Technology and Victorian Economic Domination of the 19th Century World

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This essay explains how superiority over steam transport, telegraph communications, and military technologies, especially when they were integrated, was an important foundation of Britain's economic domination of the world in the long nineteenth century (up to 1914). Despite obvious possibilities presented by the use of new technological innovations for the expansion of the British Empire, considerable continuity characterized the diffusion and application of technologies in imperial activity during the first half of the century. Once the pace of the dynamics of expansion accelerated in the second half of the century, the State in the form of the British Government began to realise the benefits of adopting the latest technologies such as the railway and the telegraph in the service of the Empire, not only or economic, but also for political and military reasons.

From Mercantile to Industrial Capitalism

The history of Victorian Britain is the history of a society which underwent a rapid technological transformation and had to respond to it. The initial cause of many of the changes was connected with the development of steam-driven machines. Until the nineteenth century, machines had always been driven by human, animal, or natural power (e.g. wind or water power), which had set natural limits on productivity. A transfer to cheap and accessible coal together with craftsmanship within a relatively orderly society and an efficient canal transport system created a stimulus that allowed British mills to produce a much higher output than ever before (see Mokyr 1990).
The evolutionary change of steam-powered technology had many effects on early Victorian society.
For instance, technological developments from 1801 to 1817 connected to the invention of the steam-powered printing press allowed for the mass production of newspapers, journals, magazines, reviews, and cheap editions of books; they thus came within the reach of the very poorest members of society and created the first 'journalising' society in the world (i.e. mass media has been interpreted as the ideological environment of the early-Victorian society). Without steam-powered printing presses, it would not have been possible to bring many of these cheap publications into existence (see Sarkka 2021; Shattock & Wolff 1982, xiv).

By the Great Exhibition of 1851 Britain had become the Workshop of the World, producing over 40% of the entire world output of traded manufactured goods, the prominent examples being Manchester piece goods and the metal goods of Birmingham and Sheffield. Respectively over a third of raw material and foodstuff exports of all other countries went to Britain, whose commercial supremacy was not confined to those areas of the globe that were under formal colonial rule. The quest for raw materials for British manufacturing knew no political boundaries but stretched from the Baltic in the form of the timber trade to the tea trade with China (see Hobsbawm 1999).
The British Empire had been built on a system of commercial monopoly. Hence control of India had been extended and strengthened by monopoly privileges granted to the East India Company, the Navigation Acts had helped to secure the Thirteen Colonies, and the Caribbean was dominated by the British slave trade. After loss of the American colonies, and abolition of slavery, Britain turned increasingly to the East, particularly India where Mughal imperial power had effectively been dismantled. During this period, the power of the East India

Company was gradually superseded by the State until the rebellion of 1857 after which the company lost its monopoly status over Indian trade. The conversion of the leading mid-Victorian politicians to the virtues of Free Trade was another reason for the abandonment of the former imperial system which was based on the principles of mercantile capitalism. In this context, the Navigation Acts, which had given British merchants a monopoly of trade with British colonies, came to be seen as an anachronism. Influenced by the Free Trade idea, Britain demanded that all countries should open their trade to every nation without discrimination. Sometimes Britain intervened militarily to secure its demands for trade, with other countries also granting access to their raw materials since they expected the benefits to be mutual. The vast Baltic timber trade provides us with a notable example of the latter pattern of trade (see Ojala & Räihä 2017).

Victorian Britain enjoyed a magnificent naval inheritance which had laid the foundation for its economic domination of the world. The eighteenth century had been a century of prolonged struggle with the French, culminating in the Napoleonic Wars, in which the Royal Navy secured mastery of the oceans. In the absence of any imminent threat, the British Admiralty was slow to adopt the latest steamship technology. It is noteworthy that the heyday of the Royal Navy's expeditions to investigate navigable sailing routes of the oceans of the world lasted more than 30 years after the Napoleonic Wars. These expeditions of the Admiralty, such as Sir John Franklin's ill-famed 1845 Arctic Expedition, relied on strongly built naval artillery vessels *HMS Terror* and *HMS Erebus*, launched in 1813 and 1826 respectively, designed to take the weight and withstand the recoil of large mortars and, in general, to strike fear into the enemy with their daunting firepower, formidable size, and infernal names ('Erebus' signifies the darkness at the entrance to Hell) (Hutchinson 2017, 41). After the government passed the Emancipation Act of 1833, the Admiralty saw the need to modernise its fleet for anti-slavery purposes, so in 1841 the Royal Navy began to replace sailing vessels in the anti-slavery squadron (Kubicek 1999, 249).

By the 1840s, the West had acquired an impressive lead in military technology over all the non-European empires and the main beneficiary was Britain, as the dominant colonial and naval power. The decaying Qing (or Manchu) dynasty (1644–1911/2) was no longer capable of staving off British interference, but in the Opium War of 1839–42 China was forced to increase the number of treaty ports from one (Canton) to five, including Shanghai, and to cede Hong Kong to the British. The first visible sign of the dominance of the new naval technology was a Laird-built iron-hulled paddle wheeler, the *Nemesis*, which was dispatched to the Pearl River to subdue Chinese resistance (Kubicek 1999, 249). In doing so, Britain enabled the local capitalists to drag the Empire into helping to gain access to new markets – an argument that formed the core of the capitalist conspiracy theory of the most notable theorist of imperialism, J. A. Hobson, who first identified imperialism as a direct product of industrial capitalism (see Hobson 1902).

The Expansion of Transport and Communications

Steam transport and the telegraph communications of Victorian Britain were transformed in the first half of the nineteenth century, and the repercussions on global relationships were profound. From the perspective of the global transport network, it was the steamship that most effectively helped to shrink the world. The steamship reduced travelling times and carried passengers, mail, and cargo to and from distant markets. The first steamboat services were coastal lines such as those between Liverpool and Glasgow, and between Dublin and Holyhead. The steamboat was in general use for short sea journeys in the 1820s, and the first ocean steamers fitted with screw propellers were built in Britain in the mid-1840s. By the mid-century, the major long-distance lines were operated by the Great Transatlantic Ocean Liners,

which conducted the passenger and mail traffic from Britain to the North Atlantic, the West Indies, and South America (Carter & Mears 2011, 14).

Before the completion of the Suez Canal in 1869, passengers bound for India boarded in Southampton, where the regular P&O shipping company route went via Gibraltar/Marseilles, Malta, and Alexandria, then overland to Suez and then by another steamer to Bombay. The journey took on average a month; so it took around two months for passengers and mail to travel to India and back (Ahvenainen 2011, 13–14). The only possible sea route to India was around the Cape, a sea voyage of over 12,000 nautical miles that took three months or more in one direction. Unburdened with the tons of coal which steamers had to carry, the sailing ship was an economically more viable vessel than the steamship for the haulage of freight from India, the Far East, or Australia to Britain, especially where it was a question of transporting relatively low value bulk goods such as wheat. Among the last sailing vessels to lose the race to the steamship were the tea clippers, designed to 'clip' through the water at speed (Carter & Mears 2011, 14).

The telegraph, the first invention to bring electricity to the service of people, had a similar effect to the steamship. The development of the telegraph, and especially the undersea cables, gave the government new opportunities to bind the Empire together organizationally, militarily, and commercially. The earliest overhead telegraph lines in Britain were established at the beginning of the 1840s. By the middle of the 1850s telegraphic communication was widely used in Britain, Europe, North America, Australia, and India, where the network extended from Bombay via Agra and Indore to Calcutta. From Agra there was a branch via Delhi to Peshawar, which was an important strategically located border city near the entrance to the Khyber Pass on the border with Afghanistan, the gateway to Central Asia. From Bombay another branch went via Bangalore to Madras (Ahvenainen 2011, 14–15). Thus, by the middle of the century there were several separate telegraph networks, but the system of communication between Britain and its colonies and dependencies still relied on postal traffic carried by steamships.

In considering constructing an undersea cable network, the directions deemed most important for commerce were on the one hand North America and on the other hand India, and, beyond it, the Far East. The first cable under the Atlantic was laid as early as 1858, but it burnt out after only 730 messages had been transmitted (Ahvenainen 1996, 10). The failure of this cable made it clear that the technical problems involved in telegraph communication technology had not been fully understood. The faults were due to the lack of technical experience in the manufacturing of undersea cables, which consisted of multiple-strand copper core, covered with several layers of gutta-percha, wrapped in tarred hemp and protected by steel wires. Even the smallest production defects had major consequences for communication.

The construction and opening of the North Atlantic Cable Line coincided with the peace negotiations of the United States Civil War, and one of the first messages announced that Lincoln had agreed to open peace negotiations with the South in 1865. The message created a panic in Liverpool and Manchester as peace in the United States would have serious economic consequences for merchants trading Indian cotton (The Times, 6 April 1865). The telegraph bound the international capitalist economy together almost in real time, and there was no way of escaping this fact once established.

After the success of the Atlantic cable, there was new optimism about long ocean cables between Britain and India. After the East India Company had lost its governing status, the India Office functioned under the Secretary of the State for India as an executive office of the British Government. Virtually all questions of administrative, economic, or political significance in India were reported through the India Office, which meant that the overall direction of Indian affairs was now concentrated in London. Uniting British and Indian telegraph networks would greatly increase the efficiency of business and colonial administration.

At the time it was estimated that the Turkish Overland Line was the best available alternative for the connection to India, but the telegraph interests of the British Government conflicted with those of the Ottoman Government, especially in the Eastern Mediterranean – another important goal, and which remained beyond the reach of London by means of the telegraph. After difficult negotiations with the Ottoman Government, the building of the line from Khanikin via Teheran to India began in February 1864, and the first telegraphs were transmitted in September of that year. A telegraph between London and Bombay/Calcutta took something between 12 and 16 hours, but the overland line through the Ottoman Empire and Persia proved very difficult to maintain without the adjoining railway network. The lines went through mountainous deserts where the mules and other pack animals provided the only means of transport. These were areas of climatic extremes, in summer extremely hot, in winter freezing cold. In virtue of the state of cable technology, there was the ever-looming possibility of a communication breakdown somewhere down the line. It was impossible to predict how long a message would take: would it arrive in ten hours, in ten days, in a month – or never? The delays caused financial losses and meant that it was always advisable to confirm a message with a letter, which reached its destination with a greater certainty (Ahvenainen 2011, 72, 81–2, 87).
In 1858–9 British engineers had already tried to link Britain to India by way of a cable laid in the Red Sea, but the technology was not yet ready for a successful undersea cable service until the opening on 25 March 1870 of the service for international correspondence. The cable ran from Porthcurno in Cornwall via Carcavelos (near Lisbon), Gibraltar, Malta, and Aden to Bombay. This connection was especially important from the point of view of Indian correspondence. It meant that it was possible to send messages between Britain and India by using cables owned, operated, and maintained by British companies (Ahvenainen 2011, 157–8). Within a few years of its establishment, the telegraph had become so important for communication to India that breaks and other irregularities in the service led to loud criticism, as illustrated by a column in the *Bombay Gazette*: 'The interruption of a day is of serious consequence and people are disposed to commit themselves to transactions of any kind without the latest information being available' (17 December 1875). By 1876 the cables extended to Australia, New Zealand, China, and Japan. New means of communication became a necessity not only for economic but also for political and military reasons. In the absence of the telegraph it took three weeks before news of British military defeat at the Battle of Isandhlwana during the Anglo-Zulu War in South Africa in January 1879 reached Whitehall (Ahvenainen 1996, 60).
In the early 1900s the introduction of the Wheatstone receiver – an automatic system by which the signals could be transmitted by mechanical means as opposed to those in which signals were sent by manually operated keys – greatly increased the speed of the transmission. In 1909 the Wheatstone's normal working speed was 40 words a minute, while transmission time between London and Indian cities was about 20 minutes. Technical development of the wireless also progressed quickly, and its practical use, especially for maritime commerce, was soon proven (Ahvenainen 2011, 297–8). In the pre-1914 period, however, the tyranny of distance was too great for wireless technology to permit a reliable connection overseas by means of radio waves – the telegraph remained indispensable.

Railway Imperialism and Maxim Power

Victorian economic domination of the world is inexplicable without considering the railway, which opened colonies to the penetration of manufactured British products and linked them to the global economy. Introduced in England in the 1820s, the railway became extensive and pervasive there in the 1830s and 1840s and shortly thereafter in India, where railway construction began in 1850. By 1860 1,000 miles of track had been laid; by the early 1870s

more than 5,000; and more than 24,000 by the end of the century. Linking Bombay by way of Delhi with Calcutta, the railway secured British colonial administration and military rule on the subcontinent. The role of the railway for the development of Indian economy is more debatable. Even in early industrialised Bengal, where the East Indian Railway Company had opened a railway line between the Raniganj Coalfield and Calcutta in 1855, high railway freight charges combined with low-value raw materials such as textile plant fibres eroded the productivity of the Bengalese textile mills (Ray 2018, 157, 166, 170).

While in the self-governing settlement colonies, the railway served to strengthen local interests, railway imperialism featured dominantly in tropical Africa, where it empowered the imperial agents – prospectors, soldiers, big-game hunters, missionaries, and district commissioners. The colonization of the central Highlands of Southern Africa is the most striking example of the Scramble for Africa, which involved the use of several types of technology. It is notable that in both East and West Africa the British Government had attempted, as in the past, to rely on private trading companies to uphold its interests, and that in both the government it had finally been compelled to step in and take over colonial administration. Nonetheless in Southern Africa too, governance was handed to the British South Africa Company, incorporated by Royal Charter on 29 October 1889. This Concession Company acted as a parastatal hybrid, combining private, for-profit interests while at the same time being endowed with quasi-governmental powers and functions for the mining industry, which had been boosted by the discovery in 1886 of huge deposits of previously unknown gold-bearing rock in the Witwatersrand in the Transvaal (see Thompson 1995).

The discovery of gold in the Witwatersrand was of profound importance for the British economic domination of the world, not least because it formed a decisive part of what is sometimes called the Mineral Revolution in Southern Africa. Within a few years, Witwatersrand became the world's greatest single source of gold and the pivot of the monetary system of the international capitalist community. Sold to London at a standard price (£3.17.10½d per standard ounce, i.e. 22 carat), the Rand gold was universally acknowledged as the only true measure of value, the main standard of price, and the dominant monetary form, which had its basis in the gold standard (Green 1982, 23).

By the end of the nineteenth century the Square Mile was recognised uncontestably as the centre of the world's money market, attracting funds from all around the world and then reinvesting them in different parts of it. Investments in railways made up a large proportion of the £4,000 million that joint-stock companies listed on the London Stock Exchange had invested abroad by 1914. To raise the money for large mining and related railway infrastructure ventures it was essential to tap the resources of the general public. The mining and railway endeavours were therefore created as public companies, thereby playing a large role in the development of the characteristic forms of modern business and investment.

Initially it was cheap African labour that boosted the mining industry in Southern Africa. While the discovery of gold brought new opportunities for labour of all colours and helped to create an African bourgeoisie, the miners who had to face the horrors of the mining work, involving extracting the ore in pitch-dark pits with picks, sledgehammers, and crowbars and the hand loading of cocopans, were almost invariably black Africans, who were restricted to the lower ranks of the industry (see Allen 1992). Despite mining being a very labour-intensive industry, up-to-date technologies were also needed to exploit the Rand gold, where minute particles lay among pyritic ore. The gold could not have been extracted without basting gelatine, which shattered the gold-bearing ore in pieces; heavy steam-driven stampers that crushed the ore; and the MacArthur Forrest cyanide process, invented in 1887 by John Stewart MacArthur, working in collaboration with the brothers Robert and William Forrest for the Tennant Company in Glasgow, with the ore being treated chemically before the gold could be separated from the rock (Brodie 2014, 36, 40–1).

Besides being a skilful businessman as well as a politician, Cecil Rhodes, the Managing Director of the British South Africa Company, was also an imperial visionary. He dreamt of an imperial railway stretching from the Cape to Cairo and ensuring British dominance over the whole of the continent. Fuelled by a railway mania and prospects of finding the Ophir, the quest for gold spread beyond the Limpopo River, in the Highveld of Southern Africa, where the British South Africa Company's expeditionary force, the Pioneer Column, trekked in 1890. The lands beyond the Limpopo River were controlled by the Matabele under chief Lobengula, who resolved to oppose the Company. On 16 October 1893 an army of 3,000 and possibly even up to 5,000 Matabele warriors, equipped with assegais, muzzle-loaders, and some even with rifles, attacked the laager of the 700 BSAC troopers on the Shangani River. The day was won by the devastating new weapon with which the troopers were equipped: the repeater called the Maxim gun, invented by Sir Hiram Stevens Maxim in 1884, capable of firing 500 rounds a minute. The result was an overkill: in a hail of bullets approximately 1,500 Matabele fell, unable to reach the enemy laager (see Thomas 1997).

In colonial Southern Africa the up-to-date rifles were destined for the Europeans who off-loaded their obsolete muzzle-loaders on the Africans. Muzzle-loaders were often sold without bullets and gunpowder or with limited and inadequate supplies so that the Africans were forced to manufacture their own ammunition. As lead is a heavy commodity and caution is needed in the handling of black powder, the white traders carried limited supplies of it so that even those tribes which could make their own bullets often ran short of supplies. They could manufacture gunpowder from local materials, as the Venda did, and use any missile that muzzle-loaders could fire, such as pieces of telegraph wire, nails, and glass balls from soda water bottles (Allen 1992, 50). The standard British Army Martini-Henry chamber rifle, which was in service throughout the British Empire until the end of the First World War, had at least three times a quicker rate of fire than a muzzle-loader – and their factory-made cartridges rarely misfired. There was also the question of combat tactics. Muzzle-loaders were designed at the time when soldiers were firing their weapons either in lines and on command or behind fortifications. But they poorly suited a combat mode in which charging combatants were firing their weapons at will, especially when the muzzle-loaders encountered rapid firing rifles and repeaters, as indicated by the high number of Matabele casualties at the Battle of Shangani River.

Thus with the help of the new military technology, a new colonial polity appropriately named Rhodesia came to be. In October 1897 the railway reached Bulawayo, a settler town declared open on the site of Lobengula's former kraal in 1894, to Wankie colliery in September 1903, to Victoria Falls in April 1904, to Kalomo in July 1905, and Kabwe (meaning 'ore' or 'smelting') lead and zinc mine in January 1906. Then the railway passed Bwana M'Kubwa copper mine in Northern Rhodesia before it was ready to link up with the railway system in Katanga, near Sakania in December 1909. The railway reached the Star of the Congo copper mine (Elisabethville) in September 1910. After completion of the railway, the road was clear for minerals to reach the world's metal markets, the most influential being the London Metal Exchange (see Särkkä 2016). It offered a forum for trading in physical metals (and more importantly in futures), which enabled daily prices to be generated which were widely held to reflect the current balance of supply and demand in the world market, even though it handled only a portion of the world supply (see Gibson-Jarvie 1976). The London price became effectively the world price – quite irrespective of the volume of physical metal in which it dealt – reflecting the complex variety of economic and political forces of the City, termed as gentlemanly capitalism (see Cain & Hopkins 1994).

With the expansion of transport and communications, non-ferrous metals such as tin, lead, zinc, and copper had become indispensable raw materials of the Second Industrial Revolution. Copper proved the most practical and economic medium, either in the form of cables or wire, for the transmission of power over distances. Telegraph wires were manufactured in ever-

growing quantities, and so were electric trams. Electric lightning installations replaced gas and oil, and electrical machinery began to take the place of steam-driven engines in factories. All these needed copper. At the same time, the traditional users of copper such as steamship builders were experiencing buoyant growth, and Britain faced an ever-increasing dependence upon imported ores, metals, and alloys (see Prain 1975). The need for copper and the danger of dependence on the few producers and sellers stimulated production in other locations than the United States, the world's main producer, and contributed to opening up the mineral resources of Northern Rhodesia and Katanga.

Victorians, Technology, and Empire

This essay has highlighted that superiority over transport, communications, and military technologies, especially when integrated, was an important foundation of Victorian economic domination of the world in the long nineteenth century. In both the formal and informal Empire, in tropical and temperate colonies, technological transformation wrought by the railway and the telegraph empowered imperial agents' abilities to control and master. They also featured significantly in the transition from mercantile to industrial capitalism that was slowly pervading business operations in the Empire.

Despite obvious possibilities presented by the use of new technological innovations for the expansion of the Empire, considerable continuity characterized the diffusion and application of technologies in imperial activity during the first half of the century. There are difficulties in pinpointing when technologies had become sufficiently diffused and effective to institute change in colonial relationships. It is difficult to establish, for example, when cost-effective, metal-hulled, propeller-driven, ocean-going vessels become sufficiently numerous to make a difference to the trade between Britain and its overseas colonies. Some researchers have emphasised the importance of the developments between the years 1845 and 1860 whereas others have stressed that the later Victorian decades are paramount in this respect (see Kubicek 1999). The mere heterogeneity of such estimates displays the fact that the role of technology for the development of colonial relationships is not something that can be measured quantitatively or confined to an exact period of time.

Even more are elusive are the prevailing Victorian norms and values which shaped the use of new technology. The blanket term Victorian is best to define a period of history when people possessed, at least in some respects, similar patterns of behaviour, shared common ideas, and understood the existing reality in similar ways. These common elements in ideas, attitudes, and culture together represent Victorianism and the people described as Victorians. A list of virtues, which an ideal Victorian would have possessed, a certain Weberian ideal type, can be found in a wide range of Victorian studies. The most often cited virtues include the love of freedom, justice, and humanity for which the British Empire is said to have fought the First World War. Similarly, belief in British technical and administrative superiority, efficiency, inventiveness, progress, and independence are considered to be typical Victorian values. In particular, a belief that Britain is the leader of humanity is a key Victorian conviction – a belief that Britain is destined to be the chosen nation, not by accident but because it deserves to be. This conviction is said to be the paramount element of British imperialism.

While some notable Victorian public figures such as Whig-liberal C. W. Dilke and imperial historian J. R. Seeley cherished the triumphs of science and technology that had made the 'Greater Britain' both necessary and possible (see Dilke 1870; Seeley 1971), others were concerned with criticizing the time in which they lived. In particular many of them felt deeply about dealing with the social problems of industrial society. For instance, Thomas Carlyle and John Ruskin, two of the most distinguished critics of the Victorian era, promoted spiritual values over materialism: 'Life, not work, must be regarded as the end' (quoted in Clarke 1978,

49). Hence their contempt for the boasted triumphs of the scientific and technological innovations that had shaped the industrial age in which they lived. They protested against the damage inflicted on the landscape by steam shovels, the pollution of water and river ecosystems by untreated effluents, pollution of the air by steam pollution, and the harm done to labour by unhealthy working conditions.

There is also the question of the multitude of attitudes to time and speed. The Victorians viewed the steamship, the locomotive, and the telegraph as means of reducing the time taken to travel, trade, and communicate over greater distances. As a veritable symptom of the age of the first global economy, by 1914 the world had been divided into 24 time zones one hour apart (Kern 2003, 12–14). The key technological innovations of the industrialised age – the railway and the telegraph – served the needs of commerce, politics, military, and diplomacy but found little use beyond businessmen, military personnel, diplomats, and various government officials. Indigenous societies, on the whole, were unconcerned with the same urgency of time and speed as the Victorians, whose care and accuracy in operating the service but also in maintaining and repairing the railway and telegraph lines proved often difficult to achieve in the pre-1914 colonial context: in the absence of engineers, workshops, and millwrights, the lines were more often out of order than functioning.

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