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

<table>
<thead>
<tr>
<th>Per capita income (1970$)</th>
<th>1840</th>
<th>1870</th>
</tr>
</thead>
<tbody>
<tr>
<td>Britain</td>
<td>567</td>
<td>904</td>
</tr>
<tr>
<td>Belgium</td>
<td>738</td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>402</td>
<td>563</td>
</tr>
<tr>
<td>Germany</td>
<td>579</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>392</td>
<td>567</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Country and year</th>
<th>Britain (1840)</th>
<th>European average</th>
<th>LDC’s (1950-1970)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urbanization</td>
<td>48.3</td>
<td>30.5</td>
<td>34.0</td>
</tr>
<tr>
<td>Labor in primary</td>
<td>25.0</td>
<td>54.6</td>
<td>57.3</td>
</tr>
<tr>
<td>Labor in industry</td>
<td>47.3</td>
<td>24.6</td>
<td>15.3</td>
</tr>
<tr>
<td>Income from industry</td>
<td>31.5</td>
<td>24.8</td>
<td>20.5</td>
</tr>
</tbody>
</table>
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
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


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.

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
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 engine
## Rate of Growth Britain

<table>
<thead>
<tr>
<th>Years</th>
<th>Y</th>
<th>K</th>
<th>L</th>
<th>R (land)</th>
<th>TFP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1700-60</td>
<td>0.7</td>
<td>0.7</td>
<td>0.3</td>
<td>0.05</td>
<td>0.3</td>
</tr>
<tr>
<td>1760-1800</td>
<td>1.0</td>
<td>1.0</td>
<td>0.8</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>1800-31</td>
<td>1.9</td>
<td>1.7</td>
<td>1.4</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>1831-60</td>
<td>2.5</td>
<td>2.0</td>
<td>1.4</td>
<td>0.6</td>
<td>1.0</td>
</tr>
</tbody>
</table>
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.
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