Was the British Industrial Revolution a Conjuncture in Global Economic History?[*]

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[*] This essay is a tribute to Ken Pomeranz, who first posed the meta question: "Why wasn't England the Yangzi Delta?" (*The Great Divergence. China, Europe and the Making of the Modern World Economy* (Princeton: Princeton University Press, 2000, 13). I also wish to thank warmly Gagan Sood and Ewout Frankema for the time and trouble that they have devoted as colleagues and editors to critiquing and improving this essay.

Past and Recent Representations of The First Industrial Revolution

As long ago as 1967, Marshal Hodgson recognized that the rise of Western economies could only be properly analysed and understood in a global context.[1] Alas, the recommendation by this eminent scholar of Islam and the Islamicate world to re-conceptualize Britain's Industrial Revolution within the wider spaces, longer chronologies and cultural frameworks of the long and interconnected history of Afro-Eurasia was not taken forward until Eric Jones published the first edition of the *European Miracle* in 1981.[2] Since then, slowly but surely, books, articles and debates relocating and reconfiguring the industrialization of Britain and the West as another cycle in global economic history have proliferated and the subject has matured into a field that has revitalized scholarly interest in very long run structural developments on a global scale. So it is now timely to follow Hodgson's advice and, by way of a critical survey of recent historiography, endeavour to ascertain in this essay whether Britain's Industrial Revolution can continue to be represented as a 'conjuncture' in global economic history due to which prospects for accelerated and sustained growth changed fundamentally.

Industrialization is a highly significant historical process. It displays common features on local, regional, national, continental and global scales. These are now understood to include social, cultural, political and geopolitical as well as economic forces. Nevertheless, industrialization can be parsimoniously encapsulated and graphically illustrated in statistical form as a conjuncture of accelerated economic transformation from an agrarian or organic to an industrial economy. Thus, following Kuznets, what the most

[1] M. Hodgson, *Rethinking World History. Essays on Europe, Islam and World History* (Cambridge: Cambridge University Press, 2002) 68.
[2] E. Jones, *The European Miracle. Environments, Economics and Geopolitics in the History of Europe and Asia* (Cambridge: Cambridge University Press, 1981).

recent wave of interpretations have observed and quantified is "structural change" proceeding more or less rapidly until majorities of national workforces cease to be closely linked to, and dependent upon, primary production. More and more labour becomes employed either directly or indirectly through linked activities - such as trade, transportation, finance, information, consultancy, protection and welfare - in the servicing of manufactured goods. Comparable trends have also been measured, albeit with far greater difficulty, in historical accounts of values of gross domestic products defined in terms of primary, secondary and tertiary outputs.[3]

Although convincing arguments have been made for the Netherlands to be recognized as 'The First Modern Economy', nobody disputes the fact that Britain was the first polity to complete a transition to an industrial economy.[4] For more than a century, this episode in Hanoverian history has been publicised as *The First* Industrial Revolution, *the First* Industrial Nation, or simply as *The* Industrial Revolution. Anglo-American historians have analysed the rapid change in British economic history for a range of sub-periods running from the mid-seventeenth through to the mid-nineteenth centuries, and represented them in arresting metaphorical terms: a watershed, a turning point, a take-off and, latterly, a little leading to the great divergence. It has been claimed that Britain's Industrial Revolution was more significant and pervasive for human history than the Florentine Renaissance and the French Revolution.[5] The Industrial Revolution continues to be represented not only as a profound discontinuity for British history but also as a conjuncture of trans-

[3] P. O'Brien (ed.), *Industrialization Critical Perspectives on the World Economy,* 4 vols (London: Routledge, 1998); K. Deng and P. O'Brien, *The Kuznetsian Paradigm for the Study of Economic History and the Great Divergence* (forthcoming, 2021).
[4] J. De Vries and A. Van Der Woude, *First Modern Economy. Success, Failure and Perseverance of the Dutch Economy 1500-1815* (Cambridge: Cambridge University Press, 1997).
[5] P. Mathias and J.A. Davis (ed.), *The First Industrial Revolutions* (Oxford: Blackwells, 1989) 1-24; J. Goldstone, 'Efflorescences and Economic Growth in World History: Rethinking the "Rise of the West" and the Industrial Revolution', *J. World Hist.* 13 (2002) 323-92.

national significance for the past and future of the world economy. This depiction periodizes European, American, Asian and African histories into a 'before' and 'after' the First Industrial Revolution.[6] Generations of scholars have not just exaggerated its Britishness (or its Englishness), they have reified its importance for global history. As a result, a recognizable, explicable and unexceptional discontinuity in the history of a well-endowed island economy was transformed into a paradigm case for liberal and neo-liberal models of economic development.

A key concern of this essay is to undermine these claims. It mobilizes the modern scholarly literature to argue that nothing approximating to a paradigm case for industrialization - which rescued first Britons and then over time growing proportions of mankind from the millennial afflictions of poverty, malnutrition, disease and early death endemic to traditional agrarian societies - can be based on the economic history of a small island located off the coast of western Eurasia. In making that claim, however, the following argument does not denigrate the range of innovative economic achievements in the century which succeeded Britain's decisive victory in the Seven Years' War (1756-63). [7] Rather, they were part-and-parcel of a conjuncture in British history, which witnessed a discernible acceleration in the *rates of increase* of real income per head and labour productivity due to structural changes in the domestic economy linked to urbanization and technical progress.[8] Considered, as Hodgson advised, in the stream of world history, on all the indicators constructed and reconstructed by economic historians since the publication of

[6] G. Clark, 'The Industrial Revolution', in P. Aughion and S. Durlaff (eds.), *Handbook of Economic Growth*, vol. 2 (Oxford, Elsevier, 2013).
[7] R. Cameron, 'The Industrial Revolution Fact or Fiction?', in F. Crouzet and A. Clesse (ed.), *Leading the World Economically* (Amsterdam: Dutch University Press, 2003) 169-194; and J. Mokyr's comments, 357-59.
[8] N. Crafts and K. Harley, 'Output Growth and the British Industrial Revolution: A Restatement of the Crafts-Harley view', *Econ. Hist. Rev.* 45 (1992) 703-30.

Ashton's classic study in 1948,[9] the pace of transformation was rapid enough to carry the British polity to a position of economic superiority and geopolitical hegemony during the long Victorian boom (1846-73).

Britain's naval and commercial primacy, along with the exceptional productivity of its agriculture, was already being recognized by its rivals as early as the turn of the eighteenth century. Thereafter, European visitors continued to appreciate the advantages exemplified by the kingdom's agriculture and the dynamism of British manufacturing, even as they retained strong reservations about the social and political consequences of the nation's pattern of urbanization and other structural changes.[10] Recently, economic historians have validated and calibrated a body of robust historical data to complement the impressions recorded by such visitors. This evidence justifies the representation of the transformations which became clear in the century after the Seven Years' War as a conjuncture enabling Britain's transition to an industrial economy. It was over this century that the country witnessed the development of novel techniques of production; the construction and gradual diffusion of engines to harness a new and eventually dominant source of energy in the form of steam power; the extension of improved modes of internal transportation (canals, turnpikes and railways); the extension of more efficient forms of business and commercial organization; the spread of responsive systems of financial intermediation and distribution; the widening and closer integration of commodity and factor markets; and the diversification of consumption.

[9] T. Ashton, *The Industrial Revolution* (Oxford, Oxford University Press, 1948).
[10] P. Langford, 'The English as Reformers. Foreign Visitors' Impressions 1750-1850', in T. Charles et al (eds), *Reforms in Great Britain and Germany 1750-1850* (Oxford: Oxford University Press, 1999) 101-19.

For generations of historians of Britain, all this occurred at a pace and on a scale regarded as extraordinary, if not revolutionary.[11] Latterly, historians of the First Industrial Revolution have become more attentive to not merely its European but also its Chinese, Indian and African antecedents. Recent interpretations seem increasingly unlikely to exaggerate the elements embodied in British political institutions, social structures and cultural norms that not long ago buttressed explanations for the polity's precocious, though relatively short-lived, economic supremacy. Only 'Whig' economists and a few patriotic historians continue to reify selected features and factors of Britain's particular trajectory towards the first industrial market economy into a paradigm case for other less advanced countries to emulate.[12] In short, historical scholarship today is concerned to make students aware of the European, Asian, African, American and Imperial dimensions of the British Industrial Revolution, and the rather rapid convergence of Western polities to comparable levels of per capita income and labour productivity conditioned by the idiosyncratic path dependent potential of each national economy. Diffusion models deployed by earlier generations are no longer regarded as suitable for comprehending the industrialization of mainland Europe, the United States and East Asia, let alone as a basis for policy recommendations to countries still struggling to industrialize. Such models have been degraded into

[11] R. Church and E. Wrigley, *The Industrial Revolutions*, 11 vols (Oxford: Blackwells, 1994); R. Floud and P. Johnson (eds), *The Cambridge Economic History of Modern Britain*, vol. 1, *Industrialization 1700-1860* (Cambridge: Cambridge University Press, 2004); R. Floud, et al, *The Cambridge Economic History of Modern Britain*, vol. 1 (Cambridge: Cambridge University Press, 2014).

[12] Examples include: D. Landes, *The Wealth and Poverty of Nations: Why Some are So Rich and Some So Poor* (New York: Little Brown, 1998); D. North, *Institutions, Institutional Change and Economic Performance* (Cambridge: Cambridge University Press, 1990); D. Acemoglu and J. Robinson, *Why Nations Fail* (New York: Crown Publishers, 2012).

consoling but simplistic narratives purveyed by nationalistic communicators of English exceptionalism.[13]

Narrated, interpreted and contextualized as a conjuncture within a long-run chronology informed by the ebb and flow of global history, the universal status of Britain's Industrial Revolution has been reconfigured to embrace mechanical innovations of worldwide significance, most notably the steam engines of Newcomen and Watt, Corts' technique for puddling iron, Arkwright's water frame, and the weaving machines of Kay and Cartwright. These can be regarded as more or less novel and indigenous to Britain. But other achievements with roots elsewhere are also now central to the story. They include the invention of roller spinning by the son of a Huguenot refugee; Wedgwood's emulation of 'China' pottery, painted by young women born in Staffordshire in colours and designs derived from Classical Greece; and the techniques used to manufacture, bleach, dye and print cotton cloth made in Lancashire from organic raw materials cultivated on slave plantations in the Americas, which drew on knowledge and skills brought to high levels of perfection in India, the Ottoman empire, Sweden and France. These achievements can no longer be acclaimed as simply 'English'.[14] In this perspective, it seems futile to separate out the 'indigenous' from the 'foreign' components in the myriad of manufactured goods that were produced and consumed in Britain during the reign of George III.[15]

Research in the last thirty years has escaped from the bunkers of national archives. This has allowed us to model, amalgamate, aggregate and

[13] Hodgson, *Rethinking World History*, part 1; C. Rider and M. Thompson (eds), *The Industrial Revolution in Comparative Perspective* (Malabar, Fla., 2002); S. Broadberry and K.O'Rourke (eds), *The Cambridge Economic History of Europe*, vol. 1 (Cambridge: Cambridge University Press, 2010); W. Easterly and R. Levine, 'The European Origins of Economic Development,' *Journal of Economic Growth* 21 (2016) 225-57.
[14] I. Inkster, *Technology and Industrialization* (Aldershot: Variorum Press, 1998) 40-58; G. Riello, *Cotton: The Fabric that Made the Modern World* (Cambridge: Cambridge University Press, 2013).
[15] M. Berg, *Luxury and Pleasure* (Oxford: Oxford University Press, 2005).

compare like never before a variety of transitions to modern economies. In particular, we are now able to assign weights - admittedly conjectural, though hopefully credible - to the *major* factors behind the accelerated growth of Britain's per capita output and labour productivity from 1763 to 1846, and thereby account for Britain's precocious industrialization over that period.[16] This essay critically reviews the historiography of the past generation, in juxtaposition with earlier historiographies, so as to present an integrated narrative of the First Industrial Revolution. In this narrative, developments in the political economy of domestic production are integrated with developments in foreign trade and in technology. Developments in these three domains were characterized by their own distinctive geographies and time scales. For this reason, the narrative below is divided into three sections. The first elaborates upon Britain's productive and responsive agriculture and accessible endowments of coal and other minerals. [17] The second details the massive, cost effective investment by the English (and later British) state in naval power which promoted and supported foreign trade and the rise of material consumption.[18] These two sections account for Stage One of Britain's industrialization, during which a favourably endowed and well situated island economy was carried to a plateau of possibilities for sustained modern growth. Those possibilities were realized in the ensuing Stage Two, which is the focus of the third section on technology. Here, stress is placed on the ways in which discovery and innovation complemented one another to consolidate and

[16] N. Crafts, 'Productivity Growth in the Industrial Revolution: a New Growth Accounting Perspective', *J. Econ. Hist.* 64 (2004) 521-35; S. Broadberry et al, *British Economic Growth, 1270-1870* (Cambridge: Cambridge University Press, 2015).

[17] B. Van Bavel and E. Thoen (eds), *Land Productivity and Agro Systems in the North Seas Area, Middle Ages – 19th century. Elements for Comparison* (Turnhout: Corn Publications, 1999); Broadberry et al, *British Economic Growth*; J.L . Van Zanden, *The Long Road to the Industrial Revolution* (Leiden: Brill, 2008).

[18] J. Mokyr, *The Enlightenment Economy. An Economic History of Britain, 1700-1850* (New Haven: Yale University Press); P. O'Brien, 'The Hanoverian State and the Defeat of the Continental System. A Conversation with Eli Heckscher ,' in R. Findlay et al (eds), *Eli Heckscher. International Trade and Economic History* (MIT Press: Cambridge Mass) 373-407.

reinforce the trends in increasing productivity already present before the Seven Years' War. In essence, evidence drawn from demographic records and historical accounts of energy consumed by the population of Britain is marshalled to narrate the First Industrial Revolution as a prolonged, two-stage process.

Stage One: Domestic Production. Natural Endowments and National Institutions for Their Exploitation

For centuries before the Seven Years' War, the British Isles had been blessed with a geography and an agricultural sector with potential to frame and support structural change. That potential stemmed from high ratios of livestock-to-grain output and very good, without being extraordinary, yields per arable hectare cultivated. Compared with most other parts of Europe - and certainly with India and China - English agriculture was also distinguished by high levels of output per worker. Its natural endowments of fertile soils, favourable climate and lush grass begs this question: how successfully were these prior advantages for a highly productive agriculture exploited?

Proponents of the traditional Anglocentric view continue to argue that a distinctive set of property rights and tenurial arrangements for access to land had appeared earlier on the British Isles than elsewhere in Eurasia. Over centuries - beginning, perhaps, with the Norman Conquest of 1066 - the evolution of a 'colonial' system of control over the realm's natural resources was established, consolidated and maintained. Its essential benefits for long-term development consisted of: the formation of larger-scale units of production; markets for access to farmland; concentration of rents from well-defined ownership of both land and other natural resources; and, above all, a steady reduction in the degree of control by peasant families over land and

labour. In time, a rising and comparatively high share of the kingdom's cultivable acres became enclosed within bigger, ecologically specialized farms supplying surplus food, raw materials and fuel to urban markets. England's kin-based agrarian workforce was gradually transformed into waged labour employed by capitalist farmers. Later on, when demand emerged for manufactured commodities, rural labour became the nucleus of a proto-industrial and eventually urban workforce.[19]

Among agrarian historians, in keeping with Arthur Young's inclination to depict the kingdom's aristocracy and gentry as distinctively entrepreneurial, there has been a deferential - but hardly credible - celebration of unequal landownership as a benign outcome of market forces.[20] Theoretically, markets can operate as rational institutions for the transfer of property rights to land, forests and minerals into the private ownership of those who can most effectively manage their use for the purposes of production. The system of agrarian property rights, which was already in place centuries before the times of the First Industrial Revolution, certainly embodied advantages for the kingdom's early transition to an industrial economy. Not least was the outstanding capacity of British agriculture to release ('expel') labour for other sectors of the economy. The origins of these advantages for industrialization cannot, however, be attributed to the early emergence and the subsequent evolution of markets, let alone to the peculiarity of 'English individualism'.[21] Political and legal histories of property and tenurial rights to Britain's

[19] P. Wallis et al., 'Puncturing the Malthus Delusion. Structural Change in the British Economy before the industrial revolution, 1500-1800,' *LSE Economic History Working Paper*, 240/2016; M. Prak (ed.), *Early Modern Capitalism. Economic and Social Change in Europe* (London: Routledge, 2001)

[20] For a refutation of Young's view, see R. Allen, *Enclosure and the Yeoman* (Oxford: Oxford University Press, 1992); E. Jones, 'Landed Estates and Rural Inequality', in *English History* (Cham, Palgrave, 2018). The agrarian history of England and Wales has been deeply researched. See J. Thirsk (ed.), *The Agrarian History of England and Wales*, 8 vols (Cambridge: Cambridge University Press, 1967-2000).

[21] A. Macfarlane, *The Origins of English Individualism* (Oxford: Oxford University Press, 1979); R. Britnell, *The Commercialization of English Society 1000-1500* (Cambridge: Cambridge University Press, 1993).

endowments of cultivable land and other natural resources reveal that they emanated from less 'benign' historical forces. These embraced internal colonization, the violent expropriation of ecclesiastical and common land, and the systematic accumulation of power by closed aristocratic elites. Over time, such developments severely attenuated rights of access to the Island's cultivable land, forests and minerals, which had traditionally been held by smaller freeholders and peasant families.[22] Persistent predation, coupled with an intensifying 'pull' from high wages potentially available to migrants from the countryside to London and other maritime cities, and the realization of gains from overseas trade and specialization, provided Britain with flexible markets for waged labour centuries before mechanized urban industries demanded an increasing share of the nation's workforce.[23]

Geographically reductionist accounts of the country's advantages for a precocious industrialization were also emphasized by physiocratic improvers who visited England in the eighteenth century. [24] Their perception that the Island's favourable environmental endowments (particularly lush grass) had encouraged the steady accumulation of sheep, cattle, pigs and, above all, horses is a commonplace in agrarian history.[25] By the accession of the Stuart dynasty in 1601, the kingdom's exceptionally large population of animals had provided the high-value raw materials (wool, leather, bones), food (meat, dairy produce) and organic fertilisers, which, together with supplies of energy in the

[22] T. Scott (ed.), *The Peasantries of Europe from the Fourteenth to the Eighteenth Centuries* (London: Longman, 1998); Allen, *Enclosure and the Yeoman* and W.G. Hoskins, *The Age of Plunder* (London: Longmans, 1976).
[23] R. Allen, 'The Great Divergence in European Wages from the Middle Ages to the First World War', *Explorations in Econ. Hist.* 38 (2001) 411-47; E. Jones, 'Landed Estates and Rural Inequality', in *English History* (Cham, Palgrave, 2018).
[24] K. Pomeranz, 'Beyond the East-West Binary. Resituating Development Paths in the Eighteenth Century World', *Journal of Asian Studies* 61 (2002) 539-90; Langford, 'The English as Reformers'.
[25] A. Wrigley, *The Path to Sustained Growth. England's Transition from an Organic Economy to an Industrial Revolution* (Cambridge: Cambridge University Press, 2016); P. O'Brien and D. Heath, 'English and French Landowners 1688-1789', in F.M.L. Thompson (ed.), *Landowners, Capitalists and Entrepreneurs* (Oxford: Oxford University Press, 1994) 23-62; Broadberry (ed.), *British Economic Growth*; M. Overton, *Agricultural Revolution in England: The Transformation of the Agrarian Economy* (Cambridge: Cambridge University Press, 1996).

form of wood, carried the productivity of English agriculture towards the top of European league tables. From that plateau, the growth of animal and arable farming allowed for an accelerated increase in population accompanied by proto-industrialization and rapid urbanization. Britain avoided Malthusian crises, economic stasis and risky dependence by importing food and raw materials from abroad when its transition to an industrialized economy was underway.[26]

Plausible statistical data recording the volumes of food, fuel and organic raw materials necessary to sustain England's gradual upward momentum towards an industrial and urbanized market economy have now appeared in print.[27] Wrigley's estimates for 1600-1800 reveal that England's population doubled over these two centuries, while the number of people resident in towns of 5,000 or more inhabitants multiplied seven times, rising from 6% to 24% of the total population. At the same time, higher rates of urban mortality sustained urban demands for migrants from villages.[28] Early modern economic and demographic regimes are depicted by most economic historians as characterized by malign Malthusian tendencies. [29] Typically, supplies of cultivable land available for arable and pastoral farming, and the production of organic raw materials and timber for fuel, cannot sustain more than moderate rates of population growth. [30] England's agrarian historians have long been impressed with the capacity of the country's agriculture to sustain extraordinarily rapid rates of urbanization, while releasing labour for work in

[26] P. O'Brien, 'Path Dependency, or Why Britain became an Urbanized and Industrialized Economy Long Before France', *Econ. Hist. Review* 49 (1996) 213-49.
[27] A. Wrigley, *The Path to Sustained Growth. England's Transition from an organic Economy to an Industrial Revolution* (Cambridge: Cambridge University Press, 2016).
[28] J. Ventura and J. Voth, 'Debt Into Growth. How Sovereign Debt accelerated the First Industrial Revolution,' *National Bureau of Economic Research Working Paper* 21280 (2015) 53-58.
[29] G. Clark, 'The Macro-economic Aggregates for England, 1209-2008', *Research in Economic History* 27 (2010) 97-136.
[30] D. Vollrath, 'The Agricultural Basis of Comparative Development', *Journal of Economic Growth* 16 (2011) 343-70; Wrigley, *The Path to Sustained Growth*; P. Wallis, 'Puncturing the Malthus Delusion'.

manufacturing, mining and services. [31] Statistically, that capacity looks remarkable because *prima facie* the number of English workers employed in the production of food, organic raw materials and fuel rose by 80% over the two centuries before 1800.[32]

Clearly the release of labour to work in other sectors of the economy and in towns alleviated the pressures on land-labour ratios in the countryside, extended markets for foodstuffs, raw materials and fuel, and promoted inter-regional trade between town and country. Favourable trends in the inter-sectoral terms of trade - measured long ago between agricultural products and industrial commodities - reinforced incentives for investment in agricultural improvements. [33] Improvements certainly occurred but not, it now seems, on a scale that is measurable or as impressive as Arthur Young and his followers among agrarian historians have tended to suggest. Current estimates accepted as credible by agrarian historians show that wheat yields per acre cultivated with grain took more than two centuries to double.[34] Over the same time span (1600-1800), neither the publication of books on best practice farming, nor applications for patents for implements designed to raise the productivity of labour and the yields from land, display any obvious upward trend until after the 1760s. So it remains difficult to ascertain when and to what extent the vaunted vogue for improvement among landowners and tenant farmers matured into what has been depicted as an 'Agricultural Enlightenment'.[35]

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[31] Broadberry et al (eds.), *British Economic Growth 1270-1870.*

[32] K. Borowiecky and A. Tepper, 'Accounting for Breakout in Britain: The Industrial Revolution through a Malthusian Lens', *Journal of Macroeconomics* 44 (2015) 219-33; J. Madsen et al, 'Four Centuries of British Economic Growth: The Rates of Technology and Population', *Journal of Economic Growth* 15 (2010) 263-90.

[33] P. O'Brien, 'Agriculture and the Home Market for British Industry', *English Historical Review* 41 (1985) 773-800.

[34] M. Overton, *Agricultural Revolution in England*; L. Brunt, 'Nature or Nurture? Explaining English Wheat Yields in the Industrial Revolution, c. 1770', *Journal of Economic History* 64 (2004) 193-225.

[35] P. Jones, *Agricultural Enlightenment, Knowledge, Technology and Nature* (Oxford: Oxford University Press, 2016).

With the new and more robust data now in print, historians of the First Industrial Revolution continue to recognize, though less enthusiastically than before, the emerging prospects for industrialization from England's well-endowed agriculture. These prospects were favoured between 1600 and 1800 by interludes of benign climate change and by the increasingly concentrated control over the country's land, capital and labour by the country's landed aristocracy and their brigade of deferential tenant farmers.[36] Historians have, moreover, been reminded just how much of the country's success in avoiding potentially malign Malthusian outcomes stemmed from the intensified exploitation of England's truly massive accessible and transportable reserves of coal. [37]

In the absence of that known, but under-exploited, subterranean endowment of fuel, Malthusian pressures, exemplified by labour-to-cultivable land ratios, could counterfactually have seriously reduced the gradual move over the seventeenth and eighteenth centuries towards an industrial market economy. *Ceteris paribus*, an unfavourable shift in the land-to-labour ratio could have had, as Malthus predicted, several potentially harmful effects on the economy's prospects for growth. These include: alterations to the balance of land allocation away from pastoral towards arable agriculture; a weakening of incentives to transform open fields and common pasture into larger scale tenant farms; rising levels of local expenditures on coercion and poor relief to maintain internal order in an over-populated countryside; and increasing rural demands for the per capita kilocalories of food required for more labour-intensive work involved in farming arable land. In the absence of coal serving as a substitute for woodland, these and other forces could have reduced the

[36] J. Ang et al., 'Innovation and Productivity advances in British agriculture 1630-1850', *Southern Economic Journal* 80 (2013) 162-86.
[37] R. Sieferle, *The Subterranean Forest: Energy Systems and the Industrial Revolution* (Cambridge: White Horse Press, 2001); B. Fernihough and K. O'Rourke, 'Coal Availability and City Growth,' *NBER Paper* 19802 (2014).

gains from inter-sectoral and urban-rural trade, weakened incentives to invest in agricultural improvements and lowered the positive externalities flowing from the agglomeration of specialized economic activities in towns. [38]

During the Revolutionary and Napoleonic Wars (1793-1815), a further, very marked change occurred in relative prices between foodstuffs and raw materials, on the one hand, and manufactured commodities, on the other. This protracted period of warfare also witnessed a shift towards greater dependence on imports of temperate foodstuffs from Ireland and of tropical foodstuffs (sugar, tea, coffee) and organic raw materials (cotton, indigo) from the Americas and Asia.[39] These trends became more acute as industrialization, urbanization and transcontinental imports matured post-war. They were sustained by an ever-increasing volume of exports of cheap manufactured goods and commercial services in exchange for imported foodstuffs and raw materials. [40]

Factors behind this preparatory stage for broader structural change can be illuminated by simple counterfactual models and tested with equally simple calculations based on demographic statistics which are almost certainly more robust than data derived from national accounts. The numbers set out below are taken from the Cambridge Group's research into the growth, occupational structure and location of England's population and workforce. They reveal the degree to which the country's transition to an industrial market economy depended on its long known, massive and under-exploited reserves of coal.[41] Wrigley's assumptions and calibrations suggest that the land which would have

[38] A. Wrigley, *Energy and the English Industrial Revolution* (Cambridge: Cambridge University Press, 2010).
[39] P. O'Brien, "The Contributions of Warfare with Revolutionary and Napoleonic France to the Consolidation and Progress of the British Industrial Revolution," in *Department of Economic History Working Papers* 50/2011 and 259/2017.
[40] R. Allen, *The British Industrial Revolution in Global Perspective* (Cambridge: Cambridge University Press, 2009).
[41] P. Malamina, 'Energy Consumption in England and Italy 1560-1913', *Economic History Review*, 69 (2016) 78-103; D. Stern et al, 'Directed Technical Change,' *New Economic Papers*, 2021-01-04, Number 17.

been needed to provide the urban population of *ca* 1800 with the same per capita volumes of grain and fuel sustaining their ancestors at the end of the Tudor dynasty (*ca* 1600) amounted to no less than 42% of England's cultivable area.[42] Thus, it seems safe to suggest that coal consumption per capita multiplied six times between 1560 and 1800, and that around 40% of the extra thermal energy required to carry the economy of England to the levels of productivity achieved in 1800 stemmed counterfactually (and in a reductionist sense) from Britain's rich and extraordinarily accessible natural endowments of coal.[43]

There is no denying that Britain's European rivals, as well as China, also possessed coal. However, their coal may not have been of the same variety and quality, nor as cheap to transport to coastal cities.[44] Britain began and completed a transition from organic to mineral sources of energy - basically for thermal purposes - before the rest of Europe, and some three centuries before Asian polities. By the early nineteenth century, English households and firms consumed around 15 million tons of coal a year, compared to 3 million tons for Europe as a whole.[45] Estimates for tons of coal mined in China are not available and, for reasons yet to be determined, the large-scale deposits in the northern provinces of the Qing Empire remained in situ until well into the twentieth century. [46] Mainland European and East Asian polities continued to utilize traditional fuels such as peat, wood, water, wind and human energy, even

[42] This ratio could be reduced by the small amounts of coal utilized for domestic heat and manufacturing in 1600, but increased by the more extensive substitution of coal for thermal purposes in manufacturing and also by the reduction in kilocalories required for work and health from the cheaper fuel that coal provided to households for warmth and cooking.
[43] Wrigley, *The Path to Sustained Growth.*
[44] A. Kander et al, *Power and the People*; P. O'Brien, *The Economies of Imperial China and Western Europe. Debating the Great Divergence* (Basingstoke: Palgrave, 2020).
[45] E. Thompson, *The Chinese Coal Industry* (London: Routledge, 2003), I. Inkster and P. O'Brien (eds), 'The Global History of the Steam Engine', *History of Technology* 25 (2004).
[46] Sieferle, *The Subterranean Forest;* Wrigley, *Energy and the English Industrial Revolution*; A. Kander and P. Warde, 'Energy Availability from Livestock and Agricultural Productivity in Europe', *Economic History Review,* 64 (2011) 1-29.

though the benefits for earlier urbanization and industrialization from using the cheaper and more efficient thermal form of energy turn out to be substantial. The energy produced from a ton of coal equals that produced from two tons of timber. Given an acre of land supplied two tons of dry wood, by 1815 approximately fifteen million acres in Britain, equivalent to 88% of its arable area, had counterfactually been released from forestry for the production of grains, vegetables, industrial raw materials, to sustain even more livestock and urbanization.[47] At the same time, heat-intensive industrial processes in, say, metallurgy, glass-making, brewing, sugar-refining and baking bricks could all operate more cheaply with coal. Furthermore, the feedbacks and technological spin-offs from these industries in the making of kilns, pots, vats and containers became important for yet more development. Lower cost bricks and metals for the construction of houses in cities, towns and industrial villages saved capital, which could then be invested in public goods and manufacturing.

Energy accounts offer an illuminating way of analysing heuristically transitions from systems of production based upon organic sources of energy to those based on inorganic sources. In a situation where technological innovation to augment labour productivity remained confined to a few sectors of industry, countries favourably endowed with fertile land, minerals, natural waterways and, above all, coal (and its links to the development of steam power) enjoyed a head start in making a transition to urban industrial economies.[48]

[48] V. Smil, *Energy in World History* (Boulder: Westview Press, 1994); P. Malamina, *Pre-Modern European Economy. One Thousand Years (10th-19th Centuries)* (Brill, Leiden, 2009); Malamina, 'Energy Consumption in England and Italy'.

Stage One: Foreign Trade. Political Institutions and State Policies for Securing Commerce Overseas

The other significant comparative advantage leading to the conjuncture when technological innovation became the prime mover of the First Industrial Revolution was provided by the state. This essay now turns to explore the nature of the British state and its significance for the process of industrialization.

Debates on the relationship between foreign trade and investment in Britain's Industrial Revolution have been protracted. Their conclusions range from "trivial and dispensable" to "necessary and sufficient".[49] Contemporary perceptions which maintained that commerce overseas had been a significant component of British industrialization through all kinds of mechanisms - difficult to capture within a modern statistical framework based on national accounts - have now been restored. For global economic history, they may even represent the most significant of Marc Bloch's salient contrasts between Britain and several of its European rivals.[50]

Over the eighteenth century, the volume of British-made commodities sold overseas increased fourfold, compared to a doubling between 1500 and 1700. Ratios of exports-to-gross national product increased from a little over 4% in the reign of Elizabeth (1558-1603), to 6% after the Restoration (1660) and 8% at the Glorious Revolution (1688), reaching 12% in the reign of George III (1760-1801). At least half of the increment to industrial production that came on stream over the long eighteenth century (1688-1815) was sold overseas. The most rapidly expanding and technically progressive of British

[49] J. Mokyr (ed.), *The British Industrial Revolution* (Oxford: Oxford University Press, 1993); K. Harley, 'Trade Discovery, Mercantilism and Technology', in R. Floud and P. Johnson (eds.), *The Cambridge Economic History of Modern Britain* 175-203.
[50] J. Cuenca-Esterban, 'The Rising Share of British Industrial Exports in Industrial Output', *J. Econ. Hist.* 57 (1997) 879-906.

industries - namely, cottons, woollens, metals and shipbuilding - acquired major shares of internationally traded commodities.[51] For the development of an economy led by modernizing industries, Britain's multi-faceted engagement with the world economy can thus no longer be denied. It was an unmistakeably significant factor in the growth and structural changes that took place before, during and after the Industrial Revolution. Already by the close of the Seven Years' War something like half of the country's workforce had no direct links with agriculture and depended directly or indirectly on overseas markets for its livelihood. Revenues from exports made possible the purchase of strategic materials - pitch, tar, hemp, timber, bar iron - for the naval defence of a mercantilist realm. Imported tropical foodstuffs such as sugar, tea, coffee and spices, consumed by 'industrious' families, produced revenues for Britain's maritime state. Fibres for the rapidly growing cotton, linen and silk industries came from abroad. [52]

Between 1790 and 1820, net imports of foodstuffs and organic raw materials rose from around 20% to 40% of domestic farm output. *Pôles de croissance* including London, Bristol, Hull, Glasgow, Newcastle, Liverpool and other maritime cities provided the infrastructure, skilled workforce, internal transportation and distribution networks to service internal as well as foreign trade. Their high wages attracted labour from the countryside. Cities with hinterlands became integrated into state's fiscal system and met its demands for customs and excise duties. These taxes funded the naval power deployed to defend British overseas markets, colonial territories and assets. Alas, we lack estimates for the total values of commodities and services exchanged across

[51] G. Clark et al, 'The Growing Dependence of Britain on Trade during the Industrial Revolution', *Scandinavian Economic History Review* 62 (2014) 109-36; R. Allen, *The British Industrial Revolution in Global Perspective*.
[52] F. Trentman, *Empire of Things* (London: Penguin, 2016); P. O'Brien and S. Engerman, 'Exports and the Growth of the British Economy from the Glorious Revolution to the Peace of Amiens', in B. Solow (ed.), *Slavery and the Rise of the Atlantic System* (Cambridge: Cambridge University Press, 1991) 117-210; Cuenca-Esterban, 'The Rising Share of British Industrial Exports' 879-906.

the world's political boundaries between 1660 and 1846. But it is reasonable to surmise that it was Britain - and not France, Portugal, Spain or the Netherlands, let alone China, India or Japan - which obtained an inordinate share of the gains from international commerce in this period of proto-globalization.[53]

A portion of the growth in commerce which generated feedbacks and spin-offs for Britain's transition to an industrial economy occurred because the world economy grew at a faster rate due to the ongoing expansion of the Atlantic economy. This expansion was coupled to the forging of closer connexions between Europe and the Americas, on the one hand, and India, South East Asia, Japan and China, on the other. The British economy appears to have performed exceptionally well during the long upswing in global trade which succeeded the consolidation of the Qing dynasty and the hollowing out of the Mughal empire from the early eighteenth century onwards.[54]

Whiggish historians new and old maintain that progress occurred because Britain's institutions, like the parliamentary system of government and laws framing commodity and factor markets, alongside its enterprising, bourgeois and enlightenment culture, were more hospitable to private investment and innovation. Implicitly, this claim belittles the cultures and institutions that conditioned the development of rival economies in Continental Europe, as well those of the maritime provinces of Qing China, Mughal India and Tokugawa Japan.[55] Research into the economic history of Europe and into perceptions by contemporary European travellers to the British Isles has, however, left us more agnostic about the superiority of British

[53] J. Cuenca-Esterban, 'Comparative Patterns of Colonial Trade: Britain and its Rivals', in L. Prados De La Escosura (ed.), *Exceptionalism and Industrialization. Britain and Its European Rivals 1688-1815* (Cambridge: Cambridge University Press, 2004) 35-69.

[54] A. Gunder Frank, *ReOrient. Global Economy in the Asian Age* (Berkeley: University of California Press, 1998) 63-171; C. Bayly, *Imperial Meridian. The British Empire and the World* (London: Longman, 1989).

[55] C.P. Kindleberger, *World Economic Primacy 1500-1990* (Oxford: Oxford University Press, 1996); J. Mokyr, *The Enlightened Economy*; D. McCloskey, *The Bourgeois Virtues: Ethics of an Age of Commerce* (Chicago: Chicago University Press, 2006).

institutions and culture in determining the pace and pattern of the economic activity before the Industrial Revolution.[56] Furthermore, recent findings on economic worlds of 'surprising resemblances' across a range of advanced regions of Eurasia, which were undergoing Smithian growth in the period, have qualified both neo-Marxist and neo-Weberian views that only certain parts of northwestern Europe had proceeded along the Smithian (or Schumpeterian) trajectories necessary for modern economic development.[57]

Both Britain and the Netherlands certainly appropriated and defended increasing shares of the gains to be reaped from their mercantilistic engagements in global trade and commerce.[58] However, one highly significant contrast between Britain and the Netherlands, among other premodern rivals for a First Industrial Revolution, has been clarified: the former's geographically conditioned but politically sustained fiscal commitment to a naval strategy for the defence of its Island realm. This commitment had unintended but benign consequences for the development of a public-cum-private maritime sector in the British economy. That sector, together with Britain's responsive agriculture and favourable endowments of coal, paved the way for industrialization.

Not long after the Hundred Years' War (1337-1453), when England's feudal armies had ignominiously retreated from centuries of dynastic warfare on the mainland of Europe, the country's kings, aristocrats and merchants began to conceive of naval power - managed by the Crown and funded by Parliament - as the first line of defence against external threats to their wealth

[56] R. Sylla and G. Toniolo, *Patterns of European Industrialization* (London: Routledge, 1991); Riello and O'Brien, 'Reconstructing the Industrial Revolution'; P. Vries, 'Does Wealth Entirely Depend on Inclusive Institutions and Pluralist Politics?', *Tijdschrift Voor Social En Economische Geschiedenis* 9 (2012) 74-93.
[57] K. Pomeranz, *The Great Divergence. China, Europe and the Making of the Modern World Economy* (Princeton: Princeton University Press, 2000). For a survey and critique of the Pomeranz thesis, see P. Vries, *State Economy and the Great Divergence. Great Britain and China* (London: Bloomsbury Academic Press, 2015) and P. O'Brien, *The Economies of Imperial China and Western Europe* (Palgrave, forthcoming).
[58] P. O'Brien, 'Mercantilism and Imperialism in the Rise and Decline of the Dutch and British Economies', *De Economist* 148 (2000) 469-501.

in England. It also furnished the force required for conquest of, and commerce with, territories outside Europe.[59] This strategy took a long time to mature into a constitutional consensus because of instability in the locus of sovereignty and balance of internal power among the realm's aristocratic elites. Political stability emerged only after nearly two centuries of fiscal stasis, malign disputes over religion, persistent acrimony between Parliament and the Crown over rights to levy taxes, and, above all, a refashioning of elite ideology following an interregnum of destructive civil war and republican rule.

After the Restoration of monarchy and aristocracy in 1660, the ruling and managerial elite managed to establish a sufficient degree of consensus to maintain institutional mechanisms for political cooperation and coordination. Thus, undemocratic Parliamentary governance by assemblies of wealthy inter-connected families safeguarded and augmented their property rights. Despite vicissitudes which included a Dutch coup d'état of 1688 and the unavoidable loss of political power over thirteen distant American colonies in 1783, the post-Restoration state became outstandingly successful in raising the funds - in the form of taxes to service loans - required for external security. Thus stability was maintained for a fundamentally *ancien regime*, which protected an established religion and sustained Europe's most egregiously inegalitarian system of property rights. Over time, rights to own, expropriate and exploit natural resources and capital located within the kingdom became increasingly protected and politically coordinated by Britain's envied but unenlightened system of governance. This was the case more so than for any other propertied elite in Western Europe, the Americas, Asia and Africa.[60]

[59] N. Rodger, *The Safeguard of the Sea. A Naval History of Britain,* vol. 1, *600-1649* (London: Allen Lane, 1997).
[60] L. Prados De La Esocoura, *Exceptionalism and Industrialization*; P. Vries, *State, Economy and the Great Divergence: Great Britain and China* (London, Bloomsbury Academic, 2015); J. Hoppit, 'Compulsion, Compensation and Property Rights in Britain, 1688-1833', *Past and Present* 210 (2011) 93-128; J. Hoppit, 'The Nation, the State and the First Industrial Revolution', *Journal of British Studies* 50 (2011); J. Hoppit, 'Political

Exceptional levels of external security, stability and good order supplied by Britain's monarchical and aristocratic regime for its wealthier citizens rested ultimately upon the country's rapidly expanding fiscal and financial base. Between 1670 and 1815, total revenues from taxes rose seventeen-fold, while national income increased by a multiple of three. The bulk of these appropriations formally sanctioned by Parliaments of 'notables' were allocated by central government to service a national debt, incurred to fund no less than eleven wars against other European powers and economic rivals, at the vanguard of whom were France, Spain and the Netherlands.[61] From a nominal capital of less than £2 million in the reign of James II (1685-88), Britain's national debt grew to reach the astronomical sum of £854 million in 1819, equivalent to 2.7 times national income. The share of taxes devoted to servicing what a majority of taxpayers regarded as an incubus of royal-cum-public debt jumped from an average of 2-3% before the Glorious Revolution to 60% after the Napoleonic War.[62] Castlereagh and other European statesmen who signed the Treaty of Vienna in 1815 were acutely aware of the costs of geopolitical strife. Yet what was now the United Kingdom of England, Wales, Scotland and Ireland enjoyed virtually complete security from external aggression and, in the course of a century and a half of prolonged mercantilist rivalry and warfare, had engrossed an extraordinary portion of world trade and income by servicing global commerce and the largest European empire since

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Power and Economic Life', in R. Floud et al (eds), *Cambridge Economic History of Modern Britain*, vol. 1, *1700-1860* (Cambridge: Cambridge University Press, 2004), ch. 12; P. Gauci (ed.), *Regulating the British Economy, 1660-1850* (Farnham, 2011); N. Zahedieh, 'Regulation rent seeking and the Glorious Revolution in the English-Atlantic Economy', *Economic History Review* 63 (2010) 865-90.

[61] J. Brewer, *The Sinews of Power: War, Money and the English State 1688-1783* (London: Unwin Hyman, 1991); A. Page, *Britain and the Seventy Years War 1744-1815* (Palgrave, Macmillan: Basingstoke, 2015); R. Torres-Sanchez (ed.), *War, State and Development. Fiscal Military States in the Eighteenth Century* (Pamplona: Universidad de Navarra, 2007); D. Ormrod (ed.), *War, Trade and the State. Anglo-Dutch Conflict 1652-89* (Woodbridge, Boydell Press, 2020).

[62] P. O'Brien, 'The Political Economy of British Taxation 1660-1815', *Econ. Hist. Rev.* 42 (1988) 1-32.

Rome. In 1815, the realm's domestic economy was also in the midst of a First Industrial Revolution.[63]

To thrive in a mercantilist order riven with dynastic, imperial and economic rivalries, the maritime state had allocated considerable resources to preclude invasion, maintain internal stability and retain its advantages over other, equally violent European powers. Geopolitical conditions formed the parameters within which state formation, institution-building and macro-economic growth occurred.[64] For the age of mercantilism, post hoc counterfactual analyses by economists of yesteryear - concerned with competitive equilibria 'distorted' by taxation and, more recently, with theoretically ambiguous and unmeasurable 'crowding out' effects flowing from high levels of government borrowing - look like anachronistic exercises in applied econometrics.[65] They are surely irrelevant for understanding a state that had raised and allocated resources which carried the kingdom and its economy to a plateau of safety, political stability and potential for future development at the Congress of Vienna. Nobody at the time or since has elaborated alternative strategies which combined industrialization with security for the realm and internal order. Comparison of Britain's maritime strategy with those pursued by rival European powers leads to the inescapable view that, in a mercantilist economic order, state taxation and expenditures to support its priorities were virtually unavoidable. Modern criticisms of this strategy, based on the assumption that more liberal, less costly and potentially

[63] P. O'Brien, 'Fiscal Exceptionalism: Great Britain and its European Rivals from Civil War to Triumph at Trafalgar and Waterloo', in D. Winch and P. O'Brien (eds), *The Political Enemy of British Historical Experience 1699-1914* (Oxford: Oxford University Press, 2002) 246-65.
[64] N. Voigtlander and H-J. Voth, 'The Three Horsemen of Riches, Plague, War and Urbanization in Early Modern Europe', *Review of Economic Studies* 80 (2013) 774-811.
[65] J. Glete, *War and the State in Early Modern Europe* (London: Routledge, 2002); A. Monson and W.Scheidel (eds), *Fiscal Regimes and the Political Economy of States* (Cambridge: Cambridge University Press, 2015).

successful policies were conceivable, are too anachronistic for historians to consider.[66]

The costs incurred to support geopolitical security and economic power can be discerned from tabulations of the state's persistently high levels of expenditure on the Royal Navy.[67] They originated with the Republic (1649-60). Thereafter they provided the kingdom with the world's largest fleet of battleships, cruisers and frigates, manned by coerced and underpaid seamen, and commanded by a highly motivated and well rewarded corps of professional officers.[68] Britain's fleet was, moreover, constructed and maintained in readiness for multiple missions at sea by an onshore workforce of skilled shipwrights, carpenters and other artisans. The Navy was supported by an infrastructure of ports, harbours, dockyards, stores for victuals and spare parts, ordnance depots and other facilities under coordinated public and private ownership and control.[69]

This huge fleet and extensive infrastructure of human and physical capital operated primarily to keep ships of the line at sea as the first bastion for defence of an island realm. At the same time, and at falling average cost, the state deployed its cruisers, frigates and other well-armed ships on mercantilist missions for the protection of Britain's trade and colonies; for predation on competitive and potentially hostile merchant marines; and for

[66] P.K. O'Brien, 'The formation of states and transitions to modern economies: England, Europe and Asia', in L. Neal and J.G. Williamson (eds), *The Cambridge History of Capitalism*, Vol 1 (Cambridge: Cambridge University Press, 2014) 357-403.
[67] *Parliamentary Paper 1868-69* (XXXV); C. Chandaman, *English Public Revenue 1660-88* (Oxford: Oxford University Press, 1975); F. Dietz, *English Government Finance 1458-1641* (New York: Frank Cass, 1964).
[68] N. Rodger, *The Command of the Ocean. A Naval History of Britain, vol 2 1649-1815* (London: Allen Lane, 2004).
[69] R. Morris, *Naval Power and British Culture. Public Trust and Government Ideology* (Aldershot: Ashgate, 2004); R. Morris, *The Foundations of British Maritime Ascendency* (Cambridge: Cambridge University Press, 2011).

the actual or threatened bombardment of enemy coastal cities and colonies.[70] This evolving maritime strategy in effect combined defence with trade and growth. It embodied all kinds of attendant and unintended spin-offs which promoted internal order, enhanced property rights and extended domestic as well as colonial and foreign markets. Ships of the line, for example, provided as floating fortresses external security at a relatively high level of efficiency compared with mobilizing large European armies, which had to be recruited, mobilized, equipped, supplied with food and forage, and moved overland to battlegrounds, places of siege and vulnerable borders to repel enemy attacks.[71]

An efficient offshore strategy for defence also allowed the British state to sustain remarkably high levels of military expenditure.[72] Paradoxically, expenditure on armies between 1688 and 1815 by a regime which was committed to naval power amounted to an average of 60% of the total allocated to its military forces.[73] Part of Britain's military expenditure included the costs of hiring regiments of Hanoverian, Swiss, Hessian and other mercenaries for combat outside the kingdom. Part consisted of subsidies to European allies willing to field forces to contain and thwart the plans of France and other enemies for Europe, India and the Americas. And part, the most politically contentious, was due to the commitment of English forces, supplemented by relatively cheap Celtic troops, to theatres of war in Continental Europe, notably in 1702-12 and 1808-15. These military

[70] D. Baugh, 'The Eighteenth Century Navy as a National Institution', in J.R. Hill (ed.), *The Oxford Illustrated History of the Royal Navy* (Oxford: Oxford University Press, 1995) 120-60; Page, *Britain and the Seventy Years War*.
[71] R. Harding, *The Evolution of the Sailing Navy 1509-1815* (Basingstoke: Macmillan, 1995) and J. Landers, *The Field and the Forge. Population, Production and Power in the Pre-Industrial West* (Oxford: Oxford University Press, 2003).
[72] P. O'Brien and P. Hunt, 'England 1485-1815', in R. Bonney (ed.), *The Rise of the Fiscal State in Europe, c. 1200-1815* (Oxford: Oxford University Press, 1999) 53-100.
[73] *Parliamentary Paper 1868-69* (XXXV); J. Ventura and H-J. Voth, 'Debt into Growth', *National Bureau of Economic Research Working Paper* 21280 (2015) 1-29.

expenditures on Britain's clients, allies and Celtic subjects hampered the Bourbon regimes of France and Spain, among other antagonists, from allocating the funds needed to construct large enough fleets to challenge the Royal Navy's effective defence of the realm and its interests in overseas trade and investment.[74]

A considerable proporition of the revenue that was surplus to requirement for the Royal Navy was allocated to British regiments, militias, volunteers and yeomanry on stations in the realm. While questionable as a second line of defence against foreign invasions, they were used repeatedly during a potentially unstable period of population growth, industrialization and urbanization to preserve an aristocratic regime against subversion on its Celtic fringes and to protect English hierarchy and property rights.[75]

From time to time, prospects for internal trade within a less than united kingdom were threatened from those seditious provinces of Scotland and especially Ireland where a colonized Catholic population resented 'English' property rights and the metropole's discriminatory regulation of commerce and industry.[76] Once external security had been ensured, other public goods - in particular, stability, good order, maintenance of property rights, support for authority over potentially unruly labour - became a key concern of landowners, merchants, farmers, industrialists and other businessmen of Hanoverian Britain. The kingdom's monarchical and aristocratic state on the whole assuaged their concerns. When lobbied, it redefined legal rights for new forms of wealth by promulgating statutes for a national economy. These superceded custom and common law which might otherwise have been used to provide

[74] D. Baugh, 'Great Britain's Blue Water Policy 1689-1815', *Int. Hist. Rev.* 10 (1988) 33-58.
[75] J. Cookson, 'Service Without Politics? Army, Militia and Volunteers in Britain during the American and French Revolutionary Wars', *War in History* 10 (2003) 381-97; P. O'Brien, 'The State and the Economy 1688-1815', in R. Floud and D. McCloskey (eds), *The Economic History of Britain since 1700* (Cambridge: Cambridge University Press, 1994) vol. 1, 205-41.
[76] L. Cullen, *An Economic History of Ireland since 1660* (London: Batsford, 1987).

greater protection for the welfare of those without assets, status and power who were threatened by the market forces associated with industrialization and the modernization of agriculture. The Elizabethan poor law is a case in point. Its institutions for dealing with poverty, unemployment, vagrancy and migration maintained a repressive system of control over the labour of children, females and unskilled men.[77] As for less vulnerable artisans and industrial workers (especially those who courageously formed 'combinations' to challenge what they perceived to be adverse changes to a traditional and more moral economy), Parliament prescribed harsh punishments. This included punishments for the formation of unions, riots against prices of basic necessities, resistance to enclosures and turnpikes, attacks upon mills, barns, factories and labour saving machinery, and insubordinate and disorderly conduct. Furthermore, attitudes to every kind of theft became increasingly subject to capital punishment.[78]

Parliament's antipathies to large standing armies in times of peace looks like Whig rhetoric because on a per capita basis the actual numbers of troops, in the form of militiamen and patriotic volunteers, in Britain and Ireland year after year appear to have been more than adequate to repress disturbances to the peace. For maintaining political stability, ensuring internal order, protecting property and upholding hierarchies of all kinds, it is not obvious that Britain's Parliamentary government commanded a smaller or less coercive armed force than the so-called 'despotisms' of mainland Europe. Parliament deployed armies not capital-intensive navies to defend their more vulnerable frontiers. Famously, E. P. Thompson noted that in 1808 the numbers of soldiers mobilized to combat Luddites in the Midlands and North of England exceeded

[77] J. Humphries, *Childhood and Child Labour in the Industrial Revolution* (Cambridge: Cambridge University Press, 2010).
[78] J. Rule, *Albion's People. English Society 1714-1815* (London: New York: Longman, 1992); E. P.Thompson, *The Making of the English Working Class* (London: Harmsworth, 1967).

the number of troops under Wellington's command in the Peninsular. The state had virtually no police at its command, but the Navy allowed the political authorities of Hanoverian Britain - at central, county and local levels - to allocate less of their tax revenues to external security. That left more to fund an effective armed presence and their exemplary displays to maintain good order, secure property and preserve authority among a population becoming more urban and potentially dangerous. Britain's 'ungovernable people' were eventually subjugated and cajoled into the culture of deference and xenophobia that characterized Victorian society.[79]

Stage Two: Technology. Discovery and Innovation after the Seven Years' War

Traditionally, the invention and diffusion of the familiar list of machines, energy converters and industrial processes defined as the prime movers of the national economy's precocious transition were represented as 'English'. More recent scholarship has situated them differently. In so doing, their significance for global history has been reconfigured, but possibly obscured. This historiographical shift has occurred in the wake of cliometric analyses seeking to elucidate trends in total factor productivity. These trends imply that the First Industrial Revolution can no longer be represented as a short, sharp discontinuity based upon fundamental breakthroughs in industrial technologies emanating from, and developed within, a singularly progressive Anglo-Saxon culture and set of institutions.[80] While several new technologies

[79] J. Brewer and J. Styles (eds), *An Ungovernable People: the English and their Law in the Seventeenth and Eighteenth Centuries* (London: Hutchinson, 1980); C. Emsley, *Crime and Society in England 1750-1900* (Longman: London, 1987); Cookson, 'Service without Politics'; B. Hilton, *A Mad, Bad and Dangerous People. England 1783-1846* (Oxford: Clarendon Press, 2006).

[80] For debate on the numbers, see M. Berg and P. Hudson, 'Rehabilitating the Industrial Revolution', in *Econ. Hist. Rev.* 45 (1992) 269-35; P. Temin, 'Two Views of the British Industrial Revolution', *Jnl. Econ. Hist.* 57 (1997) 63-83; N. Crafts and K. Harley, 'Output Growth and the British Industrial Revolution: a Restatement of the Crafts-Harley View', *Econ. Hist.Rev.* 45 (1992) 703-30; N. Crafts and K. Harley, 'Simulating the Two Views of the Industrial Revolution', *Jnl. Econ. Hist.* 60 (2000) 819-41. For the very latest set of figures that await critical

did emerge and mature in Britain during the eighteenth century, their impact was confined to particular sectors of industry (namely, cotton textiles, metallurgy, shipbuilding, transportation and steam power). Furthermore, the technologies and organizations that became first wonders and eventually the marks of a modern economy - such as heavy machinery, steam engines, chemicals and factories - matured rather slowly over the century of so-called 'revolutionary transition' after 1756.[81]

Cliometric calibrations that claim to account quantitatively for the sources of British economic growth are derived from efforts by econometricians to 'fit' production functions to extant but contested data and to weight shares of increments to national outputs in terms of inputs of land, labour and capital. *Prima facie* this work reveals the persistence of an entirely traditional, gradual and extensive form of aggregate growth in GDP per capita. Apparently, its main source was the somewhat higher rates of capital accumulation and upswings in the scale and hours worked by a labour force undergoing structural change, rather than technological innovations or even new sources of energy per se.[82] Admittedly, these taxonomic exercises provide historical perspective and quantify the significance of the *proximate* sources behind the growth of Britain's domestic product.[83] However, they tend to ignore the historical contexts and conditions leading to the discovery and

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scrutiny from an audacious but laudable attempt to construct annual estimates for GDP per capita 1270-1870, see Broadberry et al, *British Economic Growth*.

[81] C. MacLeod, *Heroes of Invention, Technology, Liberalism and British Identity 1750-1914* (Cambridge: Cambridge University Press, 2007).

[82] N. Crafts, 'Productivity Growth in the Industrial Revolution: a New Growth Accounting Perspective', *Jnl. Econ. Hist.* 64 (2004) 521-35; N. Voigtlander and H.J. Voth, 'Why England? Demographic Factors structural change and physical capital accumulation during the Industrial Revolution', *Journal of Economic Growth* 11 (2006); Broadberry et al, *British Economic Growth*. Clark's data are utilized to support his definition of an Industrial Revolution that begins with a clear discontinuity in the growth of factor productivity. See G. Clark, 'The Industrial Revolution', P. Aghion and S. Durlaf (eds), *Handbook of Economic Growth* (Amsterdam: North Holland, 2013), vol. 2, 217-62.

[83] J. Mokyr, 'Accounting for the Industrial Revolution', in Floud and Johnson (eds), *Cambridge Economic History of Modern Britain* (2004) 1-27.

diffusion of technologies which created prospects for long-run and sustained upswings in rates of growth.[84]

Inventions and their dispersion have historically occurred in many regions of a connected, though unintegrated, Eurasian Oikumene. The British case is an instance of that. After protracted debate over relevant models and acceptable statistics, economic historians now take more account of the quality of data at their disposal in order to study reciprocal interactions between potentially profitable opportunities provided by the appearance of new process and products, on the one hand, and the investment required for their development and exploitation, on the other. They have also reoriented their analyses and measurement towards the sources of *incremental additions* to the traditionally low rates of growth in real per capita incomes. Recent statistical exercises suggest that Britain's potential for technical progress - already present in the realm during the lifetimes of Newton, Newcomen and Kay - reached a high point around the time of the Victorian boom (1846-73). Its influence on the growth of the economy could then be retrospectively perceived and quantified as highly significant.[85] Thus, without the early discovery, gradual development and slow take-up of technologies and improved modes of organization that augmented capital-labour ratios and raised the range and density of skills embodied in the workforce, the British economy would never have become the world's locus for technological innovation.[86]

[84] B. A'Hearn, 'The Industrial Revolution in a European Mirror', in R. Floud et al (eds), *The Cambridge Economic History of Modern Britain*, vol. 1, 1-53.
[85] J. Madsen et al, 'Four Centuries of British Economic Growth: The Roles of Population and Technology', *Journal of Economic Growth* 15 (2010), 263-90; Tepper and Boroweicki, *Accounting for Breakout*; J. Mokyr, *A Culture of Growth* (Princeton: Princeton University Press, 2017)
[86] Allen, *The British Industrial Revolution in Global Perspective*; Broadberry et al, *British Economic Growth*; N. Crafts, 'The First Industrial Revolution: Resolving the Slow Growth/Rapid Industrialization Paradox?', *Jnl. of European Ec. Assocn.* 3 (2005) 525-34.

To understand the early stages of innovation, which later became a dominant driver for British industry, the role of technology needs, however, to be situated in a longer and more complex chronology than those suggested by discontinuities in the rates of growth of total factor productivity. Historians have long recognized the confined scope for transformation for many sectors of the British economy, including its manufacturing industry. Older economic histories dealing with industries other than cotton textiles and iron reveal the decades taken and costs incurred to develop and adapt blueprints for invention. Protracted periods of learning by doing were required before original and promising designs matured into marketable machines, processes and commodities.[87] The forward planning and investment took many years to bear fruit. Firms in Britain's industrial towns and maritime cities had to be linked to suppliers of raw materials via transportation and distribution networks in order to allow entrepreneurs to realize external economies of scale and agglomeration. The investments required to relocate and train workers and set up production in factories were a large multiple of the original outlays borne by inventors and their patrons supporting research and development into potentially useful and commercially viable knowledge in the first place.[88]

As pioneers in the exploitation of novel industrial products and processes, British investors and entrepreneurs lacked templates which distilled experience from the past or from elsewhere. They also lacked access to systemic and scientific knowledge of how, where and why things work, which later in the nineteenth century revealed the problems, ramifications and

[87] R. Church and A. Wrigley (eds), *The Industrial Revolution* (Oxford: Oxford Blackwells, 1994), vols 8-10.
[88] V. Ruttan, *Technology, Growth and Development: An Induced Innovation Perspective* (Oxford: Oxford University Press, 2001) part 2; C. Freeman, 'History as Evolution and Economic Growth', *Industrial and Corporate Change* 28 (1991) 1-44; Roger Morriss, *Science, Utility and British Naval Technology, 1793-1815: Samuel Bentham and the Royal Dockyards* (Routledge, 2021).

promise of untried methods of production and new commodities more rapidly and at lower cost.[89] Furthermore, the direct support from Hanoverian businessmen for realising the potential of the knowledge already available by the middle of the eighteenth century does not, with hindsight, appear to have been notably 'entrepreneurial'. Considered as a national group, British capitalists promoted and managed one of the slowest and, for the working classes, more miserable transitions to an industrial economy in global history.[90]

Subsequent, faster and often less socially malign industrial revolutions were marked by higher rates of saving and investment, and a more rapid take up of advance technology.[91] Compared to follower countries, British average and marginal propensities to save and invest in the capital required for industralization does not look impressive.[92] The slow rise in domestic capital formation for exploiting new technologies cannot be excused, as some economic historians have argued, by the massive sums of investible funds borrowed by the state for wars against France, Spain, the Netherlands, the United States and other rivals. Between 1652 and 1802, Britain was engaged in eleven conflicts which might, in theory, have 'crowded out' some of the potential for higher rates of private capital formation. Yet the overall impact of the virtually unavoidable strategic decisions to accumulate sovereign debt in order to facilitate warfare might have been beneficial for structural change. Comparisons of the real rates of interest received by investors in low risk government securities floated on the London capital market in wartime and

[89] J. Mokyr, *Gifts of Athena: Historical Origins of the Knowledge Economy* (Princeton: Princeton University Press, 2002); M. Jacobs, *The First Knowledge Economy. Human Capital and the European Economy 1750-1850* (Cambridge: Cambridge University Press, 2014).
[90] R. C. Allen, 'Engels Pause; Technical Change, Capital Accumulation and Inequality in the Industrial Revolution in Explorations', *Economic History* 46 (2009); Riello and O'Brien, 'Reconstructing the Industrial Revolution'; Jacob, *The First Knowledge Economy*.
[91] C. Feinstein and S. Pollard (eds), *Studies in Capital Formation in the United Kingdom 1750-1820* (Oxford: Oxford University Press, 1988).
[92] Allen, 'Engels Pause'.

peacetime years does *not* suggest that the growth of the British economy was seriously constrained by capacities to save. On the contrary, the overall supply of investible funds during three major wars (1756-1763, 1776-83, 1793-1815) appears to have been responsive to additional demands from a state selling secure, attractive paper assets to on both domestic and international capital markets. Moreover, wartime borrowing also promoted the development of financial intermediation, the integration of a national capital market and the rise of London as the financial centre for the investment of foreign capital.[93]

So analyses shaped by notions that loans to the state are at the expense of private investment neglect the advantages and incentives for investment provided by high rates of expenditure by the state upon external security, and the protection of commerce and colonization overseas. Unfortunately, balance sheets displaying the costs and benefits flowing from expenditures upon these public goods seem impossible to construct. Given that relatively high levels of expenditure on the army and navy were preconditions for state formation and the preservation of British institutions, the hypothesis is more usefully reformulated as a question: what proportion of the taxes and loans devoted to external security and internal stability were 'unnecessary and wasteful' appropriations and allocations? Few mercantilists of the period argued that the depressing effects on private savings and investment stemming from the operations of the country's fiscal and financial system exceeded the benign effects of 'crowding in' investments, which in their eyes depended upon the

[93] P. O'Brien, *Contributions of Warfare with Revolutionary and Napoleonic France*; Prados De La Escoura, *Exceptionalism and Industrialization*, 35-69; N. Palma and P.O'Brien, 'Danger to the Old Lady of Threadneedle Street. The Bank Restriction Act and the Regime Shift to Paper Money, 1797-1821', *European Review of Economic History* 37 (2019) 1-37; J. Ventura and H-J. Voth, 'Debt into Growth. How Sovereign Debt Accelerated the First Industrial Revolution', *N.B.E.R. Working Paper* 21280; A. Digby (ed.), *New Directions in Economic History and Social History* (Basingstoke: Macmillan, 1992) 37-48.

effective provision of security abroad and domestic order.[94] Adam Smith certainly appreciated that defence came before opulence and that unilateral withdrawal from the prevailing geopolitical world was never an option for an Island polity - or, historians might add, a counterfactual worth pursuing. [95]

Once expenditures by the state are reconfigured as necessary, or at least unavoidable, for macroeconomic growth then (again in retrospect) the development and take-up of advanced technologies and urban systems of agglomerated production by businessmen and investors cease to be anything like as entrepreneurial or remarkable as has been maintained in Anglo-American historiography.[96] During the period, most classical economists recognized that there was nothing especially 'progressive' about the country's aristocratic and wealthy elites. A majority of the British owners and controllers of property rights - to, in particular, cultivable land, sub-soil minerals, urban real estate, transportation systems, commercial distribution networks, and industrial buildings, plants and machinery - reinvested fairly low proportions of the rents which accrued to them from industrialization and the urban agglomeration of economic activity. Predictably, generations of patriotic historians undertaking research into Britain's agriculture, commerce and industry based on the records of firms and biographies of exceptional men of wealth have published a library of case studies which suggest otherwise. But their scholarship gives an overly favourable impression of British landowners, farmers, merchants, industrialists, bankers, professional experts and others

[94] R. Stern and C. Wennerlind (eds), *Mercantilism Re-Imagines. Political Economy in Early Modern Britain and its Empire* (Oxford: Oxford University Press, 2013); P. Vries, *State, Economy and the Great Divergence*; and T. Hutchison, *Before Adam Smith. The Emergence of Political Economy* (Oxford: Oxford University Press, 1988).
[95] K. Tribe, 'Mercantilism and Economics of State Formation', in L. Magnusson (ed.), *Mercantilist Economics* (Boston: Kluwer, 1993).
[96] Rates of diffusion could conceivably be, but imperfectly, captured by records of applications for patents. See C. Macleod, 'Patents for Invention? Setting the Stage for the British Industrial Revolution?', *Empiria, Revista de Metologia de ciencas sociale* 18 (2009) 37-58; A. Nuvolari, 'Patents and Industrialization – An Historical Overview 1624-1907', *Strategic Board on Intellectual Property Policy* (unpublished paper, 2010).

with surplus incomes to save and invest. British capitalists did not manifest a national *geist* or *kopf* for risk-taking and improvement markedly different from the cultures of their counterparts on the mainland of Europe.[97]

There are of course numerous instances of commendable foresight, perseverance, innovation and entrepreneurship in the rich historiography of the First Industrial Revolution.[98] However, esearch by the current generation of economic historians has resituated business history so as to draw on the potential insights from macroeconomic modelling and cliometrics. Their findings have seriously qualified, if not degraded, the notion that the culture of business in the British Isles was exceptionally enterprising.[99] Statistically validated arguments now suggest that the Industrial Revolution, if considered retrospectively as a macroeconomic event for a favourably endowed polity expanding into a larger and growing world economy, was nowhere near as enlightened, bourgeois or virtuous as maintained in some recent texts.[100]

This modern, cliometrically-informed view is a post hoc but defensible representation because nothing in the macroeconomic data currently available indicates that: (a) rates of return accruing to owners of property declined during the Industrial Revolution; (b) gains from investment in the capital formation required for faster and more extensive industrialization and related urbanization were eroded by rises in real product wages; or (c) warfare was anything other than an integral part of the broader historical process. On the contrary, macroeconomic trends appear to have promoted higher rates of

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[97] G. Stedman-Jones, *An End to Poverty. A Historical Debate* (London: Profile Books, 2004); E. Rothschild, 'The English Kopf', in D. Winch and P. K. O'Brien (eds), *The Political Economy of British Historical Experience* (Oxford: Oxford University Press, 2002).

[98] F. Crouzet, *The First Industrialists. The Problems of Origins* (Cambridge: Cambridge University Press, 1985); McCloskey, *Bourgeois Virtues*.

[99] Allen, *The British Industrial Revolution*.

[100] On domestic market integration, see V. Bateman, 'Markets and Growth', in *Early Modern Europe* (London: Pickering and Chatto, 2012); Mokyr, *Enlightened Economy*; McCloskey, *Bourgeois Dignity. Why Economics Can't Explain the Modern World* (Chicago: Chicago University Press, 2010).

saving, investment and innovation in Britain. Thus, after falling below average during the recession in economic activity at the time of crisis and war with the Thirteen Colonies in North America, modal rates of return on all forms of capital other than agricultural land had doubled before the mid-nineteenth century (notwithstanding cyclical fluctuations). Even rents from farmed land, the sector in relative decline, rose by nearly 50%. As for real wages in the century following the Seven Years' War, they passed through three cycles - slow improvement (*ca* 1761-1800), virtual stasis (1800-20) and upswing (1820-51) - at the end of which they were only 45% above the level of a century before.[101] Meanwhile, labour productivity had followed a different trajectory; it exhibited a faster rate of increase to reach a level 87% higher than its base line average.

Classical features of all industrial revolutions - notably, higher rates of growth in labour productivity emanating from general purpose technologies, combined with increasing returns derived from the agglomeration of production in towns - probably became more evident during The First Industrial Revolution than they had been during Italian and Dutch Golden Ages, or earlier efflorescences.[102] Yet considered globally, British industrialization seems to have been marked by a uniquely gradual rate of change, a slow adoption of new technology and a deplorably low rate of investment in the housing and infrastructures of towns required to support a more rapid but less immiserising transition to urban industrial society.[103]

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[101] Allen, 'Engles Pause'. For Clark's data, see G. Clark, *A Farewell to Alms* (Princeton: Princeton University Press, 2007); Feinstein, 'Pessimism Perpetuated: Real Wages and the Standard of Living in Britain during and after the Industrial Revolution', *Jnl. Econ. Hist.* 38 (1998) 625-58.

[102] J. L. Van Zanden, *The Long Road to the Industrial Revolution. The European Economy in Global Perspective* (Leiden: Brill, 2012); Goldstone, 'Efflorescences and Economic Growth in World History'.

[103] M. Daunton, *Progress and Poverty. An Economic and Social History of Britain 1750-1850* (Oxford: Oxford University Press); N. Crafts, 'British Industrialization in an International Context', *Jnl. of Interdisciplinary Hist.* 19 (1989) 415-28.

These features of the First Industrial Revolution, rather than machinery and factories, provoked condemnations from visitors from Continental Europe and from previous generations of British reformers and social historians.[104] The jack-up in investment rates and social amelioration took a long time to emerge. For decades after the Revolutionary and Napoleonic wars, aristocratic governments refused to help. They continued to protect their own interests in Britain's commerce and its extended empires overseas. Average real wages (and aggregate demand) increased slowly and the polity's elites, with enviable capacities to save, reinvested only small proportions of their rising share of the 'rentier type' income from stakes in inherited ownership of land and urban property rights.[105] Commendable examples of enterprise associated with the riskier and innovatory investments in industry and commerce which appeared during the period testify to the entrepreneurship of some Britons. However, their achievements must be conceived and debated within macroeconomic frameworks recently constructed by Allen, Clark, Crafts, Harley, Humphries, Mokyr, Ogilvie and other cliometricians. Their work has, in effect, reconfigured the Industrial Revolution as a precocious, but unremarkable and rather predictable, transition in the long global history of knowledge formation.[106]

Very few economic historians now regard British industrialization as a paradigm for ready emulation elsewhere, or claim that the current levels of labour productivity achieved by the world's market economies today would look different but for the economic transformation wrought by Britain

[104] J. and B. Hammond, *The Town Labourer, 1710-1832* (London: Longmans, 1925); Humphries, *Childhood and Child Labour*; Riello and O'Brien, 'Reconstructing the Industrial Revolution'.
[105] O'Brien, 'Aristocracies and Economic Progress under the Ancien Regime', in P. Janssens and B. Yun-Casalilla (eds), *European Aristocracies and Colonial Elites* (Aldershot: Ashgate, 2005).
[106] Voigtlander and Voth, 'Why England? Demographic Factors, Structural Change and Physical Capital Accumulation during the Industrial Revolution'; G. Clark, 'The Industrial Revolution'.

between 1763 and 1846.[107] Furthermore, another reason for the decline in the historiographical status of the First Industrial Revolution arises from the realization that the technological innovations which appeared in Britain during this period can be plausibly linked to an evolving base of scientific knowledge. Importantly, the accumulation of this potentially exploitable knowledge has been depicted as Eurasian in its remote origins and European in its proximate origins.[108] Britain's advantages lay more in the development, improvement and diffusion of technologies than in their discovery. [109]

Some historians continue to argue, however, that in a European perspective - and, more credibly, in a perspective which includes Asia - British 'culture' became more receptive to an intermingling of science, business, religion and politics than was true elsewhere. [110] Empirical studies of contexts for the discovery and diffusion of useful and reliable knowledge in France, Italy and Iberia have undermined assertions that the monarchical, aristocratric, ecclesiastical and especially military elites on the European mainland were less 'rational' and less open to the potentialities of scientific knowledge than their British counterparts.[111] This debate feels like a hangover from the scholarly

[107] But see Landes, *The Wealth and Poverty of Nations*; idem, *The Unbound Prometheus. Technological Change and Industrial Development in Western Europe from 1750 to the Present Day* (2nd edn, Cambridge: Cambridge University Press, 2004); Acemoglu et al, *Why Nations Fail.*

[108] A. Bala. *The Dialogue of Civilizations in the Birth of Modern Science* (Basingstoke: Palgrave Macmillan, 2006); A. Pacey, *The Maze of Ingenuity Ideas and Idealism in the Development of Technology* (Cambridge: Mass., M.I.T. Press, 1994); B. Bunch and A. Hellmans, *The History of Science and Technology, 1455-1999* (New York: Houghton Mifflin, 2004); J. Madsen and F. Murtin, 'The Mechanics of Economic Development in Britain since 1270: The Role of Great Scientists and Education,' *Journal of Economic Growth* 22 (2017) 229-72.

[109] J. Mokyr, *The Lever of Riches: Technological Creativity and Economic Progress* (Oxford: Oxford University Press, 1990); Prados de la Escosura, *Exceptionalism and Industrialization*.

[110] D. Wootton, *The Invention of Science* (London: Penguin, 2015); W. Clark et al. (eds), *The Sciences in Enlightened Europe* (Chicago: Chicago University Press, 1999); L. Hilaire-Perez, *L'invention technique au siècle des lumieres* (Paris: Albin-Michel, 2000). For a dissenting view, see Jacob, *The First Knowledge Economy.*

[111] J. Brooke, *Science and Religion. Some Historical Perspectives* (Cambridge: Cambridge University Press, 1991); K. Davids, *Religion, Technology and the Great and Little Divergencies* (Leiden: Brill, 2013); P. O'Brien, 'Cosmographies for the Discovery, Development and Diffusion of Useful and Reliable Knowledge in Pre-Industrial Europe and Late Imperial China. A Survey and Speculation', *LSE Department of Economic History Working Paper* 289/2019; D. Cantoni, 'The Economic Effects of the Protestant Reformation. Testing the Weber Hypothesis in the German Lands,' *European Economics Association* 13 (2015) 561-98.

controversies over the economic effects of the Reformation, which gave rise to memorable, but unproven, theories positing virtuous connexions between protestantism and entrepreneurship, protestantism and hard work, and protestantism and science (lifted uncritically from Max Weber's and Robert Merton's seminal hypotheses). It is surely difficult to prove that the urban and commercial cultures of Eurasia's maritime cities were discernibly less calculating and utilitarian than the cultures of elites residing in Britain's towns.[112] Although strong claims have been made for the exceptionalism of a British enlightenment, a contrary interpretation of the 'long eighteenth century' in British history as marked by the persistence of an *ancien regime* presided over by an autocratic, aristocratic and confessional state continues to be debated by political historians. Cultural turns, whether by nations, cities or elites, towards progress are indeed challenging to verify, let alone measure.[113]

European visitors in the eighteenth century certainly recognized that British industry was moving ahead in certain sectors defined by new technologies. Indeed, several governments engaged in espionage in order to close the perceived gaps as they opened up, especially for technologies with military implications. British machinery appeared even in Spain before the outbreak of the French Revolution. However, the long stretch of destructive warfare between 1792 and 1815 arrested diffusion to and across the European mainland. Within Europe, technological advances tended to emerge in branches of industrial production which had reached a certain scale and

[112] But contrast the claims of Jacob, *The First Knowledge Economy* with P. O'Brien et al. (eds), *Urban Achievements in Early Modern Europe. Golden Ages in Antwerp, Amsterdam and London* (Cambridge: Cambridge University Press, 2001). For a critique, see C. O'Grada, 'Did Science Cause the Industrial Revolution?', *UCD School of Economics Working Paper* 14 (2014).

[113] R. Porter, *Enlightenment Britain and the Creation of the Modern World* (London: Allen Lane, 2001); J. Clark, *English Society 1688-1832* (Cambridge: Cambridge University Press, 2002); I. Inkster, *Scientific Culture and Urbanization in Industrializing Britain* (Aldershot: Ashgate, 1997).

diversity in production.[114] In some well-known British cases - cotton and bar iron are prime examples - the same development occurred within processes of import substitution. Foreign products pioneered and extended access to the realm's home market. Their popularity among consumers prompted investment by British manufacturers who could rely upon a matrix of protective legislation surrounding domestic commodity and labour markets, as well as naval protection for their sales to consumers residing in imperial territories overseas.[115]

Economic historians appreciate that technological innovation depended to a considerable extent on the prior accumulation of a skilled and mobile workforce of artisans and craftsmen.[116] Nevertheless, it has not been easy to explain how, when and why the British workforce managed to build up the range of aptitudes needed to promote breakthroughs in scientific understanding and technological knowledge and carry them through development to commercial viability. Economics is not particularly helpful in explaining the formation of human capital. Historians, however, have published work on England's urban guilds, tracing their links to the rise, embodiment and maintenance of skills among European workforces.[117] Unfortunately, this programme of research is not yet at a stage where

[114] J. Harris, *Industrial Espionage and Technology Transfer. Britain and France in the Eighteenth Century* (Aldershot: Ashgate, 1997); P. O'Brien (ed.), *The Crucible of Revolutionary and Napoleonic Warfare and European Transitions to Modern Economic Growth* (Leiden: Brill, forthcoming)

[115] P. O'Brien et al., 'Political Components of the Industrial Revolution: English Cotton Textile Industry 1660-1774', *Econ. Hist. Rev.* 44 (1991) 395-42; J. Inikori, *African and the Industrial Revolution in England* (Cambridge: Cambridge University Press, 2002); G. Riello, *Cotton. The Fabric that Made the Modern World* (Cambridge: Cambridge University Press, 2013).

[116] S. Epstein, 'Transferring Technical Knowledge and Innovating in Europe', *Department of Economic History Working Paper* 01-05 (2005) 1-39; M. Prak and S. Epstein, *Guilds, Innovation and Economy in Europe* (London: Routledge, 2008).

[117] P. Wallis, 'Labour Markets and Training', in Floud et al, *Cambridge Economic History of Modern Britain* (2014), 178-201; J. Lerner and S. Stern (eds), *The Rate and Direction of Inventive Activity Revisited* (Chicago: Chicago University Press, 2012); M. Kelly et al, 'Precocious Albion – a new interpretation of the British Industrial Revolution', *Annual reviews of Economics* 6 (2014).

contrasts across the countries, areas and towns of Europe can be discerned, measured and explained.

Even so, it is clear that the contexts for human capital formation were invariably urban. On the British Isles, London, Bristol, Nottingham, Birmingham, Manchester, Glasgow and even Dublin all became important locations for the development of skilled workforces.[118] Immigrant German, Flemish, Dutch and Huguenot craftsmen, merchants and financiers, played important roles in starting and moving forward the process for Britain. Skilled men were attracted from Continental Europe to a kingdom which promised them security from aggression, religious toleration, sovereign protection and occasional subsidies. European merchants with stakes in trade with the Americas, Africa and Asia could be assured of protection by the Royal Navy. They settled and, as part of extended families and diasporas, maintained ties with knowledgeable kith and kin spread across Europe. In an age when the diffusion and adaptation of technology mainly occurred through the migration of experienced manpower, the obvious attractions of a domicile in urban England was reinforced by warfare and religious persecution elsewhere in Europe.[119]

Conclusion. Deconstructing and Reconstructing the First Industrial Revolution

After the Seven Years' War, when England's agriculture and coal mines continued to buttress urbanization, occupational diversification and other structural changes, the economy witnessed gradual growth. The polity eventually reached a plateau of possibilities for an accelerated rate of

[118] C. MacLeod and A. Nuvolari, 'Glorious Times. The Emergence of Mechanical Engineering in Early Industrial Britain', *Brussels Economic Review*, 52 (2009) 215-37; P. M. Jones, *Industrial Enlightenment. Science, Technology and Culture in Birmingham and the West Midlands* (Manchester: Manchester University Press, 2009).

[119] Van Zanden, *The Long Road to the Industrial Revolution.*

economic growth, based increasingly on technological innovation. This second stage of the First Industrial Revolution carried Britain to a position, during the long boom of 1846-73, of clear competitive advantage over the economies of mainland Europe and undoubted material superiority over the agrarian economies of south and east Asia.[120]

That short Victorian period of industrial supremacy had been centuries in the making, and was based to a significant degree on natural endowments, locational advantages and naval power. Investment in, and patronage for, a conjuncture of more rapid growth and structural changes dominated by technological innovation continued to depend upon the political support and wealth of elites, whose education, culture and confidence had become permeated by scientific views of prospects for the manipulation of nature and economic progress.[121] At the same time, as is now evident, it is only because of the long-term accumulation of ideas and experiences embodied in England's urbanized workforce that it was possible to exploit commercially the array of Europe-wide breakthroughs in scientific knowledge, blueprints for production and prototype machinery.[122]

Over the centuries which have been designated in this essay as the foundational first stage, labour, food and fuel were released from the countryside, and a relatively young workforce agglomerated in urban settings. This actively promoted the accumulation of the human capital required for discovery, development and diffusion, which has been demarcated in this essay as the second stage, when growth depended on technological

[120] Vries, *State Economy and the Great Divergence*.
[121] C. O'Grada, 'Did Science Cause the Industrial Revolution?' disagrees, but see Madsen and Fabrice, 'The Mechanics of Economic Development.'
[122] P. O'Brien, 'Historical Foundations for a Global Perspective on the Emergence of a Western European Regime for the Discovery, Development and Diffusion of Useful and Reliable Knowledge', *Journal of Global History*, 8, (2013), 1-24; M. Kelly et al, 'Precocious Albion'; M. Kelly and C. O'Grada, 'Ready for Revolution?', *University College Dublin Workng Paper* 14 (2014).

innovation. For several decades the comparative advantages that the British economy derived from the skills of its urban labour force emanated from men employed in a narrow range of industries, pre-eminently textiles, metallurgy, mining, shipbuilding and civil engineering. Although the polity's mercantilist state did its best to prevent the emigration of such men to rival economies, the attempt failed.[123] In any case, Britain's precocious advantages were destined to pass away through the familiar workings of labour migration and investment in formal and informal systems of technical education elsewhere in Europe.[124]

To enable scholars, publics, politicians and the mass media to appreciate and comprehend the actual significance of The First Industrial Revolution, and of the rapid later convergence of Western Europe into an inter-related and ultimately integrated set of successful industrial market economies, historians have latterly started to examine the British transition within much longer time spans and much wider geographical frames. These have come to embrace Africa, the Americas and Asia, as well as Continental Europe. In keeping with Marshal Hodgson's prescient interpretation, and reinforced by a recently articulated and widely cited thesis of a premodern 'world of surprising economic resemblances', the British Industrial Revolution has been heuristically reconfigured as an early but not particularly remarkable conjuncture in global history. This conjuncture allowed a tiny fraction of mankind to escape from diminishing returns endemic to all traditional economies.

Real growth - florescence's - in labour productivity and incomes per capita had, it is true, occurred in other places and other times for centuries

[123] D. Jeremy, 'Damming the Flood. British Government Efforts to Check the Outflow of Technicians and Machinery', *Business History Review* 51 (1977) 1-34.
[124] M. Berg and K. Bruland (eds), *Technological Revolution in Europe. Historical Perspectives* (Cheltenham: Elgar, 1998); D. Landes, *The Wealth and Poverty of Nations* (London: Little Brown, 1998).

prior to the Seven Years' War.[125] But in each instance natural disasters, geopolitical shocks and Malthusian checks before long condemned these complex, organically based economies to return to stasis or imperceptible rates of growth. Geography ensured that the Britain was predestined to avoid the first of these afflictions. The emergence of a properly funded Royal Navy in the wake of an interregnum of civil war and an interlude of republican rule served to protect Britain from the second. Then, from a high plateau of possibilities, the diffusion of novel technologies and inorganic sources of energy turned out to be sufficient to confound Malthus and produce a First Industrial Revolution.[126] Britain became the first polity to escape from diminishing returns. Western Europe and its European offshoots overseas soon followed.[127]

High and rising standards of living can today be observed in many regions of a rapidly integrating world economy. From the reference point of the early twenty-first century, locating and lauding a First Industrial Revolution matters a lot less than the inequalities associated with capitalism, the North-South divide and the persistence of mass poverty.[128] For solutions to such problems, there is no British paradigm, no distinctively British enlightenment and no need for patriotic histories of a quintessentially British Industrial Revolution. Art historians have shown us that the Florentines are no longer the proud possessors of the Renaissance. Modern Chinese and Japanese scholars pertinently observe neither English (nor European) history can be represented

[125] For an eloquent, but highly polemicized, elaboration of Hodgson's argument, see J. Hobson, *The Eastern Origins of Western Civilization* (Cambridge: Cambridge University Press, 2004).
[126] The confounding of Malthus is the inspiration for Broadberry et al, *British Economic Growth 1270-1870*. Also see the special issue of the *European Review of Economic History* devoted to Clark's *Farewell to Alms*.
[127] Pomeranz, *The Great Divergence.*
[128] T. Piketty, *Capital in the Twenty First Century* (Cambridge, Mass: Harvard, 2015).

as global destiny.[129] Marshal Hodgson declared more than five decades ago that "without the cumulative history of the whole Afro-Eurasian Oikoumene, of which the Occident has been an integral part, the Western Transmutation would be almost unthinkable".[130] British industrialization is not separable from the larger historical, geographical and geopolitical contexts within which it took place.[131] On evaluation, traditional claims for the First Industrial Revolution to be considered a conjuncture in global economic history seem to reside in a short cycle in British economic history when, for causally understandable reasons, the country's craftsmen and scientists made innovative contributions to the world's stock of useful and reliable knowledge.[132]

[129] R. Bin Wong, 'The Political Economy of Agrarian Empire and its Modern Legacy', in T. Brook and G. Blue (eds), *China and Historical Capitalism* (Cambridge: Cambridge University Press, 1999) 210-45; K. Sugihara, 'The East Asian Path of Economic Development: a Long Term Perspective', in G. Arrighi (ed.), *The Resurgence of East Asia* (London: Routledge, 2003).
[130] M. Hodgson, *Rethinking World History* (Cambridge: Cambridge University Press, 1993) 68.
[131] R. Allen, *Global Economic History* (Oxford: Oxford University Press, 2011).
[132] P. O'Brien, *Contrasting Cosmologies for the Development of Science in Pre-Industrial Europe and Late Imperial China* (VSG, forthcoming); Madsen and Murtin, 'The Mechanics of Economic Development.'