- LECTURE -

History of Capitalism Series:

Industrialization: Why Britain Got There First

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Introduction

The term 'Industrial Revolution' is commonly used to characterize the unprecedented experience of the British economy during the later decades of the 18th and early decades of the 19th century. Taken literally, it is a misleading phrase but carefully deployed it is a useful metaphor. These years saw a remarkable economic achievement by comparison with earlier times but it must be recognized that by later standards this was in many ways a modest beginning. Moreover, the basis on which initial success was accomplished would not be sufficient to sustain leadership over the long run.

The idea of an 'industrial revolution' conjures up images of spectacular technological breakthroughs, the triumph of the factory system, rapid economic growth and the industrialization of an economy based largely on agriculture hitherto. Indeed, these were the directions of travel for the British economy but, when they are quantified, the numbers, although impressive once put into context, do not live up to the hyperbole. For several decades, while the economy withstood formidable demographic pressure much better than could have been imagined in the 17th century, the growth of real income per person was painfully slow. Not much more than a third of the labour force worked in agriculture in the mid-18th century. In 1851, more people were employed in domestic service and distribution than in textiles, metals and machine-making combined. Until about 1830 more water power was more important than steam power in British industry.

Nevertheless, the economy of the mid-19th century was established on a different trajectory from that of a hundred years earlier. In particular, sustained labour productivity growth based on steady technological progress, higher levels of investment and industrialization had become the basis of significant growth in real income per person notwithstanding rapid population growth. There had been a transition to 'modern economic growth'. That said, growth potential was still quite limited by 20th-century standards in an economy where education and

scientific capabilities were still quite primitive, the scope to import technological advances from the rest of the world was modest, and institutions and economic policies had obvious limitations.

The aim of this paper is to establish the context for British industrialization, to set out the quantitative details of the Industrial Revolution, to consider what factors were conducive to Britain becoming the first industrial nation and the 'workshop of the world', and to discuss the difficulties of explaining the acceleration of technological progress. As a postscript, some aspects of the legacy of Britain's early start are highlighted.

The Context

Three background points are important to bear in mind. First, the Industrial Revolution came after the Great Divergence. That is to say, as is reported in Table 1, well before the late 18th century income levels in North-West Europe had pulled well ahead of those in Asia and Britain was a long way beyond 'bare-bones subsistence' which is often approximated as $400 (1990GK). This relatively high income reflects several centuries of slow economic growth (with incomes growing at about 0.2 per cent per year on average). This entailed a significant expansion of international commerce, a considerable development of small-scale industry and a demographic regime which was some way removed from the worst Malthusian nightmare. Second, relatively high income levels meant that there were aspects of the economy that were favourable for subsequent economic development including an ability to mobilize substantial funds for investment when good opportunities came along and a sizeable urban population. Moreover, Britain was a high-wage economy by the standards of the time, as is shown in Table 2. Third, even so, there were important limits to growth in the pre-Industrial-Revolution British economy which was constrained by the relatively slow advance of technology which in turn made it difficult to withstand demographic pressure. A fair description of the early 18th-century economy is that population growth above about 0.5 per cent per year put significant downward pressure on real wages and thus on living standards.

The Industrial Revolution in Numbers

The period of the classic Industrial Revolution marks the transition to modern economic growth which culminated in an economy capable of sustained productivity improvements underpinned by technological advance which delivered steady increases in real GDP per person and real wages in the face of rapid population growth. This did indeed mark the end of any possibility of being caught in a 'Malthusian Trap' and was a remarkable achievement unthinkable a century earlier. That said, by later standards growth was actually quite modest as can be seen in Table 3 with real GDP growing at less than 2 per cent per year until the second quarter of the 19th century; even so the increase in GDP growth was enough to outstrip the rise in population growth to 1.4 per cent per year. TFP growth rose to a respectable but hardly

spectacular 0.7 per cent per year by this time.[1] There was no 'take-off' of the kind envisaged by Walt Rostow.[2]

By the mid-19th century, Britain was highly industrialized with 45 per cent of employment in industry (Table 4). The structure of employment had been transformed compared with Elizabethan times. However, recent research has made clear that a good deal of this switch towards industry had already occurred prior to the Industrial Revolution and that employment in mid 18th century Britain was less agricultural and more industrial than used to be thought, especially when female employment is properly taken into account. It is still entirely valid to see Britain as an outlier in the mid-19th century compared with other countries by virtue of its very low share of agricultural employment based on the disappearance of peasant agriculture and the trade of an open economy which imported a significant fraction of its food and had a strong position in manufactured exports but, although structural change speeded up during the Industrial Revolution, it was less dramatic than used to be thought.

Precocious British industrialization was the vanguard of a more general phenomenon that was the hallmark of the 19th century economic development, namely, the simultaneous industrialization of Europe coupled with the de-industrialization of Asia. The estimates reported in Table 5 show the share of China in world industrial production falling from 32.8 per cent in 1750 to 12.5 per cent in 1880 while over the same period Britain's share rose from 1.9 per cent to 22.9 per cent. This reflected not only the impact of diverging growth rates but also the long-run effects of globalization as falling transport costs allowed the so-called 'first unbundling' in which production and consumption of industrial output could take place in far distant locations. 25 per cent of British industrial output was exported in 1851 by which the economy has earned the (somewhat over the top) label of the 'workshop of the world'.

Slow TFP Growth

It may seem surprising that TFP growth was not much faster during the Industrial Revolution which was after all the time of the inventions of Richard Arkwright, Henry Cort, Samuel Crompton, George Stephenson, James Watt and ushered in the age of steam, generally thought to be one of the most important general purpose technologies ever.

Two points can be made straightaway. First, the impact of technological progress was very uneven. Most of the service sector other than transport was largely unaffected. Textiles, metals and machine-making accounted for less than a third of industrial employment – or 13.4 per cent of total employment - even in 1851, while much industrial employment was still in 'traditional' sectors. Second, the process of technological advance was characterized by many incremental improvements and learning to realize the potential of the original inventions. This

[1] TFP or total factor productivity growth is the rate of growth of output per unit of total input (in this case taking into account inputs of capital, labour and land). The increase in TFP growth reflects the growing importance of technological progress.

[2] Rostow (1960) offered a very widely read but profoundly misleading account of the Industrial Revolution as a great leap forward when in a short space of time investment surged and growth accelerated dramatically in a process dominated by leading sectors such as iron and cotton textiles.

took time in an era where scientific and technological capabilities were still very weak by later standards.

Steam power offers an excellent example. The estimates in Table 6 show that its impact on productivity growth before 1830 was trivial. In 1830, only about 165,000 horsepower were in use. The cost effectiveness and diffusion of steam power was held back by the high coal consumption of the original low-pressure engines and the move to high pressure – which benefited not only factories but railways and steam ships - was not generally accomplished until the second half of the 19th century. The science of the steam engine was not well understood and the price of steam power fell only slowly. The maximum impact of steam power on British productivity growth was delayed until the third quarter of the 19th century – nearly 100 years after James Watt's patent.

Moreover, many aspects of the British economy were still unfriendly to innovative effort. The size of markets was still very small in 1820 when globalization proper was in its infancy and real GDP in Britain was only about 1/20th its size in the United States a century later. The costs of invention were high since the contributions that scientific knowledge and formal education could make were modest. Intellectual property rights were weak since the legal protection offered by patents was doubtful until the 1830s and the cost of taking out a patent was very high until the reforms of 1852. Rent-seeking in the law, the bureaucracy, the church and the military remained a very attractive alternative to entrepreneurship as the evidence on fortunes bequeathed attests. Table 7 reports levels of investment in physical and human capital in the early 19th century which are very low by later standards. This was clearly not a time of high college enrolment and the highly educated were to be found in the old professions not science and engineering. Investment, especially on equipment, was a small proportion of GDP. This may partly reflect the modest capital requirements of the early industrial technologies but is also a symptom of the deficiencies of the capital market at a time of very restrictive company and banking legislation.

Why Britain?

It is reasonably easy to explain why Britain became a highly industrialized economy relatively early. By the eighteenth century, there was a well-established market economy based on private property rights, the rule of law, and a strong but constrained state with a sound tax base. Incomes were relatively high following a long period of successful commercial expansion and agriculture has been reorganized along capitalist landlord-tenant farmer lines which meant larger farms and fewer workers. Geography was favourable in several important respects including the availability of coal, water power, and access to the sea. There was a substantial skill base in textile trades, in mining, and in the iron industry. If new industrial technologies came along which could benefit from this kind of environment, Britain was well-placed to exploit them. Nevertheless, there were no remarkable changes in any of these factors on the eve of the Industrial Revolution.

It is much harder to explain why the first industrial revolution happened in Britain in the late 18th and early 19th centuries. The crux of the matter is to explain the acceleration in technological progress which in the first instance revolved especially around a few pivotal breakthroughs, notably in cotton textiles, which were actually quite low-level, i.e., certainly not rocket science! The problems here are three. First, it seems reasonable to suppose that the environment for invention contained favourable aspects which allowed a small probability of a key technological advance in any one year but a sizeable cumulative probability over the long run. This means that ex-ante the timing and even perhaps the location of these advances was unpredictable. Second, it might be thought that the existence of a strong demand for a new technology would stimulate a response from profit-orientated inventors but effort does not necessarily lead to achievement especially at a time when science was quite primitive - we had to wait the 20th century for the advent of effective pharmaceutical drugs – while conversely successful invention would have little economic impact when the market for it was small – think of hot-air ballooning invented in 1783 in France by the Montgolfier brothers. So the link between an environment conducive to innovative effort and arriving at the Industrial Revolution is not straightforward. Third, we might also recognize that sometimes important advances are in the terminology of Mokyr (1990) 'macro-inventions' which is to say that they do not occur in response to economic incentives but rather result from strokes of genius or luck – Abraham Darby's discovery of coke smelting in 1709 might be one such example. This introduces an element of randomness into technological progress.[3]

Notwithstanding these difficulties, the recent literature is rich in important hypotheses to explain Britain's primacy in the Industrial Revolution with notable contributions from Allen (2009) and Mokyr (2009). These offer competing but not mutually exclusive arguments – indeed there may be important complementarities between them. Allen argues that "the Industrial Revolution ....was invented in Britain in the 18th century because it paid to invent it there" (2009, p. 2). This resulted from the unusual price and wage structure that prevailed; compared with that in other countries wages were high, capital was cheap, and energy was very cheap (cf. Tables 2 and 8). It was only worth paying the high fixed costs of commercial development of good ideas where there was a potential market if the endeavour succeeded and this would only be the case if adopting the new technology made economic sense. Allen cites the spinning jenny as an important illustration of his argument since he estimates the rate of return on buying one in England in the 1770s was 38 per cent compared with 2.5 per cent in France and minus 5.2 per cent in India.

This is an appealing but not yet completely convincing argument which at this stage still requires more empirical evidence. The story is certainly more complicated than Allen's deceptively simple summary allows.[4] For example, as is shown in Table 9, it would have paid to adopt the jenny even with low French wages if the price had been as low as in England and it surely was very profitable to adopt the jenny at Philadelphia wages and prices. In England, the jenny would have been profitable at a wage rate of 3.75d a wage rate which had already

[3] When there is the promise of significant economic rewards, macro-inventions can, of course, trigger systematic attempts to build on the breakthrough which do respond to economic incentives.
[4] A more detailed and technical review of Allen (2009) and Mokyr (2009) can be found in Crafts (2011).

been attained in 1650 over a century before Hargreaves's invention, an observation which makes the point that the technological response to economic incentives might not be immediate!

Mokyr offers a different explanation, namely, that "Britain became the leader of the Industrial revolution because, more than any other European economy, it was able to take advantage of its endowment of human and physical resources thanks to the great synergy of the Enlightenment: the combination of the Baconian program in useful knowledge and the recognition that better institutions created better incentives" (2009, p. 122). What was needed to generate an industrial revolution was the right combination of useful knowledge generated by scientists, engineers and inventors to be exploited by a supply of skilled craftsmen in an institutional environment that produced the correct incentives for entrepreneurs. The Baconian program comprised research based on experimentation and scientific method, directing the research agenda to focus on solving practical problems, and making the results widely accessible by organization and dissemination of knowledge. This promoted 'micro-inventions', the continuous flow of incremental improvements that made the new technologies more effective. Mokyr acknowledges that the impact of the Enlightenment on institutions is hard to quantify but argues that the success of its ideology reduced rent-seeking and promoted competitive markets. It was manifested in terms of legislation such as the abolition of the Corn Laws but also strengthened informal institutions in the form of social norms that favoured gentlemanly capitalism rather than opportunistic behaviour.

Once again, this is an attractive hypothesis in need of stronger empirical evidence. For example, if artisanal micro-invention is important, the connections of this with the Enlightenment remain somewhat elusive and its anonymity makes quantitative investigation rather difficult. While the notion of lower access costs to knowledge as a stimulus to micro-invention during the industrial revolution is attractive this also remains to be quantified and may be the result of the spread of tacit knowledge through the factory system or urbanization rather than the availability of technical manuals or the activities of scientific societies. Similarly, Mokyr offers no quantification of the postulated improvement in formal and informal institutions which is certainly not self-evident.

Moreover, while one can point to better economic policy in terms, for example, of the abolition of the Statute of Artificers, the Bubble Act and the Usury Laws, the reform of the patent system, and the Repeal of the Corn Laws, many of these were long-delayed. And it is easy to point to major failures of government policy which might well disappoint those imbued with Enlightenment views, for example, the refusal to promote state-financed primary education despite the high social (and fiscal) rate of return it could have delivered, the incompetent regulation of the railway system that involved the construction of a seriously sub-optimal network at high cost, and the obvious shortcomings of company law even in the second half of the nineteenth century. These really seem to be the outcome of interest-group politics not the evidence-based policy design that the Enlightenment would prefer.

It is widely accepted by economic historians that the explanation for a sustained acceleration of productivity growth must come from understanding the development and subsequent incremental improvement of new technologies. A combination of the propositions made by Allen and Mokyr would produce the hypothesis that this outcome resulted from the responsiveness, which was augmented by the Enlightenment, of many individuals to the wage and price configuration that underpinned the profitability of innovative effort in the eighteenth century. At least, this comprises an attractive research agenda if not a definitive statement.

Consolidating the Lead

Early industrial advances could lead to cumulative processes that entrenched the initial lead. The classic example of this occurred in cotton textiles which was the iconic growth sector of the Industrial Revolution and which epitomized the 'first unbundling'. Britain maintained its leading position in this industry through till World War I even though the technology had become universally known and British wages were much higher than those in Asia. Yet, prior to the Industrial Revolution, cotton textiles were a British importable and in conditions of free trade the British industry could not compete with India.

Cotton textiles were extremely spatially concentrated within the United Kingdom (see Figure 1). Lancashire was home in 1850 to 66% and in 1903 to 79% of UK spindles – in both years accounting for about 46% of world spindles. The reasons for Lancashire's dominance stemmed from 'first nature geography' such as the availability of water power, the quality of farm land or the local climate, augmented by 'second nature geography', such as access to markets, the advantages of a large agglomeration, and infrastructure. Compared with the rest of the UK, the key advantages that Lancashire enjoyed included cheap coal and excellent market access.[5] These 'acquired advantages' had been developed on the back of 'original advantages' which included the availability of water power and the relative unsuitability of the area for agriculture in a not too remote location.

What made the industry stay put was a combination of sunk costs – where steam engines were installed first to complement and later to replace water power - and the emergence of a cotton textile agglomeration. Over time, as Alfred Marshall famously recognized, Lancashire became an extremely successful agglomeration which delivered major productivity benefits from a dense network of suppliers, technological spillovers, a thick labour pool, and marketing expertise. In the early 20th century, these agglomeration benefits were still fundamental to Lancashire's ability successfully to compete with the rest of Britain while paying wages that were about a third above the rest of the country, and with the rest of the world despite paying wages that were 6 times the Japanese and 9 times the Chinese level.

The obvious point is that successful agglomerations have productivity advantages that not only can allow relatively high-wage centres to thrive but are also hard to replicate elsewhere. This

[5] The common claim that a key advantage for Lancashire was its humid climate does not seem to be correct, however (Crafts and Wolf, 2014).

suggests that an important role for policy is to facilitate, or at least not to obstruct, the growth of these agglomerations. Three aspects of British economic policy in the 19th century underpinned Lancashire's success. First, the growth of Lancashire cotton towns was not constrained by land-use planning regulations; for example, the population of both Blackburn and Preston increased by a factor about 10 during the 19th century. Second, facilitated by parliamentary legislation, the development of the Lancashire cotton industry was supported by substantial private investments in the transport system both in terms of canals and then railways. Third, later 19th century investments in the provision of local public goods significantly reduced not only the health risks of working in textile towns but also the supply price of labour to the cotton mills.

The Legacy of the 'Early Start'

As the pioneer, Britain's experience of early industrialization was idiosyncratic and left a distinctive and, in some ways, difficult legacy that has implications for its later economic development. This is not the place to explore how this played out but it may be useful to point out some features of the mid 19th century economy relevant for understanding the relative economic decline that was to follow.

With regard to economic structure, the obvious starting point is that Britain was an unusually open economy, especially after the move to free trade was completed in the mid-1840s. In 1870, exports of goods and services amounted to 29.1 per cent of GDP. Britain had a very large share of world manufactured exports – 43 per cent both in 1850 and still in 1875. Britain's position in the world economy at the end of the Industrial Revolution entailed exporting a lot of manufactures, some of which would lose their comparative advantage in the 20th century, and importing a substantial amount of agricultural goods. In 1851, exports accounted for about 25 per cent of industrial gross output and imports supplied around 30 per cent of domestic consumption of agricultural produce. In turn, this configuration of trade patterns was linked to an exceptionally industrialized and non-agricultural employment structure. A long-run implication of the large weights of exporters of manufactures and of industrial workers who consumed imported food, combined with a low share of agriculture in the economy, was a political bias towards free trade.

A striking feature of the development of industry, and, especially, the export staples, during the period is that there was strong spatial concentration. This was driven in considerable part by factor endowments, notably, the availability of cheap coal which was typically found in the north rather than the south of Britain at least during the Industrial Revolution. Coal had a significant influence on industrial location until the late 19th century. Mining itself was quite heavily localized with the North and Wales representing a third of employment in 1871 rising to 40 per cent by 1911 at which point it accounted for 21 and 25 per cent of employment in these regions, respectively. Shipbuilding and textiles were also highly spatially concentrated and in the latter almost 60 per cent of employment in the sector was in the North West (cottons) and Yorkshire (woollens) in 1871 at which point 30 per cent of the North West's and 27 per cent of Yorkshire's labour force was in textiles. If globalization went into retreat and/or comparative

advantage in these activities ebbed, these regions would be exposed to substantial labour market adjustments.

It is important to recognize the importance of agglomerations both in explaining regional patterns of employment but also in underpinning competitive advantage in international trade. As a successful agglomeration, Lancashire dominated export markets far longer than a believer in the Heckscher-Ohlin theory of comparative advantage would have predicted. The advantages of agglomeration are also central to understanding London's primacy as an international capital market and supplier of internationally-traded services which is reflected in the strong contribution already made by 'invisibles' both to the balance of payments overall and in terms of significant exports of services and property income from abroad. The rise of London to become the largest capital market was driven initially by British economic and commercial success and the blows that the Napoleonic wars delivered to rivals. But its sustained dominance of international financial services was based on input-output linkages within London based on unique advantages in accessing information that accrued to the largest financial centre. The strength of successful agglomerations such as those in Lancashire and London implied 'crowding out'; it would be harder for new industries to become successful exporters.

The institutional aspects of the Industrial-Revolution economy that both mark Britain out as somewhat unusual and have implications for later growth performance relate to the trajectories on which Britain had embarked in terms of corporate governance and industrial relations which, in the 'Varieties of Capitalism' typology (Hall and Soskice, 2001), would culminate in Britain as a Liberal Market Economy rather than a Coordinated Market Economy.
Capital market arrangements evolved under the pressure of the financing requirements of industrialization. In 1860 Britain had a higher ratio of corporate capital to GDP (at least 64 per cent) than the United States, France, or Germany and probably greater than the last two countries had reached even in 1910. The underpinning for a relatively high level of corporatization and shareholding was not only the legislation of the 1850s which allowed joint-stock limited liability companies but also the availability of a wide menu of corporate forms. Banks were relatively unimportant as delegated monitors and Britain was slow to develop investment banking, as might be expected in an economy that was rich by the standards of the time with low interest rates, high levels of private wealth and fairly competitive credit markets. There is a considerable contrast with the way in which capital markets would subsequently develop in Germany which came to rely much more on bank than equity finance and indeed on banks that exercised a significant role in control and monitoring of firms. Once the two finance systems had been established in the context of different initial conditions in terms of the supply of credit, path dependence was not surprising. The long-term implication for corporate governance was a much greater separation of ownership and control in Britain than in other countries and there were already clear signs of this by the late 19th century.
Britain's relatively small but productive agricultural sector based on capitalist farming reflected the long-standing importance of the market economy. Guilds were relatively weak in Britain and had already lost much of their ability to extract rents, enforce apprenticeships and impede the flexibility of production by the early 18th century. These institutional arrangements

contributed to the emergence of the relatively high incomes which underpinned the incentives to invent industrial-revolution technology but also put Britain on an institutional trajectory leading towards the Liberal Market Economy. The implications were a propensity towards craft unionism based on organization of skilled workers and an absence of strong business associations linked to political parties. In turn, this meant an absence of pressure for proportional representation in the electoral system. When the franchise became more democratic, the median voter was a skilled worker. Competition for his vote was pursued by both Conservative and Liberal governments which established through the Acts of 1875 and 1906 substantial legal privileges for trade unions whose strategies were to maximize their bargaining power with employers by controlling the supply of skills and content of jobs. The long-term result would see 20th century Britain with an industrial relations system based on strong but decentralized collective bargaining.

Not only were the factors conducive to the First Industrial Revolution essentially transitory but the manner in which it was achieved was not a basis on which long-run leadership could be maintained. Indeed, in some ways early success may have made subsequent economic advance more difficult. In the words of Joel Mokyr, "To the Victorians, Britain's leadership seemed like a natural outcome...To the economic historian, it has become increasingly clear that Britain's leadership in the Industrial Revolution was only temporary" (2009, p. 478).

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Table 1. Real GDP/Person, 1086-1850 ($1990GK)

	England/ Great Britain	*Holland/ Netherlands*	*Italy*	*China*
1086	754			1244
1348	777	876	1376	
1400	1090	1245	1601	948
1500	1114	1483	1403	909
1600	1123	2372	1244	852
1650	1100	2171	1271	
1700	1630/1563	2403	1350	843
1750	1710	2440	1403	737
1800	2080	2617/1752	1244	639
1850	2997	2397	1350	600

Source: Broadberry (2013)

Table 2. Silver Wages, 1650-1849 (grams/day)

	Southern England	*Antwerp*	*Strasbourg*	*China Yanszi*	*India*
1650-99	5.6	7.1	3.1		1.4
1700-49	7.0	6.9	2.9		1.5
1750-99	8.3	6.9	3.3	1.7	1.2
1800-49	14.6	7.7	8.1	1.7	1.8

Sources: Allen (2001); Broadberry and Gupta (2006)

Table 3. Growth during the British Industrial Revolution (% per year)

	Real GDP	*Population*	*Real GDP/Person*	*TFP*
1760-1800	1.2	0.8	0.4	0.4
1800-1830	1.7	1.4	0.3	0.4
1830-1860	2.3	1.4	0.9	0.7

Source: Crafts (2014)

Table 4. Employment Shares (%)

	Agriculture	*Industry*	*Services*
1759	36.8	33.9	29.3
1801	31.7	36.4	31.9
1831	26.8	41.9	31.3
1851	23.5	45.6	30.9

Source: Broadberry et al. (2013)

Table 5. Shares of World Industrial Production (%)

	1750	*1830*	*1860*	*1880*	*1913*
Britain	1.9	9.5	19.9	22.9	13.6
Rest Western Europe	15.2	18.1	25.4	30.0	33.9
USA	0.1	2.5	7.2	14.7	32.0
China	32.8	29.8	19.5	12.5	3.6
India	24.5	17.6	8.6	2.7	1.4

Source: Bairoch (1982)

Table 6. The Contribution of Steam Power to British Labour Productivity Growth, 1760-1910 (% per year)

1760-1800	0.01
1800-1830	0.02
1830-1850	0.20
1850-1870	0.41
1870-1910	0.31

Source: Crafts (2004)

Table 7. Aspects of Broad Capital Accumulation, 1801-1831 (%)

Investment/GDP	6.7
Non-Residential Investment/GDP	5.0
Equipment Investment/GDP	1.3
Adult Literacy	54
Primary School Enrolment	36
Years of Schooling (number)	2.3
University Students/Population	0.04
Civil Engineers/Employed	0.01
Traditional Professions/Employed	0.88

Sources: Crafts (1995) (1998)

Table 8. The Price of Energy (grams of silver/million BTUs)

	1650-99	***1700-49***	***1759-99***	***1800-49***
Western UK, Coal	0.81	0.81	1.13	1.13
Western UK, charcoal	2.53	3.25	5.34	6.17
Antwerp, Coal	7.12	7.95	7.20	7.37
Antwerp, Charcoal	9.16	13.09	15.23	19.04
Beijing		9.33	8.99	8.08
Canton		4.15	7.15	

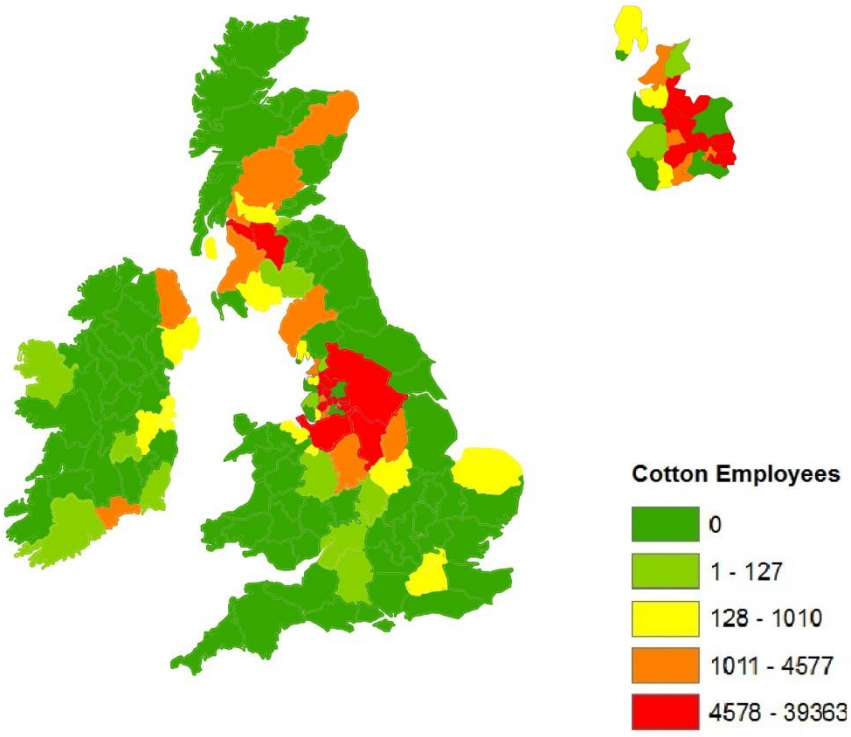
Source: Allen (2009)

Table 9. Internal Rate of Return on Purchase of Spinning Jenny, c. 1780 (%)

Cost of Jenny	840d	1450d	1500d
Wage			
9.375d	64.0	31.0	29.5
6.25d	38.0	13.5	12.0
4.66d	24.0	2.5	1.5
3.75d	15.0	-5.0	-6.5

Notes:
England: price of jenny = 840d, wage = 6.25d (Allen, 2009).
France: price of jenny = 1450d, wage = 4.66d (Allen, 2009).
United States (Philadelphia): price of jenny = 1500d (Jeremy, 1973), wage = 9.375d (Adams, 1970).
Source: Crafts (2011).

Figure 1. The location of Employment in the Cotton Industry in Britain 1838



Note: the inlay in the right upper corner shows Lancashire and its 31 Poor Law Unions.
Source: Crafts and Wolf (2014) based on Factory Inspectors' Report for 1838.