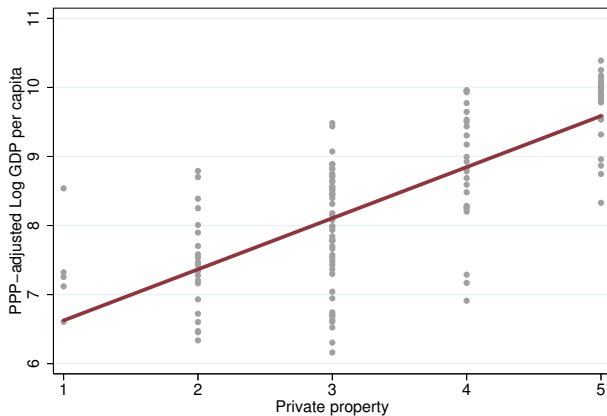
Log GDP per Capita and Property Rights, 1990s
All Countries



Source: AJ (2005), 110 countries.

Correlations: income and property rights

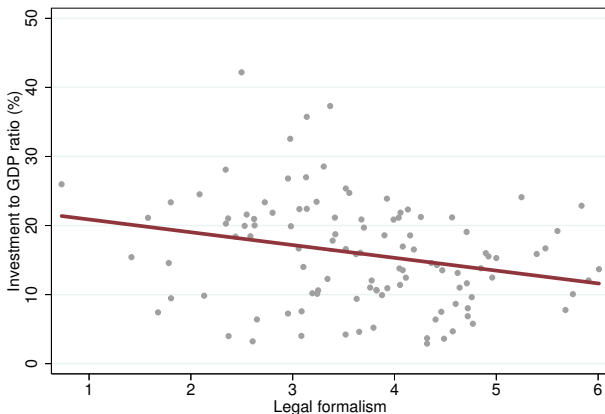
Log GDP per Capita and Property Rights, 1990s
All Countries



Source: AJ (2005), 129 countries.

Correlations: investment and contracting

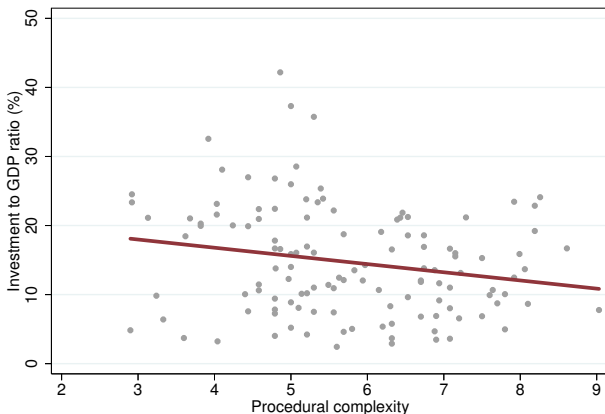
Investment to GDP and Contracting, 1990s
All Countries



Source: AJ (2005), 110 countries.

Correlations: investment and contracting

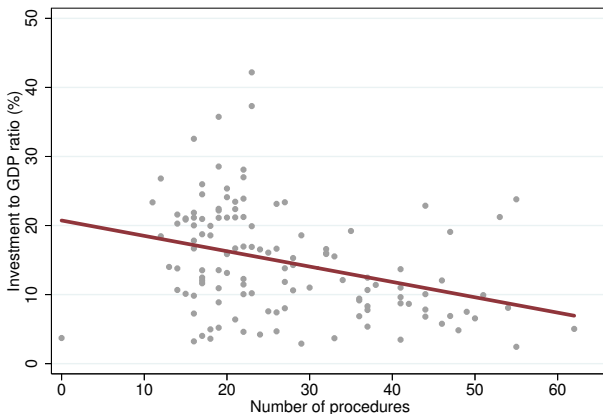
Investment to GDP and Contracting, 1990s
All Countries



Source: AJ (2005), 124 countries.

Correlations: investment and contracting

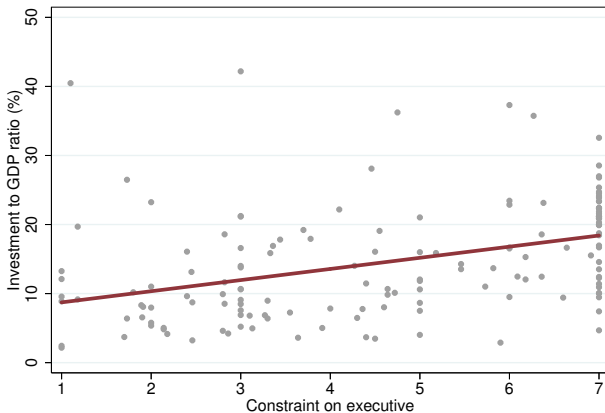
Investment to GDP and Contracting, 1990s
All Countries



Source: AJ (2005), 125 countries.

Correlations: investment and property rights

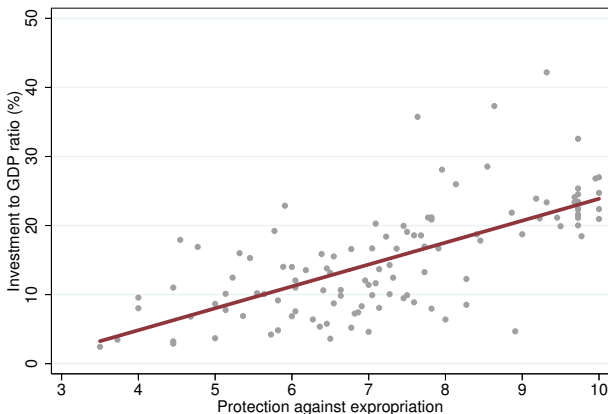
Investment to GDP and Property Rights, 1990s
All Countries



Source: AJ (2005), 149 countries.

Correlations: investment and property rights

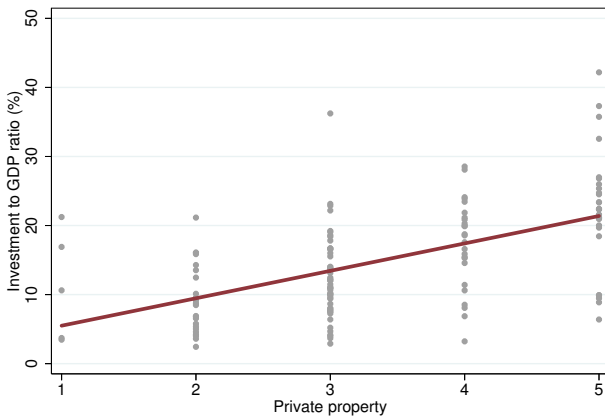
Investment to GDP and Property Rights, 1990s
All Countries



Source: AJ (2005), 113 countries.

Correlations: investment and property rights

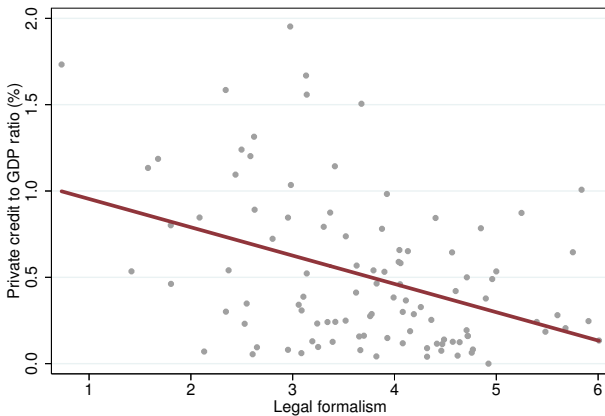
Investment to GDP and Property Rights, 1990s
All Countries



Source: AJ (2005), 131 countries.

Correlations: credit and contracting

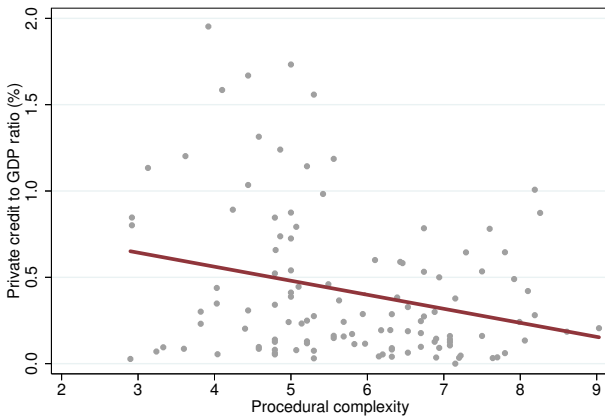
Credit to GDP and Contracting, 1990s
All Countries



Source: AJ (2005), 103 countries.

Correlations: credit and contracting

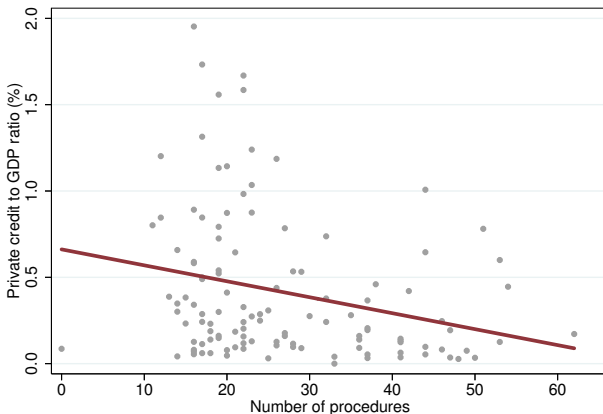
Credit to GDP and Contracting, 1990s
All Countries



Source: AJ (2005), 117 countries.

Correlations: credit and contracting

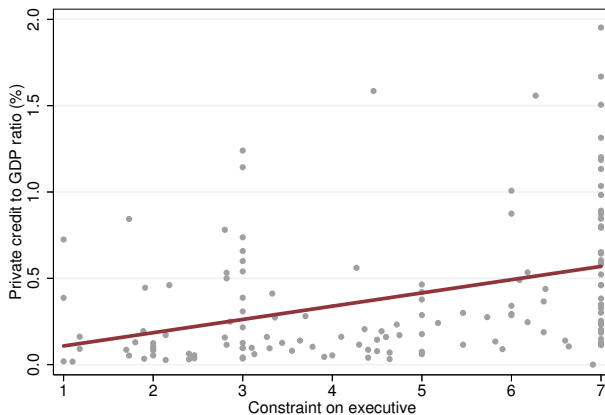
Credit to GDP and Contracting, 1990s
All Countries



Source: AJ (2005), 118 countries.

Correlations: credit and property rights

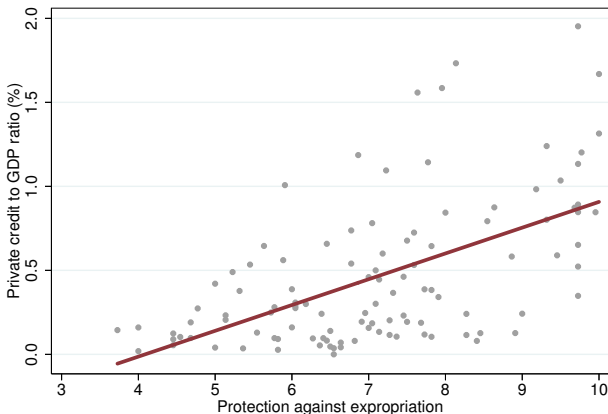
Credit to GDP and Property Rights, 1990s
All Countries



Source: AJ (2005), 140 countries.

Correlations: credit and property rights

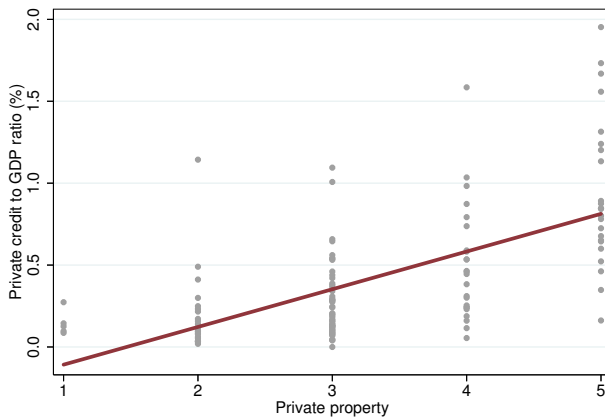
Credit to GDP and Property Rights, 1990s
All Countries



Source: AJ (2005), 109 countries.

Correlations: credit and property rights

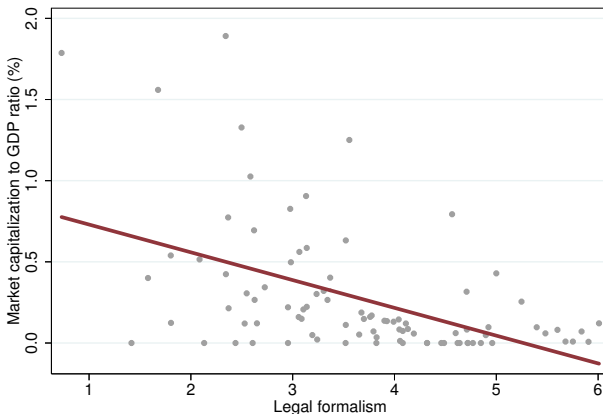
Credit to GDP and Property Rights, 1990s
All Countries



Source: AJ (2005), 126 countries.

Correlations: capitalization and contracting

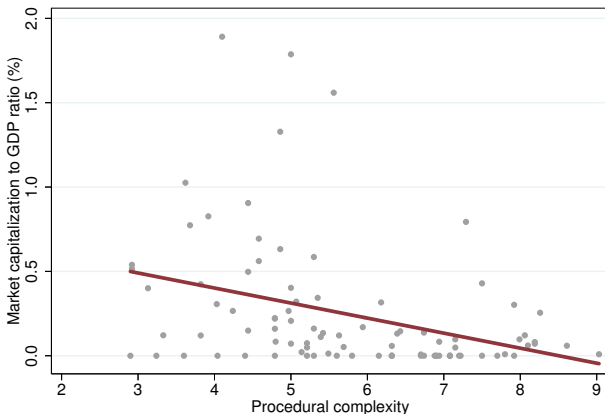
Capitalization to GDP and Contracting, 1990s
All Countries



Source: AJ (2005), 89 countries.

Correlations: capitalization and contracting

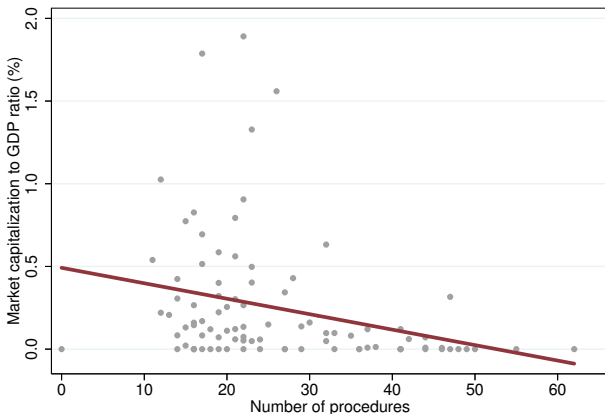
Capitalization to GDP and Contracting, 1990s
All Countries



Source: AJ (2005), 91 countries.

Correlations: capitalization and contracting

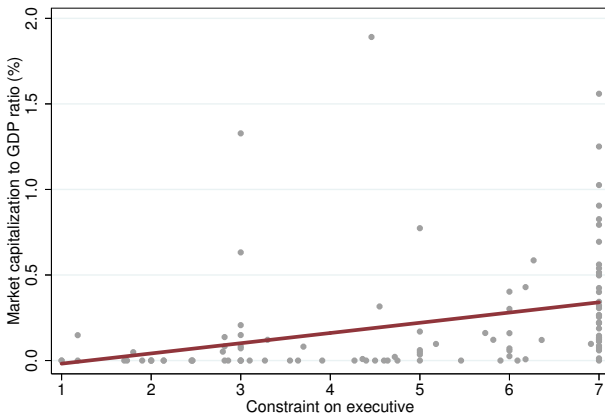
Capitalization to GDP and Contracting, 1990s
All Countries



Source: AJ (2005), 91 countries.

Correlations: capitalization and property rights

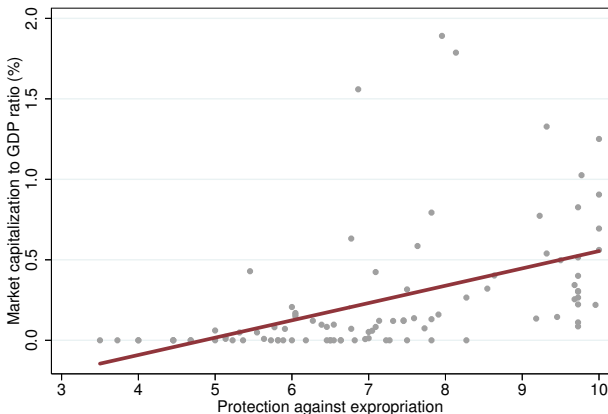
Capitalization to GDP and Property Rights, 1990s
All Countries



Source: AJ (2005), 105 countries.

Correlations: capitalization and property rights

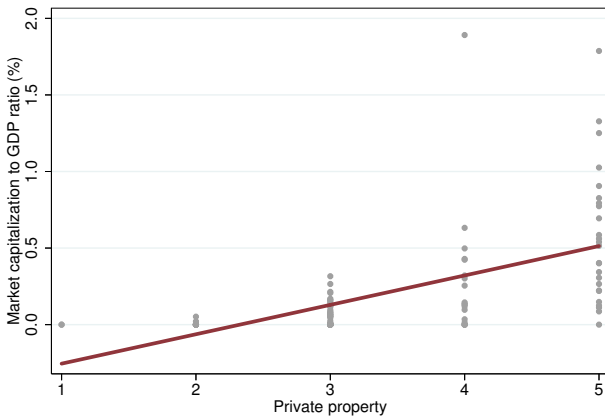
Capitalization to GDP and Property Rights, 1990s All Countries



Source: AJ (2005), 95 countries.

Correlations: capitalization and property rights

Capitalization to GDP and Property Rights, 1990s
All Countries



Source: AJ (2005), 102 countries.

Restrict Outcomes and Institutions

- Outcome: focus on Log GDP per capita.
- Contracting institutions: focus on legal formalism.
- Property rights institutions: focus on constraint on executive.
- Variables measured in the 1990s.

Baseline empirical strategy

$$Y_c = \alpha F_c + \beta I_c + \mathbf{Z}'_c \gamma + \varepsilon_c$$

- Y_c : outcome of interest in country c .
- F_c : measure of contracting institutions.
- I_c : measure of property rights institutions.
- \mathbf{Z}_c : vector of controls (geography, religion...).

Univariate OLS coefficients

Dependent variable:	Log GDP per capita			
	(1)	(2)	(3)	(4)
Legal formalism	-0.28*** [0.08]	-0.21** [0.11]		
Constraint on executive			0.33*** [0.04]	0.30*** [0.05]
Sample	All	FEC	All	FEC
Countries	108	65	145	86

Source: AJ (2005). *FEC*: Former European Colonies.

*** Significant at the 1 percent level. ** Significant at the 5 percent level.

Identification strategy

- Threats to identification.

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 - Reverse causality.
 - Omitted variable bias (e.g. geography).

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- Threats to identification.
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 - Omitted variable bias (e.g. geography).
- Measurement error.
 - Downward attenuation bias.
 - Correlated measurement error.

Identification strategy: 2SLS

- Solution: two-stage least squares (2SLS).
- Two instruments:

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 - Contracting IV: British legal origins. [La Porta et al. \(1997, 1998\)](#)

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- Solution: two-stage least squares (2SLS).
- Two instruments:
 - Contracting IV: British legal origins. [La Porta et al. \(1997, 1998\)](#)
 - Property rights IV: European settlers mortality. [AJR \(2001\)](#)

Identification strategy: first stage

$$F_c = \delta_1 L_c + \eta_1 M_c + \mathbf{Z}'_c \gamma_1 + u_{1c}$$

$$I_c = \delta_2 L_c + \eta_2 M_c + \mathbf{Z}'_c \gamma_2 + u_{2c}$$

- F_c : measure of contracting institutions.
- I_c : measure of property rights institutions.
- L_c : British colony indicator.
- M_c : log European settlers mortality.
- \mathbf{Z}_c : vector of controls (geography, religion...).

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- Exclusion restriction: $Cov(\varepsilon_c, L_c) = Cov(\varepsilon_c, I_c) = 0$.
- ε_c : error term from second-stage.

Instrument 1: settlers mortality

- Log settler mortality in former European colonies. [AJR \(2001\)](#)
- European colonization strategy \implies historical property rights institutions \implies current property rights institutions.
- Disease environment \implies settlers mortality \implies colonization strategy.

Instrument 2: legal origin

- British legal origin. [La Porta et al. \(1997, 1998\)](#)
- Two great legal traditions:
 - Common-law countries (British): low formalism.
 - Civil-law countries (French, German, Scandinavian): high formalism.

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- Exogenous to countries colonized by Europeans.
- Exclusion restriction:
 - Might affect Y_c through channels other than contracting.
 - Expect $Cov(\varepsilon_c, L_c) \geq 0 \implies$ upper bound.

First stage: contracting institutions

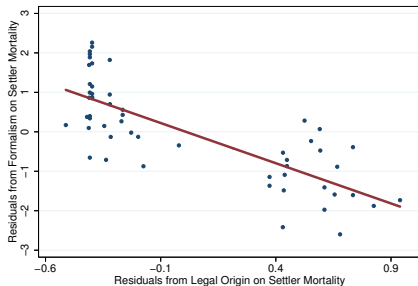
Dependent variable:	Legal Formalism		
	(1)	(2)	(3)
English legal origin	-2.13*** [0.23]		-2.04*** [0.23]
Log settler mortality		0.36** [0.14]	0.12 [0.08]
R2	0.64	0.11	0.65
Countries	54	54	54

Source: AJ (2005).

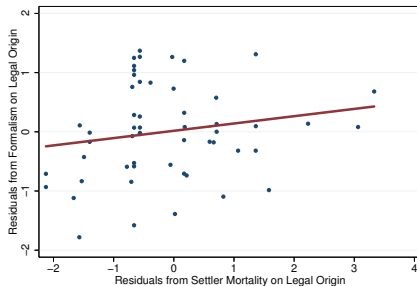
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First stage: contracting institutions

Partial Correlations



Source: AJ (2005), 54 countries.



Source: AJ (2005), 54 countries.

First stage: property rights institutions

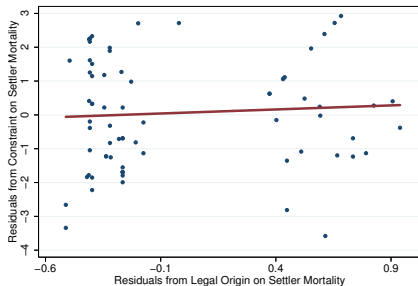
Dependent variable:	Constraint on Executive		
	(1)	(2)	(3)
English legal origin	0.65 [0.49]		0.15 [0.42]
Log settler mortality		-0.77*** [0.15]	-0.75*** [0.16]
R2	0.03	0.25	0.26
Countries	72	72	72

Source: AJ (2005).

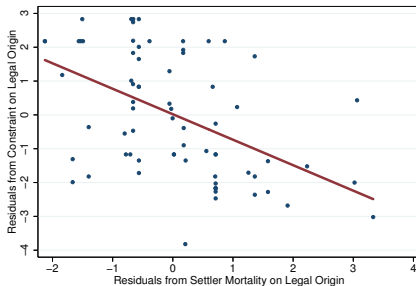
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First stage: property rights institutions

Partial Correlations



Source: AJ (2005), 72 countries.



Source: AJ (2005), 72 countries.

2SLS estimates (FEC)

Dependent variable:	Log GDP per capita	
	(1)	(2)
Legal formalism	-0.16* [0.10]	0.05 [0.23]
Constraint on executive	0.31*** [0.07]	0.99*** [0.27]
Estimator	OLS	2SLS
Countries	51	51

Source: AJ (2005).

*** Significant at the 1 percent level. * Significant at the 1 percent level.

- Similar results with other measures of institutions.
- Investment: property rights matter but not contracting.
- Credit: property rights matter but not contracting.
- Stock market: contracting matters but not property rights.

- Robust to semi-reduced form: legal origin enters second stage directly.
- Robust to alternative samples.
- Robust to controls (geography, religion, macro variables. . .).
- Robust to alternative measurement of institutions: firms surveys.

- Contracting institutions have limited consequences (flexibility).
- Property rights institutions matter much more (necessary condition).

State Capacity: Concepts

- What enables a society to adopt growth enhancing institutions?

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- Concept of state capacity:
 - Ability of a state to accomplish its intended policy actions.
 - Corresponds to infrastructural power of a state:

“We might term this ‘infrastructural power’, the capacity of the state to penetrate civil society and to implement logistically political decisions throughout the realm.” [Mann \(1986\)](#)

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 - Ability of a state to collect taxes, enforce law and order, provide public goods.

State Capacity: Concepts

- Two main elements:
 - Legal capacity.
 - ⇒ Ability to enforce rules across entire territory it claims to rule.

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State Capacity: Concepts

- Two main elements:
 - Legal capacity.
 - ⇒ Ability to enforce rules across entire territory it claims to rule.
 - Fiscal capacity.
 - ⇒ Ability to garner enough tax revenues to implement its policies.
- State capacity requires degree of political and legal centralization.

- Paradox of power:

“In framing a government which is to be administered by men over men, the great difficulty lies in this: you must first enable the government to control the governed; and in the next place oblige it to control itself.” [Madison \(1788\)](#)

State Capacity: Concepts

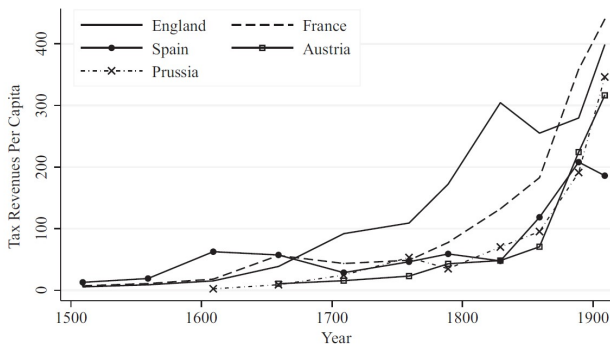
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- Effective statehood requires effective controls over the executive.

State Capacity in Europe

Log Tax Revenues per Capita



Source: Johnson and Koyama (2017)

- State capacity increased in Europe.
- But considerable institutional variation.

State Capacity in England

- High fiscal capacity, constraints on executive, rule of law.

State Capacity in England

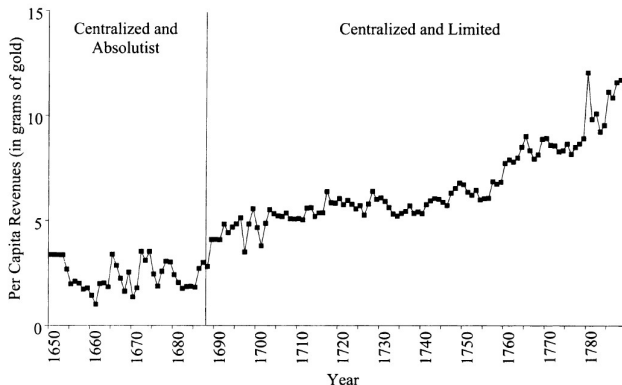
- High fiscal capacity, constraints on executive, rule of law.
 - Nationwide and representative Parliament.
 - Centralization of fiscal and legal institutions.

State Capacity in England

- High fiscal capacity, constraints on executive, rule of law.
 - Nationwide and representative Parliament.
 - Centralization of fiscal and legal institutions.
- One reason: history of homogeneous, coherent and centralized polity.

State Capacity in England

Per capita revenues, Britain



Source: Dincecco (2009)

State Capacity in France

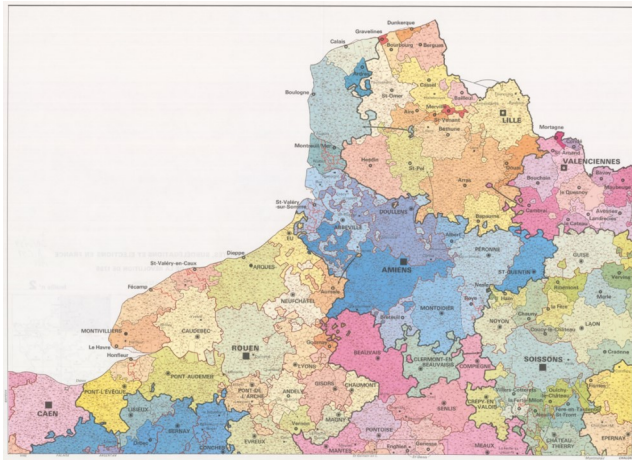
- Kingdom constituted over time through warfare and marriages:
 - Dauphiné 1349, Burgundy 1477, Provence 1486, Brittany 1532 ...
 - Collection of feudal appendages loosely held by loyalty to king.

State Capacity in France

- Kingdom constituted over time through warfare and marriages:
 - Dauphiné 1349, Burgundy 1477, Provence 1486, Brittany 1532 ...
 - Collection of feudal appendages loosely held by loyalty to king.
- France remained legally and fiscally fragmented until Revolution.
- Still, considerable improvements in state capacity 17th-18th centuries.

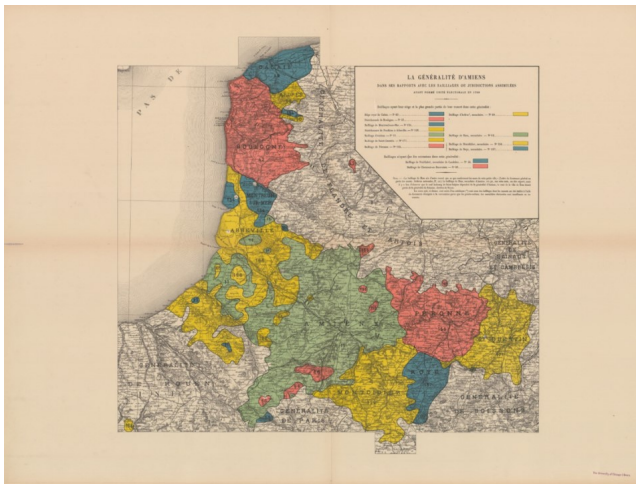
State Capacity in France

Administrative Institutions in France (Subdélégations)



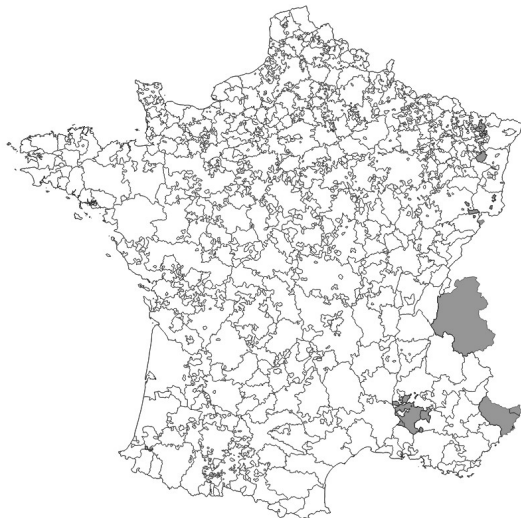
State Capacity in France

Judicial Institutions in France (Bailliages)



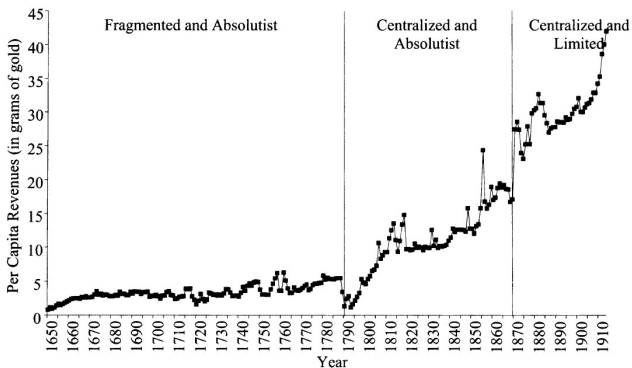
State Capacity in France

Judicial Institutions in France (Bailliages)



State Capacity in France

Per capita revenues, France



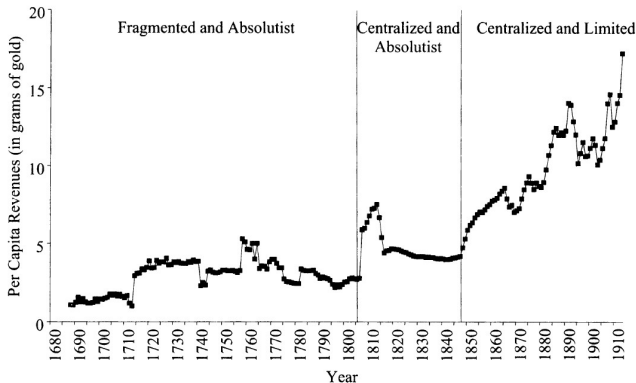
Source: Dincecco (2009)

State Capacity in Prussia, Russia, Habsburg

- Heterogeneous initial conditions: high ethnolinguistic diversity.
- State capacity took longer to build.
- Coercive path to modern statehood e.g. life-long conscription.

State Capacity in Prussia

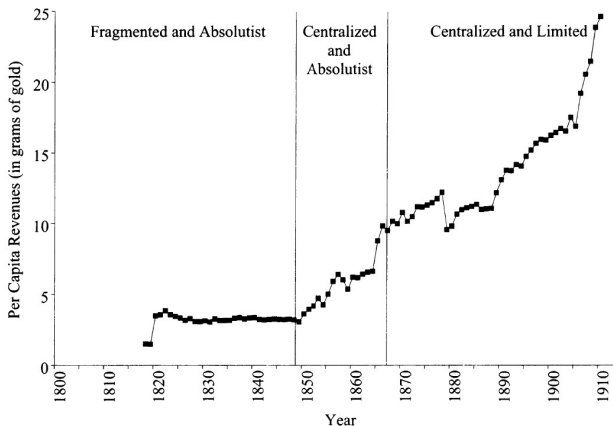
Per capita revenues, Prussia



Source: Dincecco (2009)

State Capacity in Austria-Hungary

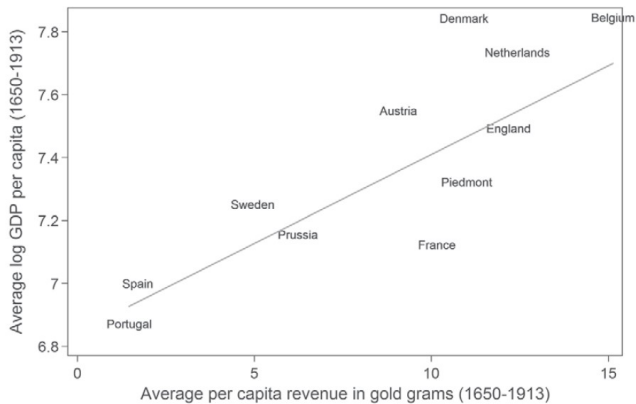
Per capita revenues, Austria-Hungary



Source: Dincecco (2009)

State Capacity and Economic Growth

State capacity and economic performance in European history



Source: Dincecco (2015)

State Capacity and Economic Growth

- Systematic empirical analysis. [Dincecco and Katz \(2016\)](#)
- Two elements of state capacity:
 - Fiscal centralization: year national government first secured revenues through uniform tax system.
 - Limited government: year parliament gained stable constitutional right to control national budget annually.

State Capacity and Economic Growth

Fiscal Centralization	Year	Limited Government	Year
England	1066	England	1688
France	1790	France	1870
Belgium	1795	Belgium	1831
Piedmont	1802	Piedmont	1848
Netherlands	1806	Netherlands	1848
Prussia	1806	Prussia	1848
Spain	1845	Spain	1876
Austria	1848	Austria	1867
Portugal	1859	Portugal	1851
Sweden	1861	Sweden	1866
Denmark	1903	Denmark	1848

State Capacity and Economic Growth

Fiscal Centralization	Year	Limited Government	Year
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Portugal	1859	Portugal	1851
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- Measurement error: downward attenuation bias.

State Capacity and Economic Growth

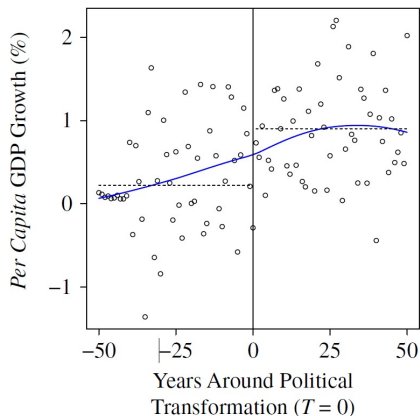
- Economic performance:
 - Log annual growth rate of real GDP per capita, 1650–1913. [Maddison](#)
 - Missing values linearly interpolated, especially 1650–1820.

State Capacity and Economic Growth

- Economic performance:
 - Log annual growth rate of real GDP per capita, 1650–1913. [Maddison](#)
 - Missing values linearly interpolated, especially 1650–1820.
- State capacity: [Dincecco \(2011\)](#)
 - Extractive capacity: government revenues per capita.
 - Productive capacity: non-military expenditures per capita.
 - Missing values linearly interpolated.

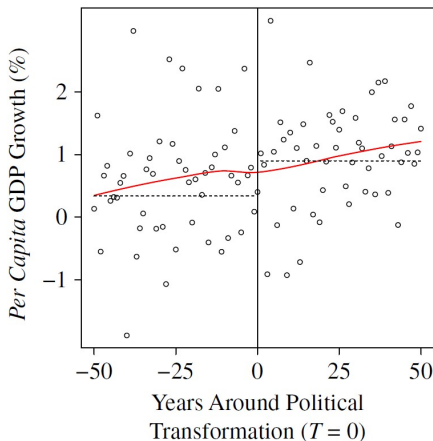
State Capacity and Economic Growth

Time-demeaned per capita GDP growth rates and fiscal centralization



State Capacity and Economic Growth

Time-demeaned per capita GDP growth rates and limited government



State Capacity and Economic Growth

- Empirical strategy:

$$\Delta y_{i,t} = \alpha_0 + \alpha_1 C_{i,t} + \alpha_2 L_{i,t} + X'_{i,t-1} \alpha_3 + \mu_i + \lambda_t + \varepsilon_{i,t}$$

- $\Delta y_{i,t}$: Log annual GDP per capita growth rate.
- $C_{i,t}$: indicator for fiscal centralization.
- $L_{i,t}$: indicator for limited government.
- μ_i : country fixed effect.
- λ_t : year fixed effect.
- $X'_{i,t-1}$: conflict indicators, population growth, lagged y .

State Capacity and Economic Growth

- Source of identification and identifying assumption:

State Capacity and Economic Growth

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 - Relative changes in growth rate across countries.
 - Parallel counterfactual trends.

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- Identification issues:

State Capacity and Economic Growth

- Source of identification and identifying assumption:
 - Relative changes in growth rate across countries.
 - Parallel counterfactual trends.
- Identification issues:
 - Reverse causality: economic growth might promote political reforms, political changes might take place in times of downturns or upswing.
 - Omitted variable bias: control for constant unobserved heterogeneity, but not time-varying.

State Capacity and Economic Growth

- Source of identification and identifying assumption:
 - Relative changes in growth rate across countries.
 - Parallel counterfactual trends.
- Identification issues:
 - Reverse causality: economic growth might promote political reforms, political changes might take place in times of downturns or upswing.
 - Omitted variable bias: control for constant unobserved heterogeneity, but not time-varying.
- Not necessarily causal interpretation: document robust pattern.

State Capacity and Economic Growth

Dependent variable:	Real GDP per capita growth			
	(1)	(2)	(3)	(4)
Fiscal centralization	0.657*** [0.087]	0.222*** [0.086]	0.268*** [0.125]	0.344*** [0.171]
Limited government	0.321*** [0.109]	0.053 [0.165]	-0.028 [0.146]	-0.080 [0.205]
Country FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes
Country time trends	No	No	Yes	Yes
Lags in y (2)	No	No	No	Yes
Observations	1,772	1,772	1,772	1,750
Countries	11	11	11	11

State Capacity and Economic Growth

- Robustness:
 - Include conflict and population growth controls.
 - Drop after 1845.
 - Averaged growth rates rather than annual.

State Capacity and Economic Growth

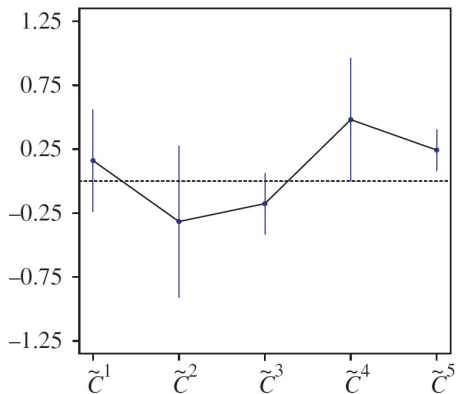
- Relax assumption of constant impact over time:

$$\Delta y_{i,t} = \alpha_0 + \sum_{j=1}^5 \alpha_{1,j} \tilde{C}_{i,t}^j + \sum_{j=1}^5 \alpha_{1,j} \tilde{L}_{i,t}^j + X'_{i,t-1} \alpha_3 + \mu_i + \lambda_t + \varepsilon_{i,t}$$

- $\tilde{C}_{i,t}^1, \tilde{L}_{i,t}^1 = 1$ for years 6–10 before.
- $\tilde{C}_{i,t}^2, \tilde{L}_{i,t}^2 = 1$ for years 1–5 before.
- $\tilde{C}_{i,t}^3, \tilde{L}_{i,t}^3 = 1$ for years 0–4 after.
- $\tilde{C}_{i,t}^4, \tilde{L}_{i,t}^4 = 1$ for years 5–10 after.
- $\tilde{C}_{i,t}^5, \tilde{L}_{i,t}^5 = 1$ for more than 10 years after.

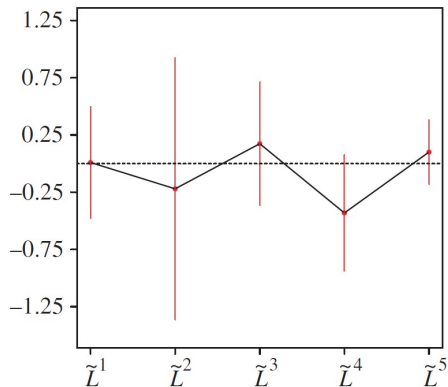
State Capacity and Economic Growth

Time-varying relationship between gdp per capita growth and fiscal centralization



State Capacity and Economic Growth

Time-varying relationship between gdp per capita growth and limited government



State Capacity and Economic Growth

- Important and direct role for fiscal centralization.
- Fiscally centralized regimes grew faster than fragmented:
 - On average by 0.2–0.4% higher per year.
 - Average 1650–1913: 0.6% \implies 1/4–2/3 of growth.

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 - On average by 0.2–0.4% higher per year.
 - Average 1650–1913: 0.6% \implies 1/4–2/3 of growth.
- Long-lasting economic improvements from fiscal centralization.

State Capacity and Economic Growth

- Test for relationship between political transformation and (extractive) state capacity:

$$\Delta E_{i,t} = \alpha_0 + \alpha_1 C_{i,t} + \alpha_2 L_{i,t} + X'_{i,t-1} \alpha_3 + \mu_i + \lambda_t + \varepsilon_{i,t}$$

- $\Delta E_{i,t}$: Log annual growth rate in per capita revenues.

State Capacity and Economic Growth

Dependent variable:	Revenues per capita growth			
	(1)	(2)	(3)	(4)
Fiscal centralization	1.405*** [0.497]	1.467*** [0.531]	2.929*** [0.926]	3.923*** [0.907]
Limited government	0.438 [0.564]	0.047 [0.638]	0.717 [0.652]	1.601*** [0.807]
Country, year FE	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes
Country time trends	No	No	Yes	Yes
Lags in y (2)	No	No	No	Yes
Observations	1,760	1,748	1,748	1,734
Countries	11	11	11	11

State Capacity and Economic Growth

- Centralized regimes have 1.4–3.9% higher growth in extractive capacity.
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State Capacity and Economic Growth

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- Some (less robust) evidence for correlation between limited government and productive capacity (non-military expenditure).
⇒ Political transformations larger impact on extractive capacity.
- Additional evidence on extractive capacity and GDP growth.

- Implement and enforce generalized institutions.

- Public goods provision:
 - Defense (securing territorial borders).
 - Transportation infrastructures (competitive market integration, spread of innovation).
 - Mass education (investment in human capital).

- States and markets as complements.
 - Competitive markets ensure allocative efficiency.
 - Need public-order property rights and contracting institutions.
 - Making fiscal revenues uniform and general increases market integration (no more internal tariffs).

- Nation-building.
 - Early modern states were “stationary bandits”: taxes and war.
 - \uparrow state capacity \implies \uparrow legitimacy.
 - Ideology (e.g. nationalism), conscription, school helped build common national identities.
 - Heterogeneity in preferences associated with less public goods, risk civil war, lower incomes.

Warfare and State Capacity

- Warfare was instrumental for building state capacity.

Warfare and State Capacity

- Warfare was instrumental for building state capacity.
 - The rise of city-states in Western Europe.
 - The rise of nation-states in Western Europe.
 - The role of political geography: Europe, China, Africa.
 - Warfare and political development.

Rise of City-States in Western Europe

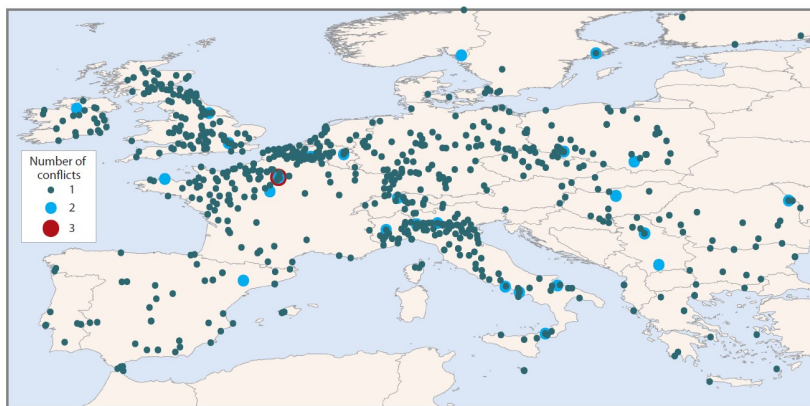
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Rise of City-States in Western Europe

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⇒ High long-lasting political fragmentation.
- 500 small independent states in late medieval Europe. [Tilly \(1992\)](#)
- High political fragmentation + scarce territory ⇒ endemic warfare.
- 100+ major military conflict per century (1000–1789).
[Dincecco and Onorato \(2017\)](#)

Rise of City-States in Western Europe

Major military conflicts in Europe, 1000–1799



Source: Dincecco and Wang (2018) based on Dincecco and Onorato (2017)

Rise of City-States in Western Europe

- Endemic warfare \implies institutional change in Europe.
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 \implies formal role in governance of elite taxpayers.
- Strong empirical relationship between war frequency and parliamentary activity (1250–1800). Stasavage (2016)

Rise of City-States in Western Europe

- State capacity emerged earlier in city-states.
- Key issue: geographical scale for early nation-states:
 - High local institutional fragmentation within (more later).
 - Little control of executive: high monitoring costs. [Stasavage \(2011\)](#)

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 - Little control of executive: high monitoring costs. [Stasavage \(2011\)](#)
- Visible in ability to borrow:
 - City-states established long-term public debt long before territorial states.
 - City-states borrow at lower cost than territorial states.

Rise of City-States in Western Europe

City State	Year	Territorial State	Year
Arras	1241	Castile	1489
Venice	1262	Kingdom of Naples	1520
Siena	1290	France	1522
Bremen	1295	Holland	1522
Douai	1295	Papal States	1526
Hamburg	1308	Duchy of Milan	1543
Genoa	1340	Wurttemberg	1550
Florence	1347	Austria	1555
Barcelona	1360	Piedmont	1684
Cologne	1375	England	1693
Dortmund	1375	Tuscany	1700
Ghent	1375	Denmark	1725
Nuremberg	1381		
Basel	1383		
Zurich	1386		
Mainz	1415		
Bruges	1489		

Rise of Nation-States in Western Europe

- Emergence in the early 16th century.
- However, remained weak for a very long time.

“The strength of a monarch’s theoretical claims to absolutist rule was frequently inversely proportional to his de facto powers.” Epstein (2000)

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- Emergence in the early 16th century.
- However, remained weak for a very long time.
“The strength of a monarch’s theoretical claims to absolutist rule was frequently inversely proportional to his de facto powers.” Epstein (2000)
- Endemic warfare \implies relinquish partial political control to local elites for funds \implies city-states obstructed centralization efforts at national level.
- Early modern nation-States were mosaics built upon medley of local institutional structures.

Warfare and Political Development

- Classical argument. [Dincecco \(2017\)](#) [Dincecco and Wang \(2018\)](#)
 - Low land-labor ratio \implies high marginal value of land \implies warfare.
 - Warfare is expensive (military revolution) \implies need to raise taxes.
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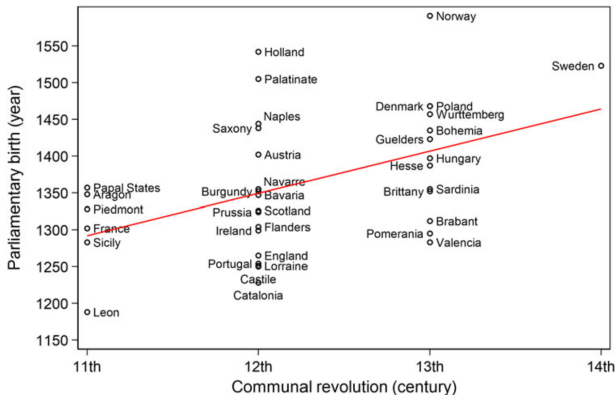
Warfare and Political Development

Cox, Dincecco, and Onorato (2024)

- Is warfare a necessary condition for the creation of Parliaments in Europe?
- Some very specific conditions in Europe:
 - After collapse of Roman Empire, no central bureaucracies to collect taxes.
 - During the medieval communal revolution (1000–1300), many European towns acquired self-governance.
- To collect taxes to finance wars, rulers had to use these self-governing towns into a decentralized tax administration system.
- Parliaments emerged earlier in polities whose major towns became a commune earlier.

Warfare and Political Development

The communal revolution and parliamentary births in Medieval Europe



Source: Cox, Dincecco, and Onorato (2024)

Warfare and Political Development

- Data:
 - 44 polities: sovereign non-tribal entity in Christendom in 1200; 5,000+ km² in 1200; survived 100+ years.
 - Parliamentary birth year: first year in which tax-controlling council included non-noble urban elites (power to reject or approve extraordinary taxation by majority vote).
 - Warfare: 848 unique conflicts over 1000–1599 from [Jacques \(2007\)](#)

Warfare and Political Development

- Empirical strategy:

$$\text{Parliament Birth}_{it} = \beta \text{Conflict}_{i(t-p,t-1)} + \alpha_i + \lambda_t + X'_{it}\Phi + \varepsilon_{it}$$

- $\text{Conflict}_{i(t-p,t-1)}$: average number of military conflicts per year for polity i over previous years p (benchmark: $p = 25$ years).
 - α_i : polity FE controlling for initial economic, cultural, institutional conditions. λ_t : year FE.
 - X'_{it} : time-varying controls: trade potential, years of ruler successions, lack of male heirs at time of succession, primogeniture.
 - Standard errors: clustered at polity level.
- Restrict sample to polity-years in century after first commune established in polity.

War and parliamentary births

Table 2. War and parliamentary births

Dependent variable	1	2 Parliamentary birth	3
Conflict participation	0.055*** (0.016)	0.055*** (0.018)	0.056*** (0.018)
Trade potential			-0.033 (0.031)
Polity FE	Y	Y	Y
Year FE	Y	Y	Y
Polity trends	N	Y	Y
Years included	Post-commune		
# Observations	8,725	8,725	8,725
# Polities	37	37	37
R ² (within)	0.134	0.146	0.146

Notes: The estimation method is OLS. The unit of analysis is polity-year. The sample period is 1000–1599. Robust standard errors clustered at polity level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Source: Cox, Dincecco, and Onorato (2024)

- 1 conflict per year average over past 25 years \implies 5.6 pp higher per-year probability of parliamentary birth.

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Warfare in China

Major military conflicts in China, 1000–1799



Source: Dincecco and Wang (2018) based on Wang (2006)

Warfare in Europe and China

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- But the nature of warfare differed greatly:
 - External (interstate) vs internal (intrastate) conflicts.
 - Multidirectional vs unidirectional foreign attack threats.
- China: 65% are rebellions and civil wars.
- China: 80% of external conflicts against Steppe nomads.

- Europe: political fragmentation.
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 - 85 states on average 1000–1799.
- China: political centralization.
 - Qin (200 BCE): first unitary state in China.
 - Early uniform written language, currency, measure and weights.
 - 1.5 states on average 1000–1799.

The Role of Political Geography: Model

- Political geography: a mediator between warfare and political development.

The Role of Political Geography: Model

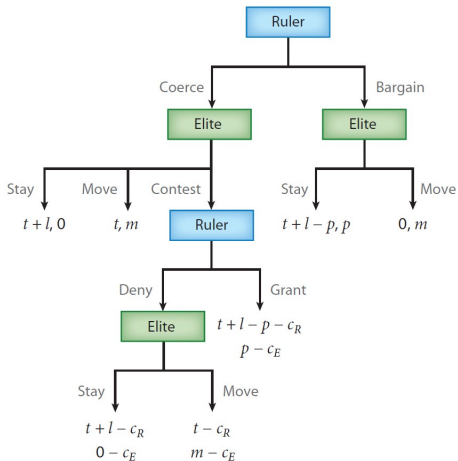
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 - To fund military defense, ruler taxes $t > 0$ on domestic elites.
 - Tax through coercion or bargaining.
- Elites actions:
 - Move (exit): payoff $m \in \mathbb{R}$. [Hirschman \(1970\)](#) [Clark et al. \(2017\)](#)
 - Contest: cost $c_E > 0 \implies$ cost to rule $c_R > 0$.
 - Stay: ruler's payoff $l > 0$ for loyalty.
 - If ruler grants demands: payoff p to elites, $-p$ to ruler.
 - If ruler denies demands: payoff 0 to elites.

The Role of Political Geography: Model

Model and payoffs



Context 1: Political Fragmentation

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- Subgame perfect equilibrium: (Bargain, Grant; Contest, Stay, Move).

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- Subgame perfect equilibrium: (Coerce, Deny; Stay, Stay, Stay).

The Role of Political Geography

Exit, voice, loyalty: Europe versus China

Attribute	Europe	China
Political geography	Fragmentation	Centralization
State size	Small	Large
Exit ability ^a	High	Low
Warfare	Common	Common
Conflict type	External	Internal
Threat direction ^b	Multidirectional	Unidirectional
Power balance	Favors elite	Favors ruler
Political representation	More likely	Less likely

Source: Dincecco and Wang (2018)

Extractive Capacity

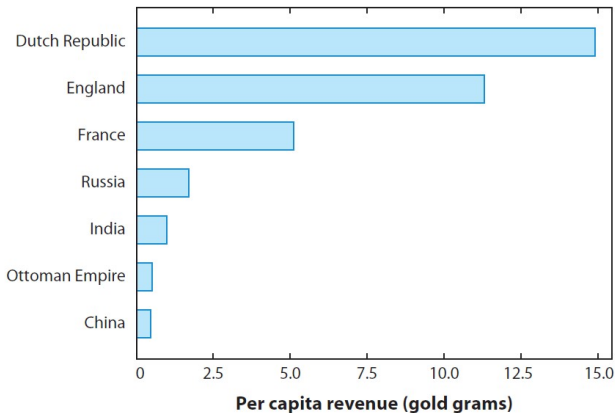
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Extractive Capacity

- In Europe:
 - Political representation helped build fiscal capacity.
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- In China:
 - No representation so little agreement on taxes.
 - Vast geography \implies communication costs and difficult monitoring.

Extractive Capacity

Per capita revenue across Eurasia in the 1780s



Warfare and Political Development in Africa

- Does this logic apply in Sub-Saharan Africa?

Warfare and Political Development in Africa

- Does this logic apply in Sub-Saharan Africa?
- Three region-specific factors break the war-state logic.
 - Political geography.
 - Transatlantic slave trade.
 - European colonization.

Political geography in Sub-Saharan Africa

- High land-labor ratio \implies little incentives to control territory.
- Mostly raiding wars: much less expensive.
- Little incentives to extract revenues and build fiscal capacity.

Slave Trade and Colonization

- Transatlantic slave trade.
 - Generated outgrowth of pre-colonial conflicts over people.
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 - Arbitrary borders \uparrow fractionalization \implies persistent civil conflicts.
- Civil conflicts \implies capture of state by specific groups
- Little incentives to invest in generalized particularized institutions.

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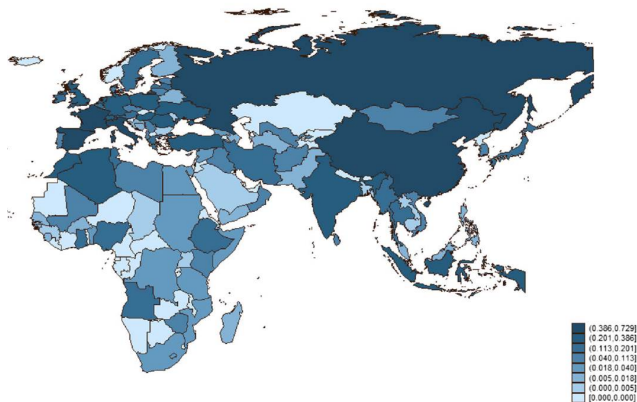
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- Civil conflict: share of years in civil war 1950–2000. [Besley and Persson \(2011\)](#)
- Fiscal capacity (1990–2014).
 - Main variable: share of income taxes in total taxes. [IMF](#)
 - Income tax require large administrative capacity.
 - Also: share of direct taxes, income taxes to GDP, tax revenues to GDP.

Warfare and Political Development: Data

Historical conflict, 1400–1799



Warfare and Political Development: Strategy

$$y_i = \alpha + \beta \text{Conflict}_i + \delta \text{Conflict}_i \times \text{Africa} + x_i' \gamma + \mu_j + \varepsilon_i$$

- i indexes countries.
- y_i : measure of fiscal capacity today.
- Conflict_i : measure of historical conflict.
- x_i : vector of controls (population density in 1500, timing of Neolithic Revolution, land suitability for agriculture, log absolute latitude, total land area).
- μ_j : FE for Asia, Europe, North Africa, Sub-Saharan Africa.
- δ : measures how relationship for Africa differs from β .

Warfare and Political Development: Results

Dependent variable:	Income tax share	Direct tax share	Income tax to GDP	Total tax to GDP	Civil war share
	(1)	(2)	(3)	(4)	(5)
Conflict (1400–1799)	0.33*** [0.11]	0.60** [0.28]	0.07* [0.03]	0.05 [0.05]	0.02 [0.183]
Conflict × Africa	-0.06 [0.24]	1.32 [3.07]	0.12 [0.13]	0.27 [0.40]	2.75*** [1.21]
Controls	Yes	Yes	Yes	Yes	Yes
Countries	110	37	110	118	116

- \uparrow 1 s.d. conflict in Old World \implies \uparrow 0.4 s.d. income tax share.
- Fiscal strength rather than government size.
- Not in Africa + no “anti-persistence” of conflict.

Warfare and Political Development: Robustness

- Additional controls: colonizer, artificial borders, legal origin, state antiquity, geographical conditions.
- Test for OVB. [Altonji et al. \(2005\)](#)
- Alternative samples:
 - Drop 18th century wars, Russia, China.
 - Add New World.
- Intermediate outcomes:
 - Infrastructural power of state (railroads in 1910).
 - Share of years with conflict 1850–1899.

A Culture of Growth

Victor Gay

Visiting professor at University of Michigan

Toulouse School of Economics

Institute for Advanced Study in Toulouse

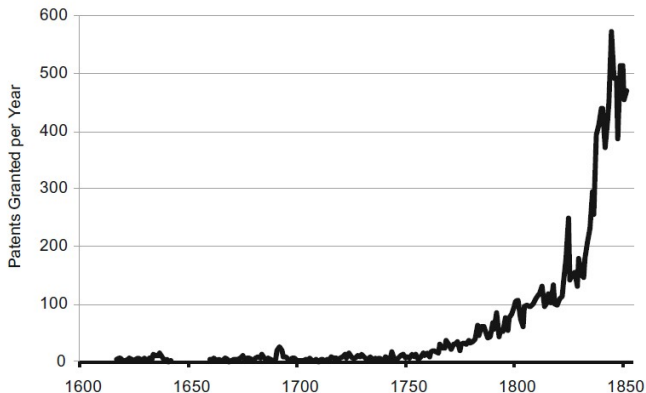
Winter 2024



Toulouse
School of
Economics

Important innovations

Patents per year in England (1660–1851)



Source: Clark (2014) based on Mitchell (1988).

Important innovations

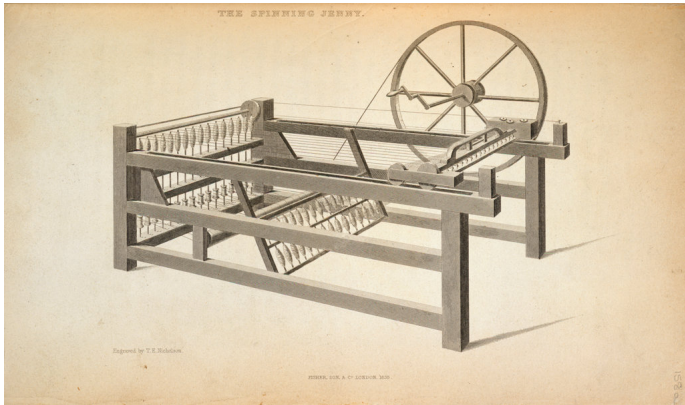
“A wave of gadgets swept over England.” Ashton (1948)

- Textile sector:
 - Hargreaves spinning jenny (mid-1760s)
 - Arkwright water frame (late 1760s)
 - Crompton mule jenny (late 1770s)
- Steam power:
 - Newcomen engine (1710s)
 - Watt steam engine (1760s)

⇒ Wave of simultaneous innovations.

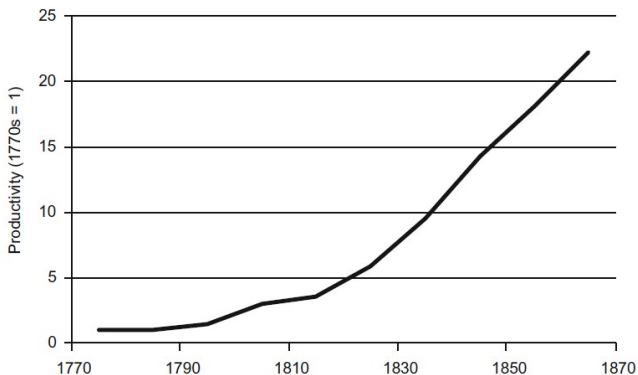
Important innovations

Spinning jenny



Important innovations

Cotton spinning and weaving productivity (1770–1869)



Source: Clark (2014) based on Harley (1998).

Cultural roots of the Great Enrichment

The Enlightenment

Mokyr (2009, 2016, 2021) McClosley (2016)

- Crucial change: ideas and culture of Enlightenment.
 - Ideas of progress 18th century Northwest Europe.
 - Mankind can improve condition through science and rationality.
 - Especially in Britain: advocate empiricism (e.g., Bacon).
- Precursor to Industrial Revolution?
- More than science, a culture of useful knowledge?

The Enlightenment

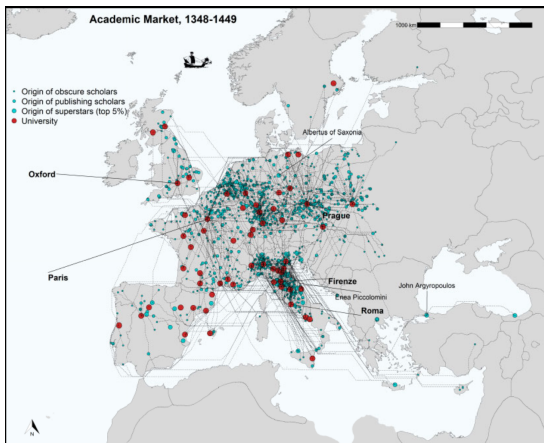
- Before: inferiority complex with respect to ancient wisdom that impeded scientific and technological progress, even accusations of heresy.
- After 1500 in Europe: Renaissance scholars rediscovered ancient scientific writings.
- By late 17th century, skepticism and intellectual deference largely gone (e.g., Newton physics).

The Enlightenment

- From late 15th and great voyages, new scientific instruments and tools, confrontation of old wisdom with discoveries (Copernicus, Galileo, . . .).
- Institutional change (Reformation) and improved technology (printing press) encouraged rapid proliferation of intellectual innovations, creating a market for ideas.
- 16th and 17th century Europe:
 - Large demand for scientific innovation through patronage of leading scholars of princes and the wealthy, and universities and academies.
 - Applications of innovations to military matters or tutors for princes: highly competitive demand side.
 - Highly competitive supply side for wealth and rise in social standing, and open evaluation of reputation through the Republic of Letters.

The Enlightenment

The academic market in Europe (1088–1800)



Source: De La Croix et al. (2023). Map of the university-scholar dyads over time. Red dots correspond to universities. Blue dots represent scholars' birthplaces. Size of blue dots are function of publications. The dashed lines link academic scholars' birth place to the university for which they taught through the least costly path. Video: <https://perso.uclouvain.be/david.delacroix/video/test2.mp4>

The Enlightenment

- A specific set of conditions enabled this market for ideas to emerge in Europe in 1500–1700.
- Europe's political fragmentation of city states, duchies, bishoprics creating competition to attract scholars.
- Suppressing new ideas became impossible due to scholars' outside options.
- This market for ideas saw the emergence of the belief in progress.

Useful knowledge

- Relatively few of these innovations found applications in the early inventions of the Industrial Revolution, especially in the cotton industry.
- But crucial inventions required such innovations, such as hydraulic and steam power.
- Attitudes from the Enlightenment drove the practical innovations later on.
- Formal knowledge increasingly found applications later on, after the 1820s (chemistry, thermodynamics, electricity).

- For economic performance, innovations should be translated to ingenious devices that could be scaled up and repaired by local mechanics.
- It required a large availability of skilled artisans throughout the country, which Britain had (not France).
- Apprenticeship was key, especially a country-wide market for apprentices.

Enlightenment ideals and belief in progress

Almelhem, Iyigun, Kennedy, and Rubin (2023)

- How did cultural change impact Britain's industrialization?
- Empirical analysis of progress-oriented view of science promoted by Enlightenment thinkers: a “culture of growth” .

Enlightenment ideals and belief in progress

Almelhem, Iyigun, Kennedy, and Rubin (2023)

- How did cultural change impact Britain's industrialization?
- Empirical analysis of progress-oriented view of science promoted by Enlightenment thinkers: a “culture of growth” .
- Method:
 - Textual analysis of 173k volumes published in 1500–1900.
 - Unsupervised machine learning to extract 60 latent topics.
 - Classify topics into 3 categories: science, religion, political economy.
 - Categories reflect the “language” used in these texts, regardless of their content.

Enlightenment ideals and belief in progress

Categories

Table 1: Categories

Category	Topics and associated words
“Political Economy”	33 - law lord show public evid opinion fact
	34 - govern nation polit parliament constitut war parti
“Religion”	47 - trade amount labour money price cent increas
	4 - church christian christ bishop holi paul doctrin
	12 - god christ lord thi faith holi sin
“Science”	52 - hath fame religion men shew virtu likewis
	7 - fig water iron engin pressur steam electr
	8 - acid solut heat carbon water sulphur iron
	41 - line angl equal equat sin sun plane

Source: Almelhem et al. (2023).

Enlightenment ideals and belief in progress

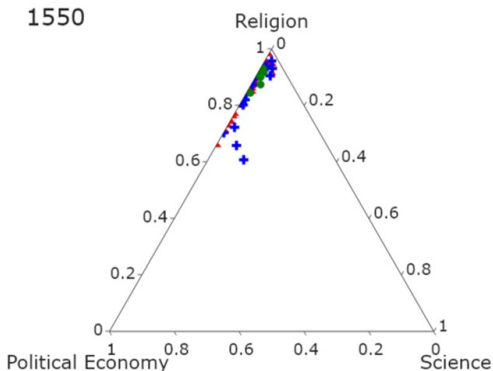
- Place individual topics relative to each category.
- Objective: observe how close topics are to one category.
- Each topic gets a yearly score in each category based on topics' placement in 1850.
- Tells about the type of “language” used by a topic, which is classified in a category.

Enlightenment ideals and belief in progress

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- The language of science separates from the religion before the IR.

Enlightenment ideals and belief in progress

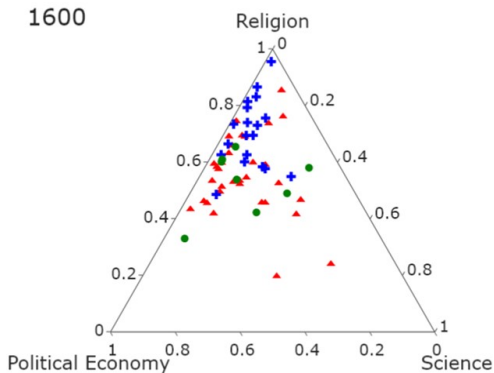
Categorization of topics into categories



Source: Almelhem et al. (2023). Red: political economy topics. Blue: religion topics. Green: science topics.

Enlightenment ideals and belief in progress

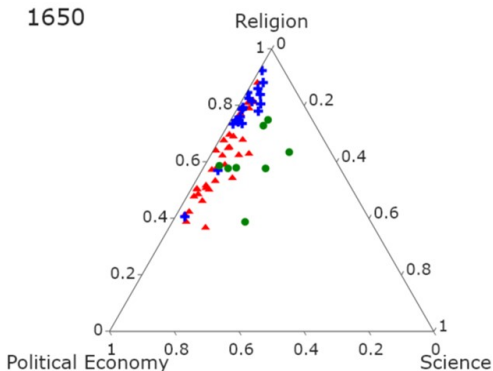
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Enlightenment ideals and belief in progress

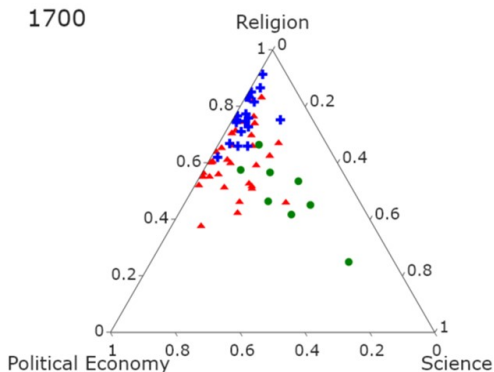
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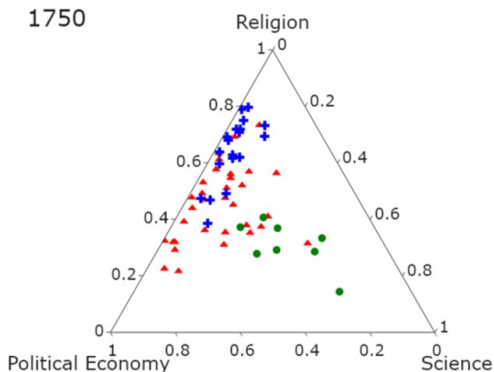
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Enlightenment ideals and belief in progress

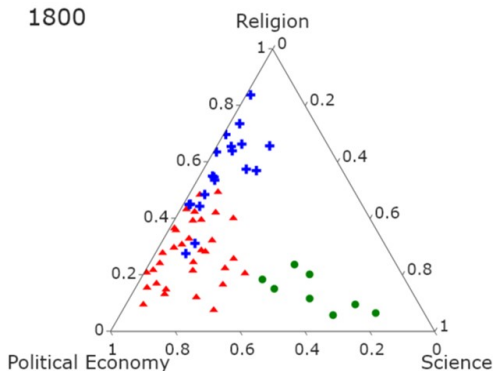
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Enlightenment ideals and belief in progress

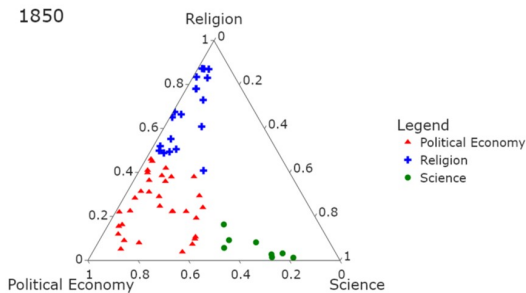
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Enlightenment ideals and belief in progress

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Enlightenment ideals and belief in progress

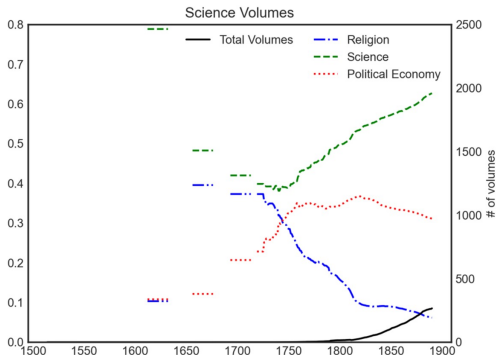
- Classify each volume in a category (science, religion, political economy).
- Analyze the type of language used in each volume.

Enlightenment ideals and belief in progress

- Classify each volume in a category (science, religion, political economy).
- Analyze the type of language used in each volume.
- Science volumes see their use of the language of science increase in early 18th century at the expense of the language of religion.

Enlightenment ideals and belief in progress

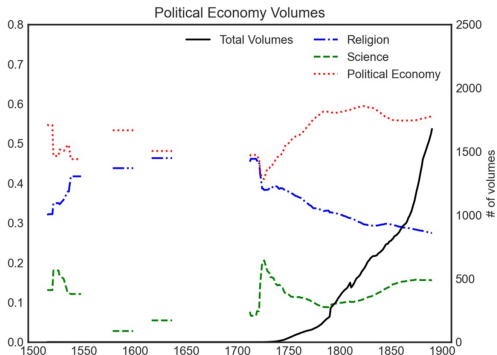
Relationship between categories over time, within volumes



Source: Almelhem et al. (2023).

Enlightenment ideals and belief in progress

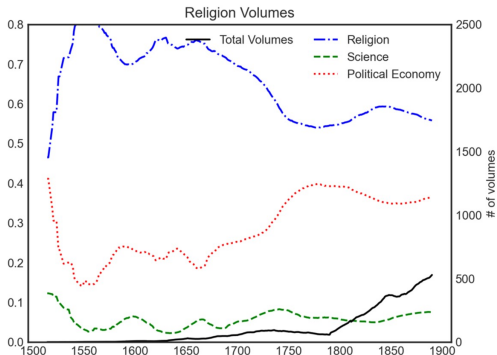
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Enlightenment ideals and belief in progress

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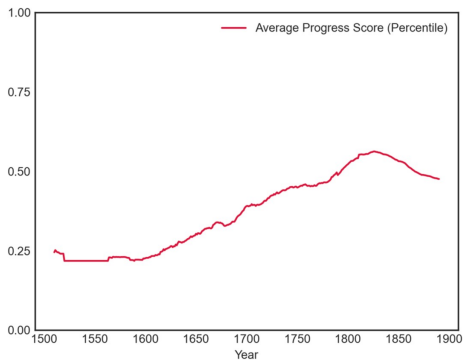
Source: Almelhem et al. (2023).

Enlightenment ideals and belief in progress

- Assess if language of science became more “progress oriented”.
- Use a “progress” dictionary of words based on a thesaurus and dictionaries prior to 1643 (Newton’s birth): progress, improvement, stride, betterment, advance, rise, amelioration.
- Calculate a sentiment index for each volume.
- Then, plot the index across categories over time.

Enlightenment ideals and belief in progress

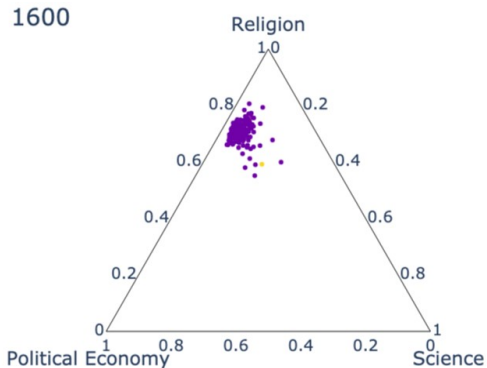
Average progress score per science volume



Source: Almelhem et al. (2023).

Enlightenment ideals and belief in progress

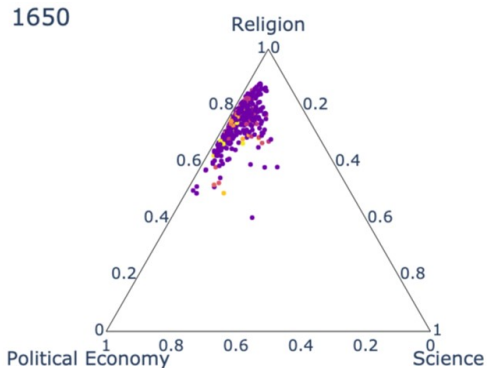
Progress sentiment (1550–1850)



Source: Almelhem et al. (2023). Lighter colors represent more progressive sentiment

Enlightenment ideals and belief in progress

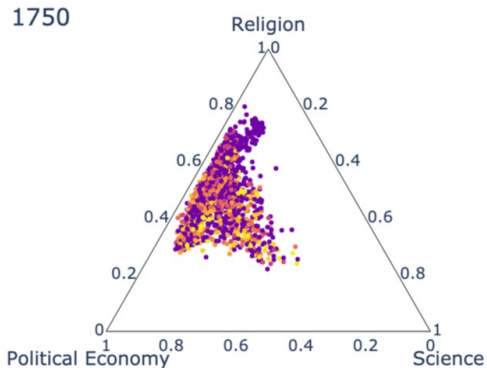
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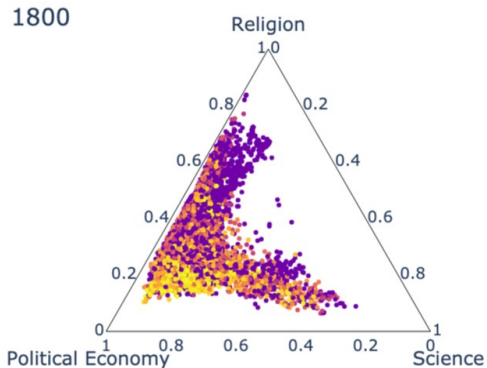
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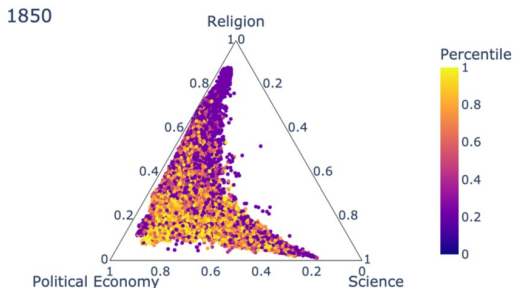
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Enlightenment ideals and belief in progress

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Why did not occur before?

Steinsson (2020), chap 2

- There were always thinkers before.

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- Diffusion of ideas was limited:
 - Without writing, technological regressions if no transmission (e.g., Tasmania).
 - When writings rare, subject to destruction (e.g., Alexandria).
 - Suppression of knowledge by interest groups (e.g., Church).

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⇒ The watershed moment: the printing press?

The Printing Press

- Movable printing press: Gutenberg 1450s.
- A watershed moment?
 - Altered balance between suppression and spread of knowledge.
 - Enabled rapid diffusion of knowledge.

The Printing Press

- Challenge 1: invented in China in 11th century.
 - Chinese characters: thousands of pieces to transport.
 - Not as useful invention for diffusion.

The Printing Press

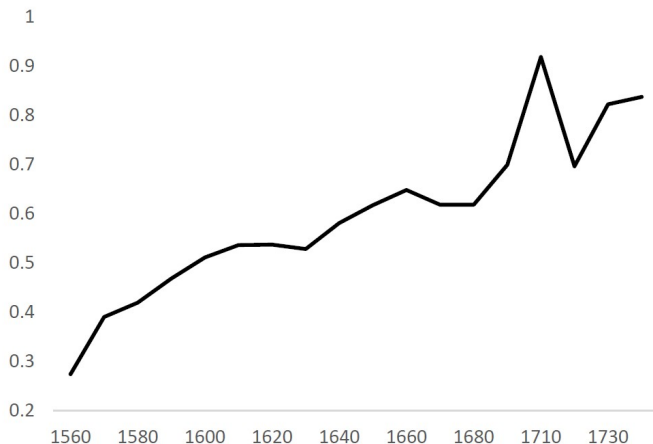
- Challenge 1: invented in China in 11th century.
 - Chinese characters: thousands of pieces to transport.
 - Not as useful invention for diffusion.
- Challenge 2: Industrial Revolutions occurred 300 years later.
 - Took time to weaken knowledge suppression forces.
 - Reformation (16–17th) precursor to Enlightenment (17–18th).
 - Printing press (15th) precursor to Reformation (16–17th).

The Reformation

- Luther against Catholic Church's indulgences (1510s Wittenberg).
- Effective use of printed pamphlet in German to spread ideas.
- Reformation laid ground for Enlightenment:
 - Censorship less severe in protestant locations (Britain, NL).
 - Reformation encouraged literacy (Bible reading).
 - Literacy rose massively before the Industrial Revolution.
 - Also a consequence of decline in book prices.

Literacy rates

Literacy rate of husbandmen in London and Middlesex (1560–1740)

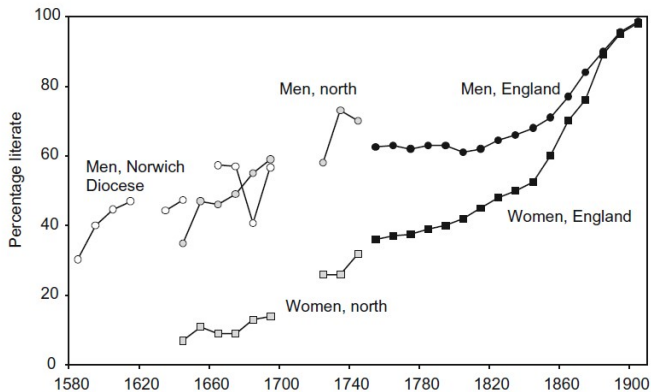


Literacy: fraction of witnesses who can sign ecclesiastical records or court depositions

Source: Steinsson (2020) from Cressy (1980) and Houston (1982).

Literacy rates

Literacy rate in England (1580–1920)



Literacy: fraction of witnesses who can sign ecclesiastical records, court depositions, or marriage registers
Source: Clark (2014) based on Schofield (1973), Houston (1982), Cressy (1977), and Clark (2007).

A Protestant prosperity?

Protestant prosperity

- “Culture of growth” encapsulates complex causal links:
 - The printing press
 - The Reformation and Protestantism
 - Literacy
 - The Enlightenment
 - The Industrial Revolution

Protestant prosperity

- “Culture of growth” encapsulates complex causal links:
 - The printing press
 - The Reformation and Protestantism
 - Literacy
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 - The Industrial Revolution
- ⇒ Let’s try to disentangle these empirically.

Protestant prosperity

Becker and Woessmann (2009)

- “Was Weber wrong? A human capital theory of protestant economic history.”

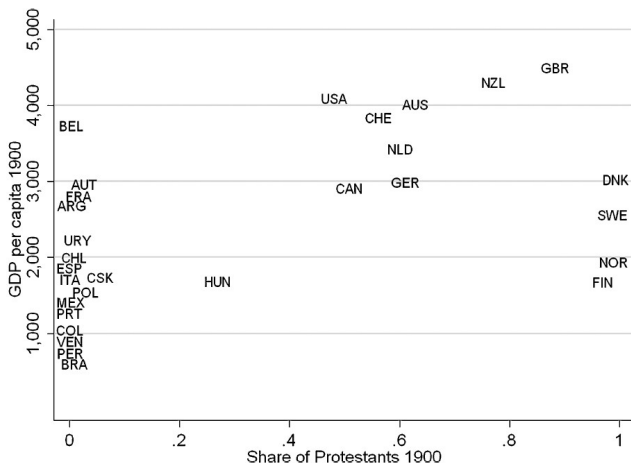
Protestant prosperity

Becker and Woessmann (2009)

- “Was Weber wrong? A human capital theory of protestant economic history.”
- Weber: Protestant ethic and the spirit of capitalism (early 1900s).
 - Empirical foundation: Protestant locations more prosperous.
 - Protestantism and religious sanctification of labor and saving.
 - Resulted in strong work ethic and capitalism.
 - Contrast with Catholicism, focused on morality and asceticism.

Protestant prosperity

Cross-Country Pattern of Protestantism and GDP per Capita, 1900



Source: Becker and Woessmann (2009).

Protestant prosperity

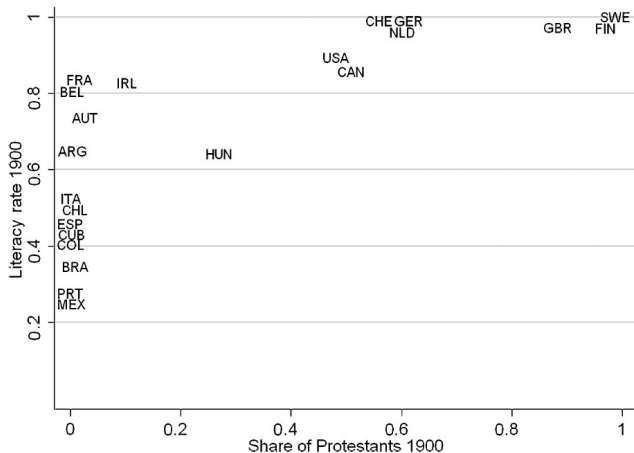
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 - But omitted variable problem: other factors may cause both (e.g., literacy).

Protestant prosperity

- Empirical test for Protestantism \implies prosperity:
 - Correlation: local prevalence of Protestantism and prosperity in 1900?
 - But omitted variable problem: other factors may cause both (e.g., literacy).
 - Need instrumental variable:
 - Relevance: correlation with variation in Protestantism.
 - Exogeneity: uncorrelated with other determinants of prosperity.
- \implies Focus on component of variation in Protestantism uncorrelated with other determinants of prosperity.

Protestant prosperity

Cross-Country Pattern of Protestantism and Literacy, 1900



Source: Becker and Woessmann (2009).

Protestant prosperity: instrument

- Literacy as an instrument?
 - Relevance: more literate locations more likely to adopt due to Luther's emphasis on reading Bible in vernacular.
 - Exogeneity: literacy affects directly prosperity (information, innovation, contracting, . . .).

Protestant prosperity: instrument

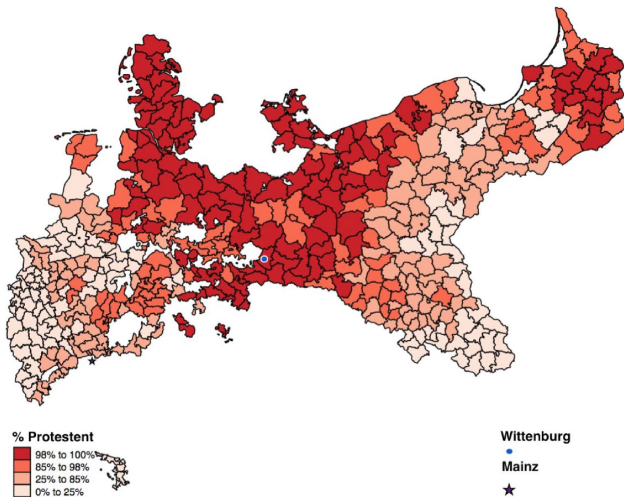
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 - ⇒ The Reformation diffused from Wittenberg.

Protestant prosperity: instrument

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- Distance to Wittenberg:
 - Relevance: more likely to adopt if more exposed to Luther ideas; travel and transmission of information was slow.
 - ⇒ The Reformation diffused from Wittenberg.
 - Exogeneity: before the Reformation, Wittenberg unimportant place.
 - ⇒ No direct prosperity effect of being close to Wittenberg.

Protestant prosperity: instrument

Protestant Population Share in Prussia in 1871



Source: Steinsson (2020) based on Becker and Woessmann (2009).

Protestant prosperity: data

- Sample: 452 counties of Prussia, dominant German State.
- Treatment: Protestant population share in 1871.
- Instrument: distance to Wittenberg.
- Outcomes:
 - Income tax revenue per capita in 1877.
 - Annual incomes for elementary school teachers in 1886.
 - Share labor force in manufacturing in 1882.
- Balancing variables:
 - Urbanization rate in 1500.
 - Indicators for imperial city, university, school in 1517.

Protestant prosperity: first-stage

- Formal test of instrument relevance (first-stage regression):

$$\text{PROT}_i = \alpha + \beta \text{DIST}_i + \mathbf{X}'_i \gamma + \varepsilon_i$$

- PROT_i : population share of Protestants in county i in 1871.
- DIST_i : distance to Wittenberg in km.
- \mathbf{X}_i : vector of control variables (share younger than 10, share Jews, share female, share born in municipality, household size, population size,...).
- ε_i : error term.

Protestant prosperity: first-stage

First-Stage: Protestantism and Distance to Wittenberg

Dependent Variable:	Share Protestants
Distance to Wittenberg in km	-0.095 (0.011)
Number of Observations	452
1st-Stage F-Statistic	74.2

Notes: These estimates are taken from Table III in Becker and Woessmann (2009). Standard errors are in parentheses. The control variables included in the regression are: % age below 10, % Jews, % females, % born in municipality, % of Prussian origin, average household size, ln(population size), population growth from 1867-1871 in %, % missing education info, % blind, % deaf-mute, % insane.

Source: Steinsson (2020) based on Becker and Woessmann (2009).

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Source: Steinsson (2020) based on Becker and Woessmann (2009).

- Each 100km is associated with \downarrow Protestant share of 9.5 pp.
- Precise estimate: clearly reject that $\beta = 0$.
- F-statistics $> 10 \simeq$ “strong instrument”.

Protestant prosperity: exogeneity

- Corroboration of instrument exogeneity.
- Instrument not correlated with observable economic characteristics prior to Reformation that may affect subsequent prosperity.
- Find proxies for economic or educational development.

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$$Y_i = \alpha + \beta \text{DIST}_i + \mathbf{X}'_i \gamma + \varepsilon_i$$

- Y_i : Urbanization, imperial city, university, school in 1500s.
- DIST_i : distance to Wittenberg in km.
- \mathbf{X}_i : vector of control variables (share younger than 10, share Jews, share female, share born in municipality, household size, population size,...).
- ε_i : error term.

Balance Tests: Pre-Protestant Prosperity and Distance to Wittenberg

Dependent Variable:	Imperial City in 1517	Urbanization in 1500	University in 1517	School in 1517
Distance to Wittenberg (in 100 km)	0.0034 (0.0071)	0.00006 (0.00013)	-0.0019 (0.0047)	-0.0073 (0.0099)
Number of Observations	452	452	452	333
R^2	0.0005	0.0004	0.0004	0.002

Notes: These estimates are taken from Table IV in Becker and Woessmann (2009). Standard errors are in parentheses. The dependent variables are: an indicator for whether a county was a free imperial city, urban population per km², indicator for whether county had a university, and indicator for whether the county had a school.

Source: Steinsson (2020) based on Becker and Woessmann (2009).

Protestant prosperity: exogeneity

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Source: Steinsson (2020) based on Becker and Woessmann (2009).

- Coefficients are small in magnitude.
- Imprecise estimate: fail to reject that $\beta = 0$.
- Claim: distance to Wittenberg is valid instrument.

Protestant prosperity: reduced-form

- Is instrument correlated with outcome (reduced-form)?
- Is distance to Wittenberg correlated with prosperity in 1870s?

$$\text{PROSP}_i = \alpha + \beta \text{DIST}_i + \mathbf{X}'_i \gamma + \varepsilon_i$$

- PROSP_i : proxy for prosperity of county i in 1870s.
- DIST_i : distance to Wittenberg in km.
- \mathbf{X}_i : vector of control variables (share younger than 10, share Jews, share female, share born in municipality, household size, population size,...).
- ε_i : error term.

Protestant prosperity: reduced-form

Reduced-Form: Prosperity and Distance to Wittenberg

Dependent Variable:	Income Tax per capita	Log Teacher Income	Share Manuf. and Services
Distance to Wittenberg (in 100 km)	-6.0 (2.3)	-1.00 (0.48)	-0.78 (0.36)
Number of Observations	426	452	452

Notes: These estimates are produced using replication code and data provided by Ludger Woessmann. They are the reduced form estimates that correspond to the instrumental variables (IV) estimates presented in Table V of Becker and Woessmann (2009) except that I have included “% missing education info” as an additional control for consistency with the first stage reported in Table 2. Income tax per capita is measured in pfennig. Standard errors are in parentheses. The control variables included in the regression are: % age below 10, % Jews, % females, % born in municipality, % of Prussian origin, average household size, ln(population size), population growth from 1867-1871 in %, % missing education info, % blind, % deaf-mute, % insane.

Source: Steinsson (2020) based on Becker and Woessmann (2009).

Protestant prosperity: reduced-form

Reduced-Form: Prosperity and Distance to Wittenberg

Dependent Variable:	Income Tax per capita	Log Teacher Income	Share Manuf. and Services
Distance to Wittenberg (in 100 km)	-6.0 (2.3)	-1.00 (0.48)	-0.78 (0.36)
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Source: Steinsson (2020) based on Becker and Woessmann (2009).

- Each 100km is associated with \downarrow income tax revenues of 6 pfennig.
- Precise estimate: clearly reject that $\beta = 0$.
- Magnitude:
 - s.d. in DIST = 150km. s.d. in INC = 70 pfennig.
 - \uparrow 1 s.d. DIST \implies \downarrow 0.13 s.d. INC (small-moderate).

Protestant prosperity: second-stage

- Second-stage (IV): impact of Protestantism on prosperity through distance to Wittenberg.
- If valid: IV not correlated with all other determinants of prosperity.
- As move away from Wittenberg, the only potential determinant of prosperity changing is share Protestantism.
- If prosperity changes as move away from Wittenberg, only due to changes in Protestantism.

Protestant prosperity: second-stage

- Causal chain:

$$\text{DIST on PROSP} = \text{DIST on PROT} \times \text{PROT on PROSP}$$

Protestant prosperity: second-stage

- Causal chain:

$$\text{DIST on PROSP} = \text{DIST on PROT} \times \text{PROT on PROSP}$$

- Second-stage is ratio of reduced-form to first-stage:

$$\text{PROT on PROSP} = \frac{\text{DIST on PROT}}{\text{DIST on PROSP}}$$

Protestant prosperity: second-stage

Second-Stage: Prosperity and Protestantism Through Distance to Wittenberg

Dependent Variable:	Income Tax per capita	Log Teacher Income	Share Manuf. and Services
Share Protestant	0.62 (0.24)	0.11 (0.05)	0.08 (0.04)
Number of Observations	426	452	452

Notes: These estimates are taken from Table V in Becker and Woessmann (2009). Income tax per capita is measured in pfennig. Coefficients in the second column are multiplied by 100. Standard errors are in parentheses. The control variables included in the regression are: % age below 10, % Jews, % females, % born in municipality, % of Prussian origin, average household size, ln(population size), population growth from 1867-1871 in %, % blind, % deaf-mute, % insane.

Source: Steinsson (2020) based on Becker and Woessmann (2009).

Protestant prosperity: second-stage

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Source: Steinsson (2020) based on Becker and Woessmann (2009).

- \uparrow 10 pp share Protestant \implies \uparrow income tax revenues of 6.2 pfennig.
- Relatively precise estimate: reject that $\beta = 0$.
- Magnitude:
 - s.d. in PROT = 37%. s.d. in INC = 70 pfennig.
 - \uparrow 1 s.d. PROT \implies \downarrow 0.33 s.d. INC (moderate).

Protestant prosperity: mechanisms

- Was Weber right?
- Was it Protestant ethic and the spirit of capitalism?

Protestant prosperity: mechanisms

- Was Weber right?
- Was it Protestant ethic and the spirit of capitalism?
- Becker and Woessmann claim: through literacy.
 - Effect of Protestantism on literacy large.
 - Enough to explain effect of Protestantism on prosperity.

Protestant prosperity: mechanisms

Mechanisms: Literacy and Protestantism Through Distance to Wittenberg

Dependent Variable:	Share Literate
Share Protestant	0.19 (0.03)
Number of Observations	452

Notes: This IV estimate is taken from Table III in Becker and Woessmann (2009). Standard errors are in parentheses. The control variables included in the regression are: % age below 10, % Jews, % females, % born in municipality, % of Prussian origin, average household size, ln(population size), population growth from 1867-1871 in %, % blind, % deaf-mute, % insane, % missing education info.

Source: Steinsson (2020) based on Becker and Woessmann (2009).

Protestant prosperity: mechanisms

Mechanisms: Literacy and Protestantism Through Distance to Wittenberg

Dependent Variable:	Share Literate
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Source: Steinsson (2020) based on Becker and Woessmann (2009).

- $\uparrow 10$ pp share Protestant $\implies \uparrow$ literacy of 2 pp.
- Relatively precise estimate: reject that $\beta = 0$.

Protestant prosperity: limits

- Claim: Protestantism \implies literacy \implies prosperity.

Protestant prosperity: limits

- Claim: Protestantism \implies literacy \implies prosperity.
- Empirical evidence:
 - Based on local differences in Protestantism and prosperity.
 - Unclear what are aggregate effects of Protestantism.

Protestant prosperity: limits

- Validity of instrument:
 - Evidence of printing press \implies Protestantism. [Rubin \(2014\)](#)
 - Evidence of printing press \implies prosperity *directly*. [Dittmar \(2011\)](#)
 \implies Threat to exogeneity of IV
 - Protestantism correlated with printing press, no effect on prosperity?

Protestant prosperity: limits

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 \implies Threat to exogeneity of IV
 - Protestantism correlated with printing press, no effect on prosperity?
- Controlling for distance to Mainz (printing press diffusion). [Steinsson \(2020\)](#)
 - First stage unchanged (DIST on PROT | PRINT).
 - IV weak and insignificant (PROT on PROSP through DIST | PRINT).

\implies Challenging to disentangle Protestantism, literacy, and growth!

Protestant prosperity: mechanisms

The diffusion of the movable type printing press

a: Cities with Printing in 1450



b: Cities with Printing in 1460



Source: Dittmar (2011).

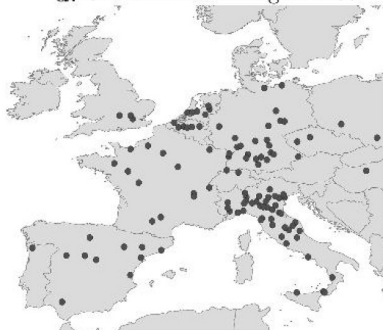
Protestant prosperity: mechanisms

The diffusion of the movable type printing press

c: Cities with Printing in 1470



d: Cities with Printing in 1480

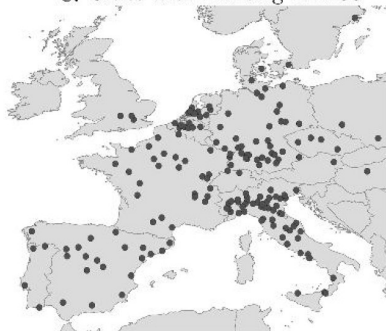


Source: Dittmar (2011).

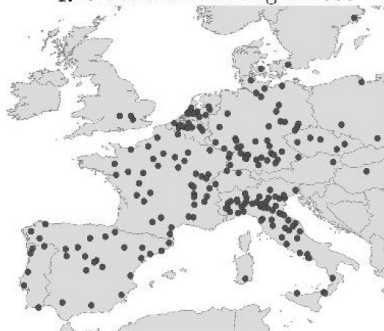
Protestant prosperity: mechanisms

The diffusion of the movable type printing press

e: Cities with Printing in 1490



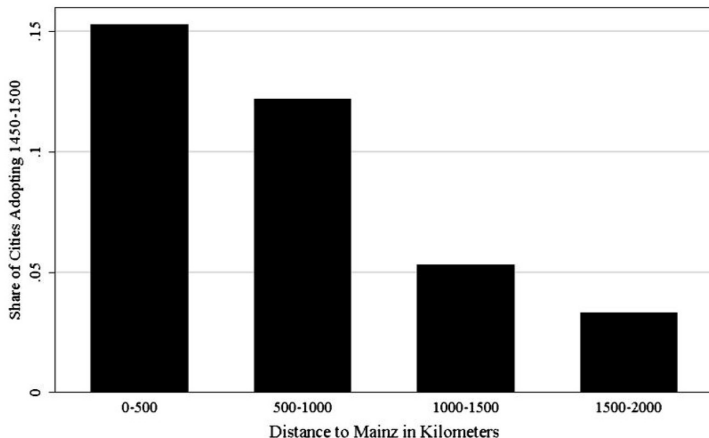
f: Cities with Printing in 1500



Source: Dittmar (2011).

Protestant prosperity: mechanisms

Distance from Mainz and adoption of the printing press, 1450–1500



Source: Dittmar (2011).

Protestant ethic: alternative interpretation

Kersting et al. (2021)

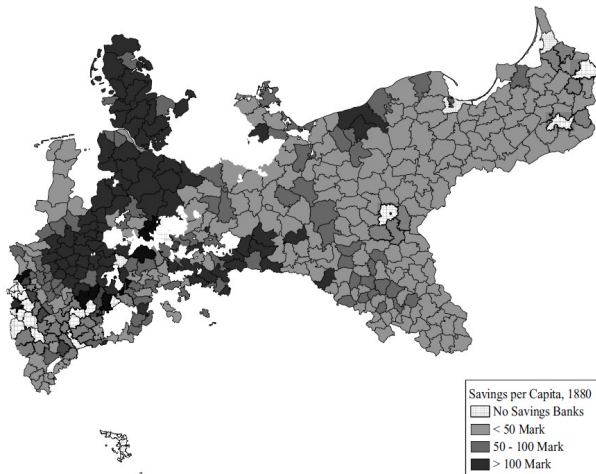
- The role of savings \implies accumulation of capital.
- The role of differences between ethnic groups as confounding factor.

Protestant ethic: data

- Sample: 434 counties of Prussia, dominant German State.
- Treatment: Protestant population share.
- Instrument: Protestant population share in 1624, residualized.
- Outcomes [Lehmann-Hasemeyer and Wahl \(2017\)](#):
 - Savings per capita (medium and lower income groups).
 - Number of saving banks.
- Years \simeq 1875, 1880, 1890, 1900, 1905.

Protestant ethic: data

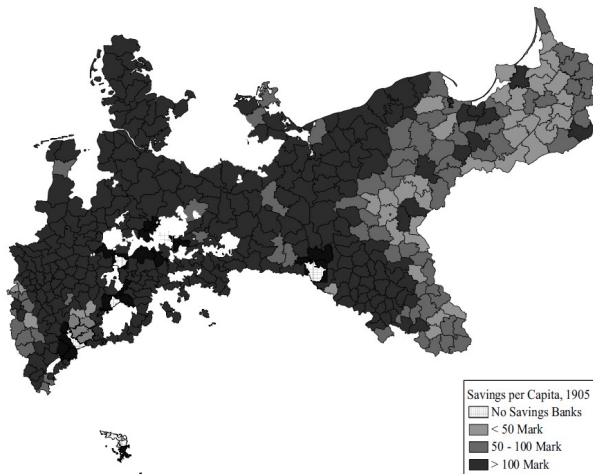
Savings per Capita, 1880



Source: Kersting et al (2020).

Protestant ethic: data

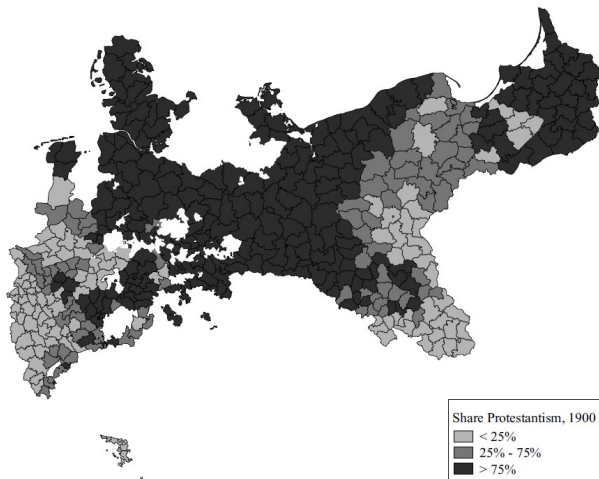
Savings per Capita, 1905



Source: Kersting et al (2020).

Protestant ethic: data

Protestantism, 1900



Source: Kersting et al (2020).

Protestant ethic: specification

- Baseline pooled OLS regression:

$$\text{Sav}_{it} = \alpha_1 + \beta_1 \text{Prot}_{it} + \mathbf{X}'_{it} \boldsymbol{\gamma}_1 + \varepsilon_{1it}$$

- Sav_{it} : savings per capita in county i in year t .
- Prot_{it} : share of Protestants in county i .
- \mathbf{X}_{it} : vector of control variables (urban population, number of savings banks, household size, share of other religions).
- ε_{it} : error term.

Protestant ethic: instrument

- Idiosyncratic element of religious denomination as of 1624 (Peace of Westphalia). [Spenkuch \(2017\)](#)
- Regress Protestant 1624 at county level on predictors :
 - [Cantoni \(2012\)](#) Latitude, contribution to federal budget of Holy Roman Empire, distance to Wittenberg.
 - [Rubin \(2014\)](#) Existence of printing press.
- Use residuals as IV.
 - No reverse causality (200-year lag).
 - By construction, uncorrelated with factors affected by controls.

Savings per capita, 1875–1905

	(1)	(2)	(3)	(4)
Panel 1: OLS		Dep. Var. Savings per Capita		
Share Protestants	0.012 (0.079)	0.022 (0.102)	0.033 (0.081)	0.065 (0.103)
Income per capita			0.350*** (0.068)	0.316*** (0.072)
R^2	0.280	0.245	0.351	0.308
Panel 2: Second Stage		Dep. Var. Savings per Capita		
Share Protestants	-0.034 (0.101)	-0.029 (0.183)	-0.057 (0.110)	-0.064 (0.193)
Income per capita			0.342*** (0.072)	0.297** (0.084)
Panel 3: First Stage		Dep. Var. Protestantism		
Residual decision 1624	0.429*** (0.083)	0.288*** (0.048)	0.432*** (0.081)	0.294*** (0.045)
Income per capita			-0.109 (0.092)	-0.162* (0.080)
R^2	0.324	0.392	0.331	0.409
Including eastern provinces	Yes	No	Yes	No
Further controls	Yes	Yes	Yes	Yes
F-statistic excluded instruments	26.65	36.26	28.73	42.32
N	1,830	1,355	1,830	1,355

Source: Kersting et al (2020).

Protestant ethic: results

Effect of Protestantism on literacy, 1871

	(1)	(2)	(3)
Panel 1: OLS			
	Dep. Var. Literacy		
Share Protestants	0.057*** (0.009)	0.033** (0.013)	0.040*** (0.012)
Share German speaking			0.213*** (0.036)
R^2	0.610	0.431	0.735
Panel 2: Second Stage			
	Dep. Var. Literacy		
Share Protestants	0.030 (0.018)	0.031 (0.017)	0.020 (0.015)
Share German speaking			0.221*** (0.036)
Panel 3: First Stage			
	Dep. Var. Protestantism		
Residual decision 1624	46.088*** (4.227)	43.094*** (3.277)	45.369*** (2.866)
Share German speaking			0.327** (0.144)
R^2	0.474	0.599	0.489
Including eastern provinces	Yes	No	Yes
Further controls	Yes	Yes	Yes
F-statistic excluded instruments	246.34	172.95	250.58
N	378	280	378

Source: Kersting et al (2020).

Geography

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Winter 2024



Toulouse
School of
Economics

Can geography explain the Great Divergence?

- Geography may matter through several channels:
 - Efforts and attitudes (Montesquieu). Not credible.
 - The timing of the Neolithic transition.
 - Territorial fragmentation and state building.
 - Natural endowments.

The timing of the Neolithic Transition

Spolaore and Wacziarg (2013)

- Prehistoric and biological conditions \implies spread of agriculture and domestication. [Diamond \(1997\)](#) [Olsson and Hibbs \(2005\)](#)
- Initial advantages of Eurasia:
 - Initial biological conditions (diversity of animals and plants).
 - East-West orientation facilitating spread of agricultural innovation.
 \implies Population growth and early Neolithic transition.
- Lead from transition enabled Europeans to dominate other regions.
- Empirical evidence for correlation between biogeographic endowments and long-run development.

The timing of the Neolithic Transition

GEOGRAPHY AND CONTEMPORARY DEVELOPMENT
(Dependent variable: log per capita income, 2005; estimator: OLS)

Sample:	Whole World	Olsson–Hibbs sample ^a	Olsson–Hibbs sample ^a	Olsson–Hibbs sample ^a	Olsson–Hibbs sample ^a	Old World only
	(1)	(2)	(3)	(4)	(5)	(6)
Absolute latitude	0.044 (6.645)***	0.052 (7.524)***				
Percent land area in the tropics	-0.049 (0.154)	0.209 (0.660)	-0.410 (1.595)	-0.650 (2.252)**	-0.421 (1.641)	-0.448 (1.646)
Landlocked dummy	-0.742 (4.375)***	-0.518 (2.687)***	-0.499 (2.487)**	-0.572 (2.622)**	-0.505 (2.523)**	-0.226 (1.160)
Island dummy	0.643 (2.496)**	0.306 (1.033)	0.920 (3.479)***	0.560 (1.996)**	0.952 (3.425)***	1.306 (4.504)***
Geographic conditions (Olsson–Hibbs) ^b			0.706 (6.931)***		0.768 (4.739)***	0.780 (5.167)***
Biological conditions (Olsson–Hibbs) ^c				0.585 (4.759)***	-0.074 (0.483)	0.086 (0.581)
Constant	7.703 (25.377)***	7.354 (25.360)***	8.745 (61.561)***	8.958 (58.200)***	8.741 (61.352)***	8.438 (60.049)***
Observations	155	102	102	102	102	83
Adjusted R^2	0.440	0.546	0.521	0.449	0.516	0.641

Notes:

^aThe Olsson and Hibbs sample excludes the neo-European countries (Australia, Canada, New Zealand, and the United States) and countries whose current income is based primarily on extractive wealth (Olsson and Hibbs 2005).

^bFirst principal component of number of annual or perennial wild grasses and number of domesticable big mammals (all variables from Olsson and Hibbs 2005)

^cFirst principal component of absolute latitude; climate suitability to agriculture; rate of East–West orientation; size of landmass in millions of sq km (all variables from Olsson and Hibbs 2005).

The timing of the Neolithic Transition

- Geographic factors influenced timing of adoption of agriculture
[Ashraf and Galor \(2011\)](#)
- Quantify impact of Neolithic transition for development in 1500.
 - First stage: geography \implies timing of transition.
 - Reduced form: geography \implies population density 1500.
 - Second stage: timing of transition (IV: geography) \implies population density 1500 ($\hat{\beta}_0 = 0.88$).
 - Exclusion restriction: geography only affects population density through Neolithic transition.
- Biogeographic factors matter through early exposure to agriculture.

The timing of the Neolithic Transition

GEOGRAPHY AND DEVELOPMENT IN 1500 AD

Dependent Variable:	Years since agricultural transition	Population density in 1500	Population density in 1500	Population density in 1500
	OLS	OLS	OLS	IV
Estimator:	(1)	(2)	(3)	(4)
Absolute latitude	-0.074 (3.637)***	-0.022 (1.411)	0.027 (2.373)**	0.020 (1.872)*
Percent land area in the tropics	-1.052 (2.356)**	0.997 (2.291)**	1.464 (3.312)***	1.636 (3.789)***
Landlocked dummy	-0.585 (2.306)**	0.384 (1.332)	0.532 (1.616)	0.702 (2.158)**
Island dummy	-1.085 (3.699)***	0.072 (0.188)	0.391 (0.993)	0.508 (1.254)
Number of annual or perennial wild grasses	0.017 (0.642)	0.030 (1.105)		
Number of domesticable big mammals	0.554 (8.349)***	0.258 (3.129)***		
Years since agricultural transition			0.426 (6.694)***	0.584 (6.887)***
Constant	4.657 (9.069)***	-0.164 (0.379)	-2.159 (4.421)***	-2.814 (5.463)***
Observations	100	100	98	98
Adjusted R^2	0.707	0.439	0.393	—

Territorial fragmentation and state building

Fernandez-Villaverde, Koyama, Lin, and Sng (2023)

- Great Divergence \Leftarrow Inclusive institutions \Leftarrow Early state formation \Leftarrow Inter-state competition \Leftarrow Political fragmentation in Europe
- Source of political fragmentation: fractured land? [Diamond \(1997\)](#)
 - Fractured = mountains, forests, ruggedness.
 - Impedes development of large empires in Europe vs China.
 - But China more mountainous than Europe. [Hoffman \(2015\)](#)
 - Too deterministic explanation?

\Rightarrow Empirical examination

Fractured land?

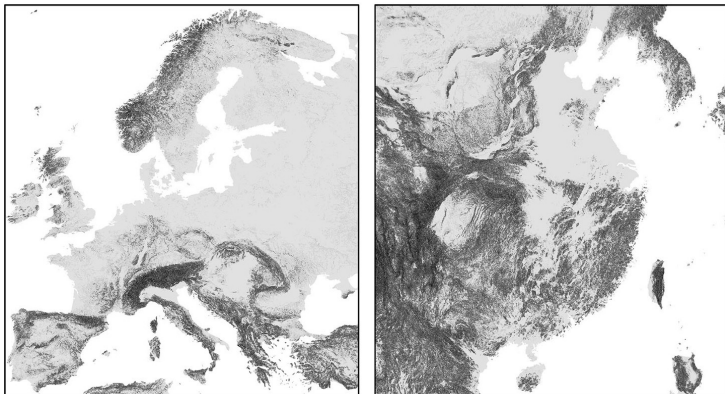
- Long-standing argument:
 - States need large area of productive land for rents.
 - Agricultural output needs easy appropriation.
 - Easiness of appropriation depends on geography.

Fractured land?

- Long-standing argument:
 - States need large area of productive land for rents.
 - Agricultural output needs easy appropriation.
 - Easiness of appropriation depends on geography.
- Concept of geographical core:
 - Successful states: core based on self-contained geographical region with fertile land, good transport connections, defensible to invasions.
 - Europe did not possess such a core (fractured land).
 - China possessed such a core (unified land—though more montaneous).

Fractured land?

Ruggedness in Europe and China proper



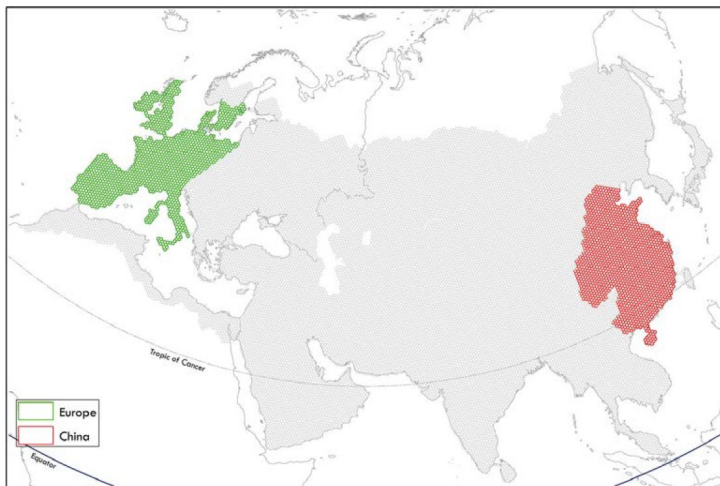
Source: Fernandez-Villaverde, Koyama, Lin, and Sng (2023)

Fractured land?

- Europe's cores:
 - British Isles
 - Scandinavia
 - Iberian peninsula
 - Italian peninsula
 - Northern European plain (Poland, Germany, France)
- China's cores:
 - Central-North plain
 - Yunnan-Guizhou Plateau in South
 - Easy connections with river system

Geographical space

Study area



Source: Fernandez-Villaverde, Koyama, Lin, and Sng (2023)

Geographical space

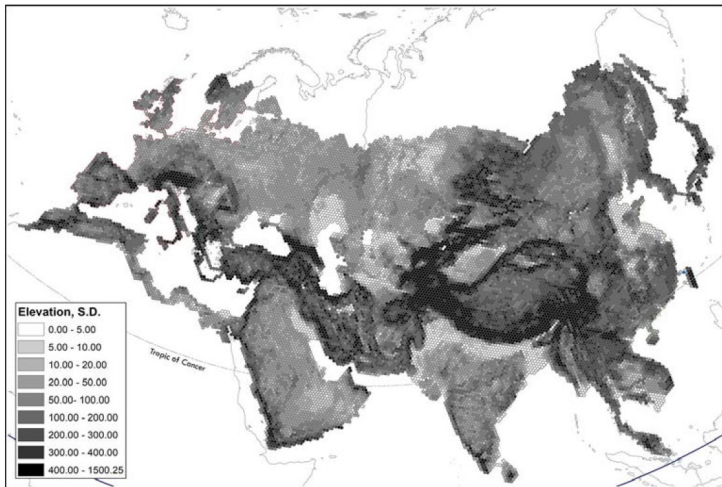
- Divide space of study:
 - 20,637 hexagonal cells of 28km radius.
 - Each cell can sustain a polity.
 - Distance by foot in one day: base polity can monitor.
- Area of study:
 - “China” 1,434 cells.
 - (Western) “Europe” 1,307

Geographical characteristics

- Geographical features affecting likelihood of regional clustering of cells into empires:
 - x_{rugged} : ruggedness (average s.d. of elevation)
 - x_{sea} : indicator for water as barrier.
 - x_{frigid} : indicator for temperature < 0 for > 6 months / year.
 - x_{torrid} : indicator for tropical or torrid zone.
 - x_{forest} : indicator for ancient forest in 0 CE.
$$\implies \mathbf{x} = \{x_{\text{rugged}}, x_{\text{sea}}, x_{\text{frigid}}, x_{\text{torrid}}, x_{\text{forest}}\}$$
- Resource availability: population density in 0 CE (Malthusian logic).

Geographical characteristics

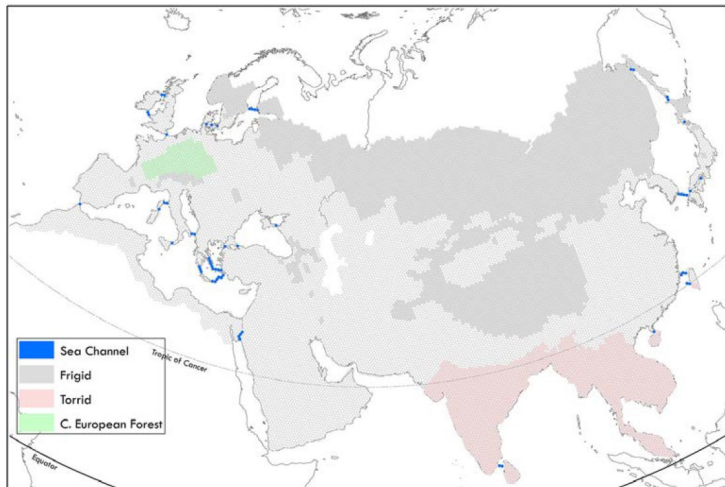
Ruggedness (standard deviation of elevation)



Source: Fernandez-Villaverde, Koyama, Lin, and Sng (2023)

Geographical characteristics

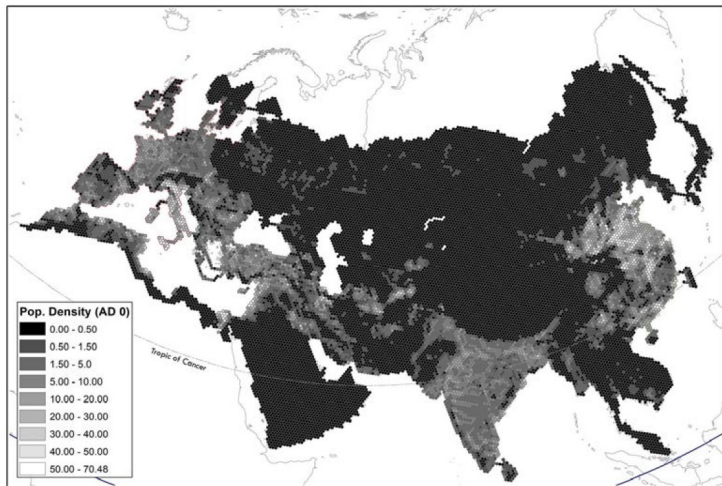
Auxiliary barriers to conquest



Source: Fernandez-Villaverde, Koyama, Lin, and Sng (2023)

Geographical characteristics

Population density (0 CE)



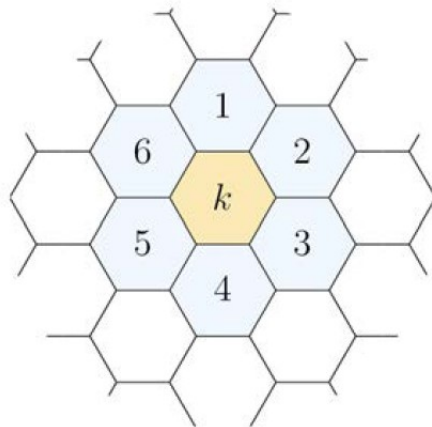
Source: Fernandez-Villaverde, Koyama, Lin, and Sng (2023)

Evolution of polities

- Time:
 - Discrete time $t = 0, 1, 2, \dots$
 - At $t = 0$, each cell is independent polity.
 - Over time, polities expand over cells or lose control of cells.

Evolution of polities

Cell k and adjacent cells



Source: Fernandez-Villaverde, Koyama, Lin, and Sng (2023)

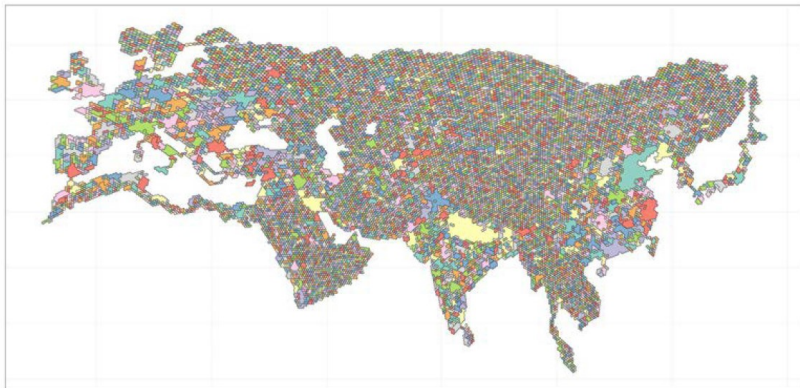
Evolution of polities

- Conquest:
 - In each period, k is in conflict with border cell with probability $\alpha \cdot y_k$, where y_k is productivity (population density) of cell k .
 - Victory in war depends on aggregate productivity and geographical characteristics:
 - More productive win more often.
 - Geography makes it harder or easier.
 - Resources allocated improve win probability (potentially multiple conflicts).
 - Winner absorbs losing polities (single or block).
- Border cells might secede with positive probability.

⇒ Simulate evolution of polities from Iron to Exploration Age

Evolution of polities

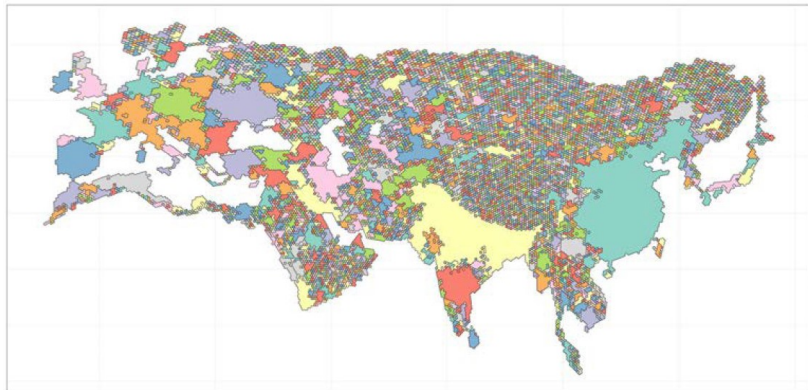
Period 50 (1100 BCE –850 BCE)



Source: Fernandez-Villaverde, Koyama, Lin, and Sng (2023)

Evolution of polities

Period 300 (1100 BCE –400 CE)



Source: Fernandez-Villaverde, Koyama, Lin, and Sng (2023)

Evolution of polities

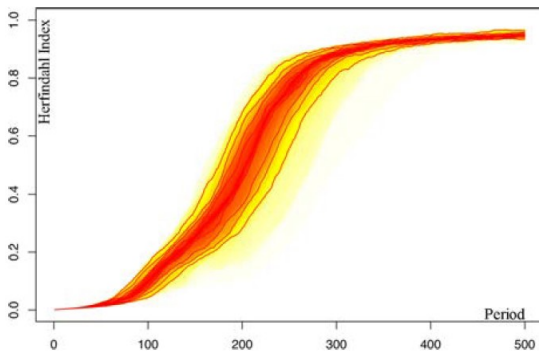
Period 500 (1100 BCE –1400 CE)



Source: Fernandez-Villaverde, Koyama, Lin, and Sng (2023)

Evolution of polities

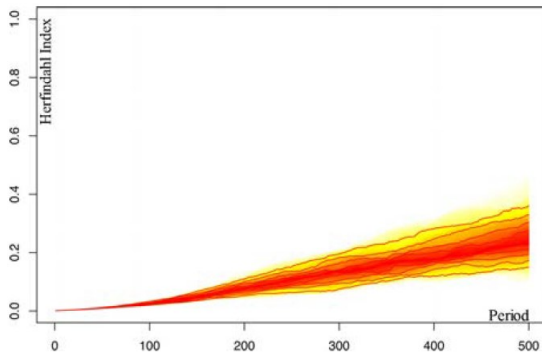
Herfindahl indices of political unity: China



Source: Fernandez-Villaverde, Koyama, Lin, and Sng (2023)

Evolution of polities

Herfindahl indices of political unity: Europe



Source: Fernandez-Villaverde, Koyama, Lin, and Sng (2023)

Historical perspective: China

- Despite ruggedness, salient role of North China in fostering unification.
- Flatness of North plain facilitates military conquest.
- Geographical characteristics enable a single powerful state to overcome rivals and build a centralized state.

Historical perspective: Europe

- Rome dominated early.
- Dense European forest impeded consolidation.
- Mountain barriers raised cost of military intervention in Western Europe.
- Central Habsburg hegemony due to marriages strategy rather than geography.

- Model does not include strategic interactions e.g. investment in military capacity, alliances, etc.
- But would strengthen results through balance of power in Europe.

- Model does not include strategic interactions e.g. investment in military capacity, alliances, etc.
- But would strengthen results through balance of power in Europe.
- Abstract from feedback from economic growth.

⇒ Fractured land generates unification in China and persistent fragmentation in Europe.

Natural endowments

- Two types of natural endowments:
 - The disease environment and life expectancy.
 - Natural resources, e.g., coal and the Industrial Revolution (skip).

The disease environment

- [AJR \(2001\)](#) Colonial origins: settler mortality as IV.

The disease environment

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 - But disease environment affecting settlers persists, affecting income today.
⇒ Exclusion restriction invalid?

The disease environment

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 - But disease environment affecting settlers persists, affecting income today.
 - ⇒ Exclusion restriction invalid?
 - [AJR \(2001\)](#) Malaria and yellow fever affected settlers, natives immune.

Life expectancy and economic growth

- Geography \implies disease environment \implies health \implies economic development?
- Improving health (e.g. malaria) should have great economic returns.

Life expectancy and economic growth

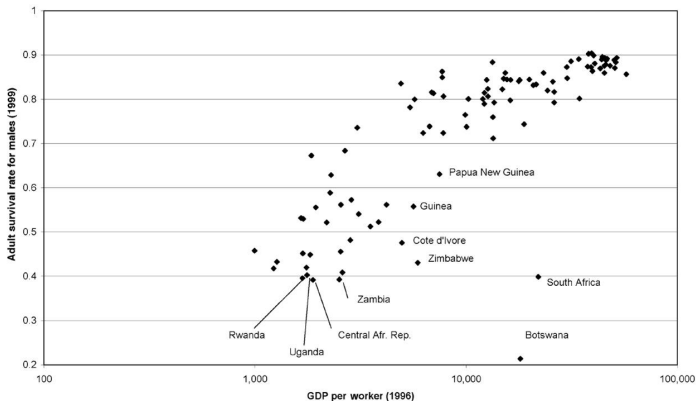
- Geography \implies disease environment \implies health \implies economic development?
- Improving health (e.g. malaria) should have great economic returns.
- Weil (2007) Health capital.

$$F(K, H, Q, A)$$

- K : physical capital.
- A : technology.
- H : human capital.
- Q : health capital.

Life expectancy and economic growth

GDP per Worker and Adult Survival Rate



Source: Weil (2007)

Life expectancy and economic growth

- Effect of life expectancy on economic growth. [AJ \(2007\)](#)

Life expectancy and economic growth

- Effect of life expectancy on economic growth. [AJ \(2007\)](#)

$$y_{it} = \pi x_{it} + \zeta_i + \mu_t + Z'_{it}\beta + \varepsilon_{it}$$

- y : log income per capita.
- x : log life expectancy at birth.
- ζ : country FE.
- μ_t : year FE.

Life expectancy and economic growth

- But yearly changes in life expectancy have full effects in long run.
- Estimate long differences: panel including two dates.

$$\Delta y_i = \pi \Delta x_i + \Delta \mu + \Delta Z_i' \beta + \Delta \varepsilon_i$$

- $t_0 = 1940$ or $t_0 = 1960$ and $t_1 = 1980$ or $t_1 = 2000$.

Life expectancy and economic growth

- Data:
 - Life expectancy, demographic data. [UN](#)
 - GDP per capita. [Maddison](#)

Life expectancy and economic growth

- Data:
 - Life expectancy, demographic data. [UN](#)
 - GDP per capita. [Maddison](#)
- Samples:
 - Whole world: 120 countries.
 - Base sample: 47–59 countries (reliable data).

Life expectancy and economic growth

Dependent variable:	Log Population		
	(1)	(2)	(3)
Log life expectancy	1.60*** [0.30]	1.75*** [0.40]	2.01*** [0.22]
Country FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Years	1960–2000	1960–2000	1940–2000
Sample Countries	World 120	Base 59	Base 47

Life expectancy and economic growth

- $\uparrow 1\%$ in life expectancy $\implies \uparrow 1.6\text{--}1.7\%$ in population.
- Not driven by sample selection.

Life expectancy and economic growth

- $\uparrow 1\%$ in life expectancy $\implies \uparrow 1.6\text{--}1.7\%$ in population.
- Not driven by sample selection.
- $\uparrow 1\%$ in life expectancy $\implies \uparrow 2\text{--}3\%$ in total births.
- Also increases ratio of population under age of 20.

Life expectancy and economic growth

Dependent variable:	Log GDP		
	(1)	(2)	(3)
Log life expectancy	1.17*** [0.56]	1.55*** [0.35]	0.85*** [0.28]
Country FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Years	1960–2000	1960–2000	1940–2000
Sample Countries	World 120	Base 59	Base 47

Life expectancy and economic growth

Dependent variable:	Log GDP per Capita		
	(1)	(2)	(3)
Log life expectancy	-0.42 [0.58]	-0.19 [0.54]	-1.14*** [0.27]
Country FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Years	1960–2000	1960–2000	1940–2000
Sample Countries	World 120	Base 59	Base 47

Life expectancy and economic growth

- $\uparrow 1\%$ in life expectancy $\implies \uparrow 1.5\%$ in GDP 1960–2000.
- $\uparrow 1\%$ in life expectancy $\implies \uparrow 0.8\%$ in GDP 1940–1980.
- Not driven by sample selection.

Life expectancy and economic growth

- $\uparrow 1\%$ in life expectancy $\implies \uparrow 1.5\%$ in GDP 1960–2000.
- $\uparrow 1\%$ in life expectancy $\implies \uparrow 0.8\%$ in GDP 1940–1980.
- Not driven by sample selection.
- Seems insufficient to compensate for increased population.

Life expectancy and economic growth

- Strong correlation between health and development.
- Causal relationship? OVB and reverse causality

Life expectancy and economic growth

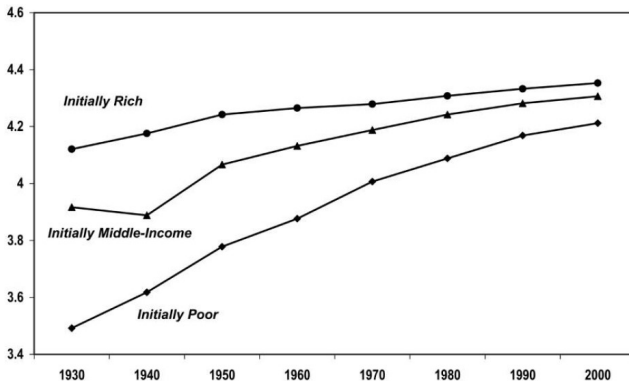
- Strong correlation between health and development.
- Causal relationship? OVB and reverse causality
 - \uparrow growth rates + \uparrow investment in health.
 - Better at solving health problems.

Life expectancy and economic growth

- Exploit the “international epidemiological transition” in 1940s–1950s.
 - Wave of drug and chemical innovations \implies cures for malaria, yellow fever, cholera, smallpox. . .
 - Establishment of World Health Organization \implies spread of technology to poorer countries.
- \implies Dramatic improvement of life expectancy across world.

Life expectancy and economic growth

Log life expectancy at birth



Source: Acemoglu and Johnson (2007)

Life expectancy and economic growth

- Build instrument for changes in life expectancy:
 - Predicted mortality of 15 diseases before intervention.
 - Interaction with global intervention dates for each disease.

Life expectancy and economic growth

- Build instrument for changes in life expectancy:
 - Predicted mortality of 15 diseases before intervention.
 - Interaction with global intervention dates for each disease.

$$M_{it}^I = \sum_{d \in \mathcal{D}} [(1 - I_{dt}) M_{di40} + I_{dt} M_{dFt}]$$

- M_{dit} : mortality in country i from disease d at t .
- I_{dt} : indicator for intervention on disease d at t (1 hereafter).
- \mathcal{D} : set of 15 diseases.

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- I_{dt} : indicator for intervention on disease d at t (1 hereafter).
- \mathcal{D} : set of 15 diseases.
- M_{di40} : preintervention mortality.
- M_{dFt} : mortality from disease d at health frontier at t .

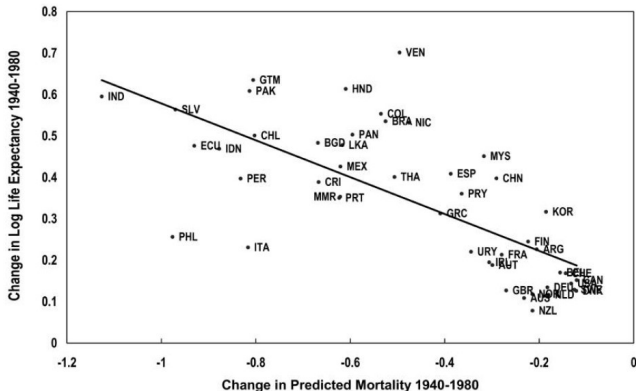
$\implies M_{it}^I$ is an instrument for life expectancy

Life expectancy and economic growth

- Predicted mortality M'_{it} is an instrument for life expectancy
 - Effect of global interventions on life expectancy depends on baseline distribution of diseases.
 - Only source of variation: interaction baseline distribution with timing of global intervention.
 - I_{dt} turns on for all countries at same time.
 - No reason for correlation with economic or population changes in given country.
- Threat:
 - Baseline mortality rates M'_{d40} s predict future changes in population or income.
 - Include differential trends to control for this.

Life expectancy and economic growth

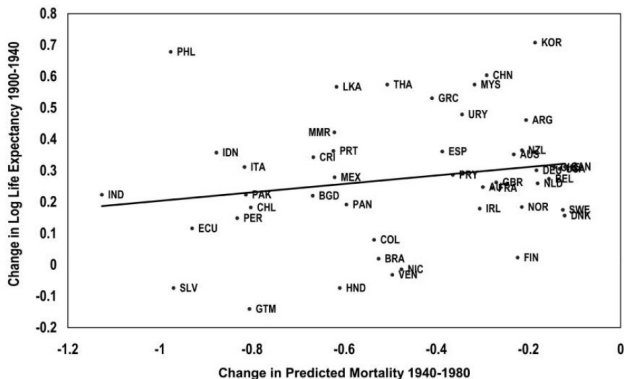
First Stage



Source: Acemoglu and Johnson (2007)

Life expectancy and economic growth

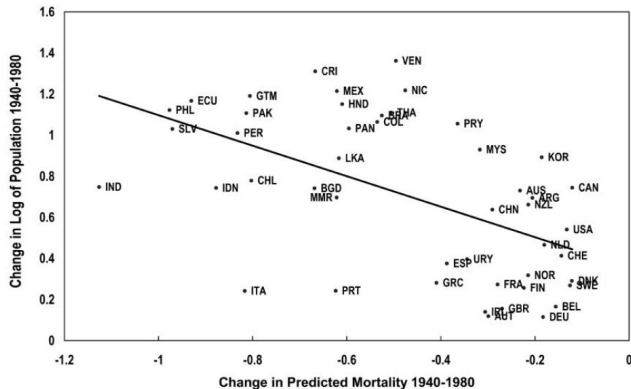
First Stage: No Pre-Trends



Source: Acemoglu and Johnson (2007)

Life expectancy and economic growth

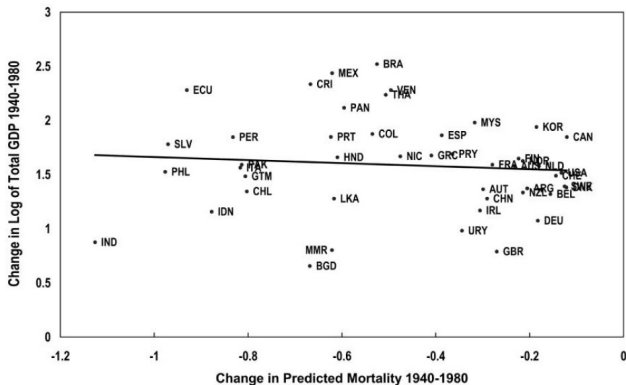
Reduced Form: Log Population



Source: Acemoglu and Johnson (2007)

Life expectancy and economic growth

Reduced Form: Log Total GDP



Source: Acemoglu and Johnson (2007)

Life expectancy and economic growth

Dependent variable:	Log GDP		Log GDP per C	
	(1)	(2)	(3)	(4)
Log life expectancy	0.85*** [0.28]	0.42 [0.52]	-1.14*** [0.27]	-1.51*** [0.57]
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Estimate	OLS	IV	OLS	IV
Years	1940–2000	1940–2000	1940–2000	1940–2000
Countries	47	47	47	47

Life expectancy and economic growth

- Increases in life expectancy increased population and births.
- Source of variation: exogenous differential changes in mortality due to international epidemiological transition.
- Increased population somewhat increased GDP.
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- But not enough to offset population growth.
⇒ Little direct effect of geography through disease burden.
- Generated heated debates. [Blum et al. \(2014\)](#) [AJ \(2014\)](#)
- Indirect effect of disease burden through institutions? [Alsan \(2015\)](#)

Life expectancy and economic growth

- Critique of Bloom et al. (2014)
 - Healthier countries in 1940 experienced faster subsequent growth and slower health gains.
 - ⇒ Initial life expectancy in 1940 affects subsequent growth.
 - The instrument essentially measures national health in 1940.
 - Including initial life expectancy is important since strong dependency over time.
 - ⇒ FS vanishes once initial life expectancy vanishes.

Life expectancy and economic growth

Dependent variable:	Log GDP per Capita			
	(1)	(2)	(3)	(4)
Log life expectancy (Δ)	-1.14*** [0.27]	-1.51*** [0.57]	3.68*** [1.30]	-21.56 [81.29]
Log life expectancy (1940)			3.77*** [0.94]	-15.23 [61.37]
Country & year FE	Yes	Yes	Yes	Yes
Estimate	OLS	IV	OLS	IV
Years	1940–2000	1940–2000	1940–2000	1940–2000
Countries	47	47	47	47
F-statistic		60.84		0.14

Life expectancy and economic growth

- Response of Acemoglu and Johnson (2014)
 - Changes in predicted mortality is uncorrelated with past changes in outcomes.
 - Cannot distinguish impact of life expectancy in 1940 and subsequent 1940–2000 change using only variation in predicted mortality (mechanical correlation)
 - Use 1900 life expectancy, interacted with decade effects: allows initial life expectancy to flexibly affect future growth.

Life expectancy and economic growth

Dependent variable:	Log GDP per Capita			
	(1)	(2)	(3)	(4)
Log life expectancy (Δ)	-1.14*** [0.27]	-1.39*** [0.36]	-0.93* [0.49]	-1.32*** [0.63]
Log LE (1900) \times decade	No	No	Yes	Yes
Log LE (1940) \times decade	No	No	No	Yes
Country & year FE	Yes	Yes	Yes	Yes
Estimate	OLS	IV	IV	IV
Years	1940–2000	1940–2000	1940–2000	1940–2000
Countries	47	47	47	47

Pollution

Victor Gay

Visiting professor at University of Michigan

Toulouse School of Economics

Institute for Advanced Study in Toulouse

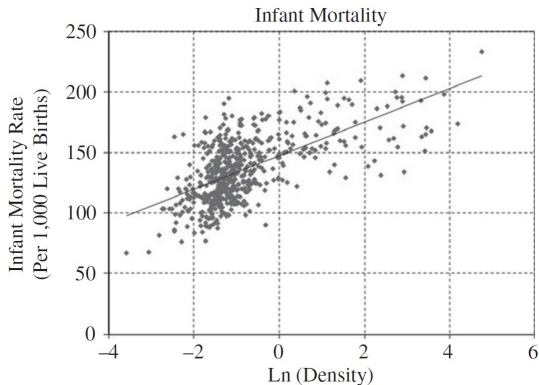
Winter 2024



Toulouse
School of
Economics

- Industrialization and urbanization generated unprecedented pollution with negative consequences on health.
 - Pollution, mortality, and the IR in Britain, 1851–1861. [Beach and Hanlon \(2018\)](#)
 - Pollution, city growth, and the IR in Britain, 1851–1911. [Hanlon \(2020\)](#)
 - Killer Cities and Industrious Cities? New Data and Evidence on 250 Years of Urban Growth. [Gindelsky and Jedwab \(2023\)](#)

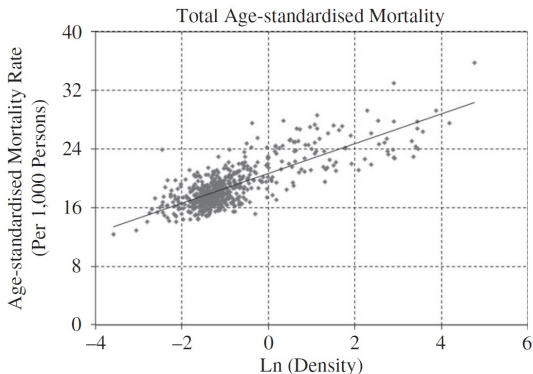
Pollution, mortality, and the Industrial Revolution



Urban mortality penalty across districts in England and Wales in 1851–1860

Source: Beach and Hanlon (2018).

Pollution, mortality, and the Industrial Revolution



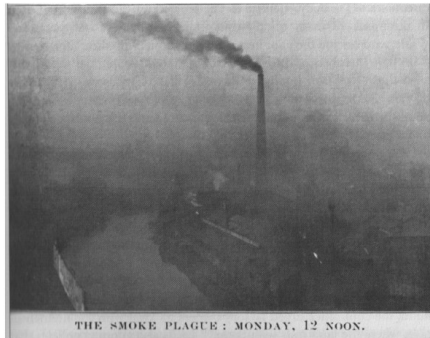
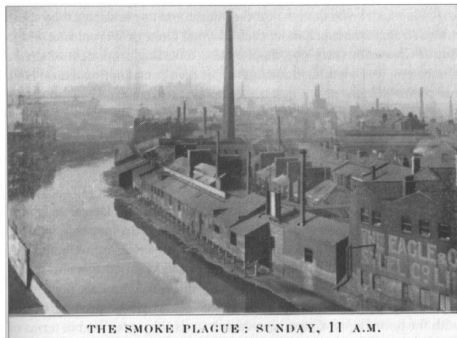
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Source: Beach and Hanlon (2018).

Pollution, mortality, and the Industrial Revolution

- Urban mortality penalty = common feature of Industrial Revolution in 19th century.
 - Urbanization and infectious diseases (unclean water + improper sewage disposal). [Kesztenbaum Rosenthal \(2011\)](#) [Alsan and Goldin \(2019\)](#)
 - Poor nutrition. [Fogel \(2004\)](#).
 - **Air pollution.** [Beach and Hanlon \(2018\)](#)

Pollution, mortality, and the Industrial Revolution



Sheffield in 1920

Source: Hanlon (2020) from Richmond (1921).

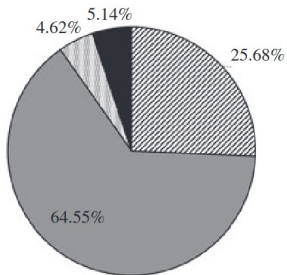
Pollution, mortality, and the Industrial Revolution

Coal production and energy consumption in England, Wales, and Scotland

	(1)	(2)	(3)	(4)	(5)
	1560s	1700-9	1750-9	1800-9	1850-9
Coal production ('000 tons)					
England	177	2,200	4,295	11,195	51,650
Wales	20	140	220	1,850	13,400
Scotland	30	300	715	2,000	9,000
Total	227	2,640	5,230	15,045	74,050
Energy consumption, England and Wales (petajoules)					
Draught					
animals	21.1	32.8	33.6	34.3	50.1
Population	14.9	27.3	29.7	41.8	67.8
Firewood	21.5	22.5	22.6	18.5	2.2
Wind	0.2	1.4	2.8	12.7	24.4
Water	0.6	1.0	1.3	1.1	1.7
Coal	6.9	84.0	140.8	408.7	1,689.1
Total	65.1	168.9	230.9	517.1	1,835.3
Total less coal	58.2	84.9	90.1	108.4	146.2

Source: Wrigley (2010).

Pollution, mortality, and the Industrial Revolution



- ▨ Household Use
- Manufacturing, Iron & Steel, and Mining
- Utilities
- Transportation

Coal usage shares for the UK in 1855

Source: Hanlon (2018).

Pollution, mortality, and the Industrial Revolution

- By mid-19th century, coal = main source of power.
- Pollution from burning coal exacerbated:
 - Coal burnt inefficiently \implies incomplete combustion \implies \uparrow pollution.
 - Coal burnt on-site at factories, located in urban areas.

Pollution, mortality, and the Industrial Revolution

- By mid-19th century, coal = main source of power.
- Pollution from burning coal exacerbated:
 - Coal burnt inefficiently \implies incomplete combustion \implies \uparrow pollution.
 - Coal burnt on-site at factories, located in urban areas.
- Serious health implications of coal pollution (respiratory and cardiovascular diseases).
- Yet, little regulation (*laissez faire* ideology).

Pollution, mortality, and the Industrial Revolution

- Mortality consequences of pollution at district level 1851–1861?
Beach and Hanlon (2018)

Pollution, mortality, and the Industrial Revolution

- Mortality consequences of pollution at district level 1851–1861?
[Beach and Hanlon \(2018\)](#)
- Mortality data:
 - From report of the Registrar General (births, marriages, deaths).
 - Decade average 1851–1861 age and cause of death by district (581).
 - Primary outcome variable: infant mortality (deaths per 1,000 births).
 - Other outcomes: deaths across age categories net of accidents.
 - Control for population sorting of less healthy population:
 - NPR (not pollution related) mortality: child not pollution related mortality.
 - Infant deaths from cholera, digestive disorders, smallpox, typhus.

Pollution, mortality, and the Industrial Revolution

- Main challenge: no reliable pollution data.

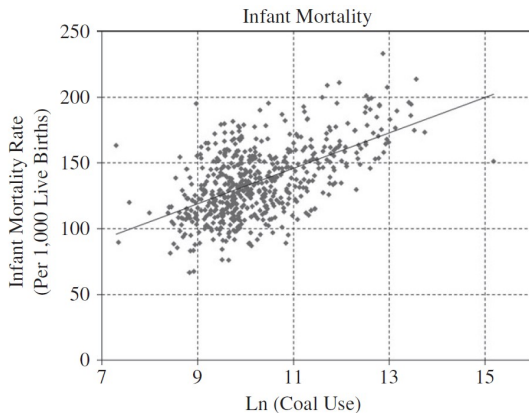
Pollution, mortality, and the Industrial Revolution

- Main challenge: no reliable pollution data.
- Indirectly capture through local industrial coal use:
 - District-level employment by industry (26) in 1851.
 - Coal use per worker from Census of Manufacturers 1907.
 - Coal use intensity at district d level in year t :

$$\text{COAL}_{dt} = \rho_t \sum_i \theta_i L_{idt}$$

- L_{idt} : local employment industry i district t .
 - θ_i : coal use intensity in industry i .
 - ρ_t : efficiency gains in coal use (absorbed, one period).
- Assume stable relative coal intensity per worker across industries.

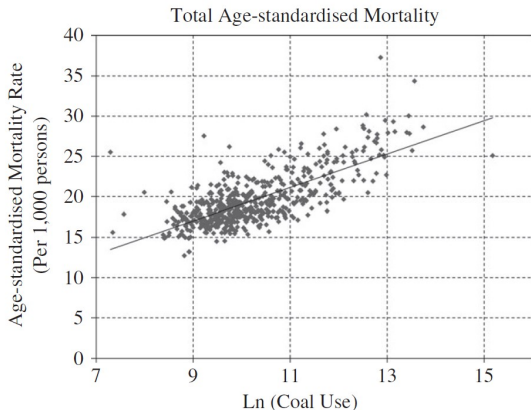
Pollution, mortality, and the Industrial Revolution



Coal use and mortality in England and Wales in 1851–1860

Source: Beach and Hanlon (2018).

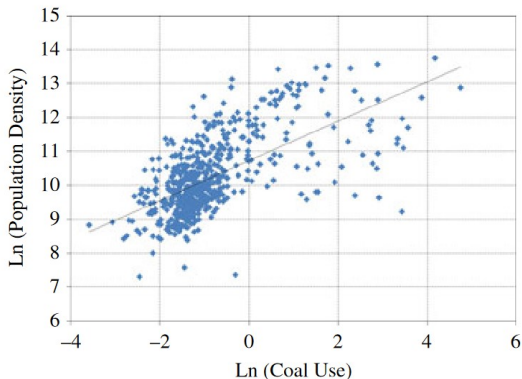
Pollution, mortality, and the Industrial Revolution



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Pollution, mortality, and the Industrial Revolution

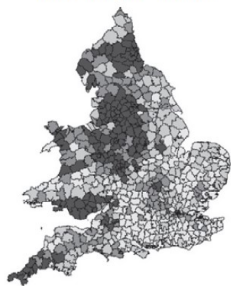


Coal use and population density in England and Wales in 1851–1860

Source: Beach and Hanlon (2018).

Pollution, mortality, and the Industrial Revolution

Coal Use per Worker



Population Density



Infant Mortality



Industrial coal use, population density, and mortality

Source: Beach and Hanlon (2018).

Pollution, mortality, and the Industrial Revolution

- Baseline specification

$$\text{IMR}_d = \alpha_0 + \alpha_1 \log(\text{DENSITY}_d) + \alpha_2 \log(\text{COAL}_d) + X_d \nabla + \varepsilon_d$$

- IMR_d : deaths children < 1 in district d / births (in 1,000s) 1851–60.
- DENSITY_d : population density in d in 1851.
- COAL_d : local industrial coal use in d .
- X_d : control variables (altitude, hilliness, FLFP, agricultural suitability, seaport indicator and tonnage).

Pollution, mortality, and the Industrial Revolution

	DV: Infant mortality rate				
	(1)	(2)	(3)	(4)	(5)
Ln(Coal use)	15.09*** (1.358)			13.68*** (2.462)	10.92*** (2.328)
Ln(Population density)		16.55*** (1.440)	7.797*** (1.531)	5.255*** (1.432)	-1.351 (1.521)
Ln(District population)			8.503*** (1.421)	-2.465 (2.612)	-1.924 (2.393)
Child NPR mortality					1.500*** (0.170)
Other controls			Yes	Yes	Yes
Observations	581	581	581	581	581
R ²	0.324	0.390	0.498	0.530	0.621

Coal use, infant mortality, and the urban mortality penalty

Source: Beach and Hanlon (2018).

Pollution, mortality, and the Industrial Revolution

- Interpretation (col. 4):
 - As population included, coal use interpreted as changes in intensity of district industrial coal use per person.
 - Strong correlation between local coal use and infant mortality.
 - Coal use explains 1/3 of urban mortality penalty.

Pollution, mortality, and the Industrial Revolution

- Interpretation (col. 4):
 - As population included, coal use interpreted as changes in intensity of district industrial coal use per person.
 - Strong correlation between local coal use and infant mortality.
 - Coal use explains 1/3 of urban mortality penalty.
- Two concerns with col. 4:
 - OVB correlated with local coal use and infant mortality \implies robust to additional controls.
 - Sorting of less healthy population into more polluted areas \implies control for NPR mortality in col. 5.

Pollution, mortality, and the Industrial Revolution

- Other patterns:
 - In cols. 2–3: population density correlated with infant mortality = urban mortality penalty.
 - Penalty remains after controlling for coal use (col. 4).
 - No penalty when controlling for NPR mortality (col. 5).

⇒ Coal use and NPR both explain infant urban mortality penalty.

Pollution, mortality, and the Industrial Revolution

- Improve identification by exploiting wind patterns:
 - In Britain, wind from south and west toward north and east.
 - Upwind and downwind coal use for each district within 25 km.
 - Upwind vs downwind unlikely to affect health besides pollution.
 - Key statistics: difference between upwind and downwind coal effects (proximity to high coal affects other outcomes).
- Placebo tests: no differential relationship between coal use in upwind and downwind districts and other district characteristics

Pollution, mortality, and the Industrial Revolution

	DV: Infant mortality rate				
	(1)	(2)	(3)	(4)	(5)
Ln(Coal use)	8.727*** (1.752)	8.441*** (1.867)	10.06*** (2.855)	13.63*** (2.722)	10.74*** (2.674)
Ln(Upwind coal)	1.694 (1.228)	2.849* (1.549)	2.638* (1.426)	1.424 (1.149)	1.907* (1.137)
Ln(Downwind coal)	-1.285 (1.070)	0.00599 (1.489)	-0.227 (1.362)	-1.420 (1.211)	-1.012 (1.173)
Ln(Population density)	9.983*** (1.486)	10.68*** (1.492)	10.85*** (1.608)	4.950*** (1.615)	-1.509 (1.546)
Ln(Nearby population)		Yes	Yes	Yes	Yes
Ln(District population)			Yes	Yes	Yes
Other controls				Yes	Yes
Child NPR mortality					Yes
Observations	422	422	422	422	422
R ²	0.463	0.467	0.467	0.566	0.664
Difference between downwind and upwind coefficients					
Coefficient difference	2.979	2.843	2.865	2.844	2.919
p-value	0.0602	0.0640	0.0614	0.0538	0.0426

Effect of coal use in upwind and downwind districts

Source: Beach and Hanlon (2018).

Pollution, mortality, and the Industrial Revolution

	DV: Infant mortality rate		
	(1)	(2)	(3)
Ln(Coal use)	11.80*** (1.364)	12.45*** (2.480)	9.462*** (2.275)
Ln(Coal use) × hilliness	3.535*** (1.091)	3.783*** (0.961)	4.239*** (0.845)
Ln(Population density)	6.739*** (1.576)	5.618*** (1.434)	-1.129 (1.454)
Ln(District population)		-1.842 (2.543)	-1.210 (2.262)
Mean altitude	1.149 (1.730)	-0.737 (1.744)	0.768 (1.672)
Hilliness	-9.334*** (1.761)	-9.496*** (1.888)	-7.834*** (1.961)
Other controls		Yes	Yes
Child NPR mortality control			Yes
Observations	581	581	581
R ²	0.527	0.549	0.645

Effect of coal use interacted with hilly topography

Source: Beach and Hanlon (2018).

Pollution, mortality, and the Industrial Revolution

- Use wind patterns to recover within-district effects of pollution.
 - Need estimate of how concentration of coal-based pollution diminishes with distance.
 - Use pollution dispersion modelling for $50\text{m} \times 50\text{m}$ cells across $20\text{km} \times 20\text{km}$ grid with smokestack at center.
 - Average concentration in district = 4 times downwind and 1.5 times in upwind.
- \uparrow log-point industrial coal use $\implies \uparrow$ 7–10 deaths per 1,000 live births.
- Little upward bias in baseline results.

Pollution, mortality, and the Industrial Revolution

DV: Mortality rate in each age category (per 1,000 persons)									
Under 5	5-9	10-14	15-19	20-24	25-34	35-44	45-54	55-64	65 up
Coefficient on coal use in upwind districts									
0.681 (0.416)	0.102* (0.0547)	-0.0002 (0.0433)	0.0804 (0.0643)	0.168 (0.103)	0.0806 (0.0828)	-0.224** (0.112)	-0.173 (0.128)	-0.136 (0.170)	-0.161 (0.360)
Coefficient on coal use in downwind districts									
-0.756 (0.477)	-0.0188 (0.0595)	-0.0504 (0.0411)	-0.0782 (0.0741)	-0.0943 (0.0864)	-0.139* (0.0761)	-0.248* (0.128)	-0.200 (0.141)	-0.348** (0.173)	-0.403 (0.314)
Difference between upwind and downwind coefficients									
1.437	0.1208	0.0502	0.1586	0.2623	0.2196	0.024	0.027	0.212	0.242
F-test for significance of difference between upwind and downwind effects (F-stat & p-value)									
6.14 0.0136	2.71 0.1004	0.88 0.3495	4.8 0.029	5.62 0.0183	8.41 0.0039	0.05 0.8176	0.05 0.8284	1.28 0.2588	0.53 0.4652

Upwind vs downwind coal use effects by age group

Source: Beach and Hanlon (2018).

Pollution, city growth, and the Industrial Revolution

- How does industrial structure affect city growth?
 - +: job growth attracts population.
 - -: pollution deters population due to ↓ quality of amenities + ↓ productivity.

Pollution, city growth, and the Industrial Revolution

- How does industrial structure affect city growth?
 - +: job growth attracts population.
 - -: pollution deters population due to ↓ quality of amenities + ↓ productivity.
- Assess impact of pollution on growth of British cities 1851–1911.
[Hanlon \(2020\)](#)

Pollution, city growth, and the Industrial Revolution

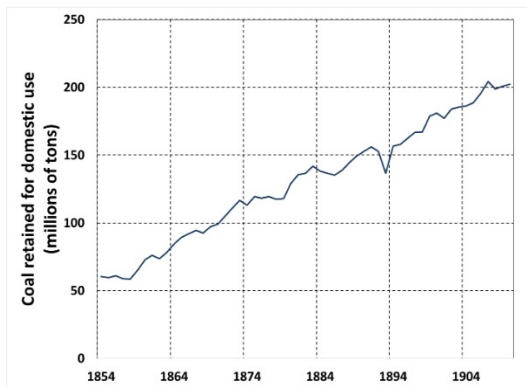
- How does industrial structure affect city growth?
 - +: job growth attracts population.
 - -: pollution deters population due to ↓ quality of amenities + ↓ productivity.
- Assess impact of pollution on growth of British cities 1851–1911.
[Hanlon \(2020\)](#)
 - Challenge 1. Pollution is one of many factors + effects take years: need high variation over multiple decades.
 - Challenge 2. No reliable pollution data: need proxy.
 - Challenge 3. Separate positive from negative effects: need empirical design.

Pollution, city growth, and the Industrial Revolution

- On pollution context: remember Sheffield 1920.
- On migration context: British population highly mobile.
 - Large flows of population from rural areas, Ireland, Scotland, to English cities.
 - 1851–1881: 1/4 people changed county of residence; 1/2 changed town. [Long and Ferrie \(2003\)](#)
 - Primary driver of migration flows: search for work.

Pollution, city growth, and the Industrial Revolution

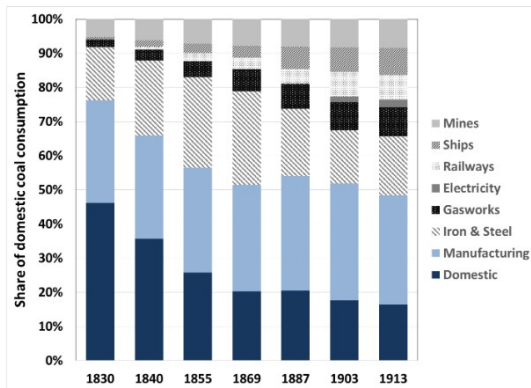
British coal consumption, 1854–1910



Source: Hanlon (2020) based on Mitchell (1988).

Pollution, city growth, and the Industrial Revolution

British coal consumption by use, 1830–1913



Source: Hanlon (2020) based on Mitchell (1988).

Pollution, city growth, and the Industrial Revolution

- Local industrial composition:
 - Occupations 1851–1911 for 31 largest cities from Census.
 - Series 1851–1911 for 26 broad industries.

Pollution, city growth, and the Industrial Revolution

- Local industrial composition:
 - Occupations 1851–1911 for 31 largest cities from Census.
 - Series 1851–1911 for 26 broad industries.
- Coal intensity for each industry:
 - Coal use per worker and industry from Census of Production 1907.
 - Coal use intensity in city c in year t :

$$\text{COAL}_{ct} = \rho_t \sum_i \theta_i L_{ict}$$

- L_{ict} : local employment industry i city t .
- θ_i : coal use intensity in industry i .
- ρ_t : efficiency gains in coal use.

Pollution, city growth, and the Industrial Revolution

English cities included in the study



Source: Hanlon (2020).

Pollution, city growth, and the Industrial Revolution

Industry coal use per worker (tons per worker)

Industry	Coal/ worker
Earthenware, bricks, etc.	48.9
Metal and engine manufacturing*	43.7
Chemical and drug manufacturing	40.1
Mining	28.9
Oil, soap, etc. production	20.7
Brewing and beverage production	19.4
Leather, hair goods production	12.1
Food processing	12.0
Textile production	10.1
Paper and publishing	9.7
Shipbuilding	6.1
Wood furniture, etc., production	5.4
Vehicle production	2.6
Instruments, jewelry, etc.	2.0
Apparel	1.6
Tobacco products	1.1

Source: Hanlon (2020).

Pollution, city growth, and the Industrial Revolution

- Estimating coal use effects on city-industry employment growth:

$$\Delta \log(L_{ict}) = b_0 + b_1 \Delta \log(C_{ct}) + b_2 \Delta \log(L_{ct}) + \zeta_{it} + e_{ict}$$

- L_{ct} : overall city employment growth (negative congestion or positive agglomeration effects).
 - C_{ct} : city coal use (negative pollution or productivity effects).
 - ζ_{it} : industry-time fixed effects (absorb industry-specific productivity and demand shocks).
- Use log because linear relationship between pollution and employment in log.

Pollution, city growth, and the Industrial Revolution

- Identification issue:
 - Changes in overall city employment and change in city coal use endogenously affected by city-industry employment growth.
 - Replace these terms with predicted values based on national-level trends and use deviations from predicted trends.

Pollution, city growth, and the Industrial Revolution

- Overall city employment:

$$\Delta \log (\text{PrCityEMP}_{ct}) = \log \left(\sum_{j \neq i} L_{jct-\tau} \times \text{GR}_{j-ct,t-\tau} \right) - \log \left(\sum_{j \neq i} L_{jct-\tau} \right)$$

- $\text{GR}_{i-ct,t-\tau}$: growth rate of industry i in all cities other than c , from $t - \tau$ to t .
- $\Delta \log (\text{PrCityEMP}_{ct})$: expected growth in employment in all other local industries, given national industry growth rates and initial industrial composition of the city.
- When studying industry i , it is dropped from the measure.

Pollution, city growth, and the Industrial Revolution

- City coal use:

$$\Delta \log(\text{PredCoal}_{ct}) = \log \left(\sum_{j \neq i} L_{jct-\tau} \times \text{GR}_{j-ct,t-\tau} \times \theta_j \right) - \log \left(\sum_{j \neq i} L_{jct-\tau} \times \theta_j \right)$$

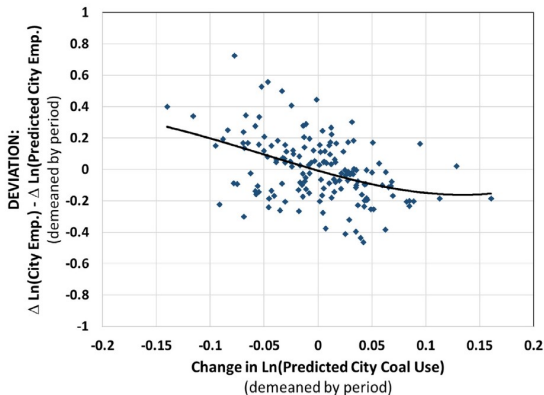
- Difference due only to variation in coal intensity of industries θ_j .

Pollution, city growth, and the Industrial Revolution

$$\text{DEVIATION} = \Delta \log (\text{CityEMP}_{ct}) - \Delta \log (\text{PrCityEMP}_{ct})$$

- DEVIATION: difference between actual change in city employment and expected change given city's initial industrial structure and industry growth rates in all other cities.
- Captures extent to which employment growth of city performs relative to predictions based on national industry growth rates.

Pollution, city growth, and the Industrial Revolution



Deviation vs predicted change in city coal use (over 2 decades)

- In cities where expect rising coal use, city employment growth systematically underperforms.

Pollution, city growth, and the Industrial Revolution

- Estimating coal use effects city-industry employment growth:

$$\Delta \log (L_{ict}) = b_0 + b_1 \Delta \log (\text{PrCoal}_{ct}) + b_2 \Delta \log (\text{PrCityEmp}_{ct}) + \zeta_{it} + e_{ict}$$

- Predicted employment picks up direct effects of employment growth in other industries in city c on employment growth of i due to congestion or agglomeration.
- b_1 captures additional impact generated when this employment growth occurs in more coal-intensive industries.
- b_1 is the impact of a rise in local industrial coal use holding constant overall local employment level.
- b_2 is the impact of increase in local employment holding fixed level of local industrial coal use.

Pollution, city growth, and the Industrial Revolution

Difference:	DV: $\Delta \ln$ of city industry employment					
	All industries			Manufacturing industries		
	One decade (1)	Two decades (2)	Three decades (3)	One decade (4)	Two decades (5)	Three decades (6)
$\Delta \ln(PredCoal)$	-0.611 (0.621)	-1.987*** (0.732)	-3.016*** (0.803)	-0.444 (0.685)	-2.218*** (0.632)	-3.257*** (0.813)
$\Delta \ln(PrCityEMP)$	-0.536 (0.586)	0.392 (0.757)	1.362* (0.826)	-0.725 (0.528)	0.383 (0.553)	1.172* (0.692)
Ind.-time effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,809	4,012	3,208	2,773	2,312	1,849
R^2	0.259	0.355	0.429	0.246	0.336	0.403

Baseline city-industry regression results

Source: Hanlon (2020).

Pollution, city growth, and the Industrial Revolution

- Coal use has a negative impact on city-industry employment growth over the long run (2 or 3 decades).
- Negative short-run effect of employment growth in other city-industries that becomes positive over time: negative congestion forces weaken while positive city-size agglomeration effects strengthen over time.

Pollution, city growth, and the Industrial Revolution

- Coal use has a negative impact on city-industry employment growth over the long run (2 or 3 decades).
- Negative short-run effect of employment growth in other city-industries that becomes positive over time: negative congestion forces weaken while positive city-size agglomeration effects strengthen over time.
- Aggregate effects on city working population are negative.

Pollution, city growth, and the Industrial Revolution

DV: $\Delta \ln$ of city employment in analysis industries (two decade differences)						
	City employment in analysis industries		Total city working population		Total city population	
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln(PrWorkpop_{ct})$	0.955 (0.666)	0.433 (0.726)	0.756 (0.664)	0.0795 (0.724)	0.385 (0.624)	-0.229 (0.730)
$\Delta \ln(PrCoal_{ct})$	-1.457** (0.657)	-1.655** (0.670)	-1.352** (0.650)	-1.400** (0.665)	-0.986 (0.633)	-1.055 (0.686)
Time effects	Yes	Yes	Yes	Yes	Yes	Yes
Other controls		Yes		Yes		Yes
Observations	155	155	155	155	155	155
R^2	0.067	0.202	0.084	0.208	0.099	0.213

City-level regression results

Source: Hanlon (2020).

Pollution, city growth, and the Industrial Revolution

- Consumer disamenities or productivity effects?
 - Need location-specific wage, rent, and price data.
 - Available for 51 cities in 1905 report of Board of Trade.
- Results:
 - Coal has small negative impact on quality of life.
 - Impact of coal seems larger through productivity effects.

Killer cities and industrious cities

Gindelsky and Jedwab (2022)

- Urbanization during the IR has been linked to high mortality rates in the UK (urban mortality penalty).
- Rising labor productivity and wages tied to the industrious revolution: higher working hours and lower birth rates.
- But despite this double demographic penalty, cities industrialized and grew.

Killer cities and industrious cities

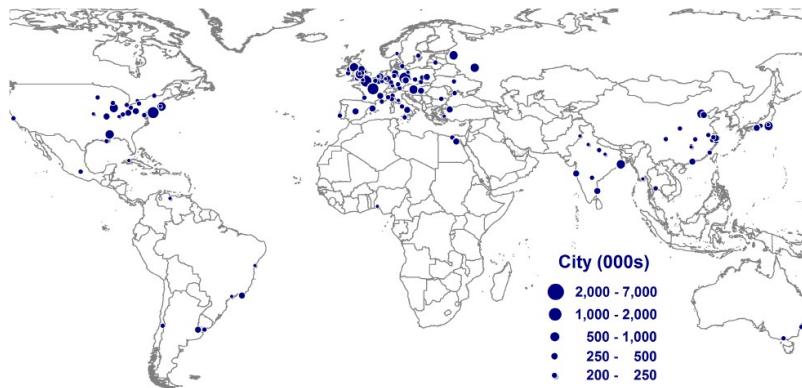
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- But despite this double demographic penalty, cities industrialized and grew.
- Assess the extent to which the demographic urban penalty changed between 1700 and 1950 worldwide.

Killer cities and industrious cities

- Data:
 - Sample of 142 cities with 200k+ inhabitants in 1900.
 - Demography indicators for each city-decade pair from 300 sources:
 - CDR. Crude death rate (death per 1000 inhabitants).
 - CBR. Crude birth rate (births per 1000 inhabitants).
 - CRNI. Crude rate of natural increase: CBR-CDR.
 - Population.
 - Timing of the IR (Britain = 1760, USA = 1790, France=1810).

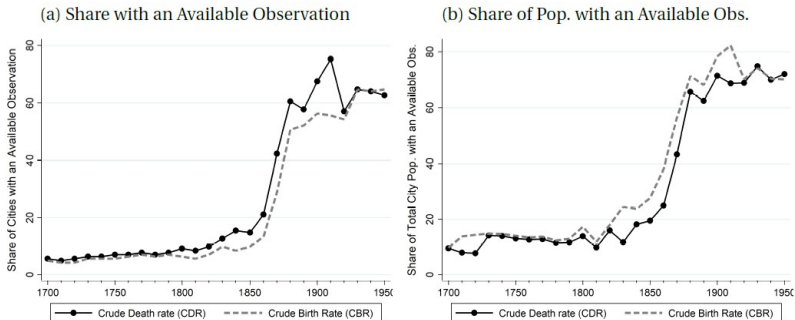
Killer cities and industrious cities



Largest cities of the world circa 1900

Source: Gindelsky and Jedwab (2022)).

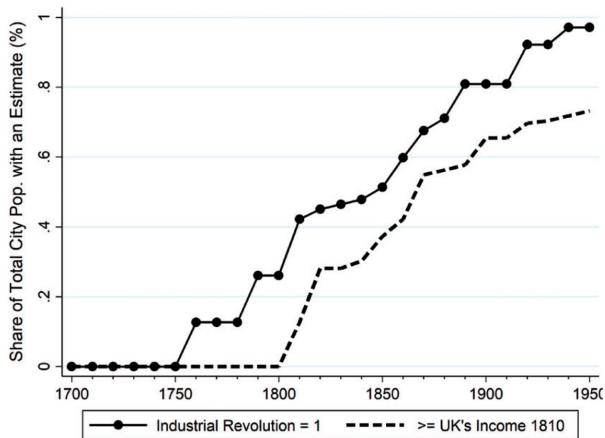
Killer cities and industrious cities



Share of sample with an available observation 1700–1950

Source: Gindelsky and Jedwab (2022)).

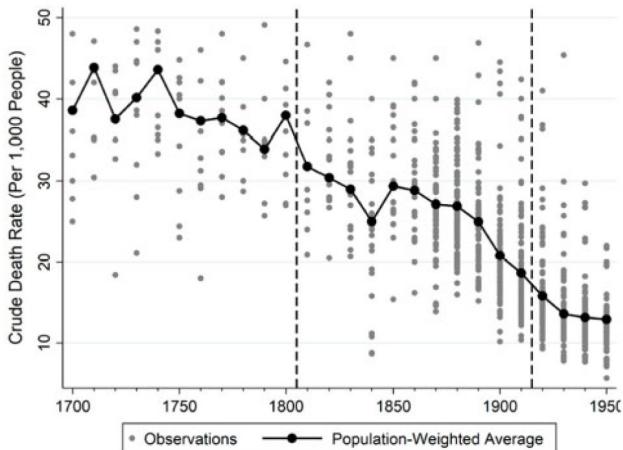
Killer cities and industrious cities



Diffusion of the IR among the 142 cities

Source: Gindelsky and Jedwab (2022)).

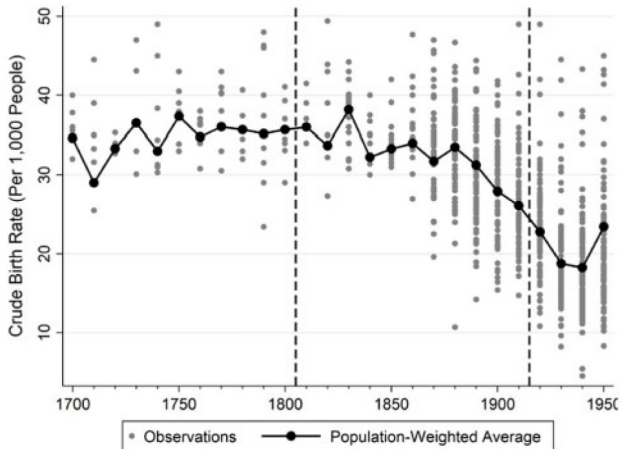
Killer cities and industrious cities



Evolution of city crude death rates

Source: Gindelsky and Jedwab (2022)).

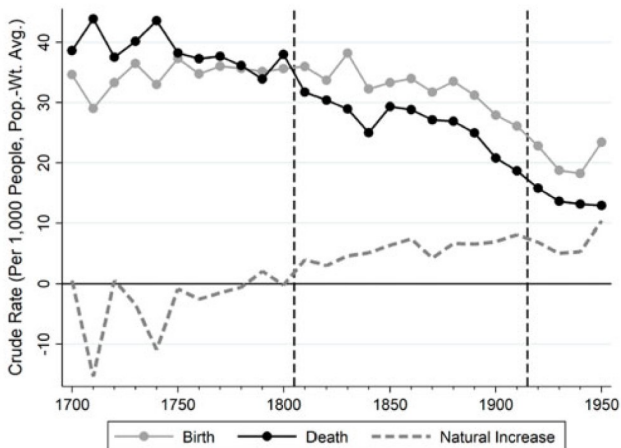
Killer cities and industrious cities



Evolution of city crude birth rates

Source: Gindelsky and Jedwab (2022).

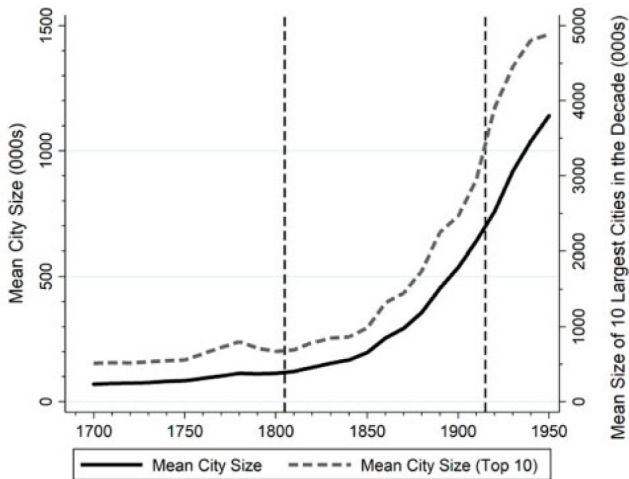
Killer cities and industrious cities



Evolution of city demographic rates

Source: Gindelsky and Jedwab (2022)).

Killer cities and industrious cities



Evolution of city population size

Source: Gindelsky and Jedwab (2022)).

Killer cities and industrious cities

- Rates of natural increase increased as city size increased during the IR era (1810–1910).
- The urban penalty may have decreased during the industrial era.

Killer cities and industrious cities

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 - Air and water pollution.
 - Congestion effects and rapid spread of diseases.

Killer cities and industrious cities

- Rates of natural increase increased as city size increased during the IR era (1810–1910).
- The urban penalty may have decreased during the industrial era.
- Negative health effects leading to higher mortality:
 - Air and water pollution.
 - Congestion effects and rapid spread of diseases.
- Positive effects leading to lower mortality (outweighing negative effects):
 - Standards of living increased (see GDP estimates, welfare ratios...).
 - Improved nutrition, public health investments (sewer systems), health care, education.

Pandemics in Historical Perspective

Victor Gay

Visiting professor at University of Michigan

Toulouse School of Economics

Institute for Advanced Study in Toulouse

Winter 2024



What can history teach us about the potential long-run consequences of COVID-19?

- Most serious health and economic crisis of 21st century:
 - Since December 2019: nearly 7M fatalities, 705M cases.
 - No natural immunity, vaccine administered since late December 2020.
 - Large-scale non-pharmaceutical interventions.
 - Large economic downturn, e.g., 2020 Q2/2019 Q2: France -19% ; USA -30% .
 - 2020 GDP growth: Euro area -7% ; USA -2.2%

⇒ Critical juncture.

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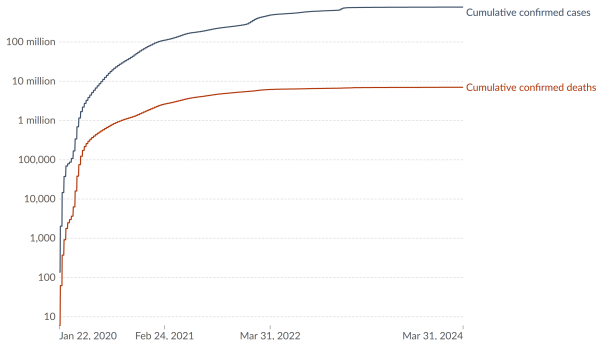
⇒ Critical juncture.

- Economic history can some provide guidance.

Cumulative confirmed COVID-19 cases and deaths, World

Our World
in Data

Limited testing and challenges in the attribution of cause of death mean the confirmed case and death counts may not reflect the true counts.



Data source: WHO COVID-19 Dashboard

OurWorldInData.org/coronavirus | CC BY

Approach of this Lecture

- Characterize features COVID–19 crisis.
- Find commonalities (and differences) with past crises.
- Leverage past experiences.
- Useful references: [Alfani and Murphy \(2017\)](#) [Arthi and Parman \(2020\)](#) [Beach, Clay, and Saavedra \(2020\)](#)

- Features of COVID-19 in Historical Perspective
- Lessons from the Influenza Pandemic of 1918–1919
- Lessons from the Great Depression of the 1930s

COVID-19 in historical perspective

COVID-19 in Historical Perspective

- Epidemiology of COVID-19.
- Demographic and distributional effects.
- Policy responses.

⇒ Characterization will generate natural historical counterparts.

COVID-19 in Historical Perspective

- Epidemiology of COVID-19.
- Demographic and distributional effects.
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⇒ Characterization will generate natural historical counterparts.

- Health effects: Influenza (1918–1919).
- Economic effects: Great Depression (1930s).

Comparison Set

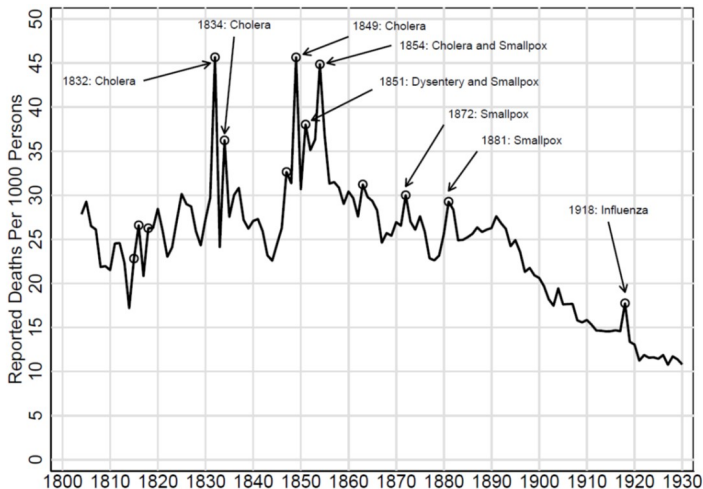
⇒ Epidemic risks were (nearly) part of everyday life.

Epidemics	Period	Regions	Deaths
Antonine Plague	160–180	Roman Empire	10–30%
Plague of Cyprian	249–270	Roman Empire	15–25%
Justinian plague	540–541	Eu., Med.	25–50M, 25–50%
Black Death	1347–1352	Eu. to Asia	~50M, 35–60% (Eu)
Italian plague	1629–1632	North. Italy	2M , 30–35%
Columbian Exchange	1492–1650	Americas	80–90%
Cholera Pandemics 1–6	1817–1923	Worldwide	1M+
Third Plague	1850s–1900s	China, India	12M
Russian Flu	1889–1890	Russia, Asia, Eu.	1M

Some Major Historical Epidemics

Data from [Alfani and Murphy \(2017\)](#)

Comparison Set



Major 19th-century Epidemics in NYC

Figure from [Beach, Clay, and Saavedra \(2020\)](#) using data from [Rosenwaike \(1972\)](#) and other primary sources.

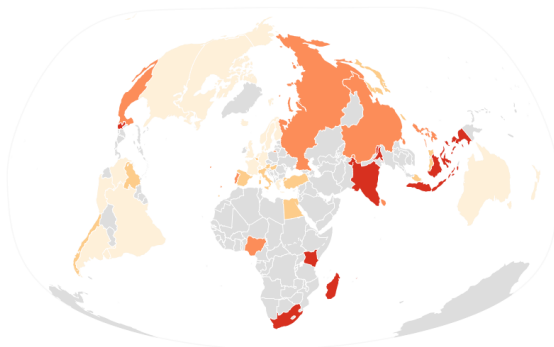
Epidemiology of COVID–19: Spatial Diffusion

- Very rapid and global diffusion (World Mapper's dynamic cartogram).

Epidemiology of COVID–19: Spatial Diffusion

- Very rapid and global diffusion (World Mapper's dynamic cartogram).
- Similar patterns in past pandemics: along trade routes, trading centers (Amsterdam, London, Venice. . .).
- Most common with worldwide spread of 1918–1919 Influenza.

Epidemiology of COVID–19: Spatial Diffusion



basemap from Natural Earth (CC0)



Made with Khartis

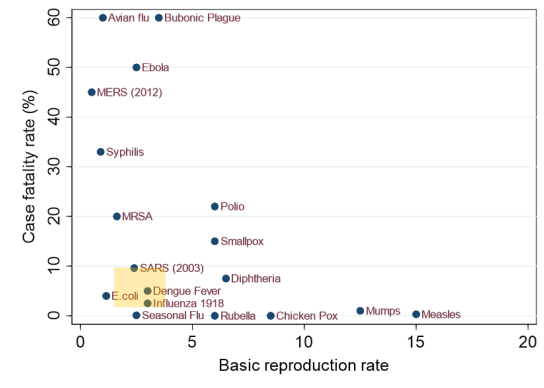
Worldwide Spread of 1918–1919 Influenza Pandemic

Data for 48 countries from [Barro, Ursua, and Weng \(2020\)](#).

Epidemiology of COVID-19: Rate of Transmission

- Basic reproductive rate (R_0): average number of secondary infections produced by a typical case in a population where everyone is susceptible.
- Estimates: 1.8–3.6 worldwide; 1.9–2.6 in W. Europe.
[Petersen et al. \(2020\)](#) [Locatelli et al \(2021\)](#)
- Comparable to 1918 Influenza, yellow fever, or SARS: ~ 3 .
- Much lower than measles, with R_0 of above 10.

Epidemiology of COVID-19: Rate of Transmission



Basic Reproduction Rates and Case Fatality Rates Across Epidemics

Data from [Arthi and Parman \(2020\)](#).

Epidemiology of COVID-19: Severity

- Measuring COVID-19 severity while unfolding is challenging:
 - Case fatality rate: death from COVID / diagnosed cases of COVID.
 - Crude mortality rate: death from COVID / total population.
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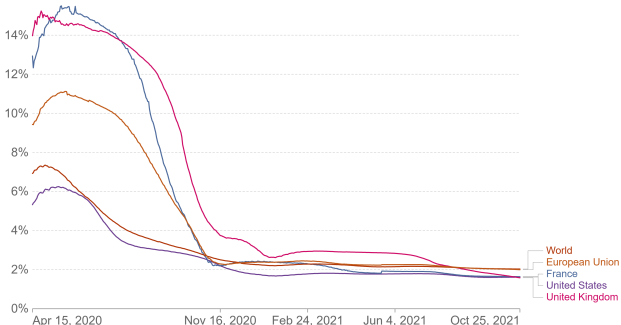
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⇒ Initial spread, transmission, severity comparable to Influenza.

Epidemiology of COVID-19: Rate of Transmission

Case fatality rate of the ongoing COVID-19 pandemic

The Case Fatality Rate (CFR) is the ratio between confirmed deaths and confirmed cases. During an outbreak of a pandemic the CFR is a poor measure of the mortality risk of the disease. We explain this in detail at [OurWorldInData.org/Coronavirus](https://ourworldindata.org/coronavirus)

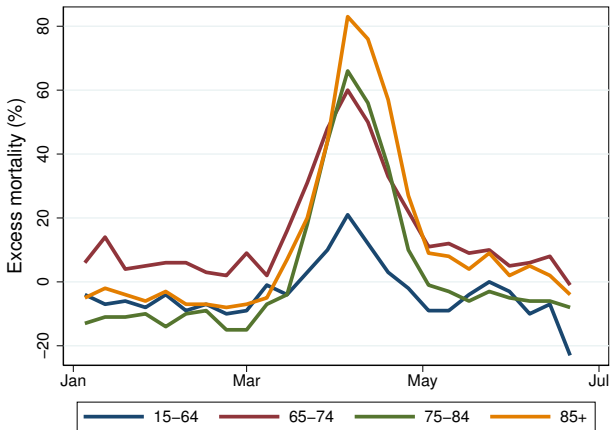


Source: Johns Hopkins University CSSE COVID-19 Data – Last updated 26 October, 09:04 (London time) Powered by ourworldindata.org
Note: Only countries with more than 100 confirmed cases are included. Only countries with more than 100 confirmed cases are included.

Data from [ECDC](https://ecdc.europa.eu/) and ourworldindata.org.

Demographic and Distributional Effects

Demographic and Distributional Effects



Excess Mortality in 2020 vs 2015–2019 by Age in France

Data from [ECDC](https://ecdc.europa.eu/en) and ourworldindata.org.

Demographic and Distributional Effects

- Old age and worse baseline health.

Demographic and Distributional Effects

- Old age and worse baseline health.
- Low SES: compounded risks.
 - High contact jobs, continuing during pandemic.
 - Likely low-paying jobs, more likely women and minorities.
 - Differential access to healthcare.

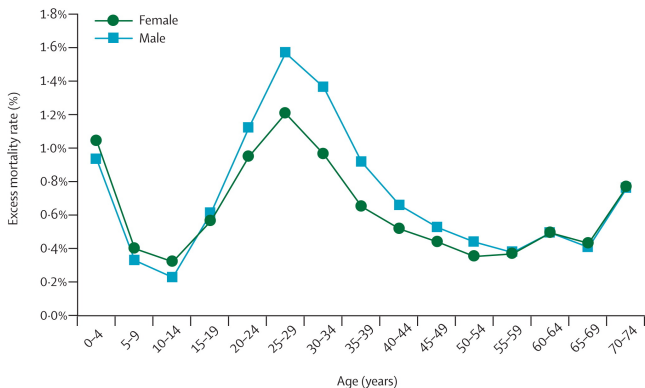
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 - Likely low-paying jobs, more likely women and minorities.
 - Differential access to healthcare.
- Low SES more affected during Influenza (more later).
- Difference with Influenza: W shape in age susceptibility.

Demographic and Distributional Effects



Median Excess Mortality Rate by Age and Sex (13 countries).

Figure from Murray et al. (2006)

Policy Response

- Absent of cure (until 2021) and limited medical capacities:
⇒ Widespread non-pharmaceutical interventions (NPIs).

Policy Response

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⇒ Widespread non-pharmaceutical interventions (NPIs).
 - Shutdowns
 - Travel restrictions
 - Quarantines
 - Social distancing
 - Mask wearing
- Open, linked, updated dataset [Desvars-Larrive et al. \(2020\) *Sci Data*](#)

Policy Response

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 - Shutdowns
 - Travel restrictions
 - Quarantines
 - Social distancing
 - Mask wearing
- Open, linked, updated dataset [Desvars-Larrive et al. \(2020\) *Sci Data*](#)
- Quarantines very common in the past, some NPI during Influenza.
- Generally not as stringent and generalized as today.

Lessons from the Influenza Pandemic of 1918–1919

The 1918 Influenza Pandemic

- Key features:
 - Brief: Spring 1918–early 1919 (last wave in 1920 in some countries).
 - Worldwide diffusion (with substantial variation).
 - Severe fatalities: 20–50M deaths.
 - Some countries implemented NPIs.

The 1918 Influenza Pandemic

- Key features:
 - Brief: Spring 1918–early 1919 (last wave in 1920 in some countries).
 - Worldwide diffusion (with substantial variation).
 - Severe fatalities: 20–50M deaths.
 - Some countries implemented NPIs.
- Useful to think about some potential consequences of COVID–19.
 - Short-run health and economic consequences.
 - Medium-run economic effects of NPIs.
 - Long-run health consequences.

Key Empirical Issues

- Measurement of mortality.
 - Limited capacities for classification.
 - Political pressure and timely information in wartime.
 - ⇒ Scholars rely on excess mortality from all causes.

Key Empirical Issues

- Measurement of mortality.
 - Limited capacities for classification.
 - Political pressure and timely information in wartime.
⇒ Scholars rely on excess mortality from all causes.
- Simultaneity of WWI (e.g., France).
 - 180k civilians, 30k soldiers. [Darmon \(2000\)](#) [Guenel \(2004\)](#)
 - Civilian fatalities: 74 départements (*Statistique Sanitaire de la France*)
 - Military fatalities: no disaggregation (*Statistique Médicale*).
 - No correlation with military death rates. [Boehnke and Gay \(2022\)](#)

What Explains Distribution of Influenza Fatalities?

What Explains Distribution of Influenza Fatalities?

Clay, Lewis, and Severnini (2019a)

- Focus on U.S. case: better data, no WWI on soil.
- Total death toll: 600–700k in 1918.
- Spread from WWI bases and through troops movements.
- Evidence from the 438 cities $>10k$ residents (1915–1925).

What Explains Distribution of Influenza Fatalities?

- Measuring influenza mortality:
 - Predict 1918 mortality using city linear trend over 1915–1925.

$$M_{ct} = \alpha_c + \beta_c t + \varepsilon_{ct}$$

- α_c : city-specific intercept; β_c : city-specific trend; 1918 excluded.
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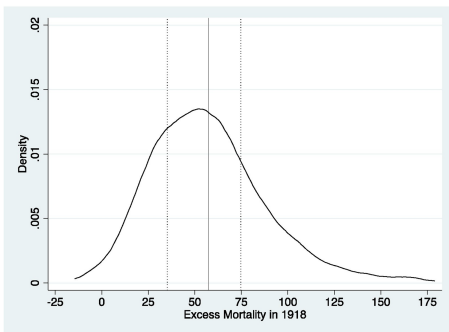
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- Similar results if predict 1918 with 1915–1917 data.

What Explains Distribution of Influenza Fatalities?



(a) Mortality, 1915-1925



(b) Excess Mortality in 1918

All-age Mortality Across U.S. Cities

Figure from [Clay, Lewis, and Severini \(2019a\)](#)

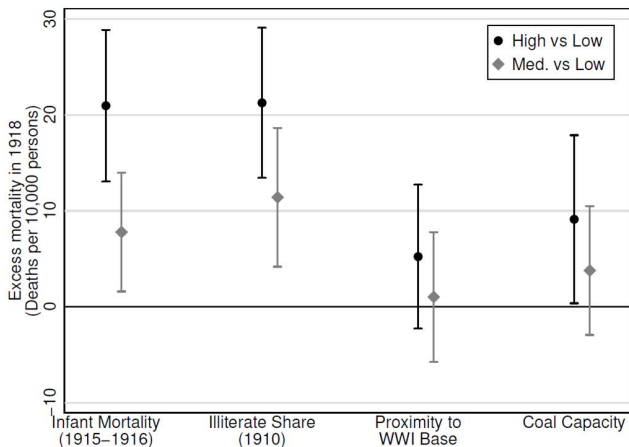
What Explains Distribution of Influenza Fatalities?

- Pre-pandemic city-level characteristics analyzed:
 - Health conditions: infant mortality (1915–1916).
 - Economic conditions: illiteracy rate (1910).
 - Timing of pandemic: proximity to WWI base.
 - Environmental pollution: coal-fired electricity capacity.

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 - Economic conditions: illiteracy rate (1910).
 - Timing of pandemic: proximity to WWI base.
 - Environmental pollution: coal-fired electricity capacity.
- Regress excess mortality on these characteristics + share of urban population through a multivariate regression.

What Explains Distribution of Influenza Fatalities?



Determinants of Excess Mortality in 1918

Figure from [Beach, Clay, and Saavedra \(2020\)](#) using estimates from [Clay, Lewis, and Severnini \(2019\)](#)

What Explains Distribution of Influenza Fatalities?

- Influenza more deadly in locations with worse baseline:
 - Health environment [Acuna-Soto, Vibond, and Chowell \(2011\)](#) [Bootsma and Ferguson \(2007\)](#)
 - Overall income [Grantz et al. \(2016\)](#) [Tuckel et al. \(2016\)](#)
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- ⇒ Aggravated pre-pandemic socioeconomic disparities.
- Some issues:
 - Mostly focus on U.S. case.
 - Few individual-level studies.

What Were the Economic Effects of Influenza?

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- Short-run macroeconomic effects [Barro, Ursua, and Weng \(2020\)](#)
 - Panel 43 countries (1901–1929). Flu death rates $\simeq 2\%$
 - Did flu deaths (and war deaths) generated differential changes across countries in rates of economic growth?
 - $\uparrow 1\text{pp flu death rates} \implies \downarrow 3\% \text{ real GDP per K.}$
 - In aggregate: pandemic $\implies \downarrow 6\% \text{ real GDP per K.}$

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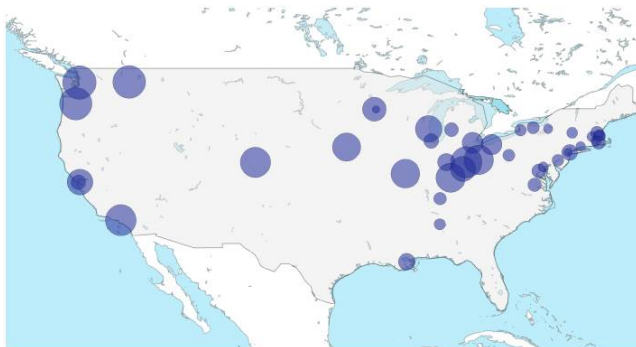
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- Medium-run economic effects (within-country analyzes):
 - Italy: $\downarrow 6.5\% \text{ real GDP}$, recover by 1922. [Carillo and Jappelli \(2020\)](#)
 - Denmark: short-lived \downarrow income growth. [Dahl et al. \(2020\)](#)
 - Complicated by WWI deaths and war production (esp. in U.S.).

What Were the Economic Effects of NPIs?

What Were the Economic Effects of NPIs?

- U.S. cities implemented non-pharmaceutical interventions (NPIs).
Markel et al. (2007)
 - NPIs: school closures, quarantines, bans on public assemblies.
 - Information for 43 cities with weekly influenza fatalities data.
 - *NPI Intensity*: cumulative number of days with each NPI.
 - More intensive toward the West.

What Were the Economic Effects of NPIs?



NPI Intensity Across 43 U.S. Cities

Figure from [Correia, Luck, and Verner \(2020\)](#) using data from [Markel et al. \(2007\)](#)

What Were the Economic Effects of NPIs?

Correia, Luck, and Verner (2020)

- Health effects:
 - NPIs flattened the mortality curve.
 - High NPI cities: 45% ↓ in peak mortality relative to the mean.
- Is there a trade-off between economic and health effects?
 - Positive effects: mitigates transmission and lowers mortality.
 - Negative effects: short-run economic disruptions while in place.

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- Is there a trade-off between economic and health effects?
 - Positive effects: mitigates transmission and lowers mortality.
 - Negative effects: short-run economic disruptions while in place.
- Impact of NPIs on city-level economic activity.
 - Manufacturing employment (1904, 1909, 1914, 1919–1927).
 - Total national bank assets (1910–1925, annual frequency).

What Were the Economic Effects of NPIs?

- Dynamic difference-in-differences specification:

$$Y_{ct} = \alpha_c + \tau_t + \sum_{j \neq 1914} \beta_j NPI_c \mathbb{1}_{j=t} + \sum_{j \neq 1914} X_c \gamma_j \mathbb{1}_{j=t} + \varepsilon_{ct}$$

- α_c : city FE; τ_t : year FE.
- X_c : city-level pre-pandemic population and employment controls.

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- Control for pre-treatment differences which relationship with outcomes might have changed over time.
- Faster growing cities (West) were more likely to implement NPIs.

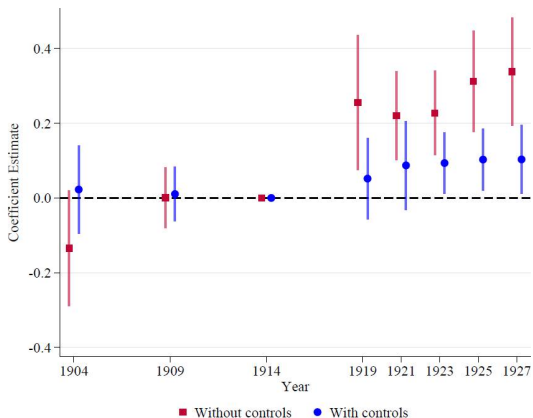
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- Discussions of pre-trends: [Lilley et al. \(2020\)](#) [Correia et al. \(2020\)](#)

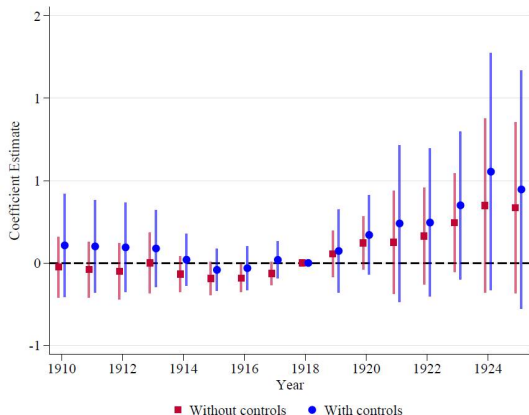
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NPI Intensity and log manufacturing employment

Figure from [Correia, Luck, and Verner \(2020\)](#)

What Were the Economic Effects of NPIs?



NPI Intensity and log national bank assets

Figure from [Correia, Luck, and Verner \(2020\)](#)

What Were the Economic Effects of NPIs?

- Little evidence for negative economic effects of NPIs.
- NPIs did not disrupt economic activities (no business closures).
- If anything, positive effects: through mitigating pandemics?
- Highly dependent on context e.g., deadly to prime-age workers.

Were There Scarring Effects of Influenza?

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Almond (2006)

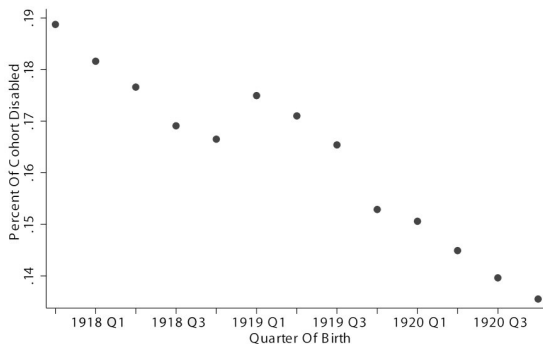
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- Long-run scarring effects through in utero exposure (“fetal origins”)?
- Socioeconomic outcomes in 1960–1980 depending on birth quarter.
- Long-lasting compared to adjacent cohorts:
 - Disability rates.
 - Human capital accumulation.
 - Income level.

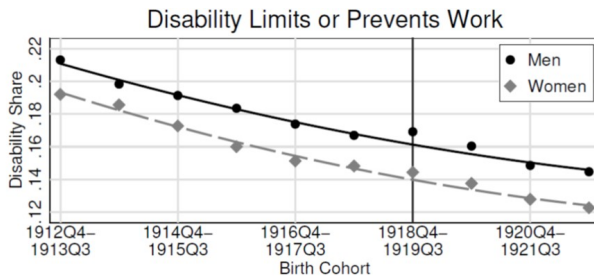
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1980 Male Disability Rates by Quarter of Birth

Figure from [Almond \(2006\)](#)

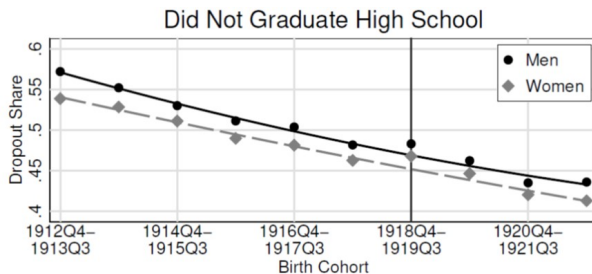
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1970 Disability Rates by Year of Birth

Figure from Beach, Clay, and Saavedra (2020) using results from Almond (2006)

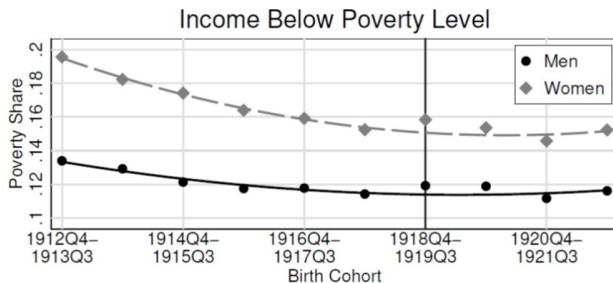
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1970 High School Dropout Rates by Year of Birth

Figure from [Beach, Clay, and Saavedra \(2020\)](#) using results from [Almond \(2006\)](#)

Were There Scarring Effects of Influenza?



1970 Poverty Rates by Year of Birth

Figure from [Beach, Clay, and Saavedra \(2020\)](#) using results from [Almond \(2006\)](#)

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 - Resources reallocation toward healthier siblings. [Parman \(2015\)](#)
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- Comparative evidence for Taiwan, Japan, Sweden, Switzerland, Brazil. [Lin and Liu \(2014\)](#) [Ogasawara \(2017\)](#) [Helgeretz and Bengtsson \(2019\)](#) [Neelsen and Stratmann \(2012\)](#) [Guimbeau et al. \(2020\)](#)

Other Influenza Effects

- Fertility:
 - Drop in fertility during, baby boom after (e.g., Norway, Sweden).
Mamelund (2004) Boberg-Fazlic et al (2017)
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- Migration
 - Increased internal mobility (e.g., India)? [Donaldson Keniston \(2016\)](#)

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⇒ For economic effects, the Great Depression more useful.

Lessons from Great Depression of the 1930s

Scarring Effects of the Great Depression?



The Great Depression in the U.S.

Figure from Moulton (2017). Lebergott vs Darby: workers in government sponsored work programs considered unemployed.

Scarring Effects of the Great Depression?

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Scarring Effects of the Great Depression?

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- Labor market entry scarring. [Moulton \(2017\)](#)
 - Assess long-term impact of entering labor market in 1929–1930.
 - Cohorts 1911–1920.
 - RDD: compare entering before/after 1930 of 8th graders.
 - Running variable: birth year with cutoff = 1916 assuming entry at 14.
 - Outcome: income in 1940 census.

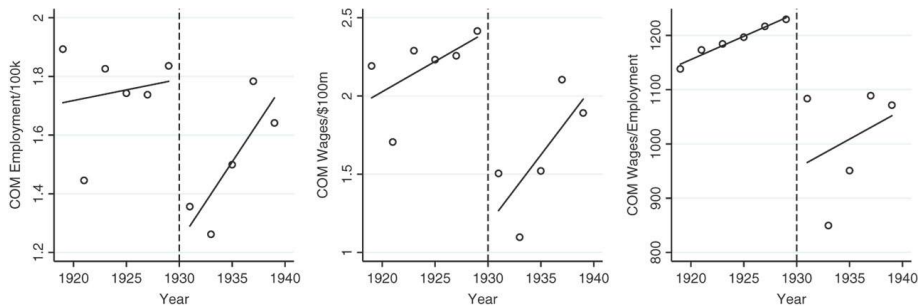
Scarring Effects of the Great Depression?

- RD specification:

$$Y_{isc} = \alpha + \beta_1 D_{isc} + \beta_2 \text{dist_1916}_{isc} + \beta_3 \text{dist_1916}_{isc} \times D_{isc} + BPL_s + \varepsilon_{isc}$$

- D_{isc} : $\mathbb{1}(\text{birth_year}_{isc} \geq 1916)$.
- dist_1916_{isc} : $\text{birth_year}_{isc} - 1916$.
- BPL_s : birth state FE.
- β_1 : discontinuity of entering labor market in 1929 vs 1930.
- β_2 : trend in relationship between Y and birth year.
- β_3 : differences in trends across cutoff.

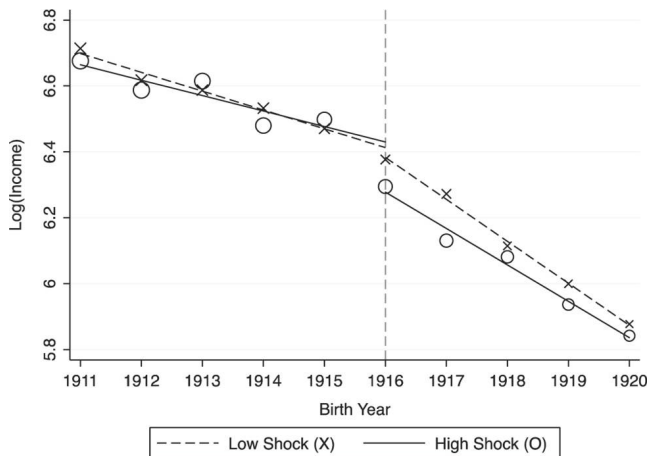
Scarring Effects of the Great Depression?



Discontinuity in labor market conditions

Figure from [Moulton \(2017\)](#).

Scarring Effects of the Great Depression?



Regression discontinuity of log(income).

Figure from Moulton (2017).

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 - Limited options to borrow and prolonging education.
 - Little evidence of differences in educational attainment.
 - Different to today.

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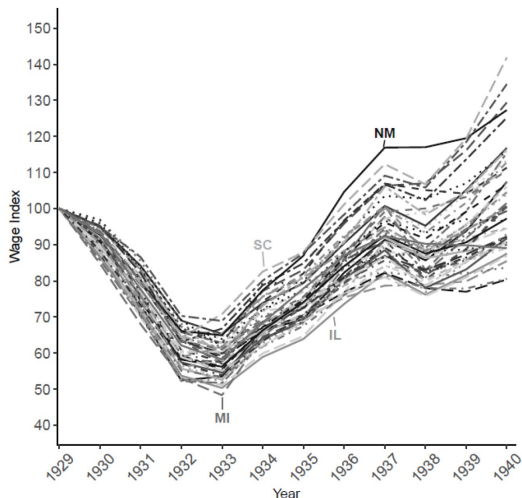
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 - Little evidence of differences in educational attainment.
 - Different to today.
- Occupational and residential displacement of younger cohorts.
[Arthi, Eriksson, and Richardson \(2020\)](#)
- Small silver-lining: move to later dynamic sectors.

Scarring Effects of the Great Depression?

Duque and Schmitz (2023)

- Instead of labor market entry scarring, look at in utero up to age 16.
- Compare individuals exposed to varying levels of economic shocks in their childhood years.
- Measurement of shock: state-year wage index while in utero.
- Use longitudinal data from Health and Retirement Study (1992–2018): 7k individuals born 1929–40 with information on health, education, earnings, labor, and childhood environment.

Scarring Effects of the Great Depression?



Variation in the Wage Index across states (1929–40)

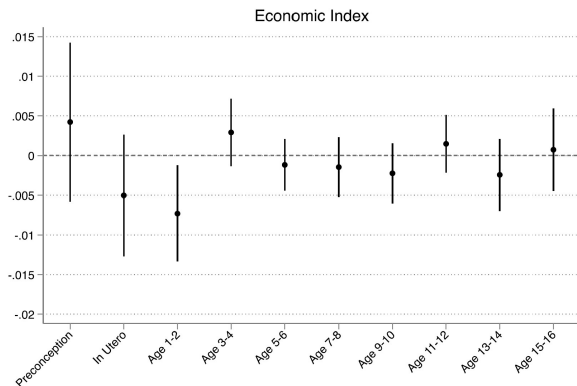
Scarring Effects of the Great Depression?

- Difference-in-differences specification with leads and lags.

$$Y_{isrct} = \alpha + \sum_{t=-3}^{T=16} \beta_t \text{Wages}_{sc} + X_i' \delta + Z_{sc} + \theta_s + \eta_c + \lambda_t + \gamma_{rc} + \varepsilon_{isc}$$

- Y_{isrct} : 50+ year old outcome of individual i born in state s , region r , year c , observed in year t in HRS.
 - Wages_{sc} : wage index at state and year level for age t of individual i .
 - X_i : individual characteristics (gender, age, maternal education, rural, father present).
 - Z_{sc} : pre-1930 state characteristics (infant mortality, maternal mortality, farmland) interacted with birth year FE.
 - θ_s : state FE. η_c : birth year FE. λ_t : HRS year FE.
- Assess effect of economic conditions throughout childhood with placebo leads (pre-birth).

Scarring Effects of the Great Depression?

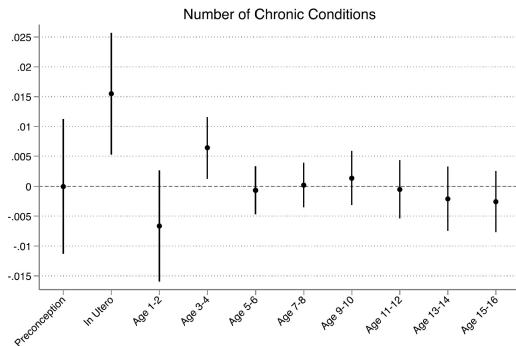


Effect of wage index on economic index

- Later-life economic outcomes negatively affected by economic conditions when 0–2.
- Magnitude: $\downarrow 1$ SD economic conditions when 0–2 $\implies \downarrow 0.1$ SD economic outcomes when 50+.

Figure from [Duque and Schmitz \(2023\)](#).

Scarring Effects of the Great Depression?



Effect of wage index on number of chronic disease conditions

- Later-life health outcomes negatively affected by economic conditions when in utero.
- Magnitude: \downarrow 1 SD economic conditions when in utero \implies \uparrow 0.15 SD health outcomes when 50+.

Figure from [Duque and Schmitz \(2023\)](#).

Scarring Effects of the Great Depression?

- Other results:
 - Economic effects driven by lower probability of professional job and age of retirement.
 - Earnings effects especially after age 50.
 - Health effects stronger the older people get (70s vs 60s).
 - Survival rates also lower.

Scarring Effects of the Great Depression?

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 - Health effects stronger the older people get (70s vs 60s).
 - Survival rates also lower.
- Mechanisms (using census data 1940–90 for 1929–40 cohorts):
 - Lower family income and home ownership rates.
 - Lower education (high school completion).
 - No effect through migration.

Scarring Effects of the Great Recession?

- Another historical case: 2007–2012 Great Recession.

Scarring Effects of the Great Recession?

- Another historical case: 2007–2012 Great Recession.
- No long-run perspective, but some evidence (US). [Rothstein \(2020\)](#)
 - 2009–2015 entrants have 2–3% lower employment rates compared to pre-crisis entrants.
 - Only 2009 entrants have lower earnings (2%).
 - Employment scarring permanent, wage scarring temporary.
 - Employment break for entrants began in 2005.

⇒ If health-economy trade-off, especially acute in current context.

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⇒ How will these interact?
 - Scarring effects for young children (school closures, distancing, masks)?
 - Consequences for gender inequality, esp. working mothers?