Lecture 16: Industrial Revolutions 1: UK and the Rest

HISTORY 1130: Themes in Global History: Trade, Economy, and Empires

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A.1. Timeline of Industrial Revolutions

The First Industrial Revolution: Textiles and Steam: 1712-1830
- 1712: The Newcomen steam engine.
- 1733: John Kay invents the flying shuttle.
- 1764: James Hargreaves invents the spinning Jenny.
- 1769: Richard Arkwright patents the water frame.
- James Watt patents a series of improvements on the Newcomen engine making it more efficient.
- 1779: Samuel Crompton perfects the spinning mule.
- 1785: Edmund Cartwright patents a power loom.
- 1793: Eli Whitney patents the cotton gin.
- 1807: Robert Fulton begins steamboat service on the Hudson River.
- 1830: George Stephenson begins rail service between Liverpool and London.

The Second Industrial Revolution: Electricity and Chemicals: 1875-1905
- 1836: Samuel F. B. Morse invents the telegraph.
- 1866: Cyrus Field lays the first successful transatlantic cable.
- 1876: Alexander Graham Bell invents the telephone.
- 1879: Thomas Edison invents the indandescent light bulb.
- 1892: Rudolf Diesel patents the diesel engine.
- 1899: Guglielmo Marconi invents the wireless.
- 1903: The Wright Brothers make the first successful airplane flight.

A.2. Overview

- The combination of improving transportation and the development of large scale power sources to drive industrial machinery led to an overall economic shift towards large scale industry rather than small scale individual operations.
- Local markets gave way to factories, vast systems of continental and worldwide distribution for both industrial goods and mass-produced consumer goods.
- Parallel revolutions in agriculture (see British Agricultural Revolution)
- Cities, corporations, and individual citizens' wealth all became able to grow to sizes hitherto unknown in the history of human society.

- Many rapidly successive improvements in the technology of communications and transportation, as well as industrial production, encouraged the tremendous pace of socioeconomic change.
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A.3. Causes

The causes of the Industrial Revolution were complex and remain a topic for debate, with some historians seeing the Revolution as an outgrowth of social and institutional changes wrought by the final end of feudalism in Great Britain following the English Civil War in the 17th century. The development of international trade, creation of financial markets and accumulation of capital are also cited as a set of factors, as is the Scientific Revolution of the 17th century.


Why the Industrial Revolution occurred in Europe and not in other parts of the world, particularly China. Numerous factors have been suggested including ecology, government, and culture. Argued that non-industrial methods were efficient enough to prevent use of industrial methods in China. Kenneth Pomeranz, in the Great Divergence, argues that Europe and China were remarkably similar in 1700 (cf. Landes and Maddison), crucial differences were sources of coal near manufacturing centers and raw materials. Concept of the initial startup of the Industrial Revolution also concerns the thirty to hundred year lead the British had over the continental European countries and America. Some have stressed the importance of natural or financial resources the United Kingdom received from its many overseas colonies or that profits from the British slave trade between Africa and the Caribbean helped fuel industrial investment. (see Wallerstein for further details)
B. THEORIES OF INDUSTRIAL REVOLUTION:

B1. Technological change – extent and causes
- What is technological progress? The ability to extract more or better output from the same inputs
- There are two characteristic technological changes in Industrial revolution:
  1. Smaller inventions were much more important (Mokyr)
  2. Large sectors were completely untouched before 1830. Change was concentrated in textiles, energy and metallurgy. New techniques were concentrated to only few aspects of these sectors:

A. **Textiles** (cotton in UK). Begins with spinning jenny 1764. Continual advances. Almost every aspect was revolutionised. Printing, bleaching. Even in cotton weaving was hardly touched till 1830.
- Second was woollens industry - change is much slower. Mechanisation comes in preparation (oiling and cleaning). Finishing was also mechanised.
- Linen - competing with cotton, much more gentle treatment needed. Slow mechanisation, cotton takes over, proto-industry loses out.
- Silk - only handwork

B. **Energy** - heat into work. Introduction of steam power. Was invented 1712, very inefficient, Watt 1762 made fuel efficient. 1784 applied to textile.
- Water power was more important than steam.
- Coal - extraction remained primitive throughout the industrial revolution.

C. **Metallurgy** - shift to oak is invented in 1709, until 1760 quality was bad. This was ore into pig iron.
- Next step to rod iron, 1704 macro invention.
- Production of steel - no advances until 1830.
- Outside these very little advances - bleaching, gas lighting. Transport was not affected, shipbuilding and retailing not affected.
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James Watts’ steam engine 1769

Life during the Industrial Revolution
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Life during the Industrial Revolution
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Life during the Industrial Revolution

Daimler and Maybach in their first automobile in 1889
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An early locomotive

Thomas Alva Edison (1847-1931)

Henry Ford (1863-1947)
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Spinning Jenny 1767

B2. Theories about technological change

- There are many debates, but no good single theory accounts for these changes satisfactorily, usually though technological change a key to this transformation:

A. **The crucial inventions happened in England.** So England got ahead. Why?

B. **Individual inventive and entrepreneurial talent theory.** Entrepreneurship is unevenly distributed and very immobile. Most new economist consider straight opposite and say that it is unimportant. Cultural differences in UK: more entrepreneurial culture.

C. (rose, but only for women and some industrial groups, causation problems), education (public education was far more spread in other countries, public spending), science (education was better in US and France, they made inventions, but British adopted by micro inventions), intellectual tradition (UK is better, hard to test empirically). Overall not important?

D. : natural resources, labour, capital - more likely to use inputs if they are cheaper. Natural resources (Iron, coal) were more abundant in UK. There was very little progress in coal production. The next countries to industrialize had very few resources.

E. **Institutions:** resisting adoptions (gilds, state permits, special interest groups enjoying the prevention of innovation, gilds were already broken down in UK, so innovation supported), allocating rewards (government funding inventions, patent systems, patent system was good- rewards were there, but patents could be diffused easily), ensuring there are rewards (low tax on revolutionary industries).
C. BRITAIN AND THE INDUSTRIAL REVOLUTION

C.1: WAS THERE AN ACCELERATION OF THE GROWTH RATE IN BRITAIN DURING THE INDUSTRIAL REVOLUTION?

- Early writers on IR believed that a major discontinuity had occurred.
- Population also growing rapidly, so growth rate of national product per head less impressive.
- During 1980s, Crafts & Harley presented new evidence, growth rate slower.
- Crafts & Harley nevertheless affirm significance of IR that Britain underwent, stressing:
  (i) GB economy was able to sustain massive increase in pop without experiencing a decline in living standards. Need to consider pop & income together, not just p.c. income.
  (ii) Sharp decline in proportion of labor force in agric, & corresponding increase in share of industry to an unprecedented extent.
- The revolutionary character of this period has been debated heatedly. Most recent challenge is from Gregory Clark who maintains that the 1770s did not form a break from the previous economic regime and that a break from the earlier regime did not take place until later in the 19th century (see http://www.econ.ucdavis.edu/faculty/gclark/ and look up the Secret History of the Industrial Revolution).

In sum, there was an acceleration of the growth rate in GB during the Industrial Revolution, although this transition was much slower than thought initially by scholars in the 1950s and 1960s.

C.2: WHAT HAPPENED TO THE POPULATION IN BRITAIN AFTER 1750?

- Pop growth in GB accelerated from 0.3% p.a. during in the 17th century to 0.8% during the 18th and 19th centuries. See e.g. Table 2-24 from Maddison: there was a sharp decline in share of employment in agric in GB between 1700 & 1820 went further than in NL, & accelerated further after 1820.

C.3: HOW UNUSUAL WAS THE STRUCTURE OF THE BRITISH ECONOMY DURING THE INDUSTRIAL REVOLUTION?

- Crafts: To what extent can growth of output be explained by growth of factor inputs, & to what extent due to improvement in efficiency with which existing inputs used?
- Table 3.4 from Crafts (1994): growth accounting identity for GB during the IR. Table 3.4 suggests that acceleration of output growth in late the 18th century based on faster growth of inputs, since productivity growth declined from 0.2 to 0.1 % p.a.
- In the early 19th century, acceleration of productivity growth to 0.35 % p.a. But still bulk of increase in growth rate of output accounted for by faster input growth. Also, while NL experienced de-industrialization, labor force in industry rose to unprecedented share in GB during the 19th century. Furthermore, the productivity calculations suggest that growth of IR period had more to do with hard work and accumulation than inventiveness. Modern industrial sector still too small to have really big effect on productivity in economy as a whole.
- By 1800 agric accounted for just 36% of labor force, down from 75% in 1500. And yet GB still self-sufficient in grain & able to feed rapidly growing pop. Only during the 19th century did GB become major net importer of grain.

In sum,
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C.4: WHAT WERE THE KEY MACRO INVENTIONS OF THE INDUSTRIAL REVOLUTION?
-in GB between 1780s & 1840s:
(i) greater use of mechanically powered machinery
(ii) use of fossil fuels as source of energy
(iii) use of synthetic materials
(iv) increase in scale of enterprise
-also, elementary machines (e.g. wheel, pulley & lever) used since antiquity, & windmills & watermills also around for centuries. Nevertheless, in the 18th century England saw a sharp increase in use of water power in industries such as grain milling, textiles & metallurgy.
-Joel Mokyr calls “macro inventions” = door-opening changes that are not easy to predict from previous developments. There were also many “micro inventions”, or gap-filling changes.
-Steam engine seen as first “general purpose technology”, spreading across many sectors:

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C.5: HOW IMPORTANT WAS THE INSTITUTIONAL FRAMEWORK IN EXPLAINING BRITAIN’S RISE TO ECONOMIC LEADERSHIP?

-In the 17th century, major changes in British institutional framework, which involved temporary establishment of republic & abolition of House of Lords. Ended with Glorious Revolution of 1688, which made restored monarchy dependent for finances on House of Commons controlled by secular elite of landlords & merchants.
-North & Weingast (1989): constitutional settlement allowed government to commit credibly to upholding property rights, so stimulated market-led growth.
*Credible commitment resulted from:
(a) Parliamentary supremacy. Crown no longer had “divine right” to be above the law
(b) Parliament had central role in finance, with control over taxation & veto over expenditure
(c) Royal prerogatives (e.g. granting of monopolies) substantially curtailed & subordinated to common law
-Important that Charles I & James II both successfully dethroned. This established credible threat against future bad behavior by Crown. But also important that Parliament not in so strong a position that it could become new autocrat (Olson).
-In new institutional framework at end of the 17th century, there was modernization of administration. Professional competence increasingly relevant in public appointments, & improved statistics significant guide to policy.
C.5: HOW IMPORTANT WAS THE INSTITUTIONAL FRAMEWORK IN EXPLAINING BRITAIN’S RISE TO ECONOMIC LEADERSHIP? (cont.)

- Parliamentary Acts played important role in some key innovations from the 18th century onwards:
  (a) Enclosure could be enacted by act of parl, & this could overcome intractable bargaining problems which could prevent voluntary enclosure
  (b) Invention of turnpike trust led to significant improvements in roads
  (c) Parliamentary Acts used to permit building of canals & railways.

- GB provided considerable institutional support for technological progress. Patents provided inventors with exclusive rights to exploit their invention for fixed period (usually 25 years). This provided an incentive to innovation, although system was expensive & often ineffective at providing legal protection for innovators, so some inventors preferred secrecy.

- Private institutions also provided support for technical progress by encouraging interactions between businessmen, scientists & practical men with an interest in science & technology.

- Within new institutional framework, London emerged as Europe’s major commercial center, surpassing Paris in population by 1700 & beginning to rival Amsterdam as financial centre.

- When Bank of England founded in 1694 with legal monopoly of joint-stock banking, private bankers had to stop issuing banknotes, but continued to perform other banking tasks, e.g. taking deposits & discounting bills of exchange.

- Growing commercialization meant moving large quantities of goods around. Road building facilitated by turnpike trusts, allowed to levy tolls to finance building & maintenance of roads.

- Canal building boom in late 18th century created dense network of inland waterways, useful for moving bulky goods, e.g. grain, timber & coal. Eventually, steam engines used in transport, first to power ships (1812), then railways (1825).

- The significance of the Glorious Revolution also challenged (see Clark), how can we measure the institutions?

In sum,

D. THE SECOND INDUSTRIAL REVOLUTION

D.1. Characteristics of “first” vs. “second” industrial revolution

<table>
<thead>
<tr>
<th>First IR</th>
<th>Second IR</th>
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<tbody>
<tr>
<td>Where started</td>
<td>Multiple countries, 1860s ff.</td>
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<tr>
<td>Prominent industries</td>
<td>Steel</td>
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<td></td>
<td>Bessemer 1856</td>
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<tr>
<td></td>
<td>Siemens-Martin 1860</td>
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<tr>
<td></td>
<td>Integrated mills</td>
</tr>
<tr>
<td></td>
<td>Chemicals (incl. organic)</td>
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<tr>
<td></td>
<td>Dyes &amp; pharmaceuticals</td>
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<tr>
<td></td>
<td>Electrical equipment</td>
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<tr>
<td>Technological change</td>
<td>US: Edison, Westinghouse</td>
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<td></td>
<td>Germany: Siemens, AEG</td>
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<tr>
<td></td>
<td>Machinery</td>
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<td>Precision as well as heavy</td>
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<td></td>
<td>More science-based</td>
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<td></td>
<td>Institutionalised R&amp;D</td>
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<tr>
<td>Organisational change</td>
<td>Factory production</td>
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<td></td>
<td>Managerial capitalism</td>
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<td></td>
<td>Modern Business Enterprise</td>
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### D.2. Patterns by country

#### Britain
- Prominent industries: textiles, iron, machinery, coal
- Largest lead over other countries c. 1850-70
- Generally small family enterprises, financed by self or locally

#### Belgium
- Earliest Continental industrialization, on British pattern
- Textiles 1801ff., modern iron production 1820s ff.; coal and machinery
- Industrial finance: Innovation of investment banking
  - Société Générale de Belgique, 1822/1830

#### Germany
- Dramatic change: leading industrial country in Europe by 1914
- 1st IR on British pattern, 1830s ff.
- 2nd IR: took lead in new technologies and industries
  - Advantage in skilled labour and scientific research
  - Organic chemicals
  - Synthetic dyes developed 1860s ff., cooperation with universities
    - By 1913, 7/8 of world market!
  - Pharmaceuticals
  - Inorganic chemicals: new processes, e.g. Solvay process for soda
  - Electrical equipment: Siemens and AEG
  - Steel: new processes + large, integrated mills

#### France
- A different model
  - Slow and steady growth, vs. "revolution"
  - Less textiles, iron, coal
  - Early leader in range of other industries
  - Small-scale family enterprises, little investment banking

#### Switzerland
- Still another model
  - Build on traditional crafts, esp. clocks and watches
  - Specialty textiles
  - Precision machinery
  - Specialty chemicals / dyes
  - Food processing

#### Netherlands
- Processing of imported raw materials and foods

#### Denmark
- Industrialisation of agriculture: meat and milk products

#### Other Nordic
- Forestry products—wood and paper
- Norway: Also fishing and shipping

#### Southern and Eastern Europe
- Late to industrialise. Parts of Italy and Spain begin around 1900.

#### Imperial Russia
- Government industrialisation policy, Sergei Witte 1892-1902
D.2. Patterns by country (cont.)

Japan—only non-'Western' country to industrialise at this time
1854 opening; 1868 Meiji Restoration
Practices adopted from 'West':
French bureaucracy, Prussian army, British navy, US banking,
industrial technology from everyone
Government industrialization policy

United States
Textiles and other aspects of British model
Mechanisation of agriculture/grain harvest → exports
“American system of manufactures”
Use machines to make machines (machine tools for shaping)
Economise on scarce skilled labour
Inexpensive products for the masses, vs. fine products for elite
Guns, sewing machines, reapers, bicycles, …
Culmination in Henry Ford’s automobile assembly line, 1914
Machine tools + metal presses + assembly line

Hierarchical organization with middle management
Divisions according to product lines, marketing, R&D, etc.
Permits exploitation of economies of scale and scope
(Alfred Chandler, Visible Hand, Scale and Scope)

Five questions. Getting three right = attendance. Getting five right = automatic half a point of extra credit.
1. Prior to the Industrial Revolution, the population grew because of: [A] improvements in medical treatments. [B] a reduction in warfare. [C] the migration of Africans into Europe. [D] the introduction of rice and kale into the European diet. [E] reliable food supplies and widespread resistance to disease.
2. Which of the following is not one of the factors that gave Britain a “head start” on the Industrial Revolution? [A] it was highly commercial, and many people were involved in production and trade. [B] it had the largest merchant marine. [C] it was the world’s leading exporter of tools, guns, hardware, and other crafts. [D] it recovered from the Plague more quickly than the rest of Europe. [E] it enjoyed a high standard of living and a “fluid” society.
3. New forms of energy were important for industrialization such as:
4. What does it mean to use a “division of labor” in manufacturing? [A] Dividing work into specialized and repetitive tasks. [B] Dividing the work force into capitalists and communists. [C] Dividing the labor unions in order to weaken them. [D] Using “division” as well as other mathematical functions. [E] Having the worker make the entire product.
5. Oceangoing ships initially did not use steam power because:
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ANY QUESTIONS ON TODAY’S LECTURE?
ANYTHING ELSE?