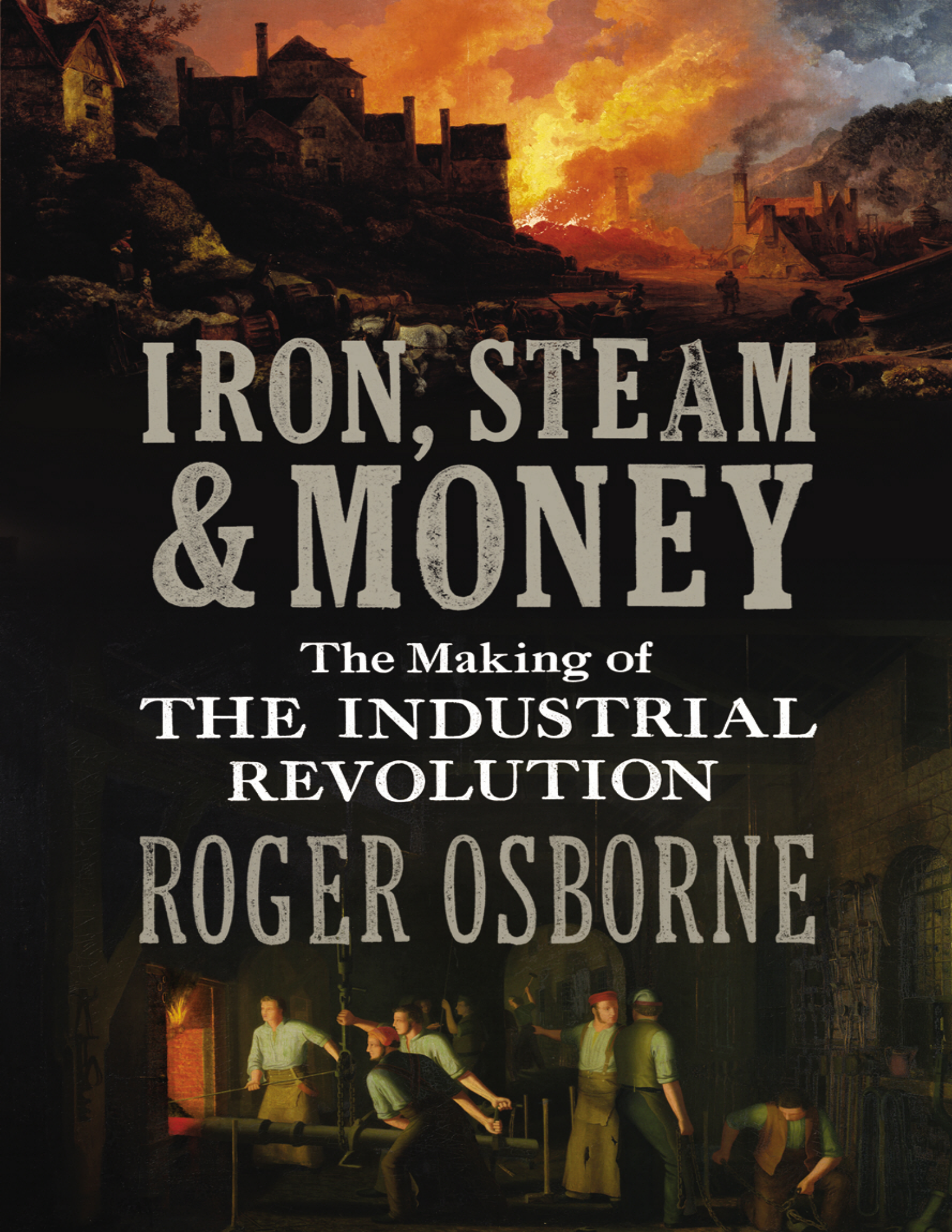
IRON, STEAM & MONEY

The Making of THE INDUSTRIAL REVOLUTION

ROGER OSBORNE



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About the Book

In late eighteenth-century Britain a handful of men brought about the greatest transformation in human history. Inventors, industrialists and entrepreneurs ushered in the age of powered machinery and the factory, and thereby changed the whole of human society, bringing into being new methods of social and economic organisation, new social classes, and new political forces. The Industrial Revolution also dramatically altered humanity's relation to the natural world and embedded the belief that change, not stasis, is the necessary backdrop of human existence.

Iron, Steam and Money tells the thrilling story of those few decades, the moments of inspiration, the rivalries, skulduggery and death threats, and the tireless perseverance of the visionaries who made it all happen. Richard Arkwright, James Watt, Richard Trevithick and Josiah Wedgwood are among the giants whose achievements and tragedies fill these pages. In this groundbreaking study Roger Osborne also shows how and why the revolution happened, revealing pre-industrial Britain as a surprisingly affluent society, with wealth spread widely through the population, and with craft industries in every town, village and front parlour. The combination of disposable income, widespread demand for industrial goods, and a generation of time-served artisans created the unique conditions that propelled humanity into the modern world.

The Industrial Revolution was arguably the most important episode in modern human history; *Iron, Steam and Money* reminds us of its central role, while showing the extraordinary excitement of those tumultuous decades.

About the Author

ROGER OSBORNE is the author of a dozen books that provide new insights into episodes, events and movements in world history. His major works include *The Floating Egg: Episodes in the Making of Geology* (1996) and *Civilization: A New History of the Western World* (2006). He is also a playwright; his political drama *The Art of Persuasion* was first performed in 2011.

Also by Roger Osborne

The Floating Egg:
Episodes in the Making of Geology

The Deprat Affair:
Ambition, Revenge and Deceit in French Indo-China

The Dreamer of the Calle de San Salvador:
Visions of Sedition and Sacrilege in Sixteenth-Century Spain

Civilization:
A New History of the Western World

The Art of Persuasion (play)

Of the People, By the People:
A New History of Democracy

Iron, Steam & Money

The Making of the Industrial Revolution

Roger Osborne

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Introduction

It is impossible to exaggerate the importance of the Industrial Revolution. Only the smelting of metals and the adoption of agriculture brought a comparable change in human history. Before the Industrial Revolution humanity, for all its ingenuity, lived in a precarious balance with the natural world.[1] The overwhelming majority of people were vulnerable to starvation, disease and debilitation, and were rarely able to rise beyond mere subsistence. All work was done by human and animal muscle, and life for most was a continual struggle against exhaustion and the spectre of death. There were great civilisations of course, but none ever freed its people from the threat of imminent famine or disease.[2]

In contrast the Industrial Revolution laid the foundations of a new world in which famine and want could be eliminated, where machines replaced human labour and where technology could be harnessed for the benefit of humankind. More than that, industrialisation changed the whole of human society, bringing into being new methods of social and economic organisation, new political forces and new social classes. The Industrial Revolution also had a transforming effect on human psychology, dramatically altering humanity's relation to the natural world and embedding the belief that change, not stasis, is the necessary backdrop to human existence.[3] We have seen too the malign effects of industrialisation – the despoliation of the natural world, pollution, climate change and increasing inequalities; the overthrow of that precarious balance has brought its own problems. For good or bad, so pervasive are

the effects of the Industrial Revolution that it is impossible for us to comprehend human history without an understanding of this momentous episode: everything was changed forever.

What then was the Industrial Revolution? That may seem like an odd question. After all, every schoolchild knows about the spinning jenny, Samuel Crompton's mule and James Watt's steam engine, even if we are a little vague about how they worked; and we all know about cotton factories, smoky cities and steam locomotives. All these, and much more, certainly came into being in Britain in the late eighteenth century – but does this justify the claim that there was a revolutionary change in human existence?

In fact the very idea that there was an Industrial Revolution in Britain has come under attack from many quarters.[4] Historians of technology have pointed out that important inventions have occurred throughout human history, often in clusters, so there is nothing unique about Britain in the late eighteenth century. In addition, several of the major innovations associated with the Industrial Revolution – from Abraham Darby's blast-furnace technique to Thomas Newcomen's steam engine and John Kay's flying shuttle – were invented decades before that period. Moreover, Britain had been developing a strong manufacturing and commercial economy since 1650, with large numbers of people involved in production of textiles, iron and steel, tin, copper, brass, metal goods, salt, glass, shipbuilding, coal mining, brick-making and construction.

Early eighteenth-century Britain already had a large urban population, boosted by the phenomenal growth of London in particular. Urbanisation became a crucial element in the process of industrialisation but London in 1700 managed to support half a million people through trade, commerce and craft-scale manufacturing. Historians have argued that the inventions of the classic period of the Industrial Revolution were mainly concerned with the cotton industry, but this

remained a small part of the British economy until the first quarter of the nineteenth century, while the factory system did not make significant inroads until after the first great phase of the Industrial Revolution had passed. Economic historians have also pointed out that the British economy grew extremely slowly through the eighteenth century. Sustained growth – the sign of a significant change in the productive capacity of the economy – did not kick in until the middle decades of the nineteenth century, at a time when the likes of Richard Arkwright, James Watt, Henry Cort and Matthew Boulton were all in their graves.

All of this provides ammunition for the argument that Britain went through a long period of gradual and sustained change, the effects of which were felt only from the 1830s onwards. If the Industrial Revolution did bring about the alteration of human society, this process had begun much earlier and its effects were felt much later than we have been led to believe. The much-vaunted transformation begins to look less and less like a revolution and more like a gradual, centuries-long process.

And yet, the Industrial Revolution has emerged from this process of intense analysis bloody but unbowed, and in many ways stronger and more clearly defined. Historians have been forced to seek answers to fundamental questions. Firstly, if this was a revolution – i.e. an episode of rapid and fundamental change – then what exactly was that change? And second, what precisely do we mean by the word ‘industrial’?

The answer to the first question is that, in a period of just three and a half decades, a series of innovations ushered in an entirely new kind of productive economy. The spinning jenny, Arkwright’s frame, Watt’s steam condenser, Crompton’s mule, Cort’s new method of iron-making, the rotary steam engine, the automatic loom and Trevithick’s steam locomotive all had effects which were threefold. Firstly, they laid the foundations for the mechanisation of

industrial production – the spinning frame and the mule, for example, were designed to be driven by external power not by human or animal muscle. Secondly, they brought in a new source of power for these machines – steam engines. Thirdly, they adapted steam power to locomotion, opening up the possibility of rapid transport. All of this was brought into being between the registration of patents for Arkwright's frame and Watt's steam engine in 1769, and Trevithick's successful trial of a steam locomotive at Pen-y-darren in 1804. This was, in any sense, a revolution in technology and the direct effects of these innovations were felt and appreciated at the time. Watt and Arkwright became famous in their lifetime and everyone soon saw that mechanised production powered by steam was opening up a new world.[5]

What, then, is the answer to our second question: what exactly do we mean by 'industry' and 'industrialisation'? It is important for us to pin this down at the outset since these words have long carried a host of meanings that can easily bring confusion. Beneath the mechanised production, the smoky factories, the technical wizardry and the reordering of society that began in the Industrial Revolution lay two essential forces that made Britain the birthplace of industrialisation.

The first was the emergence of an economy fuelled by coal. As we shall see, Britain had access to almost limitless amounts of cheap coal that were used in increasing amounts for heating and manufacturing during the eighteenth century. Thermal energy enabled Britain to become more prosperous and productive; but the crucial breakthrough into an industrial economy came with the use of coal to produce mechanical energy. Applying steam power to productive industry enabled Britain to break free from the constraints of the so-called 'organic economy' where everything was finally dependent on the resources of the land. In the past, expansion of production had been

constrained by the amount of wood, grain and grass that could be grown, the number of animals raised and the amount of power produced by waterwheels. The new mineral or industrial economy had no such constraints – providing the coal did not run out – and could grow without fear of hitting the limits of what the land could provide. It was mechanical power from fossil fuel that drove industrialisation.

The second driving force is to do with innovation itself. Before the Industrial Revolution there had of course been important technical changes throughout human history, but these had not led to a sustained momentum of innovation, development and adaption. Yet the eighteenth-century revolution began a period of technical innovation that has lasted until the present day – the microchip is the direct descendant of the Jacquard loom, while modern dynamic feedback systems derive from Watt's centrifugal governor. We can therefore describe industrialisation as self-sustaining production powered by external energy and developed by continual innovation; this is what the Industrial Revolution brought into being.[6]

One of the most exciting aspects of this analysis is that the Industrial Revolution needed technological innovation to bring it into being. Some accounts of the period imply that the innovations were less important than the general increase in prosperity that preceded and, in their view, precipitated, the Industrial Revolution. But it is clear that there were two intertwined stories in eighteenth-century Britain. The first shows a country becoming increasingly wealthy on the back of its historical wool trade, its divergence into a host of craft manufactories, and the burgeoning of international commerce through the opening up of the Atlantic and sea routes to India. Britain was exploiting its 'organic economy' to the full. The second story shows a coal economy helping craft manufacturing to thrive,

but which had not yet made the crucial transition from thermal to mechanical energy.

In fact Britain could have gone on exploiting its organic and mineral resources without ever becoming a fully industrial economy. The transition to the production of mechanical energy was not bound to happen, and any sense of inevitability comes only with hindsight. The Industrial Revolution came about because of inventors and their innovations. So, having survived a few decades in the wings of history, the great inventors – Watt, Newcomen, Hargreaves, Arkwright, Trevithick – are once again centre stage as *the* great movers in this historical drama. It was a single generation of British artisans who made possible Britain's transition to industrialisation and transformed the prospects of humanity.

Over the next few hundred pages I will explore how this momentous process unfolded, and tell of the people, inventions, industries and events that made the Industrial Revolution happen when and where it did. We will discover why there were so many crucial inventions in such a short space of time, explore the key developments that drove the revolution, and examine the immediate and lasting effects on work, life and global population.

The Industrial Revolution comprises a vast panorama of interconnected events and people; any historian of the period therefore has to choose between a straight chronological record and a thematic approach. The chronological narrative risks reducing this fascinating story to a list of individual events without providing the opportunity to understand the context within which each industry developed. So instead, this book is made up of separate sections, each covering a different aspect of industrialisation or a different industry. Each section tells its own story – often starting in the late medieval period and extending past the Industrial Revolution itself and on into

the nineteenth century – while at the same time making connections to the other sections. The section on ‘Power’, for example, explores the development of the steam engine by Newcomen, Watt and Trevithick, while ‘Invention’ shows how these men came from the same social class of engineer–artisans; the section on ‘Cotton’ details the spectacular career of Richard Arkwright, while ‘Work’ shows the lasting effects of Arkwright’s factory system. These focussed sections are bookended by a Prologue that describes Britain on the eve of industrialisation, and an Epilogue that examines the state of the country eighty years later. This structure will allow the reader to revel in the individual stories, while at the same time seeing them in the context of this world-changing process.

Innovation and technology lie at the heart of the Industrial Revolution. So, while many accounts of the period have skated over the details of atmospheric engines or spinning jennies, this book takes the opposite approach. Without a basic understanding of the process of spinning cotton, it is impossible to understand the enormous achievement that James Hargreaves’s spinning jenny or Samuel Crompton’s mule represented; without some grasp of how a hand-loom works, it is difficult to appreciate the ingenuity and the impact of the invention of the flying shuttle; and unless you know roughly how an atmospheric engine works you cannot see how James Watt’s inventions changed the world. Understanding the fundamentals of these processes gives us a far richer appreciation of our own history and allows us to share in the sheer excitement brought on by discovery and innovation. The task of the historian is not to avoid the details of technological innovation but to reveal them as the thrilling focus of human endeavour and achievement.

The Industrial Revolution is the nexus through which all of modern human history flows. In a world concerned about climate change, pollution and environmental degradation,

industrialisation can seem like the villain of the piece. But everyone reading this book leads a life of well-being beyond the imagining of those who lived before 1770: it is the great watershed and there is no going back. Instead we are beginning to understand that the world and the future of humanity depends on our instincts as makers and doers, as solvers of practical problems through mental and technical ingenuity. The Industrial Revolution is more relevant than ever.

Prologue:
Britain on the Verge

FROM 1769 TO 1804 a series of astonishing innovations in iron production, steam power and textile machinery changed the prospects of humanity. Inventors and entrepreneurs seized the opportunity that history offered, and made the machines that allowed humans to move into a different kind of existence. This was the start of a deluge of technical innovation that has carried us to the present. But how did this happen? And why did it happen in Britain in the late eighteenth century? To begin to answer those questions we need to look at the state of this rapidly changing nation, standing both on the edge of Europe and on the verge of the Industrial Revolution.

While we tend to see pre-industrial Britain as an overwhelmingly rural economy little changed since medieval times, the truth could hardly be more different. By the eve of the Industrial Revolution Britain had already been through a remarkable 200-year transformation from a relatively poor agricultural society into a powerhouse of world commerce. In 1500 just 7 per cent of the English were urban dwellers; by the 1760s Britain was, along with the Netherlands, the most urban society in Europe with close to 30 per cent of the population living in towns (the equivalent figures for France and Germany were 13 and 9 per cent); Britain's workers earned more than any of their European counterparts, and prosperity at home was enhanced by a global trade network.[1] The historic shift of trade from the Mediterranean to the Atlantic had benefitted Britain more than any other nation. A series of governments had invested

in naval expansion and Britain had begun to dominate trade with the North American colonies and with India. Gains in the Seven Years War (1756–63), mostly at the expense of France, saw Britain take effective control of the world's oceans while the Dutch had been forced to concede much of their earlier supremacy. Annual exports to North America rose from £872,000 in the 1740s to £2m by the 1760s and £4.5m by 1771, while a series of Navigation Acts restricted foreign ships from trading in British ports and so increased the size and power of the British merchant fleet.[2] Investment in harbour and port facilities at Liverpool, Bristol, Glasgow, Newcastle, Whitby, Hull, Dundee, Ipswich and elsewhere brought dividends in the international trade in tobacco, sugar, tea and slaves, with cotton increasing in importance. In the mid-eighteenth century there were around 6,000 merchant ships in Britain, double that of France (which had a far bigger population), with around 100,000 men working on board.[3]

Most importantly the wealth of Britain was spread widely across its population. Previous civilisations had accumulated vast riches but few if any societies in human history had so much wealth so widely distributed. Over the previous 200 years England had grown rich on the wool trade, first selling fleeces and raw wool to the weavers of Flanders and Italy, then making its own cloth for sale across Europe and the world. Changes in land use saw English sheep grazed on the finest pastures producing wool that was famous for its quality. Wool was produced in almost every corner of England and a series of trades from farmer and fuller to spinner and weaver prospered in every county and market town. Merchants from London, Amsterdam, Paris and Leipzig would travel to the cloth markets of Exeter, Crediton, Norwich and Leeds. In 1726 Daniel Defoe described the English wool trade as 'the richest and most valuable manufacture in the world'.[4]

Wool was the backbone of English prosperity, and the widespread wealth it created enabled the English – and later the British – to diversify successfully into other trades. In Tudor times England had looked to Continental Europe for technical expertise and had imported most of its high-quality manufactured goods; but by the eighteenth century Britain led the world in metal-smelting, iron-forging, shipbuilding, chemicals, mining, pottery, glass-making, brewing and construction. Historians have estimated that by 1700 industry accounted for 30 per cent of the British economy, with agriculture standing at 40 per cent.[5]

This diversification into small-scale manufacturing was able to happen because from roughly 1600 to 1730 Britain underwent an agricultural revolution. Small farmers, protected by so-called copyholder and beneficial tenancies, brought about a doubling of agricultural productivity. Not only was each acre of land able to produce twice as much food, but this was achieved without an increase in the number of agricultural workers. In Tudor times each farm worker fed around 1.25 people, but by 1730 this figure had increased to 2.5; in other words, each farm worker could now feed herself and 1.5 others.[6] The result was a wholesale change in the structure of society. Not only did it lead to a growing number of urban dwellers, but the rural population became evenly divided between those who made their living purely by farm work and those engaged in crafts such as spinning, weaving, nail-making, iron-forging and so on. Britain saw its overall population expand but also witnessed a radical restructuring of society away from agriculture and towards craft industries and urban living.

The growth in urban population was dominated by the rapid expansion of London, which increased from around 55,000 in 1500 to 500,000 in 1700, but other towns like Bristol, Norwich, Ipswich, Liverpool and Oxford grew significantly too. And while Britain still had a smaller population than France, Italy, Germany or Spain, it was

growing at a much faster rate – by 280 per cent between 1550 and 1820 compared to 50 to 80 per cent for other European countries.[7]

The rise in agricultural productivity had a variety of causes, but one highly significant element that agriculture shared with the growing crafts manufactories was the use of coal. Coal was easy to find and cheap to dig in many parts of Britain; it was transported in bulk by ship and boat to many parts of the island. Crafts like brick- and salt-making, tanning and brewing took advantage of cheap coal, and from 1710 onwards it began to be used in blast furnaces, replacing charcoal. Crucially coal was also used in making vast quantities of lime for use as fertiliser. Coal not only enabled farmers to fertilise more land, its use as a heat source freed them from their reliance on trees for fuel, thereby allowing more acres to be used for food production.[8]

Houses constructed to accommodate the increasing numbers of town-dwellers were built with new types of grates and chimneys as coal took over from wood as the principal fuel for heating. Coal was shipped down the east coast from the coalfields of Northumberland and Durham in vast quantities to supply the homes and workshops of London. Coal production increased from 227,000 tons in 1560 to 3 million tons in 1700 by which time 80 per cent of the coal mined in Europe was mined in Britain; it has been estimated by one historian that in 1700 Britain was producing five times as much coal as the rest of the world.[9] While coal helped increase agricultural productivity and therefore allowed more people to live in towns, these could expand due to massive production of bricks for houses that were in turn heated by coal. The coal trade also began to change Britain’s infrastructure; the new canal system that developed rapidly after 1761 was largely created to transport coal – the Bridgewater canal, Britain’s first industrial canal, was built from Worsley colliery to

Manchester to ship the Duke of Bridgewater's coal to his customers.

Coal also induced British landowners to view the coming industrialisation of society as a benefit, where previously established authorities tended to stand in the way of change. This was crucial because landowners were the dominant force in Parliament and the judiciary. A principal reason for their acquiescence was the coal that lay under their land; by the mid-century landowners across the Midlands and the north of England were benefitting handsomely from the coal economy. Coal had its tentacles in every part of this changing society.[10]

The development of commerce through the wool trade, the increase in agricultural productivity, the diversification of craft trades and the growth in the urban population created a virtuous circle of increasing prosperity. The wool trade itself became more productive and efficient, developing systems that saw more and more specialisation of work. Indeed specialisation and standardisation of work, and the concentration of crafts in particular regions, were crucial developments that emerged in the eighteenth century. While originally sheep farmers had processed wool before taking it to town for finishing, by the eighteenth century merchants were operating and controlling a 'putting-out' system where they paid piece rates to rural workers for fulling, carding, spinning, weaving and dyeing wool, linen and cotton, before selling the finished products at local markets or taking them to London for shipping out. The system became highly developed in the West Riding of Yorkshire and parts of east Lancashire and Derbyshire, leading to a decline in the wool trade in traditional areas like Devon and Norfolk. Improved transport pushed forward this regional specialisation which in turn further increased efficiencies, producing higher levels of cooperation, competition, innovation and standardisation. A patchwork of late medieval regional agrarian economies was being

gradually integrated into a single commercial capitalist market system.

Specialisation extended into other areas too. For most of human history households had been largely self-sufficient: families would grow, process and cook most of their own food, make their own clothes, build their own shelter, and so on. Naturally this varied through time and place, but while there were always a few specialist workers the overwhelming majority of people applied themselves to a variety of tasks, divided among the family, in order to fill their needs. Even those apprenticed to a particular trade would generally combine that work with other tasks. Another historic change in eighteenth-century Britain, therefore, was the gradual disappearance of self-sufficiency in favour of specialised occupations. This was of immense significance as it also facilitated the transition to a cash-based economy. A woman who had previously baked all her bread, butchered her meat and made her own clothes could now work as a frame-knitter and use her pay to buy in the goods and services she needed. This specialisation went hand in hand with urban growth, and it is easy to see that it was an important precursor to an industrialised economy.[11]

The medieval system of apprenticeships remained important but it too was breaking down along with the powers of the guilds and worshipful companies that had regulated much of the manufacturing trades for centuries; this transition was crucial as the Industrial Revolution would need both the skills of the time-served apprentices and the flexibility that came with the loosening of regulation.

Another important change in the nature of work was the standardisation of production. As we have seen, from the late 1600s a wide variety of crafts developed in Britain; over the course of the next century many of these crafts found ways to be more productive by standardising both methods of production and the products themselves. Bricks, iron fireplaces, nails, glass, pottery and even entire houses

(think of all those Georgian terraces with identical doors, windows, fittings, firebacks and stairs) began to be made in standard forms, while people like George Ravenscroft and Josiah Wedgwood standardised the production of glass and pottery. Shipbuilders began to adopt standard methods of construction so that craft could be built and repaired in different yards and ports. In the manufacture of everything from cloth dyes to beaver-skin hats and fish and whale oil, standardisation and a degree of mechanisation were being introduced.

Crafts of all kinds were made more efficient through the increased use of water power; traditionally used for grinding corn, water-powered mills were now increasingly constructed to power fulling stocks, paper-grinders, forging hammers and bellows. This required purpose-built or adapted buildings as well as engineering skills to make driveshafts, gearings, bearings and cams to transfer power from the waterwheels to the appropriate devices; millwrights and skilled metalworkers became highly sought after.[12]

We have already mentioned the high wages earned by the British. In 1725 workers in England earned three times as much as workers in Italy and Spain; this was a remarkable turnaround from 200 years previously when the Mediterranean had been the centre of economic power. While southern Europeans now struggled to earn a subsistence wage, the ordinary British household had money to spare. The first effect was an improved diet. The British ate meat, cheese and eggs regularly, as well as the basic requirements of bread and vegetables, and they indulged themselves with tea, sugar and beer. They also bought items of furniture, crockery, cutlery, bed linen and clothing that had been beyond the reach of their grandparents; household inventories from the mid-eighteenth century show widespread ownership of all these

goods, as well as clocks, ornaments and books, all of which became more affordable through the course of the century.

Although Britain was becoming a prosperous society, by modern standards life was hard for the majority, and unremittingly harsh for the poorest. The Whig aristocracy who had emerged triumphant from the Glorious Revolution of the 1690s ruled the land, while a growing middle class of lower gentry emerged into positions of local influence. British society was, however, divided in a way that is central to our story. The civil wars of the 1640s had seen a bitter religious division into Anglicans (and their equivalents in Wales and Scotland) and those who became known as Dissenters or Nonconformists. After the restoration of the monarchy in 1660 Nonconformism was constrained in a series of parliamentary acts, which became known as the Clarendon Code. Congregationalists, Presbyterians, Baptists, Unitarians, Quakers and any others who refused to acknowledge the Church of England as the ultimate Christian authority in the land were barred from public office and military service. Nonconformist ministers were forbidden to come within five miles of incorporated towns and were not allowed to establish places of worship. The restrictions were eased only slightly by the Act of Toleration of 1689 which allowed Nonconformists to worship together; the remainder of the Clarendon Code remained in place until the nineteenth century.[13]

In practice this meant that a large swathe of respectable society was not permitted to take part in public administration or to get involved in politics or military leadership. At the same time these religious groups formed strong internal bonds fostered by mutual trust and support that led them to develop their own parallel social and economic networks. Despite, or perhaps because of, its separation from ‘polite’ society, Nonconformism flourished, particularly in those newly established towns in the

Midlands and the north of England that fell outside the restrictions of the Clarendon Code.

Making up a large proportion of the ‘middling sort’, as Defoe called them, Nonconformists were noted for their lack of ostentation. Company records show how little those who went into commerce and manufacturing took out of the businesses; instead profits were reinvested to buy plant or improve infrastructure. While frugality was an important part of life, business was done on the basis of a handshake, putting great value on a reputation for decency and straight dealing.

The countervailing truth to the moral piety of the Nonconformists was the importance of slavery to British prosperity. Slave ships left Liverpool and Bristol filled with cheap goods to exchange for slaves in West Africa. Millions of Africans (the total is thought to be around 12 million over a period of 250 years) were then shipped across to the Americas in appalling conditions to work on sugar and tobacco plantations; here the ships were loaded with the produce of those plantations to be sold to an eager British market.[14] For the Africans it was a catastrophe, for the British slave merchants it was a highly lucrative system, and it was an important element in the British economy. In the second half of the eighteenth century the majority of British overseas income came from the goods traded through the Atlantic Slave Triangle. The elegant Georgian terraces of Bristol and Bath, the imposing waterfront of Liverpool, the merchants’ quarter of Glasgow, all owed their existence to the slave trade.

It is important to note too that while the commercialisation of society grew apace the political and social situation in Britain was, in many ways, unstable. Governments changed with alarming rapidity – eight times between 1757 and 1770 – and successive administrations seemed not to know quite how to deal with their colonial subjects, mishandling the American colonists disastrously.

From 1750 onwards the enclosure of common land was causing immense social disruption in the countryside, sending poor people into towns and cities in search of work, while prices rose steeply after the end of the war in 1763. There was chronic social unrest which regularly broke into open rebellion. Benjamin Franklin lived in Britain in the 1760s and early 1770s and observed: 'I have seen within a Year, Riots in the Country about Corn, Riots about Elections, Riots about Workhouses, Riots of Colliers, Riots of Weavers, Riots of Coalheavers, Riots of Sawyers, Riots of Sailors, Riots of Wilkites . . .'[15] The commercialisation of society was a painful process involving disruption, destitution, and a sense that no one was quite in control.

Increasing prosperity created a continually expanding demand for goods, particularly among the growing urban population. The growth of craft trades was able to satisfy this demand, while improving supply through specialisation, standardisation and more efficient systems. All this was based on the prosperity of the wool trade and the growing use of coal for fuel. The other important dynamic in British society was the emergence of thrusting artisan and merchant classes eager to better themselves – so called human capital.

The growing commercialism created a more fluid society as people saw that it was possible to gain an advantage in life through bettering yourself, not merely through the accident of one's birth. So, while British working people were able to afford better diets and manufactured items they also began to spend money on acquiring knowledge and skills, both for themselves and their families. This desire to learn was of immense significance: people bought apprenticeships for their children, learned to read and write and improved their arithmetic. In the second half of the eighteenth century literacy rates in England were 53 per cent; in southern and eastern Europe 20 per cent; in France and Germany 35 per cent. Only the Netherlands had a

higher literacy rate at 68 per cent.[16] While reading was often done for pleasure – the price of books fell dramatically during the century – numeracy skills were learned for work. Engineers, traders, instrument-makers, merchants and skilled sailors all needed to be able to handle figures or geometry with confidence. People knew that skilled workers like stonemasons, iron-makers, brewers, clockmakers, shipwrights, glassmakers and carpenters could earn at least 60 per cent more than the unskilled, provided they had served their apprenticeships. Families put up money at the start of the term and in return the master would feed and house the apprentice while teaching him the skills and secrets of his trade. Nearly two-thirds of young Englishmen went through the apprentice system in the eighteenth century.[17]

While these were the main factors that encouraged change and innovation, it is also important to see how barriers to change were being dissolved. The fierce religious adherences of the seventeenth century had declined, along with fears that innovation or improvement offended against nature and the Will of God, while the death of Queen Anne in 1714 brought any serious attempts at religious persecution to an end.[18] The growth of the insurance industry from the 1660s onwards also shows how people looked to Mammon rather than God to save them from destitution. The move away from the medieval system spread to trade, where laws designed to ensure standards of quality and to give protection to artisans and workers in their native towns were gradually loosened or quietly ignored. Meanwhile, in the new towns like the unincorporated Manchester and Birmingham, which lay outside the old medieval system, trade and manufacture flourished unhindered by regulation.

As well as general prosperity and an increasingly well-trained and educated workforce, there are other aspects of mid-eighteenth-century Britain that are fundamental to our

story. One is finance and banking. In the wake of the disastrous naval defeat at Beachy Head in 1690, the government had set up the Bank of England as an independent institution to raise money for the Exchequer – a strategy that proved immensely successful in stabilising the financial system. The principal debtor in the British economy had always been the state. It was therefore in the government's interests to keep interest rates as low as possible, while also allowing a decent return on investments. Governments sometimes offered high rates of return in order to be able to borrow money – especially in times of war – but as the stability of the British economy increased, the official interest rate was gradually lowered. In the 1750s the prime minister Henry Pelham consolidated all government debt into one account, which paved the way for the formation in 1757 of the Consolidated Stock (known as Consol). The long-term Consol rate of 3 per cent gave stability to the system, dictated interest rates elsewhere in the economy and encouraged long-term investment – with negligible inflation, funds could simply be left in companies to mature.

Financial investment suffered a severe setback in 1720 when speculation in the shares of the South Sea Company, which had taken on the whole of the government debt in return for a monopoly of trade in South America, inflated the market until its eventual collapse. The resulting legislation restricted joint-stock companies to those authorised by Parliament, limited the number of investors in any enterprise to six, and made all partners individually responsible for all its debts. These restrictions might have fatally restricted industrial enterprise, but they forced into being modest yet ambitious enterprises founded and supported by networks of families and trusted associates.

One of the potential barriers to a functioning commercial and industrial economy was the lack of a national banking system. In the early eighteenth century trade was the

dominant financial enterprise; London banking houses were geared up to allow people to deposit money, which was then loaned to shippers and merchants. While the Bank of England was set up in 1694 to manage the government's finances and deal with large-scale transactions with London bankers, this left the rest of the country without a financial infrastructure.

The main financial instrument in the early 1700s was the bill of exchange, drawn on a London bank. This could be transferred from one merchant to another and redeemed at the bank itself. The obvious limitation of this system was that it didn't provide the notes and coins that were needed for everyday transactions. This began to be overcome when merchants in country towns started to accept the bills and give currency in exchange – taking commission along the way – and thereby giving birth to a de facto national banking system. Private banks operating on this principle became widespread by the 1760s, as goldsmiths, textile-makers and associations of cattle drovers all set up their own banks. The foundation of joint-stock banks outside London was prohibited, so country banks had corresponding London houses and would lend money by issuing bills of exchange drawn on those banks. This quasi-national system was particularly useful in directing money where it was needed; farmers, for example, often had money to deposit in late autumn, which was the time when manufacturers were in need of funds to settle end-of-year accounts.[19]

By the mid-eighteenth century there were developments that we now recognise as important stepping stones towards an industrial economy. Iron-smelting in blast furnaces had come to Britain in the fourteenth century and become well established in areas like the Weald in Kent, the Forest of Dean, Staffordshire and east Shropshire, with steel production in the Tyne Valley and South Yorkshire. In 1709 Abraham Darby became the first ironmaster to power a

blast furnace with coal instead of charcoal, opening the way for an expansion in iron-making, and in the 1740s Benjamin Huntsman of Sheffield invented the crucible method of steel-making. Craftspeople also found ways to switch from charcoal to coal in a range of other industries like brewing, salt-making, sugar refining, baking and distilling; the production of bricks, tiles, glass, pottery and lime; the manufacture of chemicals including alum, copperas, saltpetre and starch; the processing, dyeing and bleaching of cloth; calendaring, paper-making and hot-metal printing. By 1750 manufacturers were using around 30 per cent of the coal consumed in Britain.[20] While coal produced heat it did not yet produce power, but this began to change with the Newcomen steam engine, or fire engine as it was then known. First installed in 1712, it was one of the greatest inventions in human history. Nevertheless, its huge use of coal limited its use to pumping water out of mines.

By the mid-eighteenth century Britain had begun to develop a manufacturing infrastructure and expertise, so that when the famous machines of the Industrial Revolution were invented, they were rapidly put into productive action. At the same time craft industries were being turned into manufactories as, for example, in the glass trade. Venice had been the centre of European glass-making for centuries, with English makers producing inferior versions of the famous cristallo. Glass-maker and merchant George Ravenscroft lived in Venice in the 1650s and on his return to England tried new methods of glass production. In 1676 he discovered that the addition of lead oxide gave the glass added brightness and lustre, and also made it easier to cut.[21] Ravenscroft was able to make lead crystal and, within twenty years of the end of his patent in 1681, more than a hundred English glass-makers were following his example. Britain soon overtook Venice as the centre of European glass-making, producing large volumes at low cost and high quality and utility.