The Industrial Revolution and the Netherlands:

Why did it not happen?

Joel Mokyr
Departments of Economics and History
Northwestern University
j-mokyr@nwu.edu
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Why was there no Industrial Revolution in the Netherlands? To ask the question in that form in this day and age invites controversy. Anyone who raises similar – and equally legitimate – questions about China, for instance, is likely to be told that this is a Eurocentric, teleological, and essentialist point of view, which presumes that the Industrial Revolution was some kind of crowning achievement of a concentrated effort. This kind of critique seems rather silly. To ask why any historical event that seems a priori feasible because it did happen elsewhere did *not* take place is useful analytically: why did Canada not have slavery? why did the U.S. not have a successful socialist movement? why did the Soviet Union fail to develop the microprocessor? These seem useful questions.

The stylized facts are well-known. Despite its position as a commercialized, sophisticated, and urban economy, the Netherlands was a latecomer to the Industrial Revolution. Yet while it is legitimate to pose the question why this was so, answering it is decidedly tricky. To sharpen the issue, I should like to follow a Kuznetsian way of formulating what changed in Western Europe in the years of the Industrial Revolution. It was not, it has been said often, the beginning of economic growth, it was the beginning of *modern* economic growth. That may seem to be a distinction without a difference. European economies grew in the centuries before the Industrial Revolution, even if our estimates of the exact numbers are even less precise than for those of the nineteenth century. In fact, the best numbers we have suggest that the rate of economic growth before 1760 and the rate of growth between 1760 and 1830 were both on the order of about .5% per capita per annum. If there was an acceleration, a "take-off into sustained growth" as we used to call it decades ago, it post-dated the Industrial Revolution.

And yet, I would like to suggest that the type of growth experienced after the Industrial

Revolution was of a different character than that before. The real breakthrough, in this interpretation, was not the new technology of the "years of miracles" between 1765 and 1790, but the fact that it did not slow down and peter out a few decades later. Previous episodes of economic growth in the West and elsewhere in the world had always run into ceilings and negative feedback. By *feedback* I mean, just as in biology and in systems analysis, that the output of the system becomes an input into the next time period or generation and affects its productivity and functionality. It is, so to speak, the control of a historical process by the end products of that process. Before 1750, feedback was on the whole negative. Each time economic growth of any nature took place, its consequences after a while became obstructive inputs in that process and worked to slow it down and end it.[1]

To state this is not enough. The net direction of feedback is a reduced form equation. We have to specify the structural mechanisms at work here. The most widely discussed mechanism is the Malthusian model in which growing income produces rising population. But models from political economy do the same: economic growth due to commercial expansion (known as Smithian growth), led to rent-seekers, tax-men, mercantilist protectionists, state-sponsored monopolies, and at times pure plunderers and pillagers. Such parasites often killed the geese that laid the golden eggs. A particularly interesting case of negative feedback has to do with the political economy of technological change. A successful breakthrough of a new technique, say in printing or shipbuilding, will lead to considerable investment in specific human capital. Once entrenched, these interests will then rationally resist further innovations that would reduce the value of their investment. The pre-modern Guild system by the seventeenth century had become an instrument of this conservatism (Mokyr, 1994c, 1998).

[1]The *opus classicus* describing and analyzing this phenomenon is Jones (1988).

The Industrial Revolution changed the economic system from one dominated by negative feedback mechanisms to one of predominantly positive feedback, where growth begat more growth. In other words, while before the Industrial Revolution "nothing failed like success," by the middle of the nineteenth century growth "fed on itself." It gathered speed and momentum in the years between Waterloo and the Crystal exhibition, and by 1860 a new stage was beginning that led to the technological breakthroughs of the 2nd Industrial Revolution and to the mass consumption and increases in income that the first could not quite pull off. But how and why did that happen? In part, the change was institutional: some of the rent-seeking groups and other parasites were weakened by the growing influence of Liberalism and economic rationalism brought about by British Political Economy but even more so by the French Revolution. But I would like to suggest there is something else, equally powerful that changed economic history in an irreversible and dramatic fashion, and this something had to do with new technological knowledge.

Technology *is* knowledge and if we are to understand how it works and what it does, we need to go back to its epistemology.[2] I would like to suggest that there are basically two kinds of knowledge. There is what I call S-knowledge, which catalogues and describes natural phenomena and regularities, and there is 8-knowledge which is knowledge "how" – how to do the things we now call "production."[3] The relation between the two is the crux of the historical phenomenon I want to describe. Before, it is necessary to be a bit more explicit about what these concepts look like.

First, S is a union of the pieces of knowledge possessed by individuals in a society or stored

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[2]Simon Kuznets (1965, pp. 85-87) was the first to explicitly link what he called "Modern Economic growth" to his idea of "useful knowledge" which corresponds closely to the concepts developed here.

[3]The idea goes back to at least Ryle (1945). For a recent formulation, see Loasby (1996). A more detailed presentation of this argument can be found in Mokyr (1999b).

in storage devices such as books and artefacts. Second, I include in this all knowledge about *natural* phenomena but leave out such areas as the social sciences, literature, law, and philosophy because they do not bear upon technology. This may seem an arbitrary limitation, but it is motivated by the observation that *au fond* technology involves primarily the manipulation of natural phenomena. Third, the word knowledge really means here "beliefs" – that is, it is not essential that this knowledge be in some sense "true" – by which we mean that it conforms to our own ideas. The Ptolemaic-Aristotelian image of the physical world was "knowledge" in this regard. Fourth, S knowledge would be associated today with what we call "science" but it includes a great deal more knowledge that we would call "useful" but which was more artisanal knowledge than "science": the lubricating qualities of oils, the hardness and durability of different kinds of woods, the location of minerals, the direction of the trade winds, and the strength and dietary needs of domestic animals. On the eve of the Industrial Revolution, with "science" in the modern sense in its infancy, this was most of what there was of S. The critical characteristics of S are not only its *size* but *diffusion* (who and how many know what is known?) and what I call "access costs" that is, if someone in the society knows something that I want to know, how difficult and costly is it for me to find out?

The set 8 is the union of all feasible techniques known in this society, what some economists used to call the "book of blueprints." A technique is a list of instructions on how to produce a good or a service. The existence of such a set is implicit in the concept of an isoquant, which delineates the choices among different techniques that each firm has. The set is of course much larger than the techniques on the isoquant since all the points above and to the right of it are also feasible but would not be efficient. But where exactly do these techniques come from? The answer is that normally they are based on some prior knowledge of nature, a knowledge that can be exploited and manipulated to yield a technique. The "epistemic base" of a technique in the set 8 can be wide or narrow, and its width helps determine how effective the process of technological change is. The extreme case is the one in which *nothing* is known about the how and why of a technique except that it works. Narrow epistemic bases were the rule, not the exception in the pre-Industrial era, especially in medicine and agriculture. These techniques emerged by chance discoveries and may in some cases have worked quite well, but they rarely led to new applications, extensions, refinements, or new technological trajectories. If you do not know why things work, you do not know what will *not* work and you will waste valuable resources in fruitless searches for things that cannot be made such as perpetuum mobile machines or gold out of other metals. To paraphrase Pasteur's famous aphorism, Fortune may sometimes favor unprepared minds, but only for a short while.

What does all this have to do with the Industrial Revolution? Basically, everything. The widening of the epistemic base of technologies, both new and old, allowed their sustained improvement. Economic Historians have long agonized over the possible relationship between the development of "useful knowledge" and technological progress in the eighteenth century. The argument has often been made that many of the significant breakthroughs in physics, engineering science, and chemistry occurred after the main thrust of the Industrial Revolution and therefore could not have caused it. But that misses the point: the really significant event is not the early inventions of the 1760s and 1770s but their *continued development* after 1820, in sharp contrast with earlier episodes of technological breakthroughs.

What differed was the fundamental change in the characteristics of the S set and the way it interacted with the 8 set. The period 1700-1850 experienced a profound transformation in the way useful knowledge was accumulated and communicated. The scientific revolution did more than establish the paradigm of Newtonian mechanics as the centerpiece of scientific methodology. It created standards of open science in which new knowledge was communicated freely using a common vocabulary and terms and measures that were generally understood. It established the criteria of authority and trust that were necessary for the efficient communicability of useful knowledge. It also clearly set out the purpose of science as the means by which natural forces could be tamed and subdued by people for the explicit purpose of improving the material conditions of life. And it established a belief in "progress", that is in the ability of cumulated knowledge of the "useful arts" to improve living standards. Useful knowledge, whether we would call it "science" or not, became thus more diffuse and more accessible in the critical years between 1720 and 1780. We often refer to this process as the enlightenment, although that term is often used for related phenomena. The Industrial Revolution was preceded by something like a "knowledge revolution" which widened the epistemic base of technology and made it possible for the people who created the new techniques to access useful knowledge more easily.[4]

Describing in detail the exact phenomena I am referring to here will take me too far from my main point. It is well understood how access to useful knowledge became easier and cheaper in this period. The establishment of learned societies in Provincial towns, for example, provided a fruitful opportunity for entrepreneurs and industrialists to communicate and exchange ideas.[5] At the same time, the enlightenment produced new ways of organizing "useful knowledge" which made access all the more easy. The paradigmatic example of this new approach was the encyclopedia, which

[4]This argument is made in detail in a forthcoming book by Daniel Headrick (2000).

[5] For an excellent survey see Inkster, 1980. Yet, as Robert Schofield (1972) has argued, the formal meetings were secondary to the networking and informal exchange of technical information between members.

reproduced useful knowledge in alphabetical order. Diderot and d'Alembert *Grande Encyclopédie* is the most famous but by no means the only example of this.[6] Alphabetization and indices were the search engines of the eighteenth century, cheapening the access to knowledge. Nobody, of course, is suggesting that one could pick up a volume such as these and start boiling soap or so; but what this literature illustrates is a live, continuous, deep interaction between the *savans* and the *fabricans*. For new mappings from S to 8 to occur, the economically active have to converse with the intellectually informed.

It is *that* interaction, I propose, that contains the explanation of the positive feedback I noted before. The broadening of the epistemic base permitted three types of positive feedback: the feedback from technology to useful knowledge; the feedback from useful knowledge to other knowledge; and the feedback from some techniques to others without the necessary augmentation of S. By the 1820s, this take-off had begun.[7]

The enlightenment and the scientific revolution were not British phenomena, they were European ones. Asia, despite its enormous scientific achievements, never attained anything like it. But within Western Europe, the differences were not all that large. No single country had a monopoly on science or engineering, and a large number of the most significant breakthroughs of the period were made by Continental scientists. All the same, the closing decades of the eighteenth century found the British at an advantage. Compared to the economic gap between Europe and

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[6]Other ways of organizing useful knowledge were experimented with: consider only the 80 volumes of the *Description des Arts et Métiers* (1761-1788). They included articles on candle making, sugar refining, masonry, glassmaking, and most famously (since it inspired Adam Smith's celebrated Ch. I), pin making.

[7]Two examples are Sadi Carnot's theory of the steam engine (1824) and the invention of the modern microscope in 1830. Cf Cardwell (1971, pp. 186-238), Reiser, (1978, p. 76).

Africa or Central America, this leadership was small and temporary. It was much on the minds of contemporaries, however, and led to many decades of British industrial leadership and the Pax Britannica in Europe and to a smugness and self-congratulary mood in Britain that took many decades to fade.

Not only that the Netherlands was not the first country to follow Britain, but its Industrial Revolution came late, not until the last third of the nineteenth century by which time Belgium, Switzerland, and important parts of France and Germany had passed it by. Its slowness to adopt and emulate the new technologies we associate with the Industrial Revolution has been the subject of a substantial literature. Technical innovation in the Netherlands, once part of the glory of the Golden Age, never completely came to a halt, but it slowed down in the later eighteenth century exactly at the time that it accelerated in Britain. By 1825 or so, the Netherlands had been transformed from a paradise of technological ingenuity to a museum (Davids, 1991, pp. 18, 36).

On the surface, this is an astonishing fact of economic history: after all, on the eve of the Industrial Revolution the Netherlands was in some ways the most advanced economy in Europe. Some of the glittering edges of the Golden Age had worn away, perhaps, but Adam Smith for one was unimpressed by arguments of Holland’s decay (Smith, 1776, 1976) Book I, Ch. ix, p. 102. In their recent magnum opus, De Vries and V.D. Woude (1997) describe in great detail the many forms that this “modernity” took: sophisticated capital and labor markets, a high degree of monetization, advanced education and high literacy rates, an urbanized, commercialized economy, and a highly productive, market-oriented agriculture.

There are a number of hypotheses competing for an explanation of why this “modern” economy did not become the first Industrial Nation. The most obvious one was simply contingency, that is, bad luck: the Netherlands from 1780 on were almost continuously at war, mostly with England, subject to political turmoil and instability, and from 1795 were dominated in one form or another by France which did not have its interest at hand. In a sense, the disastrous events between 1780 and 1815 could themselves be regarded as an example of classic negative institutional feedback. One of the first decrees the victorious French ordered was an indemnity of 100 million guilders (later increased to a total of 230 million). The Dutch also had to maintain a French army of 25 thousand men (De Vries and V.D. Woude, 1995, p. 686; Schama, 1977, pp. 186-98 and 206-07). The vulnerable maritime economy of the Netherlands was set back grievously during the war, and the economy of western provinces suffered simultaneously from inflation and unemployment.[8] A sharp decline in the demand for capital reflected these shocks, and much of the Dutch capital supply fled overseas or was hoarded. In 1814, the Dutch economy emerged dazed and diminished in a new age. After the dust of war and revolution settled, it was exposed to the tough competition of British manufacturing and the protectionism on the Continent, coupled like a Siamese twin to the Belgian provinces whose economic structure and interest was quite different from the Northern Netherlands. No wonder it took them a long time to recover. To be sure, the growth rate between 1815 and 1840 in the Netherlands was quite respectable, but that was largely because of the very low starting point.

An influential interpretation of the tardiness of the Industrial Revolution in the Netherlands concentrates on the lingering heritage of the Golden Age. Under the old economic regime, as I argued above, negative feedback assured that nothing would fail like economic success. Economies whose

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[8]Dutch manufacturing known as “trafieken” depended heavily on imported raw materials which became hard to come by as they had to arrive through neutral ports. The British occupied the Dutch colonies and the Dutch East India Company, a symbol of the success of the Dutch economy in the Golden Age, was abolished in 1798. Fisheries and shipbuilding also suffered heavily. On the other hand, more traditional industries such as agriculture and rural-domestic industries prospered by comparison. Enterprising Dutch merchants were able to use neutral and French registration and make large profits. On the whole the declining sectors outweighed those gaining from the war. For details see Buyst and Mokyr (1990) and Van Zanden and Van Riel, 1999, ch.2.

prosperity was based on international and domestic gains from trade and specialization were always more vulnerable to political and social disruptions, but even in the absence of such disruptions, such gains by their very nature were subject to diminishing returns. Yet a view of the Dutch economic golden age as based largely on trade and finance misses much of what is interesting about the golden age: a sophisticated manufacturing sector, a productive agriculture, highly developed shipping, advanced engineering (especially hydraulics). Much of the golden age had depended on advanced technology.[9] In 1650 or so, the Dutch were on the cutting edge of technology in Europe. Yet negative feedback assured that such leadership would be relatively short-lived, a phenomenon I have termed Cardwell's Law. Cardwell's Law basically states that nations that are technologically creative are so only for a short time. Much like Hegelian dialectics, the negative feedback implies that technological success produces the seeds of its own demise. Further progress was blocked by special interest lobbies and distributional coalitions such as guilds, informal employee organizations, and local government regulations whose main function eventually became to protect vested interests from new technologies which were perceived to threaten their livelihood and human capital (Davids, 1991, p. 34; Davids, 1995, pp. 349-53; De Vries and V.D. Woude, p. 685). Complaints against technological conservatism can be readily documented in the political literature of the 1780s and 1790s, although the actual magnitude of this effect is hard to estimate and it does not fully explain why there was little technological change after they had been removed.[10] In this way, the relics of the

[9] Although, like any technologically creative society, the Dutch between 1550 and 1650 adopted a substantial number of foreign inventions, they also generated many original ones (Davids, 1993; 1995; Unger, 1978; De Vries and Van Der Woude, 1997, ch. 8; Cook, 1991).

[10] The general historical issue of resistance to technological progress as an obstacle to economic performance is discussed in detail in see Mokyr (1998, 1999). For other views that the evidence for resistance is ambiguous, see Davids, 1995, pp. 350-52; t'Hart, 1993, pp. 117-18.

Republic's former greatness stood in the way of the innovations of the Industrial Revolution. As Van Zanden and Van Riel (1999) emphasize, in the eighteenth century the feedback from institutions to technology was strongly negative.

The flip side view of these events has it that the cathartic events following the French Revolution were necessary to clear away the institutional debris of the *ancien régime*.[11] Antiquated fiscal rules, technologically reactionary guilds and other distributional coalitions, obsolete legal systems of local government and land use and property rights, a huge public debt, a decentralized political organization bordering on the chaotic, all needed to be swept away. Unlike the rest of the European continent, the obsolete structures were not feudal but the relics of a commercial economy. But obsolete they were, all the same. If the cost of these reforms was falling behind Britain for a few decades, so be it. As has been emphasized by Kreeft (1988) and more recently by Van Riel and Van Zanden (1999), the Dutch Republic underwent a complete re-organization of its fiscal system during the Batavic and French periods, had its guilds system done away with (though not without resistance), unified its internal transport system, and above all created something that looked like a modern centralized government.[12] If Britain was able to avoid these expensive institutional investments, it was because she had the political mechanism to bring about change without violence, and because as an Island she managed to keep the French armies out.

One mechanism that might be responsible for the tardiness of an Industrial Revolution in the

[11]As De Vries and V.D. Woude note (1997, p. 715), in the eighteenth century the Dutch Republic tried and largely failed to reinvent itself. "Vested interests proved too strong to reform a system that by the late eighteenth century appeared to possess a distinctly archaic and obfuscatory character."

[12]The view that most of these reforms came fairly late during the leadership of R.J. Schimmelpenninck has effectively been challenged by Fritschy (1988).

Netherlands operated through labor markets: a rich, urban economy with high taxes and a highly developed poor law system would have relatively high wages. This surely was the case for the Dutch maritime provinces as Adam Smith already pointed out.[13] High wages, ceteris paribus, meant high labor costs and thus either a disadvantage in competitive world markets (especially textiles), or at the very least lower profits and thus a lower rate of capital formation and growth in the modern sector.

Without necessarily rejecting these explanations, I should like to submit that the advanced technology that helped propel the Dutch economy into unprecedented and even "embarrassing" riches in the seventeenth and eighteenth centuries was still mostly the traditional, pragmatic knowledge at the level of artisans or applied engineers: mechanically clever, well-designed techniques, but without much of an epistemic base in the deeper natural phenomena that made them work. As a consequence, technological progress ran into diminishing returns.[14] The narrow epistemic bases of the techniques in the 8-set created, so to speak, a fixed factor that prevented sustained expansion. British manufacturing at this time was not all that much different from this, and it surely would have ended up the same way had there not been an expansion and structural change in S happening at the same time.

The Netherlands did not quite match Britain in its ability to absorb and process useful knowledge and to embark on an Industrial Revolution. But then, the *explanandum* is not all that large

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[13]This argument was first presented in detail in Mokyr (1976). For more recent reflections see Mokyr (1991) and Van Zanden (1993a).

[14]A similar point is made by Van Zanden and Van Riel (1999, ch. 1, pp. 26-27). They argue that technological systems reach a certain "saturation point." This is surely true for the pre-1750 systems, but it is far less obvious for the novel systems created by the Industrial Revolution. Their comparison of the Dutch eighteenth century economy with the British economy after 1870 is therefore misleading as far as the technological aspect is concerned.

either: the Netherlands did not end up with an economy like Haiti's or Bangladesh's.[15]

By the early eighteenth century, even when the technological creativity of Dutch society appears to have dried up a bit, there still was a great deal of interest in useful knowledge, as the traditions begun with Isaac Beeckman and Christiaan Huygens continued. The Newtonian revolution found in Willem s'Gravesande one of its main disciples and popularizers, and other Dutch scientists such as Boerhaave and Musschenbroek were world-famous (Cook, 1991). Above all, the United Provinces could boast a system of universities which was as good as anywhere in Europe.

And yet by the middle of the eighteenth century it seems that something had gone amiss in the way the Dutch were processing useful knowledge. Margaret Jacob (1997), the most notable scholar working on this topic, is unequivocal in whom she blames for this: the Dutch commercial elite simply lost interest in the "mechanical arts."[16] In her view the Dutch fell between two stools: in Britain, private enterprise, that is, the commercial and rural elites, were so interested and versed in technical topics that the private sector on its own generated the technological breakthroughs and, more importantly, adapted and improved these breakthroughs through a continuous stream of small, anonymous "microinventions" which cumulatively accounted for the gains in productivity. In France, where the private sector was weaker, the state took an active if sometimes wrong-headed role in fostering the "useful arts." In the Netherlands, in Jacob's view, neither the private sector nor the

[15]It is obvious that the industrial structures emerging on the Continent would not be carbon copies of Britain: differences in Geography alone would account for that, to say nothing of History and Politics. Flanders and Switzerland, too, picked paths that were somewhat different from Britain, specializing in rough cottons and linen products, and in the Swiss case, relying on water power and later on finding niches in chemicals, precision engineering, and food processing.

[16]One of the striking examples is developments in late eighteenth century Dutch farming. Although a Society for the Advancement of Agriculture was founded in 1776, specialists dissent from De Vries and V.D. Woude's rosy view that compares the interest in agricultural technology in the Netherlands by the educated and commerical elites to the eighteenth century British movement toward rational farming. Van Zanden (1993b, p. 54) states that the movement toward a "scientific agriculture" skipped the Netherlands and many of the provincial committees appointed after the 1795 revolution existed on paper only. Not until the 1830s and 1840s did the movement start again. For a similar view, see Davids, 1995, p. 361.

weak and vacillating government were ever in a position to carry out this function, and as a result there was little change in the structure of the S set in the decades before the French conquest. The relic from the Golden Age that stood in the way of progress was, above all, cultural. The narrow bridge that had been built between those who made and built things and those who explored the regularities of nature became even narrower after 1740 or so.

Even in the second half of the eighteenth century, the Netherlands did not lack international distinction in the sciences. Some of its earlier glory had been lost, as it had in so many other areas. It is striking that in the great advances in chemistry and physics in the late eighteenth and early nineteenth century, Dutch names play less of a role than one would have expected by virtue of the country's numbers of literate, urban people. The most famous name of his time was probably Petrus Camper, Professor of Medicine in Franeker and later in Amsterdam, whose fame was based on his studies in the geometry of the human face and the secret of beauty.[17] While from a scientific point of view this topic seemed at the time a perfectly valid subject of inquiry, it lacked the Baconian impulse of usefulness that flavor so much of British science at the time. Jacob concentrates on a man named J.S. Allamand, Professor of Physics in Leiden and s'Gravesande's successor. Her conclusion from her examination of his life was that "there was not the slightest suggestion that he did serious science or that anyone expected him to" (Jacob, 1997, p. 146).

The decline of the Dutch Universities in the eighteenth century was also sharp. Israel (1995, p. 1050) has noted that the number of foreign students is a good indication to the viability and degree of sophistication of Universities, an observation surely not lost on American academic economists

[17]Camper was recently brought back to the attention of the English-speaking world by the wide-ranging intellect of Stephen Jay Gould (1991).

today. By that standard, the Dutch universities did very poorly: in the first quarter of the century Leiden counted 3,164 foreign students, in the third quarter only 1,132 and by the end of the century their numbers were 10 percent of what they had been a century before.[18] Jacob tends to blame the lack of competition and the culturally determined "absence of interest" in science and technology (1997, p. 146).

Yet the picture is far more nuanced than this somewhat bleak argument suggests. Much like in England – though *unlike* Scotland – the gap left by the universities was filled by private societies. The first of these was established in Haarlem in 1752, and within a few decades the phenomenon spread much like in England to the provincial towns. The Scientific Society of Rotterdam known oddly as the *Batavic Association for Experimental Philosophy* was the most applied of all, and advocated the use of steam engines (which were purchased in the 1770s but without success). The Amsterdam Society was known as *Felix Meritis* and carried out experiments in physics and chemistry. These societies stimulated interest in physical and experimental sciences in the Netherlands, and they organized prize-essay contests on useful applications of natural philosophy. A physicist named Benjamin Bosma for decades gave lectures on mathematics, geography, and applied physics in Amsterdam. A Dutch Society of Chemistry founded in the early 1790s helped to convert the Dutch to the new chemistry proposed by Lavoisier (Snelders, 1992). The Dutch high schools, known as *Athenea* taught mathematics, physics, astronomy, and at times counted distinguished scientists among their staff.[19]

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[18] In Israel's view this decline reflected the fall in funding, though Mijnhard (1992, p. 212) points out that events elsewhere over which the Dutch had no control probably accounted for much of the dwindling of the number of foreign students.

[19] Among them was Jan Hendrik van Swinden, who lectured on such topics as Chinaware manufacturing and steam engines and subsequently was on the staff of the French team of physicists who measured the earth's meridian in an attempt to formalize the metric system.

Moreover, the Netherlands on the eve of the French revolution, was a highly literate and well-educated society compared with most other countries. Like Germany and the Scandinavian countries, it was “a backward sophisticate,” a country in which a large proportion of the population went to school and could read, yet somehow this did not translate itself into an early technological lead, or even an early followership in the industrialization of the Continent. Instead, Belgium, where illiteracy rates were considerably higher, took the lead on the Continent as did other Catholic areas such as Alsace and the German Rhineland (Van Lente, 1993, p. 181-84).

Above all, cultural arguments such as Jacob’s need to be reconciled with economic rationality. Would an early, wholesale adoption of British techniques have made sense? The old commercial and financial elites, who so often are accused of being lethargic and conservative, probably did not see many profitable opportunities in the new technologies of the 1770s and 1780s. Neither did the commercial elites in most other places on the Continent. What was lacking in the Dutch economy was not capital but venture capital. But what with hindsight seems to us a technological breakthrough may have seemed ex ante a reckless speculation. By the time that the power of the new technology to create wealth became abundantly clear, political events got in the way.

A small, open economy such as the Netherlands could not behave as if the changes in S around it never took place, even if its own contribution to them was marginal. The marketplace for useful knowledge was international, and the Dutch were too sophisticated to turn their back to it. International transfer of useful knowledge before 1790 was quite common and easy. The Netherlands were at a cross-roads, dense with commercial connections around the world, with an exceptional number of printing houses and publishers. To be sure, in the late eighteenth century useful knowledge remained by and large a form of amusement and rarely led to direct applications. Many members of Bosma's audience were booksellers and their wives; the new chemistry found few applications and the prize essays that won were of the hand-wringing kind such as the one in 1786 that explained why German chemistry was at such a higher level than the one in the Netherlands. All the same, many Dutch intellectuals were able to read foreign languages and there were long lists of Dutch subscribers to the *Grande Encyclopédie* and other French language books. Translations from other languages were the most widely published books in the Netherlands.[20]

The picture of a deficient Dutch capability for technological advance in the eighteenth century is thus not as stark as it is sometimes drawn, but clearly the Republic was hardly in the position of technological leadership it had been in the first half of the seventeenth century. Contemporaries understood this. Much of the push for a more pragmatic and utilitarian approach to natural knowledge came from individuals in opposition to the old commercial oligarchy and the calls for reform coincided to a large extent with the unhappiness with the institutions of the old *stadhouderlijk* government. The innovators were predominantly of Patriotic sympathy, and they blamed the oligarchy of the *Pruikentijd* for the economic decline of the Dutch. After the failed revolution of 1787, the French invasion of 1795 finally broke the back of the reaction and opened the door to new opportunities. But the timing, as I already noted, was unusually unfortunate. The years 1780 to 1815 were the years in which Britain made the transition from a society dominated by negative feedback to one of positive feedback. These were the very years Dutch society went through a set of external and fiscal shocks that drained its resources, focused the best minds of the nation on political reform, and shifted their attention to matters quite different from steam and cotton. To compound the

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[20]The Amsterdam pharmacist Petrus Johannes Kasteleyn took the initiative in translating large parts of the *Descriptions des Arts et Métiers*. Many of the works of Johann Beckmann, whose *Anleitung zur Technologie* (1777) was one of the first works to actually use the term, were known in the Netherlands (Verbong, 1993, p. 39).

difficulties, the center of the technological action had moved decisively across the North Sea, and the repeated wars with Britain made the flow of technology more difficult.[21]

What is amazing, in retrospect, is not that the Netherlands failed to undergo this transition but that Britain did. The Netherlands was not the exception, Britain was. In Britain the key to success was precisely in the ease by which manufacturers linked up with people who studied nature (as the term "scientists" seems anachronistic and too confining) and to make the new ideas actually work on the shopfloor.[22] British engineers and technicians engaged in a successful conversation with British businessmen and persuaded them that money could be made from the new technology. Once that became obvious, new generations of inventors saw an incentive to make further improvements. In this fashion, Britain was able to break the tyranny of negative feedback and launch itself into something entirely new, and it did so by exploiting its unique position and social parameters. Europe would never be the same. Britain blazed the trail, others followed – some on trails that were very close such as Belgium, others on trails that were rather different such as the Switzerland, France, and eventually the Netherlands.[23] There was a price to be paid for picking a different trajectory: economic growth in Belgium exceeded that in the Netherlands by an impressive margin after 1840, and Belgian GDP per capita passed that of the Netherlands in the mid 1860s and stayed above it until 1910

[21] To be sure, war did not completely close off the Continent to British entrepreneurs and technicians: it was in those very years that men such as Hodson and Cockerill opened their enterprises in Belgium. But the Dutch provinces were not included in the French Empire till 1810 and it made little sense to start a mechanized enterprise there.

[22]For a more detailed view of the causes of Britain's superiority in "microinventions" see Mokyr (1994a).

[23]In a somewhat oddly phrased statement, De Vries and V.D. Woude (1997, p. 716) seem to qualify the notion that the late Industrial Revolution in the Netherlands constitutes a historical problem by arguing that many modern economies "cannot plausibly claim the British Industrial Revolution as its linear ancestor." It is far from clear what a "linear ancestor" means in this context. What is obvious is that the old "cotton, steam, and iron" caricature does not strictly hold even for Britain, but that differences in sectoral composition and technological choices created a fairly wide spectrum of "paths to prosperity." Yet they all shared the fundamental property of avoiding the kind of blockages and ceilings that earlier growth episodes ran into – including of course the Dutch economy described in magisterial detail by De Vries and V.D.Woude in the preceding seven hundred pages.

(Horlings and Smits, 1997).

All the same, we should not look at the Dutch experience as a "failure" and think of them as being in some sense "backward." Indeed, from a social welfare point of view it is far from obvious that making the transition early did much to improve living standards before the mid-nineteenth century -- the examples of Belgium and Britain seem to indicate as much.[24] It may well be that the historical trajectory chosen by the Netherlands led in the long run to a more desirable outcome than if they, rather than Britain, had been the first Industrial Nation.

To summarize we might ask two counterfactual questions that may put the issue in sharper focus.[25] Would there have been a Continental (including a Dutch) Industrial Revolution in the absence of a British one? It would seem to me that the answer to that question must be affirmative, but it would have looked somewhat different and would have taken place later and probably slower. Dutch engineers by the middle of the nineteenth century had considerable capabilities to absorb the new technologies and did so successfully, even if it took them a bit longer.[26] The technological advances after 1860 were even more a joint North Atlantic effort and while British inventors remained very much part of it, British leadership reverted to a status of coequal.

The other counterfactual is a more difficult one: what would the economic history of the

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[24]Given that nineteenth century Belgium consistently had a higher investment rate than the Netherlands, the difference in real consumption per capita was smaller than that of GDP per capita. It is also clear that much of Belgium's more rapid growth was in heavy industries and mining, and that higher incomes to some extent compensated (in a welfare sense) for the dis-utility of this kind of work. At the same time, the share of wages in GDP in Belgium was considerably below that in the Netherlands, and remained so throughout the century. It also appears as if the Netherlands had lower female participation ratios (given its higher birth rates). An inference that higher GDP per capita in Belgium was indicative of higher living standards is thus unwarranted.

[25]Counterfactual history has recently become fashionable again among historians and social scientists. See e.g. Ferguson (1997).

[26]Unlike other European economies, the Dutch built their railroad system, such as it was, by themselves without resorting to British engineers (Veenendaal, 1993). The Dutch also succeeded, after some trouble, to adopt modernized production techniques in paper making and sugar refining, and eventually found some niches in some industries such as the straw-based cardboard industry.

Netherlands have been in the absence of a French Revolution? This scenario seems more plausible: the French Revolution as it took place was far from inexorable, and there were many occasions before 1792 at which it is conceivable that the events in France could have developed in a much less radical direction. Given the tremendous costs that the events between 1795 and 1830 imposed on the Netherlands, it is hard to imagine that in the short run, Dutch economic performance in the nineteenth century would not have been far better. To be sure, in the long run, the old régime in the Netherlands needed drastic reform. It is hard to see why this kind of weaning could not have been achieved peacefully and gradually without the pains of the Napoleonic period.[27] It seems quite plausible to believe that a Netherlands without the victory of the *patriotten* and a French occupation would still have ended up sooner or later re-examining its institutional setup in view of the rapid changes occurring in Britain and followed in its footsteps. The bridges between the intellectuals and the producers would have been widened gradually even without the repression, extortions, and the commercial disasters of the French years. If the old commercial elite would not have carried out its entrepreneurial functions, someone new would have stepped in.

Why should we believe this? Let me wind up by returning to the concept of Cardwell's Law. As I have argued elsewhere (Mokyr, 1994), the mortal enemy of Cardwell's Law is open-ness. In an open economy, as long as there is progress somewhere, it is difficult for an economy to maintain institutions that keep progress out. In a counterfactual world in which there was an Industrial Revolution in Britain but no war, privateering, and Continental blockades, the Netherlands would have remained committed to the ideology of free trade and remained a small open economy in an

[27]Britain overhauled its economic and political institutions repeatedly over the nineteenth century without any major disruptions or violence. Prussia, while it did suffer a brief humiliation at the hands of France, was in essence able to do the same. In the great liberal reforms of 1848 and following years, in fact, the Netherlands did exactly that.

environment of technological progress. It seems highly unlikely that the institutional and political reforms could have been kept out permanently.[28]

On the whole, then, the Dutch economy's actual path was determined by the heritage of the Golden age and the political difficulties of the critical years between 1780 and 1815. Yet in the end all these obstacles, while they slowed progress down, were overcome thanks to the fact that the Netherlands remained an integral part of the Western world. It was propelled forward by the powerful technological thrust of the Western world in the age of the railroad and steel. The real riddle is why some economies such as Spain, Ireland, Portugal and much of Central Europe were unable to ride this wave.

[28]For one thing, the inept Stadtholder William V would eventually have been replaced by his energetic and ambitious son who eventually became King William I. William I was very much in tune with the new Industrial age, and his actual career was dedicated to bringing the Industrial Revolution to his country, mostly to his Belgian provinces.

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