Long Run Demand for Energy Services and the Consumer Benefits from Energy Transitions

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Grantham Research Institute on Climate Change and the Environment

Centre for Climate Change Economics and Policy

E·S·R·C Economic & Social Research Council

The Grantham Foundation for the Protection of the Environment

University of Leeds

LSE The London School of Economics and Political Science

Motivation for Talk

- Understand what drives consumer behaviour and rising energy consumption

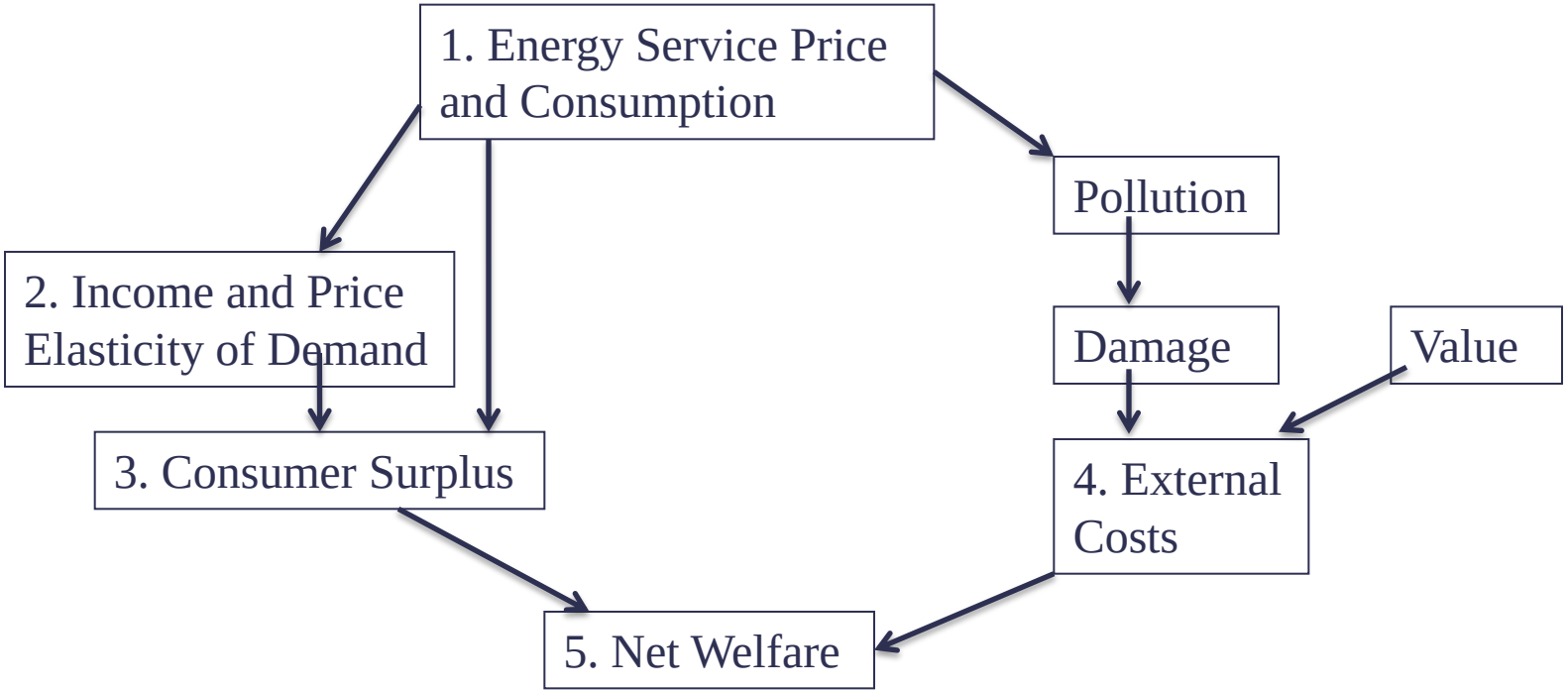
- CC & Air Pollution: Negative Aspects of Energy
- Energy & Technology Transformed Lives But Today Diminishing Returns? (Gordon 2016)

- Little Evidence on Scale of Benefits and Decline

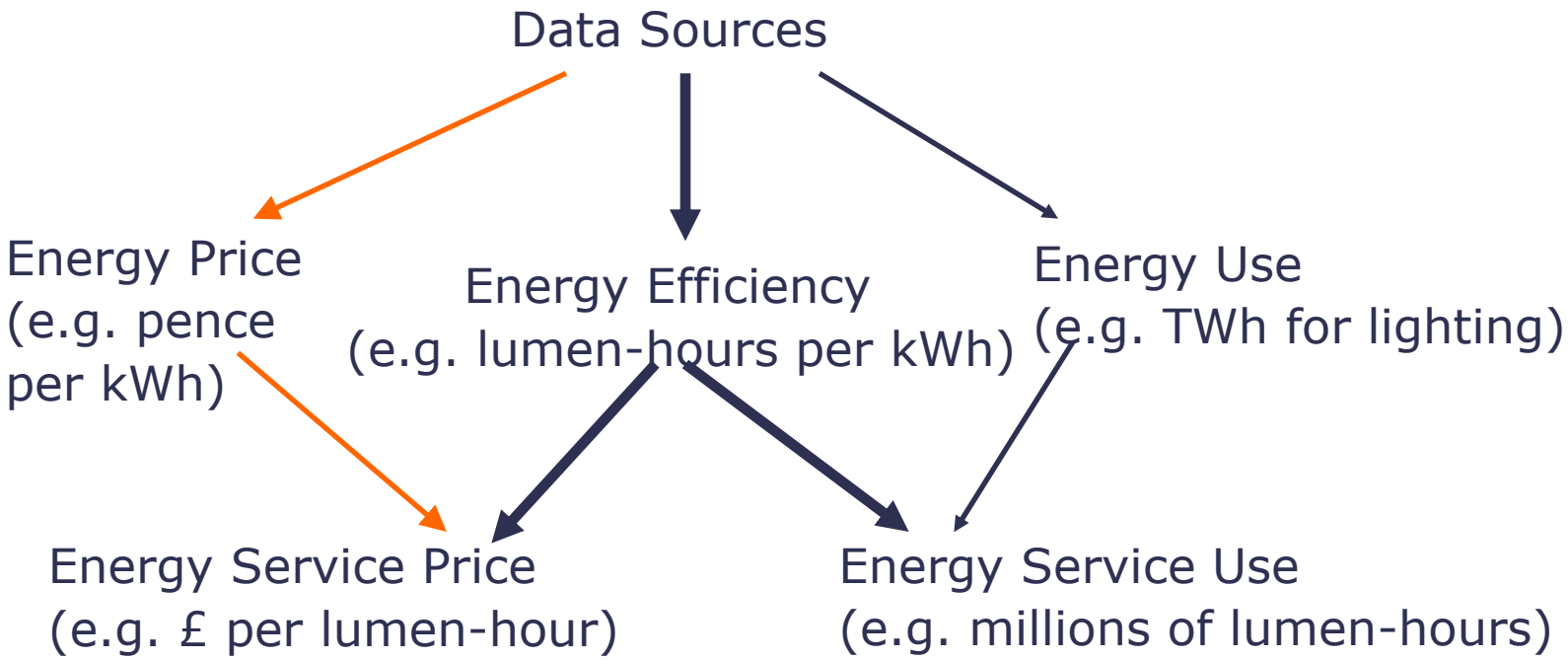
Questions

- What are the net benefits and Costs of Energy Services, Technologies and Transitions
- Have Energy Technologies and Transitions Improved Well-being?
- Lessons for Future Energy Tech & Transitions?

Estimate Net Welfare (Historical CBA)



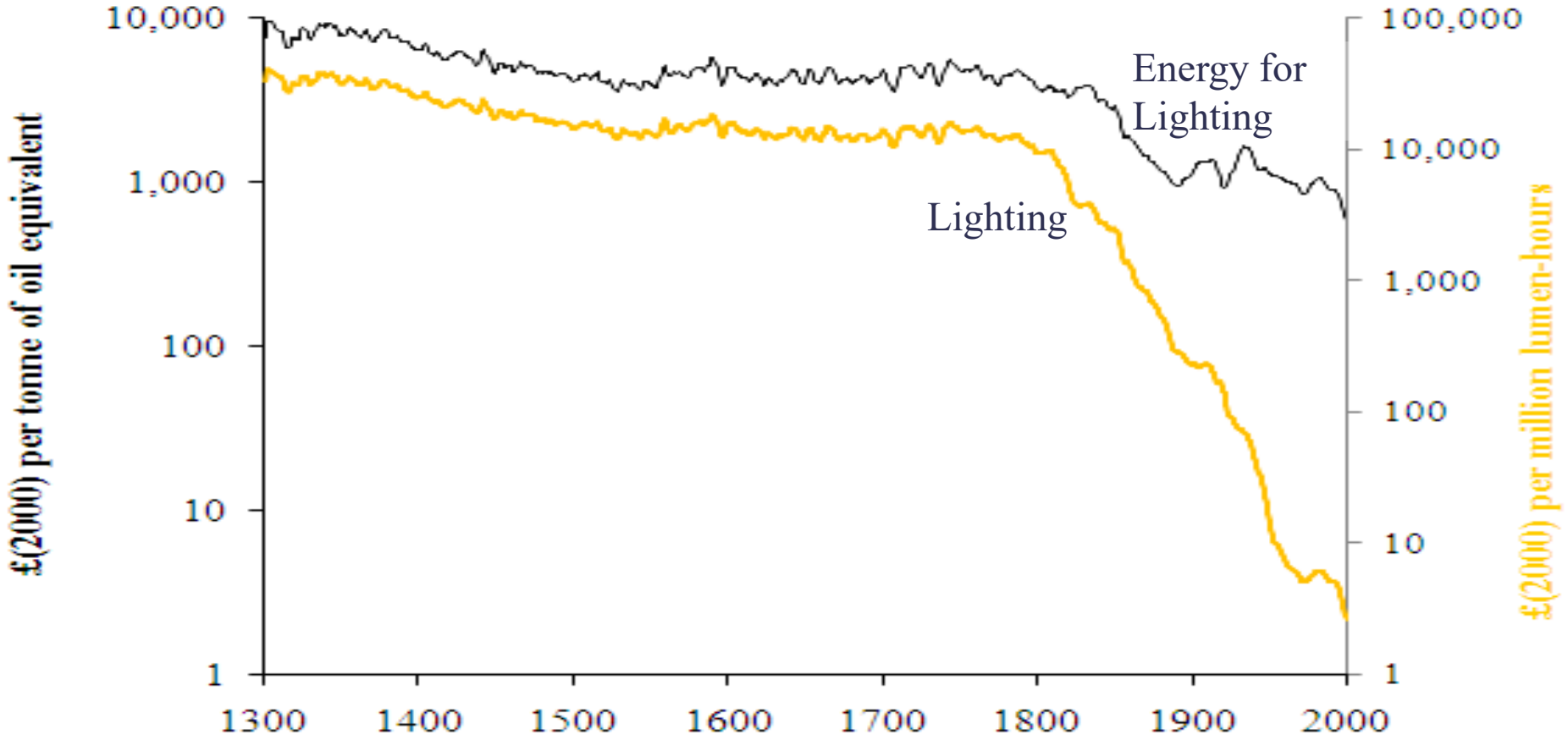
Measuring Energy Service Prices and Use (Nordhaus 1997)



UK Lighting Efficiency Improvements

		Efficiency of Lighting	
		lumen-hours per kWh	Index 1800=100
	1300	17	50
	1700	27	75
	1750	29	79
	1800	35	100
	1850	150	440
	1900	240	1,450
	1950	11,600	34,000
	2000	35,000	100,000

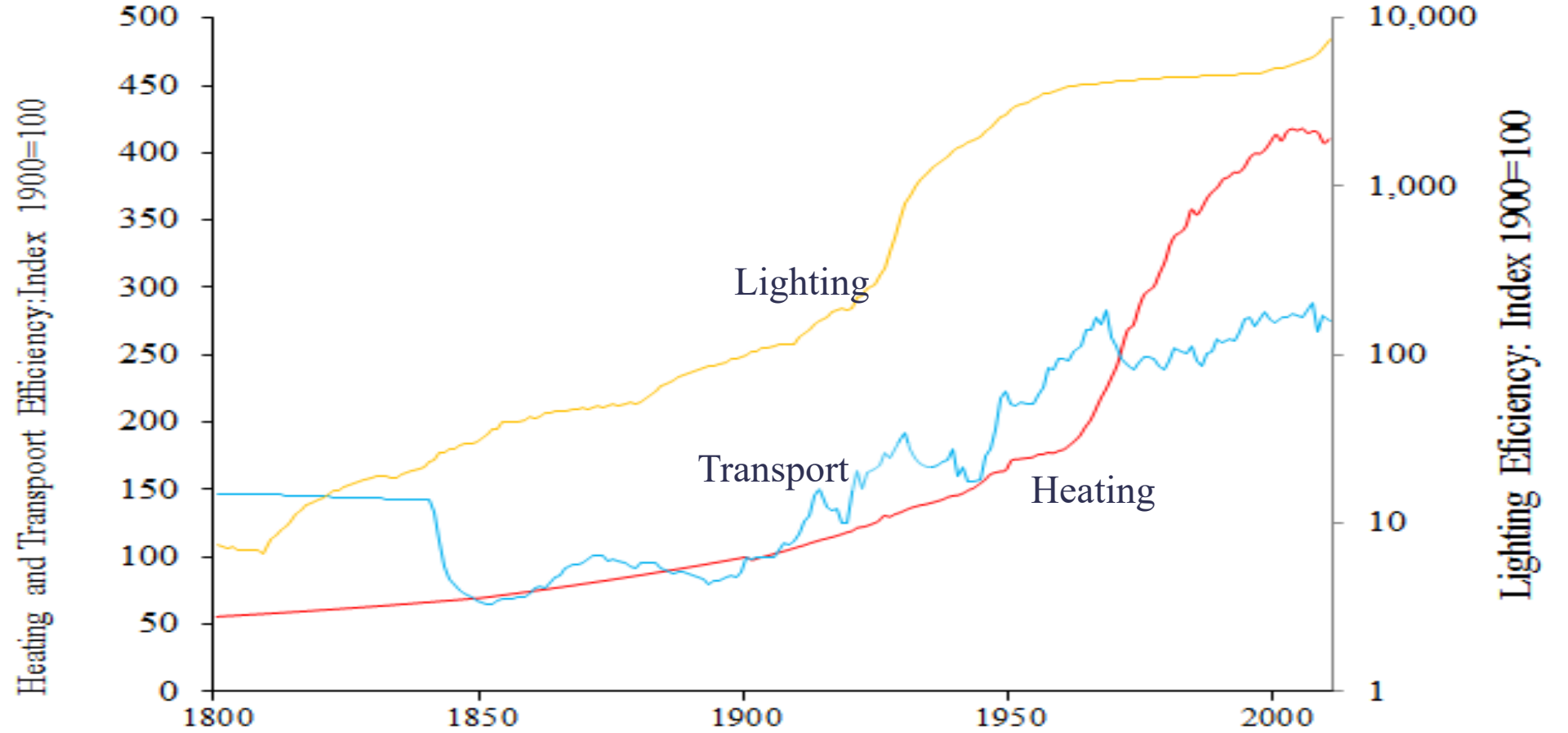
Price of Energy and Lighting in the United Kingdom, 1300-2000



1 million lumen-hours is equivalent to 100 watt bulb burning for one month

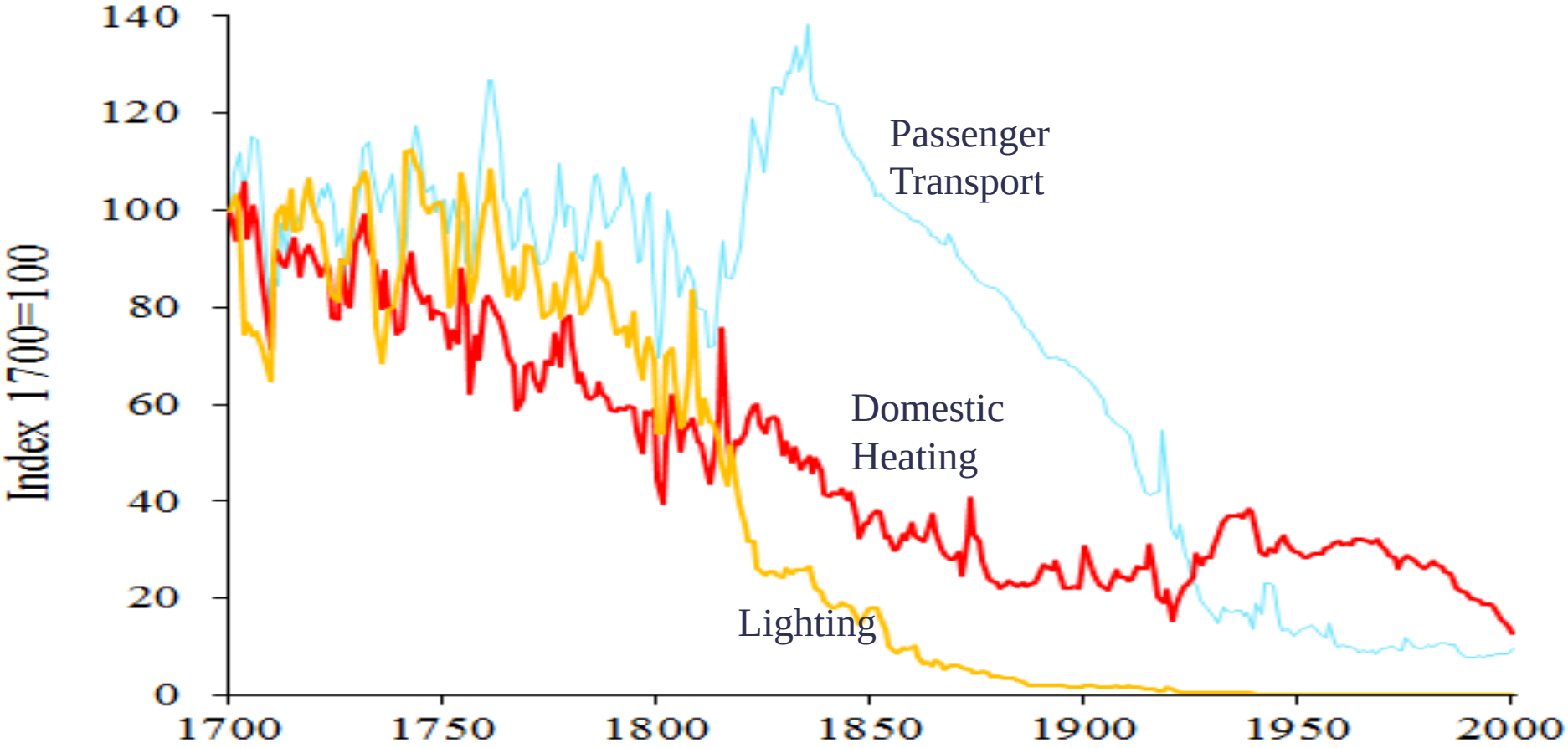
Source: Fouquet (2011)

Average Efficiency by Energy Service in the United Kingdom, 1800-2010



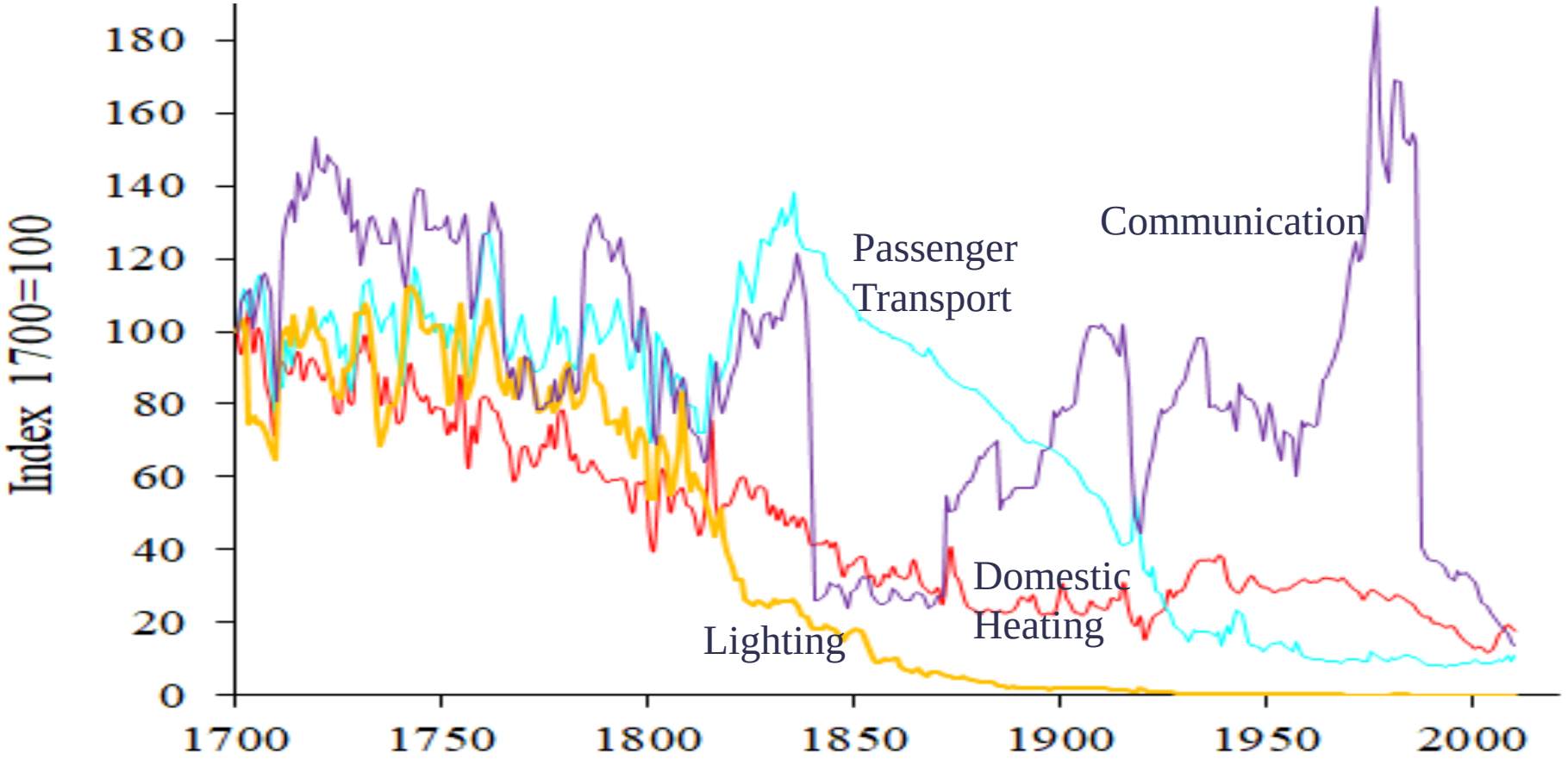
Source: Fouquet (2011)

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

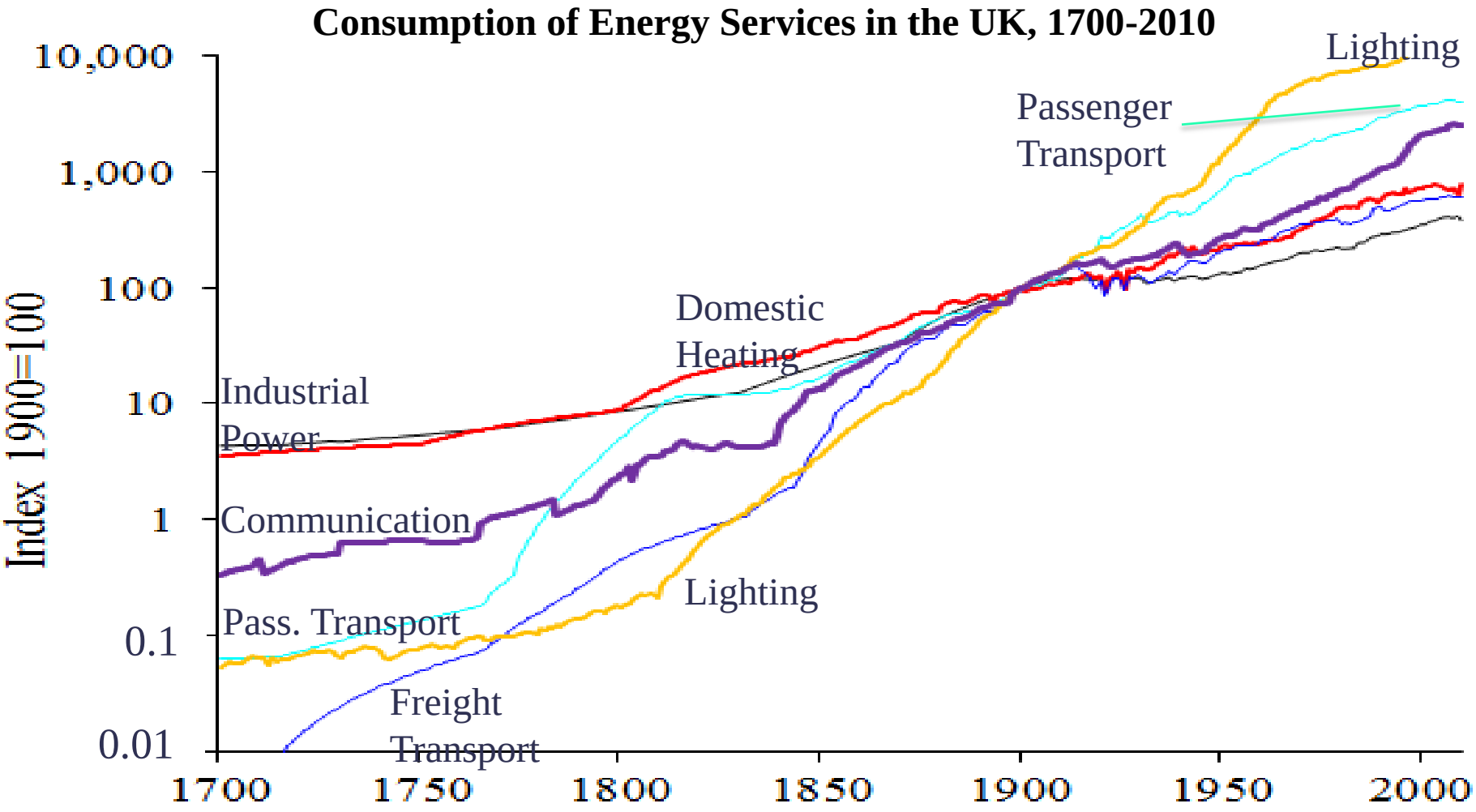


Source: Fouquet (2014)

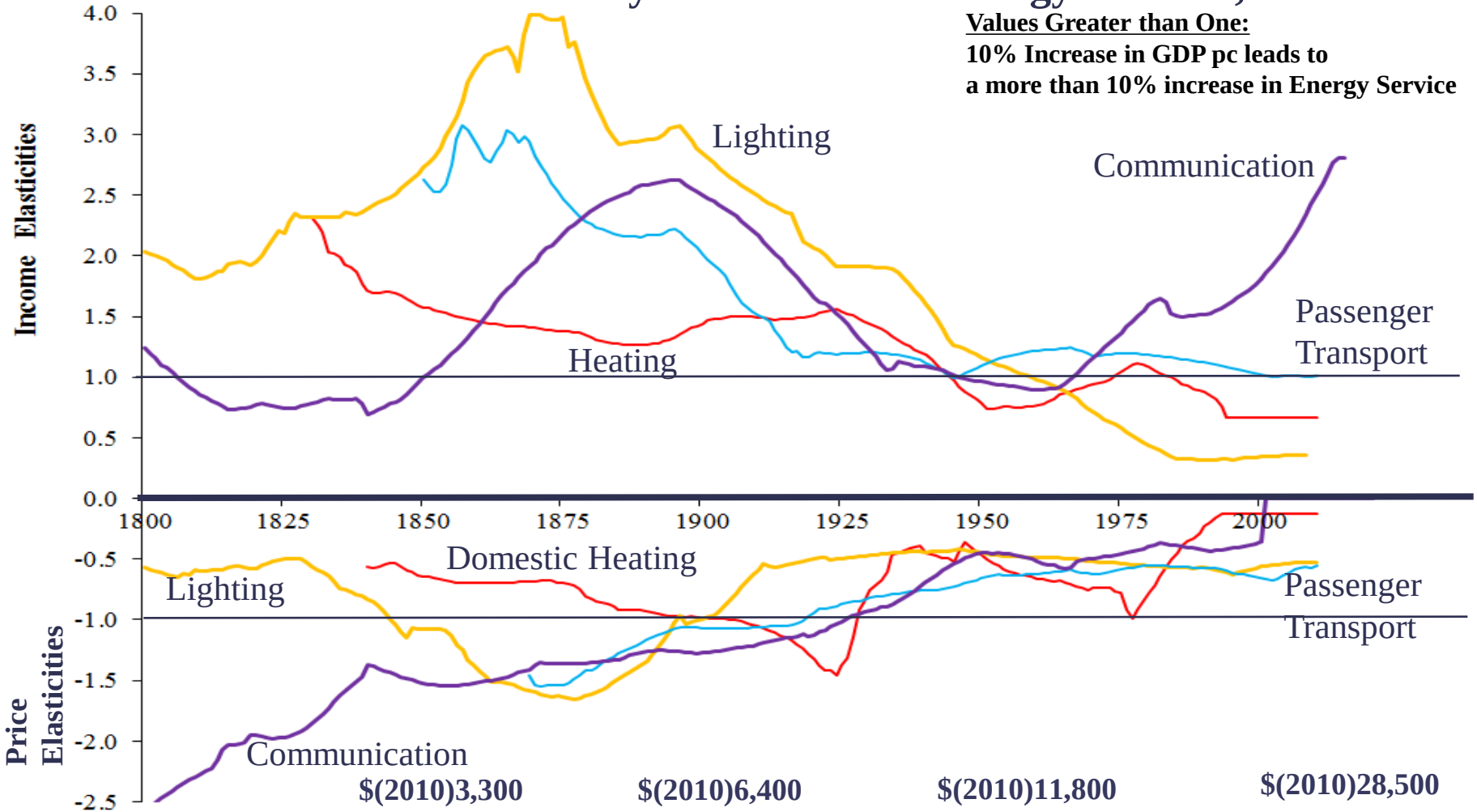
Price of Consumer Energy Services in the United Kingdom, 1700-2010



Source: Fouquet (2014)

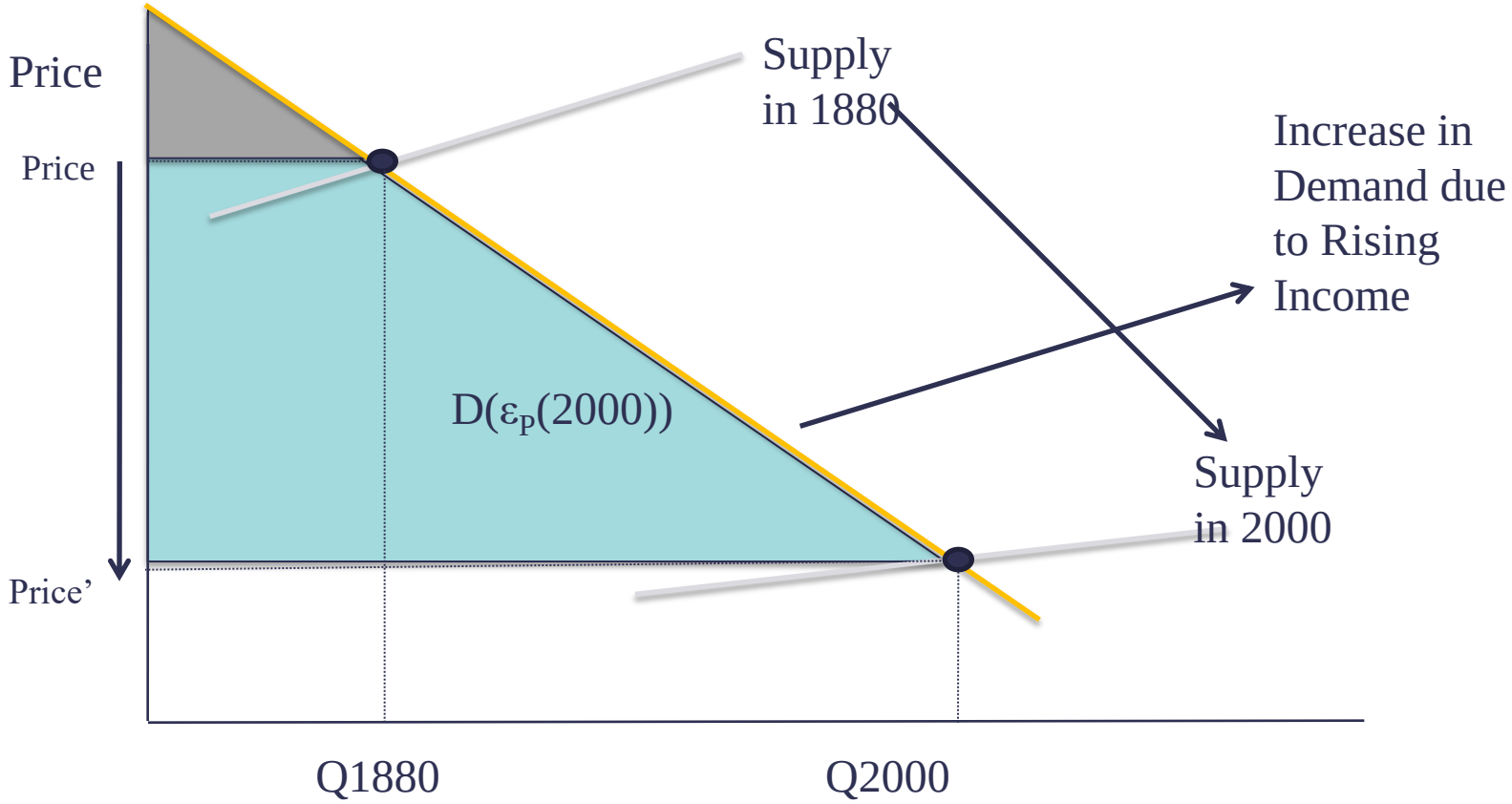

Consumption of Energy Services in the UK, 1700-2010
Index 1900=100
10,000
1,000
100
10
1
0.1
0.01
1700
1750
1800
1850
1900
1950
2000
Lighting
Passenger Transport
Domestic Heating
Industrial Power
Communication
Lighting
Pass. Transport
Freight Transport

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



Source: Fouquet (2014)

How does Consumer Surplus Change?



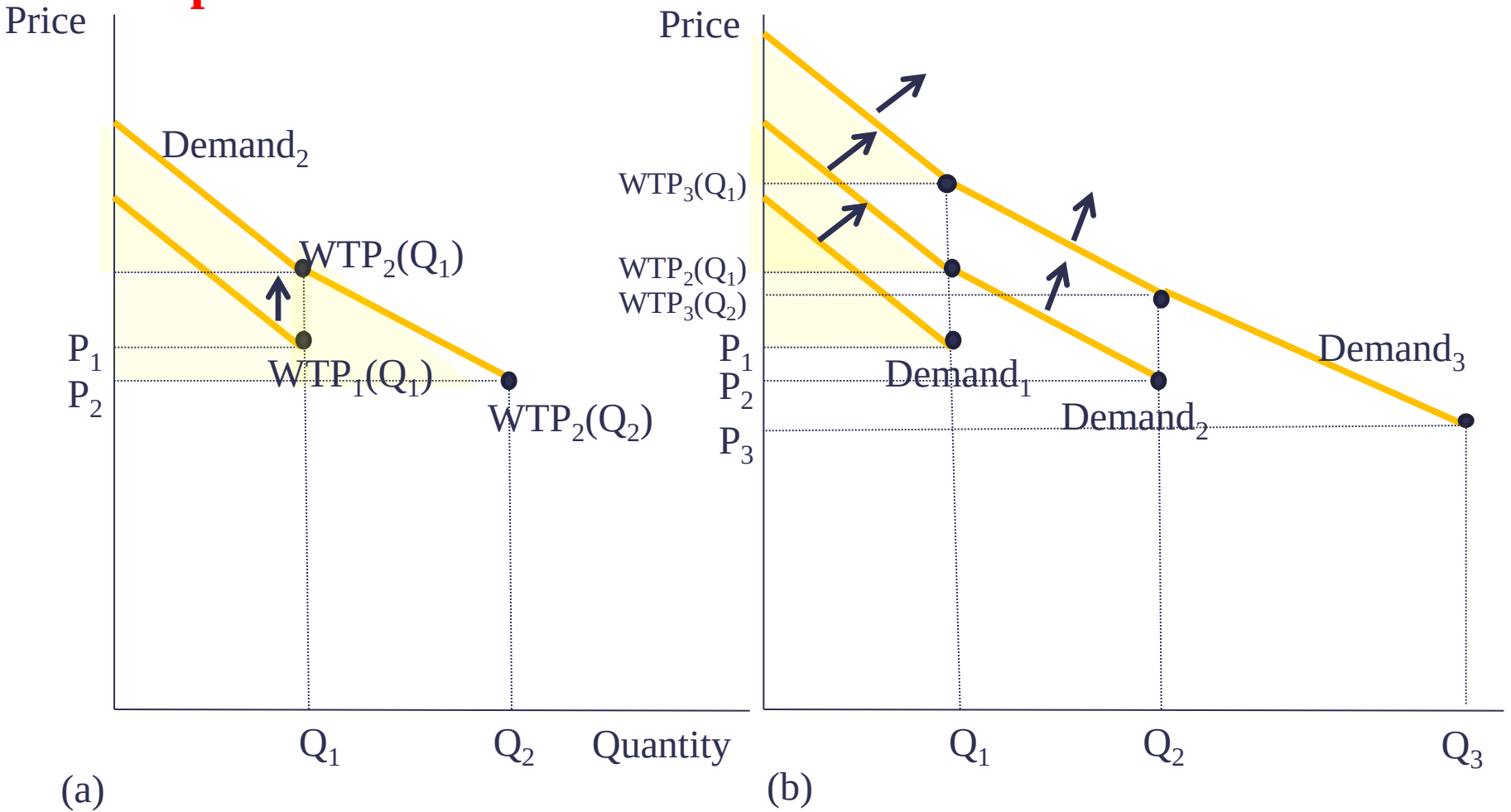
Locating the Demand Curve

- Use Historical Data to
  Perform "Benefit Transfer" through time

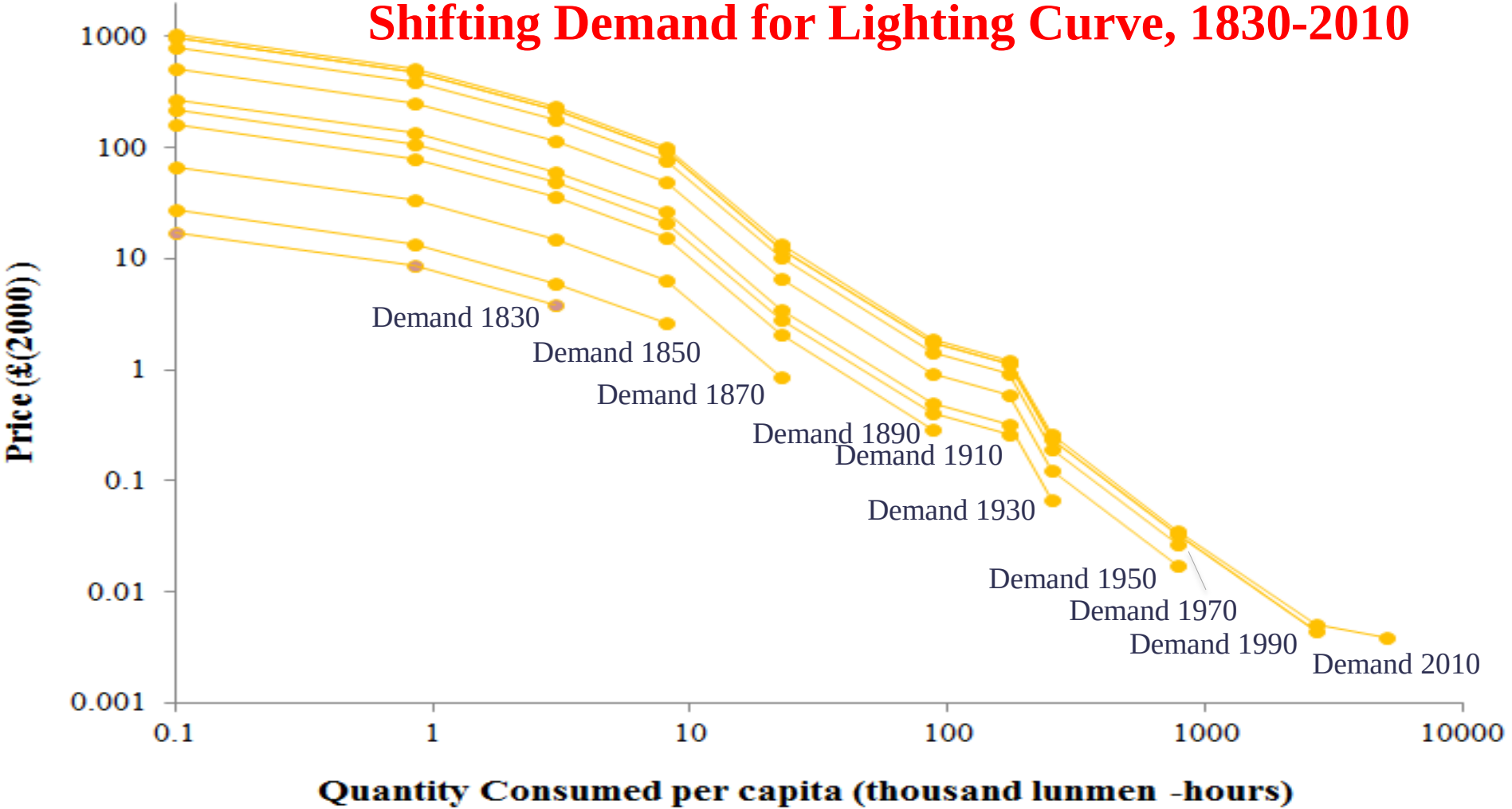
$$WTP_2(Q_1) = WTP_1(Q_1).\ \varepsilon_Y\ .\ ((Y_2 - Y_1)/\ Y_1)$$

where ε_Y is the income elasticity

Temporal Benefit Transfer

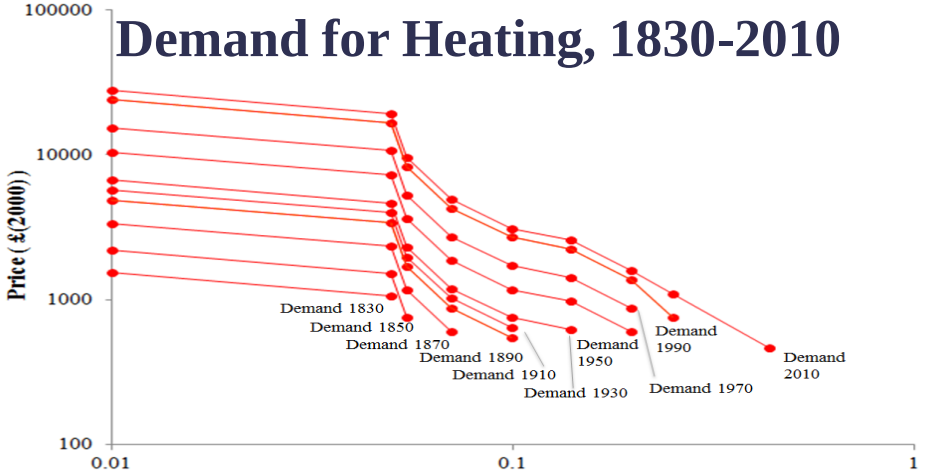


Shifting Demand for Lighting Curve, 1830-2010



Source: see text

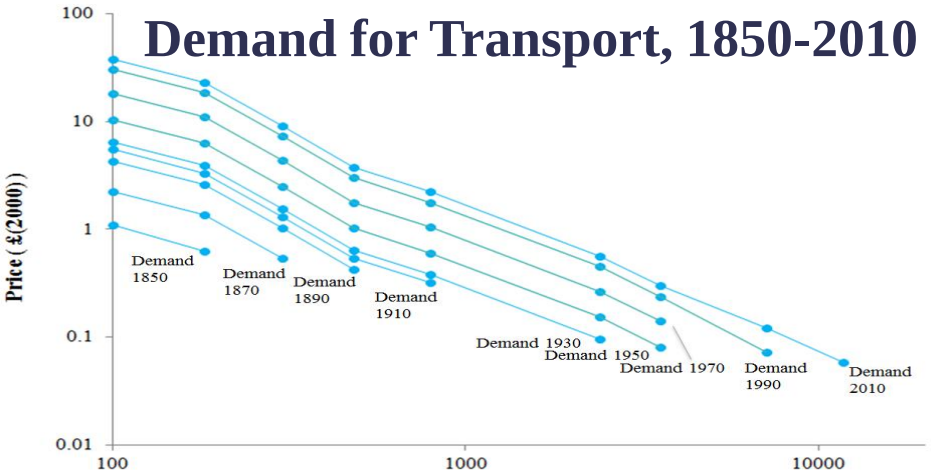
Demand for Heating, 1830-2010



(a)

Source: see text

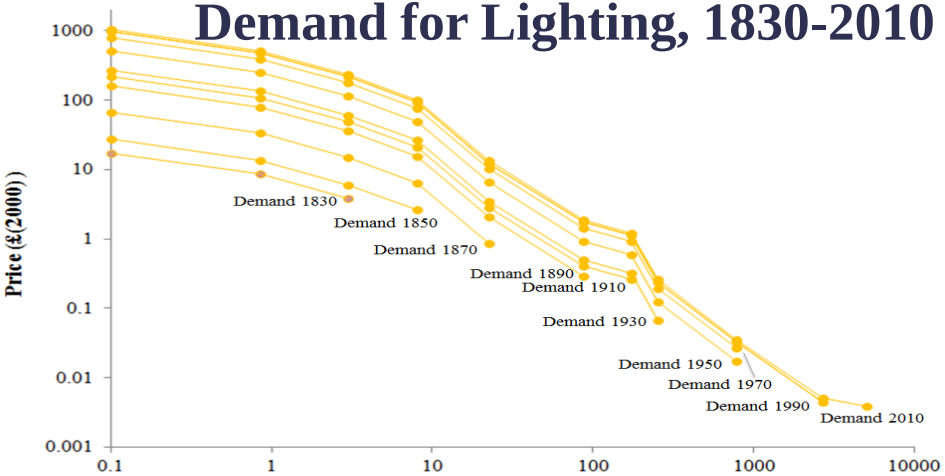
Demand for Transport, 1850-2010



(b)

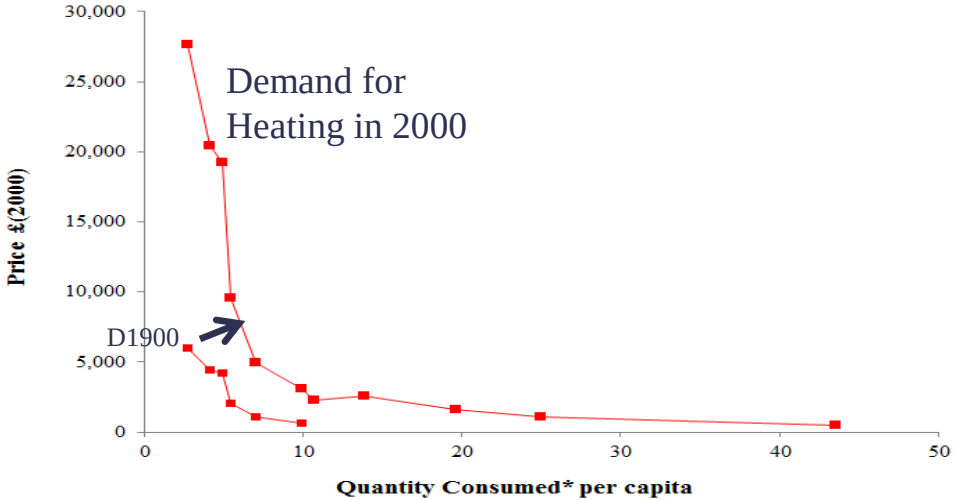
Source: see text

Demand for Lighting, 1830-2010

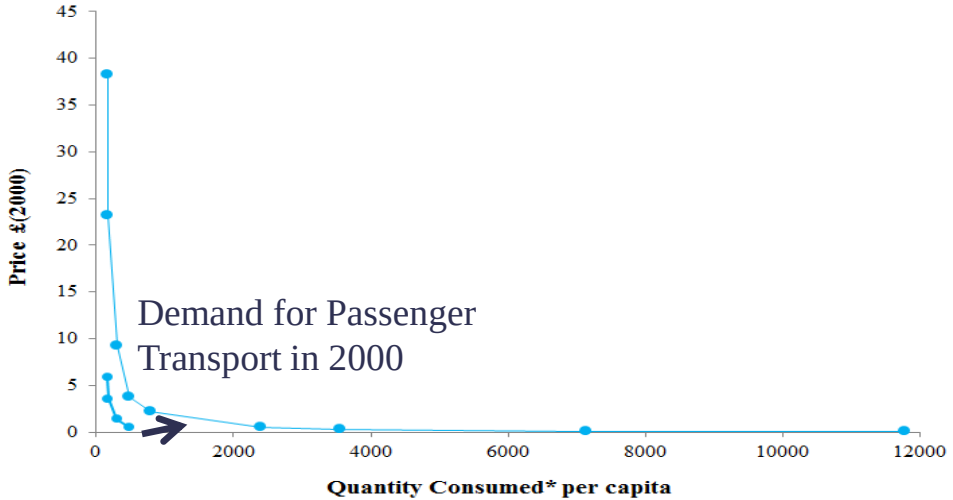


(c)

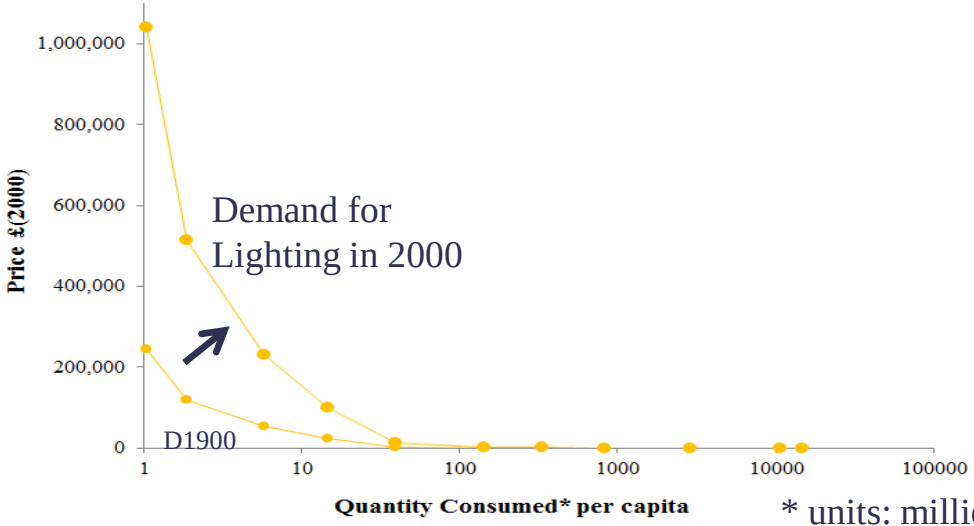
Source: see text



* units: 10s of kgs of oil equiv. heating

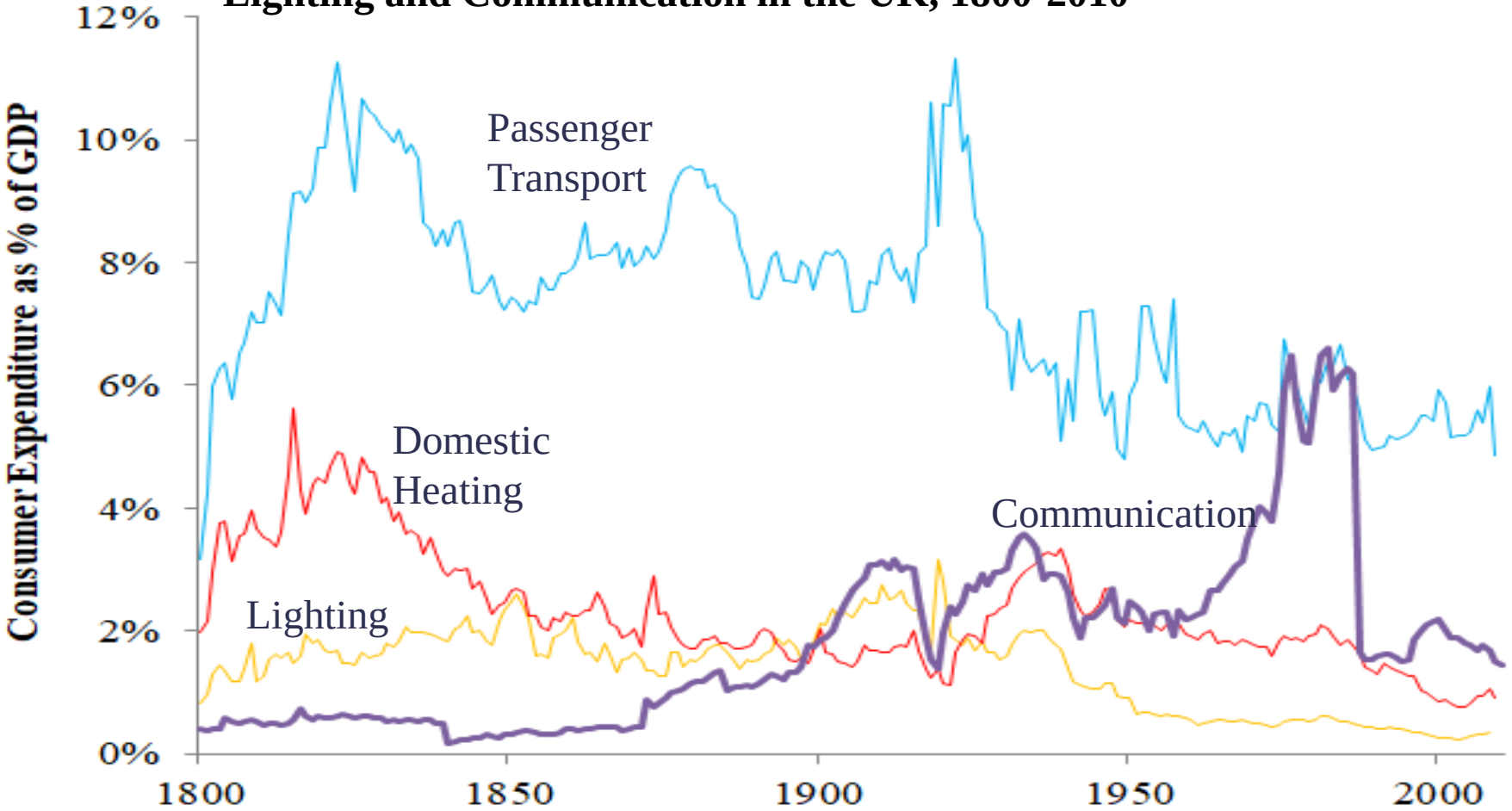


* units: passenger-kms

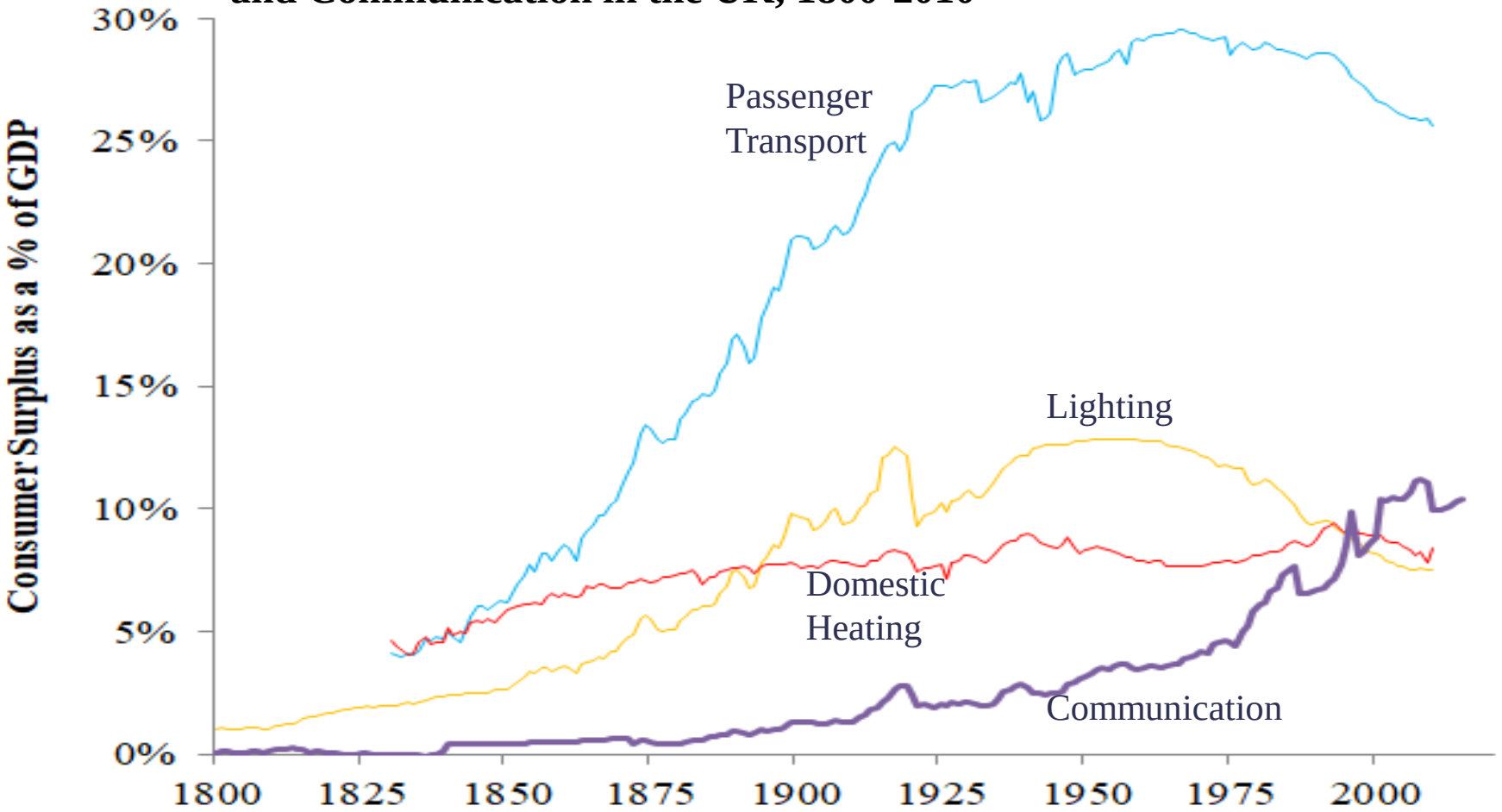


* units: million lumen-hours

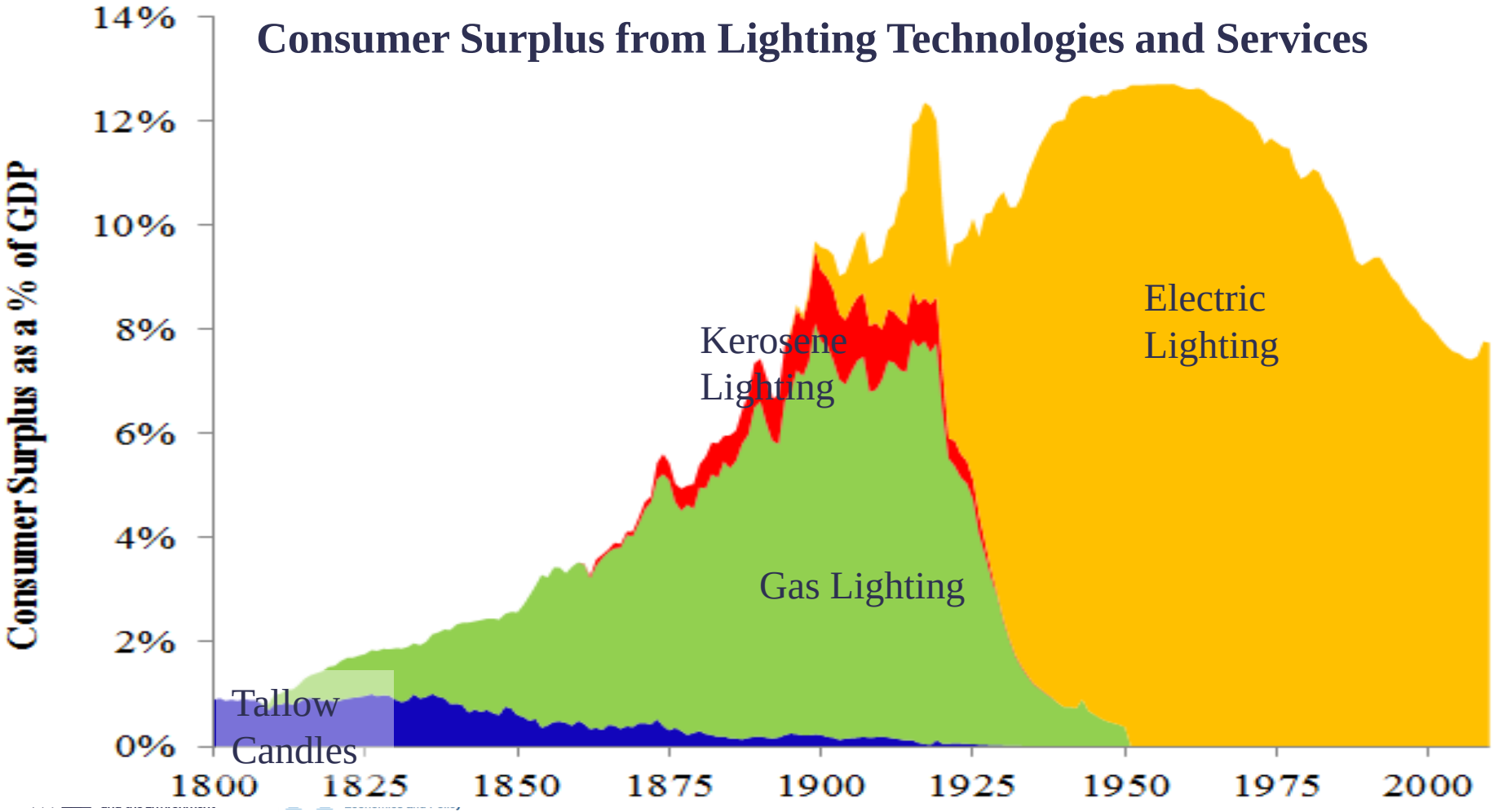
Consumer Expenditure of Domestic Heating, Passenger Transport, Lighting and Communication in the UK, 1800-2010



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

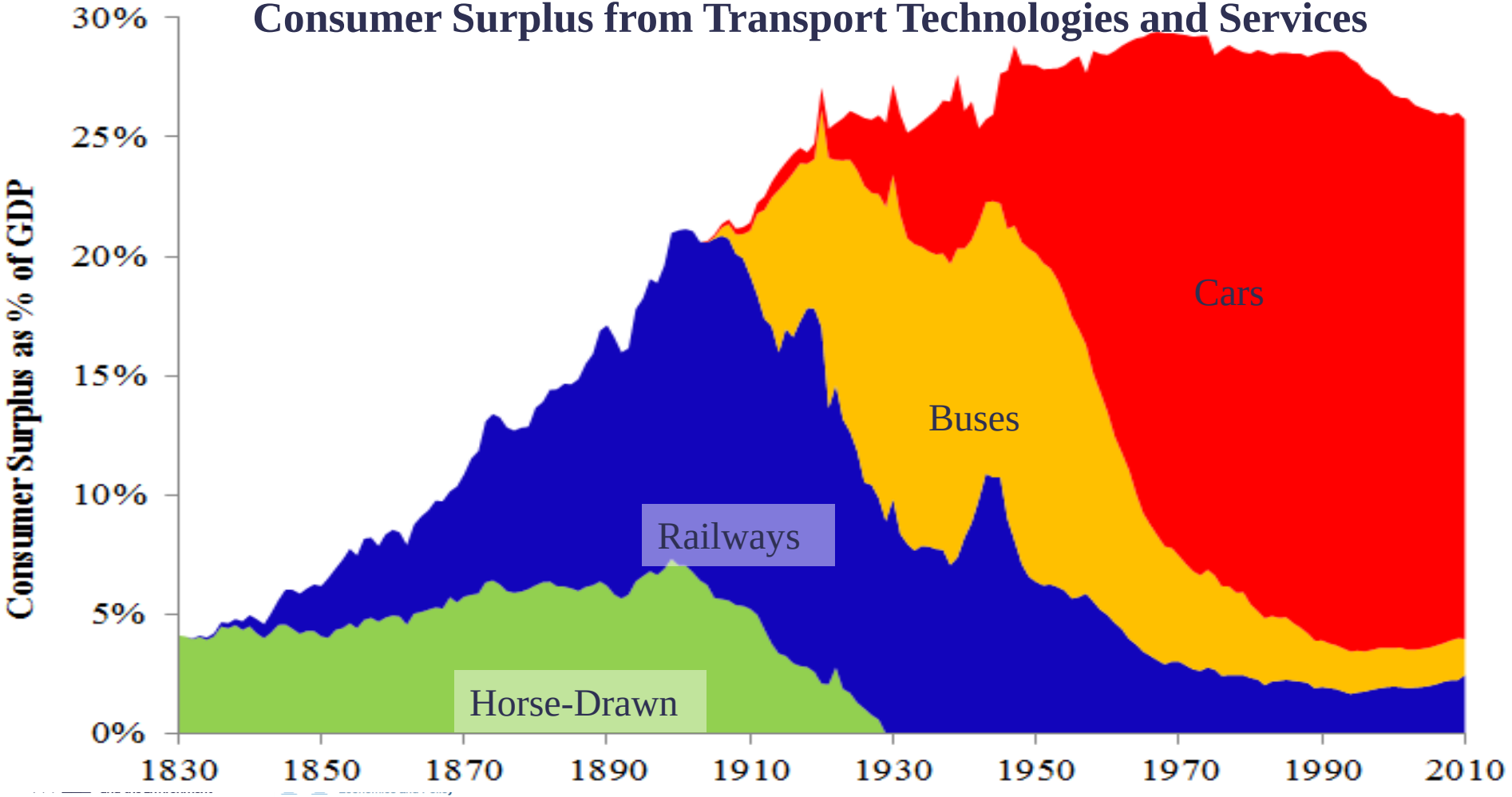


Source: see text



Source: see text

Consumer Surplus from Transport Technologies and Services



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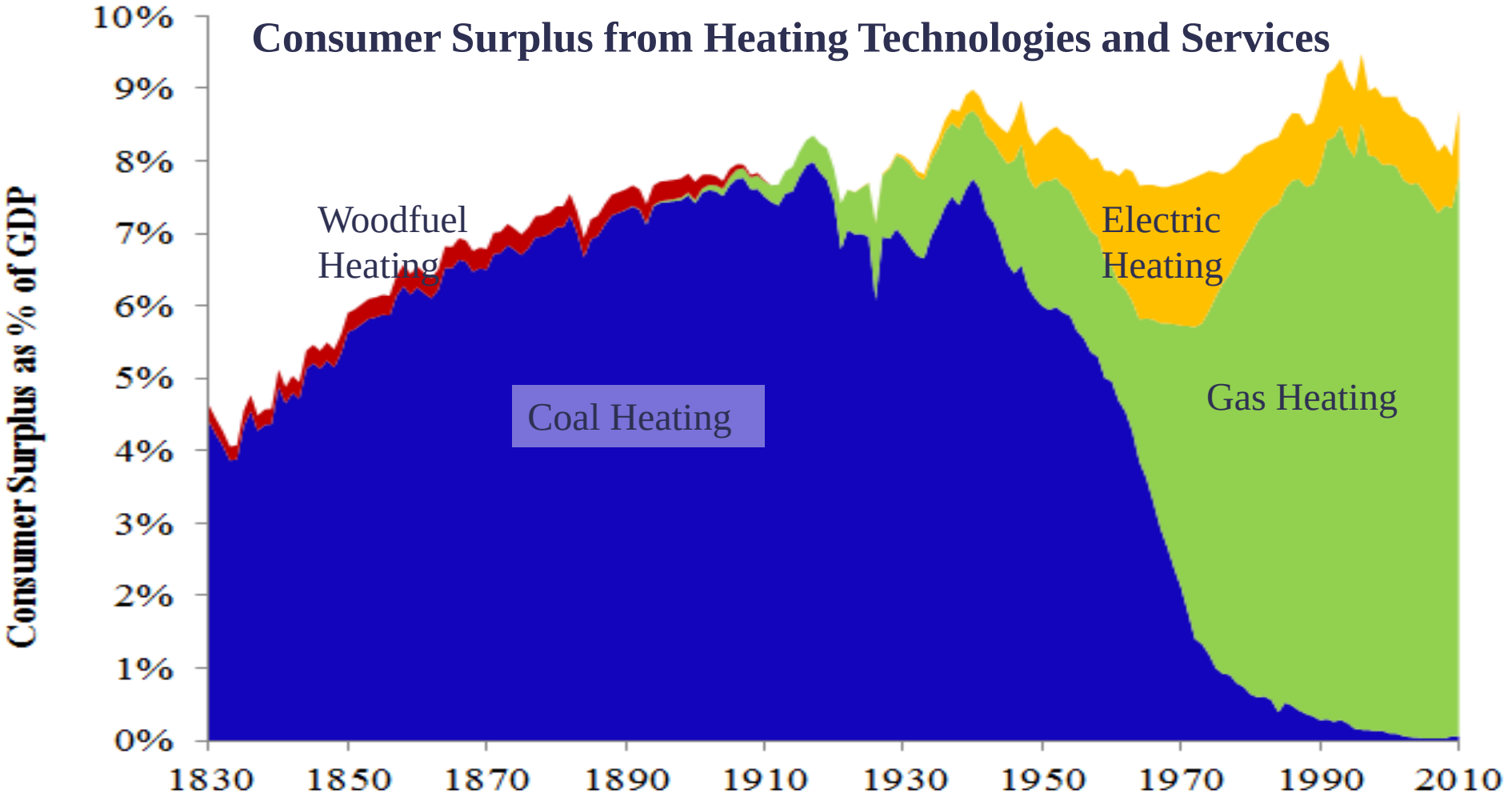

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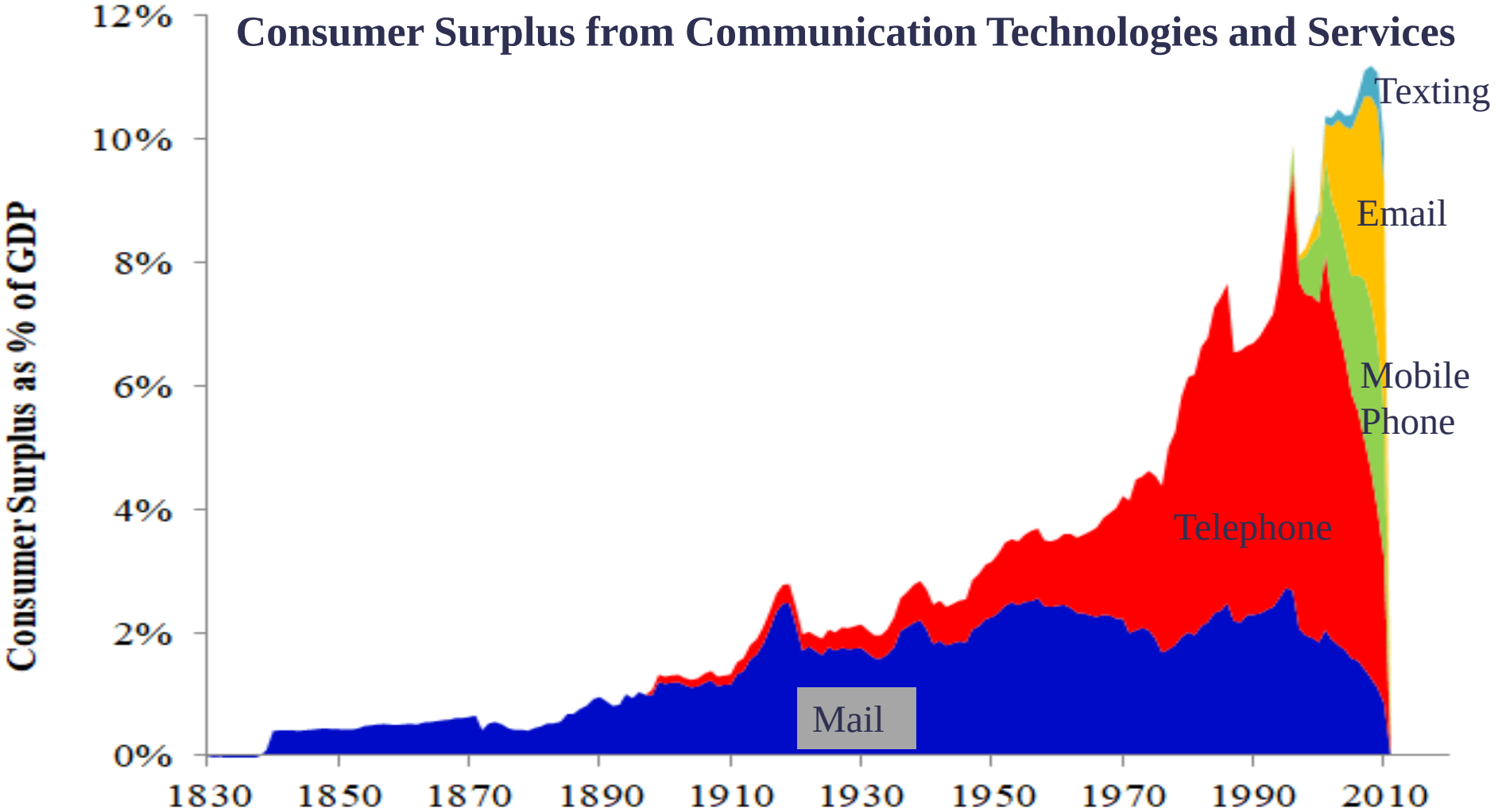
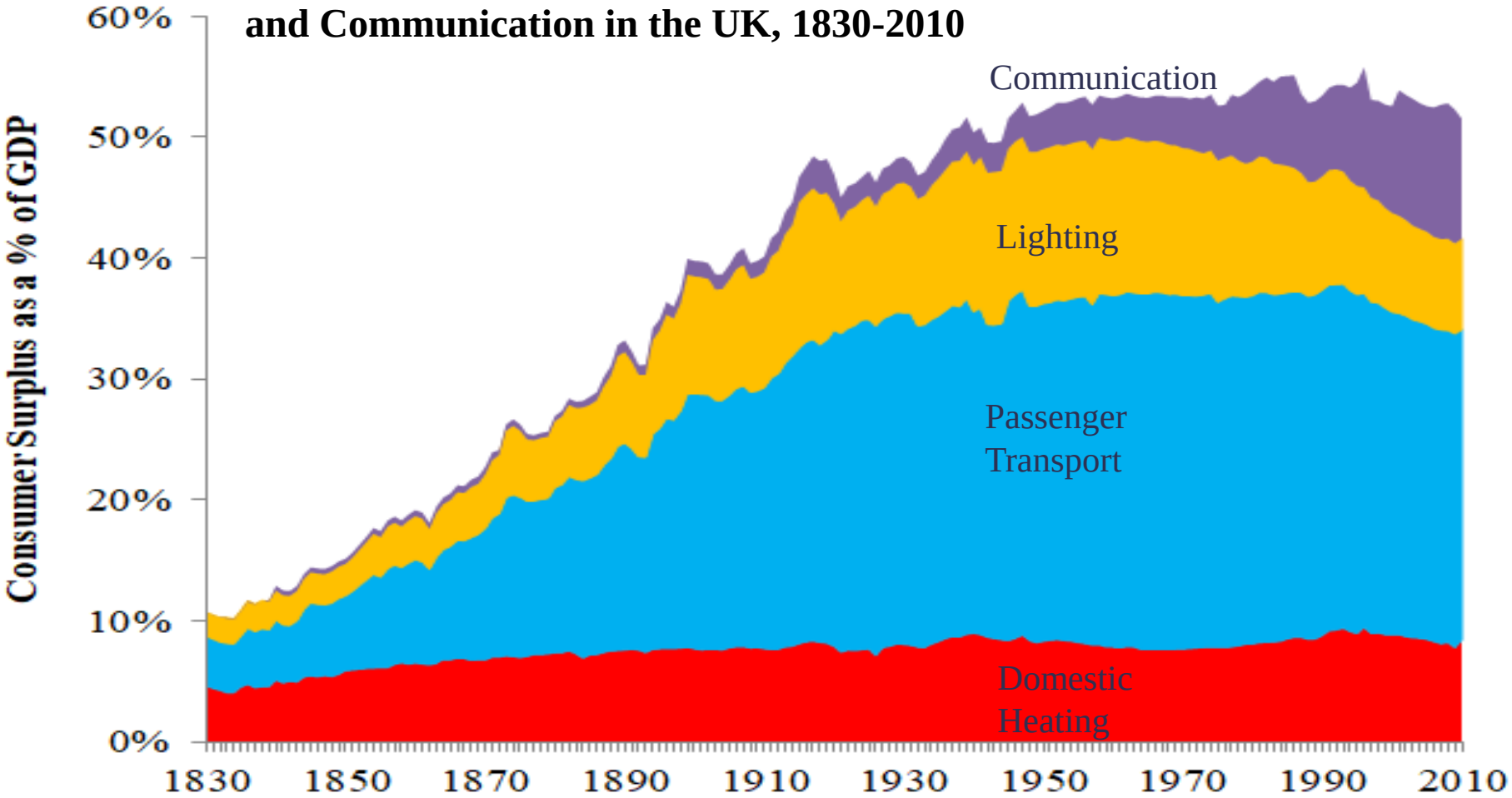


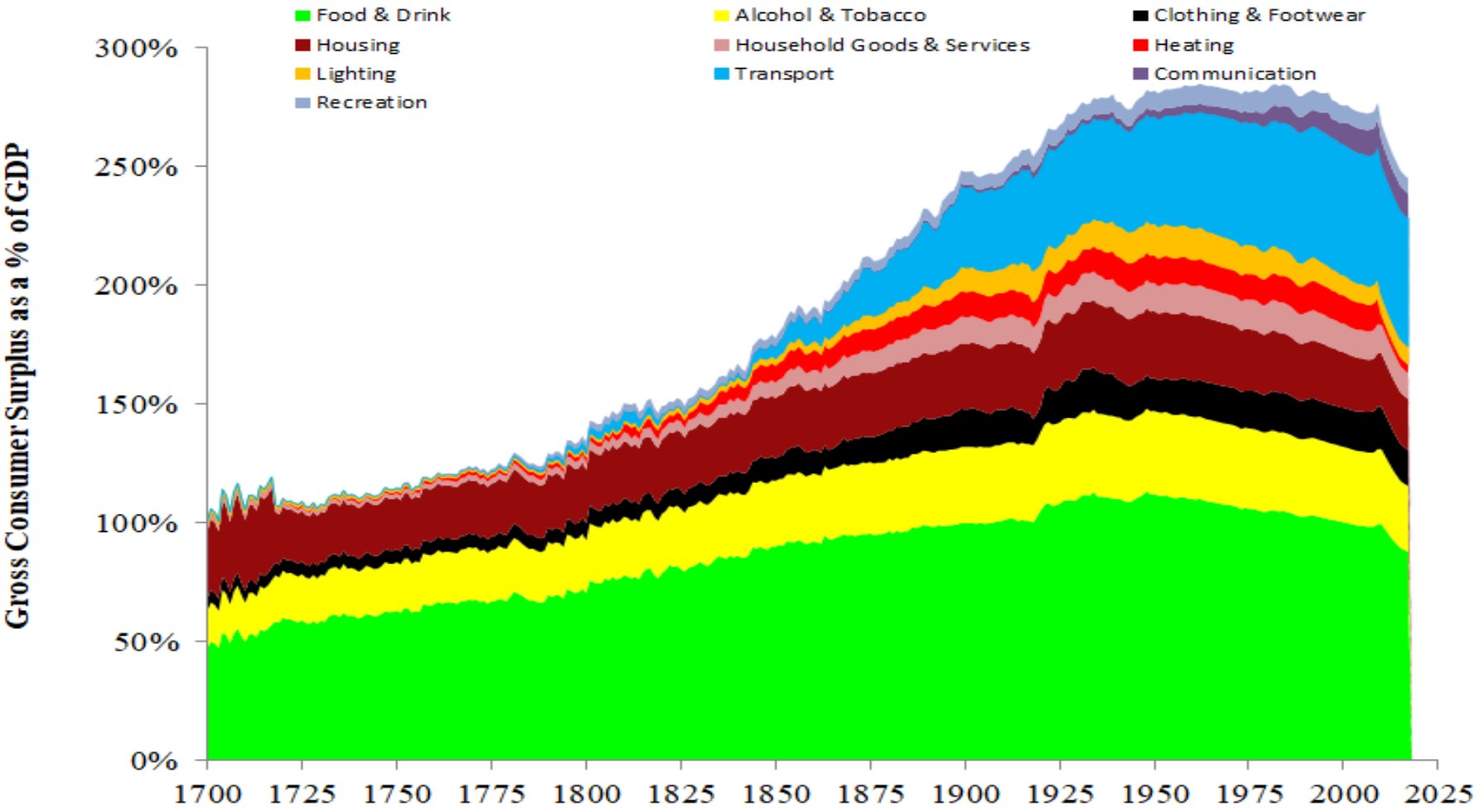
Source: see text

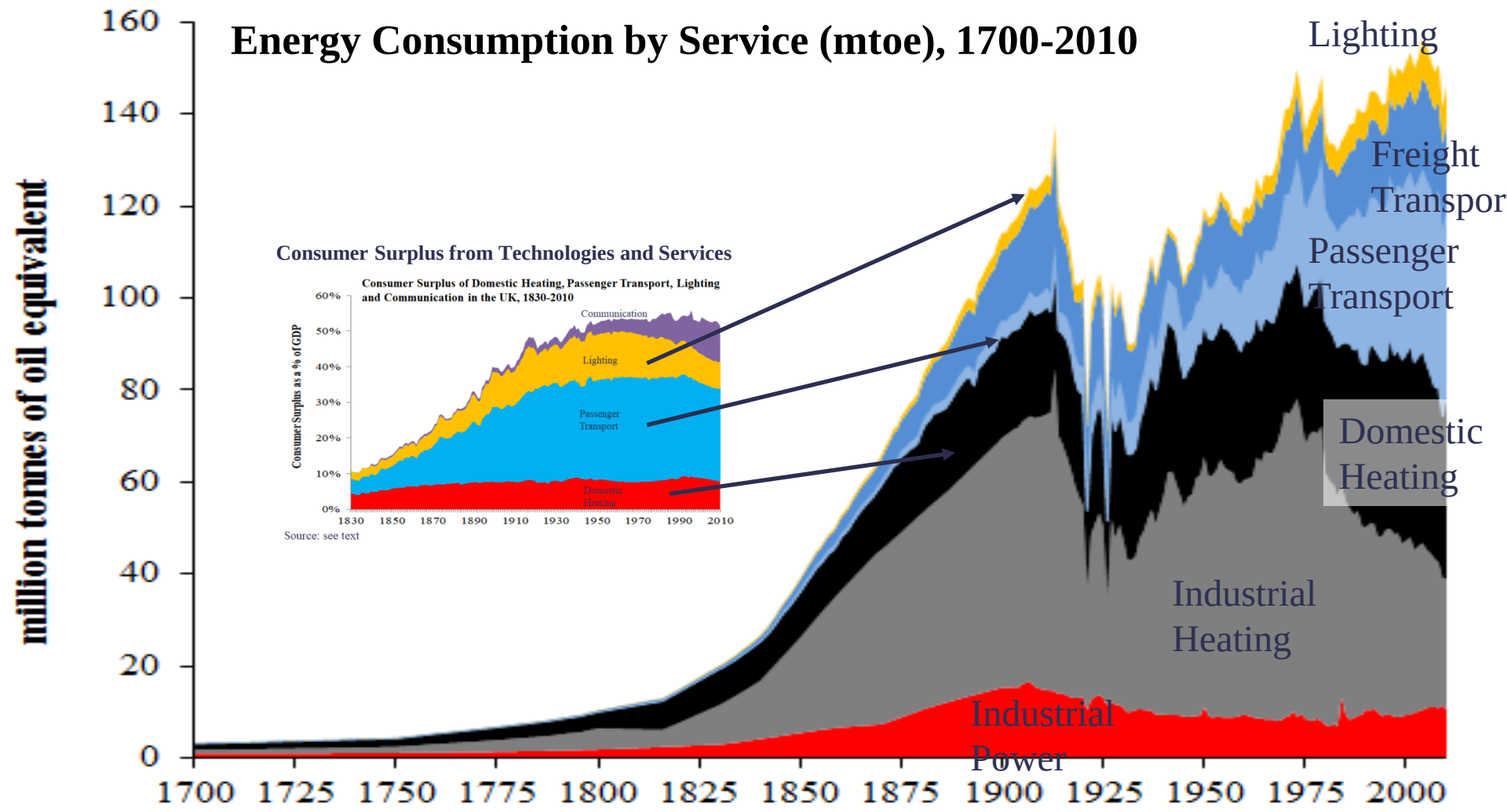
Consumer Surplus of Domestic Heating, Passenger Transport, Lighting and Communication in the UK, 1830-2010



Source: see text

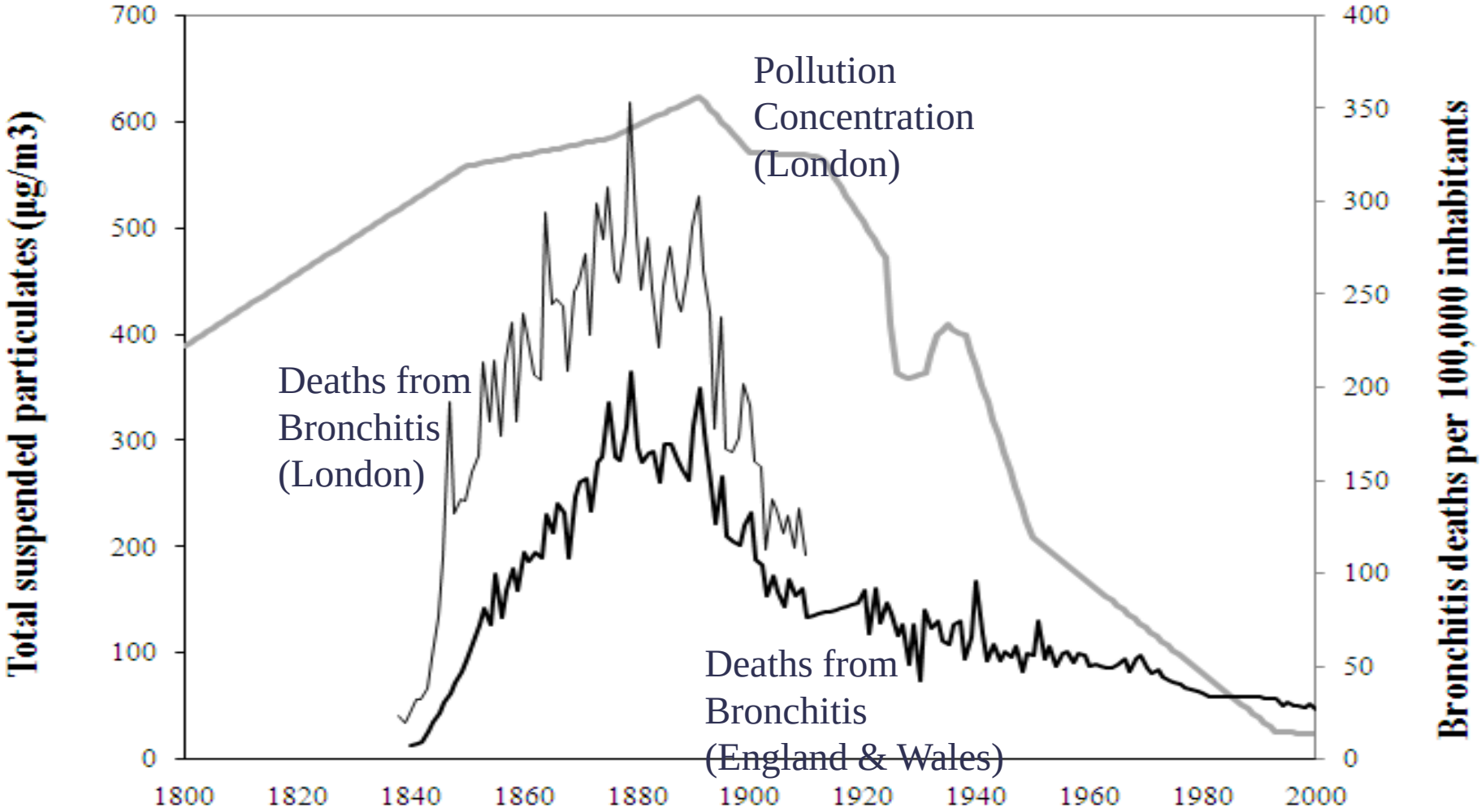
Gross Domestic Consumer Surplus/GDP in the United Kingdom, 1700-2017





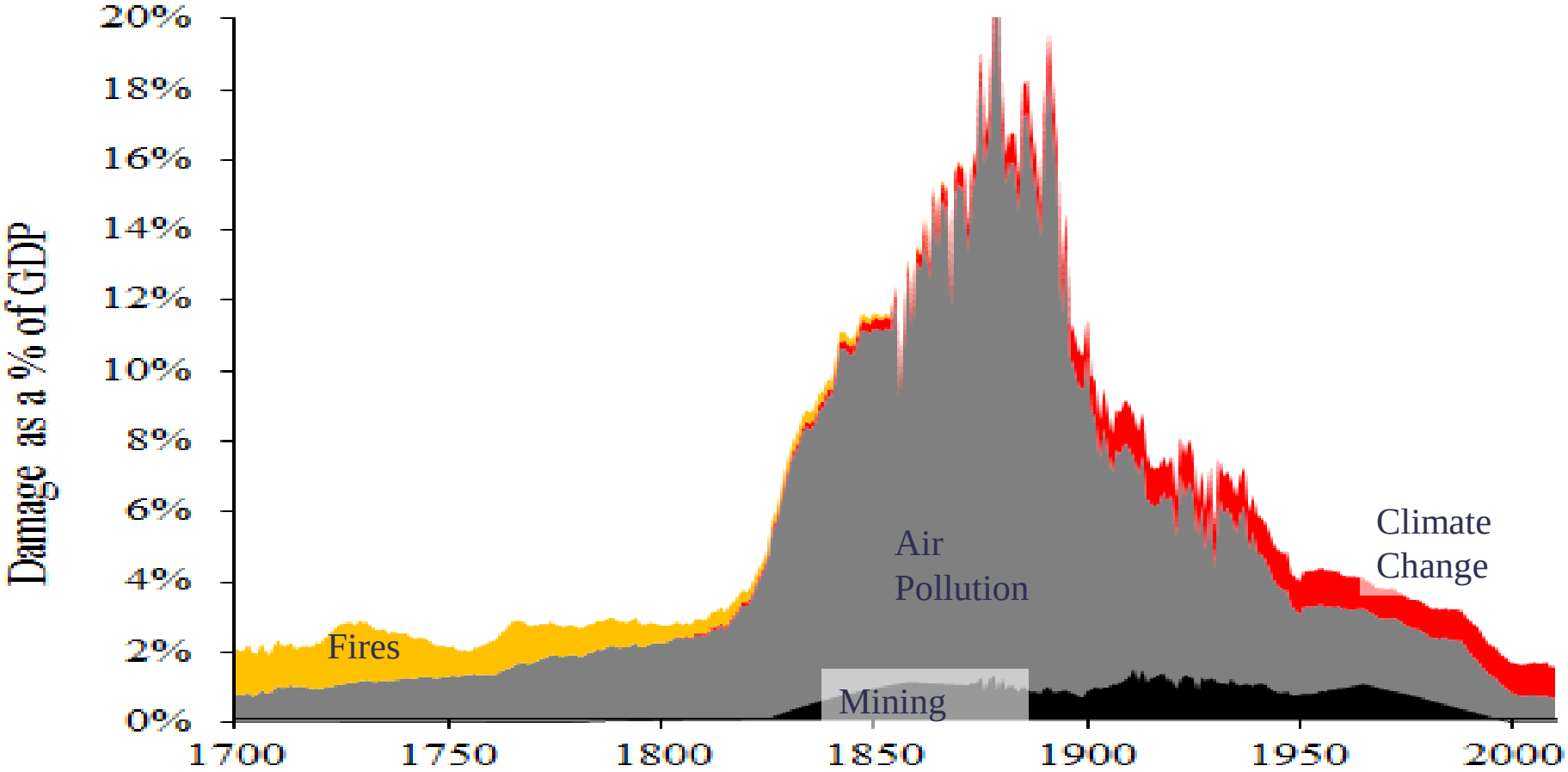
Source: Fouquet (2014)


N.Y.C.& H.R.R.

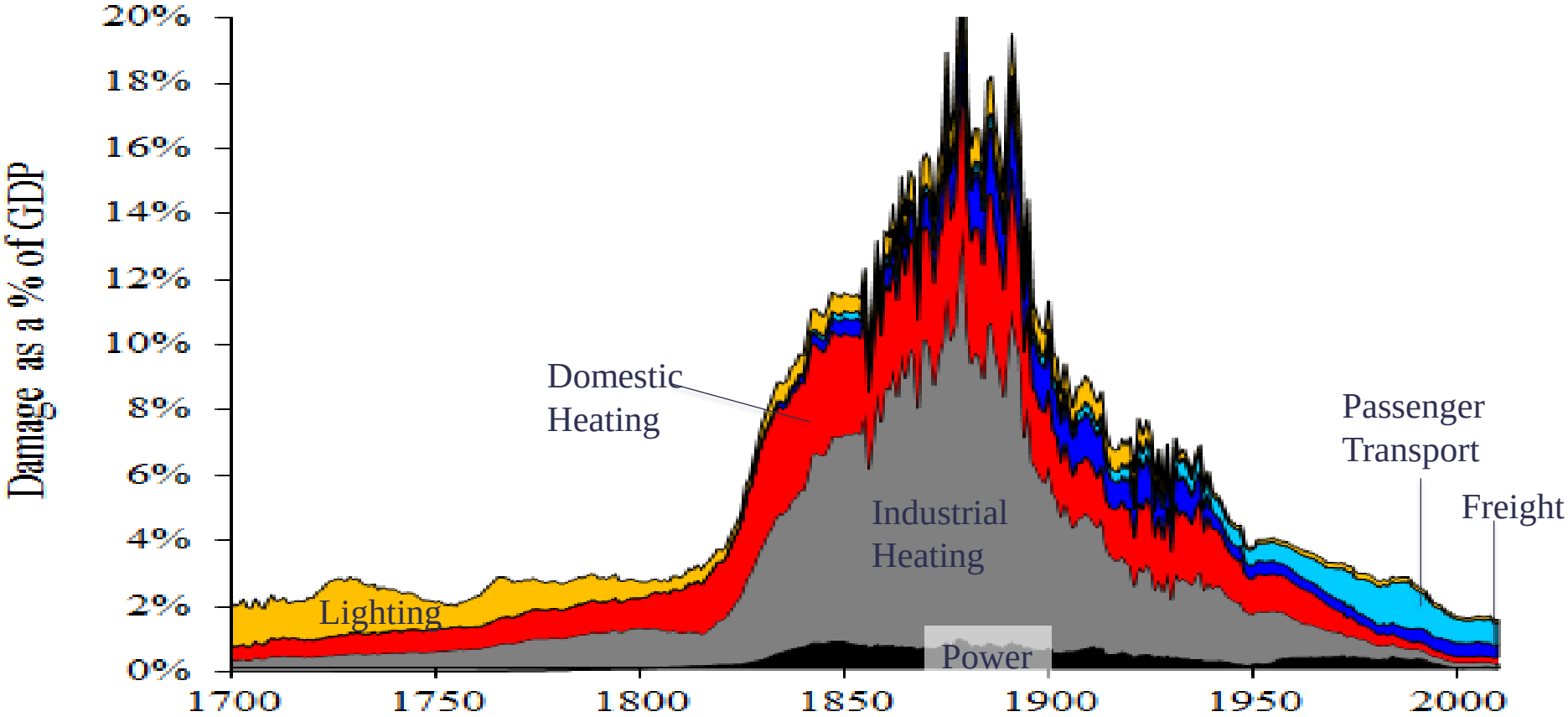


Source: Air Pollution: Brimblecombe (1987); Deaths: Registrar General (1838 onwards)

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

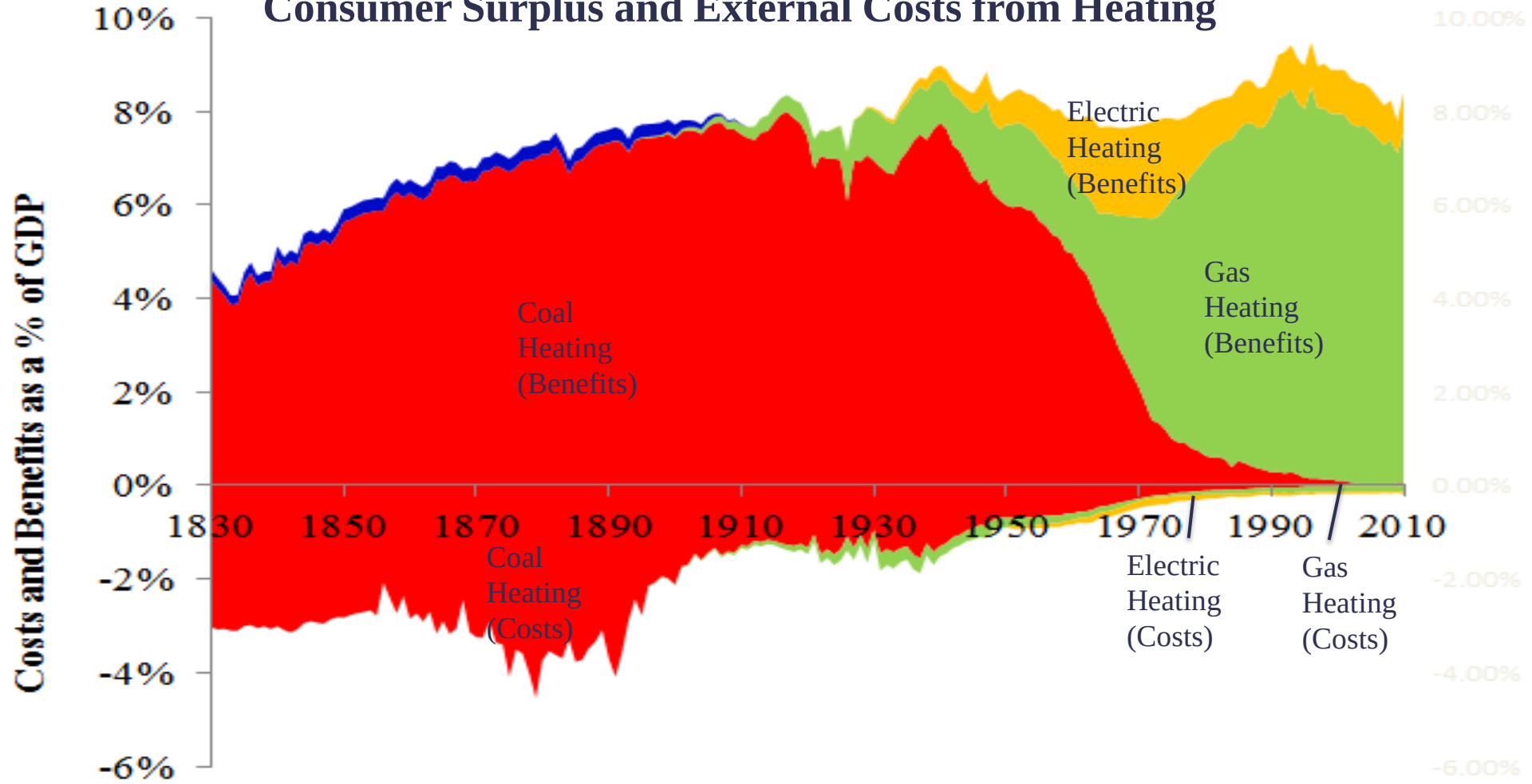


External Costs of Energy Services as a % of GDP in the United Kingdom, 1700-2010



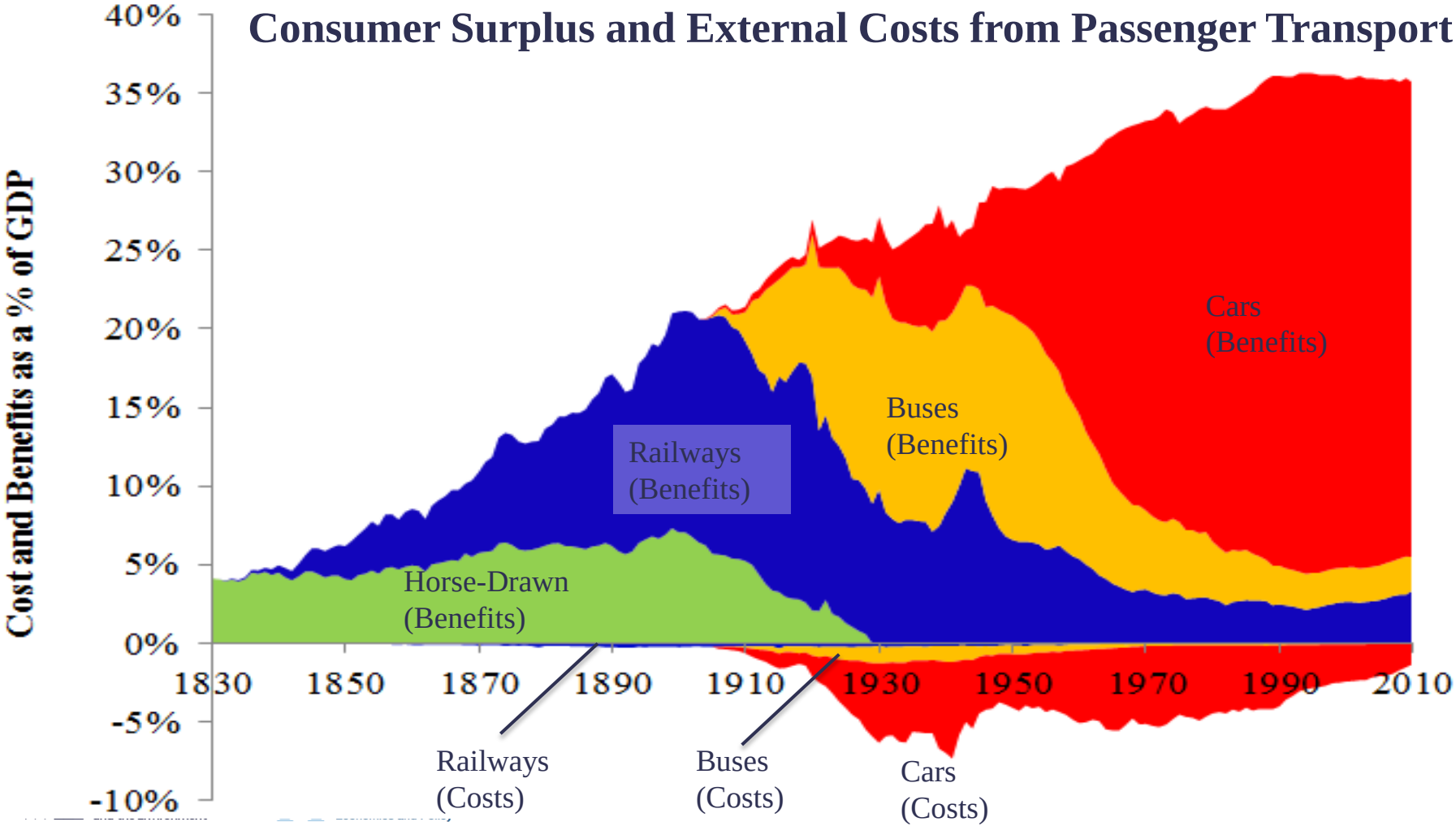
Source: Fouquet (2017)

Consumer Surplus and External Costs from Heating



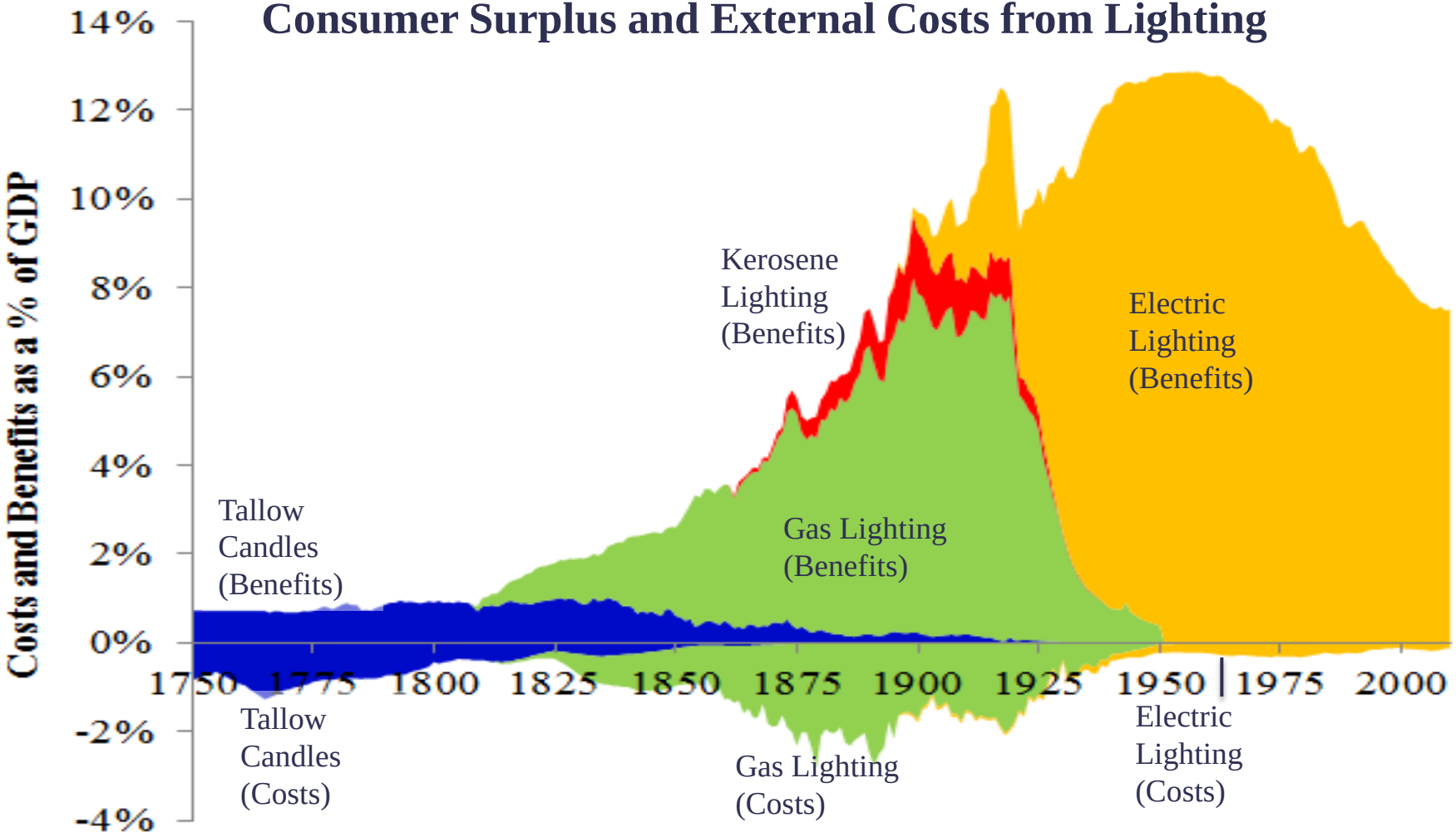
Source: see text

Consumer Surplus and External Costs from Passenger Transport

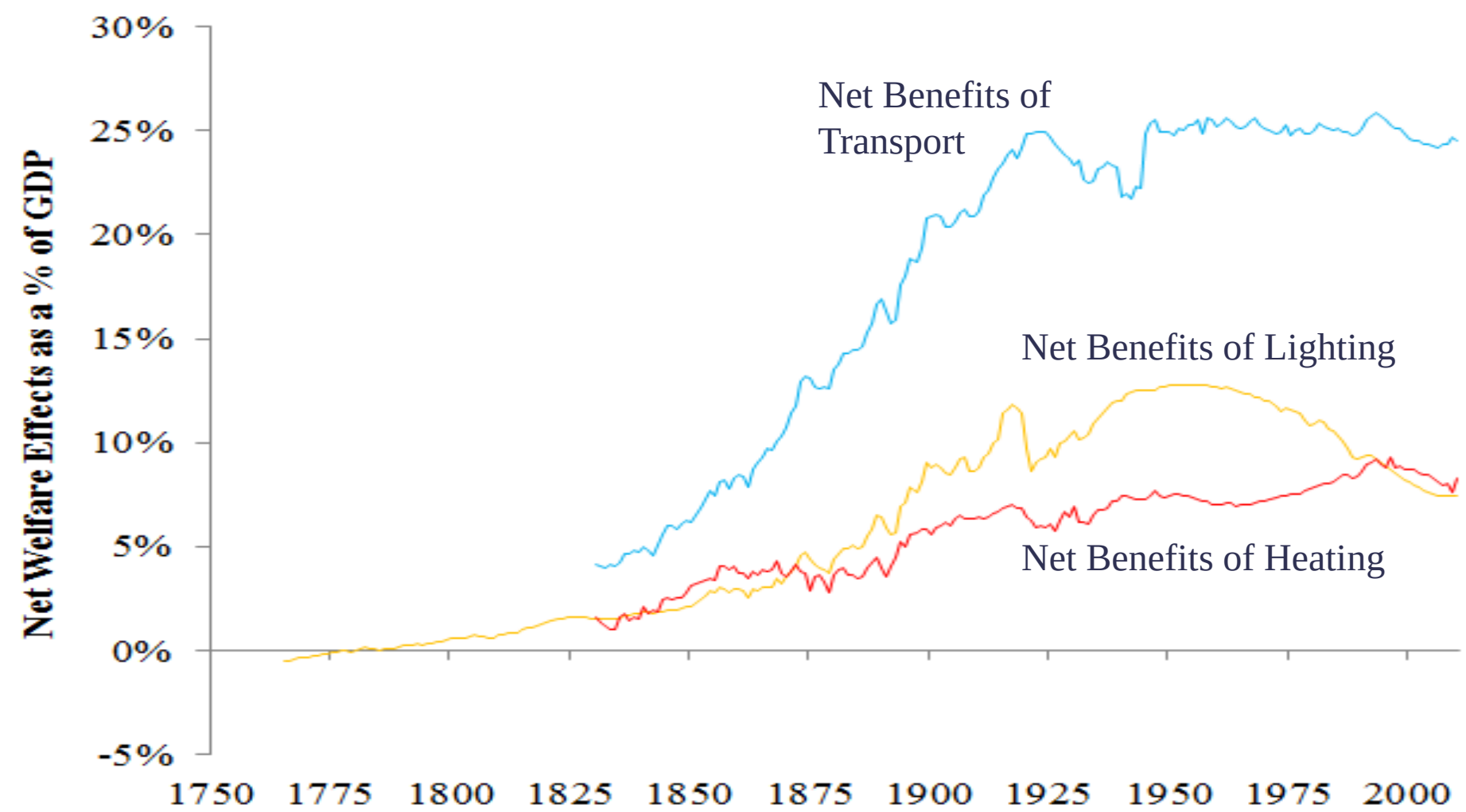


Source: see text

Consumer Surplus and External Costs from Lighting



Source: see text



Source: see text

Limitations

- **Estimates of Elasticities**
- **Assumptions about Demand Curve Shift**
  - Identical result as Leunig and Voth (2011)
- **Assumptions about Damage and Valuation**
- **Variables Not Estimated:**
  - Producer Surplus or Profits
  - Spillovers (Consumption/Countries)
  - Complements & Consumer Surplus
  - Technology Impact on GDP
- **Consumer Surplus based on Expenditure not truly on Utility of Energy Services**

Lessons: Net Benefits

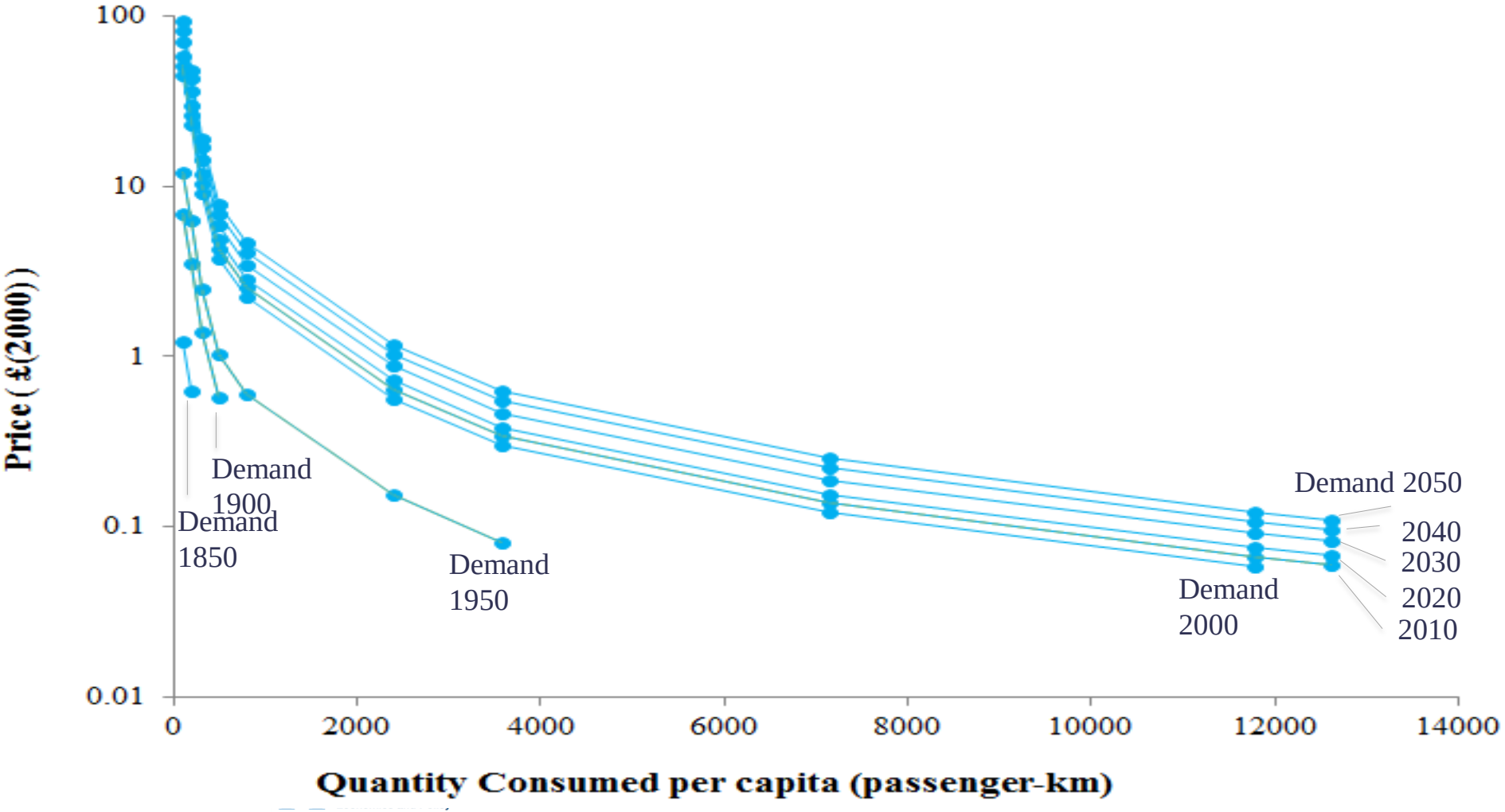
- Maximise Net Benefits in LR

- Energy Services & Technologies: Beneficial
- Think about Utility/Net Benefits per kWh

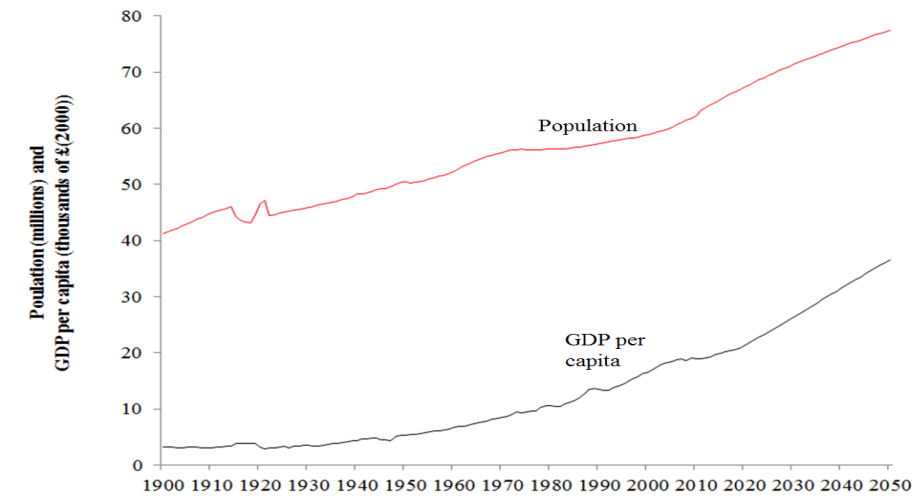
- Marginal Analysis:
  - Declining MB: Saturation Effects
  - Rising MC: Escalating Climate Change
  - MB < MC??
- Not Optimal Level of Consumption?
  - Reduce Consumption?


RECORD MONDIAL DE VITESSE
515,3 km/h
LE 18 MAI 1990

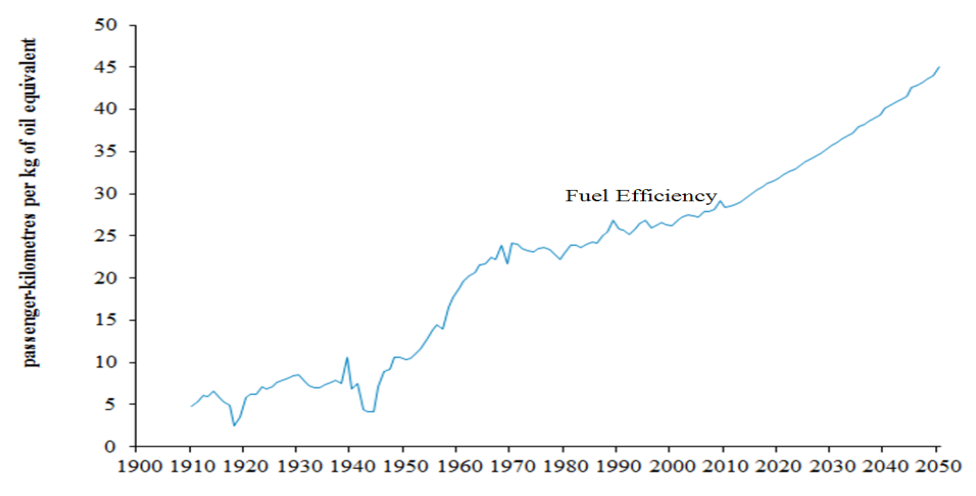

CHALLENGE



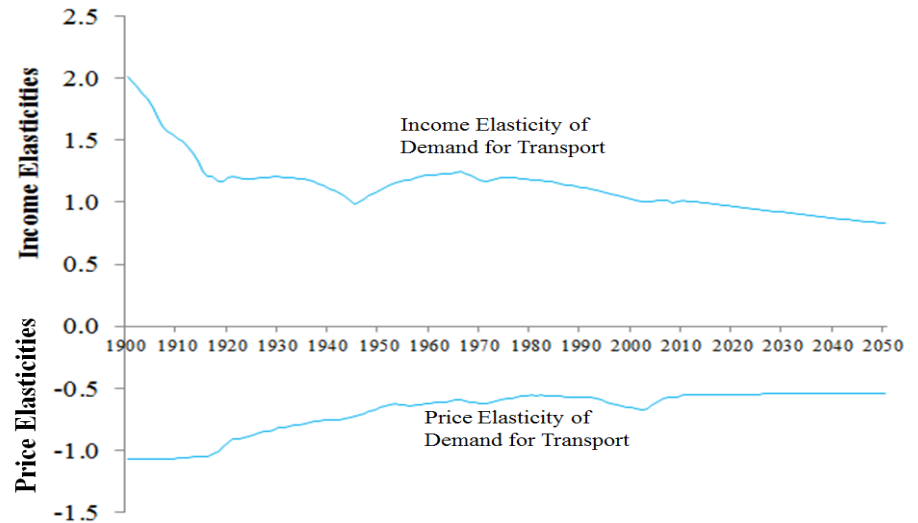
Source: 1850-2010: Fouquet (2017), 2020-2050: see text.



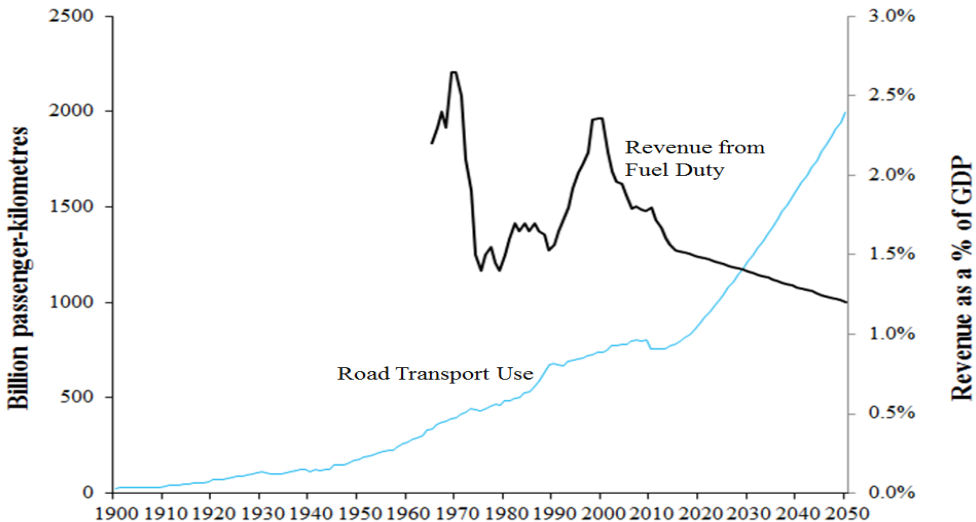
Source: 1900-2015: Mitchell (2015), ONS (2016); 2016-2050: see text.



Source: 1910-2015: Chitnis et al (2016); 2016-2050: see text.

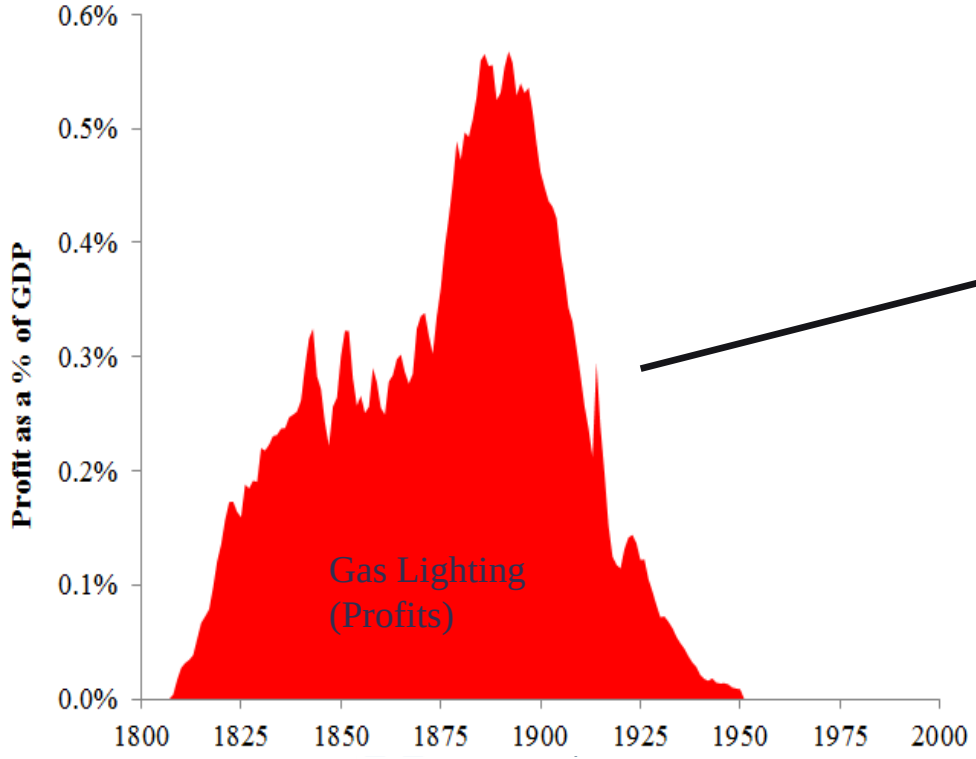


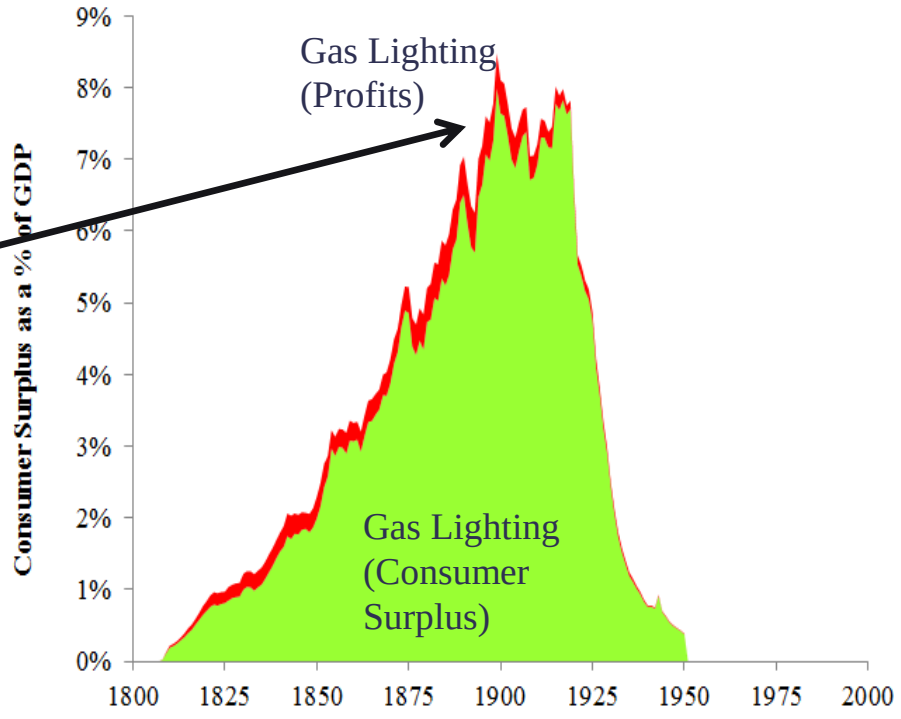
Source: 1900-2010: Fouquet (2014); 2011-2040: see text.



Source: DfT (2002, 2008, 2016), Johnson et al (2012)

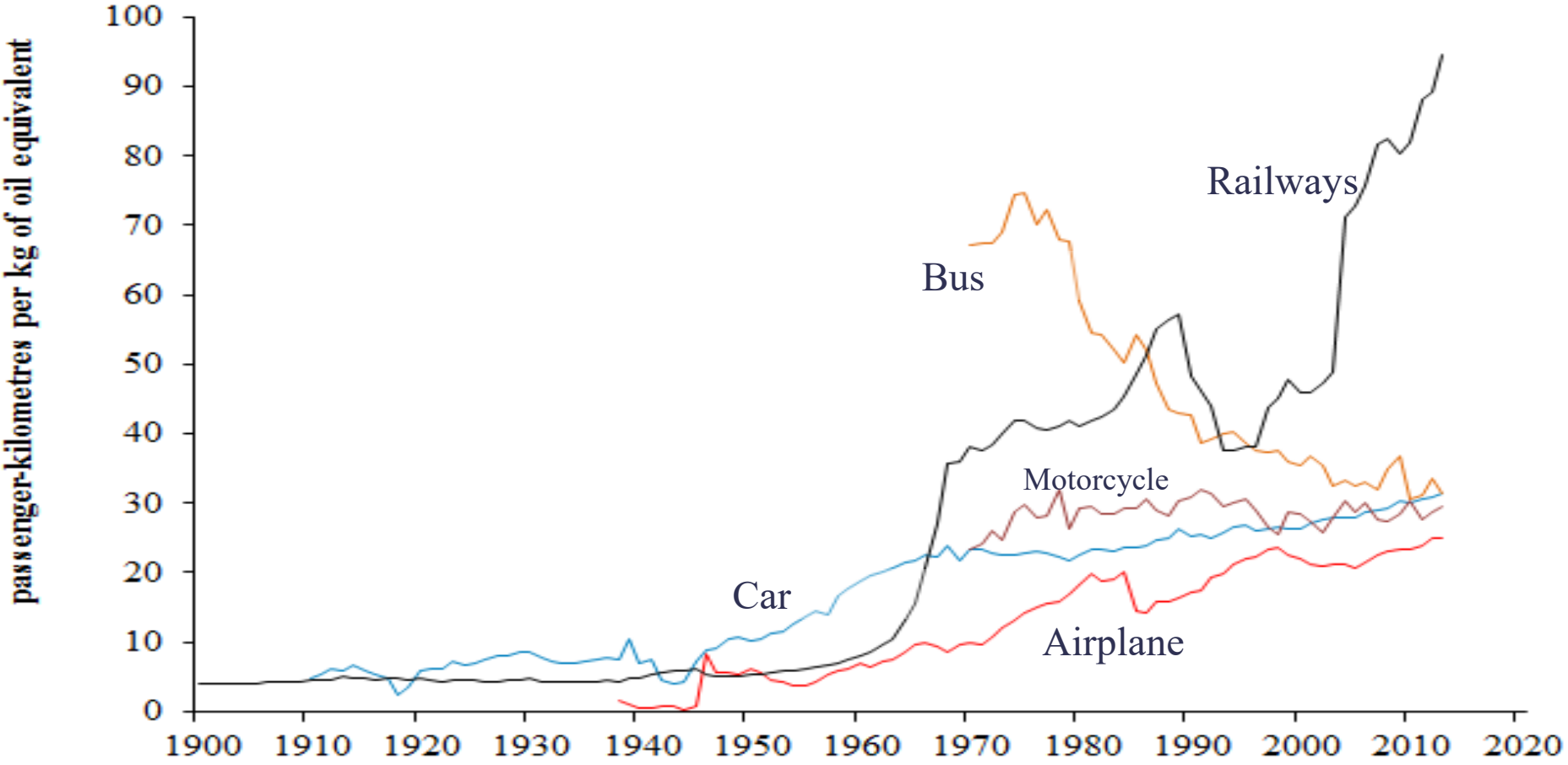
Profits and Consumer Surplus from Gas Lighting





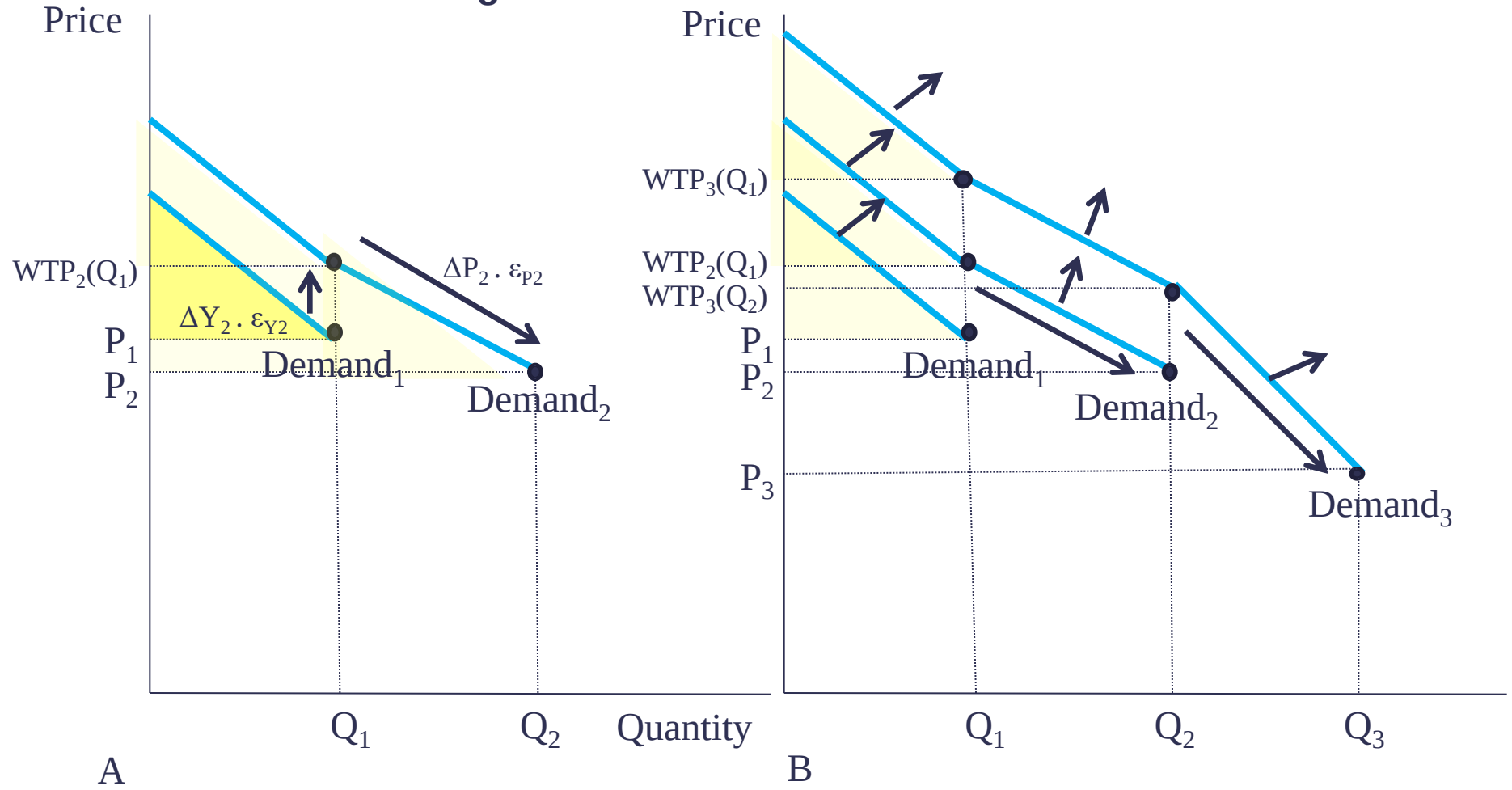
Source: see text

Average Efficiency by Transport Services in the United Kingdom, 1900-2013

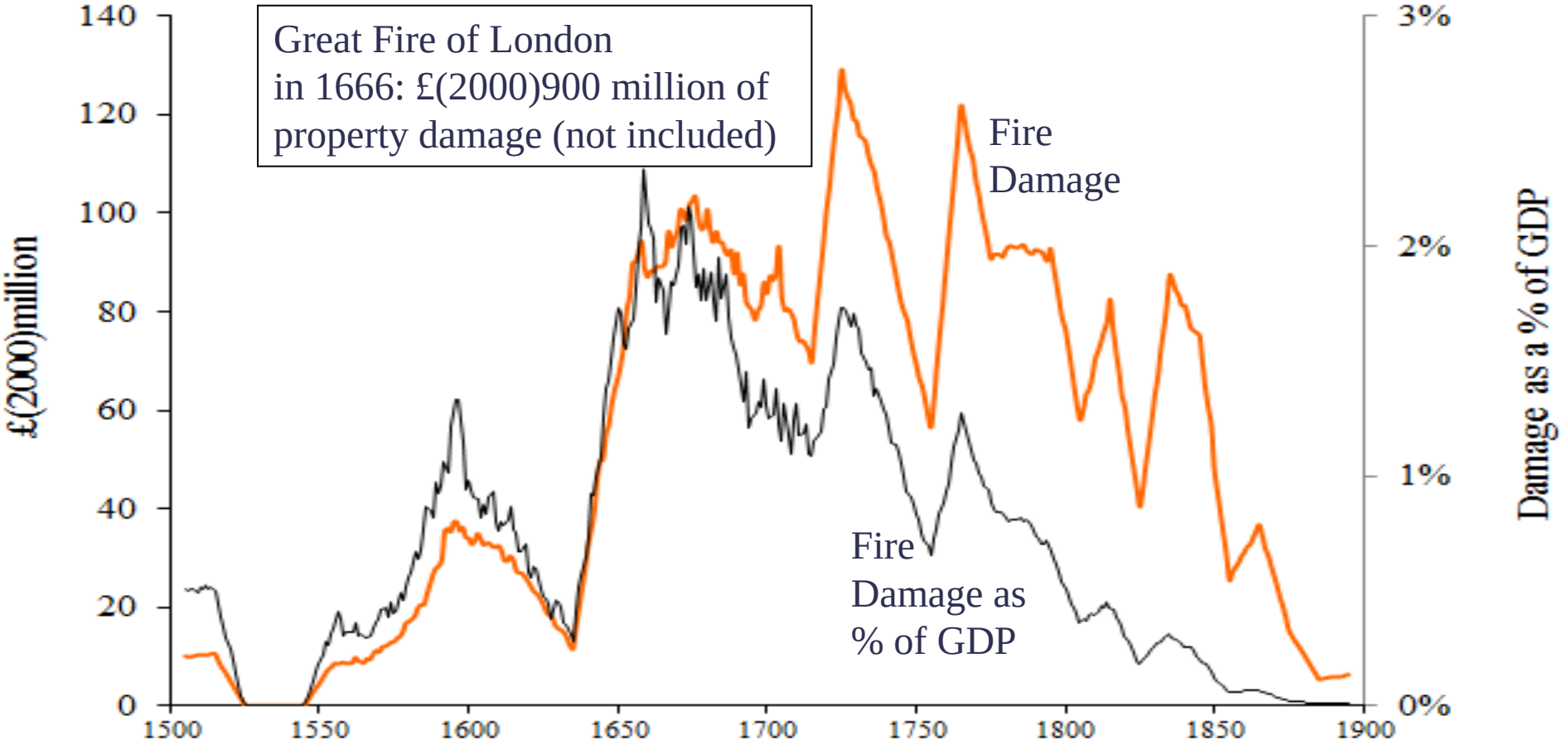


Source: Chitnis, Fouquet and Sorrell (2016)

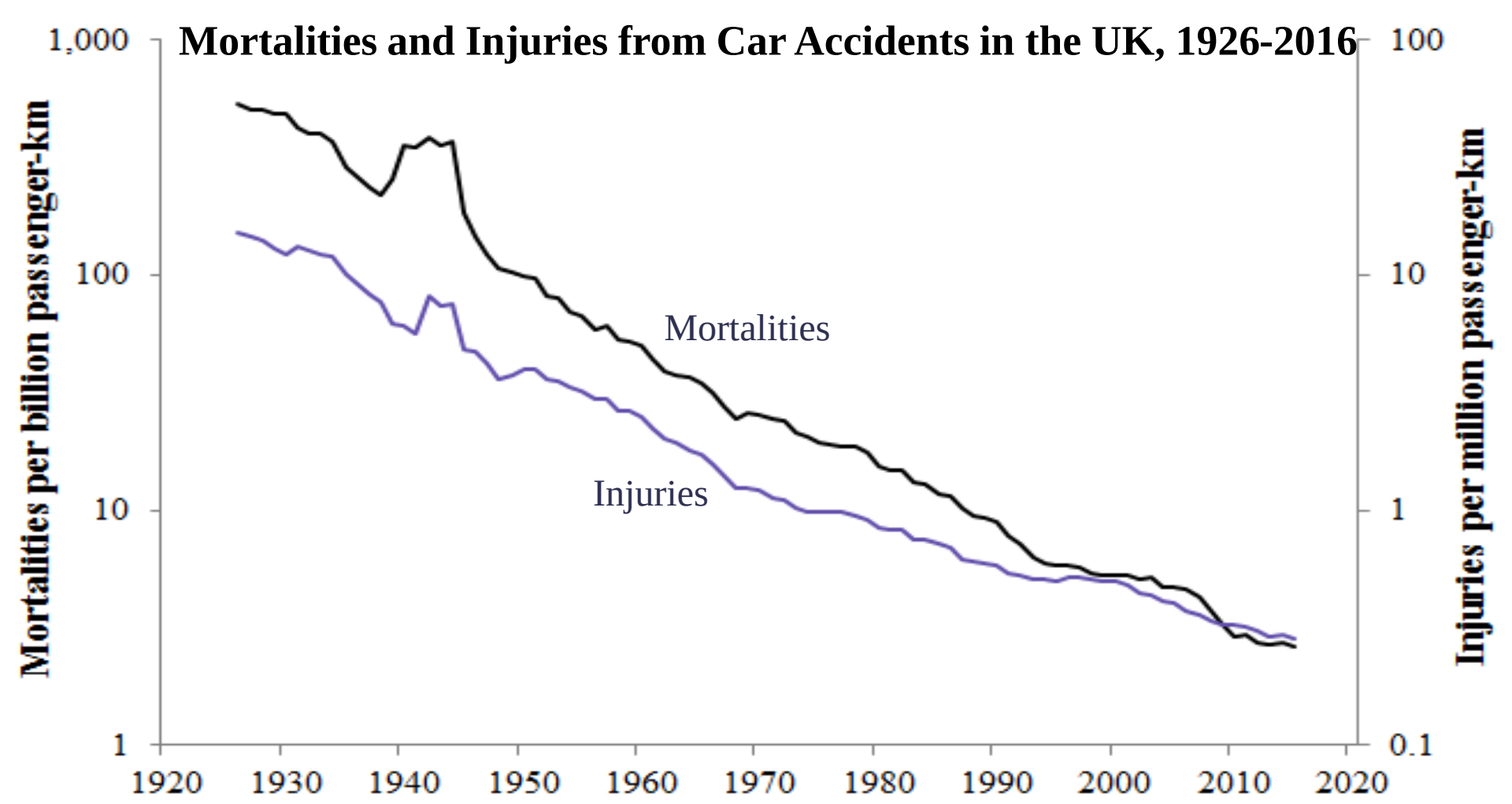
Plotting a 'Linear Approximation' of a Convex Demand Curve using a Historical Benefit Transfer



Fire Damage in the United Kingdom, 1500-1900



Source: see text



Source: DfT (2016)

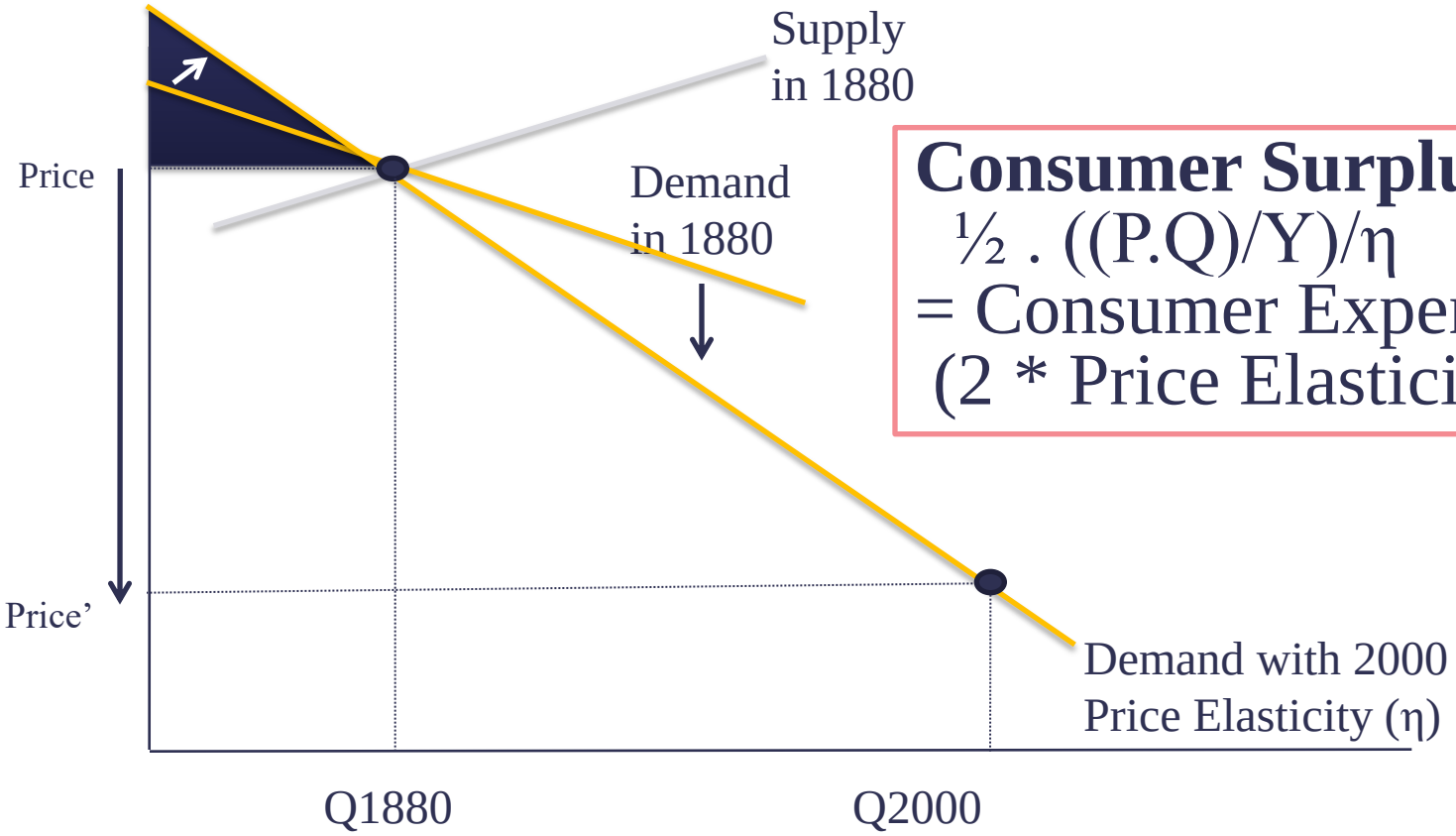
Model of Energy Service Consumption

- **Consumption of Energy Services**
  $$Q(Sjt) = f (Yt, P(EnS (P(Ent),Eff(Sjt)), ..)$$
- $LnQ(Sjt) = \beta_0 + \beta_1.LnYt + \beta_2.PEnSt + \ldots$
- **Potential Results:**

  Income El.: $\beta_1 > 0$ for Normal Service; $\beta_1 > 1$ 'Luxury' Service

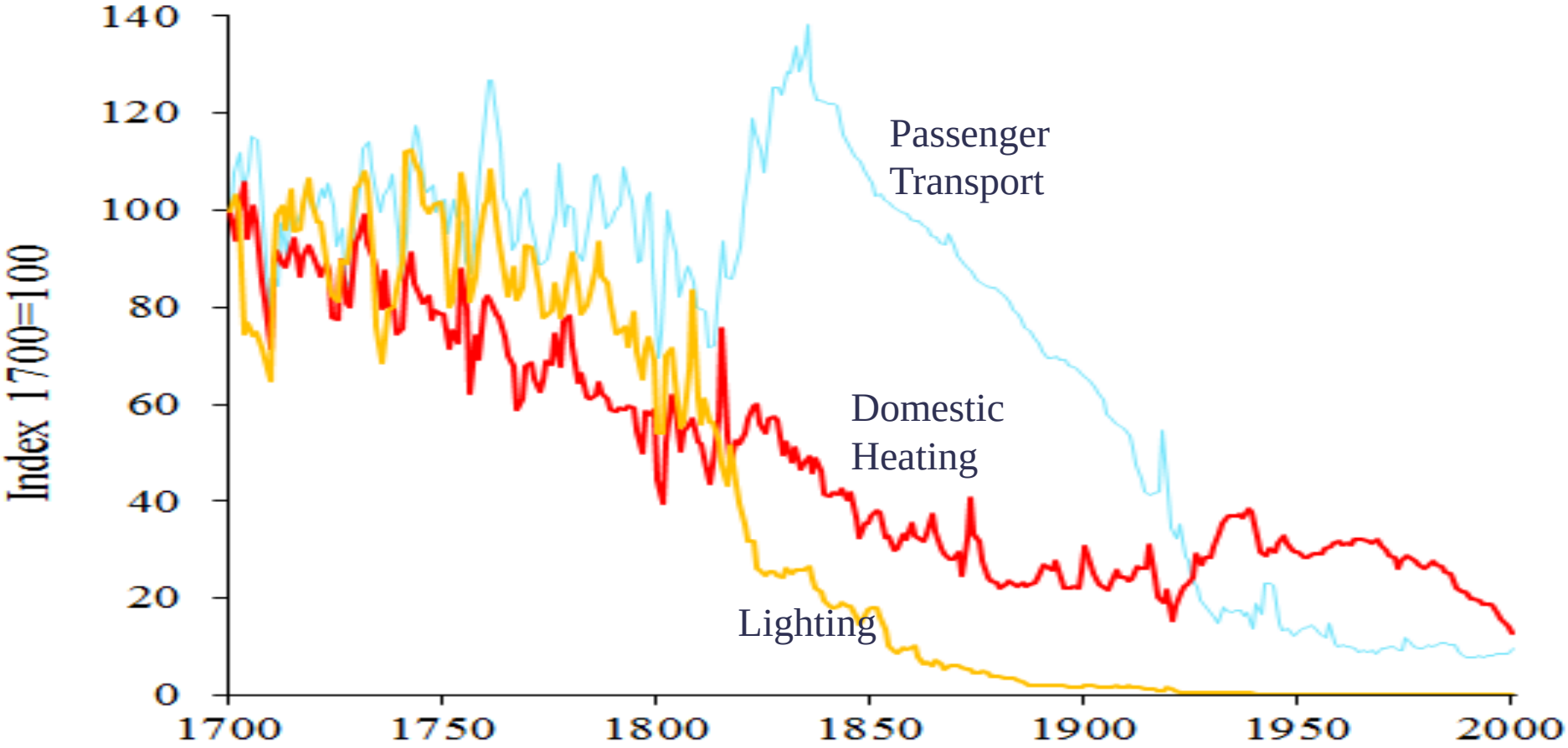
  Price El.: $\beta_2 < 0$ Dir. Rebound Effect; $\beta_2 < -1$ Rise in Energy Cons.

The Net Benefits of Energy Technologies and Services



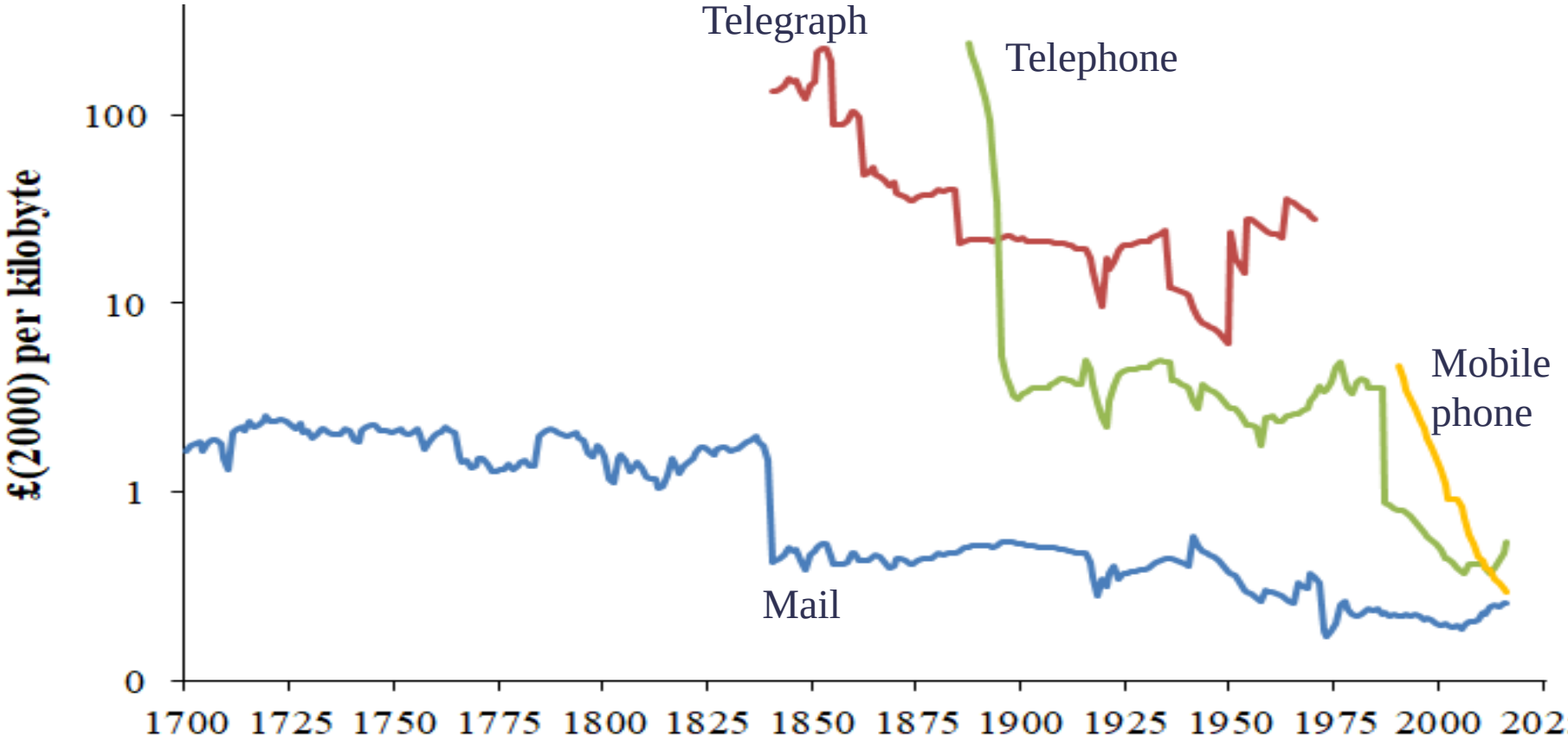
Consumer Surplus =
½ . ((P.Q)/Y)/η
= Consumer Expend./
(2 * Price Elasticity)

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

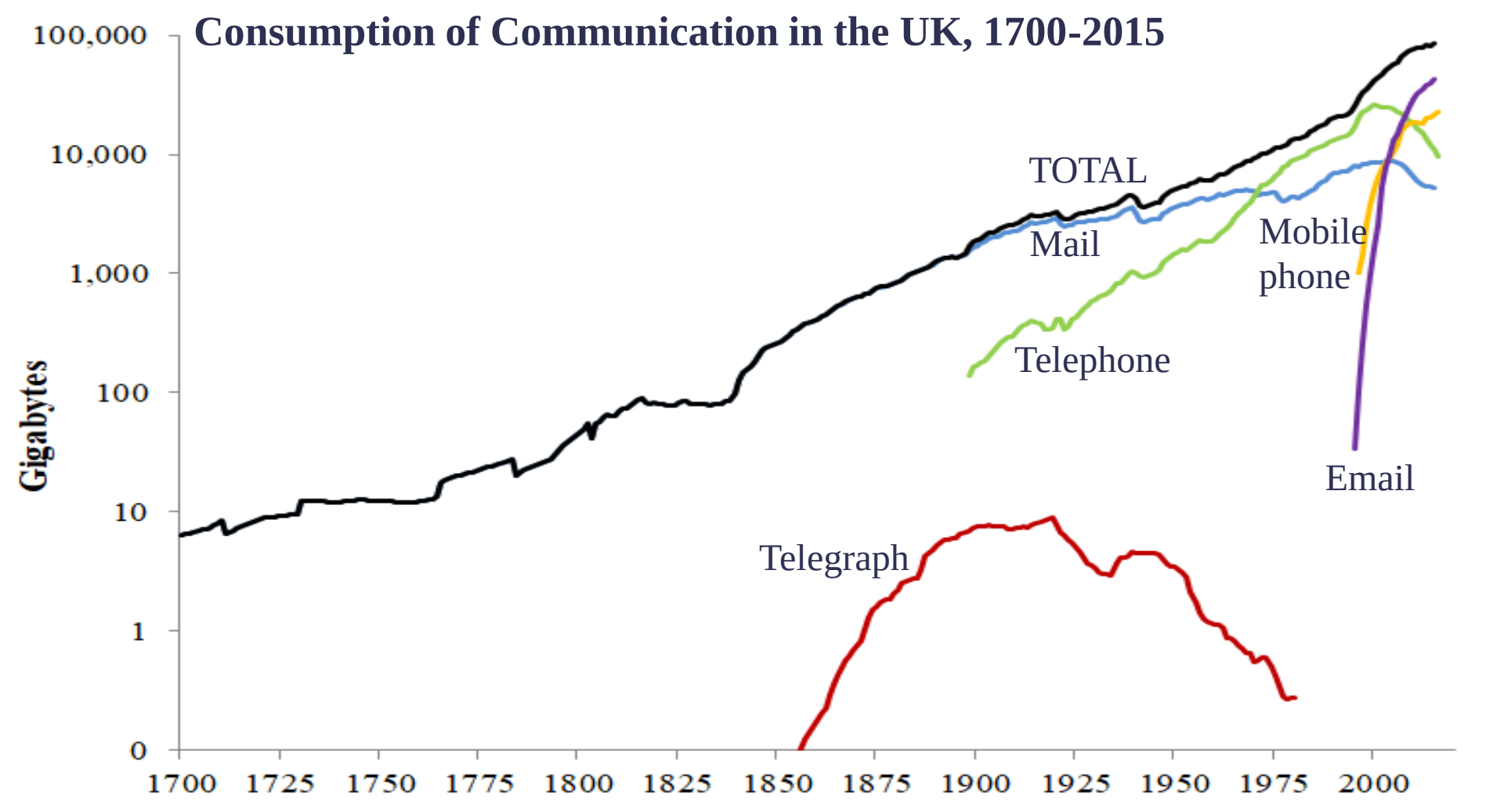


Source: Fouquet (2014)

Price of Communication Services in the United Kingdom, 1700-2015



Source: Fouquet (2014)



Source: Fouquet (2014)