The Workshop of the World

Industrialization in Britain, France, and Germany

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The process of industrialization that took place in Britain in the eighteenth and early nineteenth centuries brought about huge social and economic changes. In this revolutionary time, a period known to history as the British Industrial Revolution, Britain increased production in almost all economic sectors, and came to dominate the world. The period of industrialization in continental Europe began later, and unfolded quite differently than the British Industrial Revolution. France and Germany, in particular, provide examples into the nature and causes of continental European industrialization, and why it was a significantly different process than the British industrialization experience. “France and Germany, in comparison to Britain, had a poorer transportation system, fragmented markets, less coal and iron deposits, and a weaker capitalist system.” Differences in scientific culture and resultant education system, means of acquiring technological innovations, and political structure and stability, with some later colonialism effects are the main reasons why France and Germany fared differently than Britain in the industrialization game.

To a large degree, the education system in a society determines the future progress of that society. The education system is inextricably linked to, and in fact determined by the culture of the society. In the case of technical and scientific education, the scientific culture is so linked. A view that technology is the be all and end all of civilization, coupled with an education system befitting this view, promotes great advances in technology. Margaret Jacob puts forward a set of cultural explanations to account for Britain's acknowledged lead in industrialization, far ahead of developments in Germany and France. As she has said so succinctly, “Knowledge has consequences.” It is clear that the British opined that “technology [w]as the most objective and unassailable measures of their own civilization’s past achievement and present worth,” even before their use of the technological superiority argument as a rationalization for colonialism. The British
education system also quickly adopted the applied mechanics system, based on Newton’s natural philosophy. “By the eve of the Industrial Revolution... [t]here was a new mode of thinking, a widespread acceptance of machines, and an impressive understanding of the technical principles that lay behind the working of mechanical devices.”\(^4\) Additionally, “The consensus is growing among historians that technical change in eighteenth-century England owed much more to science than was previously thought.”\(^5\) Hence both conditions, a suitable worldview and a suitable curriculum in schools, with active scientific activity, were well established in Britain before the Industrial Revolution. Professor Kline has repeatedly said that invention is the product of a society, rather than an individual inventor. “Where mechanical knowledge was widespread and institutionalized in the educational system, and where capital, natural resources, and exploitable labor were also present, the results of that coincidence transformed both nature and society, creating in its wake the modern industrial world.”\(^6\) Britain had just the society to produce invention upon invention, during the Industrial Revolution.

“The ability to think mechanically... permeated Western societies only selectively in the course of the eighteenth century.”\(^7\) In France, the Newtonian system was not adopted until very late, and even then, not in the applied mechanics sense, as in Britain. In early periods of the 18th century, “Protestant Freemasons attempting to spread Newtonian science... were arrested in Paris.”\(^8\) The homegrown philosophy of René Descartes was strongly rooted, not to be supplanted by the philosophy of the Briton Isaac Newton until decades later. I believe this was due to a cultural resistance of foreign ideas. “Cartesianism was not an ideal science for industrialists. Its approach to problem solving was far too theoretical, deductive, and erudite to benefit merchant-investors.”\(^9\) Due to the shortcomings of Cartesianism and the resistance of the education system to adopt Newtonianism, “it is clear that a generation or more of French students in over 400 colleges did not have access
to knowledge directly useful to the process of industrialization."\textsuperscript{10} Even when
Newtonian thought was received in France, it was entirely theoretical and so
had many of the shortcomings of Cartesianism. "One of the earliest textbook
explications of Newton’s system in French, Sigorne’s \textit{Institutions Newtoniennes}
(1747), relied entirely on mathematical explanations and never mentioned
machines or illustrated local motion mechanically."\textsuperscript{11} The reason for the
emphasis of theoretical science at the expense of applied science can be traced
to the prevailing French culture where science was an aristocratic activity.
"France suffered... from a sociopolitical division (and attendant lack of
communication) between scientists entrenched semi-officially in the Academy of
Science, on the one hand, and businessmen, on the other."\textsuperscript{12} In addition,
technological attainment was not seen as the highest measure of achievement.
The aristocrats pursued science for the sake of science, while the businessmen
and technicians had little knowledge of scientific thought to base their
innovations on. Consequently, much of France’s industrialization was based on
imported British technology. Even then, the industrialization process did not
proceed as smoothly. "Relatively sophisticated mechanical knowledge had to be
a part of one’s mental world before such mechanical devices could be invented,
and more to the point, effectively exploited."\textsuperscript{13} Since mechanical knowledge
was not widespread among French commoners, technology could not be utilized
very effectively.

Early German education, a system developed by the church and the state,
was quite theological in its focus. "The earlier marriage of convenience
between the dominant absolutist state and the Protestant clergy had produced
little widespread, practically oriented scientific and technological
education."\textsuperscript{14} Much like France, Germany was resistant to the Newtonian system.
"In one Berlin gymnasium of the 1730s... Cartesian and Leibnizean science were
still the dominant paradigm."\textsuperscript{15} Again, the philosophies of the German Leibniz,
and continental Descartes were hard to supplant in the Germanic states. I
believe this was also due to a cultural resistance of adopting foreign philosophy and science. The Pietists, a religious group in Germany that set up schools, instituted a curriculum which was supposed to be practical, but failed in the opposite extreme from the erudite French system. That is to say, the students were taught applications, without being given the scientific underpinnings of the technologies. "Schools under Pietists emphasized the necessity for a practical education and children were exposed to technology and working models of machines. Not innovation but work training for artisans was the goal."\textsuperscript{16} Since students did not have an understanding of the principles behind machines, they could not scientifically develop new technologies. Also, "The best and brightest students from the Prussian schools went on to the University of Halle... [where] Theology remained the dominant subject, followed by medicine."\textsuperscript{17} Hence, the people going into the technical fields had less natural ability. This, coupled with the poorer education given, produced less competent engineers.

Almost every single major invention from the period of industrialization was independently invented in Britain. In the textile industry, John Kay's flying shuttle, patented in 1733;\textsuperscript{18} James Hargreaves's spinning jenny, patented in 1770;\textsuperscript{19} Richard Arkwright's water frame, patented in 1769;\textsuperscript{20} and Samuel Crompton's spinning mule of 1779\textsuperscript{21} were all developed in Britain. Thomas Newcomen's steam engine; James Watt's improved steam engine; and James Smeaton's transportation systems were also independently invented in Britain. The whole "Technological System of the Industrial Revolution,"\textsuperscript{22} in fact was developed in Britain. Eric Brose has said that, "many industries 'effected comparable advances' that were 'mutually reinforcing' and that, in turn, 'made possible further gains on an ever-widening front.'"\textsuperscript{23} That is to say, that the synergy of the situation has invention leading to invention. Since there was so much independent invention occurring, it was requisite that there existed a deep understanding of technologies and how to make use of them fully. There
was also a natural flow to the technological development, where one technology arose from another and so on, with smooth transitions. This smooth and rapid development characterized British industrialization.

France and the German States received these industrial technologies as well as the technological system through technological dialogue with Britain. In this dialogue, however, Britain was supplying most of the technologies, and so it was much like a direct transfer. The transfer, however, was not a one-way exchange. Much science flowed from the French academies across the channel to Britain. The French and Germans actively sought out the British technologies. Mechanisms of technology transfer used were, "immigration of artisans, importation of machinery, and exchange of information such as patents, technical journals, books and exhibitions." Since so much technology was transferred, industrialization was not as systematic in France or the German states as in Britain. It was spurred by technology transfers that occurred somewhat haphazardly. The smooth and logical progression found in Britain did not exist. Despite the active efforts of the French and Germans to obtain industrial technologies, only technological artifacts were transferred. Technology, however, has three aspects, "artifacts, knowledge, and social relations." In fact, the other two aspects are probably more important than the artifacts themselves. If the social structure that enables the artifacts to function, or the knowledge and techniques necessary for employing them are not present, artifacts are worthless. The British technological system of the Industrial Revolution was well adapted to the British landscape and social structure. Contrarily, the German and French societal structures did not allow the technological artifacts to be utilized to their full potential, because the supporting infrastructure was not present.

Governmental structure and stability also played a role in differentiating the British and continental European industrialization experience. Based on historical evidence, it is clear that a freer political
system and a better process of industrialization go hand in hand. Likewise, stability acts as a promoter for industrialization. In 1688, on the eve of the Industrial revolution, the British had a, "new king, William III of the House of Orange, [who] reigned as a ‘parliamentary monarch’ who abandoned the efforts of his predecessors, the Stuarts, to rule ‘absolutely.’" Britain maintained this same parliamentary monarchy throughout the Industrial Revolution. There was also very little internal strife, so people could focus their energies on technology, rather than just trying to stay alive. In addition, there were no major military fronts fought on the British homeland at this time.

On the other hand, France and the German states had absolute monarchies, which were not consistent with the idealized industrialization. In Prussia, "the state entirely predominated." In the absolute monarchies, everything citizens did was for the state. Prestige was associated with military engineering and aristocratic science. Consequently, civil engineering and the development of new commercial technologies were not emphasized. Also there were less financial benefits for these types of ventures, without the strong capitalist economic structure. Hence the populace had little incentive for widespread, systematic growth of industrial technologies, and the development of new inventions. France was riddled with instability and changing governments from the French Revolution in 1789, through the Reign of Terror, until well past the fall of Napoleon in 1815. This time period could have fostered a boom in industrialization, but instead it was a period of decline. At the height of the French Revolution in 1793, French scientific academies were abolished and their leaders executed, laying a severe setback to the process of industrialization. Many other symbols of the old regime were also destroyed. "The devastation of the Thirty Years War (1618-48)" had put Germany a step behind, because "the fighting left mines and metallurgical centers... wrecked, flooded, or idle." The Napoleonic occupation of the Rhineland in 1797 didn’t help stabilize matters. The many small princely
states also fought skirmishes amongst themselves. The disjunction of the small states also prevented a unified market from forming, where all goods could be bought and sold. These facts of government contributed to the slow and oft-interrupted industrialization in France and Germany.

By the 1820s, Britain was well into the swing of industrialization, and its colonial empire was expanding. “Europeans,” and particularly the British, “translated their material superiority into global hegemony”\textsuperscript{31} through the flooding of colonial markets with cheap manufactured goods. Because Britain was so far ahead of its European competitors, they had access to more markets, and so the demand for industrially produced goods kept growing. France and to an even greater degree Germany, were unable to match the output of the British and so fell behind to an even greater extent. “England [had become] the ‘workshop of the world.’”\textsuperscript{32}

Culture and education, technology transfer, and government all contributed to the differences in the way French and Germanic Europe industrialized as compared to the British Isles. Colonial prowess also contributed at the later stages of the Revolution. It is evident that strong incentives for industrial development facilitate an industrial revolution. Financial motivation like patents and large profits, and cultural motivation like prestige provide this drive. A particular societal setting is also valuable, one that has mechanics as the central paradigm, one that has an open and stable government, and one that has a capitalist system that rewards innovative industrialists. Clearly, Britain had these many characteristics and that is why the dawn of the Industrial Age arose in Britain. France and Germany were copies, and the process of copying has an inherent loss of quality.

\textsuperscript{1} Naubahar Sharif, lecture, October 5, 2001
\textsuperscript{2} Margaret C. Jacob, \textit{Scientific Culture and the Making of the Industrial West}, New York, p. 132.
\textsuperscript{3} Michael Adas, \textit{Machines as the Measure of Men: Science, Technology and Ideologies of Western Dominance}, Ithaca, p. 134.