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TSE M1 Economic History (2021)

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Economic History

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University of Toulouse 1 Capitole

Toulouse School of Economics

Institute for Advanced Study in Toulouse

M1, Semester 1, 2021



Toulouse
School of
Economics

Plan of the Course

10 sessions of 1 hour and 30 minutes:

- S1–S2 Introduction: what is economic history?
- S3–S4 Modern economic growth in historical perspective
- S5 Institutions and modern economic growth
- S6 A culture of growth
- S7 Directed technical change
- S8 Pandemics in history
- S9–10 Environment and the Industrial Revolution

Topic 1

What is economic history?

Plan of the Session

- Does the past have useful economics?
- Methodological issues in economic history
- (Short) Intellectual history of economic history

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 \(2019\)](#)

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 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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Trevelyan (1942)

“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.

More and Better Economic Facts

- 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.

More and Better Economic Facts

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 - Penn World Tables: real GDP PPP 182 countries since 1950.
 - Maddison project database: real GDP since 1000.

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

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 - Maddison project database: real GDP since 1000.
- 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

Ruggles et al. (2015)

- Greatest accomplishment for empirical economics.
- 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.

More and Better Economic Facts

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- Full access to companies' records and manufacturing censuses.
- Populations: no anonymity rule.
 - USA: linked samples across censuses (IPUMS).
 - France: linked samples across vital records (TRA).

More and Better Economic Facts

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- Full access to companies' records and manufacturing censuses.
- Populations: no anonymity rule.
 - USA: linked samples across censuses (IPUMS).
 - France: linked samples across vital records (TRA).
- Access dramatically improved recently.

More and Better Economic Facts

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 - Existence of historical data.
 - Inaccuracies and measurement errors.

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 - Existence of historical data.
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 - But be creative and knowledgeable about the data production process.

More and Better Economic Facts

- 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)

- 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.

Better Economic Theory

- Obvious that economic history uses economic theory in Popperian sense (as all applied economics).
- The converse is less obvious but no less true.

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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.
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- 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.
- So read, read, read!

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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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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.

- 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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- Is economics like physics, true for all time, or are its laws historically conditioned?
- 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.

- Economic history to improve economic policy.

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).

Answer Big Questions

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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 (2020)

- 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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- Taxonomy of three primary motives for examining historical natural experiments:
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 - Natural experiments yielding general economic insights (cat. 2).
 - 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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 - Historical variation in public policies, historical human-made or natural events provide better sources of variation for identification (category 2).

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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 2020).

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Learn About Historical Episodes: Challenges

- Critique of “looking under the lamppost.”
 - Only study component of episode exhibiting useful identifying variation.
 - 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 arrival of new information on stock prices: use variation in wind delaying boats between England and Amsterdam as a source of variation in arrival of information (Koudijs 2016).
 - 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 slave trade: Nunn (2008) uses distance to major slave-receiving ports as IV for intensity of slavery.
 - 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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- Spatial correlation when persistence is underestimated (Kelly 2019).

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- Causally linking past to present is subject to historical contingency:
 - Especially salient when little data around the experiment: challenges to the exclusion restriction.
 - A lot of work is needed along the causal chain.
- Spatial correlation when persistence is underestimated (Kelly 2019).
- Bias toward persistence. When and why does history not persist?

Methodological issues in economic history

Methodological Issues in Economic History

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

Economics versus history

Blum and Clovin (2018) Chap 1.

- Interdisciplinary field: between economics and history.

Economics versus history

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- Traditional history:
 - Focus on the particular, explain individual events, outliers.
 - No counterfactual thinking.
 - Attributes cause and effect through timing.

Economics versus history

Blum and Clovin (2018) Chap 1.

- Interdisciplinary field: between economics and history.
- 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

- Bad economics is purely deductive:
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 - Reasoning from premises to reach logical conclusions.
 - Might rely on stylized facts, but might generate self-referential systems with little explanatory power.
- 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 and Clovin (2018) Chap 44

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

Measurement and historical data

Blum and Clovin (2018) Chap 44

- Measurement and source criticism is fundamental:
 - Right measure and level of aggregation.
 - Data generated how, by whom, for what?
 - 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 Clovin (2018) Chap 45

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

Econometric Identification

Blum and Clovin (2018) Chap 45

- 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.

- Deep institutional knowledge essential for credibility of identification.

Econometric Identification

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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.

Blum and Clovin (2018) Chap 49

- 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)

Blum and Clovin (2018) Chap 49

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 - 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)
- 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.

Geographic Information Systems (GIS)

- 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.

(Short) Intellectual history of economic history

Diebolt and Hauptert (2018)

- The economic history discipline
- The New Economic History or the Cliometric Revolution
- Bibliometric approach to Cliometric Revolution

The Economic History Discipline

- Formal discipline of economic history:
 - Germany mid-19th (Gustav Schmoller). Developing states.
 - UK late-19th (John Clapham). Social concerns for working class.
 - Method: narration with little quantitative data.

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 - UK late-19th (John Clapham). Social concerns for working class.
 - Method: narration with little quantitative data.
- Methodological debates with economics of late 19th century:
 - Economics: inductive vs deductive.
 - Economic history: against deductive theories of classical economics.
 - Aim: develop theories inductively with little generalizations.
 - Method: narratives and comparative.

The Economic History Discipline

- Early 20th century:
 - Some successes: LSE (UK), Annales School (France).
 - Failure: formal and deductive approach in economics (Marhsall, Edgeworth).

The Economic History Discipline

- Early 20th century:
 - Some successes: LSE (UK), Annales School (France).
 - Failure: formal and deductive approach in economics (Marhsall, Edgeworth).
- After WWI: economics and economic history closer.
 - Economic history in America
 - The National Bureau of Economic Research (NBER)
 - The Economic History Association (EHA)

Economic History in America

- Long tradition of interest in historical data.
- American Statistical Association created in 1839: compiling time series data.
- Courses in economic history at Harvard since 1880s.
- Many founders of EH: Dunbar, Ashley, Gay (Edwin).
- Chairs in economic history early 20th century.

The National Bureau of Economic Research (NBER)

- Gay and Mitchell: economic theories are not immutable laws, but depend on context and evolve over time.
- Helped found NBER in 1921.
- Gather tremendous empirical data on business cycles.
- Goal: use data about America since 1870s for theoretical generalizations.

⇒ NBER helped shift EH from narrative to quantitative.

The Economic History Association (EHA)

- In the 1930s, mathematical approach dominated economics.
- For fear of extinction, EHA created in 1940.
- E. Gay (first president) in “The Task of Economic History” (1941) calls for reunification of economic history and economics.
- Among the main institutional actors in EH since then.
- Journal: *Journal of Economic History*.

The New Economic History or Cliometrics

- Cliometrics: use of techniques of modern economic theory to frame historical questions, influence hypotheses about the past, suggest data to be collected from archives.
- Advocate for rigorous testing of hypotheses through econometrics.
- With advances in computing and statistics, quantitative analysis possible.

The New Economic History or Cliometrics

- Infancy: joint EHA-NBER conference 1957.
- Manifesto through two articles: Conrad and Meyer (1957, 1958).
 - “Economic Theory, Statistical Inference, Economic History” (*JEH*).
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 - Reinterpretation of economics of slavery. Fogel and Engerman (1974)
 - Stature as a measure of well-being. Fogel (1986)

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 - Stature as a measure of well-being. Fogel (1986)
- Institutional economics: Douglass North (Nobel 1993).

The New Economic History or Cliometrics

- New approach: combination of measurement and theory.
- New techniques: econometrics and counterfactual approach.
- New method: use of hypothetico-deductive models.
- New datasets: bigger data, OCR, GIS.

⇒ The Cliometric Revolution

Cioni, Federico, and Vasta (2020)

- Capture cliometric revolution in top 3 EH journals:
 - *Economic History Review (EHR)*.
 - *Journal of Economic History (JEH)*.
 - *Explorations in Economic History (EEH)*.

Bibliometric Approach to Cliometric Revolution

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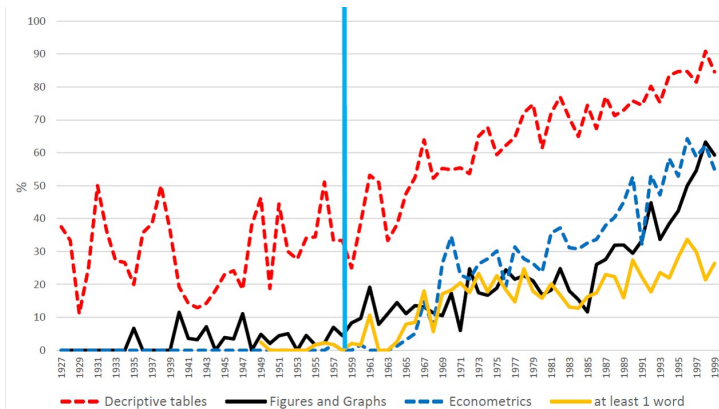
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⇒ Cliometric Revolution across journals and countries, but slow.

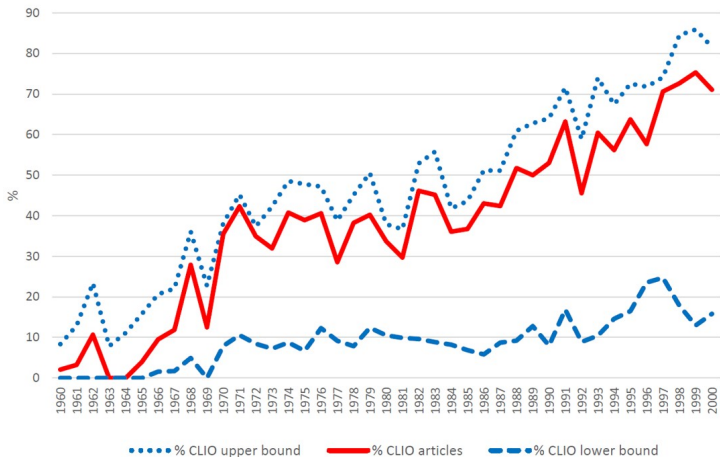
Bibliometric Approach to Cliometric Revolution



Use of theory and quantitative tools in top-3 EH journals

Figure from Cioni, Federico, and Vasta (2020)

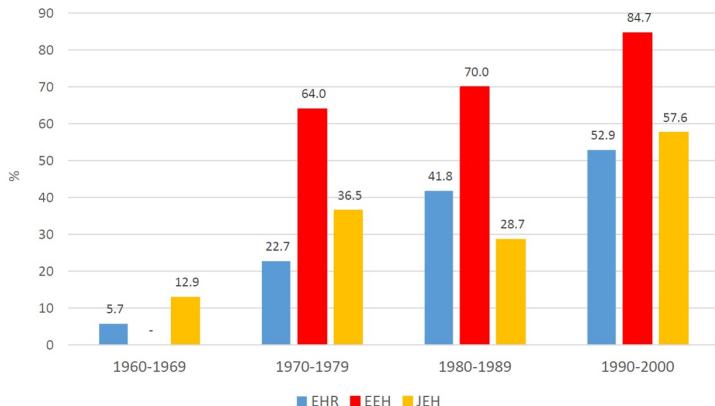
Bibliometric Approach to Cliometric Revolution



Use of either theory or quantitative tools in top-3 EH journals

Figure from Cioni, Federico, and Vasta (2020)

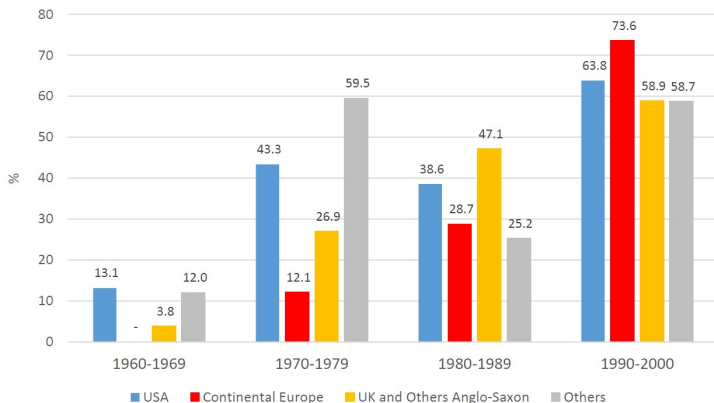
Bibliometric Approach to Cliometric Revolution



Share of cliometric articles by journal

Figure from Cioni, Federico, and Vasta (2020)

Bibliometric approach to Cliometric Revolution



Share of cliometric articles by country of affiliation

Figure from Cioni, Federico, and Vasta (2020)

Conclusion

- The integration of economic history into economics over time.
Margo (2018)
 - Economic historians and economists use the same (econometric) language.
 - Publication histories of successive cohorts are similar.
 - Pace of convergence was slow.

Conclusion

- The integration of economic history into economics over time.
Margo (2018)
 - Economic historians and economists use the same (econometric) language.
 - Publication histories of successive cohorts are similar.
 - Pace of convergence was slow.
- Still relatively small field within economics (5–8% top-journals).
- Difficult field: master two disciplines, interdisciplinarity.

Topic 2

Modern economic growth in historical perspective

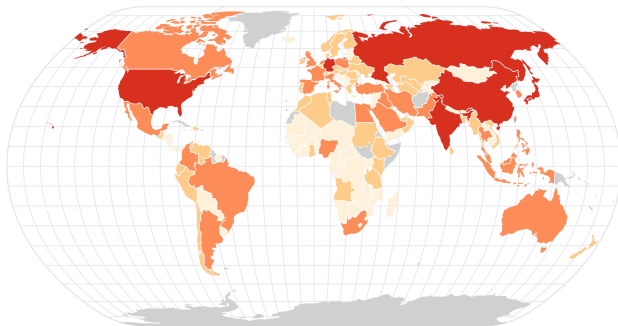
Plan of Session

- Current cross-country differences in income
- GDP: definition and measurement
- Economic growth and income differences
- Long-run growth: the Great and the Little Divergences
- Britain and modern economic growth
- Overview of deep roots of modern economic growth

Current cross-country differences in income

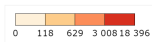
Current Cross-Country Differences in Income

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



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

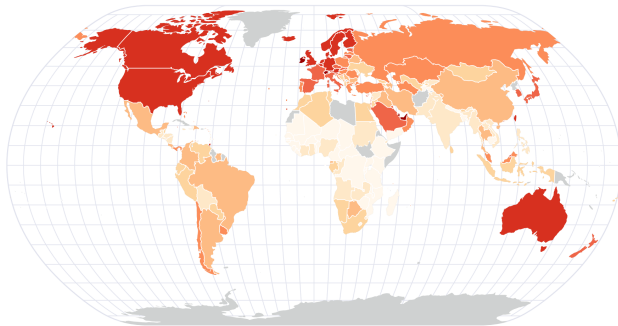
basemap from Natural Earth (CC0) - Penn World Table



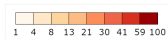
Made with Khartis

Current Cross-Country Differences in Income

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



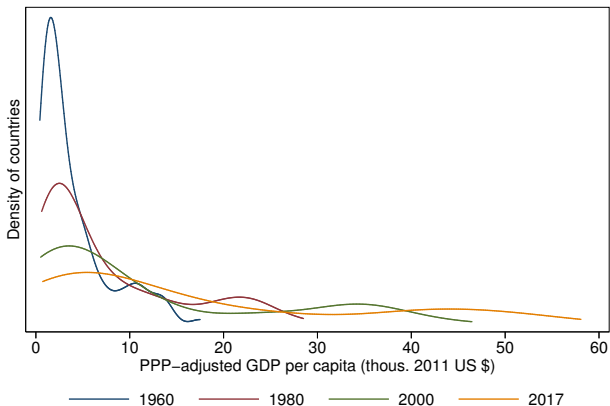
USA = 56. CHN = 13. FRA = 41. NGA = 4.
basemap from Natural Earth (CCO) - Penn World Table 9.1



Made with Khartis

Current Cross-Country Differences in Income

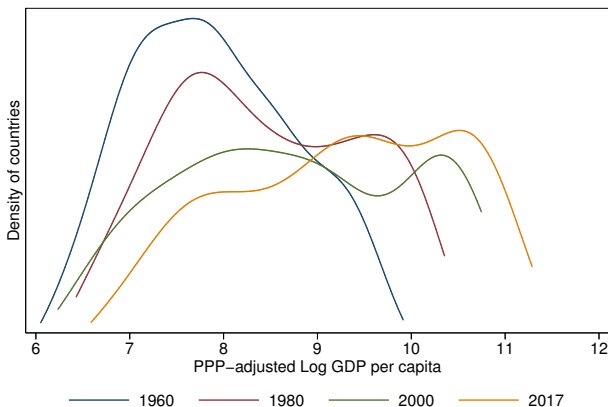
Distribution of Countries: GDP per Capita



Source: Penn World Table 9.1, 110 countries.

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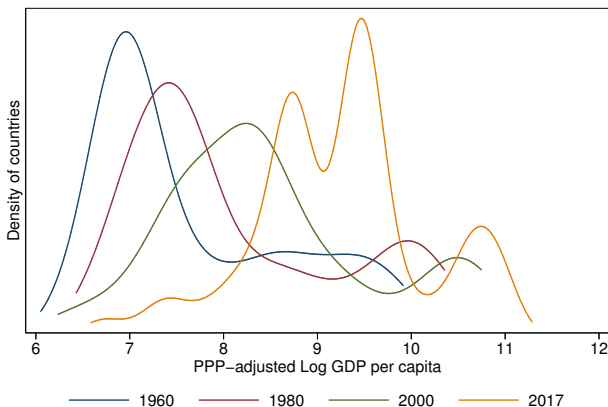
Distribution of Countries: Log GDP per Capita



Source: Penn World Table 9.1, 110 countries.

Evolution of Cross-Country Differences in Income

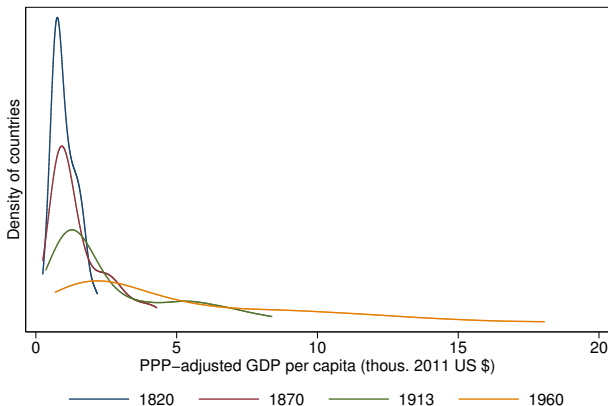
Population-Weighted Distribution of Countries: Log GDP per Capita



Source: Penn World Table 9.1, 110 countries.

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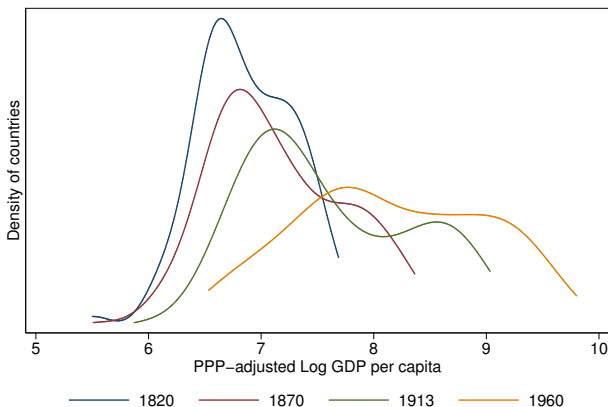
Distribution of Countries: GDP per Capita



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 9.1](#).
- Reference paper: [Feenstra, Inklaar and Timmer \(2015\)](#).
- GDP, consumption, TFP measures.
- PPP-adjusted, constant prices (2011 US \$) \implies comparability.
- 182 countries, 1950–2017, 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: definition and measurement

GDP: Definition and Measurement

- Definition
- A distorted picture
- Income and welfare
- Measuring historical GDP

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

- 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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⇒ 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

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- 1 GDP per capita matters.

A Distorted Picture of Reality

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

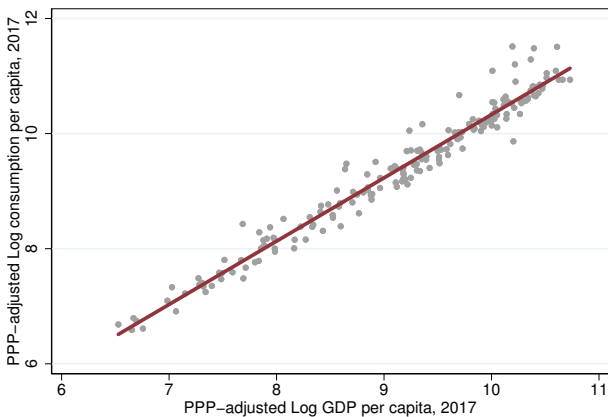
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- ③ Many things that contribute to wealth are not measured:

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.

Income and Welfare

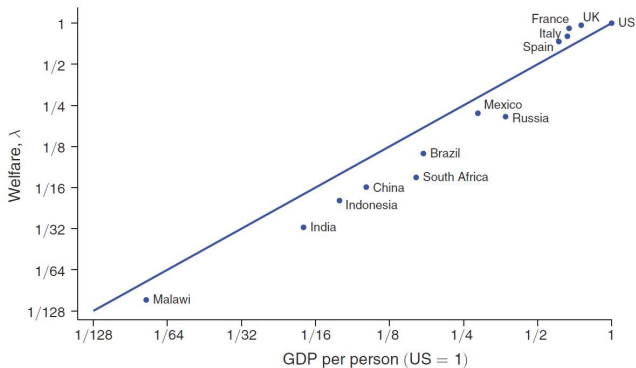
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France vs USA in 2005

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

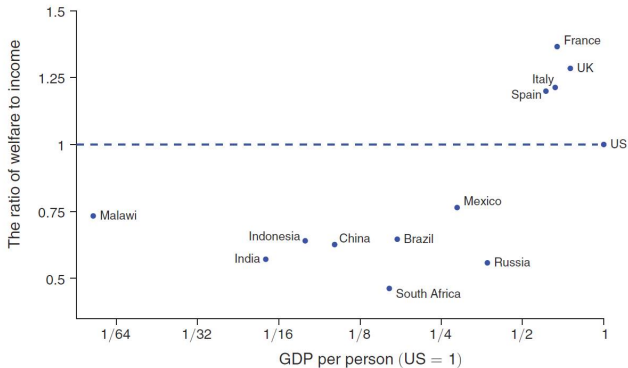
Income and Welfare

Welfare and income are correlated at 98%



Income and Welfare

Welfare differs from income by about 35%



Measuring historical GDP

Broadberry (2020) Crafts and Woltjer (2021)

- Historical national accounting
- Methods for data-abundant nations
- Methods for data-scarce nations
- Data reliability

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.

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.

Historical National Accounting

- 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 .

⇒ How to estimate Y ?

- Maddison's (2001) *The World Economy: A Millennial Perspective*.
- Result of 50 years of research.
- Maddison (2010) Online database.
- Maddison Project: extends Maddison work.

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.

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- Broadberry et al. (2015) *British Economic Growth, 1270–1870*
 - Agricultural output.
 - Industrial output.
 - Service sector output.

Britain Agricultural Output

- Three databases:
 - Medieval Accounts: manorial accounts.
 - Early Modern Inventories: inventories of Church.
 - Modern Farm Accounts: sample of farmers accounts.

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- Convert output into current prices, weights for real output index.

Britain Industrial Output

- Many databases:
 - Wool and woolen cloth: detailed export records.
 - Iron: capacity of blast furnaces.
 - Tin: receipts of coinage dues.
 - Construction: cathedral building, housebuilding (population).
 - Book production: titles listed by British Library.

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 - Book production: titles listed by British Library.
- Use series to build industrial production index.

Britain Services Sector Output

- Broken down into subsectors:
 - Commerce: trade, freight transport, financial services.
 - Housing and domestic services: rate of population.
 - Government: revenues.

- Putting it together:
 - Combine output series with sectoral weights.
 - Use price series to convert into nominal series.
 - Create a chained index of GDP.
 - Divide by population to estimate GDP per capita.

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- Attempts from income side, but changes in working hours (“industrious revolution” 1700–1820).

Methods for Data-Scarce Nations

- Rely on modelling and proxies.

Methods for Data-Scarce Nations

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- Estimate agricultural output through consumer theory. [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.

- Real consumption per capita (log-linear):

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

- 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.

- Homogeneity condition (by total differentiation):

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

Methods for Data-Scarce Nations

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- Values from developing countries:
 - $\alpha_1 = -0.6$.
 - $\alpha_2 = 0.1$.
 - $\implies \beta = 0.5$.

- 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

Reliability grade	Margin of error	Average margin
A. Firm figures	$< 5\%$	$\pm 2.5\%$
B. Good figures	$\pm 5\text{--}15\%$	$\pm 10\%$
C. Rough estimates	$\pm 15\text{--}25\%$	$\pm 20\%$
D. Conjectures	$> 25\%$	$\pm 40\%$

Source: Broadberry (2020) based on Feinstein (1972)

Data Reliability Grades

Country	Series	Grade
Netherlands	1347–1510	C
	1510–1650	B
	1650–1750	A
	1750–1807	B
China	Northern Song (980–1120)	B
	Ming (1400–1620)	B
	Qing (1690–1840)	A

Source: Broadberry (2020) based on van Zanden and van Leeuwen (2012) and Broadberry, Guan and Li (2018)

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

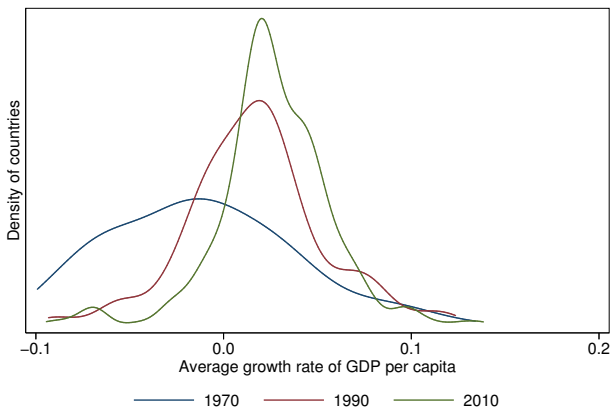
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- Suppose $g_A = 2\%$ and $g_B = 0\%$.
 - After 100 years, A 7 times richer than B.
 - After 200 years, A 52 times richer than B.
- How long to:
 - double GDP? $\log 2 / \log(1 + g)$. If $g = 2\%$, then 35 years.
 - decuple GDP? $\log 10 / \log(1 +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

Economic Growth and Income Differences

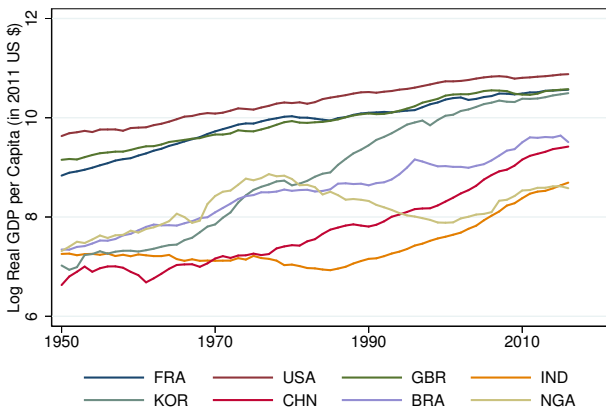
Distribution of GDP per Capita Growth Rates



Source: Penn World Table 9.1

Economic Growth and Income Differences

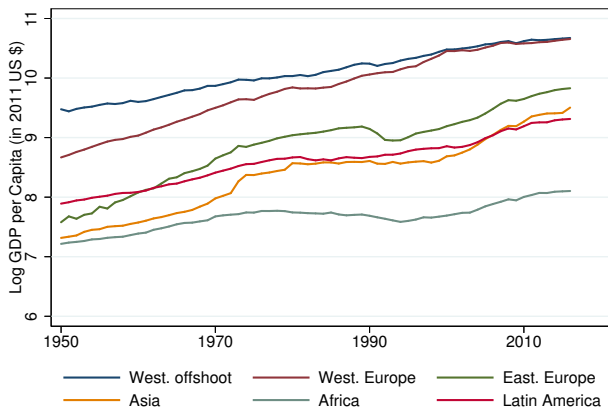
Evolution of Income per Capita across Countries



Source: Maddison Project Database 2018.

Economic Growth and Income Differences

Evolution of Income per Capita across Continents



Source: Maddison Project Database 2018.

Long-run growth: the Great and the Little Divergences

Broadberry (2020) Court (2020)

- Comparisons over time and space
- Europe's Little Divergence
- Asia's Little Divergence
- The Great Divergence

⇒ New estimates enable to revise past views from e.g., Maddison (2001)

Comparisons Over Time and Space

- Comparisons over time:
 - Inflation rates make output value change.
 - Convert all values into 1990 monetary units.

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 - Nominal exchange rates fluctuate independently of local prices.
 - Purchasing power parity (PPP) between two currencies: ratio of prices of same basket of goods.
 - Accounts for price and expenditure weights differences across countries

⇒ International weights: 1990 Geary-Khamis international dollars

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⇒ International weights: 1990 Geary-Khamis international dollars

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

Issues with Historical GDP Estimates

Blum and Clovin (2018) chap 46

- Within countries:
 - Deflation issues: changing baskets of goods over time.
 - Heterogeneous sources: systematic and changing biases.

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- ⇒ Current issues with measurement relevant for HGDP estimates.

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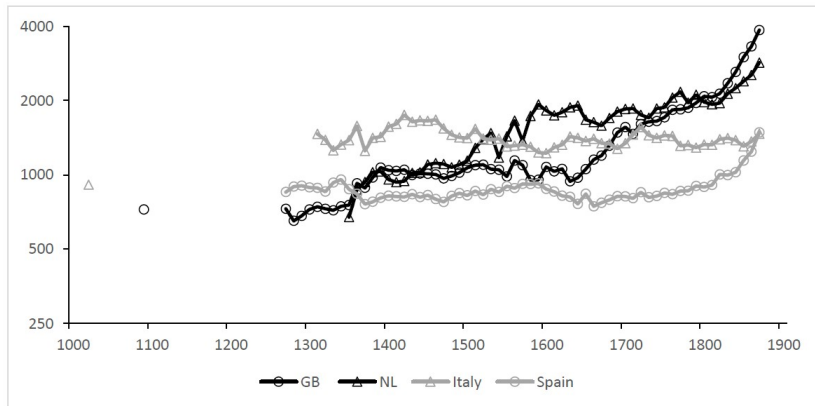
⇒ Current issues with measurement relevant for HGDP estimates.

- 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.

Europe's Little Divergence

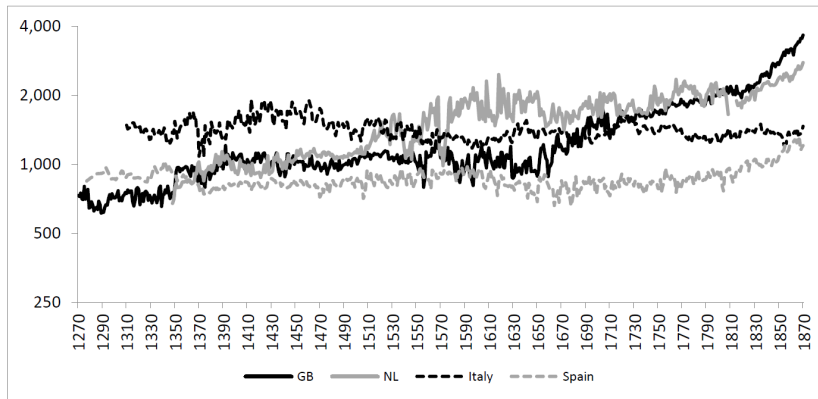
GDP per Capita in Europe, 1270–1870 (1990 GK\$, Log scale)



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).

Europe's Little Divergence

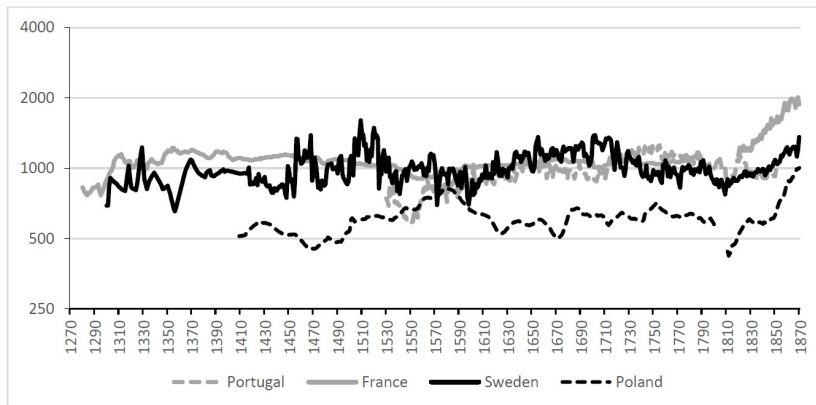
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Source: Broadberry (2020) based on Broadberry et al. (2015), van Zanden and van Leeuwen (2012), Malanima (2011), and Alvarez-Nogal and Prados de la Escosura (2013).

Europe's Little Divergence

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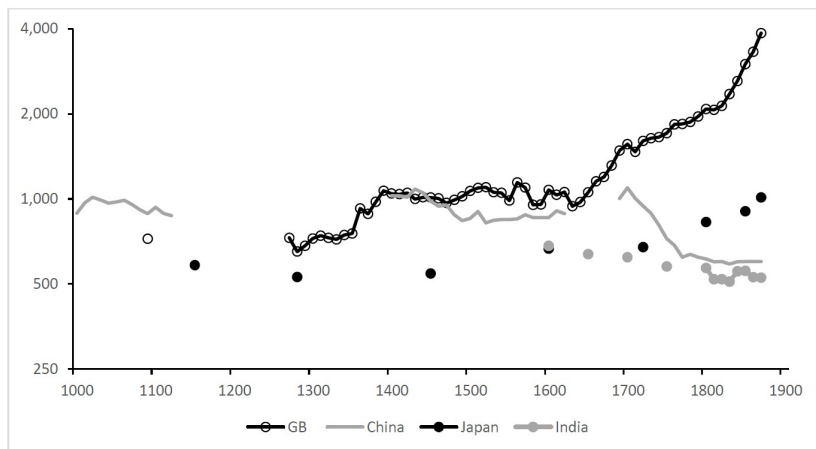
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⇒ Europe's Little Divergence (North-West vs rest) circa 1500

Asia's Little Divergence

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



Source: Broadberry (2020) 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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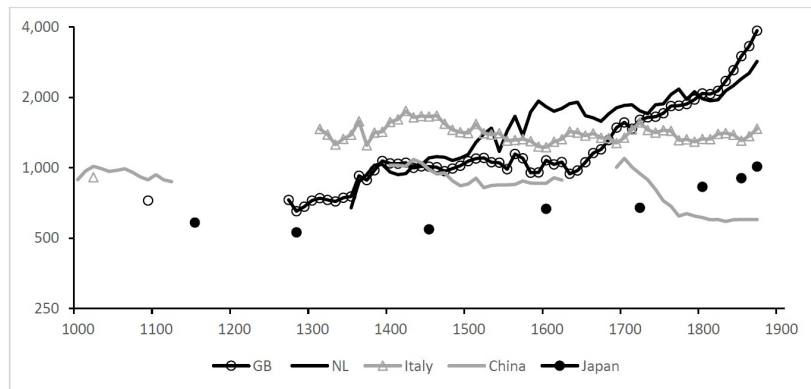
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⇒ Asia's Little Divergence (Japan vs China) circa 1700

The Great Divergence

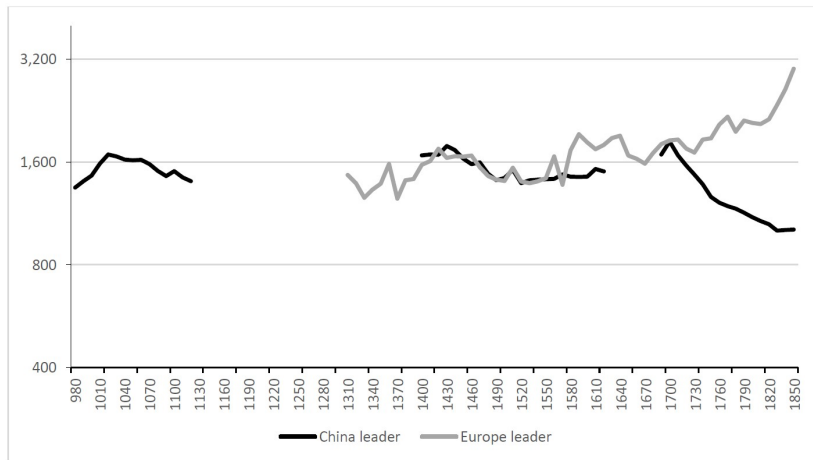
GDP per Capita in Europe and Asia, 1000–1870 (1990 GKI\$, Log scale)



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).

The Great Divergence

- Year 1000:
 - Leadership of China at \$1,000.
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⇒ The Great Divergence (Europe vs Asia) circa 1700

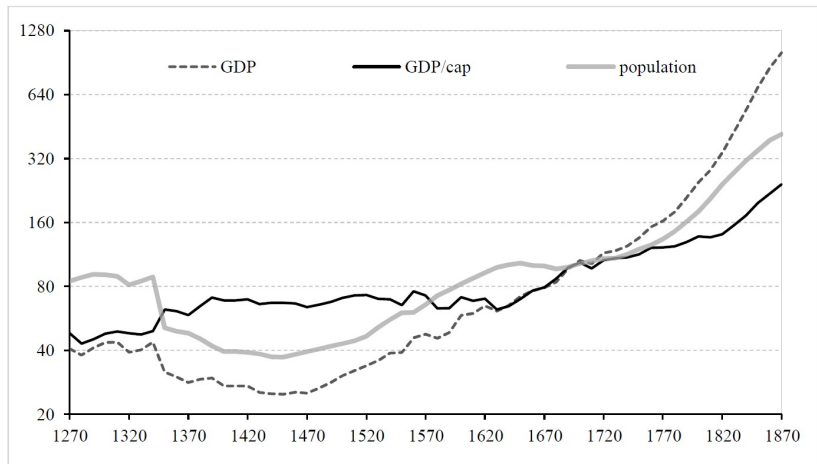
Britain and modern economic growth

Broadberry (2020)

- British economic growth in long-run perspective
- Characteristics of modern economic growth
- Why did Britain industrialize first? An overview

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

British Economic Growth in Long-Run Perspective

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 - GDP per K plateau.
 - Population recovers.

British Economic Growth in Long-Run Perspective

- Post-Civil War (1650s–1700):
 - Population stagnation.
 - Strong GDP and GDP per K growth.

British Economic Growth in Long-Run Perspective

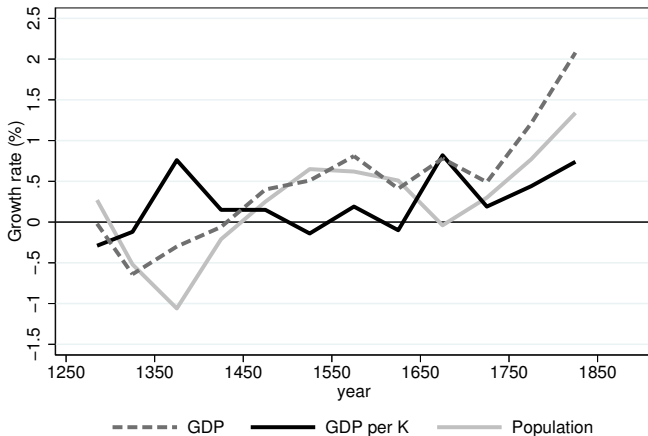
- Post-Civil War (1650s–1700):
 - Population stagnation.
 - Strong GDP and GDP per K growth.
- Industrial Revolution (1700–1850s):
 - Population growth resumes.
 - GDP per K growth positive.
 - Growth positive, stable, no shrinking.

Revising 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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 - Structural change: shift from agriculture to industry and services.

Broadberry and Wallis (2017)

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Broadberry and Wallis (2017)

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 - Short run rate of growing has **declined** over time.
 - Frequency of growing has increased

Growing and Shrinking Decomposition

- Periods of growth T_g over period of T years (e.g., 50):
 - Frequency of growth: $\text{freq}_g = T_g/T$.
 - Average rate of growth when growing: $\bar{g}_g = \sum_{T_g} g_{t_g} / T_g$.

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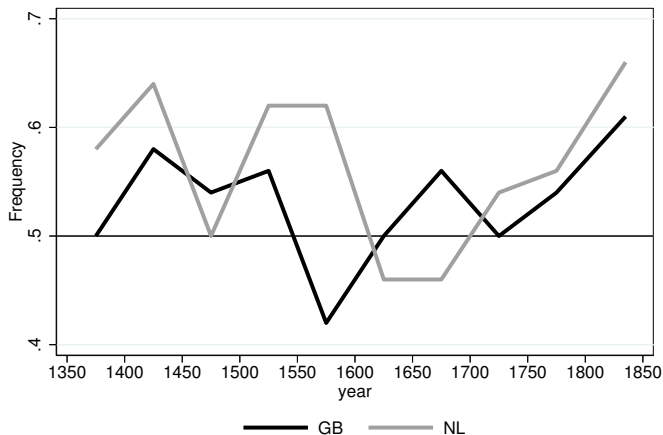
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- Decompose long-run growth g over T years as:

$$g = \underbrace{\text{freq}_g \bar{g}_g}_{\text{contribution of growing}} + \underbrace{\text{freq}_s \bar{g}_s}_{\text{contribution of shrinking}}$$

Growing and Shrinking

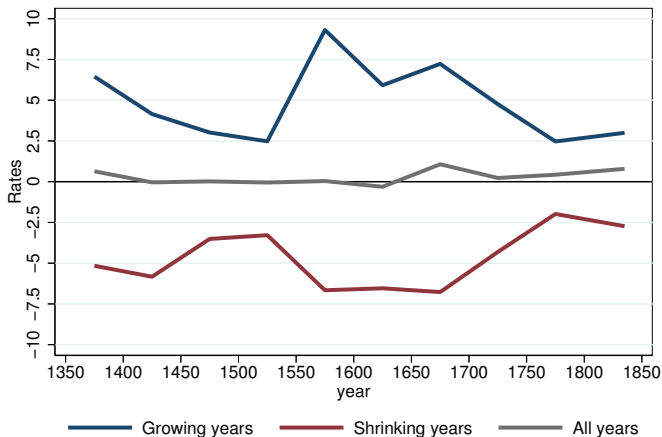
Annual frequency of growing of GDP per capita (50-years averages)



Source: Broadberry and Wallis (2017).

Growing and Shrinking

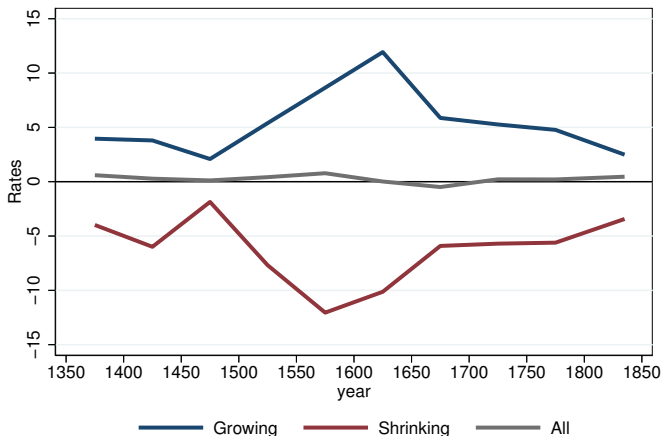
Average growing and shrinking annual rates Great Britain (50-years averages)



Source: Broadberry and Wallis (2017).

Growing and Shrinking

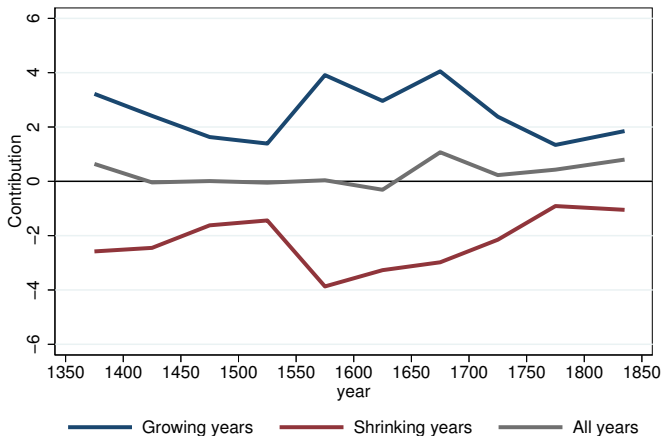
Average growing and shrinking annual rates Netherlands (50-years averages)



Source: Broadberry and Wallis (2017).

Growing and Shrinking

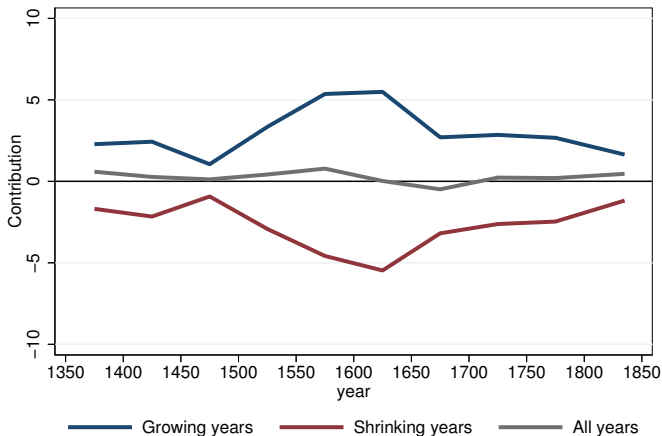
Average contributions of growing and shrinking to growth Great Britain (50-years averages)



Source: Broadberry and Wallis (2017).

Growing and Shrinking

Average contributions of growing and shrinking to growth Netherlands (50-years averages)



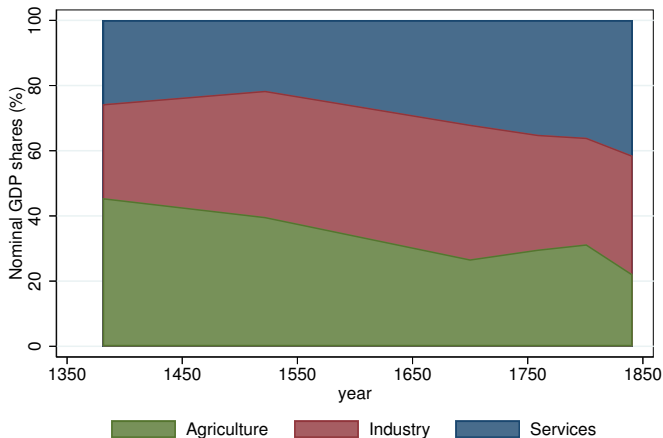
Source: Broadberry and Wallis (2017).

Growing and Shrinking

- Frequency: fluctuations around 50% before 1800.
- Rates: growing and shrinking rates move together.
- 18th-century GB: both rates low, but growing $>$ shrinking.
- Modern growth: not increased growing, but reduced shrinking.
- We will re-interpret main explanations in this light.

Structural Change in Britain

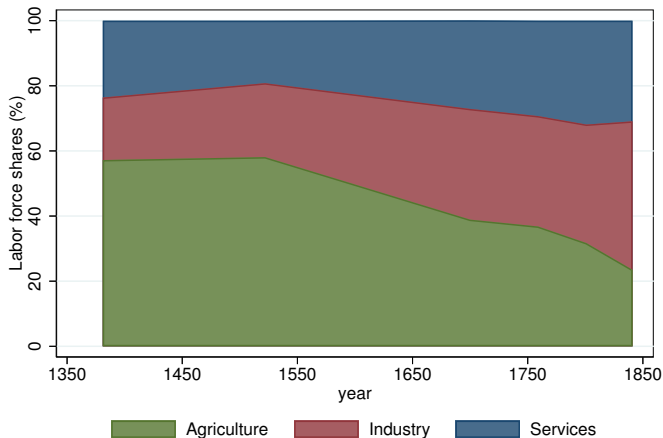
Sectoral Shares in Nominal GDP in England (1381–1700) and Great Britain (1700–1870)



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).

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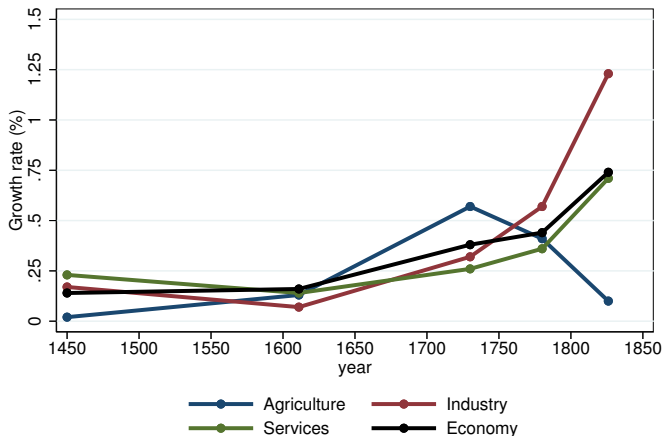
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- As early as 1381, agriculture for less than half of GDP and labor.
- Until 1800, agriculture is the low productivity sector.
- During IR, industry increases share slower than services due to declining industrial prices.
- Shift of labor from agriculture to industry occurred before 1759.

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

Structural Change in Britain

Sectoral Annual Average Productivity Growth Rates in England (1381–1700) and Great Britain (1700–1870)



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

Why did Britain industrialize first? An overview

Why Did Britain Industrialize First? An Overview

⇒ The “Holy Grail” of economic history

- Overview of main answers for British exceptionalism (1700–1850).
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
- Fundamental difficulties

- North and Weingast's long-standing argument.
 - Balance of power between sovereign and society through Parliament.
 - Secured property rights.
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 - 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.

Factor Prices and Technological Change

- Robert Allen's view:
 - High wages, cheap capital and resources (coal).
 - Relative factor prices \implies High demand for innovation.
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Factor Prices and Technological Change

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 - Profitable to mechanize and substitute machines for labor.
- But debated measurement problem (only proxies cost of labor):
 - 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.
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- But very little evidence of link between EMP and growth.

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 - Food: sugar mostly, tea and coffee.
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- 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.
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 - 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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- Applies to the Great Divergence:
 - Warfare and inter-state competition due to land and political fragmentation.

Topic 3

Institutions and modern economic growth

Plan of the Session

- Defining institutions
- Constitutions and commitment
- Long-run empirical evidence

Defining institutions

North (1990, 1991)

“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.
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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.
- Rational-theoretic approach:
 - Importance of theory of selection of institutions.
 - Selection through centralized (bargaining) or decentralized (evolutionary competition) process.

Defining Institutions

- Examples:
 - Property rights.
 - Functioning markets.
 - Contractual opportunities.

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Defining Institutions

- Examples:
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- 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.

Defining Institutions

Greif and Kingston (2011)

- Some disagree with rational-choice approach to 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.

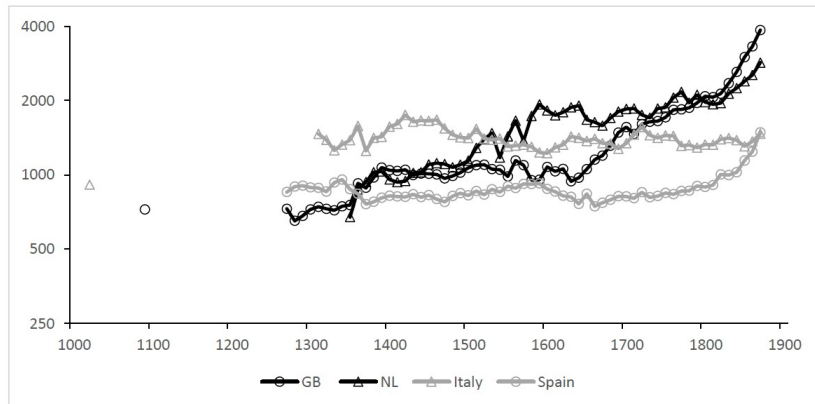
Constitutions and commitment

Constitutions and Commitment

- Historical context
- Constitutions and commitment
- Criticism

Historical Context: Industrial Revolution in Britain

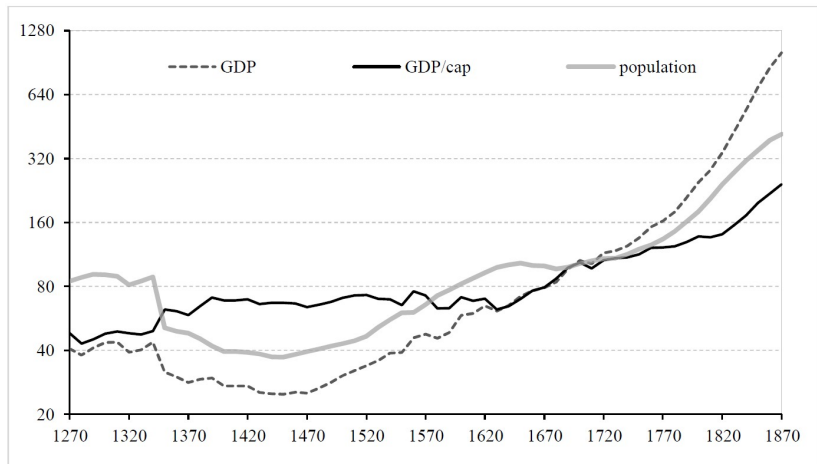
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 - Conflict between monarchy (Charles I) and Parliamentarians.
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 - Parliament prevailed, setting up Commonwealth (Cromwell).
- Instability \implies Charles II restored by Parliament 1660.
- 1680s: James II reestablish Crown supremacy over Parliament.
- Glorious Revolution of 1688.
 - Parliament overthrow 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.

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 - Achieving this goal \implies strong state.
 - But this implies risk of predation by the state.
- High expropriation risk \implies no incentive 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.
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 - But as returns grow, so do incentives to renege and expropriate.
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- ⇒ Sovereign must make credible commitment.

Constitutions and Commitment

- Two ways to solve commitment problem.

Constitutions and Commitment

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- 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

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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.

Constitutions and Commitment

- 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.

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 - 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

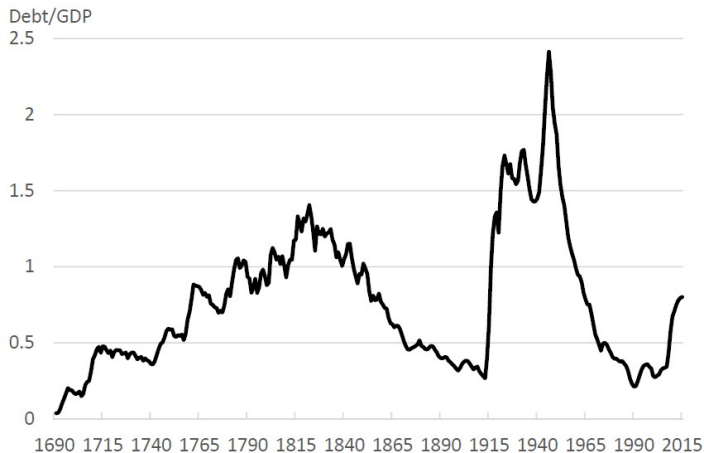
Constitutions and Commitment

- 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

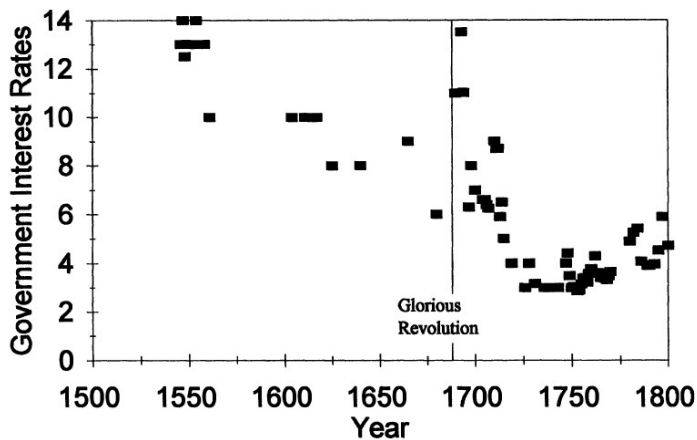
Government Debt to GDP for Britain (1691–2015)



Source: Steinsson (2020) based on Barro (1987) and Thomas and Dimsale (2017).

Constitutions and Commitment

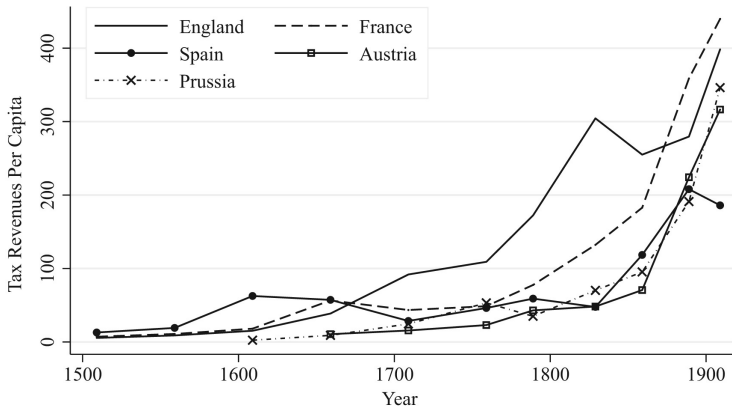
Interest Rates on Government Debt in England



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.

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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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 - Strong Parliament with representatives of each Seven Provinces (16th–18th centuries).
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 - After the miracle, stagnation post 1670.

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⇒ 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.

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 - Enforcing contracts (enables resource allocation to best use).

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Long-run empirical evidence

Long-Run Empirical Evidence

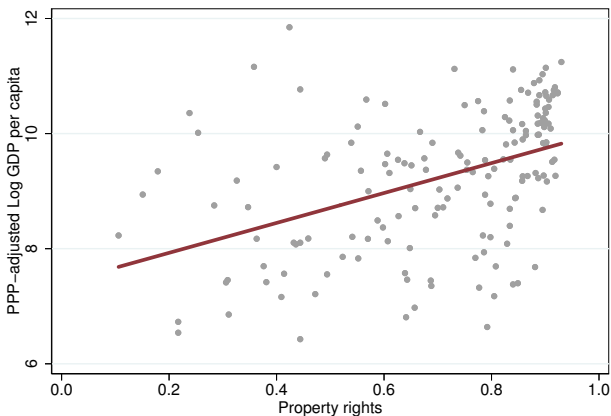
- Do institutions matter for long-run development?
- Extremely difficult question due to endogeneity.

Long-Run Empirical Evidence

- Do institutions matter for long-run development?
- 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 \(2001\)](#)

Correlations Between Institutions and Development

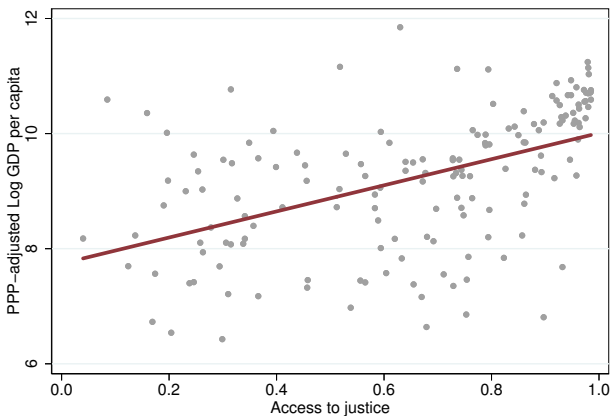
Log GDP per Capita and Property Rights, 2016



Source: V-Dem 9, Maddison Project Database 2018, 160 countries.

Correlations Between Institutions and Development

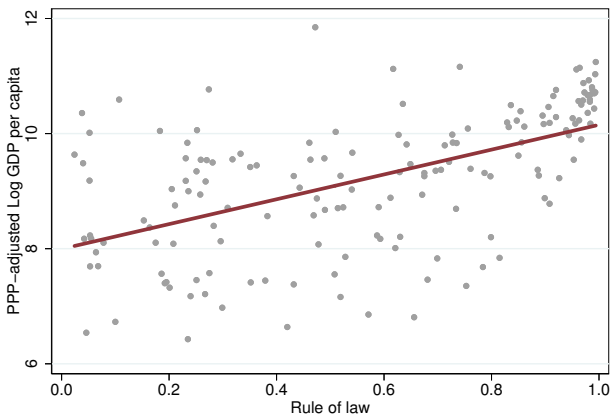
Log GDP per Capita and Access to Justice, 2016



Source: V-Dem 9, Maddison Project Database 2018, 160 countries.

Correlations Between Institutions and Development

Log GDP per Capita and Rule of Law, 2016



Source: V-Dem 9, Maddison Project Database 2018, 160 countries.

Correlations Between Institutions and Development

$$Y_{cy} = \alpha + \beta X_{cy} + \varepsilon_{cy}$$

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
2016	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.

Data Source: Varieties of Democracy

- Best cross-country institutions data source: [V-Dem](#).
- 450+ indicators, 81 indices, 202 countries, 1789–2018.
- Consistent coding, extremely complete.
- Vastly superior to alternatives.

Data Source: Varieties of Democracy

- Property rights (v2xc1_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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- 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](#) (1973–2018).
- [Political Regimes](#) (1800–2015). [Boix et al. \(2012\)](#)
- [Word bank governance indicators](#) (1996–2017). [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. \(2013\)](#)

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.

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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Reversal of Fortune

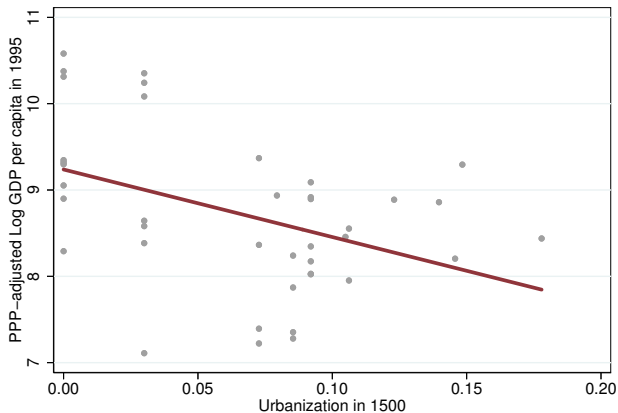
- Acemoglu, Johnson and Robinson (2002)
- Use colonization as a natural experiment to assess the causal impact of institutions on economic development.
- Question: richest ancient civilizations are today among poorest nations. Why?
- Document reversal of relative income among former colonies.
- Evidence 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.
 - Population density.
 - 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.

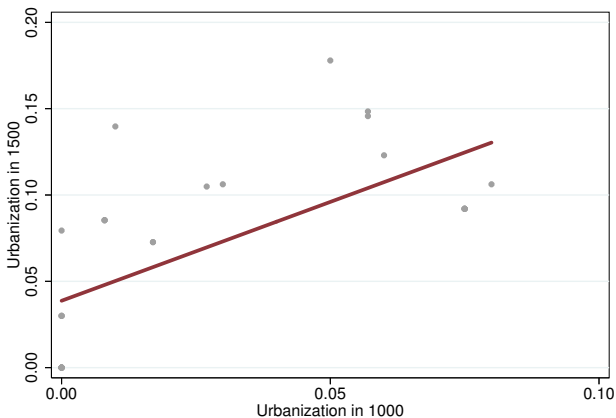
Reversal of Fortune

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: Timing

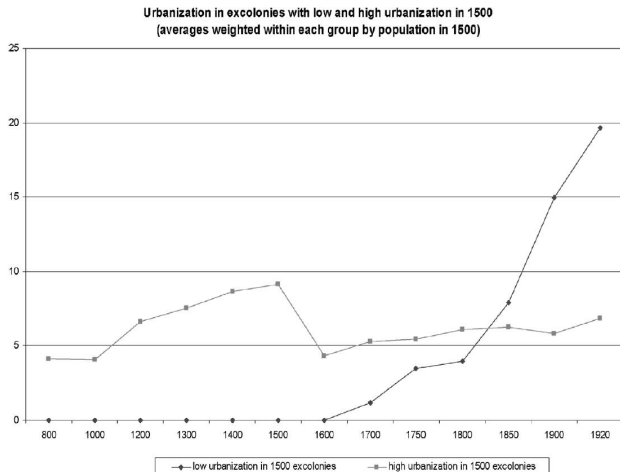
Urbanization in 1500 and 1000
Former European Colonies



Source: AJR (2002), 30 countries.

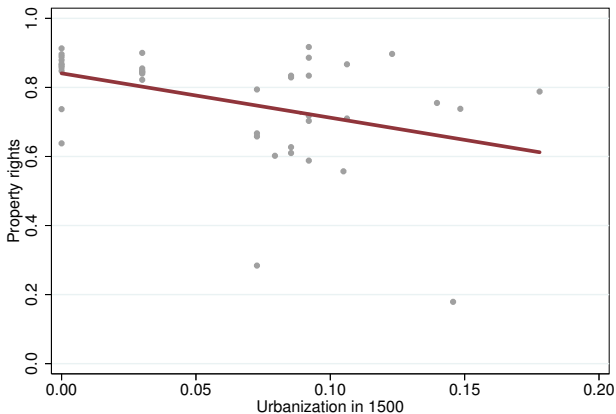
Reversal of Fortune: Timing

Evolution of Urbanization in Former European Colonies



Reversal of Fortune: Institutions

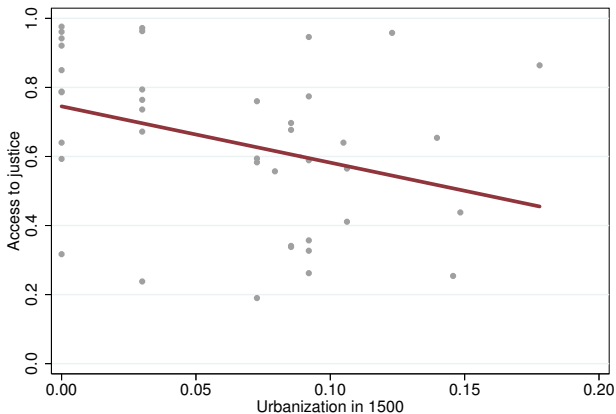
Urbanization in 1500 and Property Rights in 2016
Former European Colonies



Source: V-Dem 9, AJR (2002), 40 countries.

Reversal of Fortune: Institutions

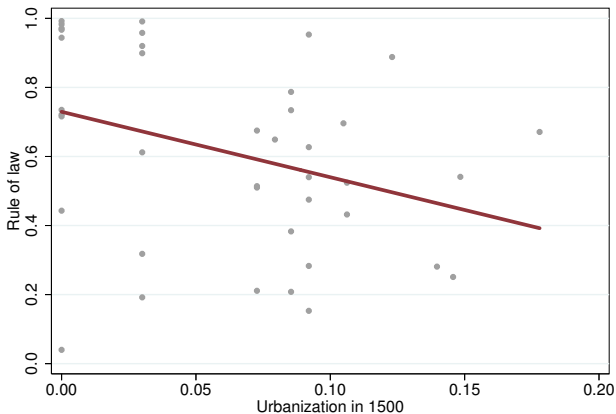
Urbanization in 1500 and Access to Justice in 2016
Former European Colonies



Source: V-Dem 9, AJR (2002), 40 countries.

Reversal of Fortune: Institutions

Urbanization in 1500 and Rule of Law in 2016
Former European Colonies



Source: V-Dem 9, AJR (2002), 40 countries.

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

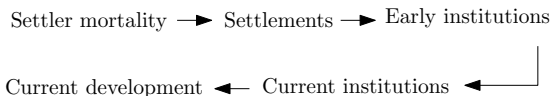
- Factors for choice of colonial institutions:
 - Economic profitability of extractive institutions.
 - Dense population \implies large supply of labor.
 - Pre-existing system of tax administration \implies continue.

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.

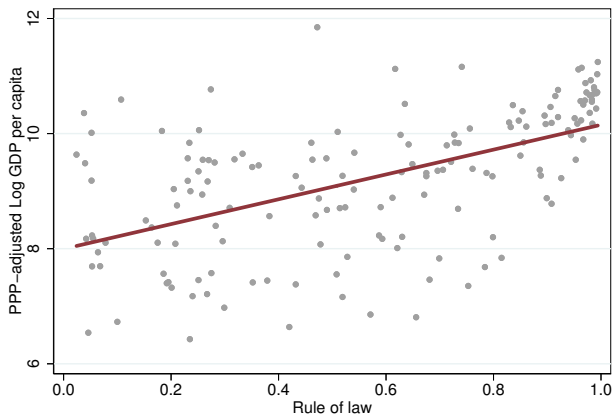
Colonial Origins

- 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, 2016. Causal?



Source: V-Dem 9, Maddison Project Database 2018, 160 countries.

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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$$\log y_i = \mu + \alpha R_i + \mathbf{X}'_i \gamma + \varepsilon_i$$

- 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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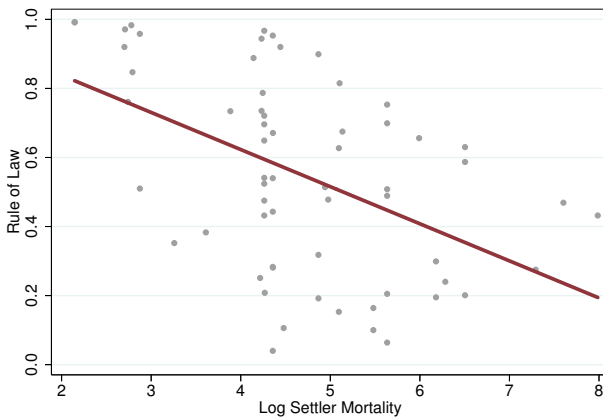
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- y : income per capita.
 - R : measure of institutions.
 - \mathbf{X} : controls.
 - M : settler mortality rate.
- Exclusion restriction: settler mortality only affect development through institutions.

Colonial Origins: First Stage

Settler Mortality and Rule of Law, 2016 Former European Colonies



Source: V-Dem 9, AJR (2001), 62 countries.

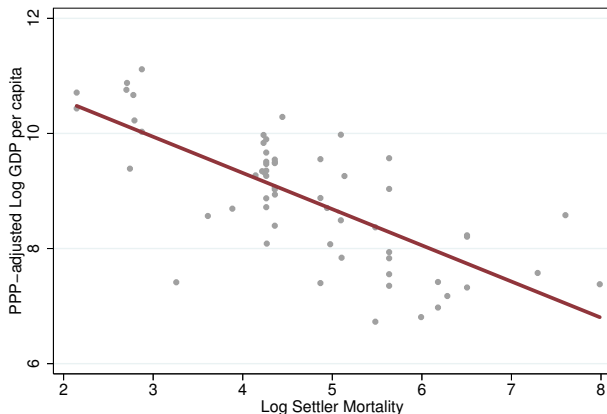
Colonial Origins: First Stage

Dependent variable:	Rule of Law in 2016			
	(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, 2016
Former European Colonies



Source: Maddison Project Database 2018, AJR (2001), 62 countries.

Colonial Origins: Reduced Form

Dependent variable:	Log GDP per Capita in 2016			
	(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 2016			
	(1)	(2)	(3)	(4)
Rule of Law in 2016	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.

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.
- 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.

Topic 4

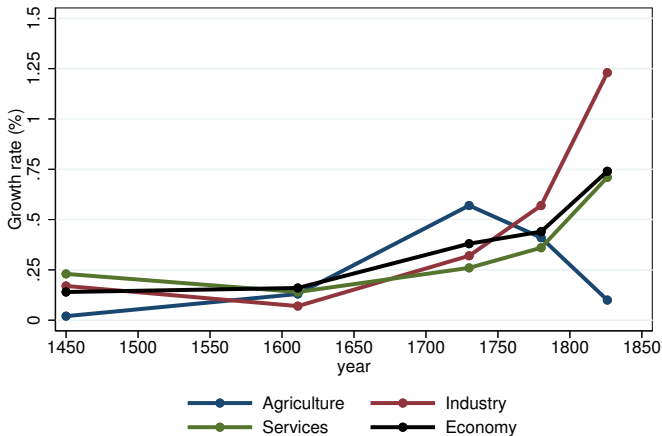
A culture of growth

Plan of the Session

- The Enlightenment
- The printing press
- Protestant prosperity

Productivity Growth in Britain

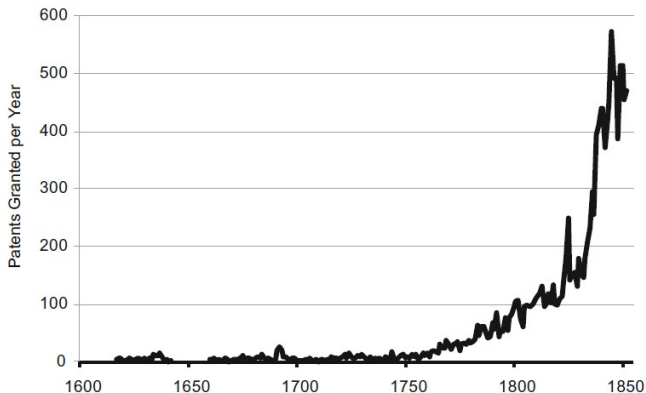
Sectoral Annual Average Productivity Growth Rates in England (1381–1700) and Great Britain (1700–1870)



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

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.

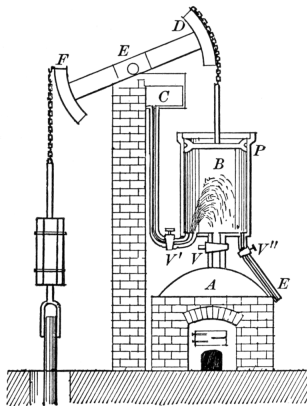
Important Innovations

Spinning jenny



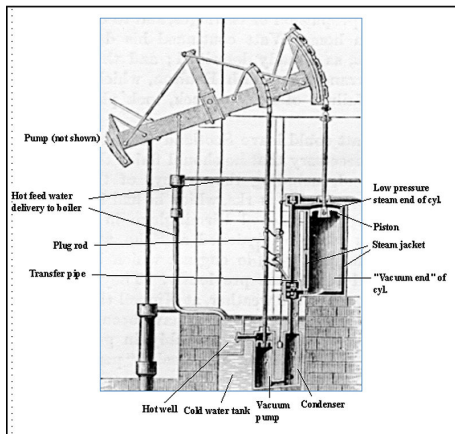
Important Innovations

Newcomen engine



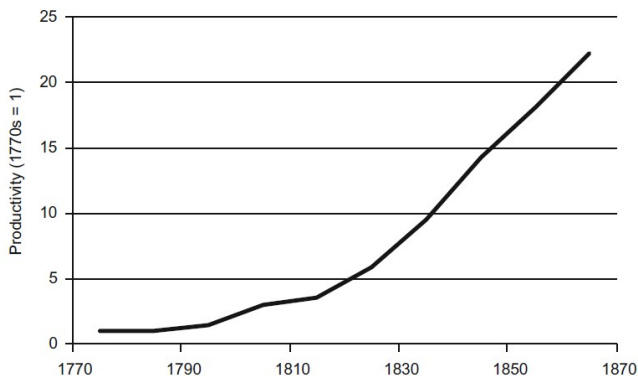
Important Innovations

Watt steam engine



Important Innovations

Cotton spinning and weaving productivity (1770–1869)



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

The Enlightenment

Mokyr (2009, 2016) 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 progress and empiricism?

Why Did It Not Occur Before?

Steinsson (2020), chap 2

- There were always thinkers before.

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Steinsson (2020), chap 2

- There were always thinkers before.
- 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

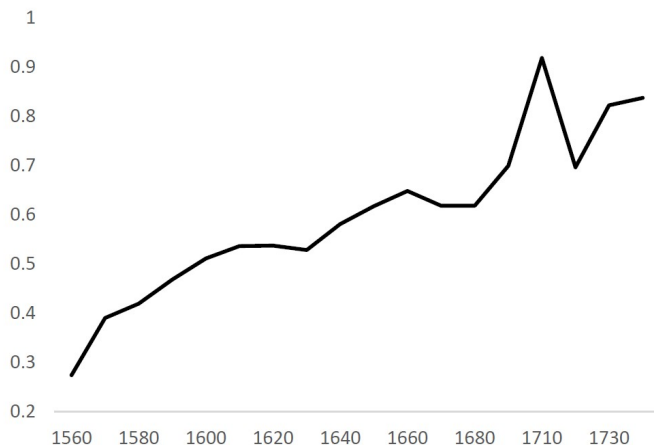
- Challenge 1: invented in China in 11th century.
 - Chinese characters: thousands of pieces to transport.
 - Not as useful invention for diffusion.
- Challenge 2: Industrial Revolutions occurred 300 years later.
 - Took time to weaken knowledge suppression forces.
 - Reformation (16–17th) precursor 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)

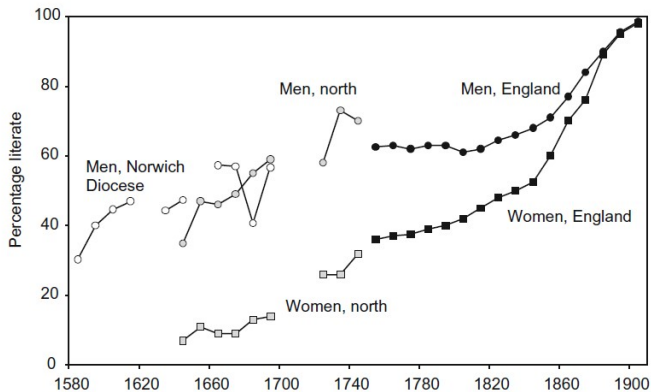


Literacy: fraction of witnesses who can sign ecclesiastical records or court depositions

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).

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
 - The Enlightenment
 - The Industrial Revolution
- ⇒ Let’s try to disentangle these empirically.

Becker and Woessmann (2009)

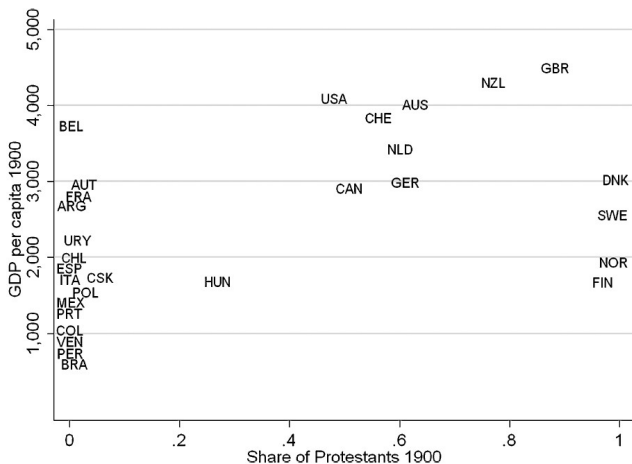
- “Was Weber wrong? A human capital theory of protestant economic history.”

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

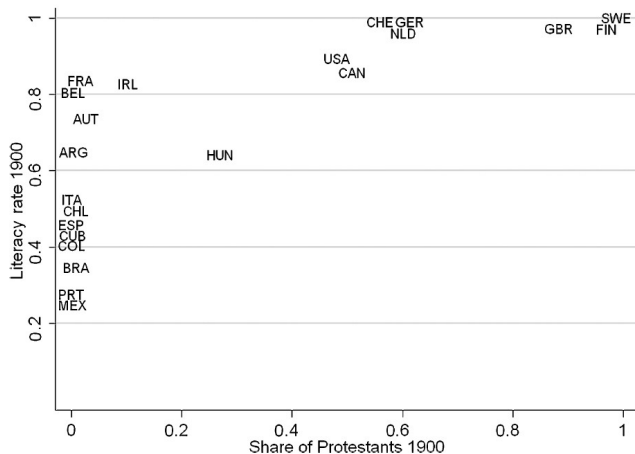
- Empirical test for Protestantism \implies prosperity:
 - Correlation: local prevalence of Protestantism and prosperity in 1900?
 - But omitted variable problem: other factors may cause both (e.g., literacy).

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

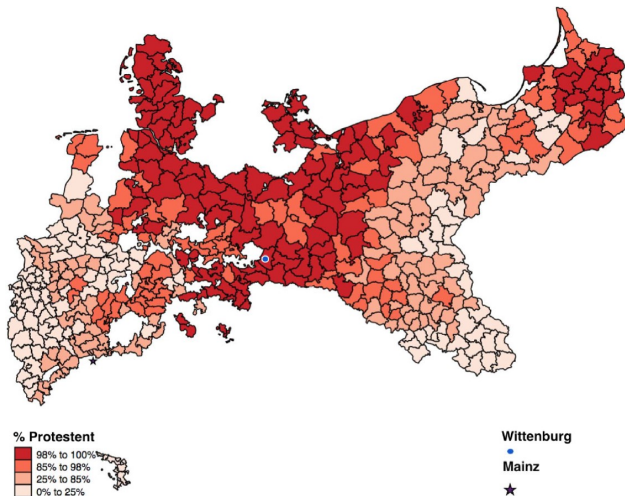
- Literacy as an instrument?
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- Distance to Wittenberg:
 - Relevance: more likely to adopt if more exposed to Luther ideas; travel and transmission of information was slow.
 - ⇒ The Reformation diffused from Wittenberg.

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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.

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Source: Steinsson (2020) based on Becker and Woessmann (2009).

- Each 100km is associated with ↓ 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.

Protestant Prosperity: Exogeneity

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- Instrument not correlated with observable economic characteristics prior to Reformation that may affect subsequent prosperity.
- Find proxies for economic or educational development.

$$Y_i = \alpha + \beta \text{DIST}_i + \mathbf{X}'_i \gamma + \varepsilon_i$$

- 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.

Protestant Prosperity: Exogeneity

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).

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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?

$$\text{PROSP}_i = \alpha + \beta \text{DIST}_i + \mathbf{X}'_i \gamma + \varepsilon_i$$

- PROT_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.

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Source: Steinsson (2020) based on Becker and Woessmann (2009).

- Each 100km is associated with ↓ 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.
 - ↑ 1 s.d. DIST \implies ↓ 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.

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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

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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?

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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).

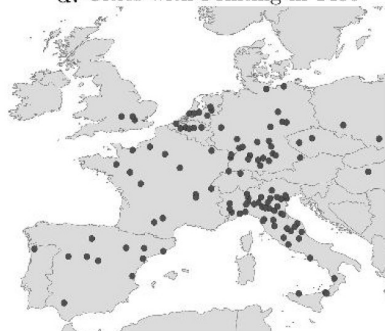
Protestant Prosperity: Mechanisms

The diffusion of the movable type printing press

c: Cities with Printing in 1470



d: Cities with Printing in 1480

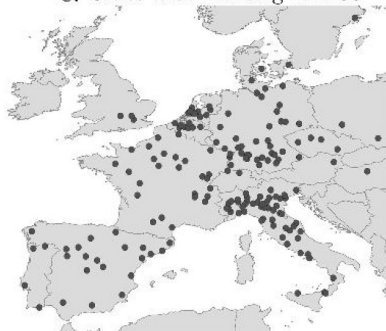


Source: Dittmar (2011).

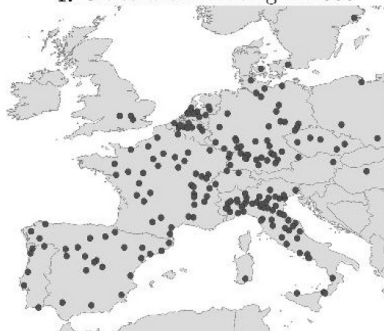
Protestant Prosperity: Mechanisms

The diffusion of the movable type printing press

e: Cities with Printing in 1490



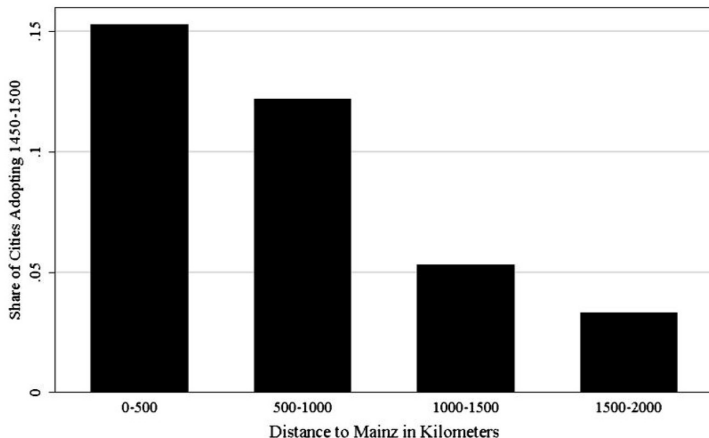
f: Cities with Printing in 1500



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)

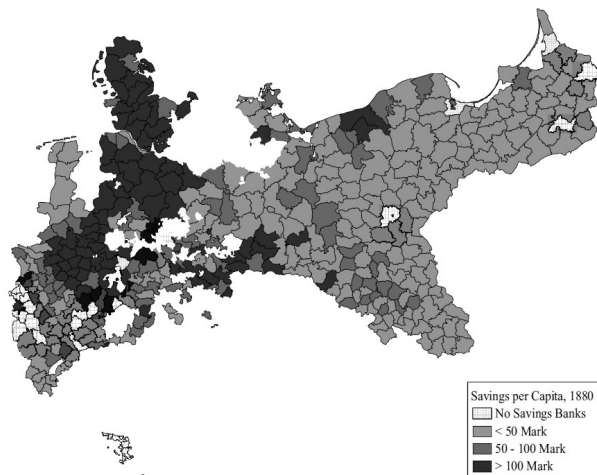
- The role of savings \implies accumulation of capital.
- The role of differences between ethnic groups as confounding factor.

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

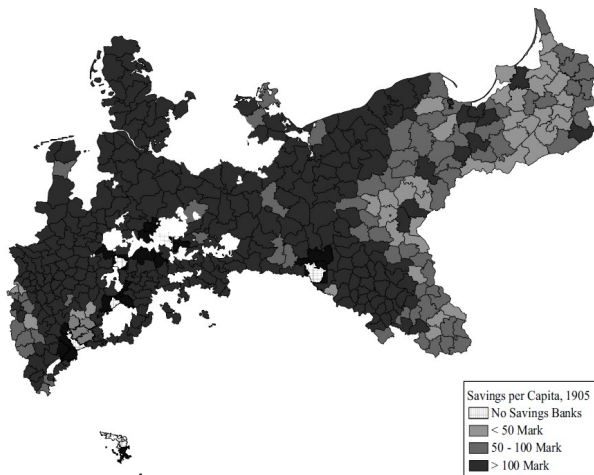
Savings per Capita, 1880



Source: Kersting et al (2020).

Protestant Ethic: Data

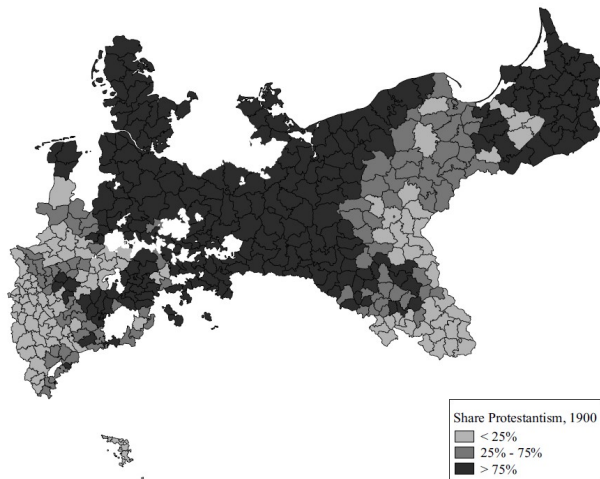
Savings per Capita, 1905



Source: Kersting et al (2020).

Protestant Ethic: Data

Protestantism, 1900



Source: Kersting et al (2020).

Protestant Ethic: Specification

- Baseline pooled OLS regression:

$$\text{Sav}_{it} = \alpha_1 + \beta_1 \text{Prot}_{it} + \mathbf{X}'_{it} \gamma_1 + \varepsilon_{1it}$$

- 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).

Topic 5

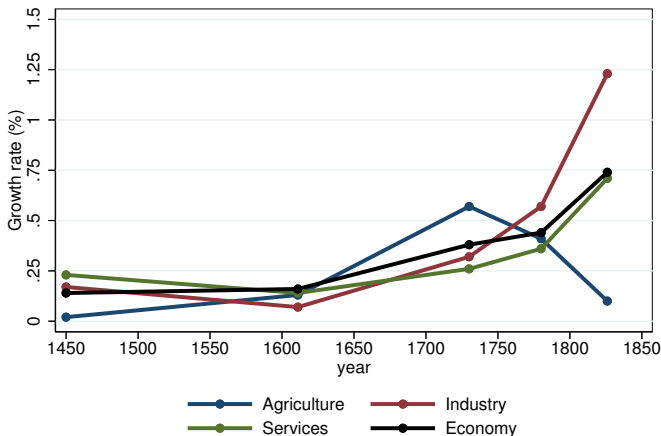
Directed technical change

Plan of the Session

- Measuring innovation
- The High Wages argument
- The Energy Revolution

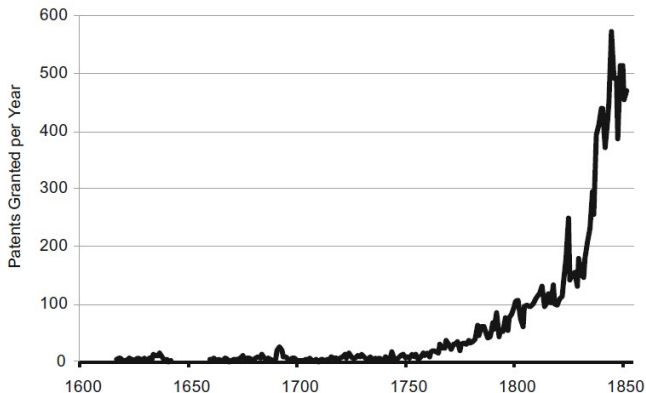
Productivity Growth in Britain

Sectoral Annual Average Productivity Growth Rates in England (1381–1700) and Great Britain (1700–1870)



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

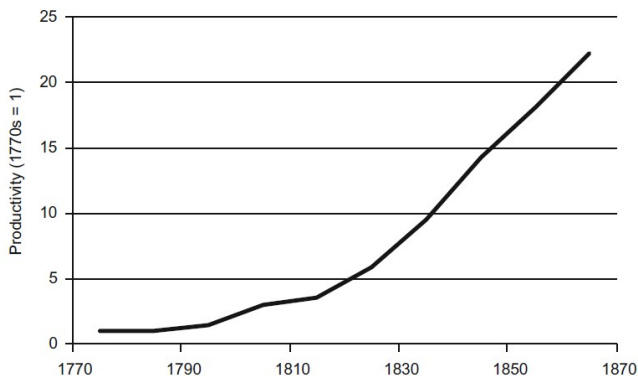
Patents per year in England (1660–1851)



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

Productivity Growth in Britain

Cotton spinning and weaving productivity (1770–1869)



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

The Cotton Industry

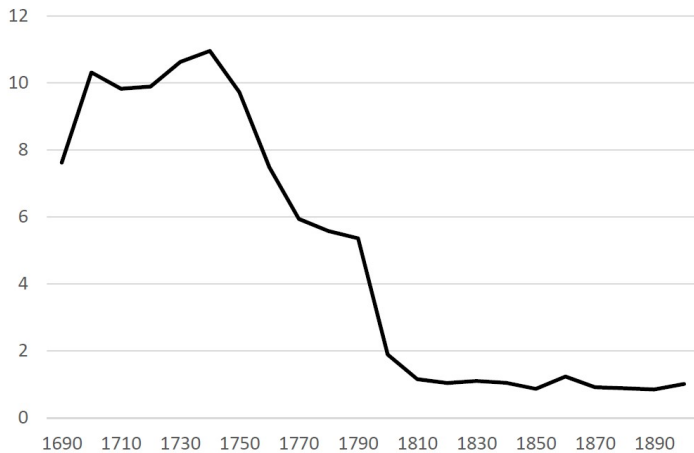
- The cotton industry epitomizes the IR in Britain.
 - Production growth: 7% per year 1770–1815.
 - Total factor productivity growth: 2.6% per year 1780–1860.
 - Accounted for 25% of British productivity growth 1780–1860.
 - Reduction in output price by factor 10 1750–1820.

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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).

The Cotton Industry

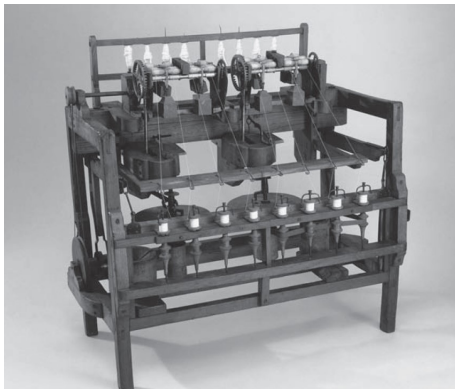
Hargreave's spinning jenny of 1770



Source: Allen (2009).

The Cotton Industry

Arkwright's water frame of 1775



Source: Allen (2009).

Measuring innovation

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.”

Mokyr (1990)

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 - 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 for the 13,070 English patents 1700–1850.

Nuvolari et al. (2021)

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

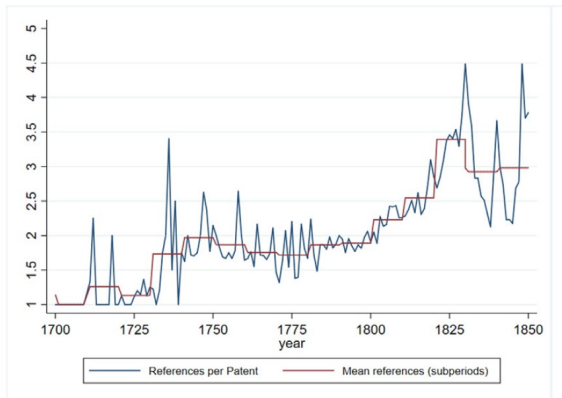
- Sources of the “Bibliographic Composite Index of patent quality”
 - Number of times patent mentioned in Schookler’s (1966) list of “important inventions.”
⇒ Captures visibility of patents in modern reference books of history of science and technology.

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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.

- 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.

Measuring Innovation

Average number of references per patents over time

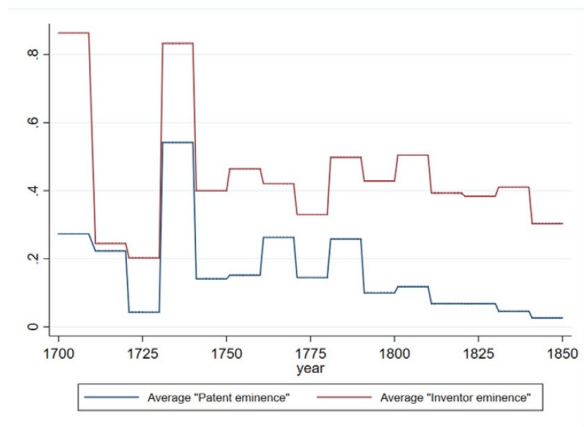


(a) Average number of references per patents in Woodcroft (1862), yearly and by decade.

Source: Nuvolari et al. (2021).

Measuring Innovation

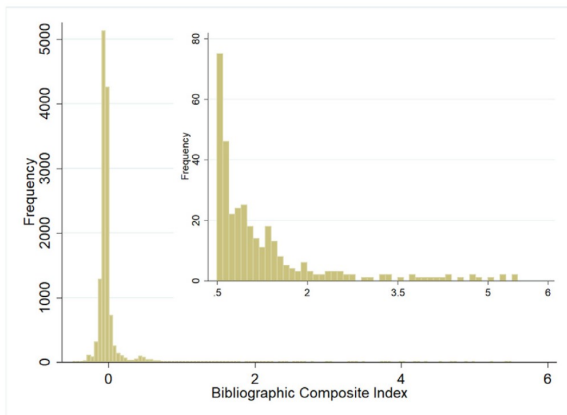
Average number of references per patents over time



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

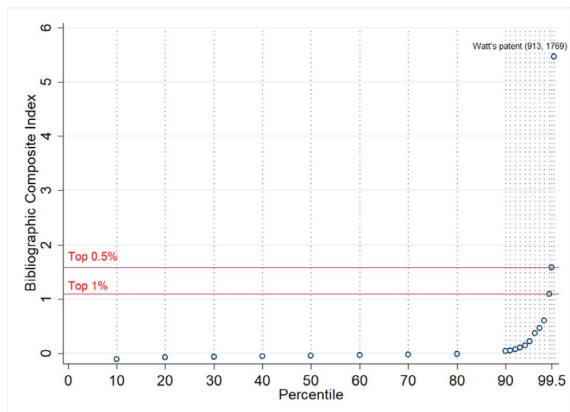
- Building the Bibliographic Composite Index (BCI):
 - Take into account time and sector correlated patterns.
 - Regress each indicator on time and sectoral indicators, extracting residuals.
 - Residuals capture share of variance due to intrinsic quality of patents.
 - Extract latent common factor for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

Empirical distribution of the BCI



Source: Nuvolari et al. (2021).

Percentile plot of the BCI



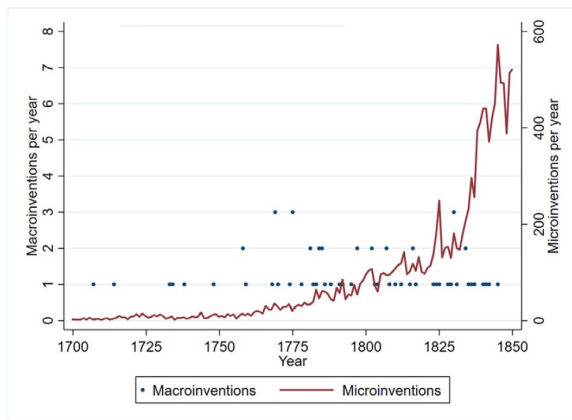
Source: Nuvolari et al. (2021).

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

Patterns of innovation during the IR

- Hypothesis of Mokyr (1990):
 - 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).

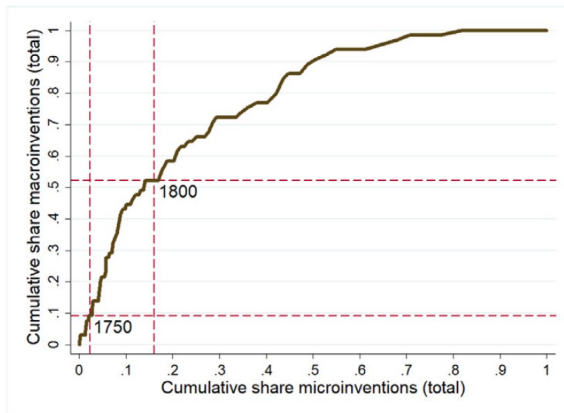
Number of inventions per year



Source: Nuvolari et al. (2021).

Measuring Innovation

Relative cumulative distribution of macro vs micro inventions

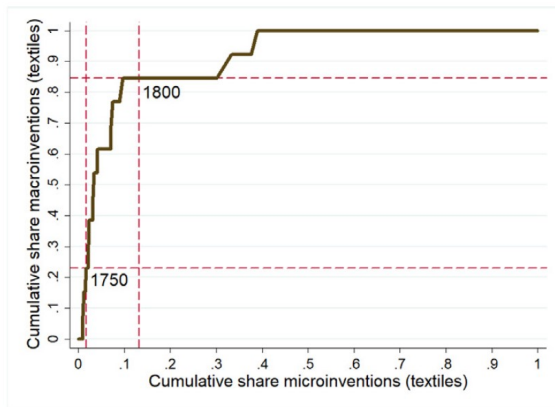


(a) All patents

Source: Nuvolari et al. (2021).

Measuring Innovation

Relative cumulative distribution of macro vs micro inventions



(b) Textile sector

Source: Nuvolari et al. (2021).

The High Wages argument

The High Wages Argument

Allen (2009)

- Institutions and culture (and literacy) played a role.
- Another crucial factor: relative factor prices in Britain?
 - Wages higher in Britain than elsewhere.
 - Energy prices lower in Britain than elsewhere

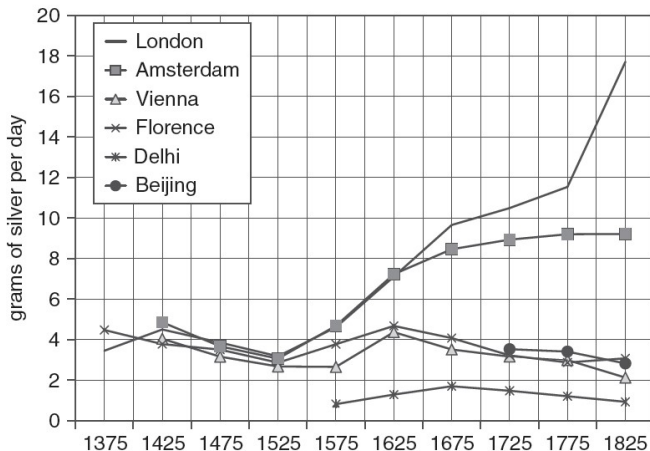
⇒ Incentives to produce labor-saving innovations, e.g., spinning jenny.

“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 Wages Argument

Laborers' wages around the world, grams of silver per day



Source: Allen (2009).

The High Wages Argument

- Why would high cost of labor induce labor-saving innovations?

The High Wages Argument

- Why would high cost of labor induce labor-saving innovations?
- Innovation can be directed to factors of production that are expensive. [Acemoglu \(2002\)](#)
 - Depends on innovation possibilities frontier.
 - Cost and technical difficulty of innovation matters for direction of technical progress.
 - Skills availability matter.
 - Demand as well: affects profitability.

The High Wages Argument

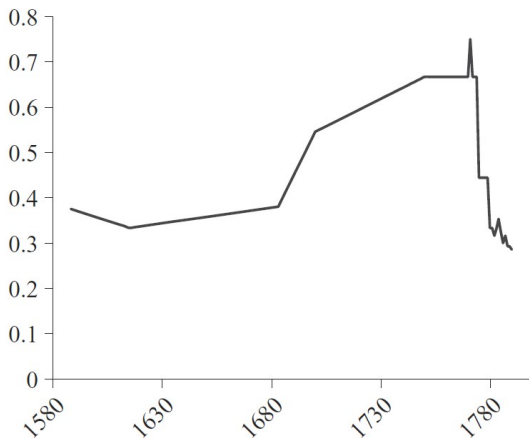
- Was Britain a high wage economy before industrialization?
- Allen highlights innovations in spinning, leading sector in IR:

“[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

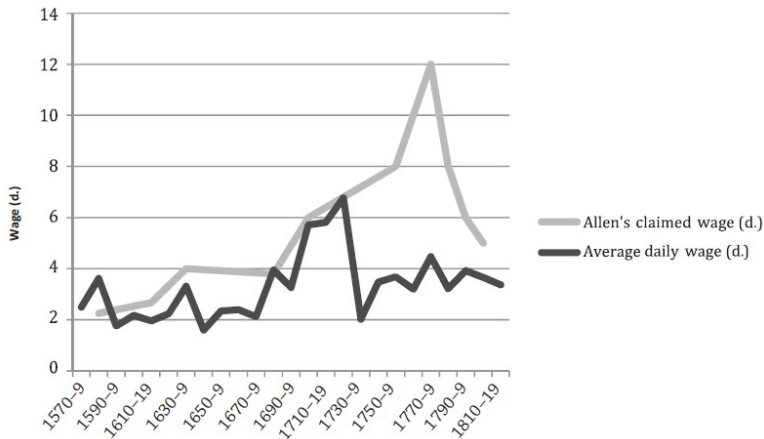
- [Humphries and Scheinder \(2018\)](#) criticize Allen's sources.
 - Allen's productivity estimates rely on one source. [Muldrew \(2012\)](#)
 - [Muldrew \(2012\)](#) based on biased observers (social commentators) and overestimate wages.

The High Wages Argument

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 - Allen's productivity estimates rely on one source. [Muldrew \(2012\)](#)
 - [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

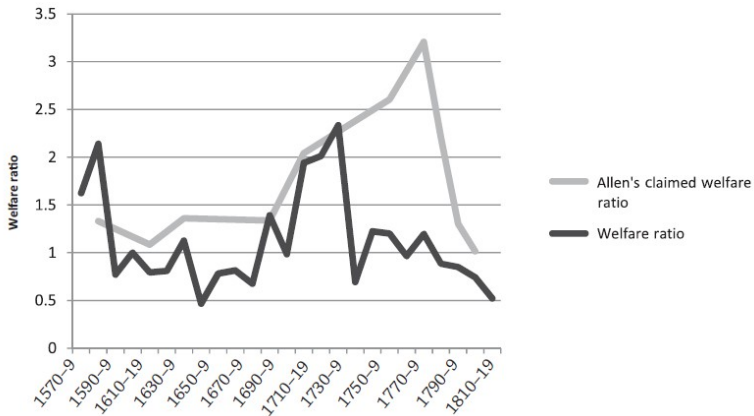
Nominal daily wages, decadal averages



Source: Humphries and Schneider (2018).

The High Wages Argument

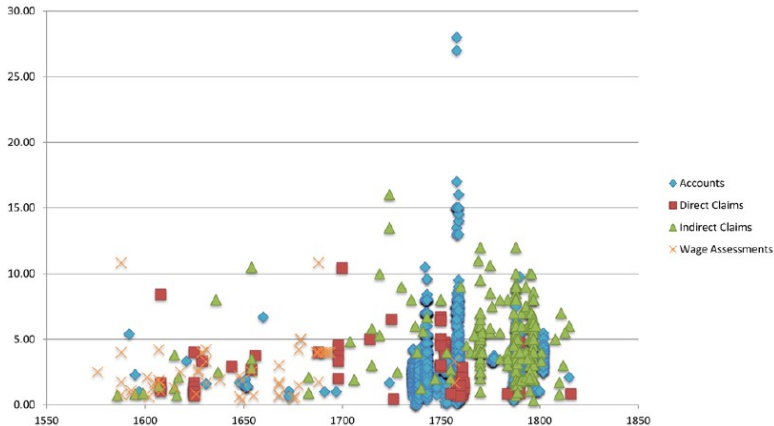
Welfare ratios, decadal averages



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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 - Biases from putting-out network data: paid women were splitting money with other family members or other women hired by paid women + hours worked unknown.
 - ⇒ This source might provide unreliable information.

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

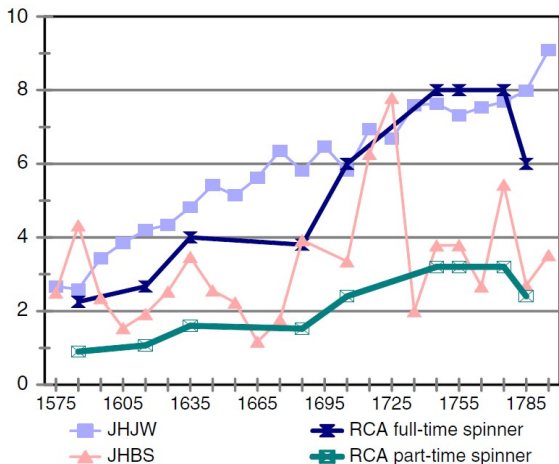
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⇒ This source might provide unreliable information.
- Allen’s data comparable to other series produced with wider coverage, showing wage growth.

⇒ “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

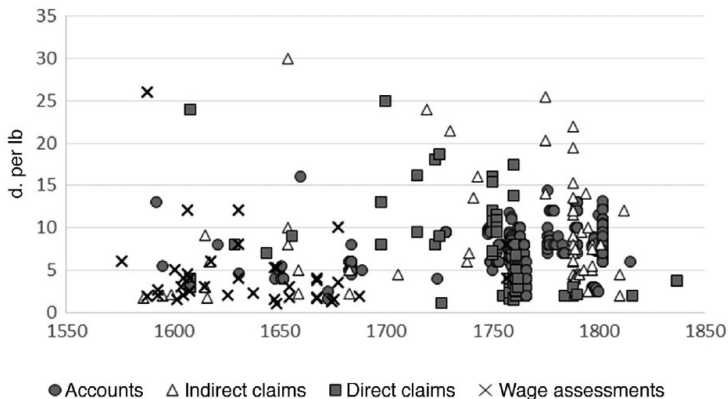
- Humphries and Schneider (2020) “Losing the thread” respond to the rebuttal to the criticism of the original thesis.
- Criticism of wage data used by Allen (low quality, small sample).
- Add 16 data sources, 1,700 observations less subject to biases. Find same results.

⇒ “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

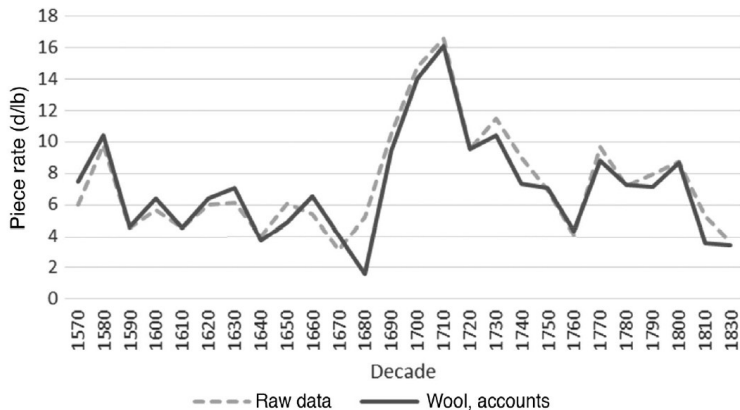
Piece rates by source type, nominal daily



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 >> 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

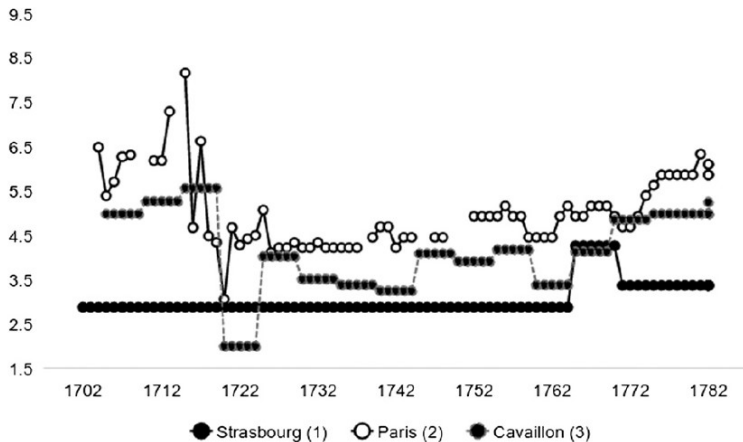
Real wages of Paris workers as a share of real wages of London workers

	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	MOISONNEUR	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).

The Energy Revolution

The Energy Revolution

- Before the Industrial Revolution, an ecological constraint:
 - Land was in fixed supply, no labor-saving technology.
⇒ Strong diminishing returns to labor.

The Energy Revolution

- Before the Industrial Revolution, an ecological constraint:
 - Land was in fixed supply, no labor-saving technology.
⇒ Strong diminishing returns to labor.
 - Production was extremely land intensive:
 - Food for humans and animals.
 - Heat: firewood.
 - Mechanical energy: animal power.
- ⇒ Increase production would require extra land.

The Energy Revolution

- The advent of steam engines powered by coal was a Revolution.
 - Relaxed the ecology constraint.
 - “Coal provided ‘ghost acres’ on a huge scale.” [Wrigley \(2010\)](#)
 - Enabled a shift from organic to energy-powered economy.
- ⇒ 30-fold ↑ in energy consumption during IR.

The Energy Revolution

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 - Relaxed the ecology constraint.
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 - Enabled a shift from organic to energy-powered economy.
- ⇒ 30-fold ↑ in energy consumption during IR.
- Coal became the main source of energy in Britain:
 - 1700: half of energy from coal.
 - 1850: 90% of energy from coal.

The Energy Revolution

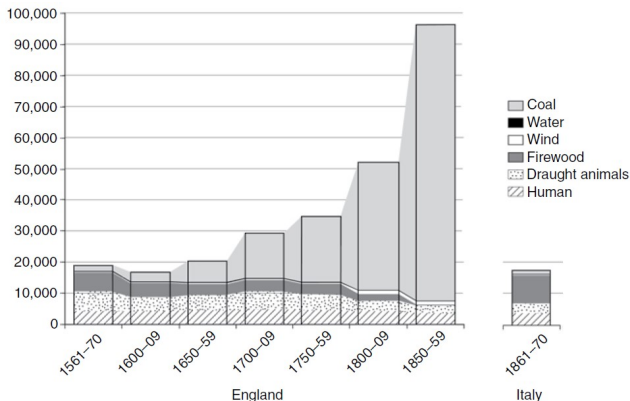
Coal production and energy consumption in England, Wales, and Scotland

	(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).

The Energy Revolution

Annual energy consumption per head (megajoules) in England, Wales, and Italy



Source: Wrigley (2010).

The Energy Revolution

- Thomas Newcomen steam engine in 1712:
 - Primary usage: mine draining.
 - Based on scientific discoveries in 17th century.
 - Decade of experimentation and considerable expenses.
- Incentives for innovation:
 - High demand for energy due to London population growth (driven by international trade).
 - High price of wood vs coal.
 - Coal free where steam engine used.

The Energy Revolution

- Positive feedback loop between:
 - Population growth
 - Coal production
 - Steam engine innovation to improve efficiency
- ⇒ Innovations + coal availability kept energy prices low.

The Energy Revolution

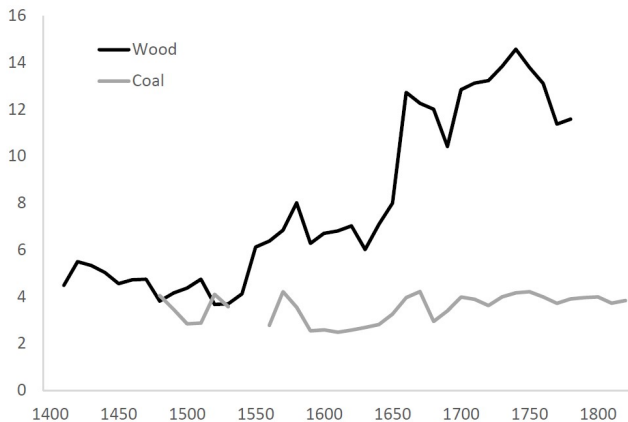
Urban population estimates for England and London

Population ('000s)						
	<i>c.1520</i>	<i>c.1600</i>	<i>c.1670</i>	<i>c.1700</i>	<i>c.1750</i>	<i>c.1800</i>
England	2,400	4,150	5,150	5,200	5,900	8,600
London	55	200	475	575	675	960
Other urban populations (5,000 or more inhabitants)	70	135	205	275	540	1,420
Total urban	125	335	680	850	1,215	2,380
Ten historic regional centres ^a	62	73		107	126	153
Urban populations as percentages of the national total						
London	2.25	4.75	9.25	11.00	11.50	11.25
Other urban	3.00	3.25	4.00	5.25	9.25	16.50
Total urban	5.25	8.00	13.25	16.25	20.75	27.75

Source: Wrigley (2010).

The Energy Revolution

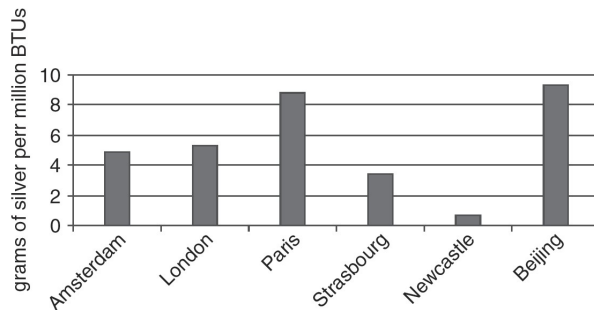
Real prices of wood and coal in London



Source: Steinsson (2020) based on Wrigley (2010).

The Energy Revolution

Prices of energy in the early 1700s



Source: Allen (2009).

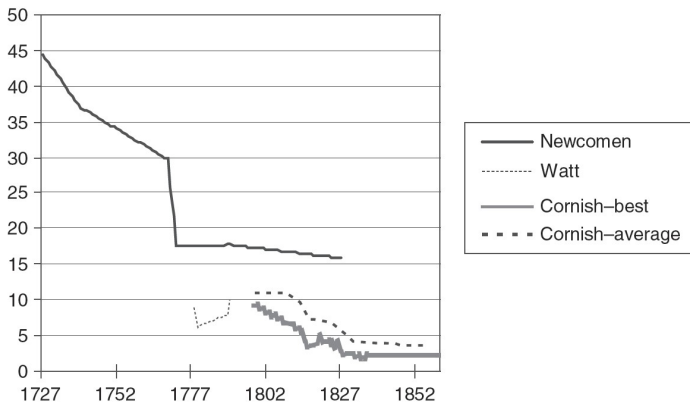
The Energy Revolution

- Steam engine innovations could be applied to other purposes (e.g., metallurgy).
- Switch from wood to coal induced tremendous innovation in building industry.
- Further incentives to improve steam engine (e.g., rotary engine for smooth motion).

⇒ Initiated general mechanization of British industry

The Energy Revolution

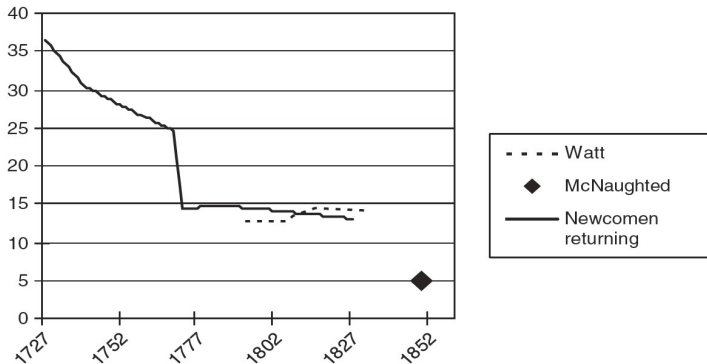
Coal consumption in pumping engines (pound of coal per horsepower-hour)



Source: Allen (2009).

The Energy Revolution

Coal consumption in rotary engines (pound of coal per horsepower-hour)



Source: Allen (2009).

The Energy Revolution

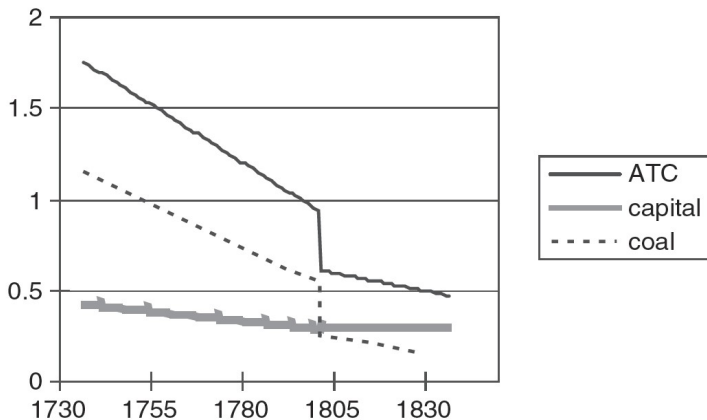
Stationary power sources in Great Britain

	1760	1800	1830	1870	1907
Steam	5,000	35,000	160,000	2,060,000	9,659,000
Water	70,000	120,000	160,000	230,000	178,000
Wind	10,000	15,000	20,000	10,000	5,000
Total	85,000	170,000	340,000	2,300,000	9,842,000

Source: Allen (2009).

The Energy Revolution

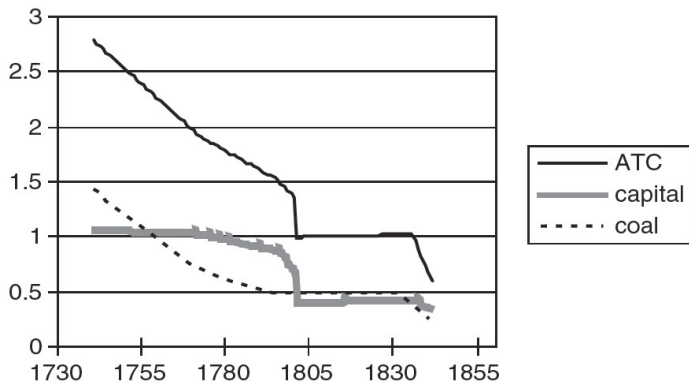
Pumping engine: cost per horsepower-hour



Source: Allen (2009).

The Energy Revolution

Rotary engine: cost per horsepower-hour



Source: Allen (2009).

The Energy Revolution

Capacity of stationary steam engines

	1760	1800	1840	1870
Britain	5	35	200	2,060
France		3	33	336
Prussia			7	391
Belgium			25	176
United States		0	40	1,491

Source: Allen (2009).

Conclusion

- Why did the Industrial Revolution occurred in Britain?
- Many potential answers, still uncertainties.
 - Institutions.
 - A culture of growth and literacy.
 - Directed technical change: high wages and cheap coal?
- Probably combination of all explanations.

Topic 6

Pandemics in history

What can history teach us about the potential consequences of COVID-19?

- Most serious health and economic crisis of 21st century:
 - Since December 2019: nearly 5M fatalities, 240M cases.
 - No natural immunity, vaccine administered since late December 2020.
 - Large-scale non-pharmaceutical interventions.
 - Large economic downturn, e.g., France: 2020 Q2/2019 Q2: -19% .
 - Euro area 2020 GDP growth: -7% .

⇒ Critical juncture.

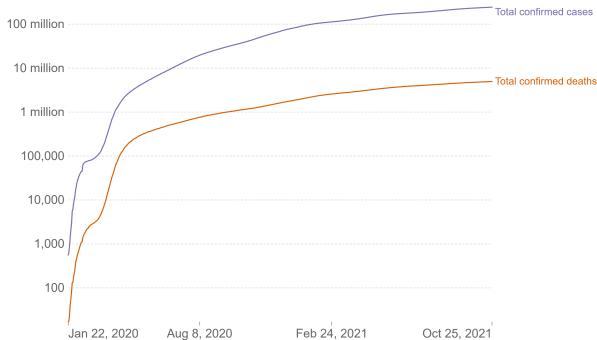
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⇒ Critical juncture.

- Economic history can some provide guidance.

Cumulative confirmed COVID-19 cases and deaths, World

Limited testing and challenges in the attribution of the cause of death means that the number of confirmed cases and deaths may not be an accurate count of the true totals.



Source: Johns Hopkins University CSSE COVID-19 Data – Last updated 26 October, 09:04 (London time)
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 \(2020\)](#)

Plan of the Session

- 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.
- Policy responses.

⇒ Characterization will generate natural historical counterparts.

- Health effects: Influenza (1918–1919).
- Economic effects: Great Depression (1930s).

Comparison Set

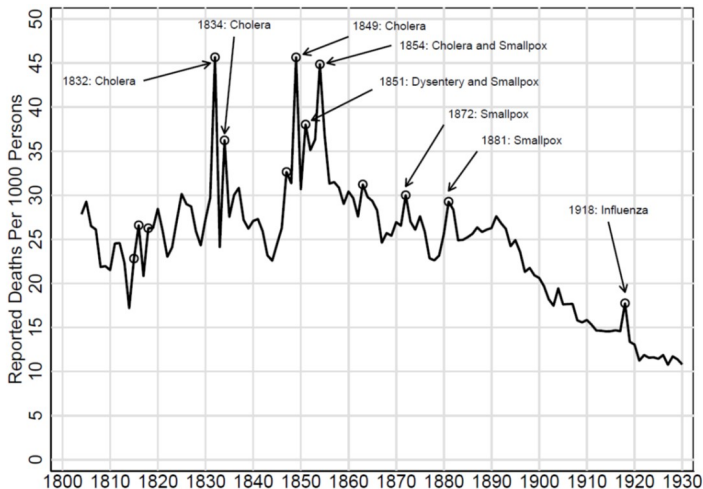
⇒ Epidemic risks were (nearly) part of everyday life.

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.

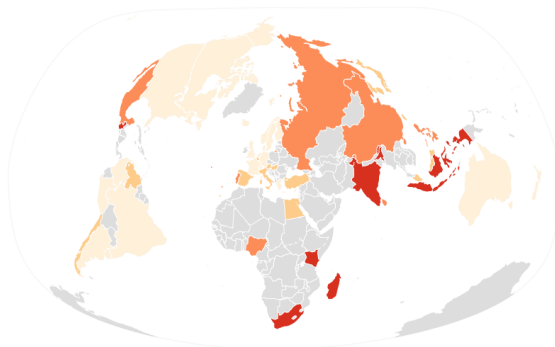
Epidemiology of COVID-19: Spatial Diffusion

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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

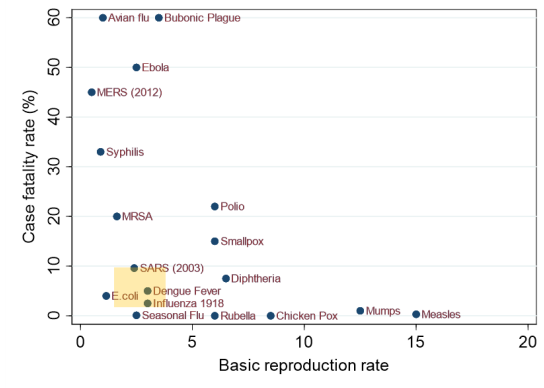
Worldwide Spread of 1918–1919 Influenza Pandemic

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.
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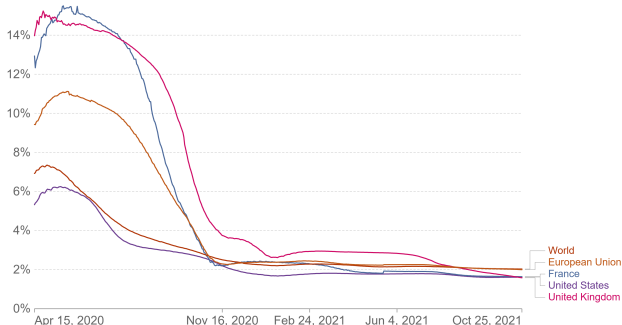
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- Much lower than Ebola, or smallpox.

⇒ 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)

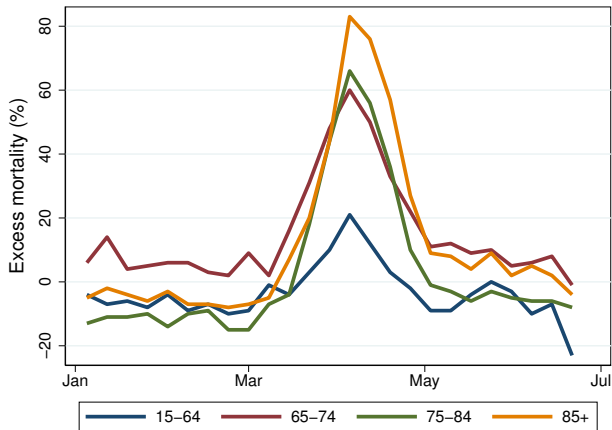


Source: Johns Hopkins University CSSE COVID-19 Data – Last updated 26 October, 09:04 (London time) Powered by ourworldindata.org
Note: Only countries with more than 100 confirmed cases are included. Only countries with more than 100 confirmed cases are included.

Data from [ECDC](https://ecdc.europa.eu/) and ourworldindata.org.

Demographic and Distributional Effects

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Excess Mortality in 2020 vs 2015–2019 by Age in France

Data from [ECDC](#) and [ourworldindata.org](#).

Demographic and Distributional Effects

- Old age and worse baseline health.

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- Low SES: compounded risks.
 - High contact jobs, continuing during pandemic.
 - Likely low-paying jobs, more likely women and minorities.
 - Differential access to healthcare.

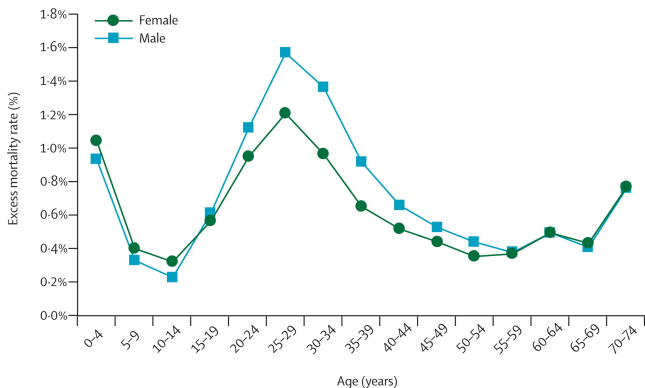
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 - Likely low-paying jobs, more likely women and minorities.
 - Differential access to healthcare.
- Low SES more affected during Influenza (more later).
- Difference with Influenza: W shape in age susceptibility.

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).

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 - Shutdowns
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- 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.

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- Measurement of mortality.
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⇒ 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 \(2020\)](#)

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.
- Excess mortality: $M_{c1918} - \hat{M}_{c1918}$

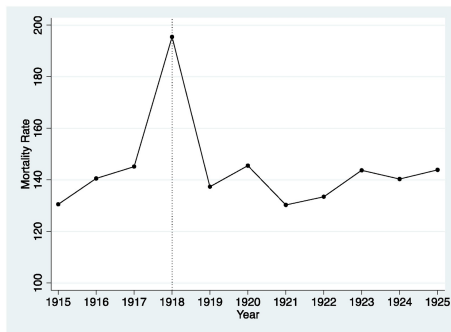
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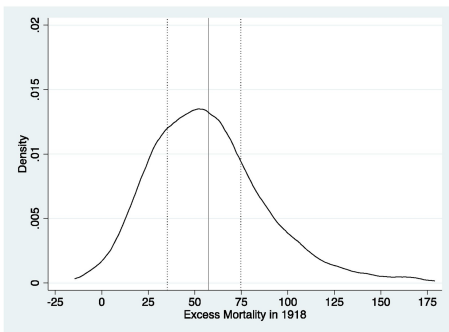
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- Similar results if predict 1918 with 1915–1917 data.

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 \(2019a\)](#)

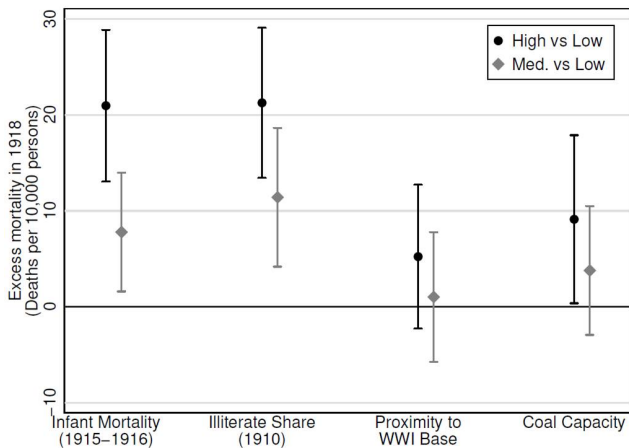
What Explains Distribution of Influenza Fatalities?

- 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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 - 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.

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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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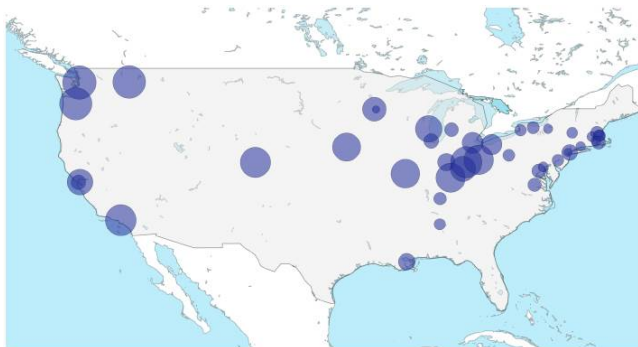
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 - In aggregate: pandemic $\implies \downarrow 6\% \text{ real GDP per K.}$
- Medium-run economic effects (within-country analyzes):
 - Italy: $\downarrow 6.5\% \text{ real GDP}$, recover by 1922. [Carillo and Jappelli \(2020\)](#)
 - Denmark: short-lived \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?

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- 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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 - 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.

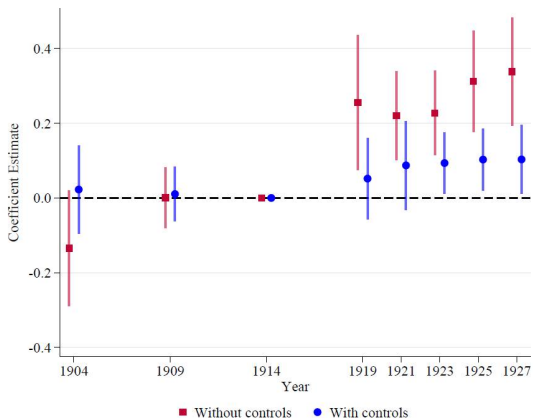
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- Discussions of pre-trends: [Lilley et al. \(2020\)](#) [Correia et al. \(2020\)](#)

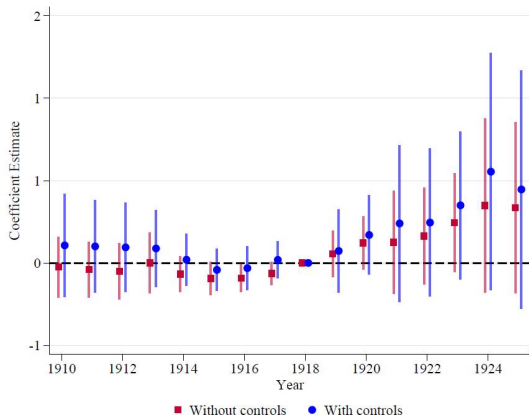
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NPI Intensity and log manufacturing employment

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)

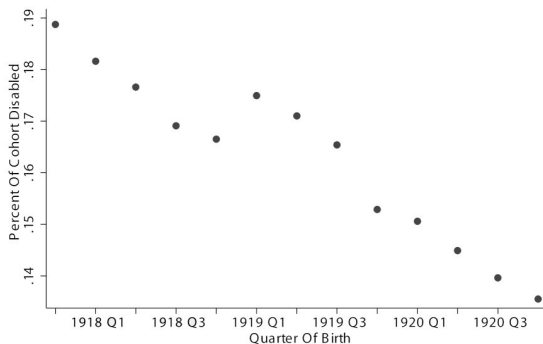
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- Long-run scarring effects through in utero exposure (“fetal origins”)?
- Socioeconomic outcomes in 1960–1980 depending on birth quarter.
- Long-lasting compared to adjacent cohorts:
 - Disability rates.
 - Human capital accumulation.
 - Income level.

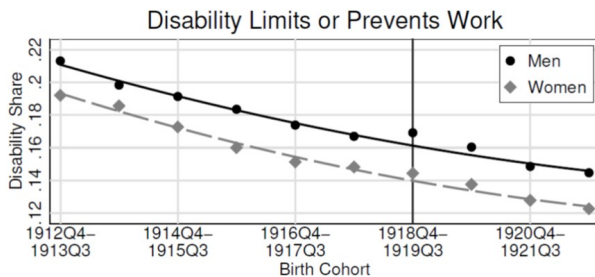
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1980 Male Disability Rates by Quarter of Birth

Figure from [Almond \(2006\)](#)

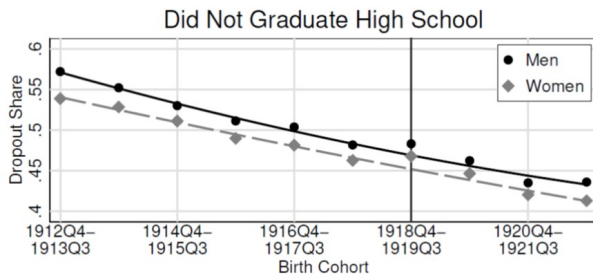
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1970 Disability Rates by Year of Birth

Figure from Beach, Clay, and Saavedra (2020) using results from Almond (2006)

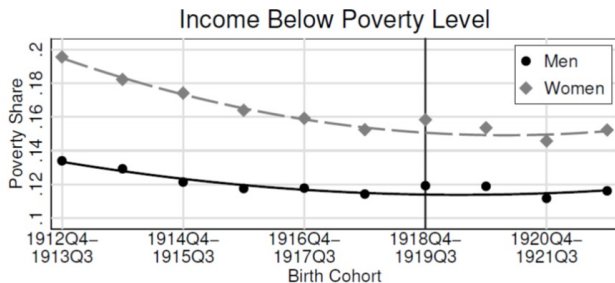
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1970 High School Dropout Rates by Year of Birth

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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- 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?

- Long-run scarring effects through in utero exposure to negative income shocks in Great Depression. [Fishback and Thomasson \(2014\)](#)

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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.

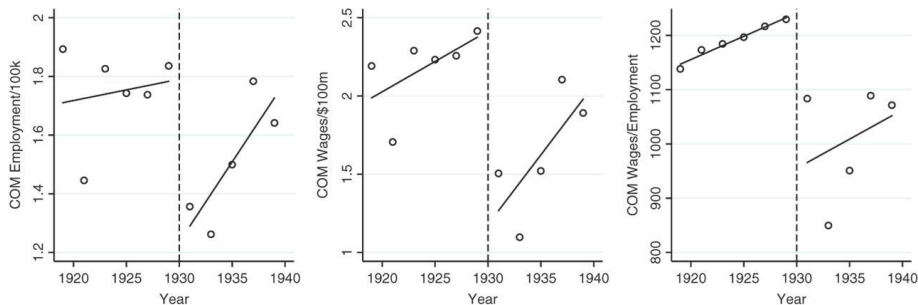
Scarring Effects of the Great Depression?

- 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.

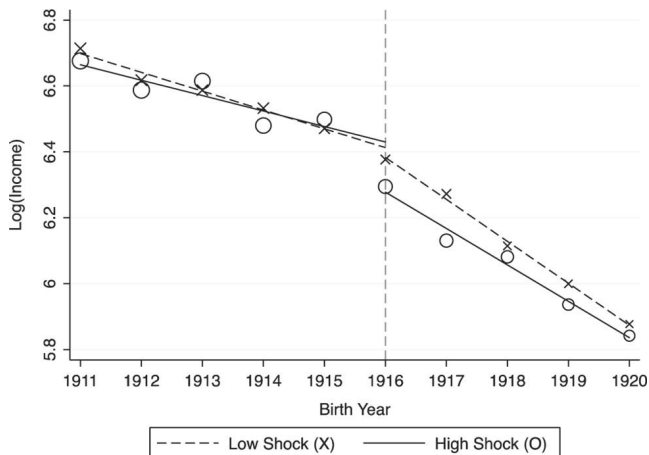
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Discontinuity in labor market conditions

Figure from [Moulton \(2017\)](#).

Scarring Effects of the Great Depression?



Regression discontinuity of log(income).

Figure from Moulton (2017).

Scarring Effects of the Great Depression?

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 - Little evidence of differences in educational attainment.
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 - Limited options to borrow and prolonging education.
 - 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 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.

Conclusion

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- History can be a useful guide for policy.
- Absent of interventions:
 - Low SES individuals bear disproportionate burden of health crisis.
 - Labor market entrants bear disproportionate burden of economic crisis.
 - Long-lasting scarring effects.

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 - Original features of COVID-19: combines health and economic crises.
⇒ How will these interact?

Conclusion

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 - Low SES individuals bear disproportionate burden of health crisis.
 - Labor market entrants bear disproportionate burden of economic crisis.
 - Long-lasting scarring effects.
- More historical evidence needed:
 - Original features of COVID-19: combines health and economic crises.
⇒ How will these interact?
 - Scarring effects for young children (school closures, distancing, masks)?
 - Consequences for gender inequality, esp. working mothers?

Topic 7

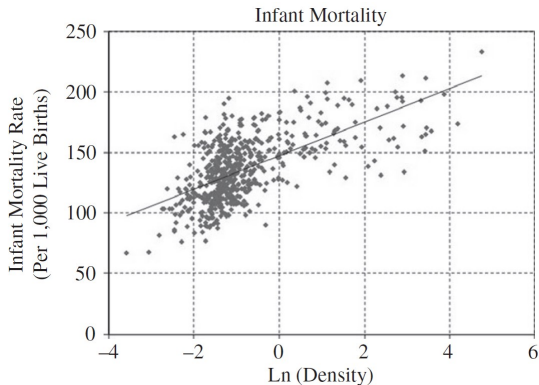
Environment and the Industrial Revolution

Plan of the Session

- Pollution, mortality, and the Industrial Revolution in Britain, 1851–1861. [Beach and Hanlon \(2018\)](#)
- Pollution, city growth, and the Industrial Revolution in Britain, 1851–1911. [Hanlon \(2020\)](#)
- Temperature, disease, and death in London, 1866–1965. [Hanlon et al. \(2021\)](#)
- * Dust Bowl migrants: environmental refugees and economic adaptation. [Hornbeck \(2021\)](#)

Pollution, mortality, and the Industrial Revolution in Britain, 1851–1861

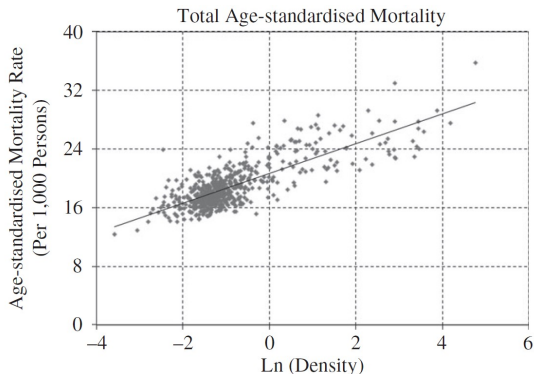
Pollution, Mortality, and the Industrial Revolution



Urban mortality penalty across districts in England and Wales in 1851–1860

Source: Beach and Hanlon (2018).

Pollution, Mortality, and the Industrial Revolution



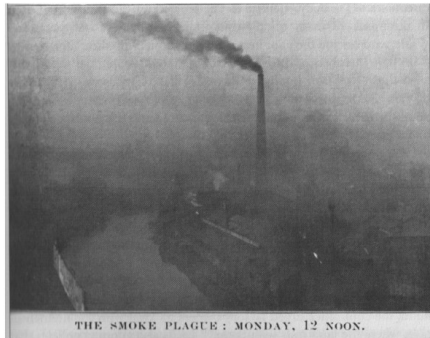
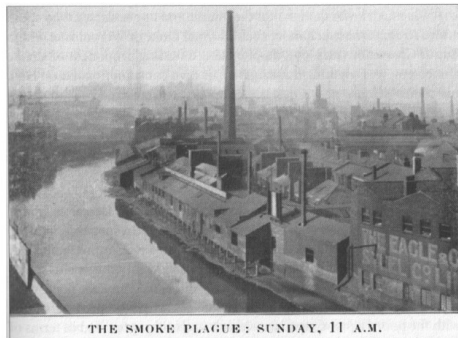
Urban mortality penalty across districts in England and Wales in 1851–1860

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).

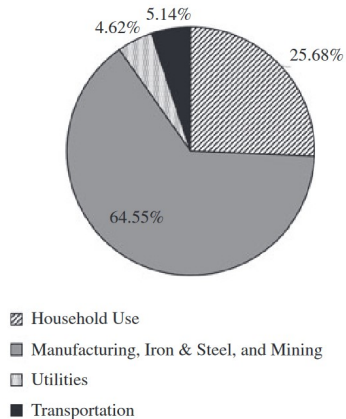
Pollution, Mortality, and the Industrial Revolution

Coal production and energy consumption in England, Wales, and Scotland

	(1)	(2)	(3)	(4)	(5)
	<i>1560s</i>	<i>1700–9</i>	<i>1750–9</i>	<i>1800–9</i>	<i>1850–9</i>
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



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 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.

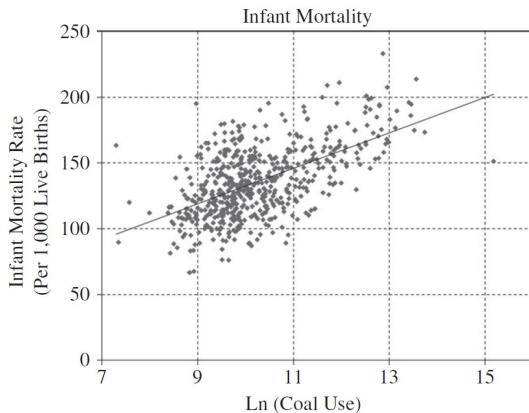
Pollution, Mortality, and the Industrial Revolution

- 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.

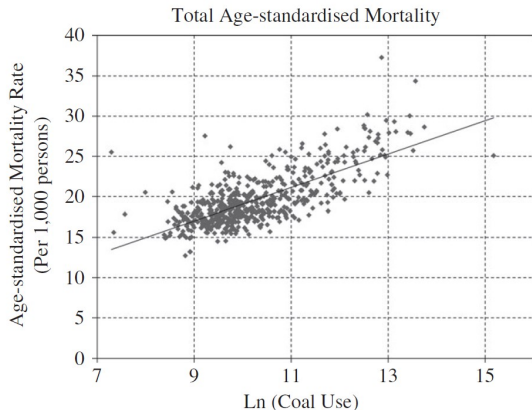
Pollution, Mortality, and the Industrial Revolution



Coal use and mortality in England and Wales in 1851–1860

Source: Beach and Hanlon (2018).

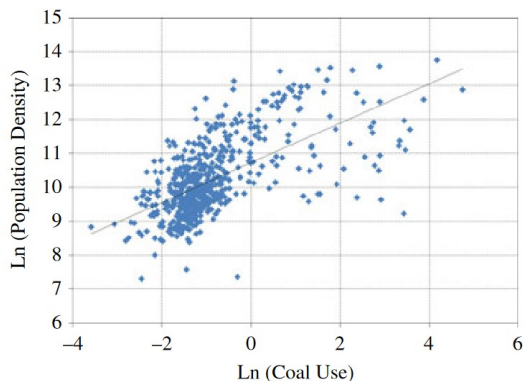
Pollution, Mortality, and the Industrial Revolution



Coal use and mortality in England and Wales in 1851–1860

Source: Beach and Hanlon (2018).

Pollution, Mortality, and the Industrial Revolution

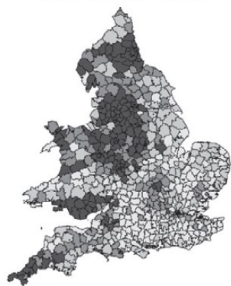


Coal use and population density in England and Wales in 1851–1860

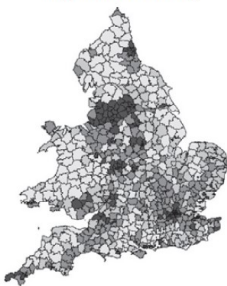
Source: Beach and Hanlon (2018).

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).

- 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 in Britain, 1851–1911

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

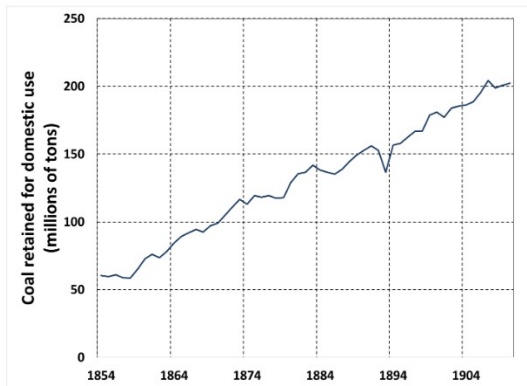
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 - +: job growth attracts population.
 - -: pollution deters population due to ↓ quality of amenities + ↓ productivity.
- Assess impact of pollution on growth of British cities 1851–1911.
[Hanlon \(2020\)](#)
 - Challenge 1. Pollution is one of many 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

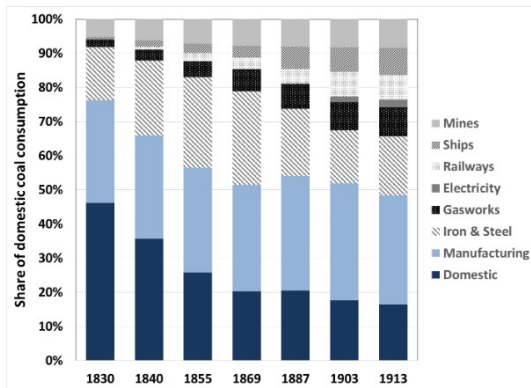
British coal consumption, 1854–1910



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 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:

$$\Delta \log (\text{PredCoal}_{ct}) = \log \left(\sum_{j \neq i} L_{jct-\tau} \times \text{GR}_{j-ct,t-\tau} \times \theta_j \right) - \log \left(\sum_{j \neq i} L_{jct-\tau} \times \theta_j \right)$$

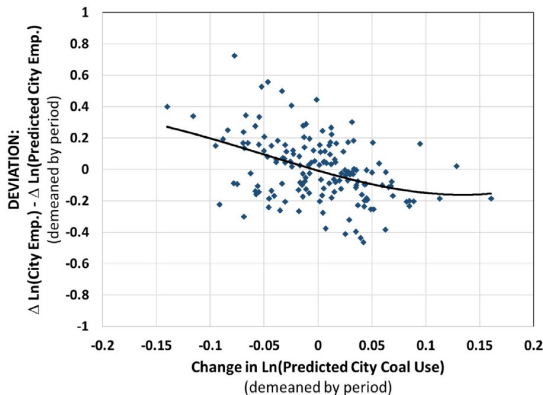
- Difference due only to variation in coal intensity of industries θ_j .

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)
$\Delta \ln(\text{PredCoal})$	-0.611 (0.621)	-1.987*** (0.732)	-3.016*** (0.803)	-0.444 (0.685)	-2.218*** (0.632)	-3.257*** (0.813)
$\Delta \ln(\text{PrCityEMP})$	-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).

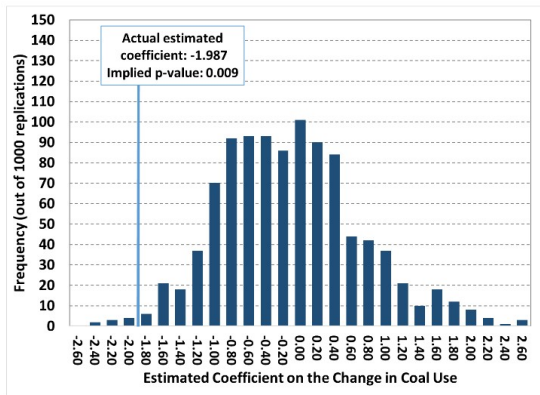
Pollution, City Growth, and the Industrial Revolution

DV: Δ Log of city-industry employment (two decade differences)						
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta \ln(\text{PredCoal})$		-2.485** (1.001)	-2.485** (1.005)		-2.130** (1.011)	-1.886** (0.956)
$\Delta \ln(\text{PrCityEMP})$	-0.944 (0.733)	0.676 (1.045)	0.678 (1.153)	-1.487*** (0.485)	0.360 (0.952)	-0.248 (0.917)
Lagged $\Delta \ln(\text{PredCoal})$	-0.484 (0.448)	0.0261 (0.464)	0.0308 (0.743)			
Lagged $\Delta \ln(\text{PrCityEMP})$			-0.00654 (0.888)			
Leading $\Delta \ln(\text{PredCoal})$				0.0381 (0.677)	0.368 (0.596)	-0.630 (0.775)
Leading $\Delta \ln(\text{PrCityEMP})$						1.843*** (0.702)
Ind.-time effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,400	2,400	2,400	2,400	2,400	2,400
R-squared	0.328	0.342	0.342	0.355	0.360	0.364

City-industry regression results with previous or future changes in predicted coal use

Source: Hanlon (2020).

Pollution, City Growth, and the Industrial Revolution



Histogram of permutation results and estimate from true data

- Permutation exercise: random reassignment of coal use across 26 industries 1,000 times and re-estimate.

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.

Temperature, disease, and death in London, 1866–1965

Temperature, Disease, and Death in London

- London had very high mortality rates in mid-19th century:
 - Mortality concentrated on infants and young children.
 - In 1860–1899: 158% died before age one.
 - In 1900–1910: 132% died before age one.
 - In 1920–1930: 66% died before age one.
- Causes of deaths:
 - In the 1870s, among all ages, most deaths due to infectious diseases: tuberculosis (14%), bronchitis (13%).
 - In the 1870s, among infants, most important category: digestive diseases (13%).

Temperature, Disease, and Death in London

- No consensus on reasons for decline in mortality after 1900.
 - Concentrated among infants, driven by reduction of digestive diseases.
 - Water filtration and sewer access occurred decades before.
 - Other factors that might have played a role:
 - Improvements in milk quality.
 - Better nutrition.
 - Improved maternal care.
 - Better housing.
- Explore the role of weather in contributing to mortality patterns in London.

Temperature, Disease, and Death in London

- Weekly mortality data in London:
 - From the Registrar General.
 - 300,000 mortality observations for 4,540 weeks, 1866–1965 (before air conditioning).
 - Deaths by cause and age group for whole city.
 - Consistent geographic area encompassing all modern Central London.
 - Aggregate death causes in consistent categories.

Temperature, Disease, and Death in London

- Weekly temperature data in London:
 - Data from Radcliffe Observatory in Oxford, 80km outside central London.
 - Single location throughout.
 - Provides weekly average maximum and minimum temperature.
 - Abstract from urban heat-island effects, potentially endogenous to city growth.
 - Complement with precipitation and humidity information.

Temperature, Disease, and Death in London

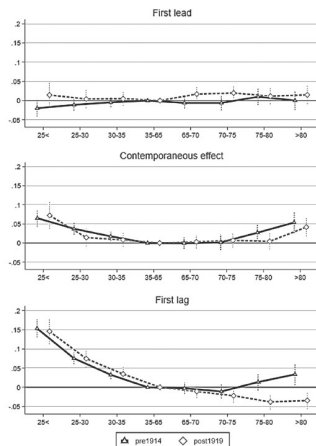
- Estimate relationship between unusually high or low temperature in a week on mortality in that week, and previous and subsequent weeks.
- Lead-lag regression model.
- Classify weeks into temperature bins with 35–65°F (1–18°C) as reference weeks.
 - < 25°F (−4°C).
 - 25–30°F (−4–−1°C).
 - 30–35°F (−1–1°C).
 - 35–65°F (1–18°C).
 - 65–70°F (18–21°C).
 - 70–75°F (21–24°C).
 - 75–80°F (24–27°C).
 - >80°F (27°C).

Temperature, Disease, and Death in London

$$\log(y_{wt}) = \sum_{j=-m}^k \sum_{q=1, q \neq 4}^8 \alpha_j^q \text{TEMP}_{wt}^q[w = j] + \delta_w + \delta_t + X_{wt}\beta + \varepsilon_{wt}$$

- $\log(y_{wt})$: log infant deaths in week w of year t .
- TEMP_{wt}^q : set of indicators taking value 1 if weekly temperature is in q th bin, with $q = 4$ the reference bin.
- m leads, k lags.
- δ_w : week-of-the-year FE.
- δ_t : year FE.
- X_{wt} : week-by-year varying controls (precipitation, heavy fog).

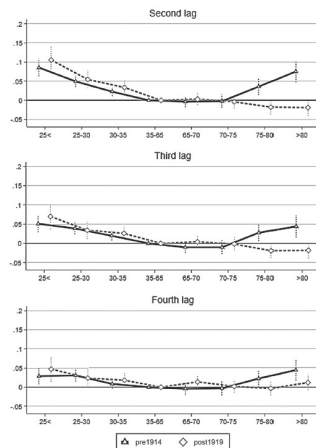
Temperature, Disease, and Death in London



Temperature and total mortality before and after WWI

Source: Hanlon et al. (2021).

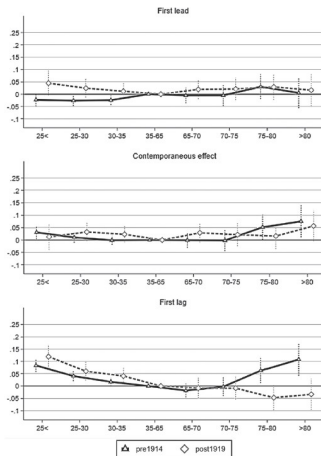
Temperature, Disease, and Death in London



Temperature and total mortality before and after WWI

Source: Hanlon et al. (2021).

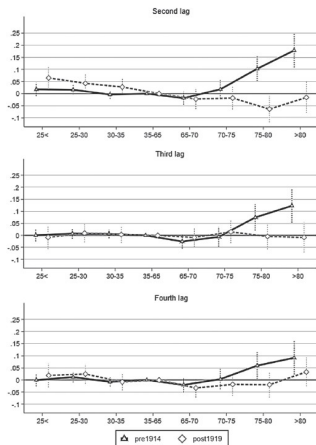
Temperature, Disease, and Death in London



Temperature and infant mortality before and after WWI

Source: Hanlon et al. (2021).

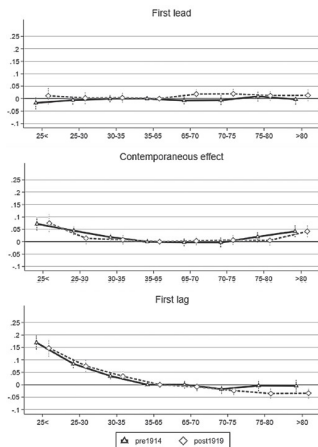
Temperature, Disease, and Death in London



Temperature and infant mortality before and after WWI

Source: Hanlon et al. (2021).

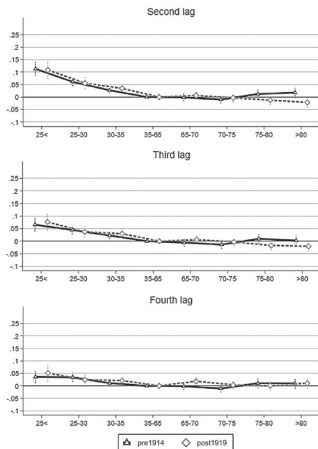
Temperature, Disease, and Death in London



Temperature and non-infant deaths before and after WWI

Source: Hanlon et al. (2021).

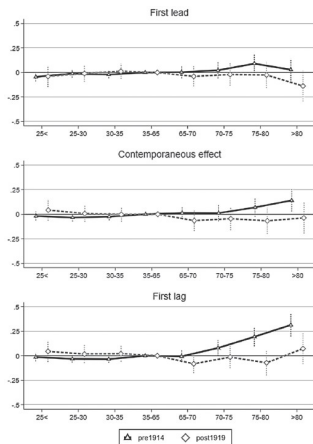
Temperature, Disease, and Death in London



Temperature and non-infant deaths before and after WWI

Source: Hanlon et al. (2021).

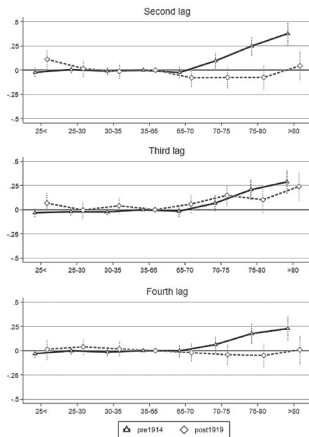
Temperature, Disease, and Death in London



Temperature and digestive mortality before and after WWI

Source: Hanlon et al. (2021).

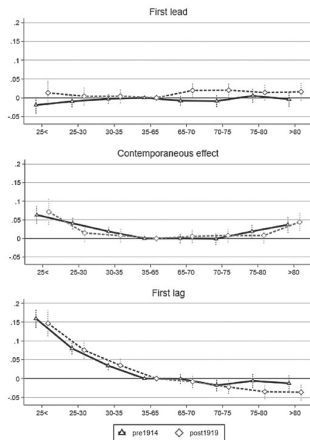
Temperature, Disease, and Death in London



Temperature and digestive mortality before and after WWI

Source: Hanlon et al. (2021).

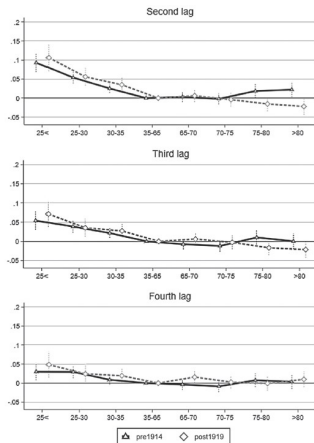
Temperature, Disease, and Death in London



Temperature and non-digestive mortality before and after WWI

Source: Hanlon et al. (2021).

Temperature, Disease, and Death in London



Temperature and non-digestive mortality before and after WWI

Source: Hanlon et al. (2021).

Temperature, Disease, and Death in London

- In late 19th and early 20th, both unusually cold and warm weather associated with elevated mortality.
 - Cold weather increased mortality among elderly, especially from respiratory-related diseases.
 - Warm weather increased mortality among infants and young children, especially from digestive diseases.
- After WWI:
 - Effects of warm weather disappeared.
 - Driven by reduction in infant deaths, especially those due to digestive diseases.
 - Impact of cold weather largely unchanged.

⇒ The disease environment mediates the mortality effects of temperature.

Dust Bowl migrants: environmental refugees and economic adaptation

Dust Bowl Migrants



The American Dust Bowl of the 1930s

Dust Bowl Migrants

- The American Dust Bowl of the 1930s:
 - Late 19th century, agricultural production expanded on American Plains, with native grasslands plowed up for crops.
 - But severe drought during the 1930s \implies loss ground cover.
 - Farmland susceptible to self-perpetuating dust storms (wind erosion).
 - By the 1940s, many Plain areas had cumulatively lost more than 75% of original topsoil.
 - Led to \downarrow agricultural land values and migration (during Great Depression). [Hornbeck \(2012\)](#)

Dust Bowl Migrants

Hornbeck (2021)

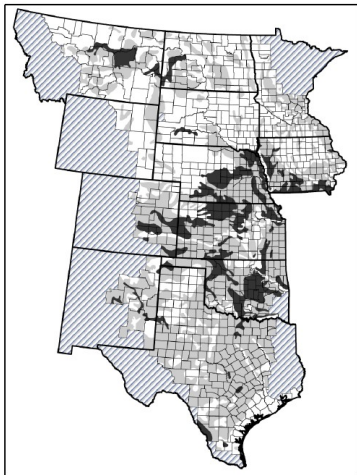
- How did migration respond to environmental collapse and associated economic upheaval?

Dust Bowl Migrants

Hornbeck (2021)

- How did migration respond to environmental collapse and associated economic upheaval?
- Challenge: identify Dust Bowl migrants separately from other migrants moving due to:
 - The Great Depression.
 - New Deal policies.
 - Agricultural mechanization.
 - Broader drought.

Dust Bowl Migrants



The 843 Plains counties, shaded by erosion level

Source: Hornbeck (2021). Map of low (< 25% topsoil lost), medium (25%–75%), or high (> 75%).

Dust Bowl Migrants: Data

- Study characteristics of Dust Bowl migrants using the full 1940 census:
 - County of residence 1940 and 1935.
 - Age, gender, education, farm status in 1935, birth state.
 - Sample selection: 25–55 in 1935 (50 million).

Dust Bowl Migrants: Data

- Study characteristics of Dust Bowl migrants using the full 1940 census:
 - County of residence 1940 and 1935.
 - Age, gender, education, farm status in 1935, birth state.
 - Sample selection: 25–55 in 1935 (50 million).
- Migration rate in county c :
 - Numerator: movers from county c to other counties from 1935 to 1940.
 - Denominator: People in 1940 reporting living in c in 1935 (recall error of 1935 location).
- Census of Agriculture (1910–1930): acres of farmland, cropland share, rural population, farms per acre, farm size, cattle per acre...

Dust Bowl Migrants: Empirical Strategy

- Estimate relative impact of Dust Bowl erosion on migration rates from Plains counties:

$$Y_c = \beta_1 H_c \beta_2 M_c + \alpha_s + \theta X_c + \varepsilon_c$$

- Y_c : migration rate for county c .
 - H_c : fraction of county in high-erosion area.
 - M_c : fraction of county in medium-erosion area.
 - α_s : state FE.
 - X_c : county characteristics in 1910, 1920, 1930.
- Identification from comparing more-eroded counties to less-eroded counties within same state with similar pre-1930s characteristics.

Dust Bowl Migrants: Empirical Strategy

- Estimate average differences between Plains migrants and non-migrants:

$$Y_{ic} = \beta \text{Migrant}_i + \gamma_c + \varepsilon_{ic}$$

- Y_{ic} : individual characteristic of individual i in c .
 - Migrant_i : indicator for having moved from a Plains county in 1945 to different county in 1940.
 - γ_c : county FE.
-
- When county FE 1935: β is average difference between Plains migrants and non-migrants from their old origin counties.
 - When county FE 1940: β is average difference between Plains migrants and natives in their new destination counties through U.S. (in-selection).

Dust Bowl Migrants: Empirical Strategy

- Estimate how Dust Bowl erosion induced different migrants:

$$Y_{ic} = \beta_1 H_c \times \text{Migrant}_i + \beta_2 M_c \times \text{Migrant}_i \\ + \alpha_s \times \text{Migrant}_i + \theta X_c \times \text{Migrant}_i + \gamma_c + \varepsilon_{ic}$$

- β s indicate how selection of Plains migrants from high-erosion and medium-erosion counties is different than selection of Plains migrants from low-erosion counties.

Dust Bowl Migrants: Results

		Relative to Low Erosion Counties:	
	All Plains Counties (1)	High-Erosion Counties (2)	Medium-Erosion Counties (3)
Panel A. Migration To All Counties			
Migration Percent	17.05 [5.19]	3.05 (0.64)	1.86 (0.46)
Panel B. Migration Beyond 200 Miles			
Migration Percent	7.19 [3.82]	2.57 (0.56)	1.38 (0.33)
Panel C. Migration Within 200 Miles			
Migration Percent	9.86 [3.41]	0.47 (0.38)	0.47 (0.28)

Estimated Migration From 1935 to 1940, by Original County Erosion Level

Source: Hornbeck (2021).

Dust Bowl Migrants: Results

Outcome:	Migrants to All Counties		
	Migrants from All Plains Counties (1)	Relative to Low-Erosion: Migrants from High-Erosion Counties (2)	Migrants from Med-Erosion Counties (3)
Years of Education			
Men	1.11 (0.06)	-0.51 (0.13)	-0.37 (0.10)
Women	1.02 (0.05)	-0.44 (0.13)	-0.37 (0.10)
Percent Living in Birth State in 1935	-8.47 (0.64)	2.63 (1.35)	1.92 (1.02)
Percent Living on a Farm in 1935	-9.79 (0.68)	1.34 (1.40)	0.93 (0.98)
Age	-2.95 (0.04)	0.08 (0.14)	-0.10 (0.10)
Percent Male	3.65 (0.21)	-0.32 (0.40)	-0.45 (0.32)

Estimated Out-selection of Migrants, by Original County Erosion Level

Source: Hornbeck (2021).

Dust Bowl Migrants: Results

Outcome:	Migrants to All Counties		
	Relative to Low-Erosion:		
	Migrants from All Plains Counties (1)	Migrants from High-Erosion Counties (2)	Migrants from Med-Erosion Counties (3)
Percent Living on a Farm			
in 1935	0.81 (1.74)	3.22 (1.31)	2.03 (0.99)
in 1940	-5.01 (0.70)	0.98 (0.79)	0.82 (0.64)
Years of Education			
Men	1.14 (0.15)	-0.35 (0.17)	-0.28 (0.09)
Women	1.12 (0.15)	-0.26 (0.14)	-0.29 (0.08)
Log Income in 1939			
Men	-0.017 (0.039)	-0.078 (0.029)	-0.071 (0.017)
Women	-0.156 (0.047)	-0.073 (0.040)	-0.044 (0.021)
Log Income in 1939, Skill-Adjusted			
Men	-0.093 (0.025)	-0.050 (0.022)	-0.049 (0.013)
Women	-0.214 (0.028)	-0.052 (0.024)	-0.031 (0.018)
Weeks Worked			
Men	-2.16 (0.25)	-0.14 (0.29)	-0.01 (0.19)
Women	-0.48 (0.30)	0.25 (0.42)	0.47 (0.26)

Estimated In-selection of Migrants, by Original County Erosion Level

Source: Hornbeck (2021).

Dust Bowl Migrants: Results

- Substantial migration response to Dust Bowl.
- While general migrants were positively selected, Dust Bowl migrants were negatively selected.
- Dust Bowl migrants pushed by environmental collapse rather than pulled to economic opportunities.
- Dust Bowl migrants struggled economically in 1939, relative to native, especially from more eroded areas.