The Industrial Revolution

- First Britain, 1760-1830; then continent
- British Industrial Revolution fascinating for several reasons
- First episode of sustained technical change
- More structural change than anywhere else
- Served (wrongly) as model for growth

Questions about the British Industrial Revolution

- When and where did it happen?
- How much structural change was there?
- What technology changed and why?
- What was rate of growth?
- How were the gains distributed?
- Why was Britain the first to industrialize?

Took place generation earlier in Britain, but even there localized

Per capita income (1970$)	1840	1870
Britain	567	904
Belgium		738
Denmark	402	563
Germany		579
France	392	567

How much structural change was there when Britain industrialized?

- More than in any of the continental countries
- More than in developing countries today
- The contrast is striking if we look at urbanization rates or the fraction of the labor force in industry or in agriculture or other primary sectors

Comparison at $550 (1970 $) per-capita income

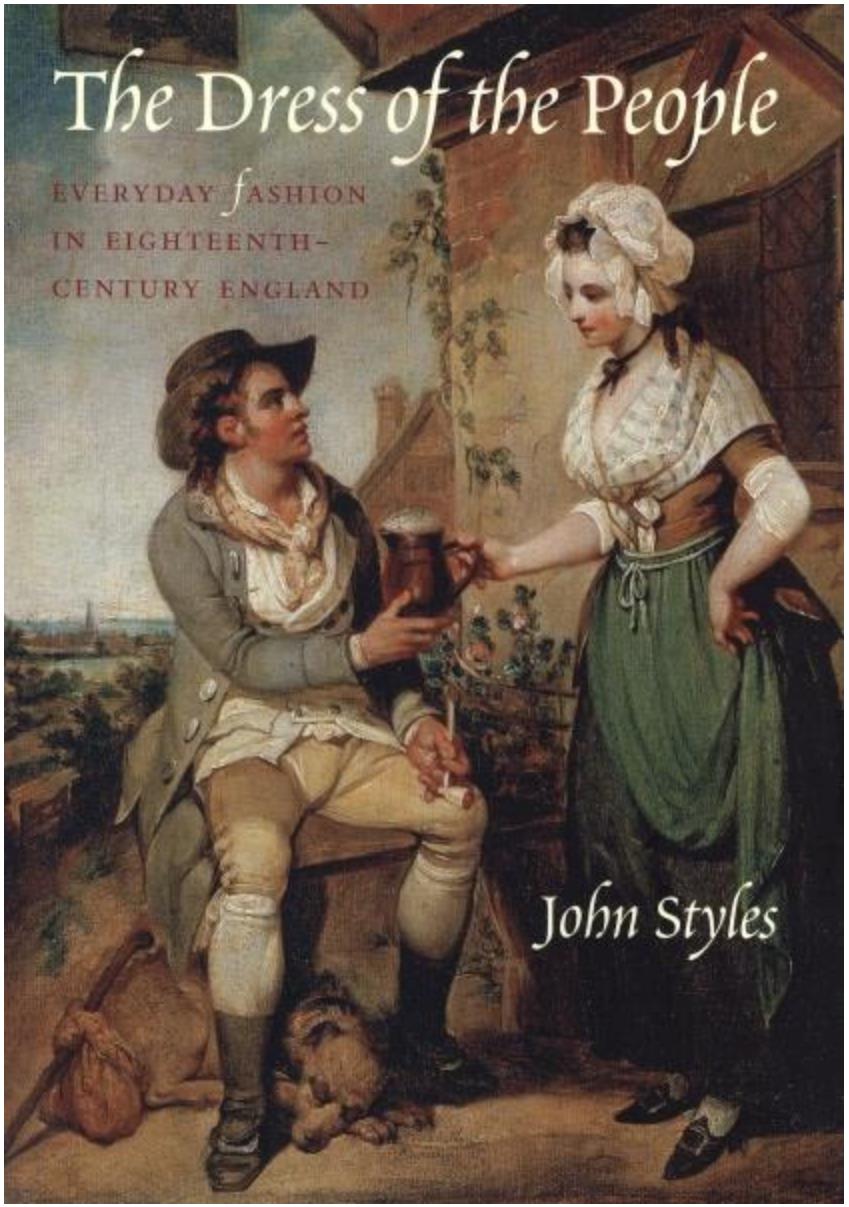
Country and year	Britain (1840)	European average	LDC's (1950-1970)
Urbanization	48.3	30.5	34.0
Labor in primary	25.0	54.6	57.3
Labor in industry	47.3	24.6	15.3
Income from industry	31.5	24.8	20.5

What technology changed?

- Wrought iron
- Steam power less important
- Above all else textiles, especially cotton
  - drastically reduced cost of clothing
  - put fashion in reach of all with printed fabrics that rivaled expensive and unwashable silk
  - idea stolen from India; popular throughout Eurasia
  - now middle class could copy the rich
  - big market and big reward for innovators

Pioneering research by John Styles

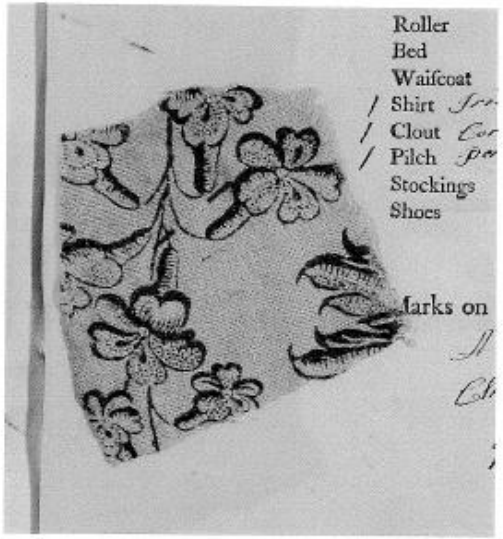
Clever use of sources and pictures

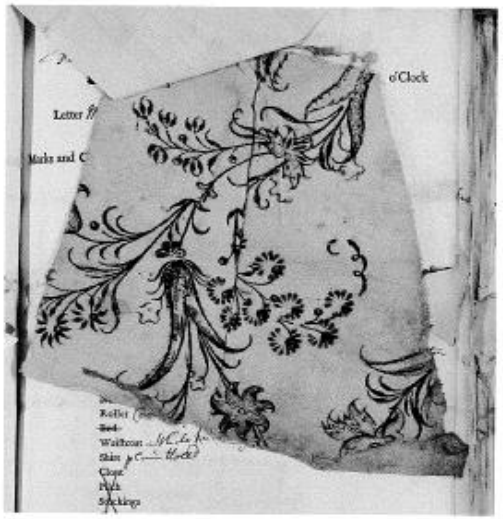


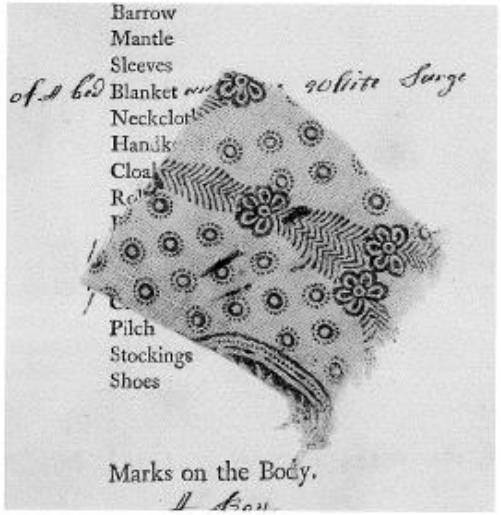
7 Henry Walton, *A Group of Figures with a Fruit Barrow*, 1779, oil on canvas, private collection. The small girl is portrayed in a straw hat with elaborate ribboning. The wealthy young woman who accompanies her is shown wearing an expensive, exquisitely laced, pink silk gown and a black silk hat with a high soft crown. Working women were often portrayed during the subsequent decade wearing cheaper versions of the same kind of hat.

Examples of printed cottons

From foundling archives







44 (*top*) 'Flowered cotten', 1759, cotton printed in purple, London Metropolitan Archives, A/FH/A/9/1/139, Foundling no. 12536.

45 (*top*) 'Flowered Lining', 1759, linen printed in blue, London Metropolitan Archives, A/FH/A/9/1/133, Foundling no. 11877.

46 (*above*) 'Flowered cotton', 1747, cotton printed in red and black, London Metropolitan Archives, A/FH/A/9/1/5, Foundling no. 374. See fig. 43 for a similar pattern on linen.

47 (*above*) 'Purpel and white flowered cotten', 1759, cotton printed in purple, London Metropolitan Archives, A/FH/A/9/1/127, Foundling no. 11337.

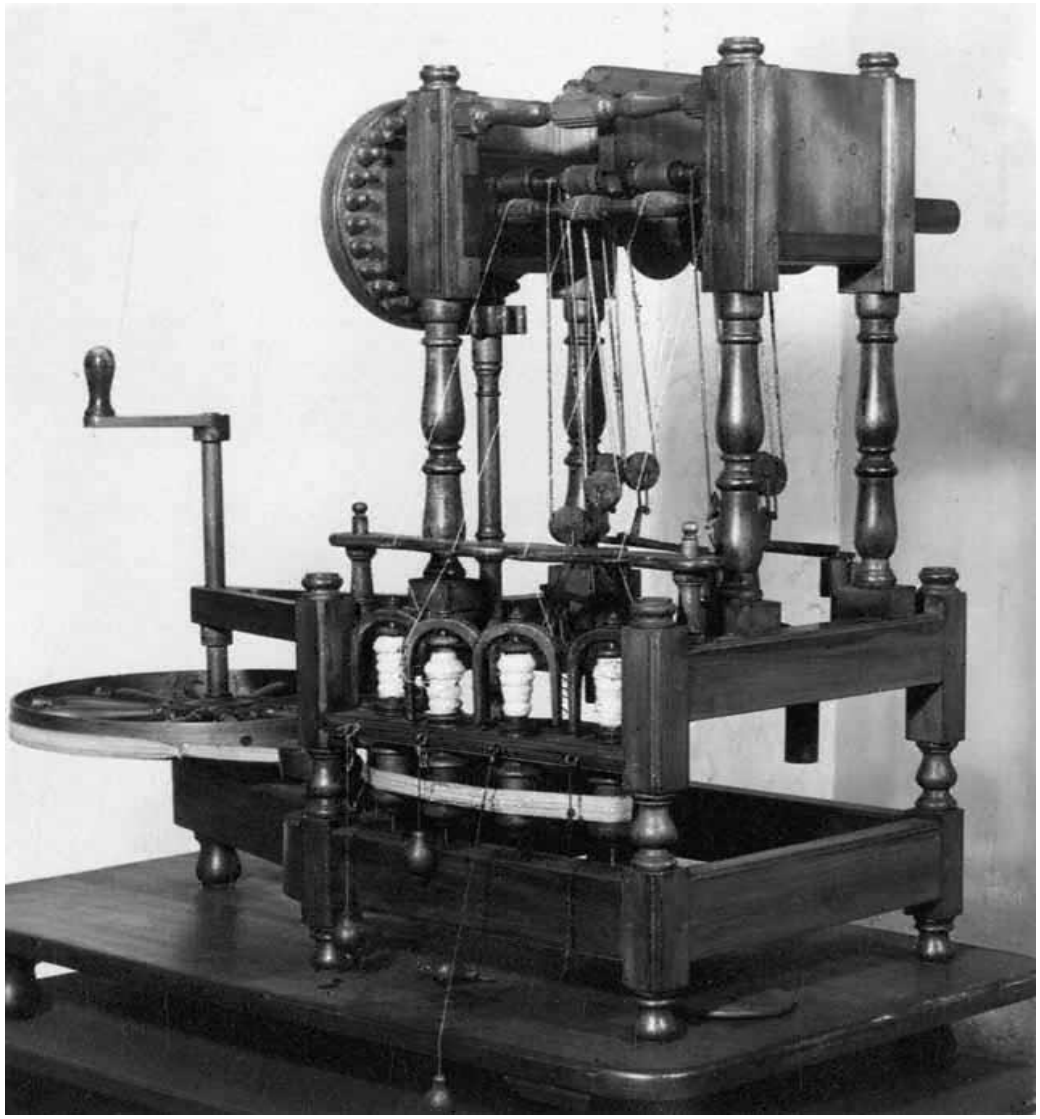
Textile inventions

- affected cotton more than wool and linen; led to first factories (“mills”)
- spinning first
  - Hargreave’s jenny 1765, Arkwright’s throstle 1769, Crompton’s mule 1779, self acting mule 1825
  - hours needed to spin 100 lbs cotton fell from 50000 (best handspinners in India) to 300 hours 1790s, to 135 hours late 1820s
  - cost of cotton drops by factor of 12 for 40 warp 1780-1825 & by factor of 4 for 18 weft 1770-1825
- weaving later: no good power looms till 1820s
- Carding, ginning mechanized; chlorine bleach replaces sun

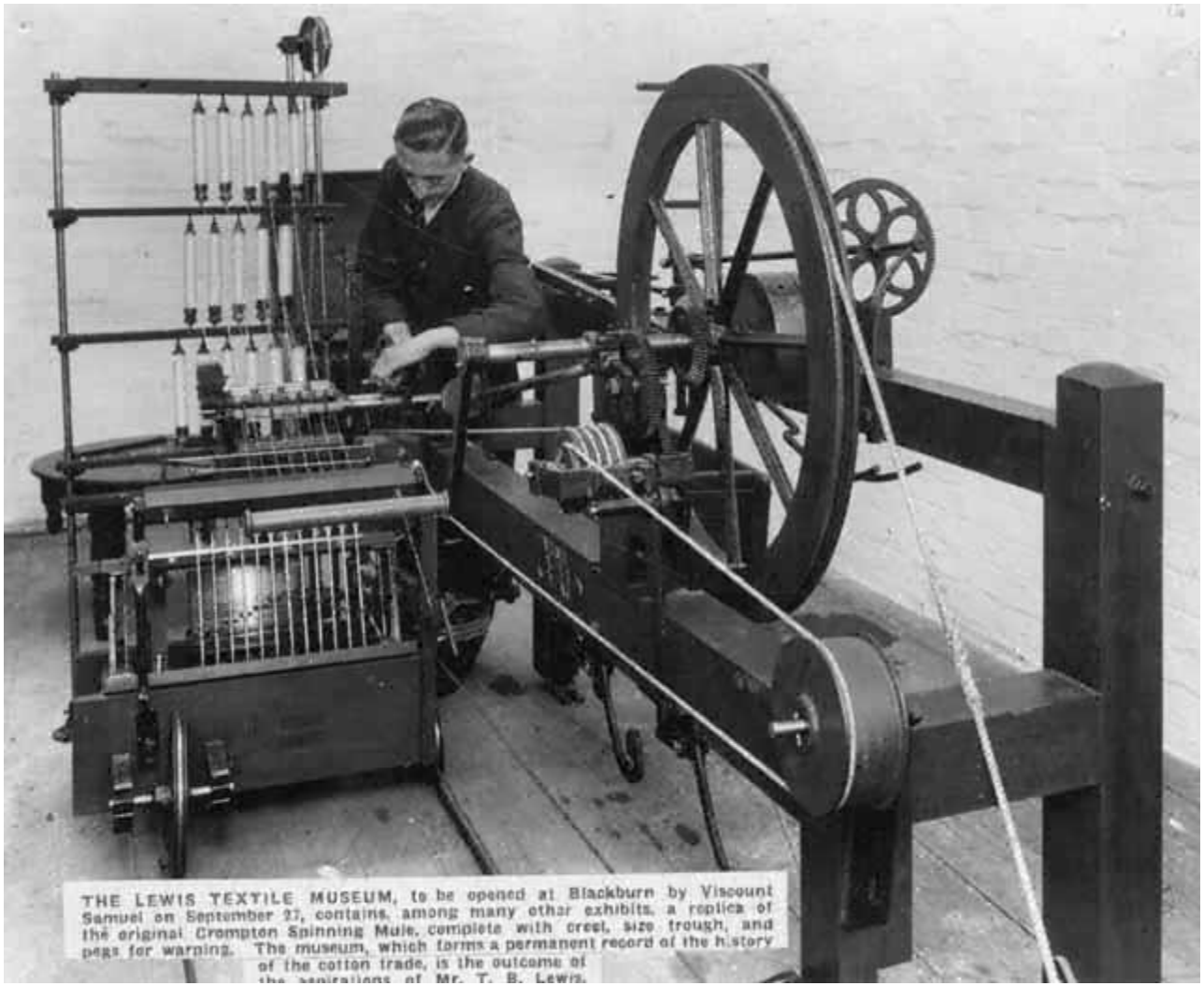
Hargreave's Spinning Jenny

Hargreaves's Jenny: Improved Model (1856)

Arkwright's Water Frame



Crompton Spinning Mule



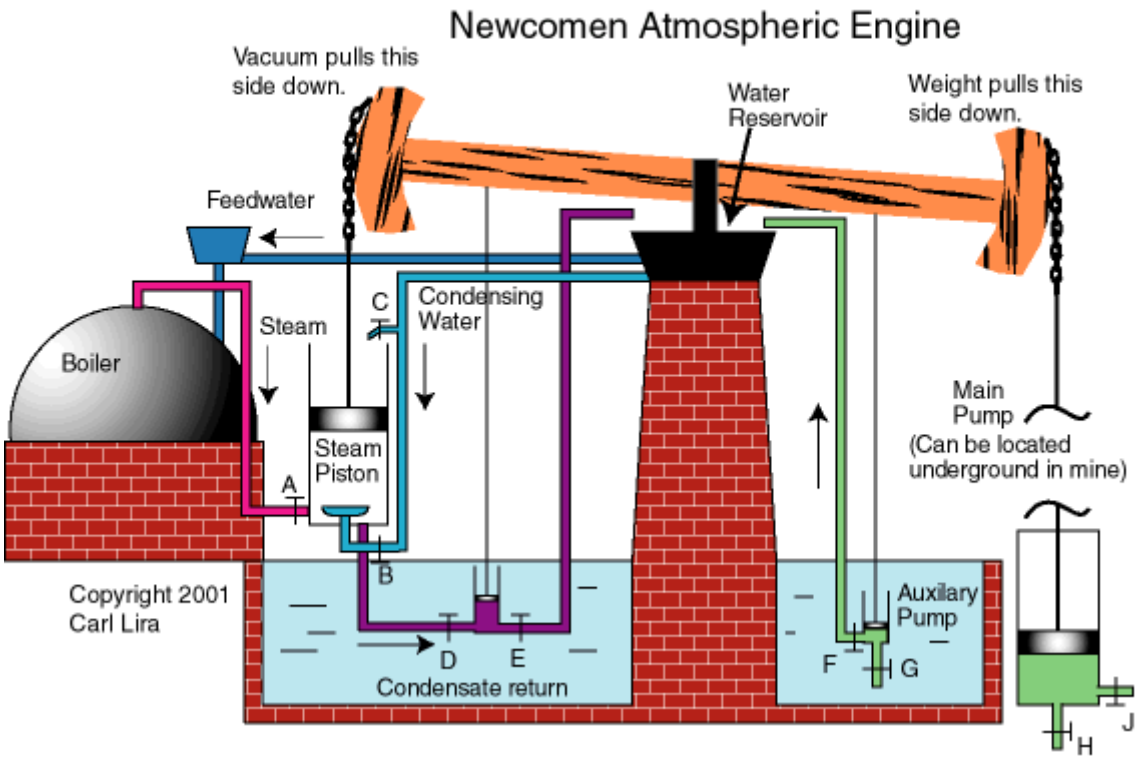
THE LEWIS TEXTILE MUSEUM, to be opened at Blackburn by Viscount Samuel on September 27, contains, among many other exhibits, a replica of the original Crompton Spinning Mule, complete with creel, size trough, and pegs for warning. The museum, which forms a permanent record of the history of the cotton trade, is the outcome of

Changes in iron industry

- Charcoal replaced by coke (purified coal) in blast furnaces; no longer need to be built near forests
- Blast furnaces improved (reuse of own gases 1828)
- refining pig iron (what blast furnace produced) into malleable and useable wrought iron improved via Cort’s puddling process 1785

Steam power

- Newcomen engine to drain mines (prototype France late 17th century; first working model Britain 1712)
- Watt's separate condenser and other improvements late 18th century; partnership with entrepreneur Boulton
- high pressure engine (after Watt's patent expires 1800) were used on locomotives by 1825
- Of some 2200 steam engines in Britain in 1800, almost half in mining/quarrying, 40% in manufacturing


Newcomen Atmospheric Engine
Vacuum pulls this side down.
Water Reservoir
Weight pulls this side down.
Feedwater
Steam
C
Condensing Water
Boiler
Steam Piston
A
B
Main Pump
(Can be located underground in mine)
Copyright 2001 Carl Lira
Auxilary Pump
D
E
F
G
Condensate return
H
J

Newcomen engine

Watt's Single Acting Steam Engine

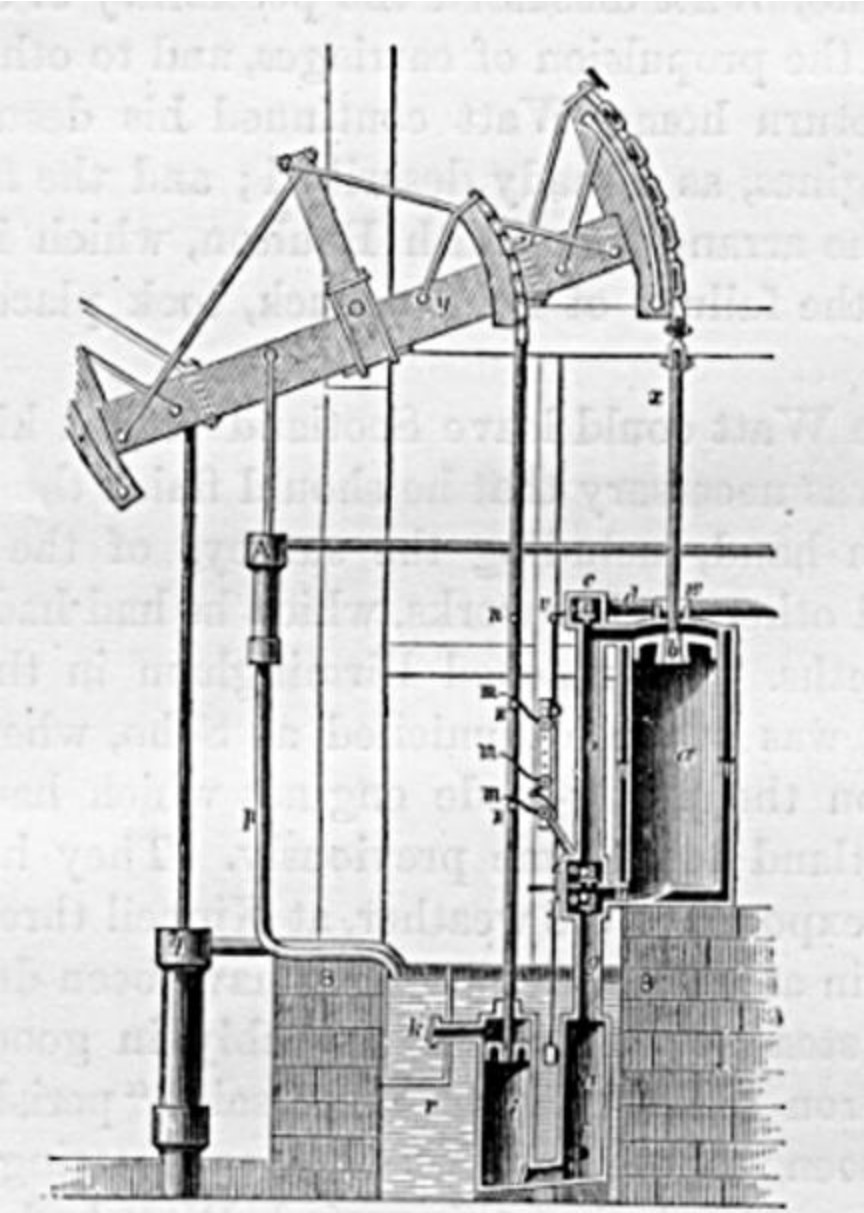


FIG. 26.—Watt's Engine, 1774.

Rate of Growth Britain

	Growth Rate (%/year) of				
Years	Y	K	L	R (land)	TFP
1700-60	0.7	0.7	0.3	0.05	0.3
1760-1800	1.0	1.0	0.8	0.2	0.2
1800-31	1.9	1.7	1.4	0.4	0.5
1831-60	2.5	2.0	1.4	0.6	1.0

Was growth even slower?

- Above calculations do not take into account increase in number of hours worked per year
  - Grew 1760-1800, as days traditionally off became working days.
  - Clever detective work (Voth) → negative TFP growth (-0.1 to -0.9%/year, 1760-1800)
    - ↑ working hours explains 20 to 100% of output growth
- But welfare might have increased
  - Shift from family production to market goods

Gains distributed unevenly until 1820

- Absolute living standards of workers stagnated until 1820, but then real wages rose
- inequality probably rose somewhat between 1750 and 1815
- life expectancy stagnated till circa 1800, though not for elite.

Why Britain first? Textiles popular through Eurasia!

- Advantages relative to rest of Europe
- Wars delay industrialization on continent
- Favorable institutions
  - Parliament and centralized tax system
    - Votes high taxes to win wars
    - Facilitates private transportation improvements
  - Better apprenticeship and patents system
- French inventions put to use in Britain—argument of revealed preference

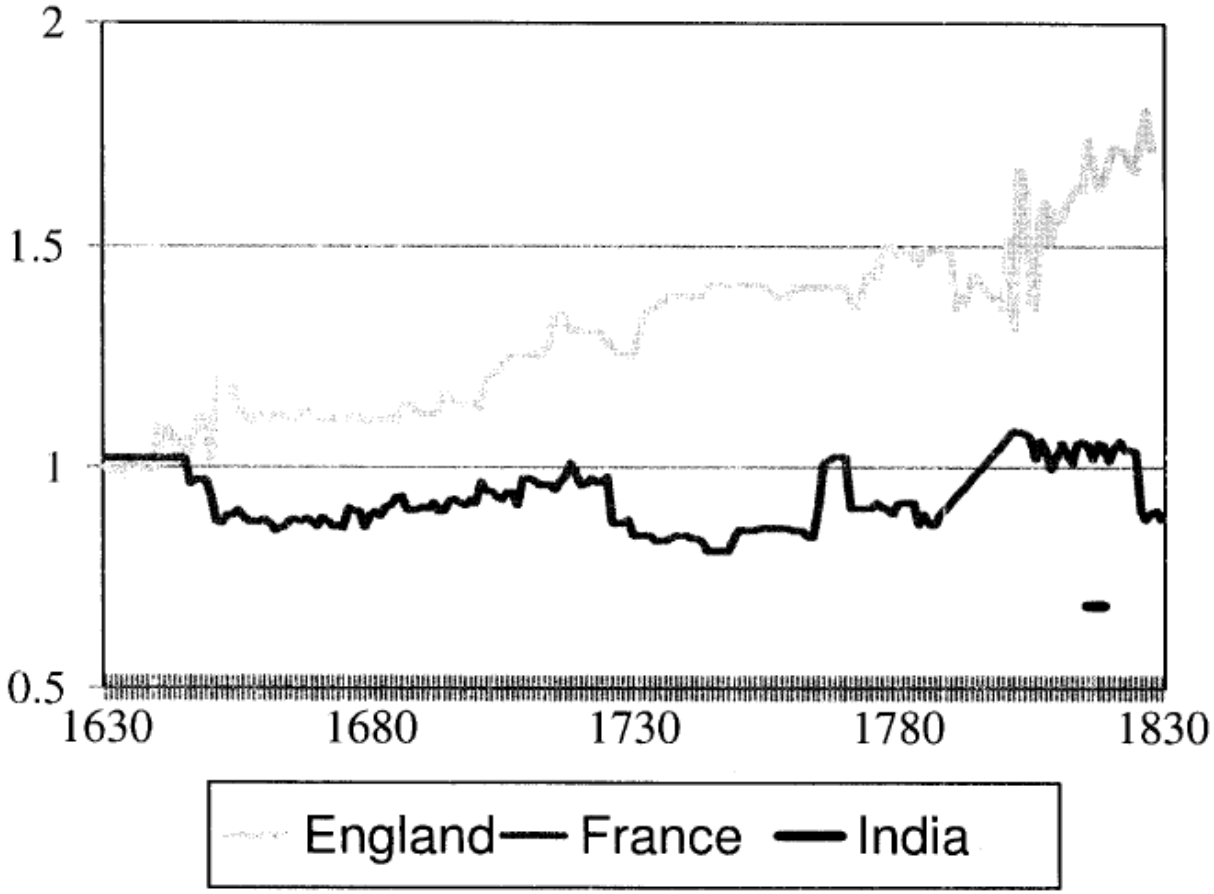
Other reasons Britain first

- Was it science?
- No, say most economic historians
- More important: clock making
  - Instruments for Scientific Revolution make England center of clock making
    - Benefits from flight of French Protestant clockmakers
  - Great expertise (human capital) in making gears
  - Very important for industrial machines (steam engine, mule)

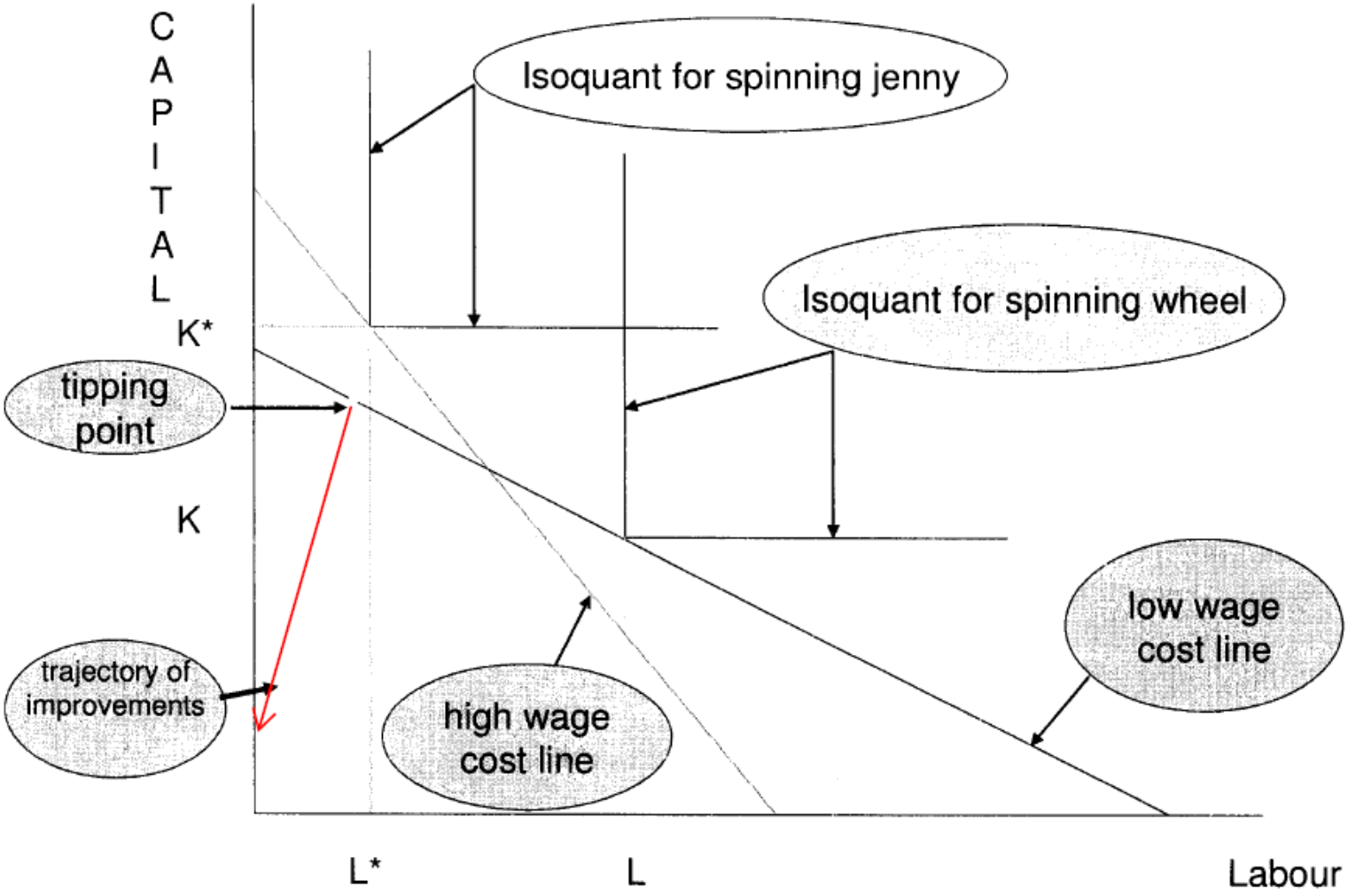
High wages make it profitable to invent and use machines (Allen)

- Wages high relative to rest of Eurasia
  - Netherlands and Belgium sole exceptions
- Relative cost of capital cheap low in England
  - Energy also cheap
  - True in Netherlands too but it had no cotton industry (R&D expenses spread over many machines in England)
- Incentive (says Allen) to
  - Substitute labor for capital
  - Do R&D which was profitable given huge market for cotton textiles
- Unprofitable to do so elsewhere

Wage Relative to Price of Capital



sources: See text.


CAPITAL
K*
K
L*
L
Labour
Isoquant for spinning jenny
Isoquant for spinning wheel
tipping point
trajectory of improvements
high wage cost line
low wage cost line

Improvements eventually allow mechanization to spread

- Note role of historical accidents
  - No cotton industry Netherlands, no land war UK
- But delayed outside western Europe, North America, and Japan?
- And why wages high in England?
  - Higher than elsewhere in Eurasia
  - Institutions and victories in trade wars?
- And is Allen's argument correct?

Problems with Allen

- Incentive to cut any cost not just labor
  - Can model focus on labor (Acemoglu)
  - But may only work with 2 inputs and obstacles replacing men with machines
- If true, unskilled should migrate to UK
  - They don't, but skilled machinists try to move from UK to France—a 3d input
- And spinning jennies are used in France
  - Use does not ↑ with conscription in France

Why did Britain keep lead for so long? Was it just high wages?

- Allen would say yes
- But was it learning by doing?
  - Think of as accumulating human capital or as a positive externality
  - Technology transfer involves this know how
  - British trainers in French mills then, US workers train foreign replacements
- British built up much more of this human capital

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- Last one still unanswered