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THE LONDON SCHOOL
OF ECONOMICS AND
POLITICAL SCIENCE ■

Lessons from Economic History for Green Growth

Roger Fouquet and Ralph Hippe

**Grantham Research Institute on Climate Change and Environment
London School of Economics (LSE)**



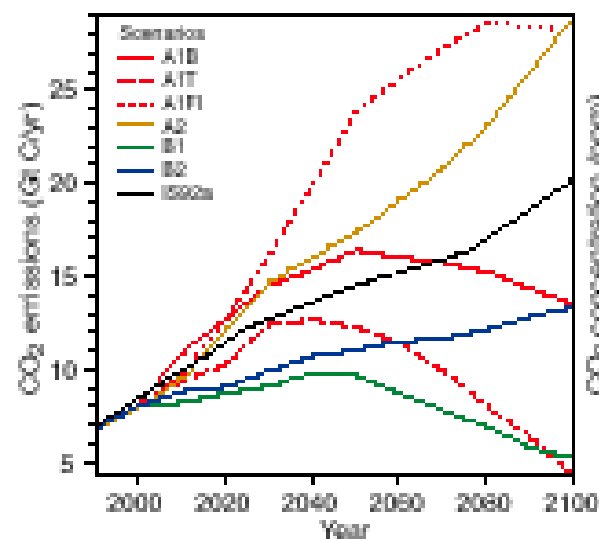
The Importance of History



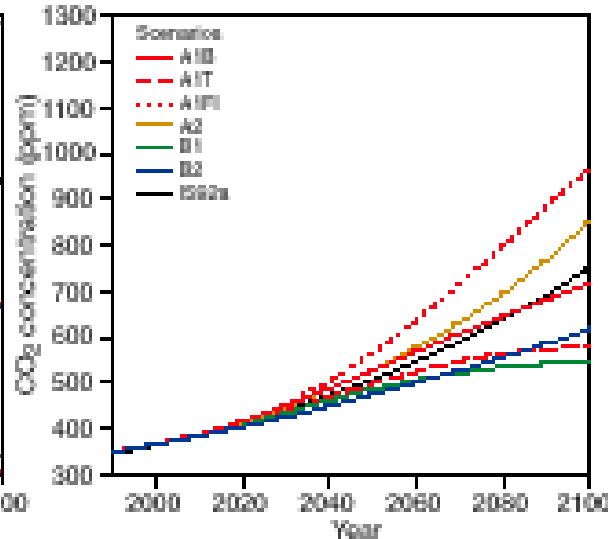
- **“Those who cannot remember the past, are condemned to repeat it” George Santayana**
- **Long Run and Very Long Run Trends**
- **Experiences to Learn from (Shocks, Transitions)**
- **Generalizable from Many Experiences**
- **History Matters: Past Technologies, Institutions and Culture matter to Present Behaviour and Development (Acemoglu et al. 2001, Nunn 2009)**
- **Yet, Lack of Historical Lessons for Policy**

The global climate of the 21st century

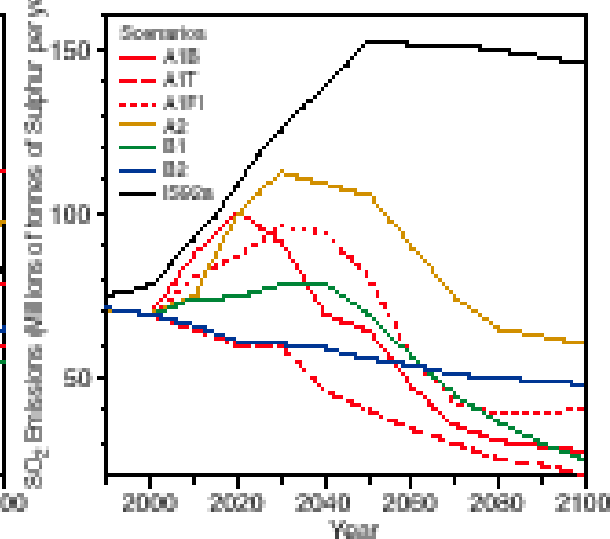
(a) CO₂ emissions



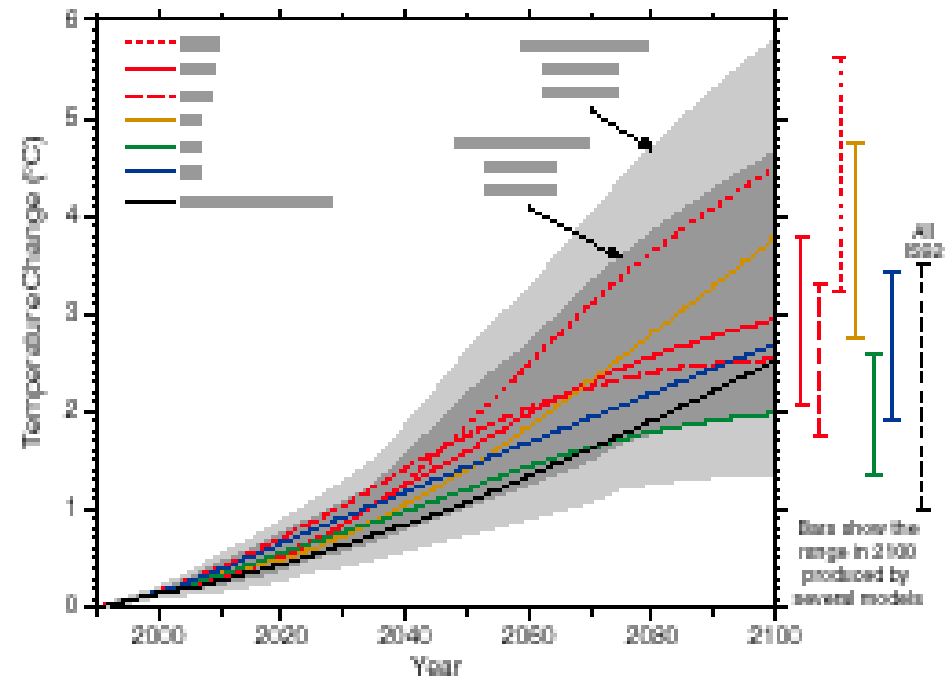
(b) CO₂ concentrations



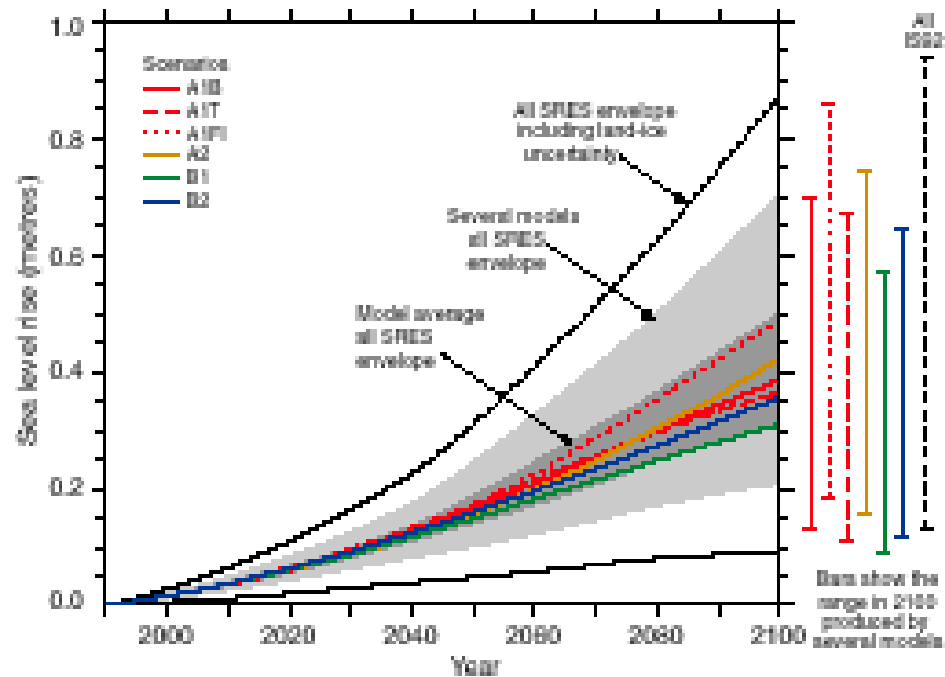
(c) SO₂ emissions



(d) Temperature change



(e) Sea level rise



Outline

- **History of Economic Growth and Development**
 - **Broad Understanding of Trends and Drivers**
- **Energy and Environmental History**
 - **LR Relationship with Economic Growth**
 - **Role of Technologies in Economic Development and Welfare**
- **The Development of the Knowledge Economy**
 - **Future Key Source of Low-Energy Growth?**
 - **Understand and Learn LR Development**



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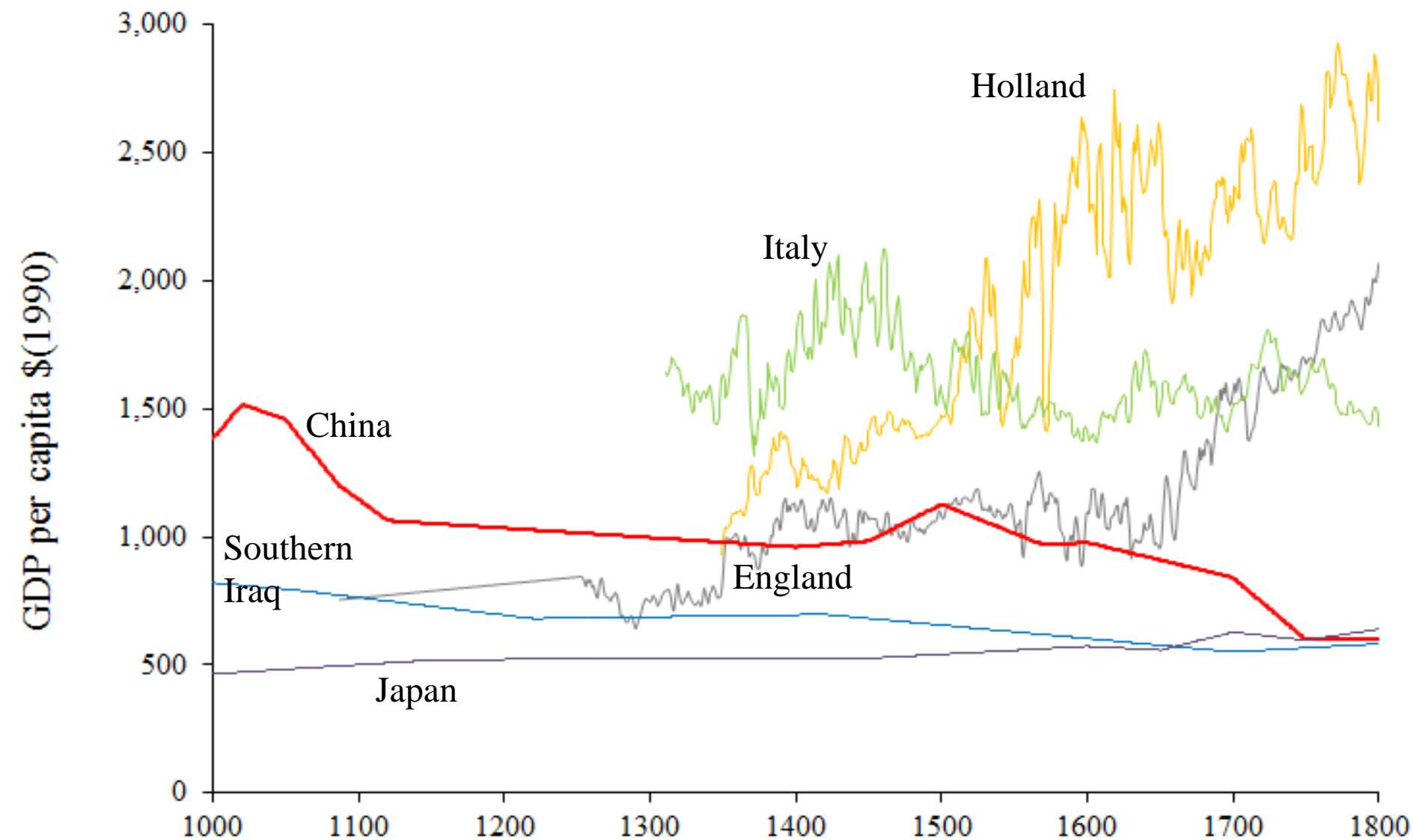
Part 1

History of Economic Growth and Development



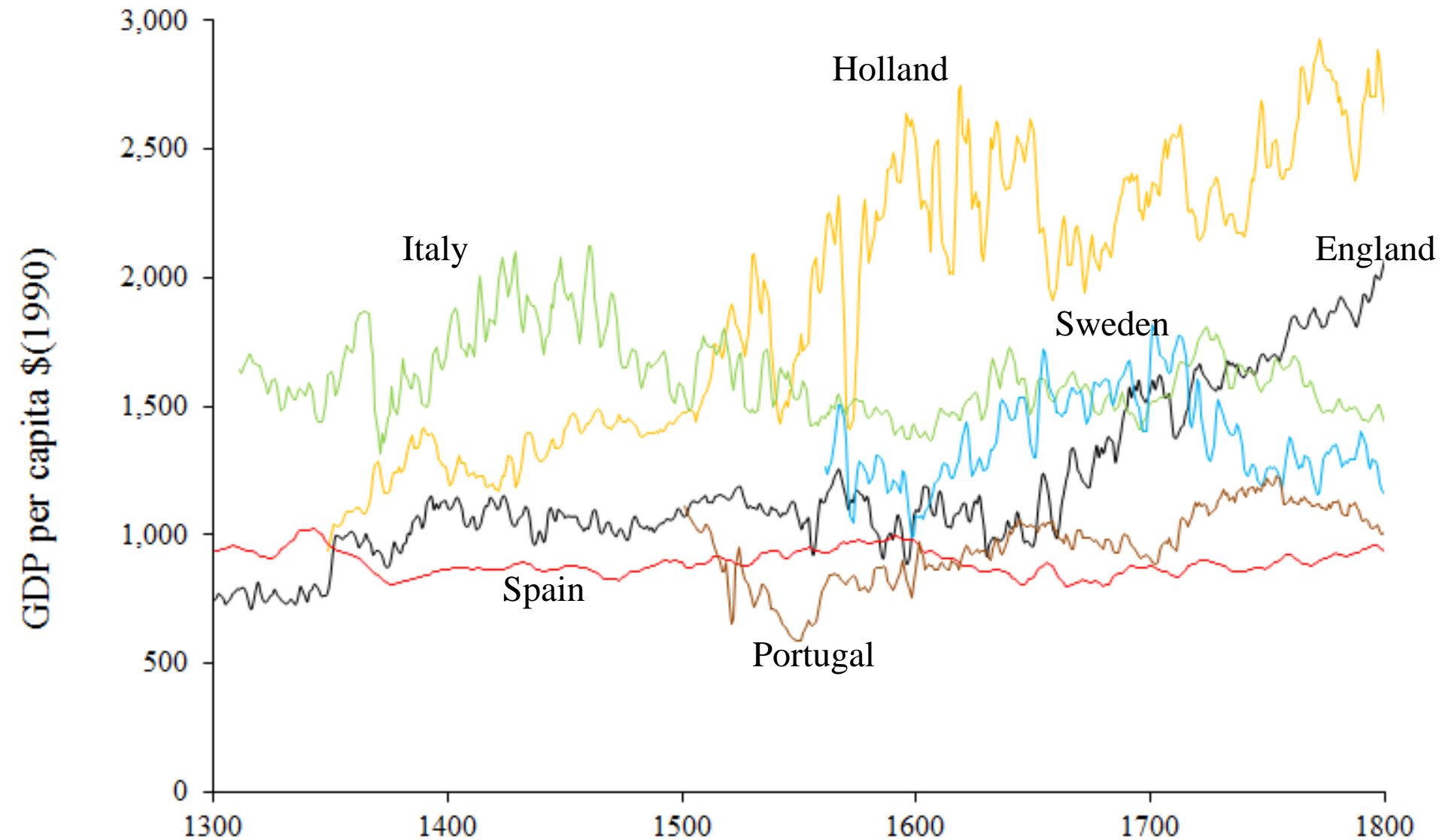
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GDP per capita in Selected World Countries, 1000-1800



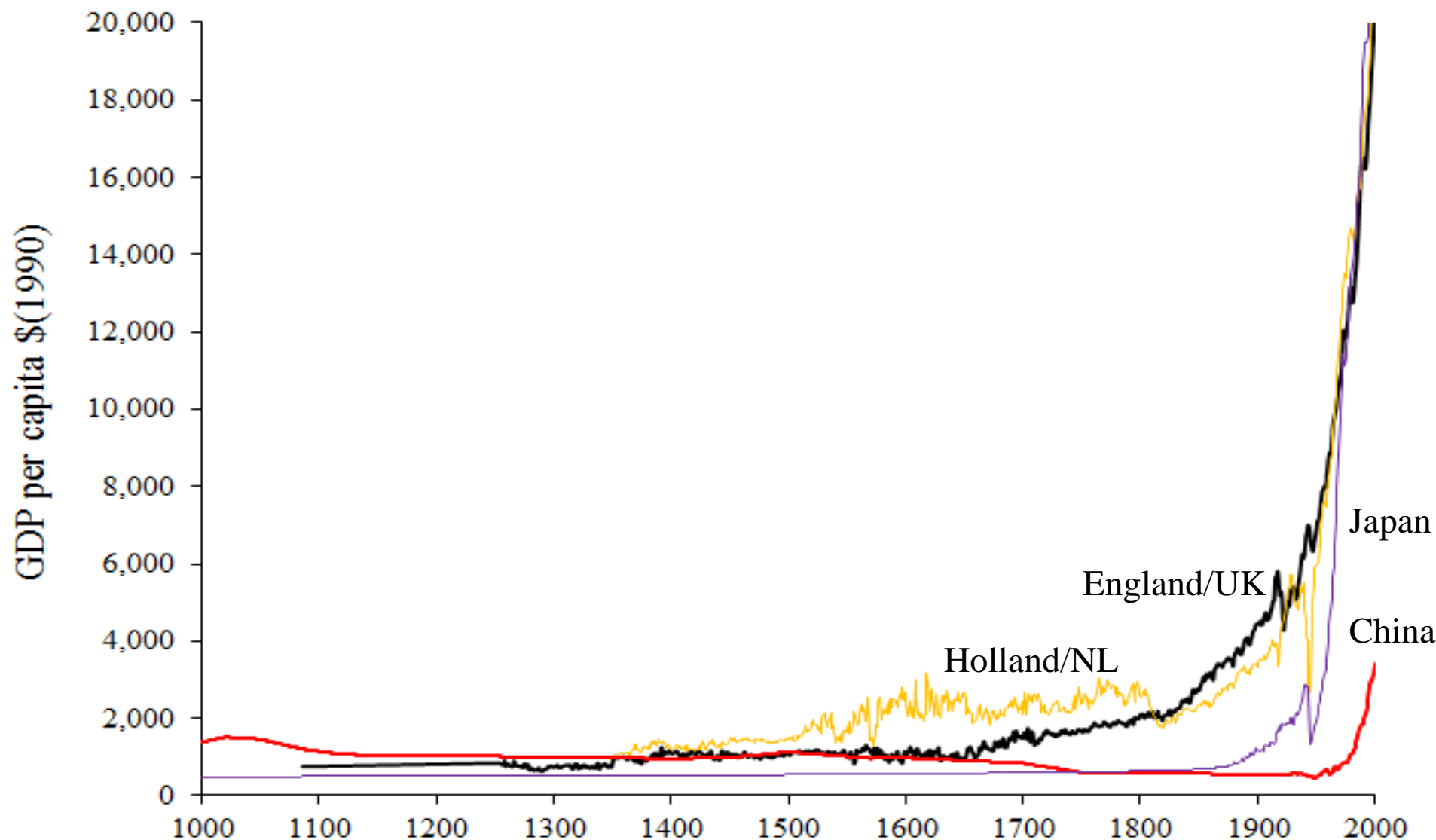
Source: see Fouquet (2015a); * 3-year average.

GDP per capita* in Selected European Countries, 1300-1800



Source: Fouquet 2015; * 3-year average; (Spain: 11-year average).

GDP per capita in Selected World Countries, 1000-2000



Source: Maddison/Bolt and van Zanden (2014), Fouquet (2015).



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Part 2

Energy and Environmental History

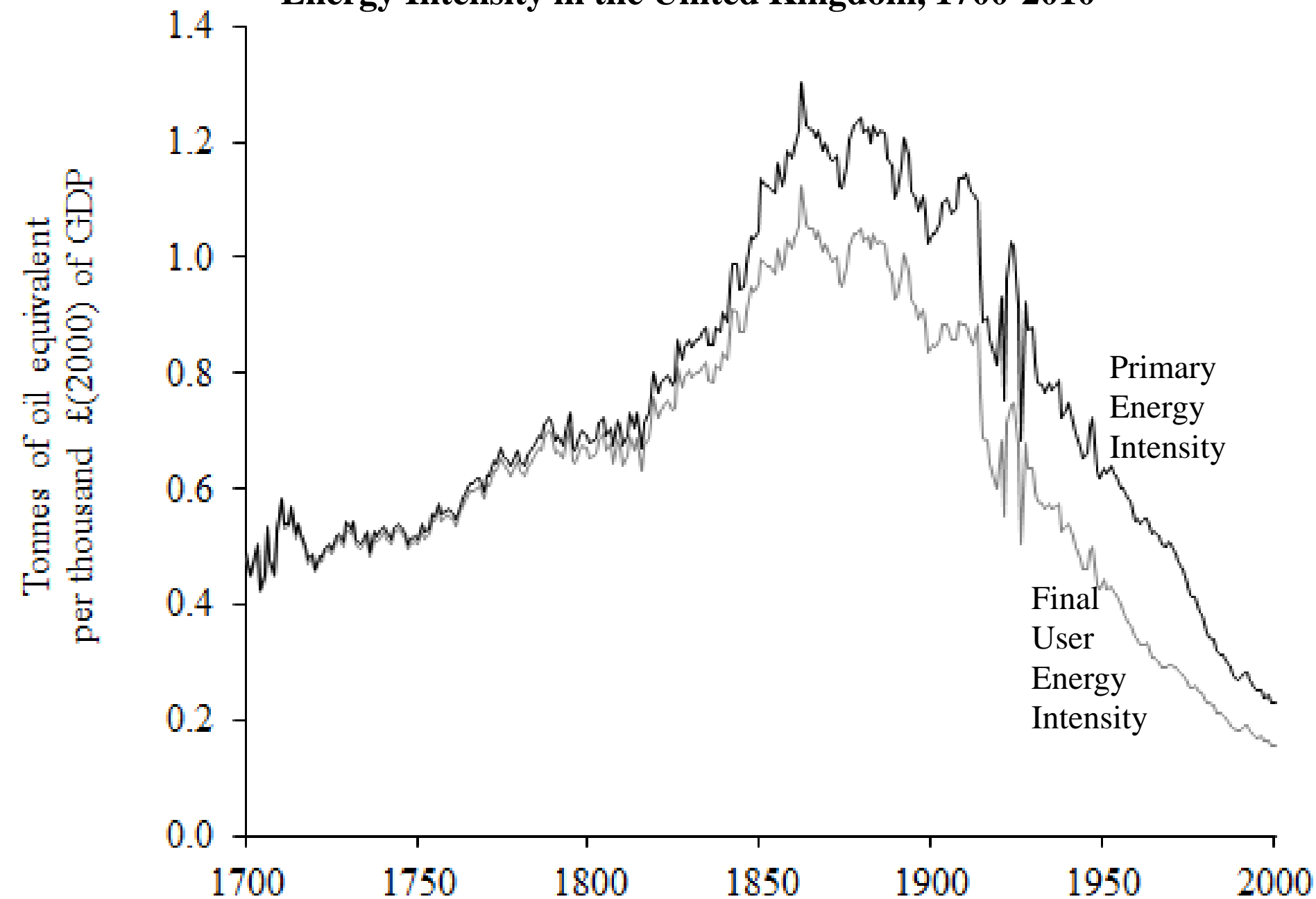


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The Role of Energy in Industrial Revolution

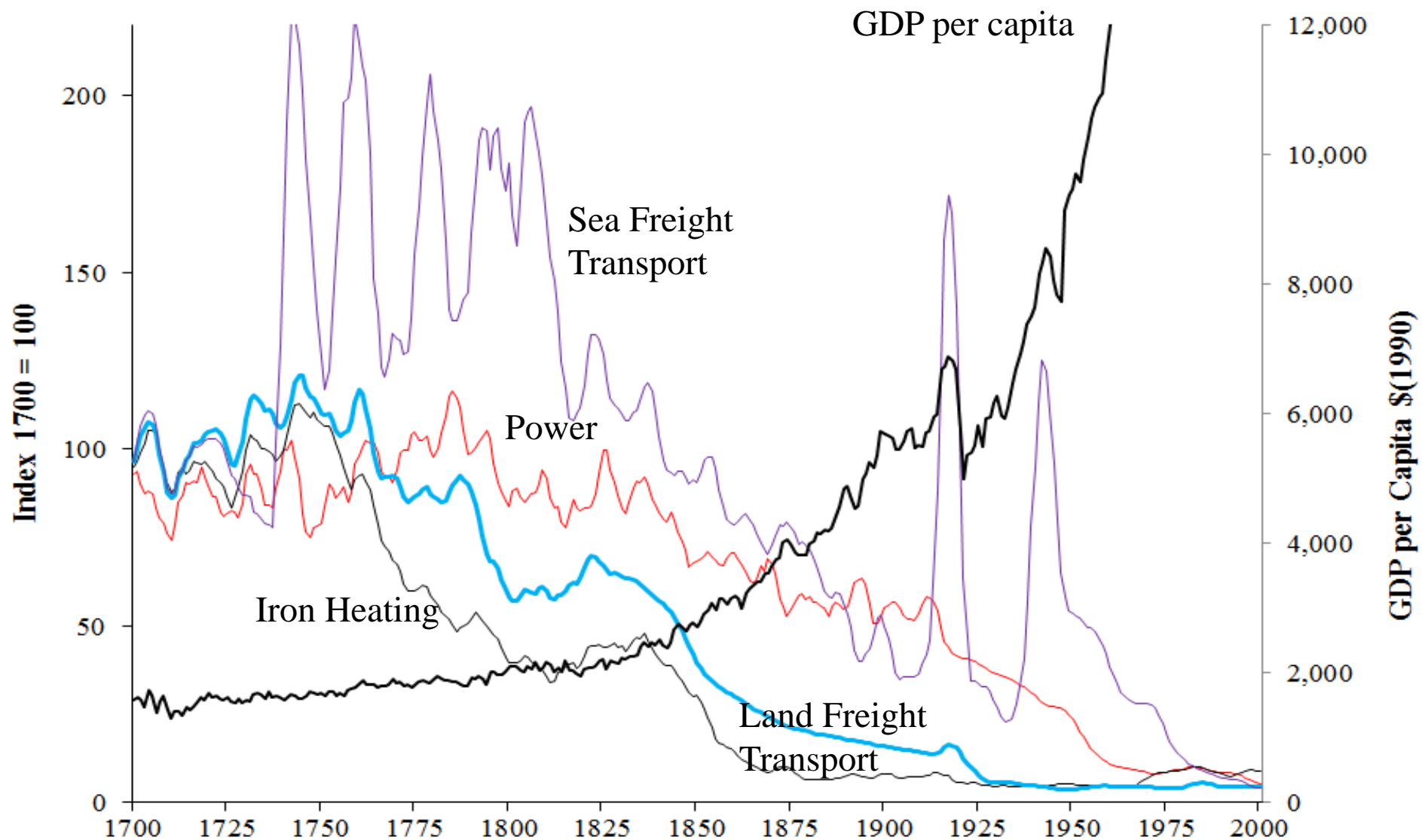
- **Many Factors: Technology, Institutions, Culture**
- **Cipolla (1962), Landes (1969), Wrigley (1988), Allen (2009)**
 - **Importance of the Transition to Coal**
- **Ayres and Warr (2009)**
 - **Role of Energy and Technical Efficiency**
- **Toman and Jemelkova (2003)**
 - **Importance of Energy Services**
 - **Different Channels of Effect of Energy Services**
 - **Effects Change with Economic Development**

Energy Intensity in the United Kingdom, 1700-2010



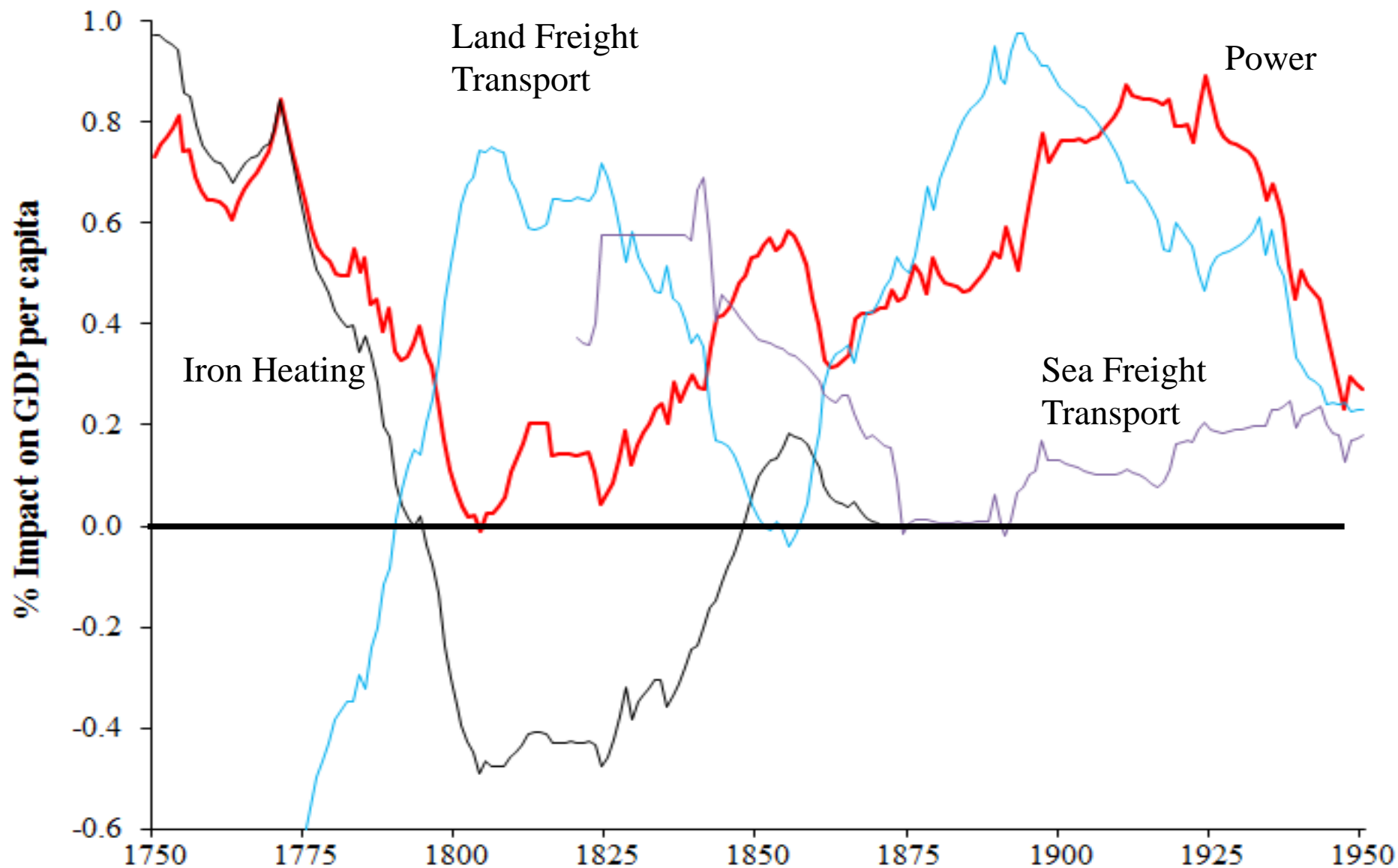
Source: updated from Fouquet (2008)

Price of Producer Energy Services in the United Kingdom, 1700-2010



Source: Fouquet (2011) REEP, Broadberry et al (2013).

Impact of 1% Decline in Energy Service Prices on GDP per capita, 1750-1950

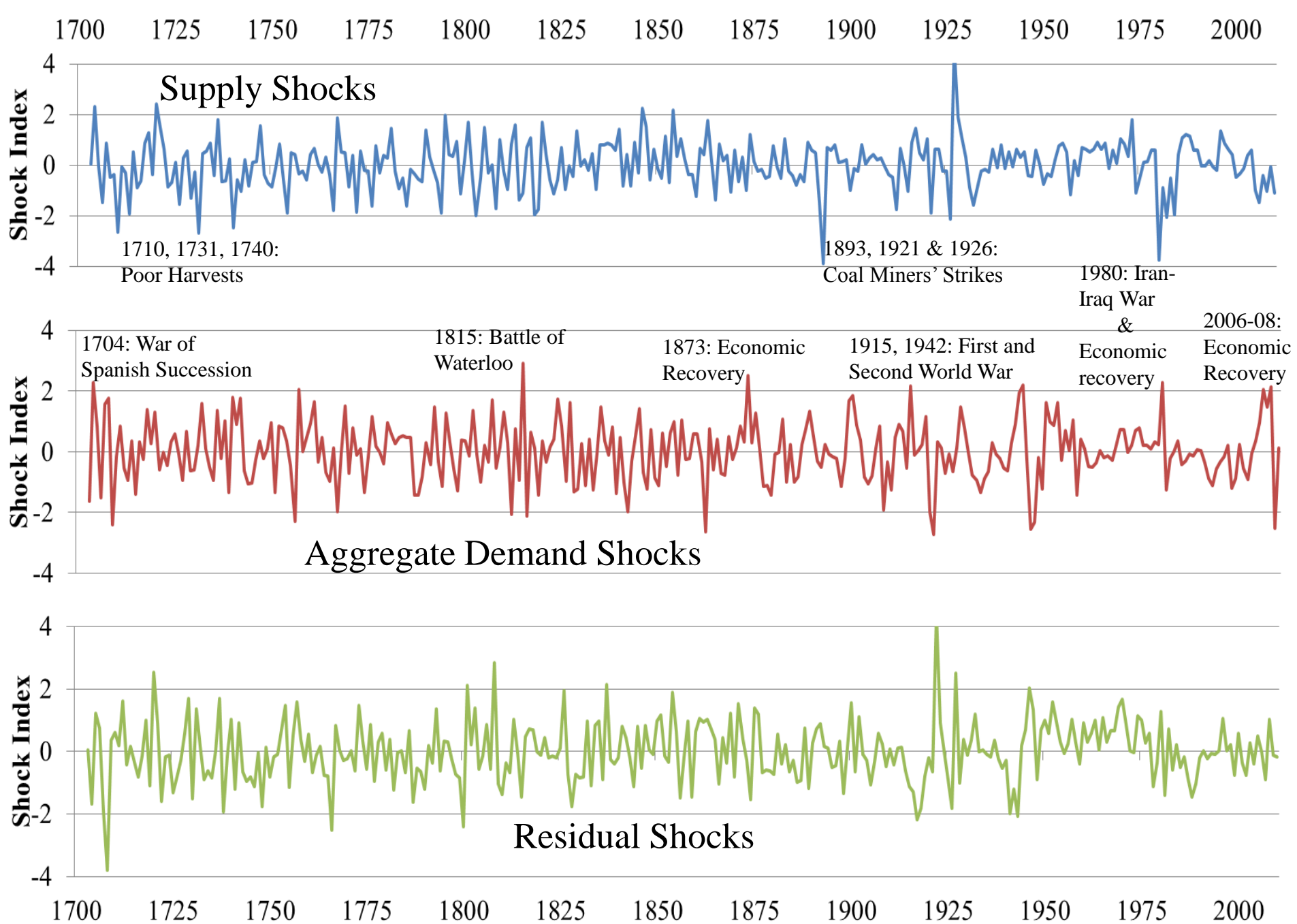


The Role of Producer Energy Services on the Industrial Revolution

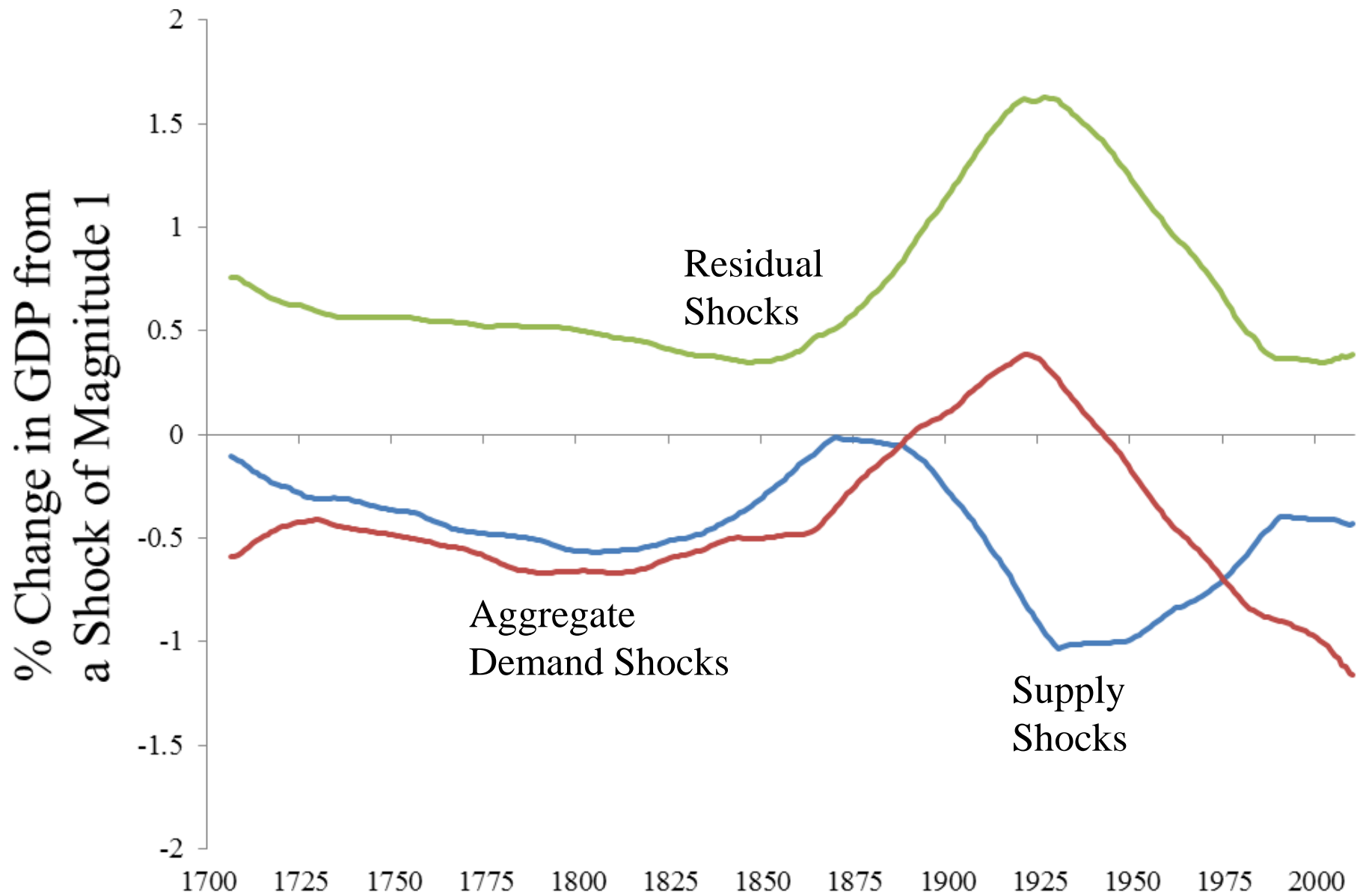
- **Confirms: Effect on GDP pc Changed**
- **Technological Impact on GDP per capita:**
 - **Kick-Starters and Drivers of Periods of Ec. Growth**
 - **Co-Evolution and Synergies between Technologies**
 - **Transformative Effect of Energy Technologies**
- **Need to Understand How Cheap Energy Services
Intensifies Energy Service Use in the Economy**

The Importance of Energy Price Shocks on Economic Growth

- **Kilian (2009), etc..:**
Since 1948, Declining Impact of Energy Price Shocks
- **Our Hypothesis:**
**Impact of Energy Price Shocks declined
as Economies Developed**
- **Separate Shocks into:**
 - **Supply Shocks**
 - **Aggregate Demand Shocks**
 - **Residual/'Speculative'/Energy-Specific Shocks**



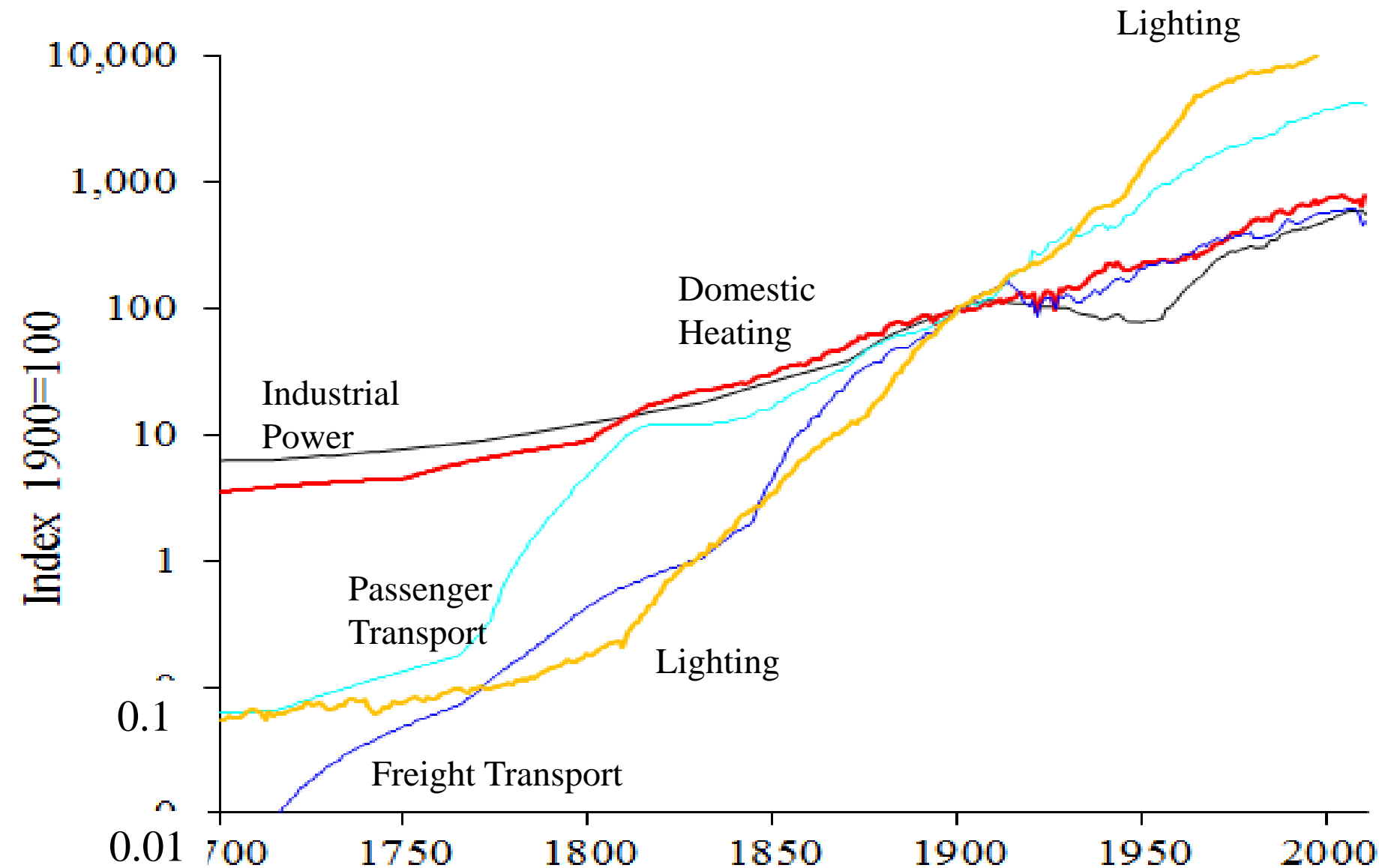
Source: van de Ven and Fouquet (2014)



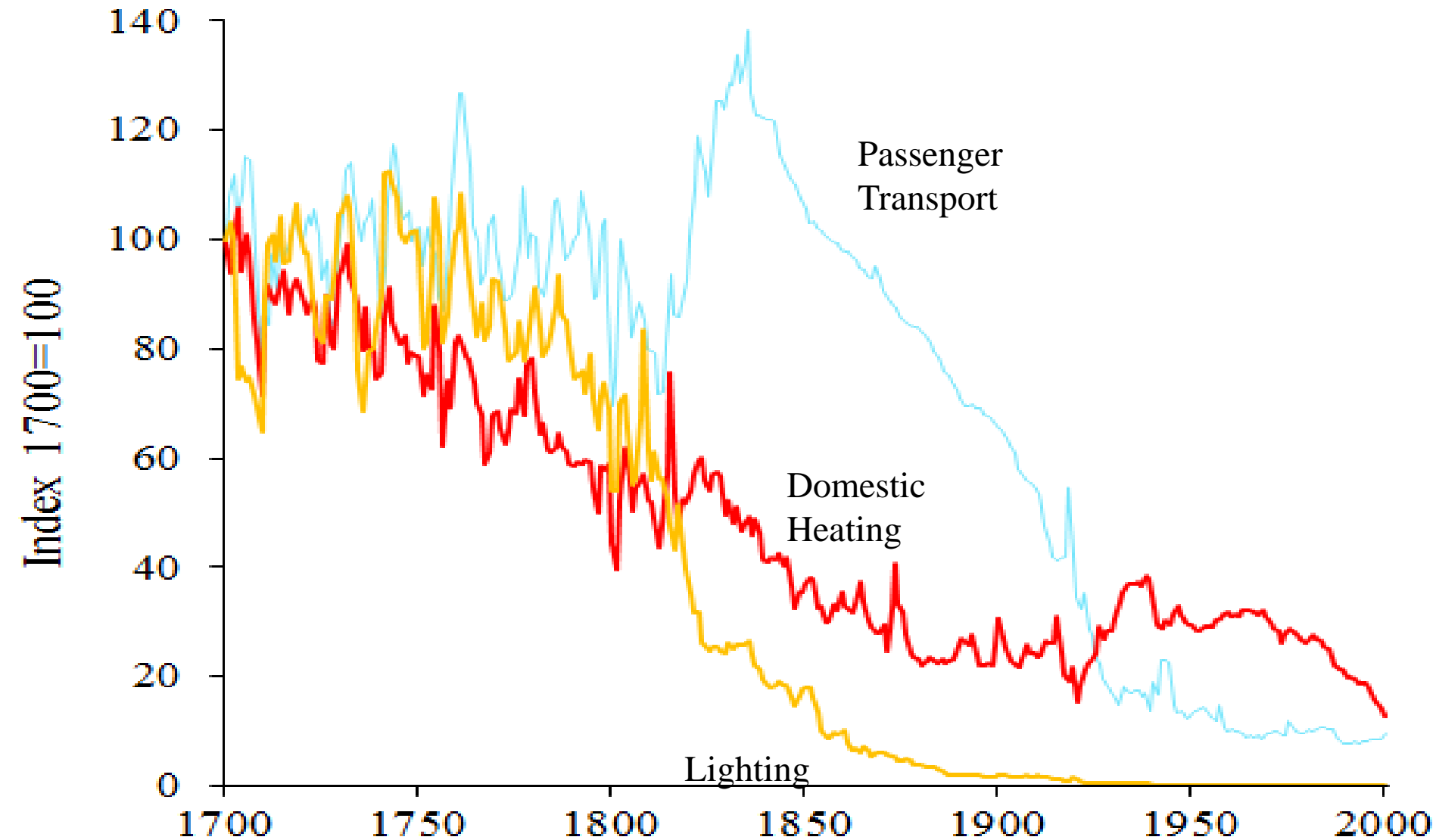
Changing Impact of Energy Price Shocks on Economic Growth

- **Supply shocks:**
 - **Stronger with Increasing Dependence on Coal (1920s)**
 - **Declining Impact after WW-II Confirmed**
- **Aggregate Demand shocks:**
 - **Positive Impact Dependent on Import-Export**
- **Reject Hypothesis:**
 - **Impact does Not Decline as Economy Develops**
- **But, Still a lot to Understand...**

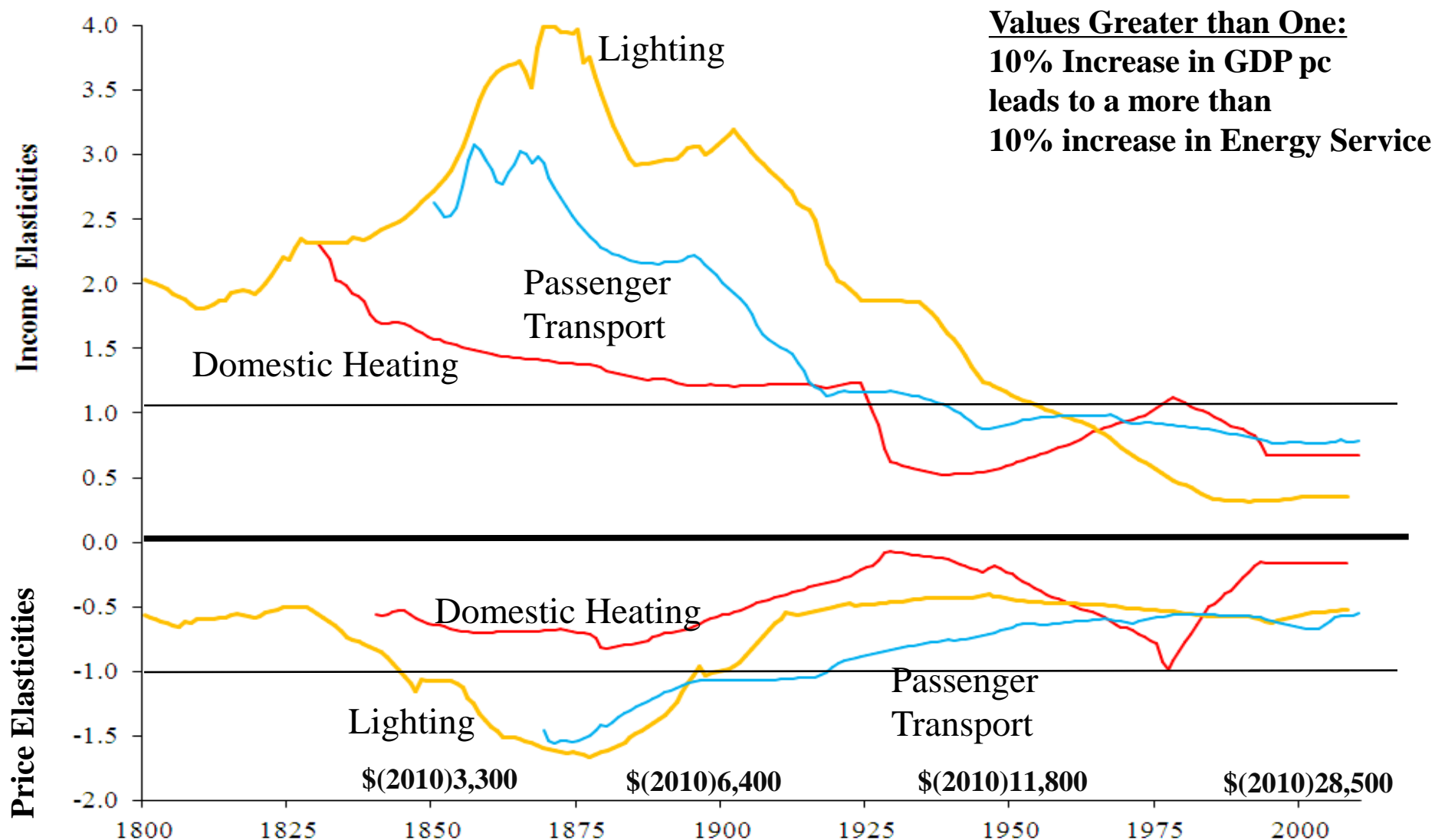
Consumption of Energy Services in the UK, 1700-2010



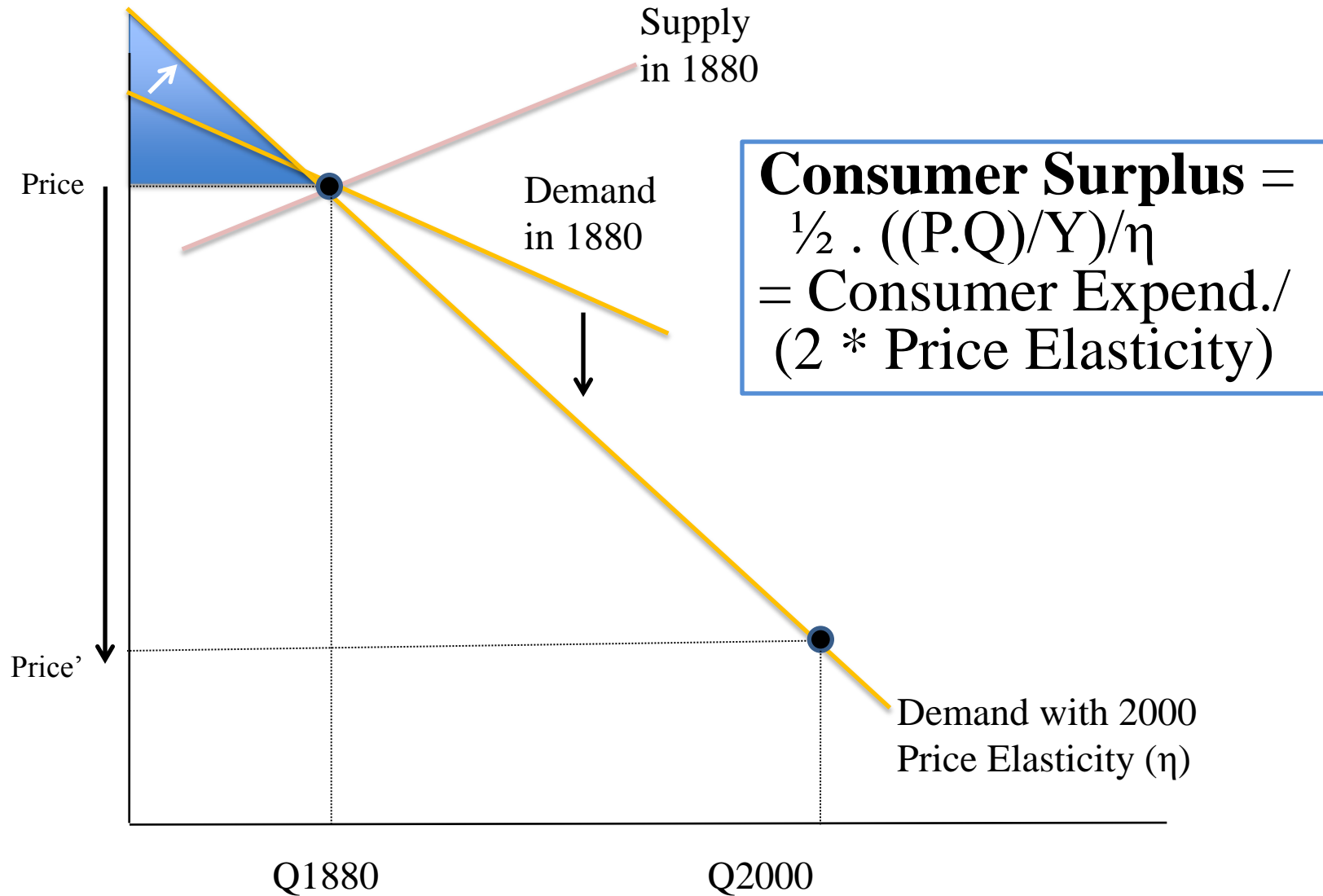
Price of Energy Services in the United Kingdom, 1700-2000



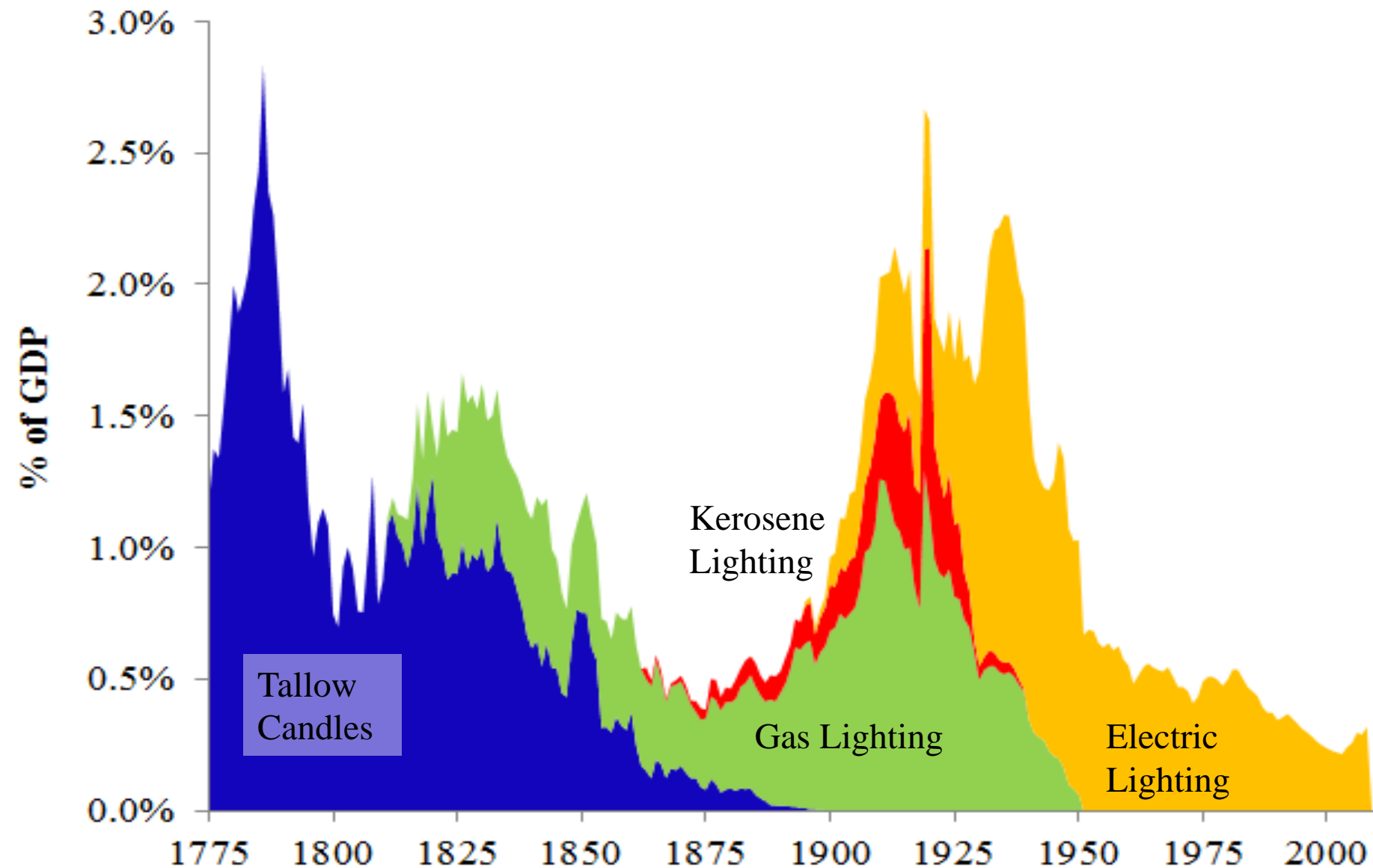
Income and Price Elasticity of Demand for Energy Services, 1800-2010



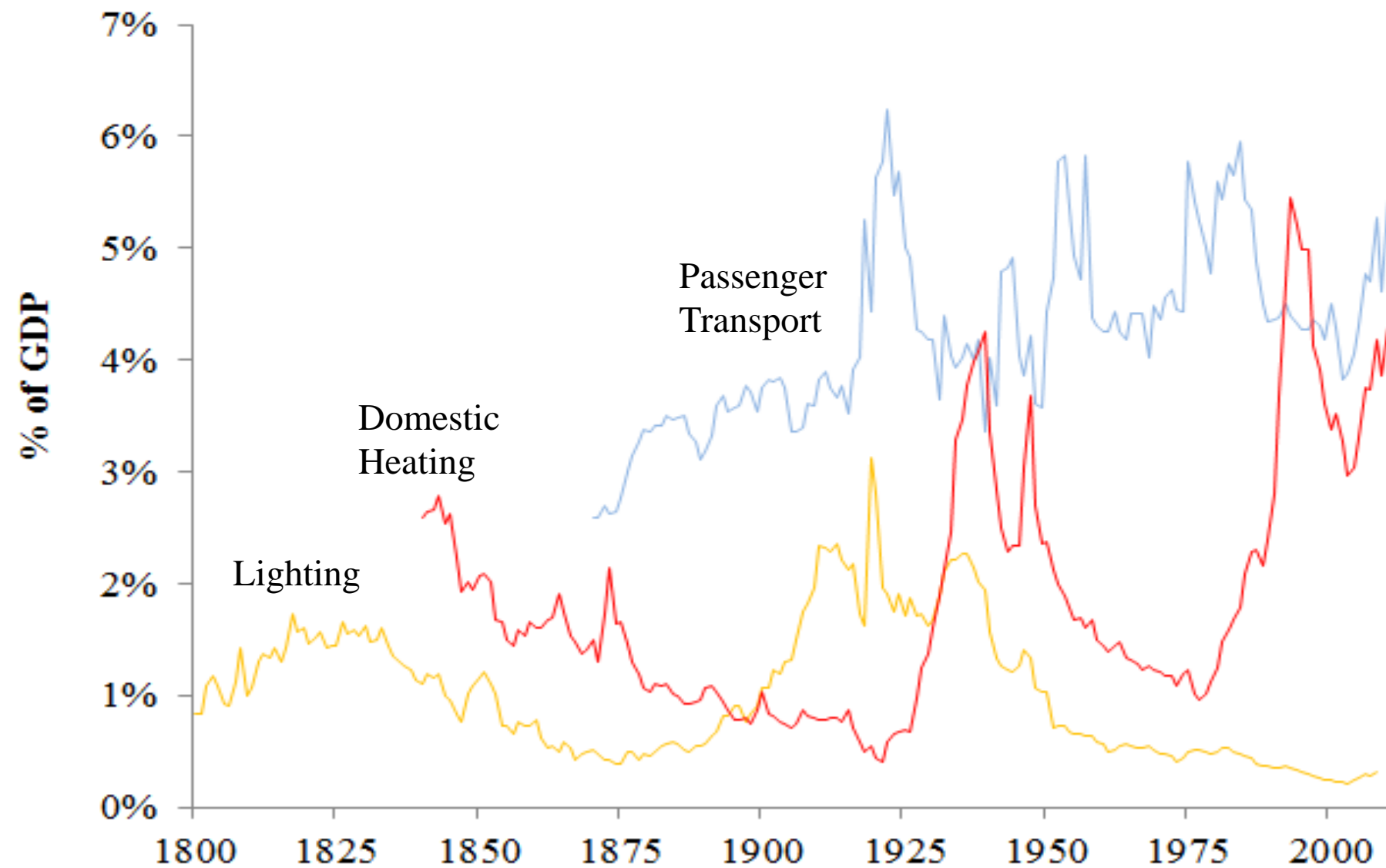
The Net Benefits of Energy Technologies and Services

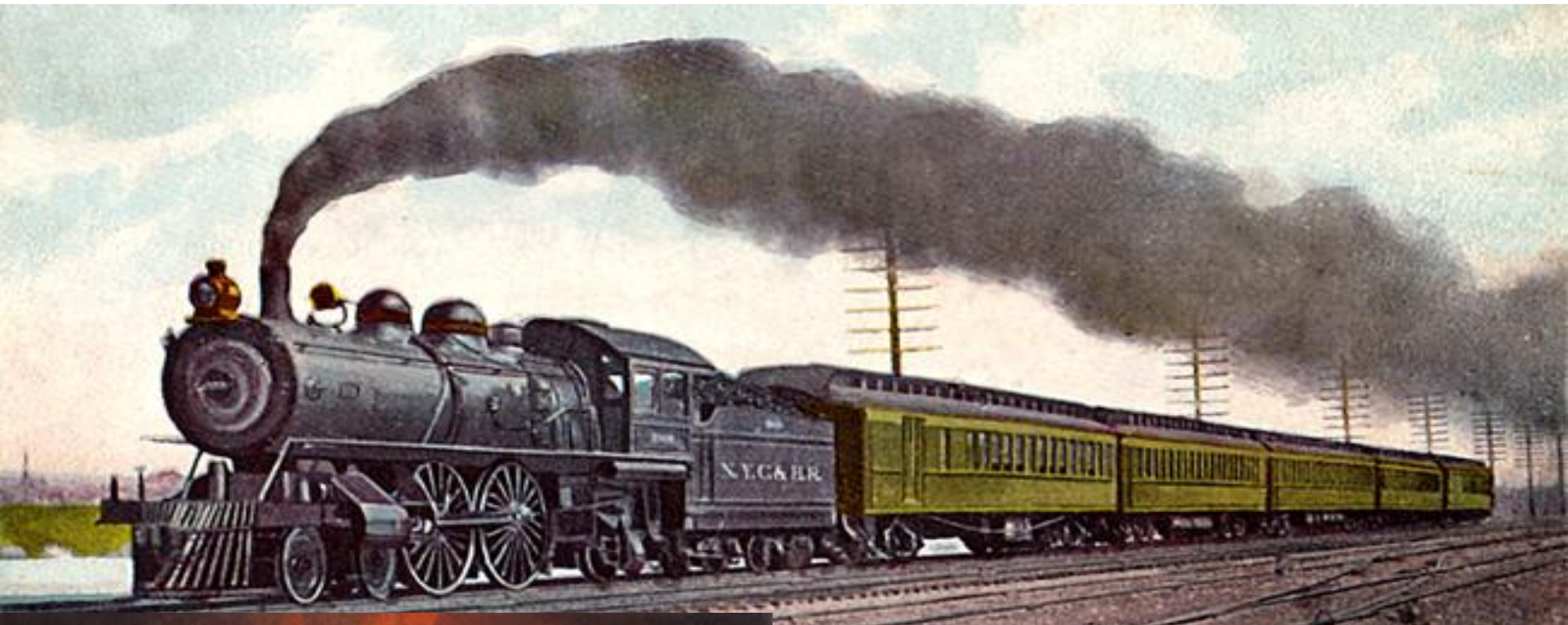


Consumer Surplus of Lighting by Energy Source (relative to GDP) in the UK, 1800-2010

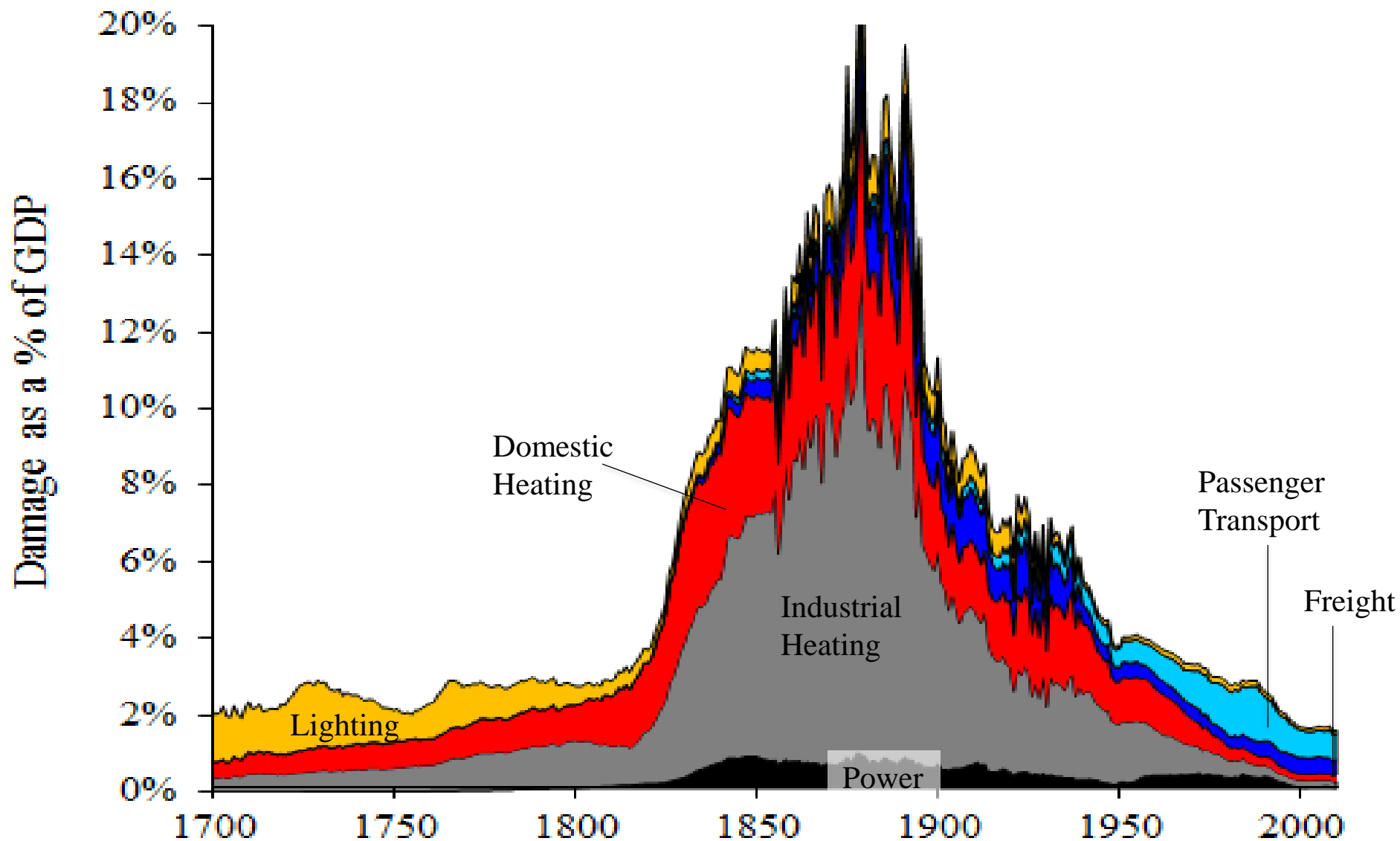


Consumer Surplus of Domestic Heating, Passenger Transport and Lighting in the UK, 1800-2010

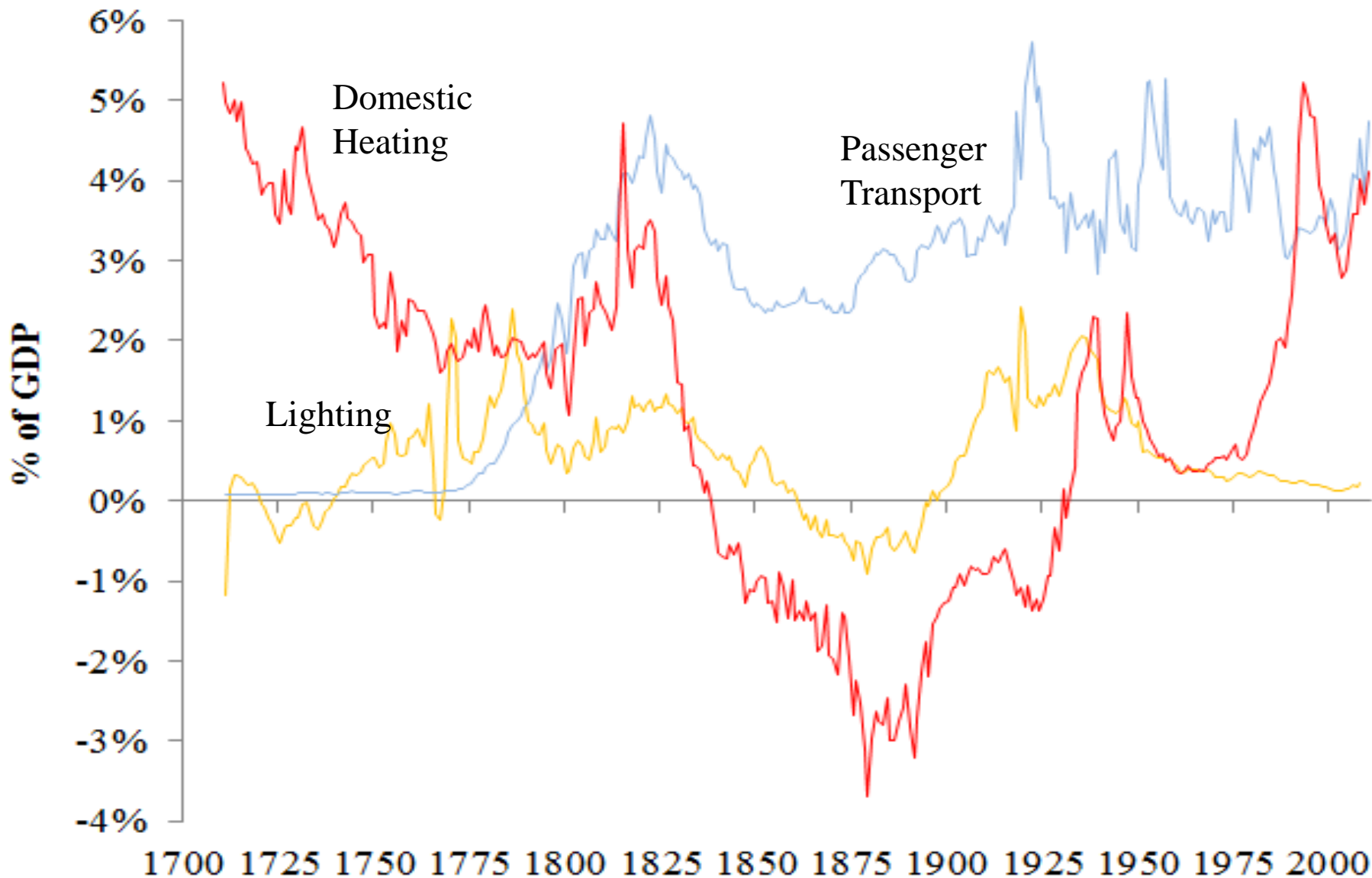




External Costs of Energy Services as a % of GDP in the United Kingdom, 1700-2010

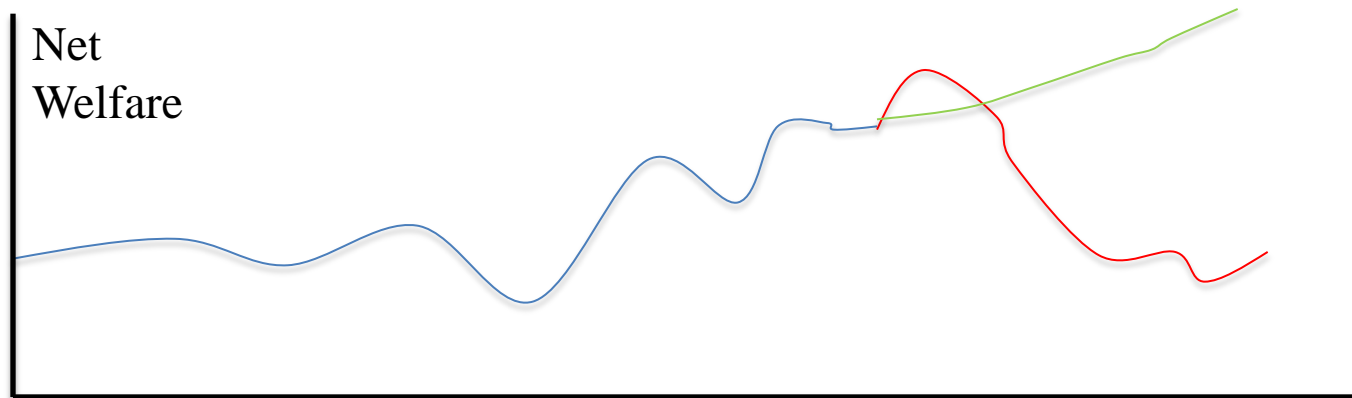


Net Welfare (i.e. Cost-Benefit Analysis) of Domestic Heating, Passenger Transport and Lighting in the UK, 1700-2010



Net Welfare Effects of Energy Services

- **Value of Innovations to Society**
 - **Are some Technologies Socially Undesirable?**
- **Where should we focus Investment in R&D rel. to Energy Services, Sources and Technologies?**
- **Do Economies fail to take the Optimal Path?**





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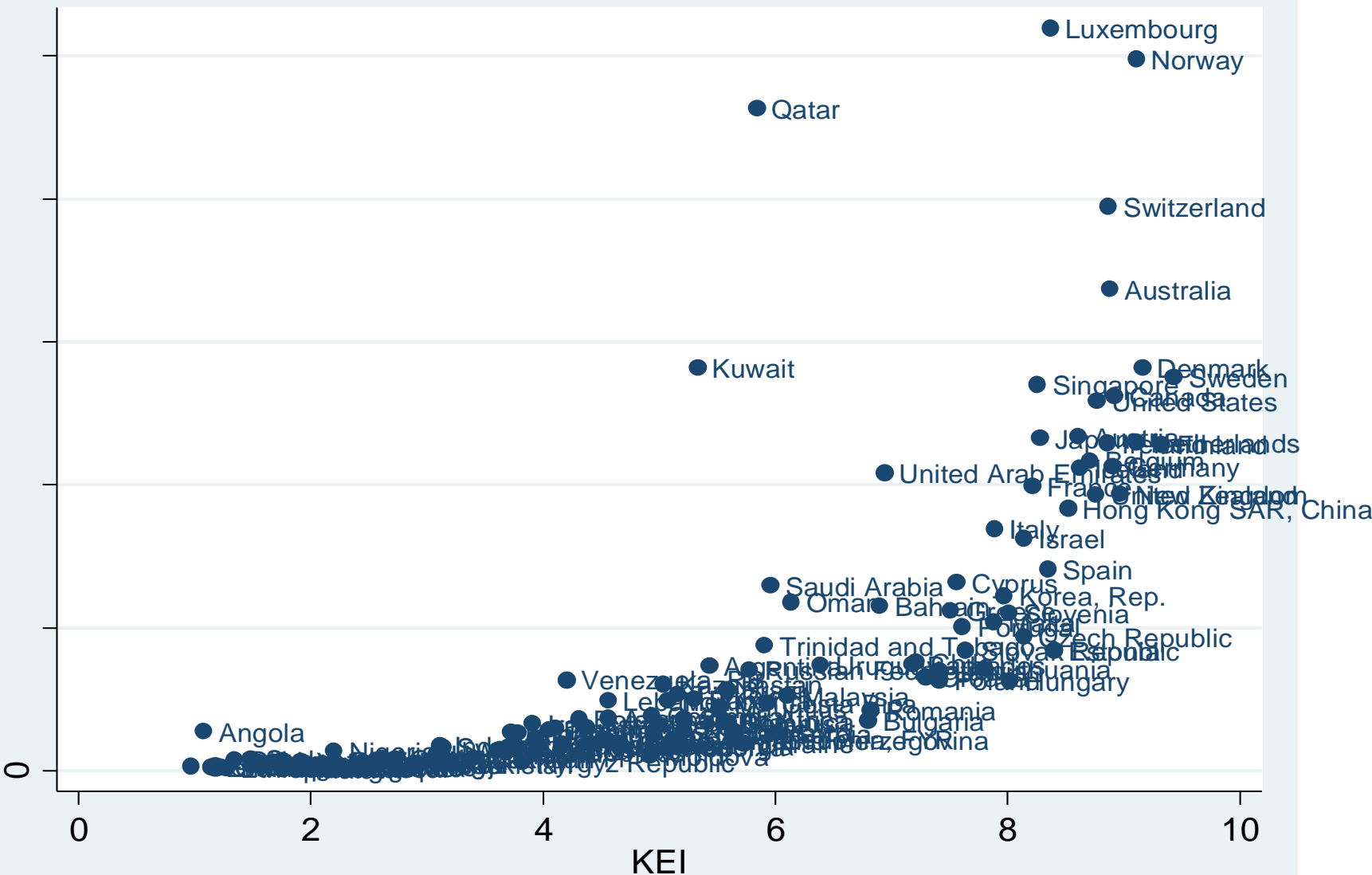
Part 3

The Development of the Knowledge Economy



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Knowledge Economy Index and GDP per capita, 2012



Source: World Bank (2008).

Pillars of the Knowledge Economy

- **Human Capital**
- **Information and Communication Technologies and Infrastructure**
- **Knowledge Production and Innovation System**
- **Seeking to Understand
the Development of Knowledge Economy**

The Role of the Knowledge Economy in Green Growth

- **Potential for Low-Energy/Resource Growth**
- **Dematerialisation of the Economy**
- **Lessons from History of Governance**
 - **Openness to Change**
 - **Investments in Public Goods**

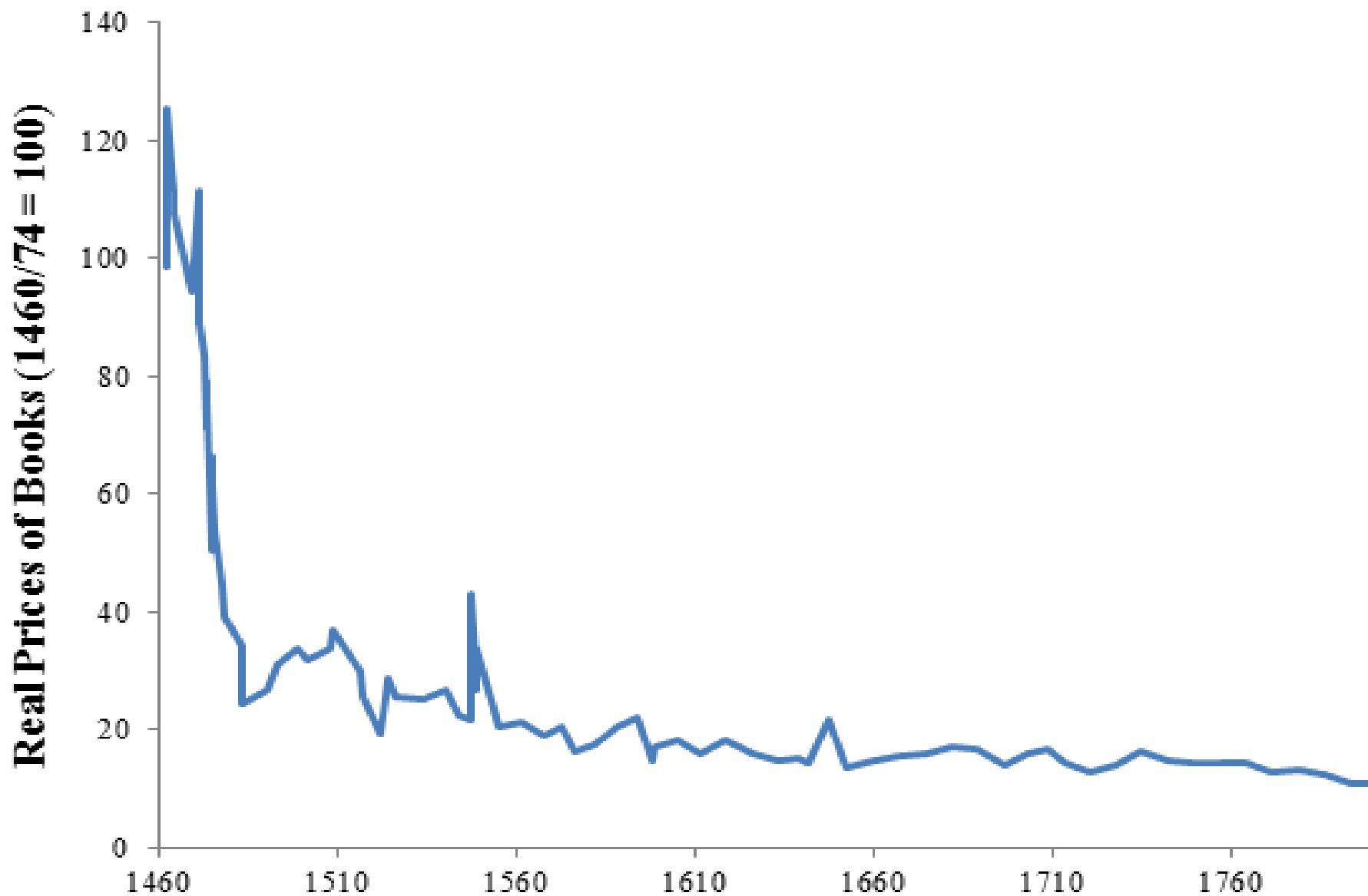
The Human Capital Transition

- **Why the Shift from Low to High Human Capital?**
- **Was it Demand- or Supply (ICT)-Driven?**
- **Were there Market or Government Failures?**
- **What Role did Government Play?**
- **What Lessons does the Transition offer?**

The Printing Press (ICT) and Government

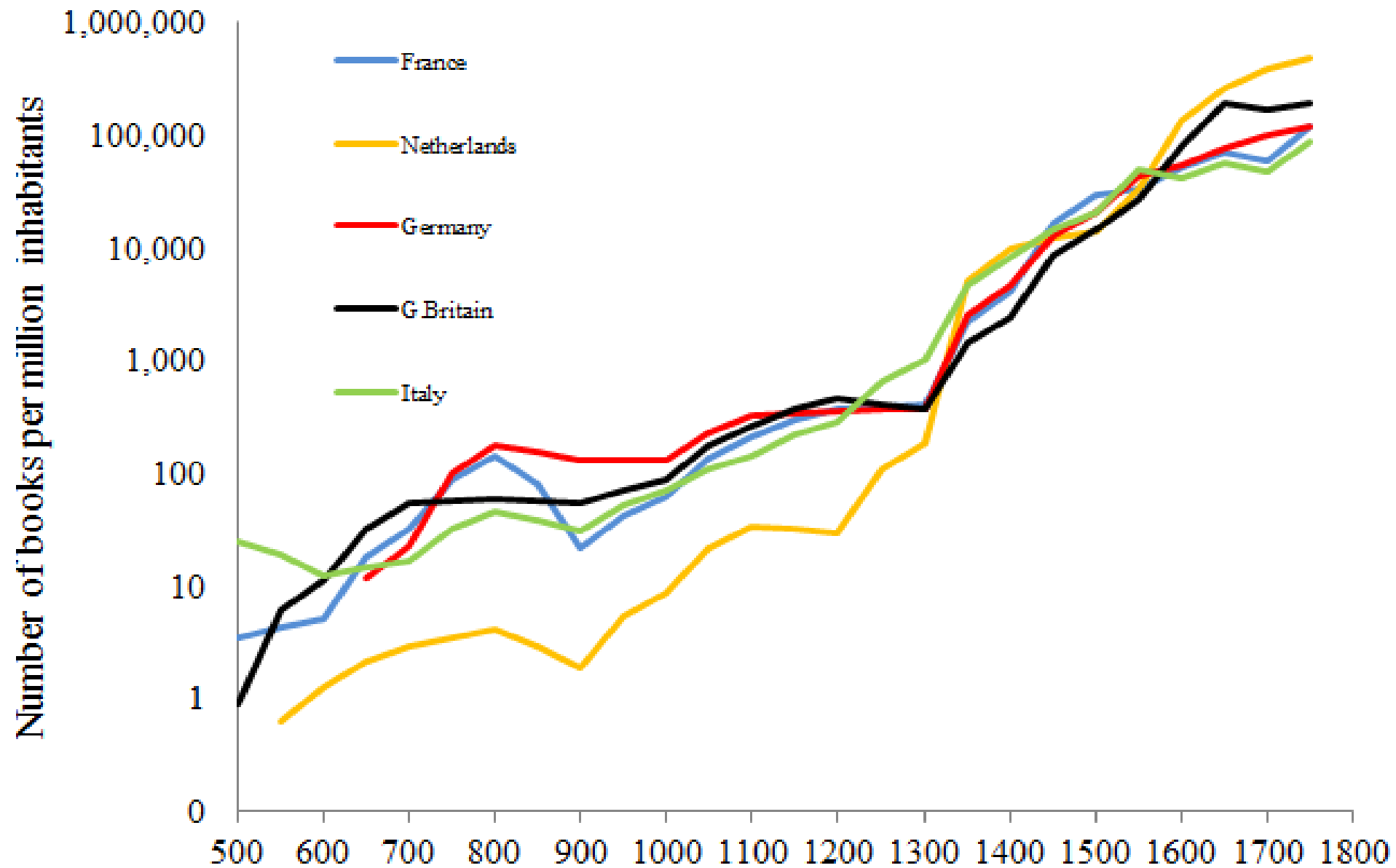
- **Gutenberg Press (Late 1440s)**
 - Responding to Demand
 - Revolutionised
- **Government/Authorities Response**
 - Europe:
 - Church Initially Positive
 - Governments: Lack of Power to Control
 - Ottoman Empire: Effective Ban
 - Korea: Strong State Control

Price of Books in the Netherlands, 1460-1800



Source: van Zanden (2009).

Book Production in Selected European Countries, 500-1750

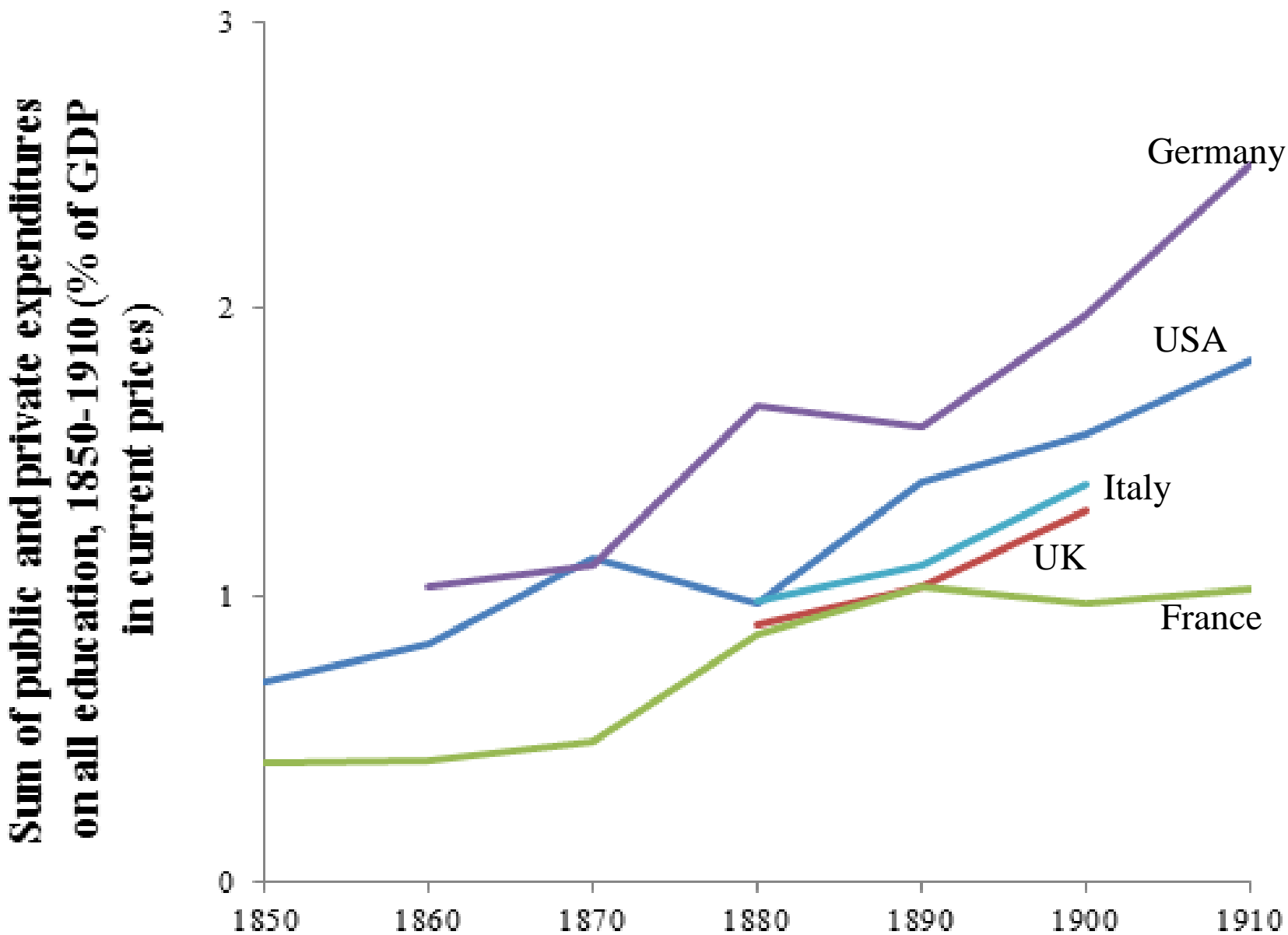


Source: Based on Buringh and van Zanden (2009).

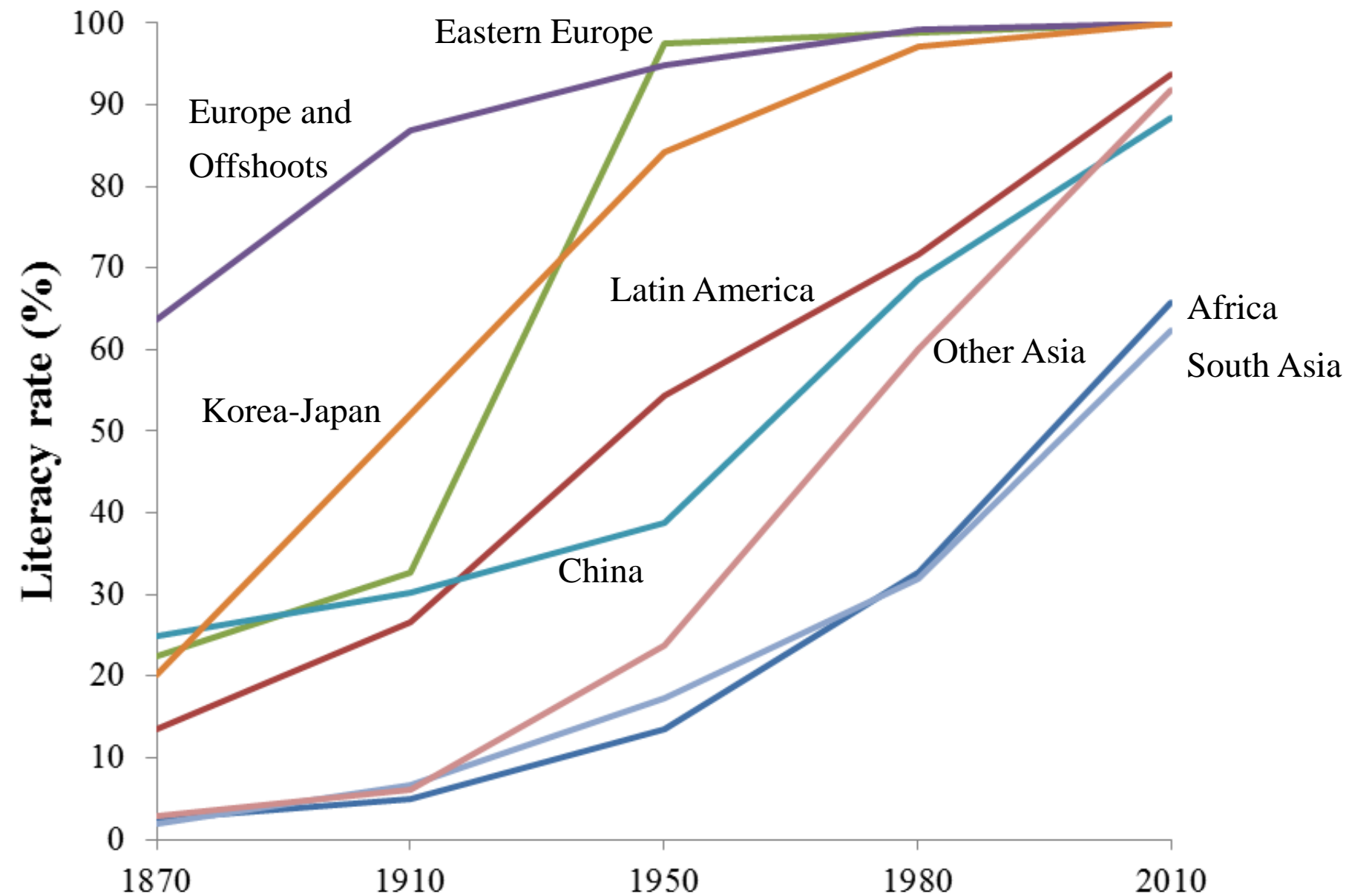
European Human Capital Transition

- **Supply**
 - **Cheaper Books (1460-1600, 1800s)**
 - **Church Provider of Education**
- **Private Demand (Religious, Political, ...)**
 - **Broader Interest amongst Wealthier Pop.**
- **‘Public’ Demand**
 - **Military: Educated Soldiers**
 - **Industrialists: Educated Worker**
- **Public Education**
 - **Direct Benefit: Moulding Minds of Nation State**

Public Expenditure on Education in Europe, 1850-1910



Literacy in the world, 1870-2010



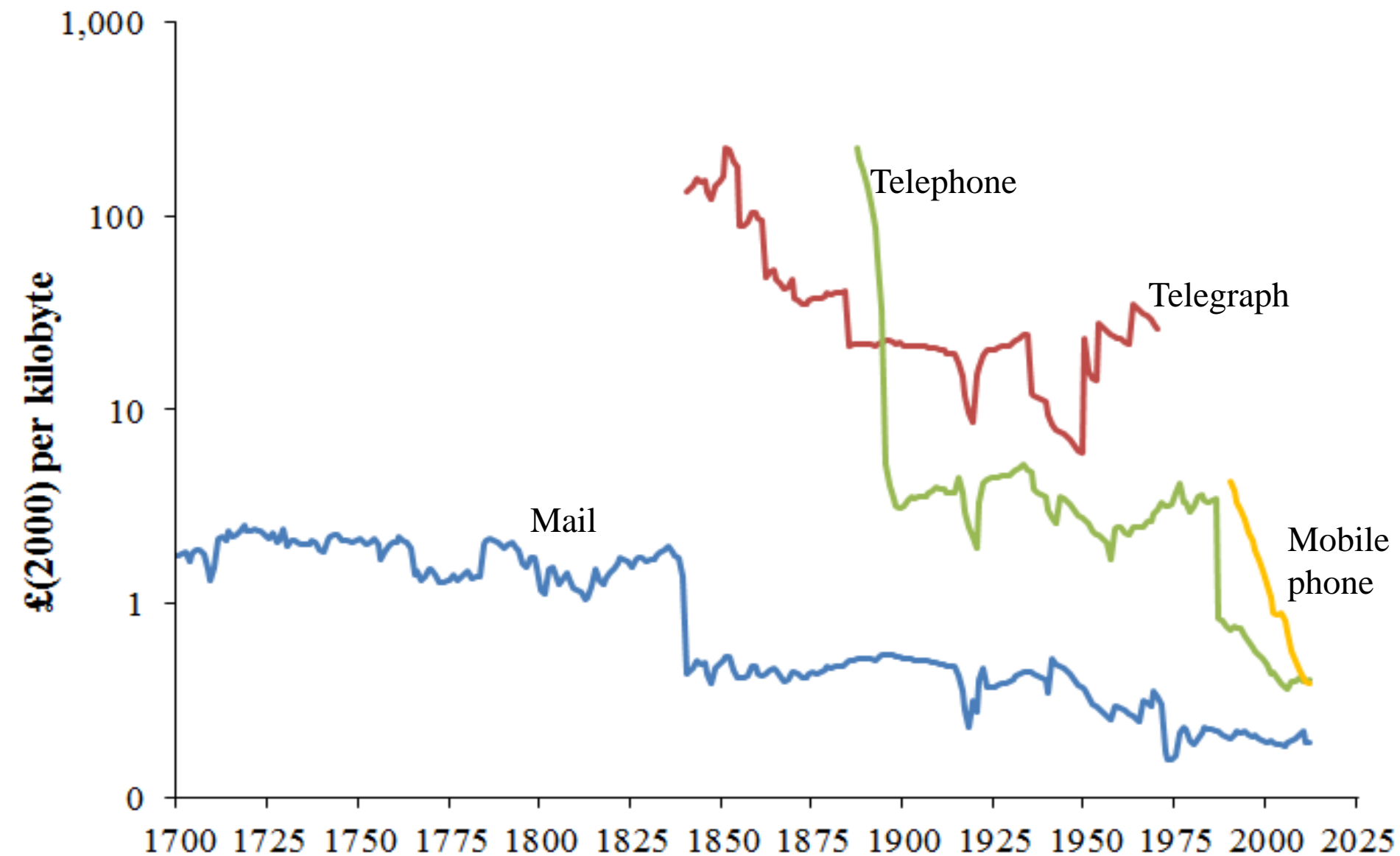
Creating a Learning Society

- **Mokyr (2009): “Economic Change in all periods depends [...] on What People Believe”**
- **Stiglitz and Greenwald (2014):**
 - **Attitudes to Change are Crucial**
 - **Social Construction of Learning**
 - **Belief Systems**
 - **Government Needs to Correct Market Failures to Create Dynamic Learning Economy**

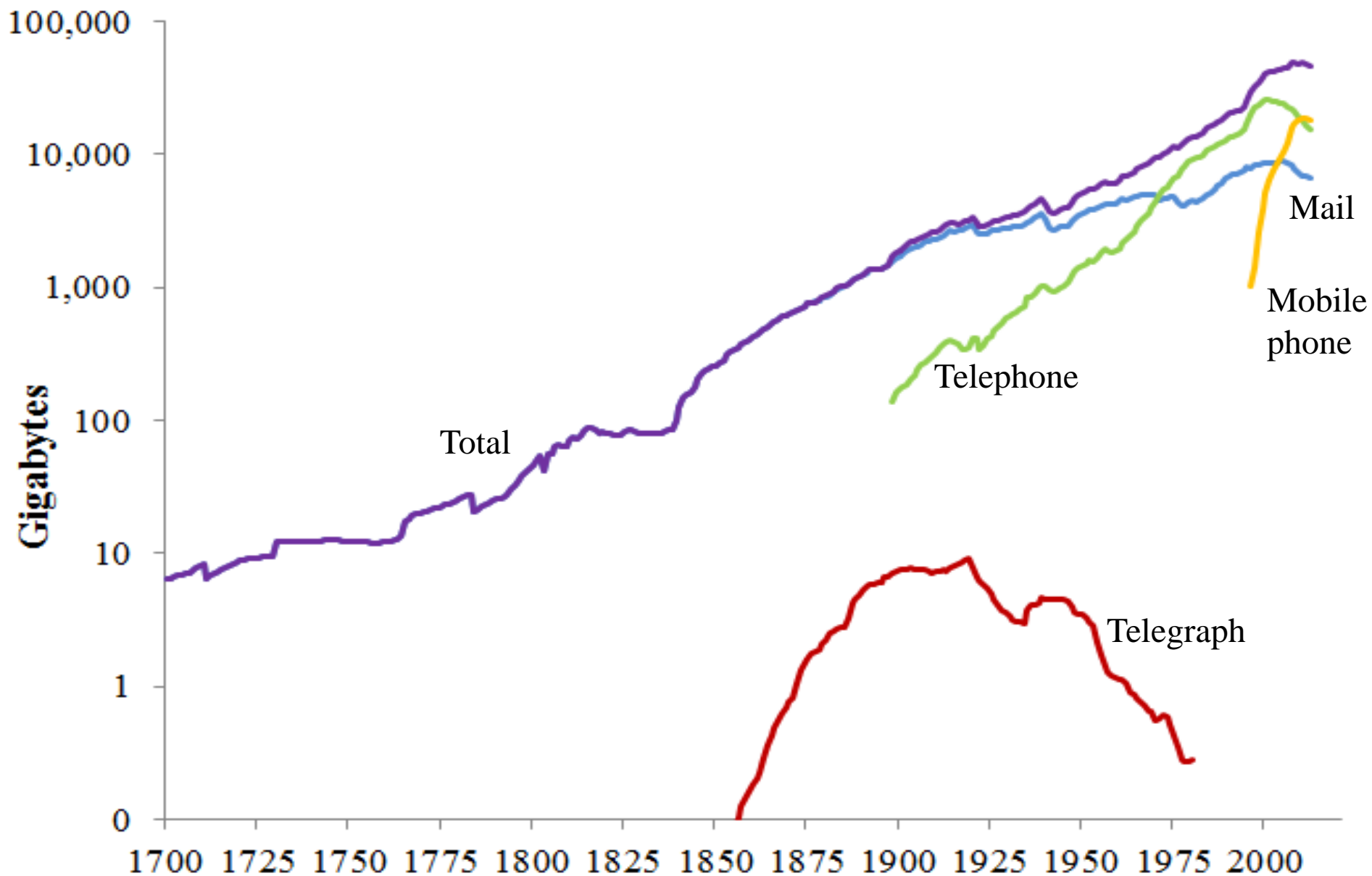
Towards a Dematerialised Economy?

- **ICT: Pillar of the Knowledge Economy**
- **What Insights from ICT for Dematerialisation?**

Price of Communication Services in the UK, 1700-2012

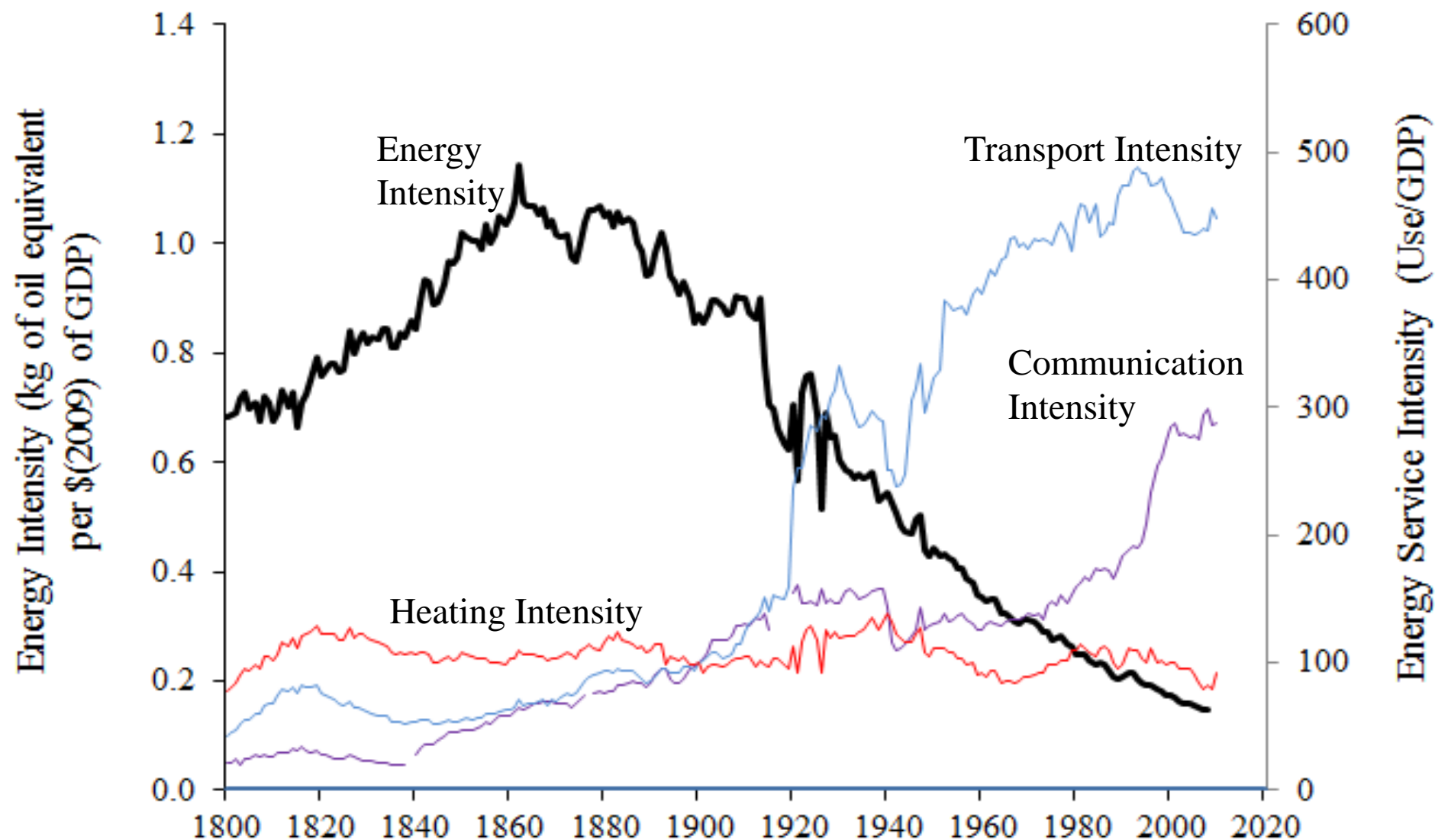


Consumption of Communication Services in the UK, 1700-2012



Source: Fouquet and Hippe (2015).

Energy Intensity and Energy Service Intensity in the UK, 1800-2010



Dematerialization of Energy Services

- Dematerialization of Communication Services
- **How Many Mail Coaches for Global Internet?**
 - 2010: 9 Zetabytes = 13 trillion mail coach j.
 - 183 billion horses/year = 18,000 mtoe
 - = **1.5 times Global Prim. Energy Cons.**
 - = 800 times Global Data Center Cons.
- Can Other Energy Services Dematerialise?
- Race between Rebound Effects & Income Elast. versus Dematerialization...



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Part 5

Lessons and Conclusions



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The Long Road to Green Growth

- **History of Economic Growth and Development**
 - **Economic Growth: Building on Others' Ideas**
 - **Avoid Major Risks of Decline**
- **Energy and Environmental History**
 - **Change in Energy Tech. in Ind. Revolution**
 - **Vulnerability to Shocks depends on Market**
 - **Value of New Technologies for Society?**
- **The Development of the Knowledge Economy**
 - **Market Forces and Market Failures**
 - **Government (Hindering or Helping)**
 - **Dematerialisation of the Economy**

Lessons for Green Growth

- **Develop a Tool-Kit for Analysing the LR**
 - **Trends, Cycles and Transitions**
 - **Critical Junctures, Lock-Ins & Path. Depend.**
 - **Understand Virtuous & Vicious Cycles**
- **Achieving Green Growth**
 - **Role of Technology (but not blind-faith)**
 - **Role of Institutions (Desirable Incentives)**
 - **Open to Change, but Directed Change**
- **Change Policy-Thinking**
 - **Thinking about the Long Run**
 - **Balance of Short Run v. Long Run**





Concerns about the Use of History (Woolcock JDS 2011):

- **History Cannot provide Direct Lessons**
- **Each time and place is Unique**
- **Can the 'Future' be guided by human reason?**
- **The Use of History unleashes undesirable Consequences (Stalin, Hitler, Pol Pot)**
- **The Complexity of History will be Lost**
- **Agencies (WB, ...) tend to embrace Single Path**

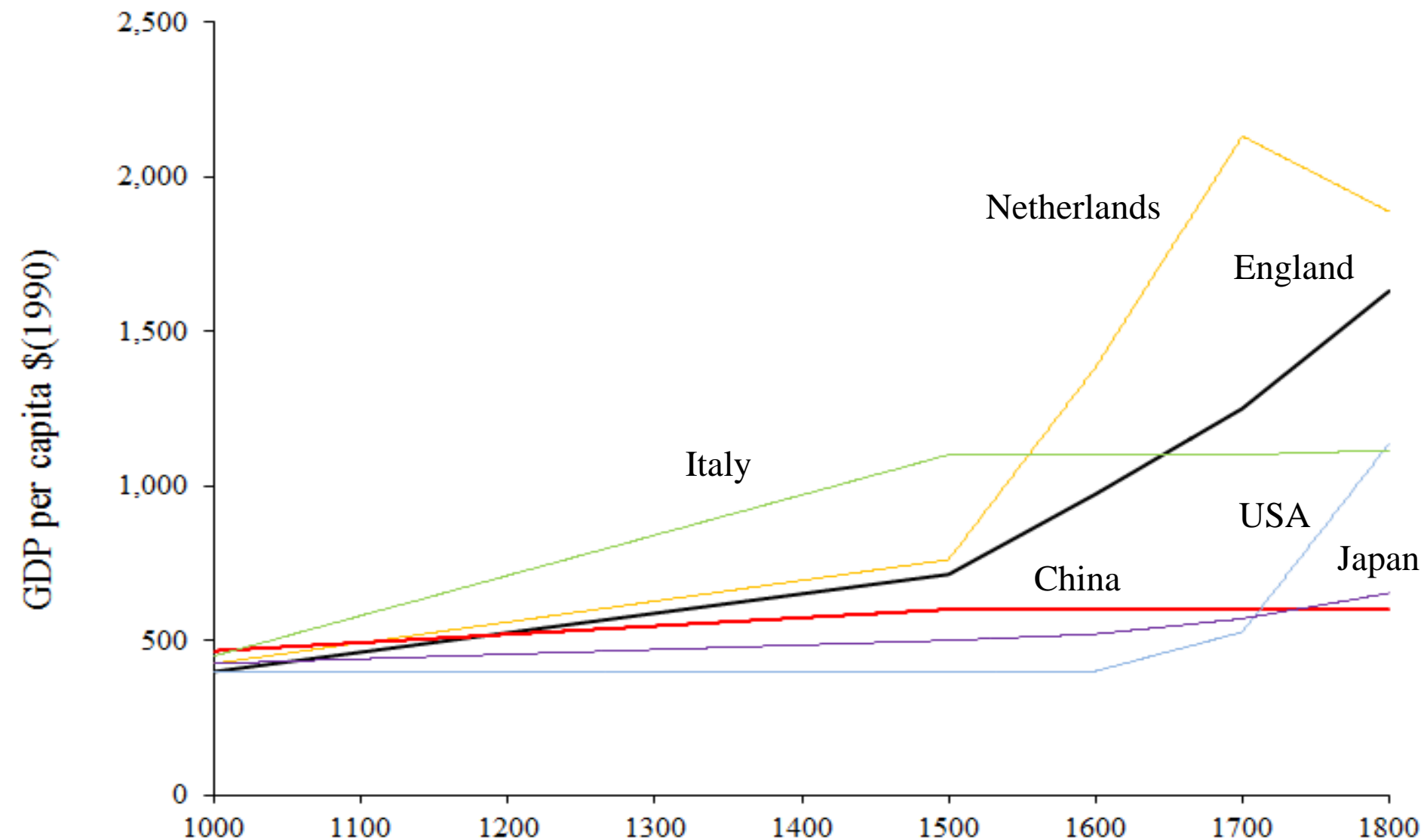
The Power of Path Dependence

one of them had a pressing question to ask the mayor of Hiroshima.

“Everywhere else we’ve been in Japan,” said the MP, “the streets have been higgledy-piggledy. Yet here in Hiroshima your streets are laid out in a well-organised grid. How did you achieve that?”

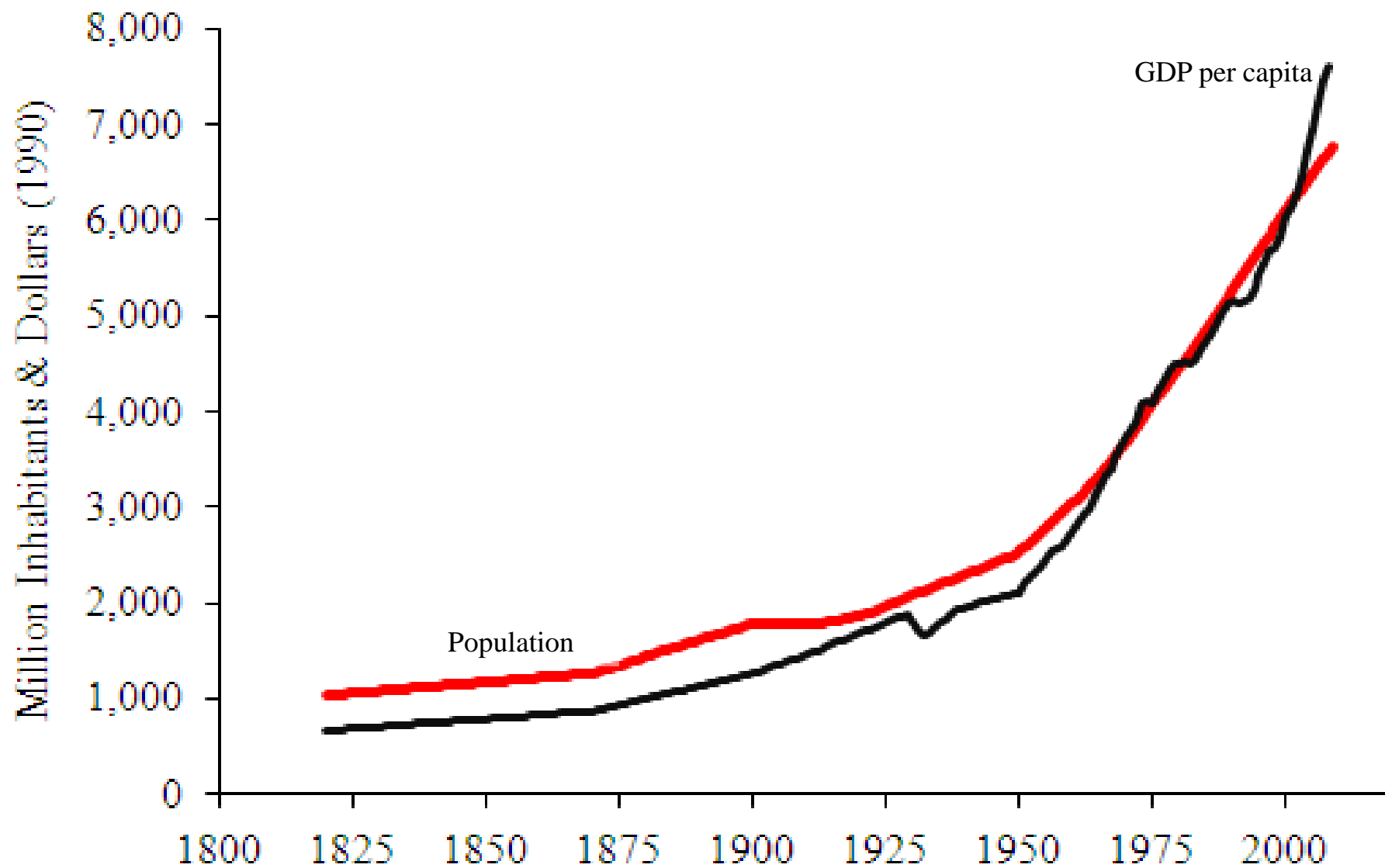
The mayor paused and quietly responded: “We had some help. From the Americans.”

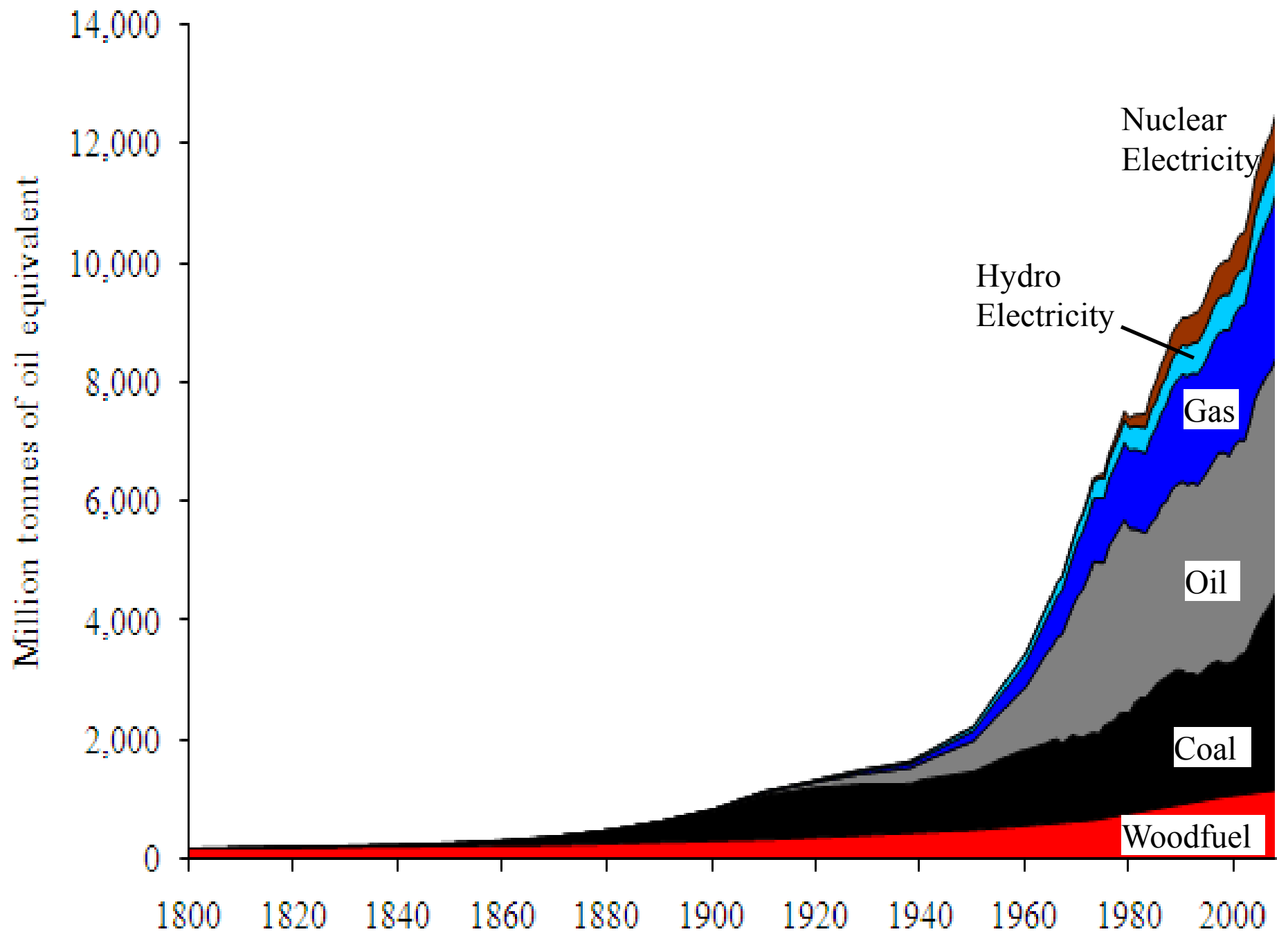
GDP per capita in Selected World Countries, 1000-1900



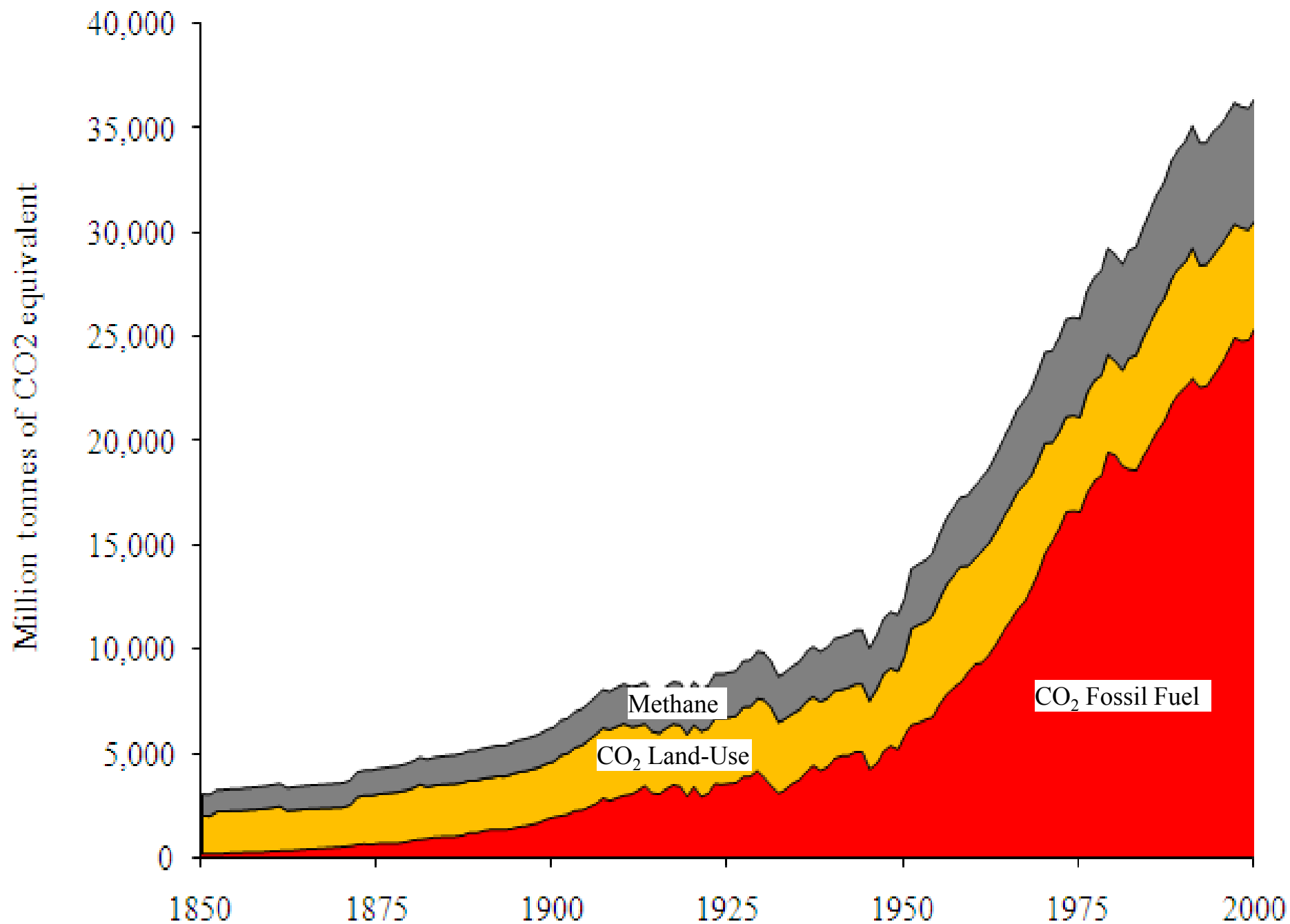
Source: Maddison/Bolt and van Zanden (2014).

Global Population and GDP per capita, 1820-2008



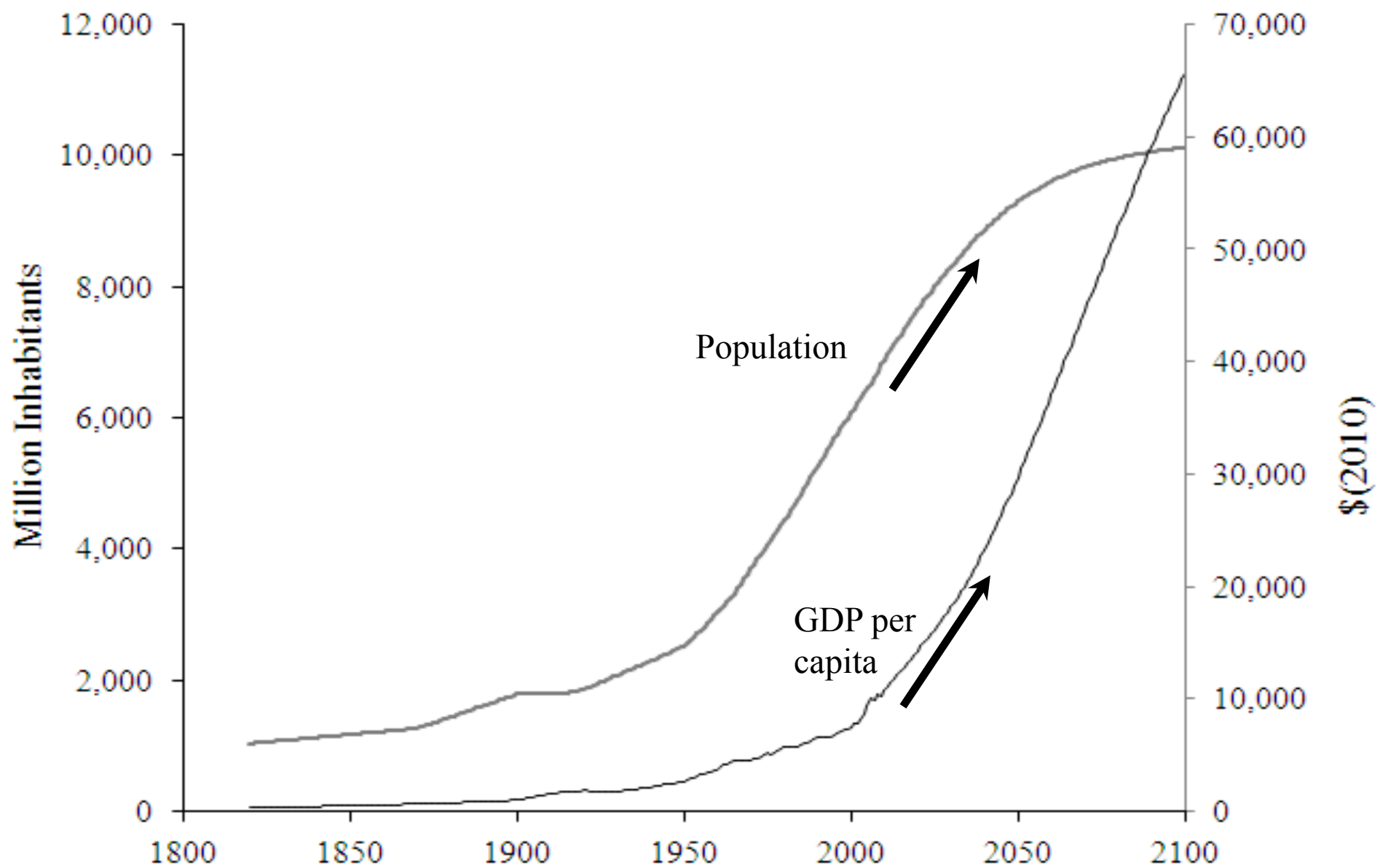


Source: Fouquet (2009)



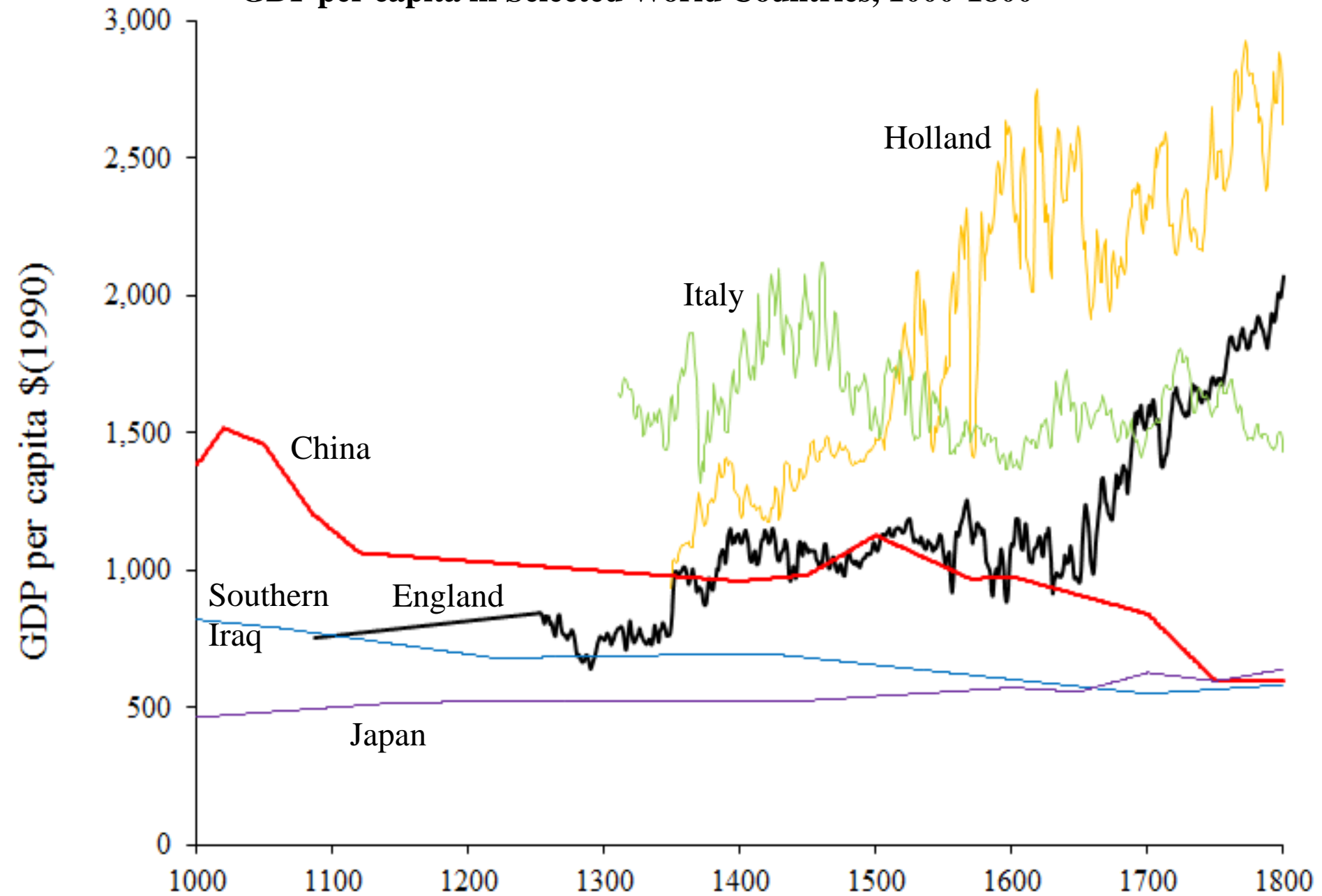
Marland et al (2007), Houghton (2008), Stern and Kaufmann (1998)

A UN Forecast of Global Population, 2010-2100



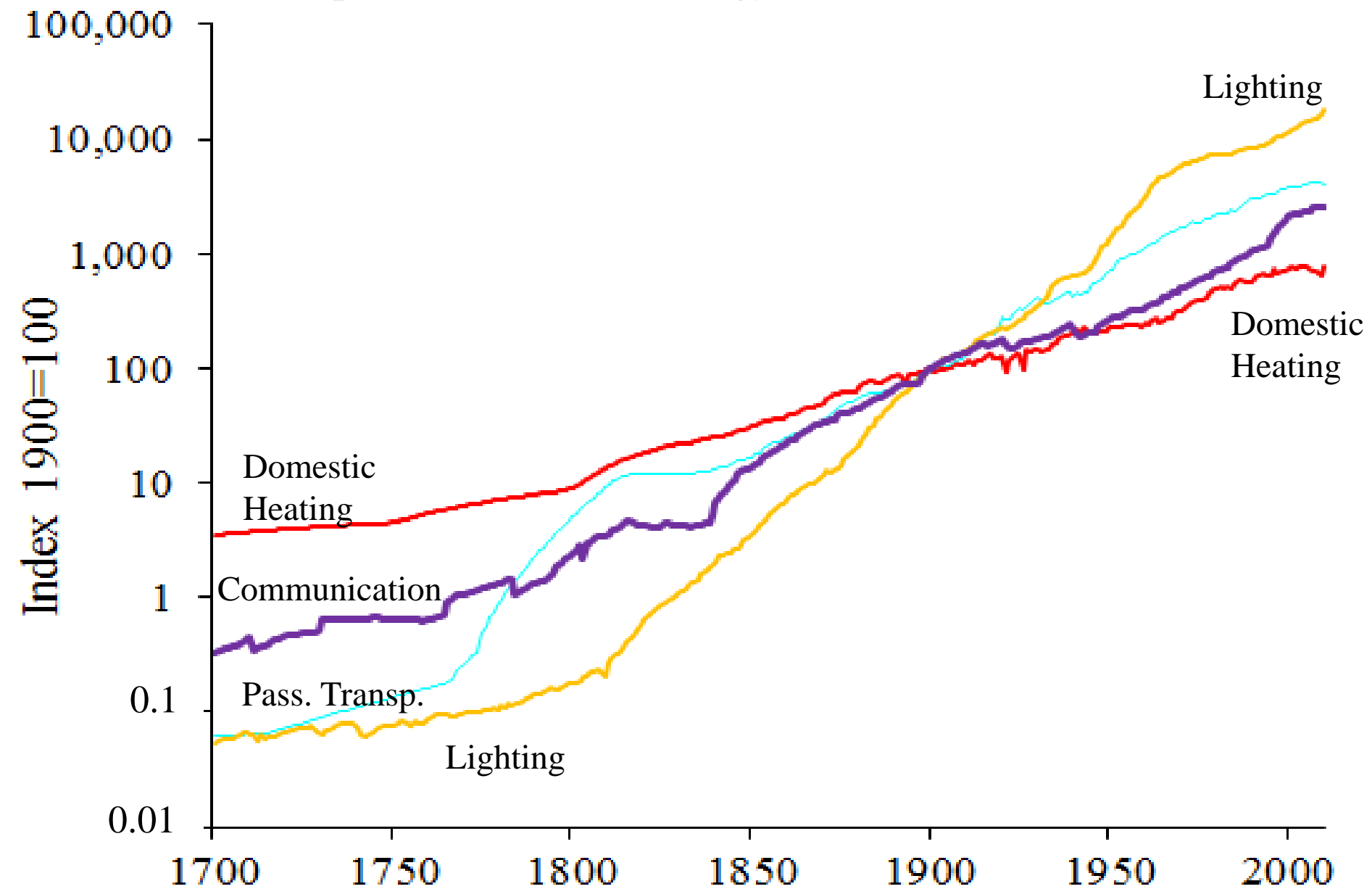
Source: Population: UN (2010); GDP: World Bank (2009)

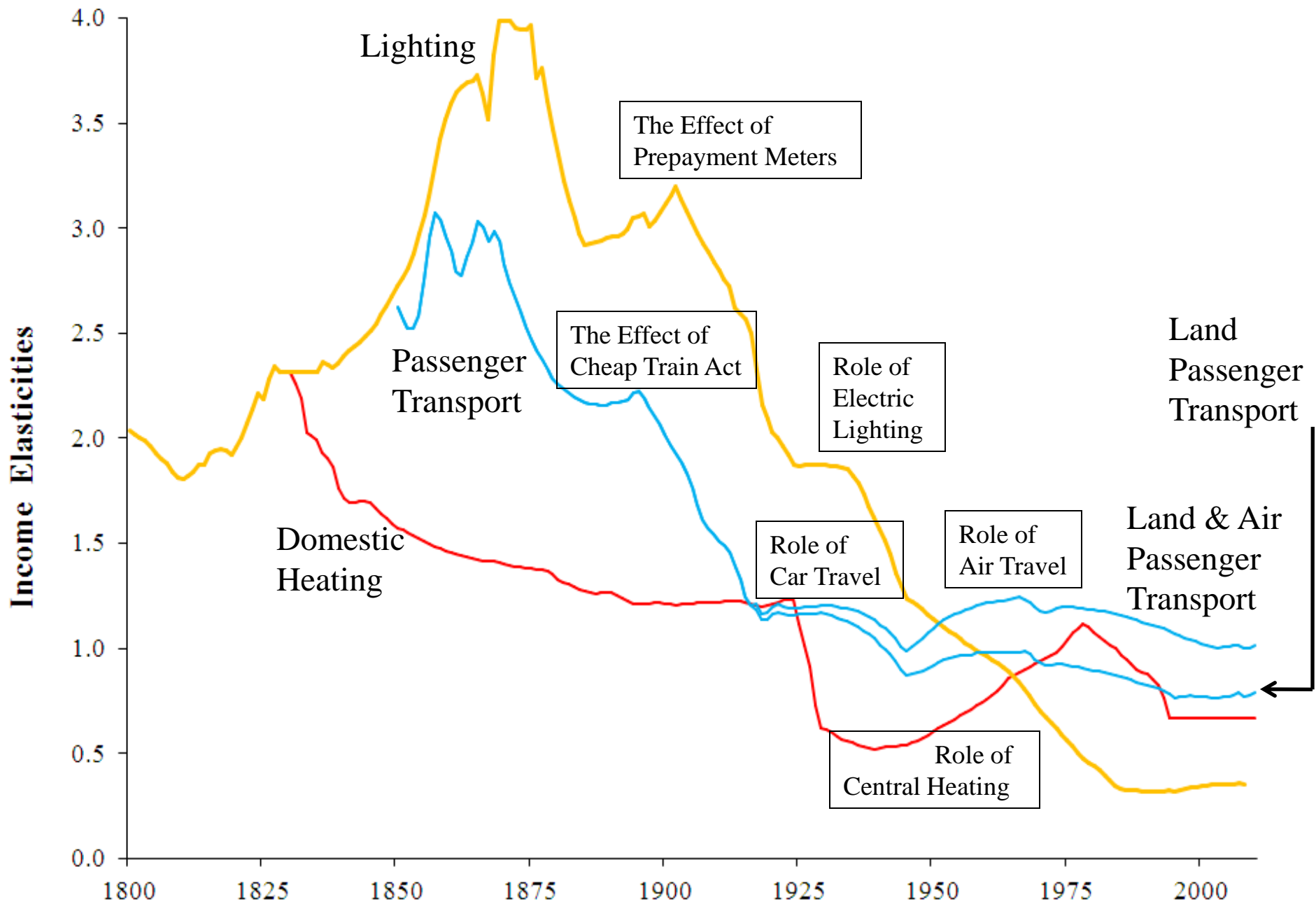
GDP per capita in Selected World Countries, 1000-1800



Source: see Fouquet 2015a; * 3-year average

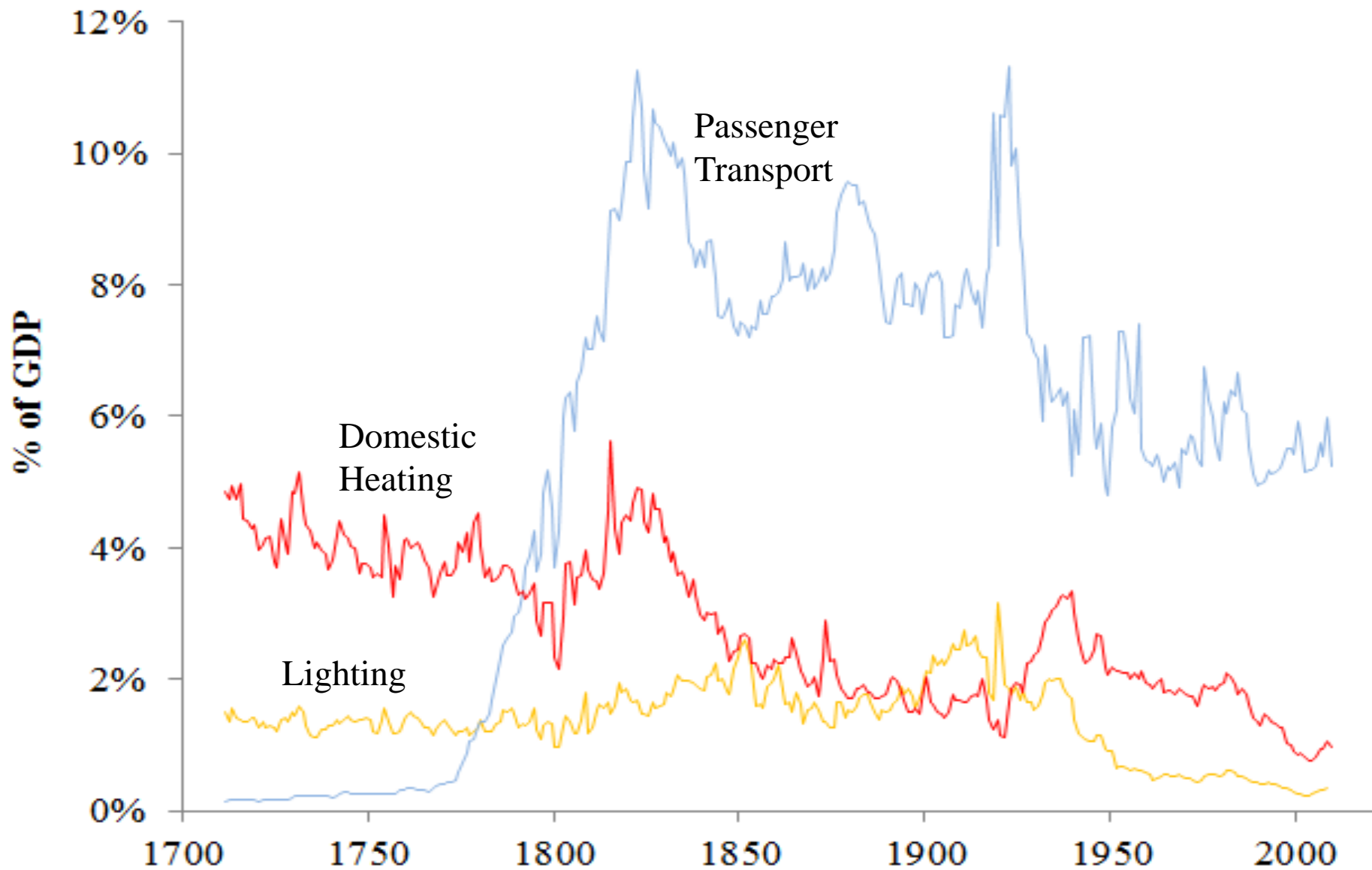
Consumption of Consumer Energy Services in the UK, 1700-2010





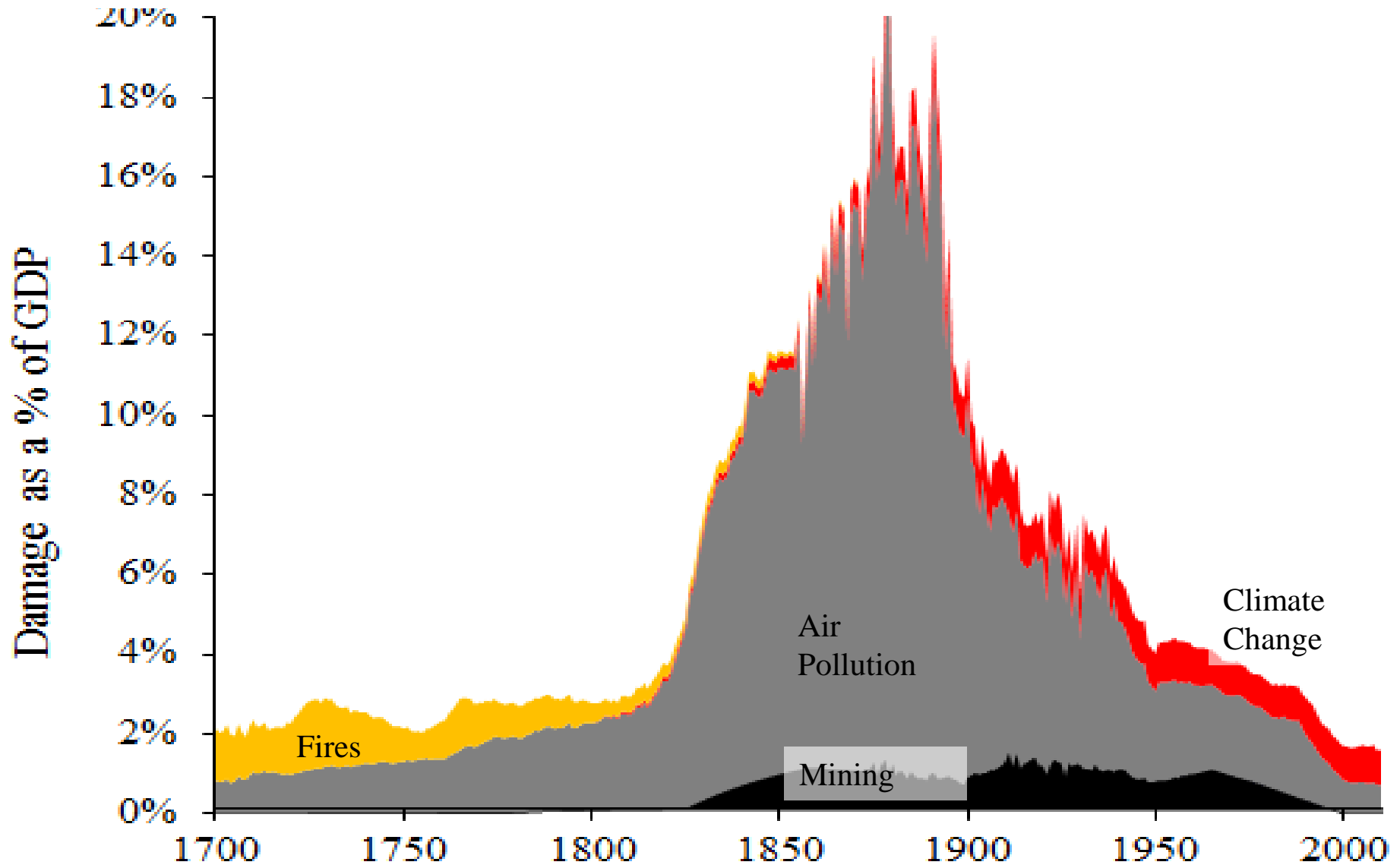
Source: Fouquet (2014)

Consumer Expenditure on Domestic Heating, Passenger Transport and Lighting in the UK, 1700-2010



Source: Fouquet (2014)

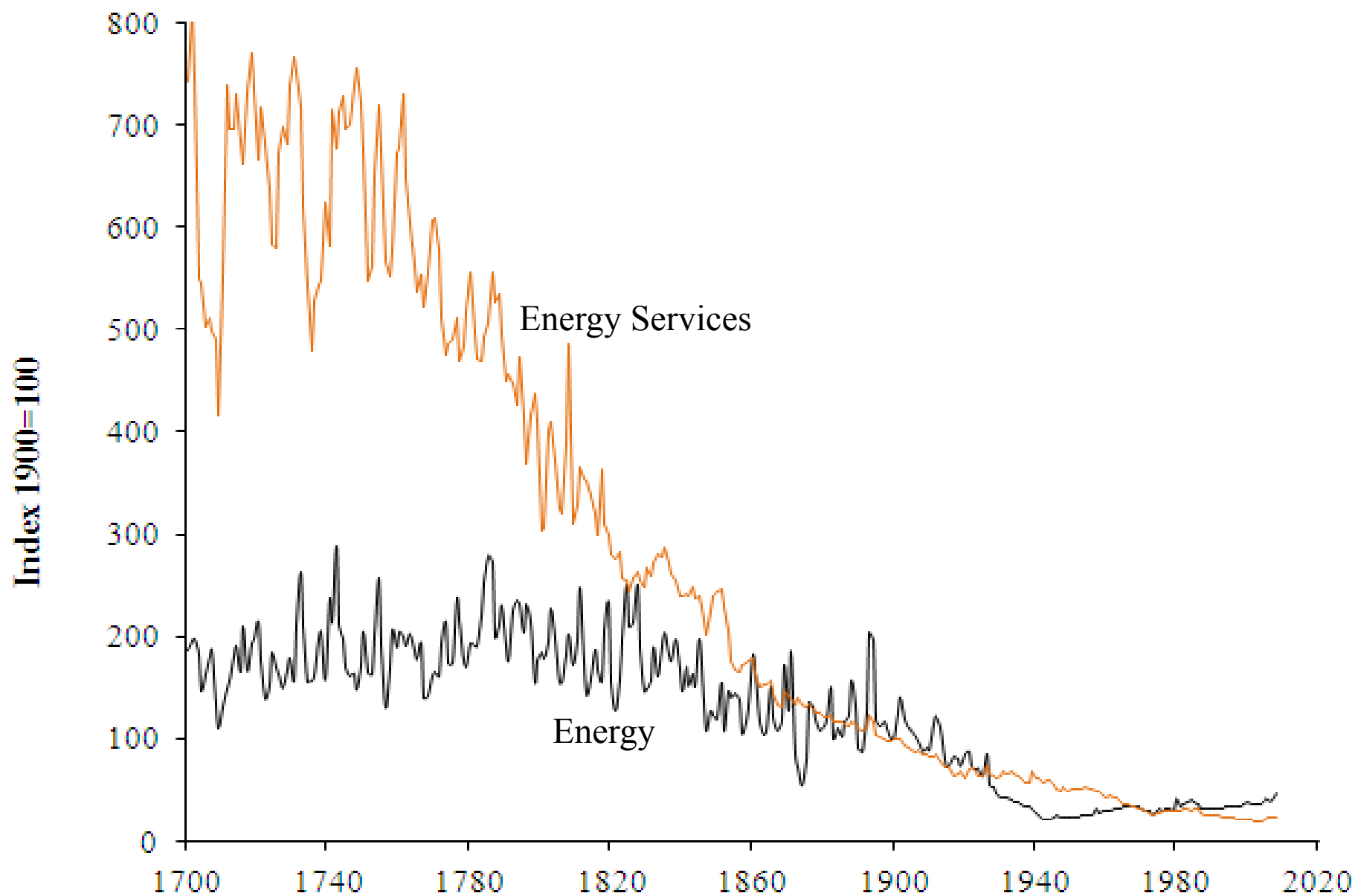
External Costs of Energy Services (by cause) as a % of GDP in the United Kingdom, 1700-2010



How might Consumer Surplus Change?

- $CS = \frac{1}{2} \cdot ((P.Q)/Y)/\eta$
- Hypothesis 1:
CS increases then falls,
because Inc. el. rises then falls
so, increasing then decreasing $(P.Q)/Y$
- Hypothesis 2:
CS falls then increases,
because η (price el.) rises then falls
- So, Two Opposing Forces

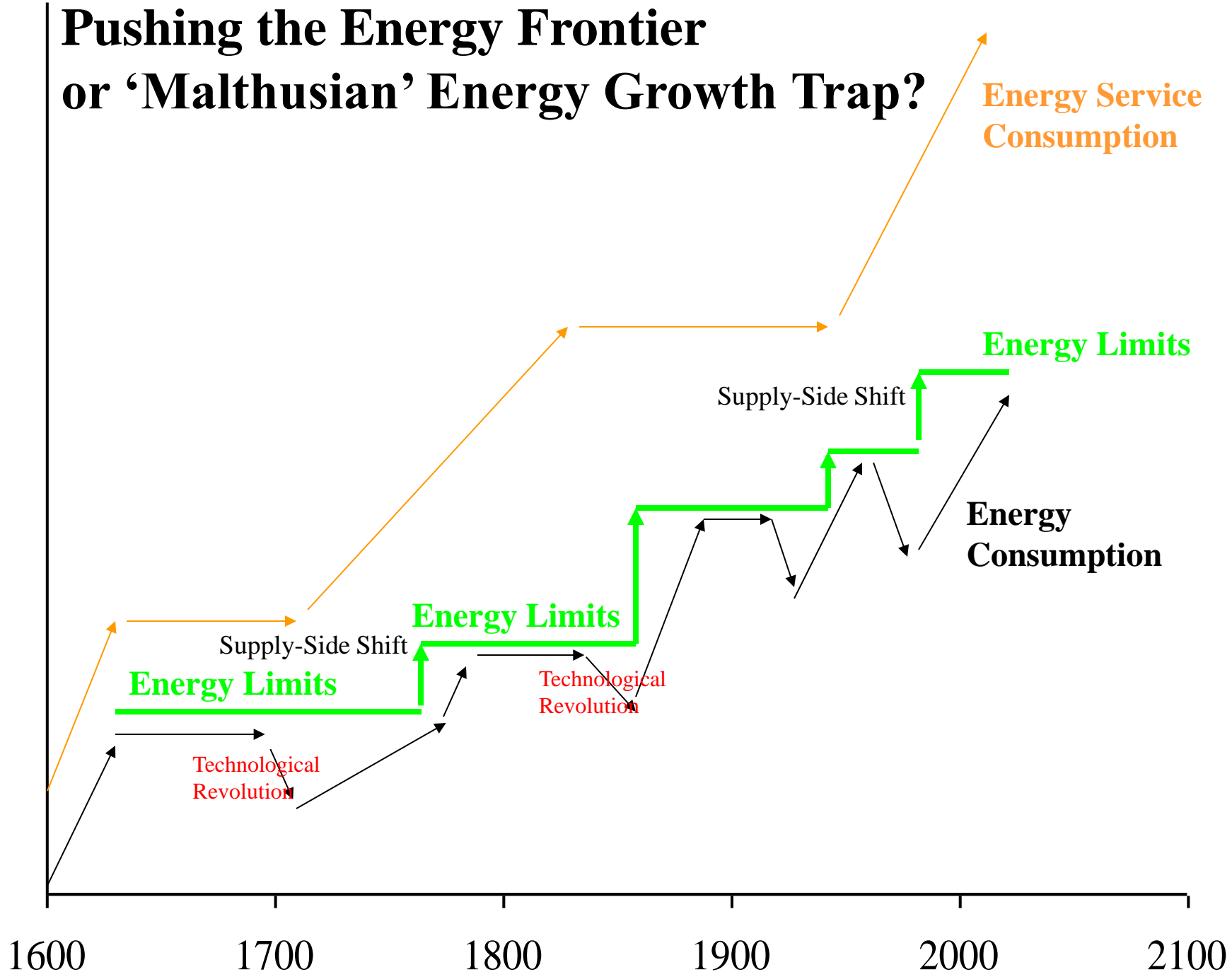
Price of Energy and Energy Services in the United Kingdom, 1700-2010



Source: Fouquet (2011)

Pushing the Energy Frontier or 'Malthusian' Energy Growth Trap?

Consumption



Global Energy and CO2 Emissions in 2050

- **Need for Markets to Meet
Demand for Services of 10bn people
in a Low Carbon Economy**
- **New Industrial Revolution**
(Technologies, Energy Markets and Services, Economic Structure, Climate, ..)
- **Slow Energy Transitions:**
 - **Many Possible Solutions for Different Countries**
- **Rising Global CO2 Emissions**

Lessons of Early Modern Phases

- **Many Phases of Economic Development**
- **Before Increase in GDP per capita,
Create an Industrial Base**
- **Build on Past Phases of Economic Development**
- **Phases of Structural Transformation**
- **Technological Development**
- **Highly Unstable/Vulnerable Economic Expansion**

Lessons from Industrial Revolutions

- **Lower Costs of Production Driver of Economic Dev.**
- **Drivers of Ec. Dev. Change at Different Phases**
- **Technological Innovation**
- **Increasingly Stable Economic Expansion?**
 - **But, still Vulnerable (esp. Wars)**
 - **Environmental Damage can Escalate w. Growth**



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Appendix

Energy Price Shocks on GDP

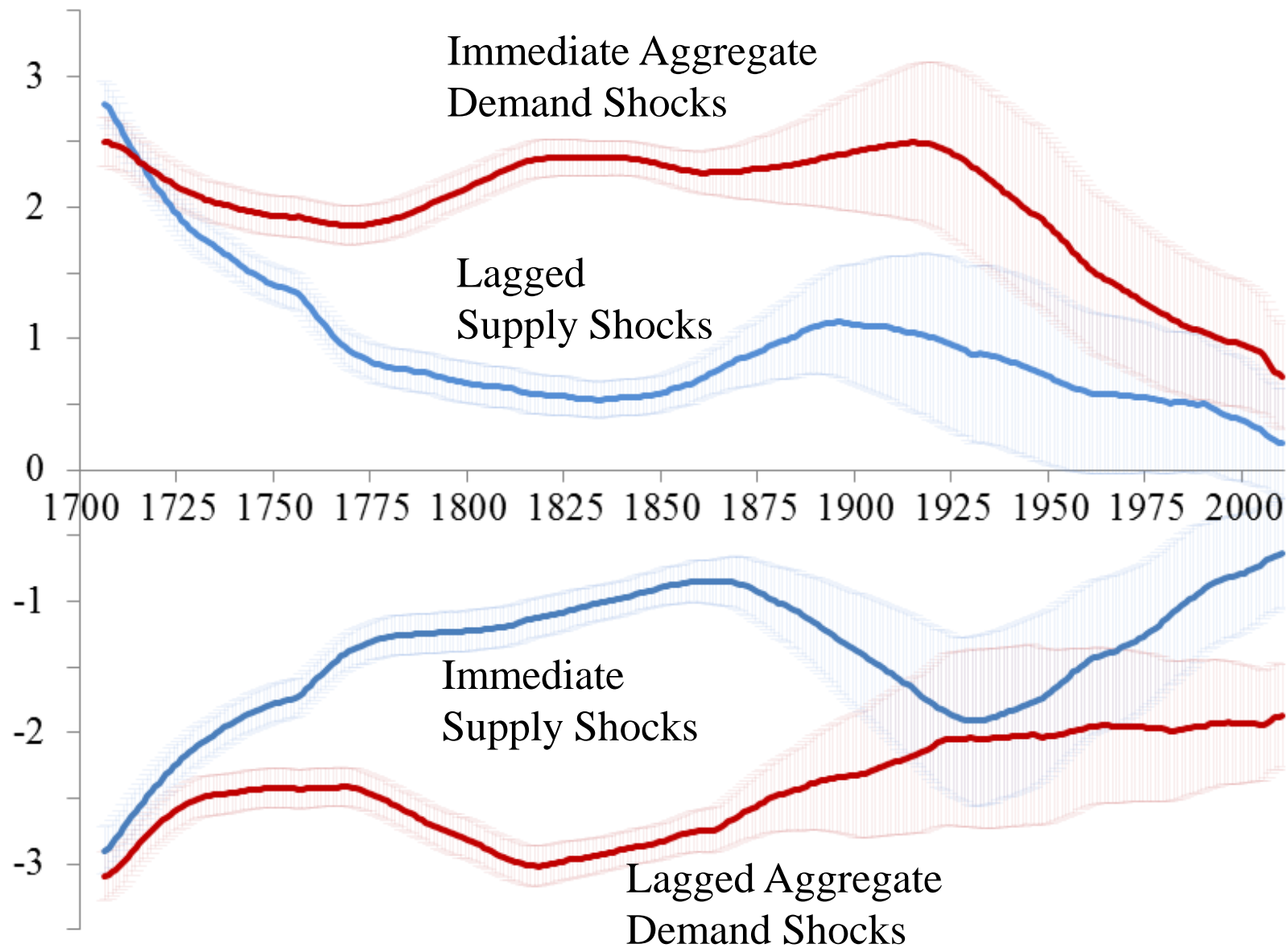


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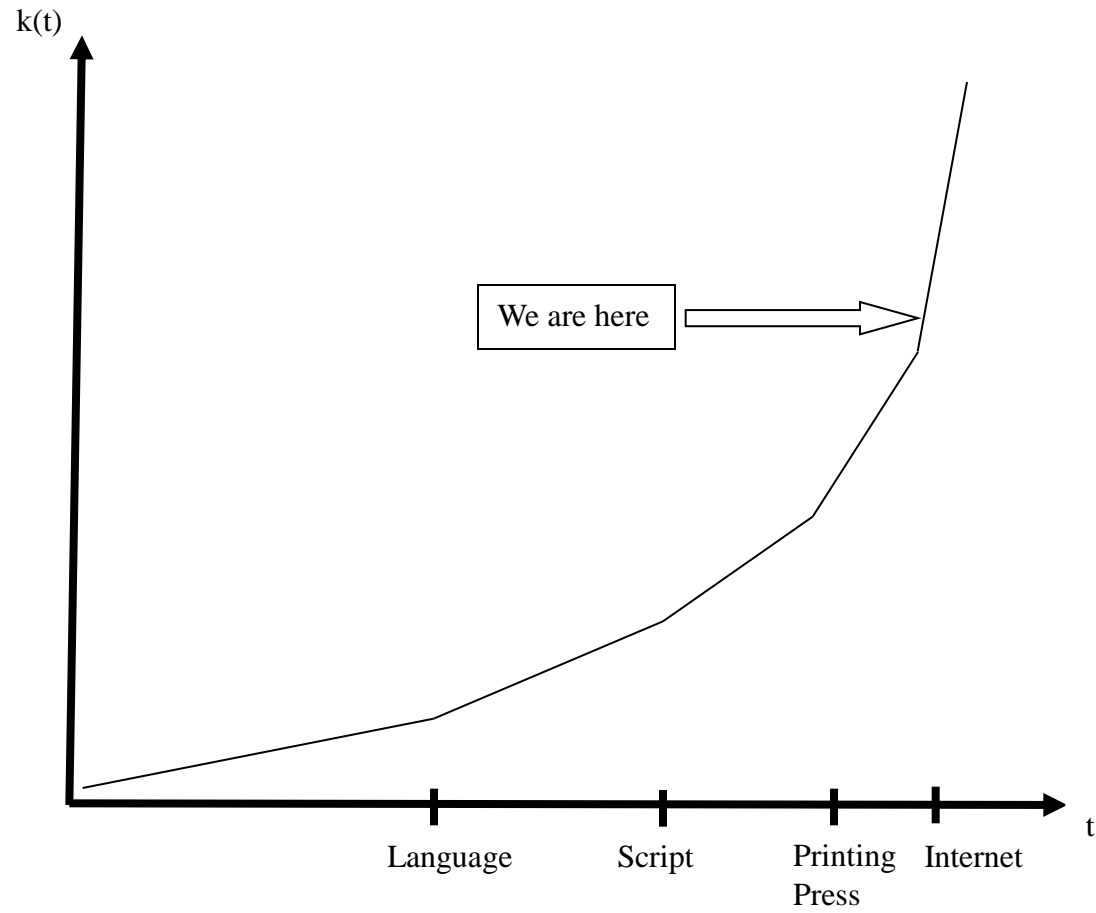
Direct and Lagged % Change in GDP from a Shock of Magnitude 1



Changing Impact of Energy Price Shocks on Economic Growth

- **Supply shocks:**
 - **Stronger with Increasing Dependence on Coal (19th C)**
 - **Declining Impact after WW-II Confirmed**
- **Aggregate Demand shocks:**
 - **Immediate Positive Impact Dependent on Import-Export**
 - **Lagged negative impact declining with transition to fossil fuels**
- **Residual shocks (Undefined Energy Price increase):**
 - **More positive with higher export share of energy**

Stages of knowledge production



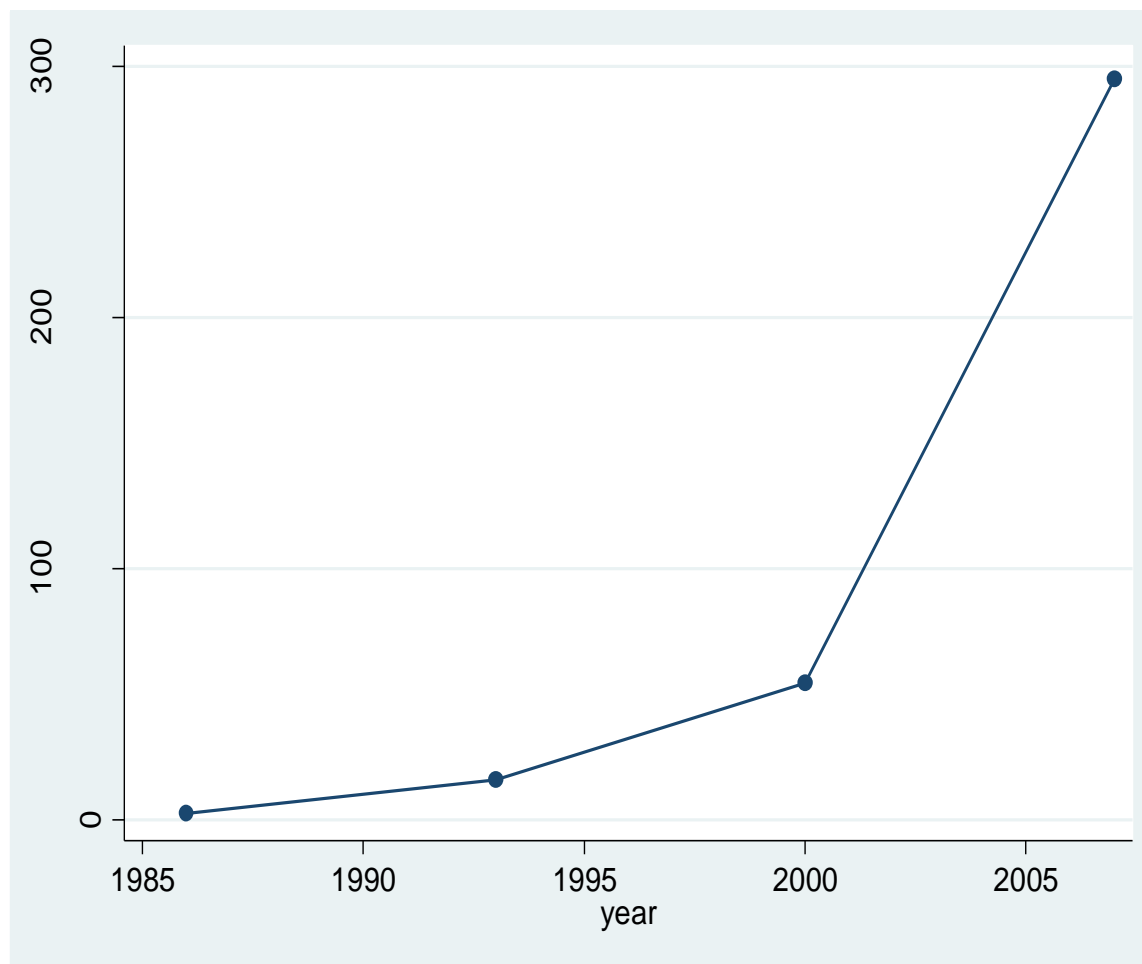
Total Worldwide Information Provision, 1987-2007



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Source: based on Hilbert and López (2011)'s data.

3 eras of education



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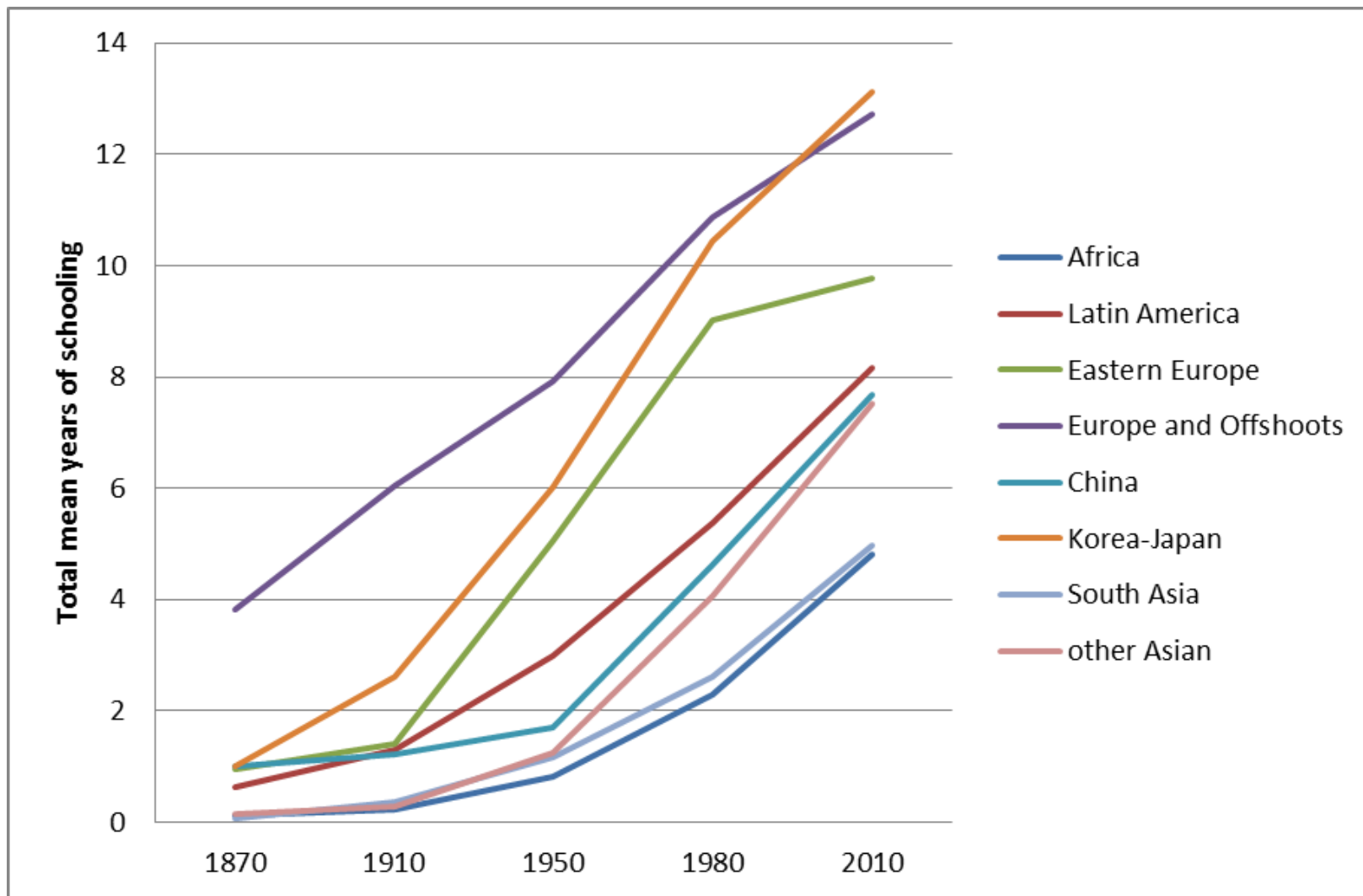


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Dimension	Apprenticeship	Universal schooling	Life-long learning
Responsibility	Parents	State	Individual, parents
Content	Practical skills	Basic skills, disciplinary knowledge	Generic skills, learning to learn
Pedagogy	Apprenticeship	Didacticism	Interaction
Assessment	Observation	Testing	Embedded
Location	Home	School	Multiple
Culture	Adult	Peer	Mixed-age
Relationships	Personal	Authority	Computer-mediated

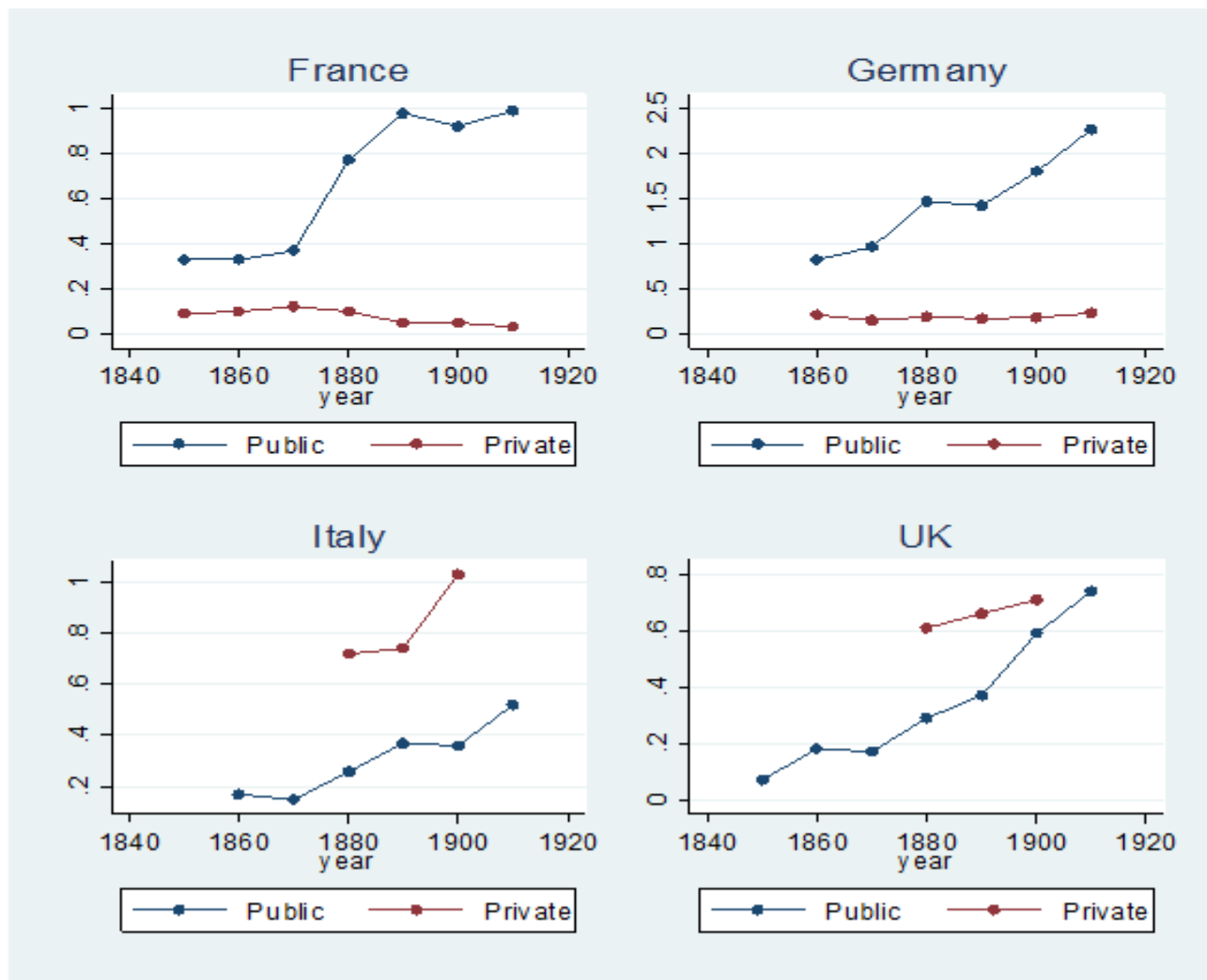
Source: Collins and Halverson (2010).

Schooling in the world, 1870-2010



Source: Morrisson and Murtin (2013).

Public Expenditure on Education in Europe, 1850-1910



Source: Lindert (2004).