

The Industrial Revolution in Theory and in History: World Economic Growth Since 10,000 BC

Gregory Clark, University of California, Davis, CA 95616
gclark@ucdavis.edu
www.econ.ucdavis.edu/faculty/gclark

Lecture 2 – The Industrial Revolution

Figures and Tables

Figure 1: Conventional Estimates of TFP Growth in the English Industrial Revolution

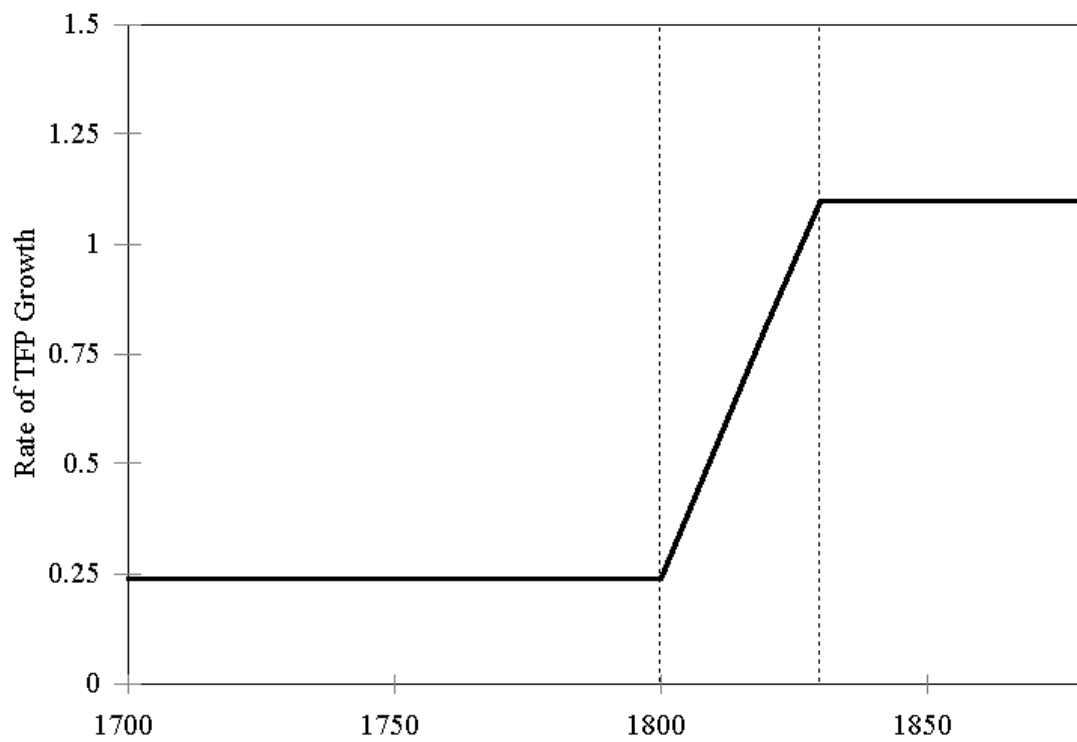


Table 1: Crafts/Harley Estimates of TFP Growth in the Industrial Revolution

Period	Output per Person Q/L (%)	Capital per Person K/L (%)	Land per Person T/L (%)	Total Factor Productivity (%)
1700-1760	0.30	0.31	-0.29	0.24
1760-1801	0.21	0.22	-0.72	0.24
1801-1831	0.45	0.36	-1.35	0.53
1831-1861	1.09	0.59	-1.42	1.10
1760-1861	0.54	0.37	-1.12	0.58

Note: Productivity growth is calculated assuming that the share of capital in national income is 35%, and the share of land is 15%, so that the share of labor is 50%.

Approaches to the Industrial Revolution

1. Appropriability of Knowledge

North and Thomas (1973), North (1981)
Jones (2001, 2002)
Lucas (2002)

2. Scale in Knowledge Production

Kremer (1990), Diamond (1997)

3. Property Rights in General

North and Weingast (1988)
Acemoglu, Johnson and Robinson (2002)
Jones (2002)

Engerman and Sokoloff (2001)

4. “Industrious Revolution”

1. Appropriability of Knowledge

Consider how the model economy would behave in the absence of property rights. In this case, innovators would be unable to earn the profits that encourage them to undertake research in the first place, so that no research would take place. With no research, no new ideas would be created, technology would be constant, and there would be no per capita growth in the economy. Broadly speaking, just such a situation prevailed in the world prior to the Industrial Revolution (Jones 2002, p. 121).

3. Property Rights in General

Over the vast course of history, the process of economic growth was sporadic and inconsistent. Because institutions such as property rights were not sufficiently developed, discoveries and inventions were infrequent. The investments in capital and skills needed to generate and apply these inventions were absent. Similar problems impoverish many nations throughout the world today (Jones, 2002, p. 196)

“The United States inherited a set of institutions – among them common law and property rights – from Great Britain. These institutions made Britain the world’s leading nation by the end of the eighteenth century....The result has been two and a half centuries of economic growth.”

Douglass North, Nobel Prize Winner,
Economics, 1993

Figure 2: Patents per Year, England, 1660-1851

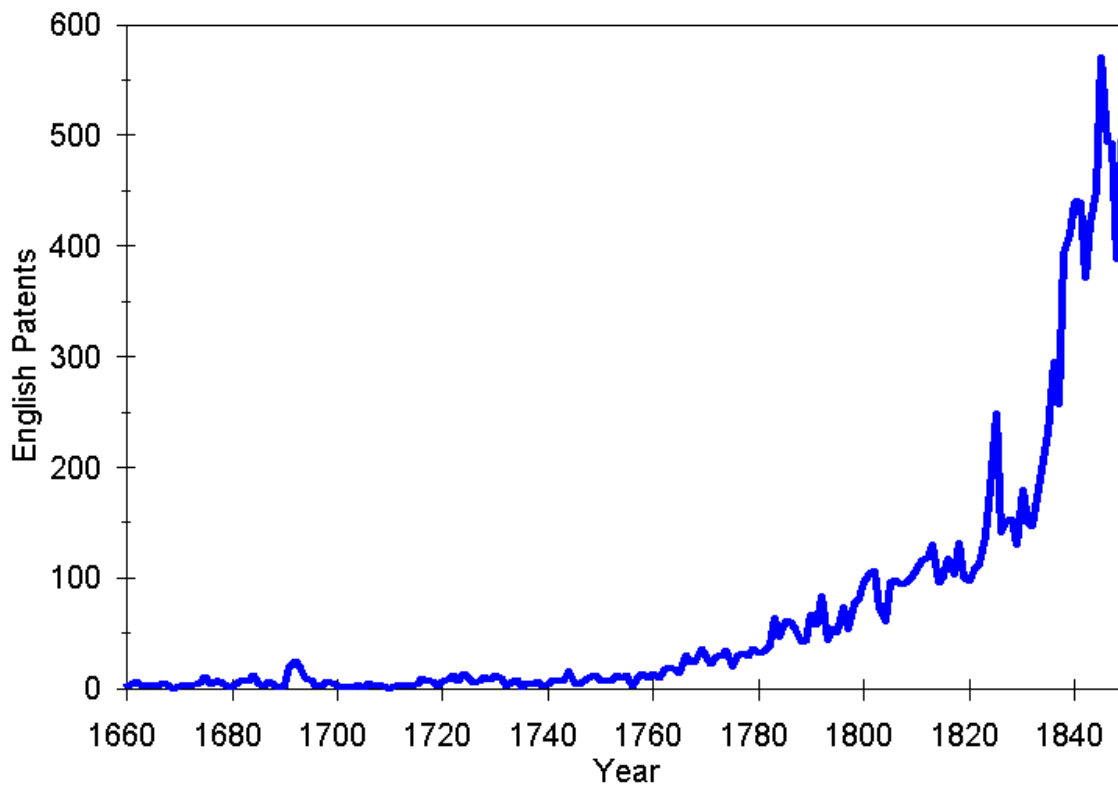


Figure 3: External Benefits from Innovation

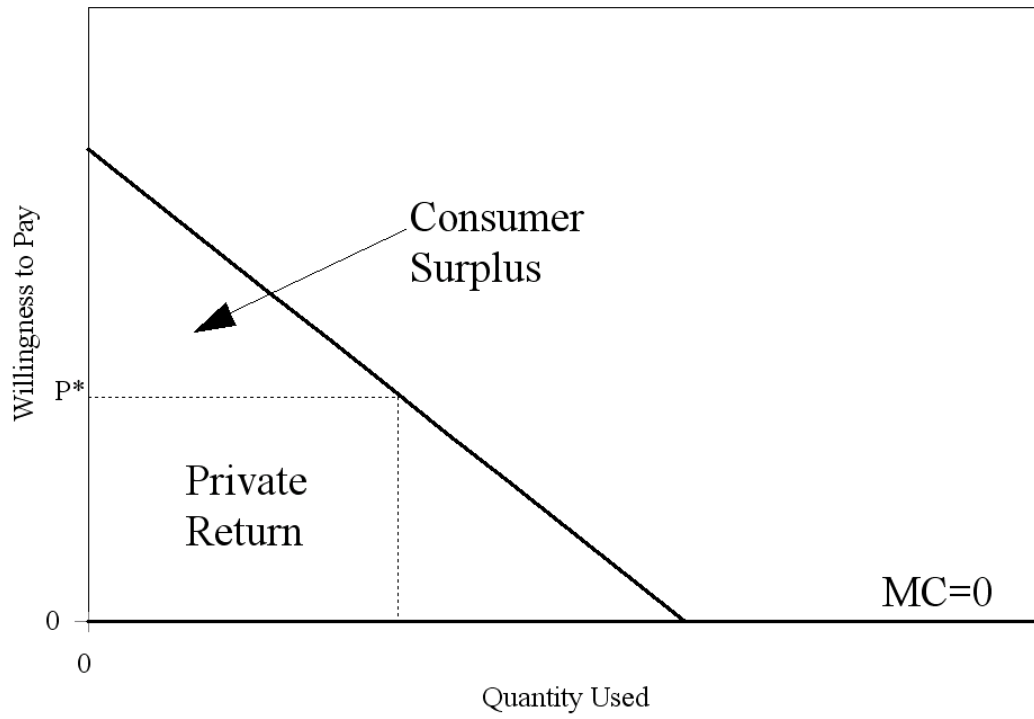


Table 2: The Rewards to Textile Innovators in the Industrial Revolution

Innovator	Device	Year	Patent?	Result
John Kay	Flying Shuttle	1733	Yes	Impoverished by litigation trying to enforce patent. House destroyed by machine breakers 1753. Died in poverty in France c. 1764
Richard Arkwright	Water Frame Carding Frame	1769	Yes	Patents invalidated by courts 1785. Most of £0.5 m. fortune at death in 1792 probably made post 1781 when patents in dispute.
James Hargreaves	Spinning Jenny	1769	No – application denied	Forced to flee by machine breakers in 1768. Died in obscurity in workhouse in 1777.
Samuel Crompton	Mule	1779	No – gave innovation to Bolton industry for £70.	Given grants of £500 by manufacturers subscription in the 1790s, and in 1811 of £5,000 by Parliament. Died subsisting on an annuity of £63 in 1827.
Reverend Edmund Cartwright	Power Loom	1785	Yes.	Machine commercial failure during life of patent. Early Manchester factory destroyed by machine breakers. Granted £10,000 by Parliament in 1809.
Eli Whitney (USA)	Cotton Gin	1793	Yes	Forced out of business by infringers by 1797 (even though granted \$50,000 by the State of Georgia). Congress refused to renew patent in 1807. Made a fortune in mass production of muskets, but never again patented any innovations.
Richard Roberts	Self-Acting Mule	1830	Yes.	Patent revenues £7,000 by 1839, compared to development costs of £12,000. Government extended patent by 7 years. Died in poverty in 1864. Daughter granted pension of £300 by Parliament.

Table 3: The Occupations of those leaving at least £0.5 m. in Britain, 1860-79

Sector	All	Share of Non-Landed (%)
New Economy		
Textiles	17	13.8
Iron and Steel	15	12.2
Coal Mining	2	1.6
Old Economy		
Manufacturing	13	10.5
Banking and Commerce	69	56.1
Law etc	7	5.7
Non-Land	123	100.0
Land	256	-
All	379	-

Source: W. D Rubinstein, Men of Property: The Very Wealthy in Britain Since the Industrial Revolution. London: Croom Helm, 1981.

Figure 4: British Military Expenditure as a Percentage of GNP

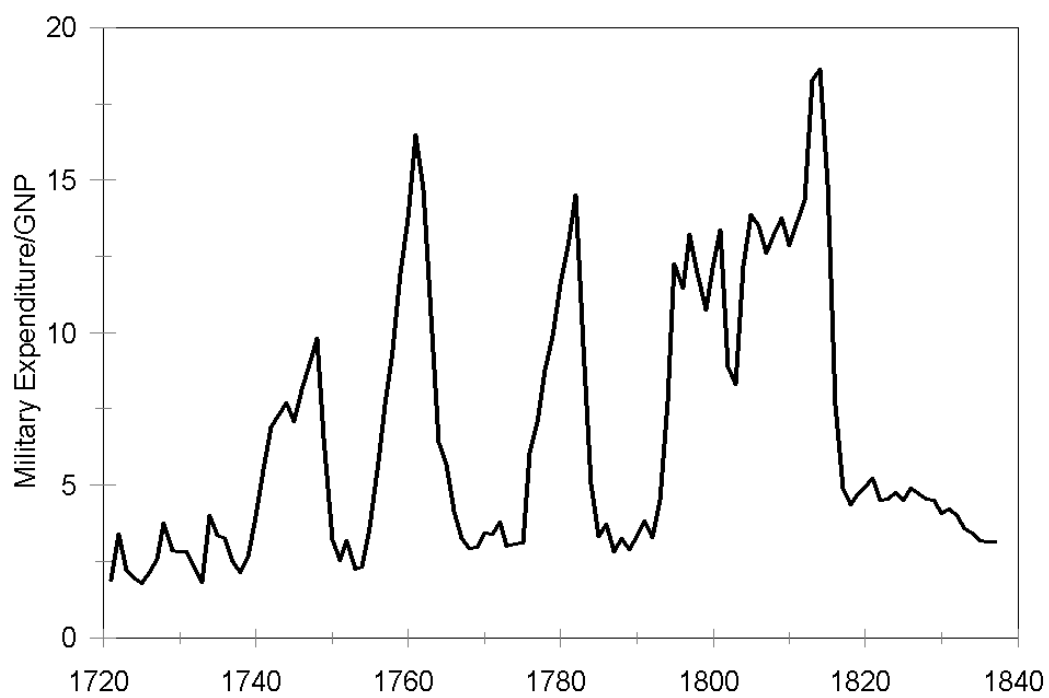


Table 4: Books as a Share of English GDP

Decade	Average annual Domestic Printed Output (pages)	Value of Output (m. £)	GDP (m. £)	Books as share of GDP (%)
1480-9	2,916,900	0.0007	(7.7)	0.01
1490-9	3,493,950	0.0009	(7.7)	0.01
1500-9	5,142,000	0.0013	7.7	0.02
1510-9	9,369,000	0.0023	7.6	0.03
1520-9	8,577,000	0.0021	8.2	0.03
1550-9	54,720,000	0.0140	13	0.11
1570-9	54,138,000	0.0138	18	0.08
1620-9	81,348,000	0.0203	44	0.05
1670-9	235,590,000	0.1048	62	0.17
1720-9	274,786,500	0.1539	72	0.21
1851	-	-	-	0.69

Notes: The share of paper making and printing in GDP in 1851 is estimated from the share of employment (weighted by gender and age) in papermaking and printing and publishing (including booksellers and bookbinders). GDP in the fifteenth century is assumed to be the same as the first decades of the sixteenth century.

Sources: Nominal GDP is from Clark (2001).

TABLE 5: AGE-REPORTING BY AURELIUS ISIDORUS

Date	Declared Age	Implied Birth Year (AD)
April 297	35	262
April 308	37	271
August 308	40	268
pre-June 309	45	264
June 309	40	269

Source: Richard Duncan-Jones, Structure and Scale in the Roman Economy (1990), p. 80.

TABLE 6: AGE-HEAPING, ROME VERSUS LATER EUROPE

Place	Index of Rounding, Z		
	All	Male	Female
Imperial Rome			
Rome	48.6	47.0	50.2
Italy outside Rome	42.2	42.6	41.8
Gaul	43.6	44.1	43.1
Africa and Numidia	51.8	51.4	52.2
Spain	57.5	56.6	58.4
Germany	39.0	57.3	20.7
Modern Europe, death records			
Geneva, 1560-1600	54.5	-	-
Geneva, 1601-1700	44.5	-	-
Geneva, 1701-1800	23.4	-	-
Liege, 1740	26.2	-	-
Paris, c. 1750	15.3	-	-
England, Poor House, 1816	23.1	-	-
England, Cotton Factory Workers, 1833	5.5	6.4	4.2

Source: Richard Duncan-Jones, Structure and Scale in the Roman Economy (1990), p. 84, 90.

Figure 5: Investment in Education in a Two Class Society

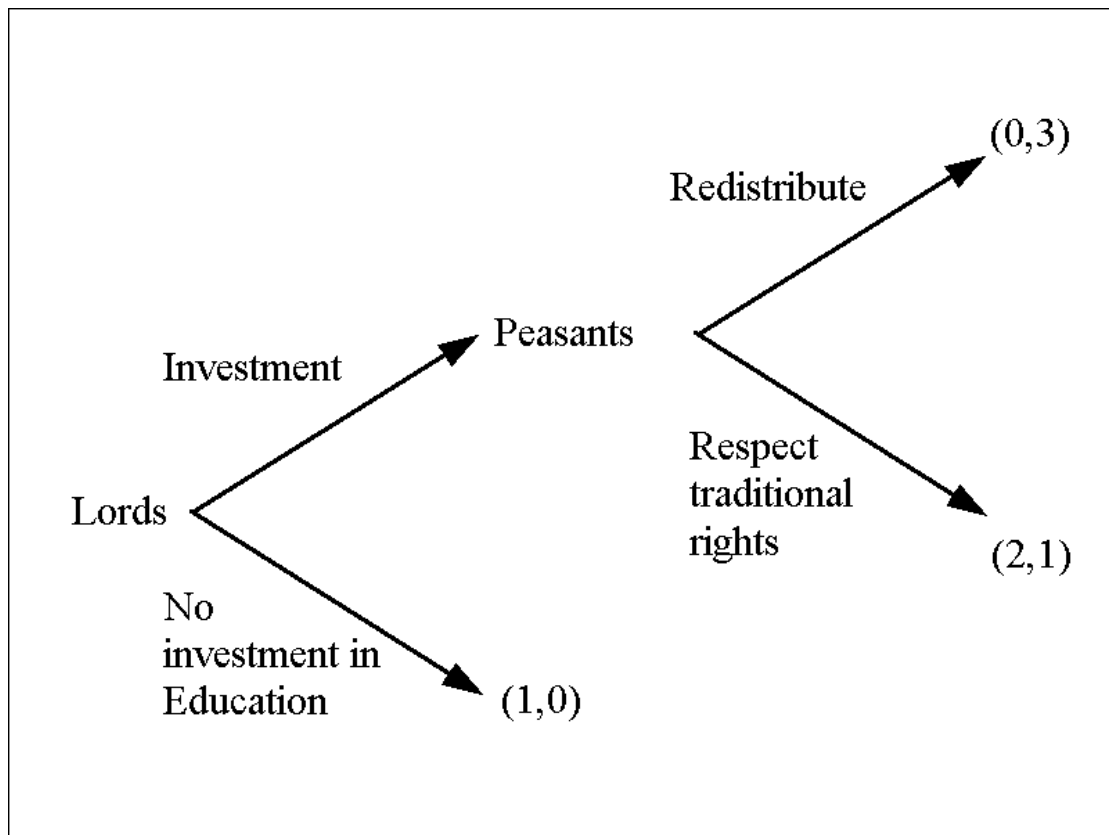


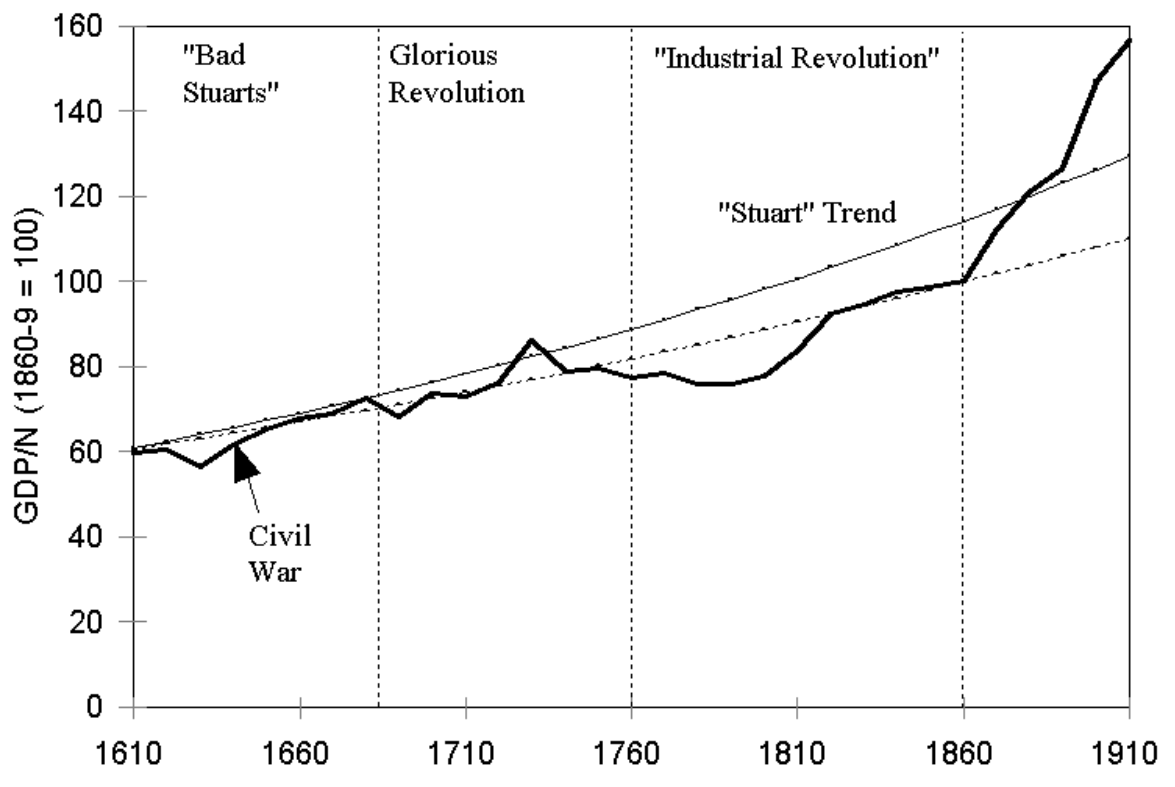
Table 7: Books, Articles with “Industrial Revolution” in the title

	Books	Articles
All	594	*1,385
Last Ten Years	91	479

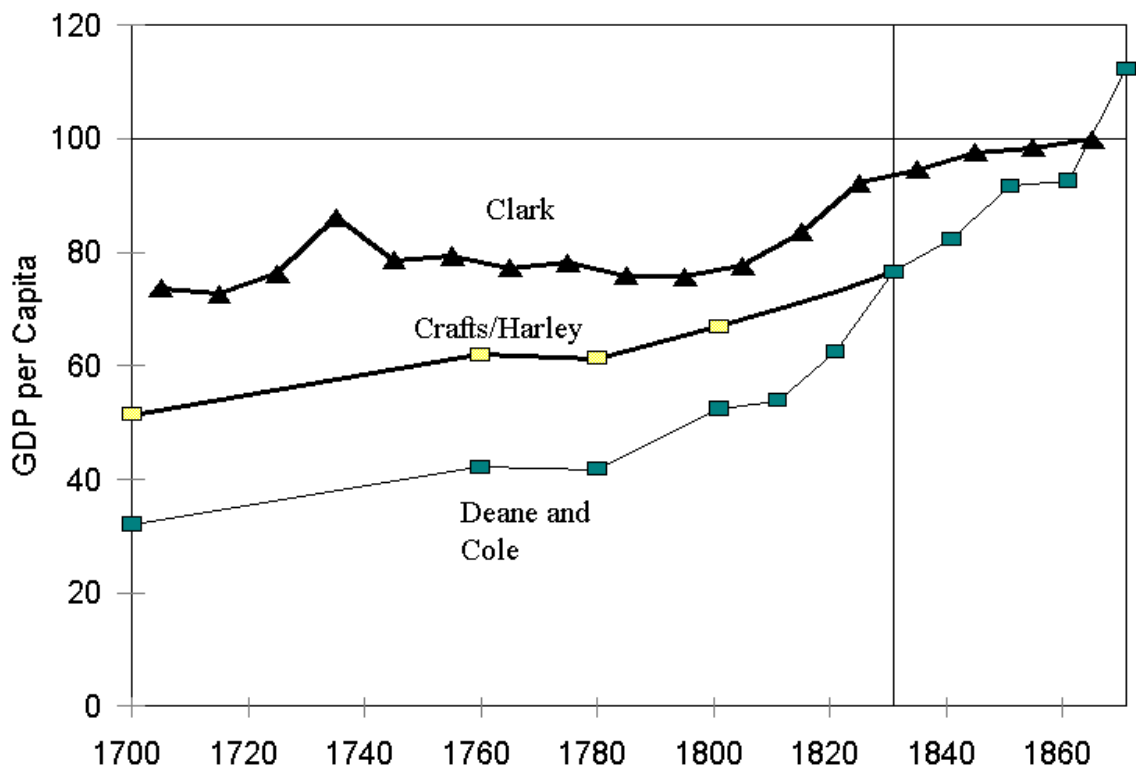
*1975-2001

- **1770 in Britain was not the great turning point in human history.**
- **An Industrial Revolution did take place but its exact date will be very hard to locate.**

Figure 6: Real GDP per Person, England, 1600-1914



**Figure 7: Real GDP per Person, England, 1700-1869 – Estimates
Compared**



Note: The Deane and Cole numbers pertain to Great Britain.

Source: Deane and Cole, British, pp. 78, 166, 170. Crafts and Harley, "Output Growth," p. 715, Crafts, British, p. 45.

Figure 8: Real GDP per Person, England, 1260-1914

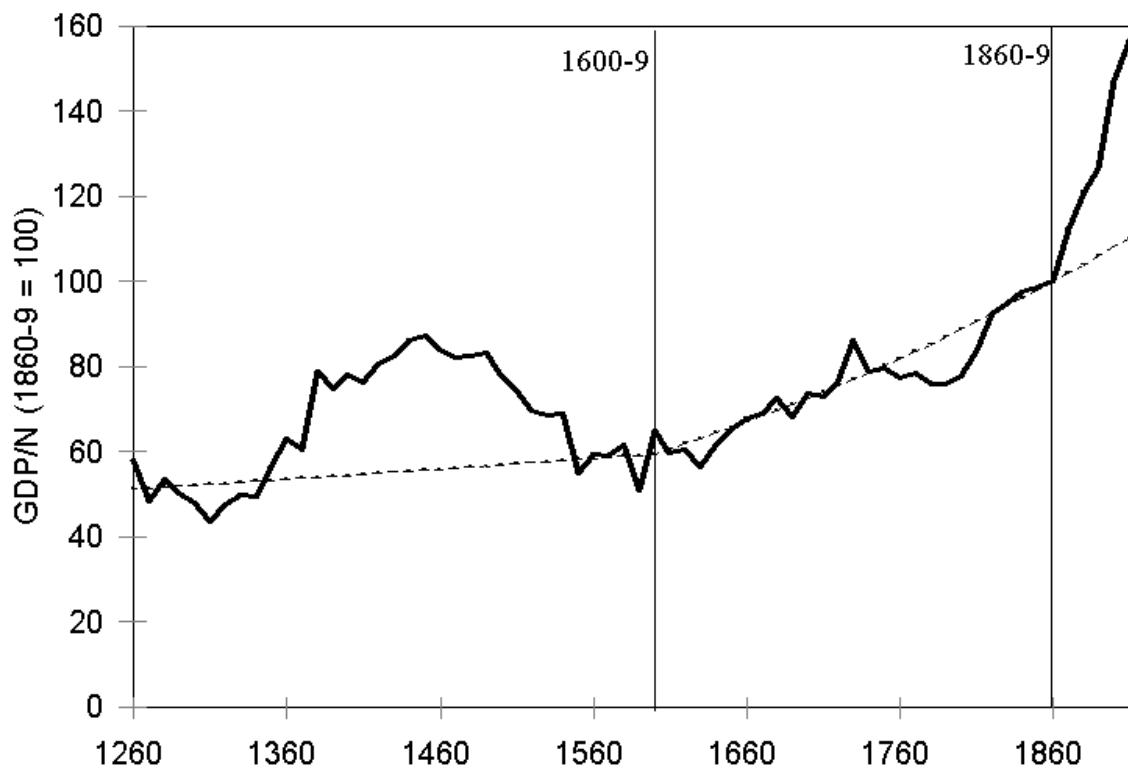


Figure 9: GDP per Capita relative to Population

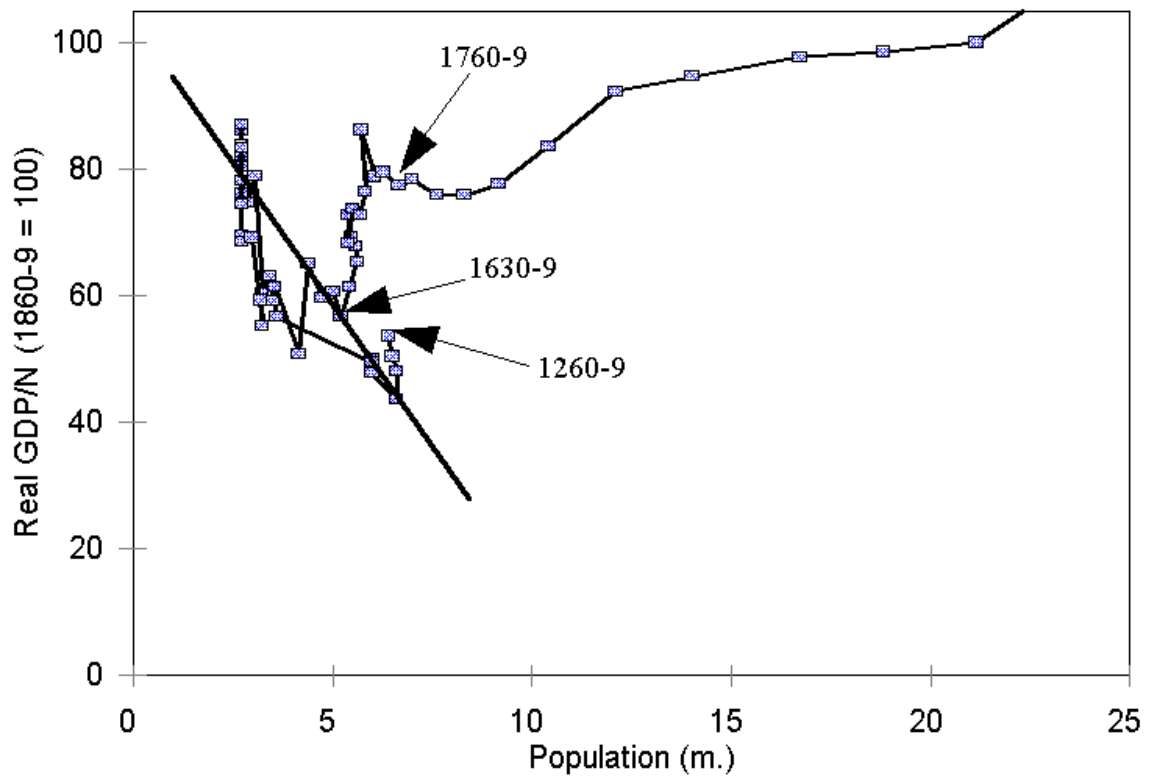


Figure 10: Overall TFP in England, 1610-1860

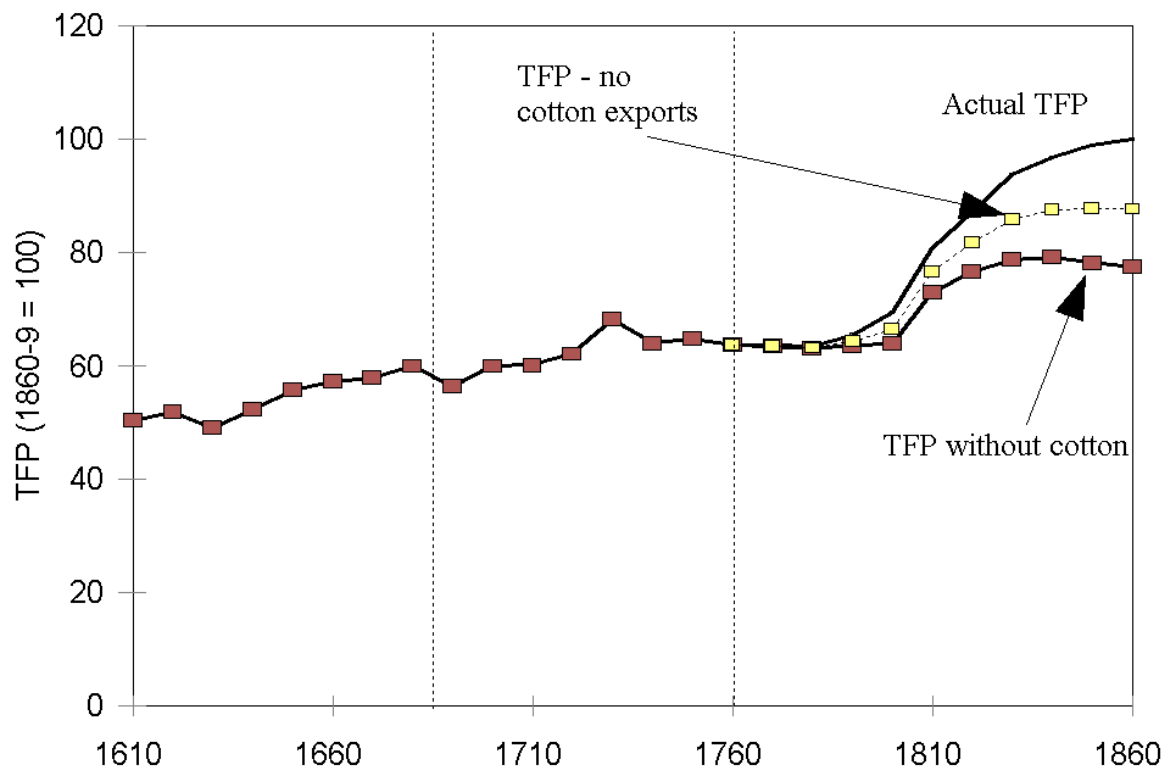


Figure 11: Cotton Spinning and Weaving Productivity, 1770-1869



Note: The squares show the decadal average productivities. The years 1862-5 were omitted because of the disruption of the cotton famine.

**Figure 12: A Young Man Knighted, from Historia Major
(Chronica Majora), 1233**

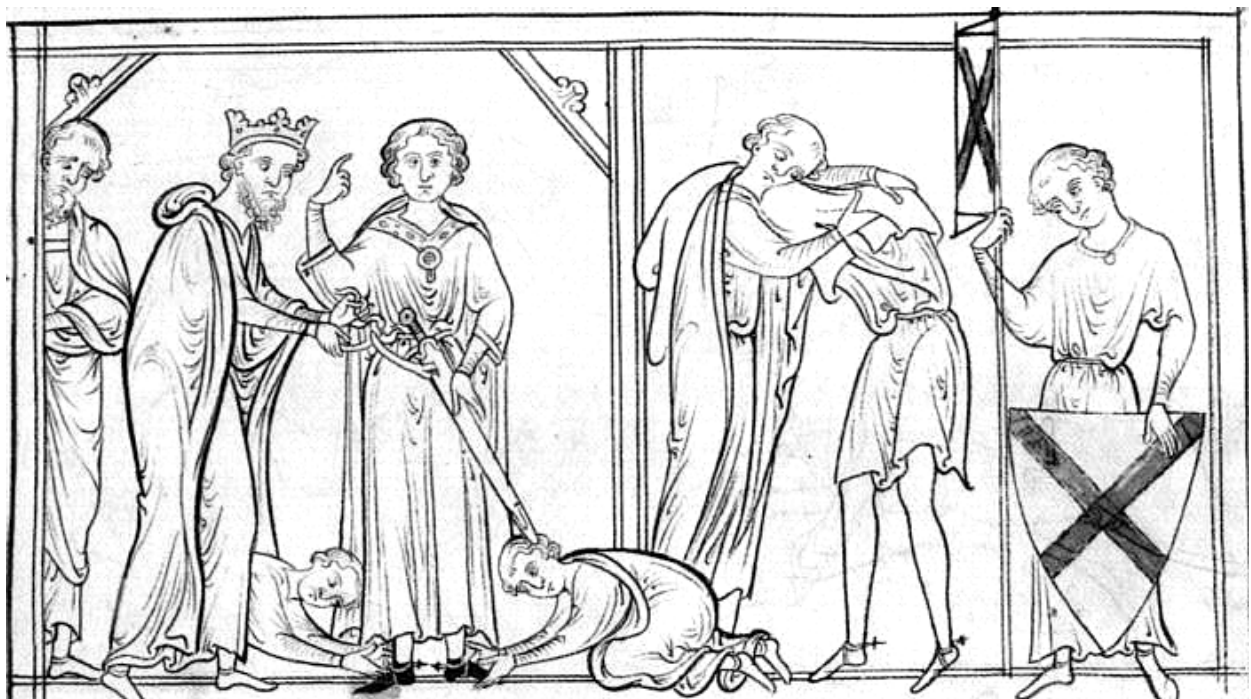
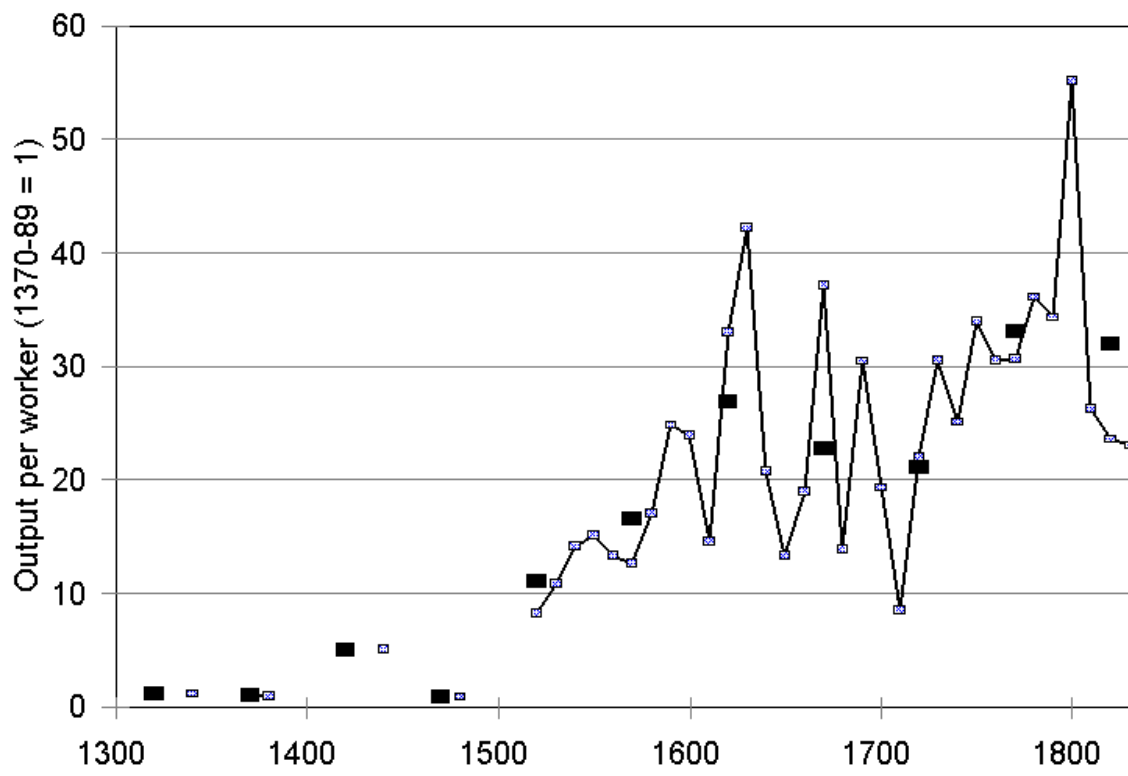


Figure 13: Portrait of Sir Thomas Kytson, 1573



Figure 14: Output per worker in printing, 1340-1839



Notes: The measure of productivity used here treats paper as a basic input. The solid squares indicate the 50 year averages of productivity.

Source: Clark and Levin (2001)

Figure 15: The Prices of Pepper and French Wine relative to Domestic Farm Products

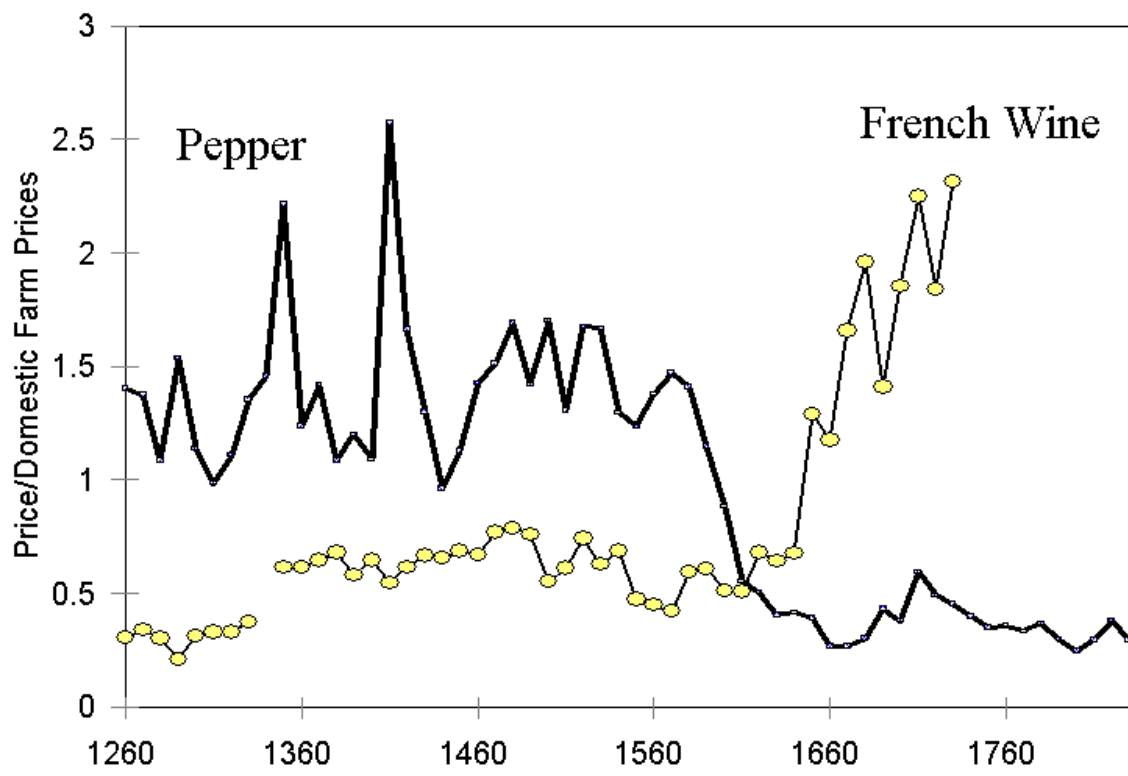


Figure 16: Population in England and Western Europe Relative to 1770-9



Note: The Rest of Europe after 1850 comprises Austria-Hungary, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, with a total population of 182 m. in the 1860s compared to 20 m. in England. The population of the equivalent area in the 1770s is estimated as 102 m. for Europe, and 7 m. for England.

**Table 8: Agricultural Consumption per Person in England, 1700s
to 1860s.**

	1700-9	1860-9
Population (millions)	5.16	19.97
English Farm net output (£ m.)	63.1	111.7
Net Food Imports (£ m.)	2.2	75.2
Net Raw Material Imports (£ m.)	-1.3	62.7
Domestic Coal Consumption (£ m.)	1.7	50.3
Total Food, Energy and Raw Material Consumption (£ m.)	65.7	309.9
Consumption per Person (£)	12.7	15.5
Predicted Consumption (£)	12.7	15.8

Notes: Cotton, wool, flax, and silk retained for home consumption are estimated by subtracting the raw material content of textile exports estimated using figures given in Deane and Cole (1962).

Sources: Coal production: Flynn (1984, p. 26) and Church (1986, pp. 19, 53, 85-97).

Imports 1860-9: Mitchell (1988). Imports 1700-9: Schumpeter (1960, tables XV, XVII).

Exports 1700-9: Schumpeter (1960, tables VII, IX, X, XII, XIII), Mitchell (1988), pp. 221-2).