Science, Bourgeois Dignity, and the Industrial Revolution

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Part 12 of 13: "Science, Bourgeois Dignity, and the Industrial Revolution"

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Bourgeois Dignity: Why Economics Can't Explain the Modern World

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To Readers: The argument is, I fancy, complete, but some details in footnotes and references, and occasionally matters of routine calculation in the main body, need to be cleaned up.

Abstract: What happened to make for the factor of 16 were new ideas, what Mokyr calls "industrial Enlightenment." But the Scientific Revolution did not suffice. Non-Europeans like the Chinese outstripped the West in science until quite late. Britain did not lead in science---yet clearly did in technology. Indeed, applied technology depended on science only a little even in 1900.

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Chapter 30:

The Cause was Not Science,

We are back to what actually happened 1700-1848, and then on to 2010 and beyond, a rise of income per person by a factor by the end, let us say very conservatively, of 16. The happening was recognized slowly in the twentieth century. Among many economists and economic historians the recognition slowly killed the notion that thrifty saving was the way to massive and colossal productive forces. In 1960 the economist Friedrich Hayek questioned "our habit of regarding economic progress chiefly as an accumulation of ever greater quantities of goods and equipment."[1]

So: it was not capital. Nor was it any such thing. It was not for example the better allocation that comes with better institutions, or commercialization. Yet even many good economists could not grasp that static allocation is not the key to the success of market societies. Nice though it is, efficiency---making supply equal to demand---is not the main point. Innovation is. The inefficiency of democratic socialist regimes, therefore, is a pity, but it has not yet been a catastrophe either politically or economically. It has *not* led down the road to serfdom, which is why Western Europe's moderate version of socialism has proven viable.[2] True,

1 Hayek 1960, p. 42.

2 Berman 2006.

empirically, as a contingent fact about human nature, the dignities and liberties of the bourgeoisie do result in more innovation. But the "social market economies" of Finland and Holland continue to deliver pretty well, because they do not rigorously assault the dignities and liberties. The supply curves keep moving out in Holland and Sweden.

It could be, conceptually, that the nature of man under the other, more rigorous socialism---central-planning, zero property, shoot-the-bourgeoisie socialism ---would result in such a rise in public spirit, say, or such a reduction of alienation, that desirable innovation would flourish, and the supply curves move out. Since nothing would stand in the way of the use of the Caspian Sea for irrigation, all would be well, and no destruction of the environment would result. The Public Good would be served by consulting the *Volonté General*. But the evidence is in, and it speaks unambiguously. Serf socialism *is* a catastrophe and probably always will be. In 1917 one might reasonably have believed that a society without an admired and enabled bourgeoisie would in fact innovate more than one with the appalling bourgeoisie in power, and thereby socialism would pull the poor out of their poverty. By now the belief that Stalinism is Good For You is unreasonable. "Communist" China innovates, but does so precisely in its capitalist, bourgeois-admiring parts, only. Elsewhere it constructs by government fiat great armies to crush dissent and great dams that will silt up in twenty years.

All right. Again: what then explains innovation?

New thoughts, new habits of the mind, what Mokyr calls the "industrial Enlightenment." "The rise of our standard of living," wrote Hayek, "is due at least as much to an increase in knowledge" as to accumulation of capital.[3] The great economist Simon Kuznets, notes his student Richard Easterlin, believed that "the 'givens' of economics—technology, tastes, and institutions—are the key actors in historical change, and hence most economic theory has, at best, only limited relevance to understanding long-term change."[4] Mokyr and Goldstone and Jacob and Tunzelmann and I and some others would go one step further, to ideas. It was ideas of steam engines and light bulbs and computers that made Northwestern Europe and then much of the rest of the world rich, not new accumulations from saving. As Nicholas Crafts wrote: "The hallmark of the Industrial Revolution was the emergence of a society that was capable of sustained technological progress and faster total factor productivity growth."[5] The new society was one of innovation.

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Many scholars with whom I agree on many other points, however, think that it was in particular the ideas of the Scientific Revolution that caused the innovation.[6] Lay people (not the scholars) speak loosely in a portmanteau phrase of "science-and-

3 Hayek 1960, pp. 42-43.

4 Easterlin 1997, p. 8.

5 Crafts 2004 (2005), p. 10 of manuscript.

technology" making us better off. The phrase makes it possible to ignore the political and social change, the bourgeois Revaluation, that put the science to work. There's politics in it. With "science-and-technology" as the explanation of the modern world one can sit comfortably on the left, for example, and contrary to the opinion of Marx and Engels will not need to admit that the bourgeoisie has created more massive and colossal productive forces than have all preceding generations. Or one can sit comfortably on the right, too, and admire the aristocratic genius of the Great Scientists—not the alertness of the mere vulgar businesspeople who made the science economically relevant. Combining "science-and-technology" in one hurriedly pronounced phrase mistakes the past, certainly, and much of the present, justifying a worshipful attitude towards science that is not entirely *economically* justified. The phrase needs to be broken in two. Science. Technology.

In one respect I am inclined to agree with the Science-Did-It scholars, and even the Science-and-Technology lay people, because the impulsive force is then ideas rather than matter alone. As Richard Easterlin put it, "the growth of scientific knowledge [he instances biological discoveries improving public and then private health] has been shaped much more by internal [that it, intellectual] factors than external factors such as market forces."[7]

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6 The classic statement for science as the cause is Musson and Robinson 1969 and Musson 1972, but I refer here especially to later work by Jacob, Mokyr, and Goldstone.

7 Easterlin 1995 (2004), p. 99.

But of course one problem that has to be faced by advocates of science is that Chinese and at one point Islamic science and technology, separately and together, were superior to Western in every way, and yet resulted in no industrial revolution. Another is that the inspiriting discoveries of a Newtonian clockwork universe, and the great mathematization in Europe of earthly and celestial mechanics in the eighteenth century, had practically no direct industrial applications until the late nineteenth century at the earliest. The historian of technology Nathan Rosenberg noted that "before the twentieth century there was no very close correspondence between scientific leadership and industrial leadership," instancing the United States, which had negligible scientific achievement around 1890 and yet industrial might, and Japan, ditto, around 1970.[8]

Mokyr concludes that "the full triumph of technology was only secured after 1870 with the arrival of cheap steel, electrical power, chemicals, and other advances associated with the second Industrial Revolution," and associated sometimes with science.[9] "Cheap steel," though, is not a scientific case in point. Tunzelmann notes that even in the late nineteenth century "breakthroughs such as that by Bessemer in steel were published in scientific journals but were largely the result of practical tinkering."[10] My own early work on the iron and steel industry came to the same

8 Rosenberg 1978, pp. 282-283; compare Rosenberg 1982, p. 13.

9 Mokyr 2007a, p. 30.

10 Tunzelmann 2003, p. 86.

conclusion. Such an apparently straightforward matter as the chemistry of the blast furnace was not entirely understood until well into the twentieth century, and yet the costs of iron and steel had fallen and fallen for a century.

The economic heft of late-nineteenth-century innovations that did *not* depend at all on science (such as cheap steel) was great: mass produced concrete, for example, then reinforced concrete (combined with that cheap steel); air brakes on trains, making mile-long trains possible (though science-dependent telegraph was essential to keep them from running into each other); the improvements in engines to pull the trains; elevators to make useful the tall reinforced concrete buildings (though again science-based electric motors were better than a steam engine in every building more than four storeys tall, though the "science" in electric motors was hardly more than noting the connection between electricity and magnetism); better "tin" cans; faster rolling mills; the linotype machine; cheap paper; and on and on and on.[11] In 1900 the parts of the economy that used science to improve products and processes —electrical and chemical engineering, chiefly, and even these sometimes using science pretty crudely—were quite small, reckoned in value of output or employment. And yet in the technologically feverish U.K. in the eight decades (plus a year) from 1820 to 1900 real income per head grew by a factor of 2.63, and in the next eight decades "scientific" decades only a little faster, by a factor of 2.88.[12] The

11 See for example on cement Prentice 2008.

12 Maddison 2006, pp. 437, 439, 443, in 1990 international Geary-Khamis dollars, uncorrected for improved products à la Nordhaus.

result was a rise from 1820 to 1980 of a factor of (2.63) (2.88) = 7.57. That is to say, since 2.63 is quite close to 2.88, nearly half of the world-making change down to 1980 was achieved before 1900—in effect, before science. This is not to deny science *after* science: the per capita factor of growth in the U.K. during the merely twenty years 1980 to 1999 was fully 1.53, which would correspond to an 80-year factor of an astounding 5.5. The results are similar for the United States, though as one might expect at a more frenetic pace: a factor of 3.25 in per capita real income from 1820 to 1900, 4.54 from 1900 to 1980, and about the same as Britain after 1980.[13]

But understand the main point here: even today a great deal of economic growth in a country has little or nothing to do with science. The spread of economic growth to places like Brazil or Russia or India or China uses some science-based technologies, but uses also a great many merely *technology*-based technologies free of much input from science (I offer again reinforced concrete). And the international spread of growth has on the contrary intensively used the social "technology" of bourgeois dignity and liberty.

I do not deny that economic growth nowadays depends to some degree on science. We are all very thankful for the physical and biological scientists among us--- though observing that most of them work on problems that will never bear technological fruit (an extreme case being modern pure mathematics, such as number theory). But I do deny that modern enrichment by an unprecedented and Malthus-denying factor has been heavily dependent on the physical and biological sciences.

13 Maddison 2006, pp. 465, 466, 467.

Just as Britain in 1850 was far from exclusively a steam-driven cotton mill, so the world now is very far from a computer-driven automatic lathe. Strictly speaking a world without modern electrical, electronic, chemical, agronomical, aeronautical, or for that matter economic science would still be very much richer than the world of 1800.

Tunzelmann also notes that Britain was not "particularly conspicuous as a leader in science," which is to say, propositional as against applied science and especially technology. Scientific advance was pan-European from Copernicus to Carnot, and then became strikingly German. Yet the Industrial Revolution of the eighteenth and early nineteenth century was strikingly British, and despite the mistaken rhetoric of late Victorian "failure" the British continued into the late nineteenth and indeed into the twentieth century to be great innovators. It is conventional to observe in explanation that unlike the French or Germans the British were not significant theorists (with rare if glorious exceptions like Newton, Darwin, Maxwell, Kelvin, Hawking), but that they were very significant tinkerers and muddlers through. Technologists.

Goldstone defends the science-based argument this way:

> The distinctive feature of Western economies since 1800 has not been growth per se, but growth based on a specific set of elements: engines to extract motive power from fossil fuels, to a degree hitherto rarely appreciated by historians; the application of empirical science to understanding both nature and practical problems of production; and the marriage of empirically

> oriented science to a national culture of educated craftsmen and entrepreneurs broadly educated in basic principles of mechanics and experimental approaches to knowledge. This combination developed from the seventeenth to nineteenth centuries only in Britain, and was unlikely to have developed anywhere else in world history.[14]

One can agree especially with the "since 1800" specification. The economic historian George Grantham has argued that the real economic payoff from Continental science —chemistry and plant science in particular—came as a result of the massive up-scaling of science in the German universities during the 1840s, allowing the training of hundreds of careful experimenters and theorists, some of whom made breakthroughs such as the discovery of the carbon ring. Until then Continental science had been pursued mainly an aristocratic hobby. "For science to develop on a wide base, it could not continue to rest on a small number of wealthy persons supporting themselves in a life of research. The growth of organized science thus implied an institutional structure in which researchers are salaried."[15] "From an intellectual standpoint," Grantham concedes, "the Scientific Revolution takes its roots in the breakthroughs of the seventeenth century." But "from the institutional perspective, the Revolution belongs to the nineteenth."[16] Without a doubt Western

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14 Goldstone 2002b, abstract.

15 Grantham 2009, p. 13.

16 Grantham 2009, p. 5

science eventually pays off to some degree economically. Look around at your light bulbs and TV sets and synthetic fibers and cell phones and ample food supply, and offer up prayers of thanksgiving to the physical and biological scientists. But the payoff was late in modern economic growth, and it would not have had such consequences without dignity and liberty for the bourgeoisie.

The relative price of bourgeois standing changed, and made for large innovation in total. In doubting with Tunzelmann and me that theoretical science had much to do with the Industrial Revolution, Robert Allen quotes a fine passage from an author whom Adam Smith and I do not much admire, Bernard Mandeville, in 1714. The people who merely "inquire into the reason of things," declared Mandeville, are "idle and indolent," "fond of retirement," and "hate business."[17] Until 1871 Oxford and Cambridge excluded Nonconformists (that is, non-Anglicans such as Quakers, Unitarians, Baptists, Congregationalists, and later in great numbers Methodists), which left the dissenting academies to give Nonconformist children an education that did not inspire the hating of business, or favor retirement in studying the argument from design or the three forms of indirect speech in Attic Greek. From around 1700 the Scottish universities took a practical turn, notes Alastair Durie, and were "not merely concerned with the niceties of theology but endeavored to relate scientific enquiry to industrial application."[18] Theology itself in Britain joined

17 Allen 2006, p. 14 of manuscript, quoting Mandeville, Vol. II, "Third Dialogue," p. 144.

18 Durie 2003, p. 458.

enthusiastically with Newtonian science, whether inside or outside the universities. Scottish intellectuals invented a *social* "natural theology" in parallel with the physical one of their English neighbors, one step towards the Scottish discovery of economics.[19]

Celestial mechanics and anti-clericalism, in other words, could not by themselves have revolutionized Europe, any more than the great lead in science until 1600 or so by China and the Muslim world had revolutionized them. Mere curiosity and originality by a handful of Galileos and Newtons does not an industrial revolution make. Mandeville's dialogue again: "*Horatio*: It is commonly imagined that speculative men are best at invention of all sorts. *Cleomenes*: Yet it is a mistake." It is impossible to imagine our world view without Galileo's *Dialogo* or Newton's *Principia* or Hutton's *Theory of the Earth* or Darwin's *Origin of Species*. But it is easy to imagine our industry up until about 1900 without them. The new dignity and liberty for the bourgeoisie were essential. Greece's invention of most of the arts and sciences (with borrowings from eastern sources), and its partial freedom to doubt the gods, had not revolutionized the Greek economy or enriched its poor. Ancient Greek society despised physical work as slavish and womanly, and devalued gadgets (with Archimedean exceptions), and above all looked down on the bourgeoisie. French science in the eighteenth century depended notably on aristocrats such as Lavoisier and Laplace and Georges-Louis Leclerc, Comte de Buffon, retaining a glorious and axiomatic impracticality imparted first by Descartes. As Jacob emphasizes, "the

19 The economist and theologian Paul Oslington has argued so to me.

aristocratic character of French scientific institutions" was in sharp contrast to the workmanlike and practical tone in Britain.[20] Science in the Anglophone world depended much more on bourgeois, working, experimental figures like Newton or Priestley or Franklin or Hutton or Davy or Thomson.

And scientists, by the way, are not always harbingers of progress. After all, a little after the stirrings of dignity for the bourgeoisie and its world-changing innovations, the most advanced scientists and the most Enlightened thinkers commonly became the most virulent enemies of economic innovation, and often the most virulent enemies, too, of the freedom to have children or the freedom to speak one's mind or the freedom to live outside of a gulag. Consider, to take apparently hard cases, the much-admired geneticist and statistician R. A. Fisher (1890-1962), who passionately supported a racist eugenics; or the also-much-admired ecologist, as I have said, Garrett Hardin (1915-2003), who passionately supported compulsory sterilization. Though often very nice, the scientists and atheists—the two are not the same—are not automatically the best friends of human dignity and liberty.

The crux around 1700 was not the new sciences about anatomy and astronomy (neither of which much affected industrial development), but the new rhetoric about bourgeois innovation. True, some little of the New Science improved industry, as Jacob has argued for hydrology. Yet what mattered for the scale of innovation in total, Mandeville argued, is not to have scientists, but to have masses of "active, stirring, laborious men, such as will put their hand to the plow, try experiments

20 Jacob 1997, p. 108.

[there's the scientific attitude], and give all their attention to what they are about."[21] And especially what matters is that the rest of the society honor and liberate such people.

Jacob and Mokyr would reply that such active people of whatever class were increasingly merged with the scientists. Mokyr for example argues that "eighteenth-century Britain was what we may call a technologically competent society. It was teeming with engineers, mechanics, millwrights, and dexterous and imaginative tinkerers who spent their time and energy designing better pumps, pulleys, and pendulums."[22] In the English-speaking world, however, such practical savants attended to business, and that is the main point. Mokyr continues: "Even wealthy landowners and merchants [in Britain] displayed a fascination with technical matters." Yes. In 1752 an elaborate diagram of the "Yorkshire maiden" washing machine, which was in actual use, was displayed in the January 1752 edition of *Gentleman's Magazine*. Note: by then "gentlemen" had long been presumed in Britain to have an interest in mechanical devices other than machines of war. The very word "engine," which had once named hunting snares and then catapults and siege engines, comes by 1635 to name civilian machines, and gives rise by 1606 to "engineers" and their flourishing in England and Scotland and America and France towards 1800. It climaxes in the lives of the engineers, devoted to profitable (and

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21 Mandeville, Vol. II, "Third Dialogue," p. 144.

22 Mokyr 2003, p. 50.

unprofitable) projects of industrial design, experimenting madness. Henry Maudslay (1771-1831), for example, an English working class boy who became prosperously bourgeois, and redesigned machine tools, came upon the problem of screw-making. In the immortal words of the historian of the lathe, one Holtzapfell, "Mr. Maudslay effected nearly the entire change of screw making . . . to the modern exact and scientific method. . . . and he pursued the subject of the screw with more or less ardor and at enormous expense until his death."[23]

23 Bowden, Karpovich, and Usher 1937, p. 311. By the way, I believe the historian gets the date of Maudslay's death wrong—but after all he did not have the advantage of Google and Wikipedia other modern aids to high-class scholarship.

Chapter 31:

But Bourgeois Dignity and Liberty Entwined with the Enlightenment

One can agree with Goldstone, who in defending the new-old view of Margaret Jacob and Joel Mokyr that Science Did It, writes that "what transformed [European] production was a generalized belief in the possibility . . . of progress. . . . The longstanding traditional barriers between upper-class philosophers, market-driven entrepreneurs, large-scale industrialists, and skilled craftspeople and technicians dissolved, so that all of these groups came together to initiate a culture of innovation."[24] But then it is not science but the "breakdown of traditional barriers"—precisely the coming of a business-respecting civilization—which is the crux. The widening belief that the physical and therefore the social world can be changed, and is not frozen in a Great Chain of Being, might be attributed in part to science, though the Reformation and the Revolutions and above all the Revaluation surely figure, too. And one could just as well believe that a Newtonian universe would be worshipped instead for its clocklike stability, with conservative social conclusions. Jacob has taught us that Newton himself drew such conclusions.[25] The success of business

24 Goldstone 2009, p. 134.

25 Jacob 1997, p. 65.

projectors, whether bourgeois or aristocratic, was surely more effective than science in showing people that they too, and not only God's grace and miracles, could change things. By the middle of the eighteenth century the literary man Samuel Johnson, though a Tory in politics, could write in favor of innovation thus:

> That the attempts of such men [projectors] will often miscarry, we may reasonably expect; yet from such men, and such only, are we to hope for the cultivation of those parts of nature which lie yet waste, and the invention of those arts which are yet wanting to the felicity of life. If they are, therefore, universally discouraged, art and discovery can make no advances. Whatever is attempted without previous certainty of success, may be considered as a project, and amongst narrow minds may, therefore, expose its author to censure and contempt; and if the liberty of laughing be once indulged, every man will laugh at what he does not understand, every project will be considered as madness, and every great or new design will be censured as a project.[26]

There's a declaration for bourgeois dignity and liberty, against their enemies.

Easterlin draws a striking comparison between the Industrial Revolution and the Mortality Revolution. He notes that the demographer Samuel H. Preston's decomposition of falling mortality into the outcome of mere enrichment with given technology as against the outcome of technology with given enrichment is analogous to the economist Robert Solow's decomposition of enrichment itself into mere capital accumulation as against technology. He concludes that "when the quest for the

26 Johnson 1753.

economic historian's Holy Grail, the causes of the Industrial Revolution, is couched in terms of commonalities in the Industrial and Mortality Revolutions, economic explanations of the Industrial Revolution become less persuasive."[27] So they do. "In seeking an explanation," he continues, ". . . one must ask what is new on the scene." For both Revolutions, he says, with Jacob, Mokyr, and Goldstone, that it was science.

But what was also "new on the scene," and tracks the beginnings of economic growth and mortality reduction more precisely (considering that after the steam engines and water treatment plants are invented, they can be imitated), is the attribution of bourgeois virtue, such as from Johnson. It is seen in an early form around 1720 as a new dignity and liberty for traders and innovators (consider *Robinson Crusoe*, and all of Defoe's works). And a century before Defoe the English were beginning to learn from the Dutch the improving spirit of active, stirring, laborious men, such as will put their hand to the plow, try experiments, and give all their attention to what they are about. Henry Robinson was very busy in the 1640s issuing pamphlets advocating improvements such as compulsory swimming lessons for the poor. Francis Bacon's proposals during the 1620s for improving science look like those of a bourgeois projector (though my Lord Bacon was as far from bourgeois, and as far from an advocate for dignity and liberty, as one can imagine). Let us do thus-and-such, organized in this way, says the projector in Holland and then England, and—behold!— what great benefits will flow! It is a methodical and accounting rhetoric, foreign to an aristocratic society.

27 Easterlin 1995 (2004), p. 99.

Much later the rhetoric appears in the public and bourgeois spirit of people like Nassau Senior around 1840 or John Snow around 1850 calling for urban renewal and the redirection of water intakes. The germ theory of disease, Mokyr has emphasize, was of course a late nineteenth-century discovery, before which and quite independent of science a cleanliness obsession had taken hold among bourgeois men and especially women, long anticipated in the Low Countries and finally spreading to France and England. Nobody took care of the water supply or public education in London in the eighteenth century. Benjamin Franklin stood out in Philadelphia for his bourgeois public spirit. A century later in both places a very great care indeed was being taken—again, proper theoretical science aside. The banker and writer Matt Ridley in 1996 looked back his home town of Newcastle-upon-Tyne in 1800, as "a hive of local enterprise and pride" with "great traditions of trust, mutuality and reciprocity on which such cities were based."[28] Bourgeois dignity and liberty contains much more than isolated monads and an ethic of devil-take-the-hindmost. The Market of the economist's imagining is in truth and in history embedded in ethics and society.

Further, the political revolutions of the seventeenth century in England were surely more important to more people than the novelties of the Scientific Revolution —though the point can hardly be used against Jacob because she herself made it. She writes in the Preface to a new edition of her book of 1981 introducing the idea of a

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28 Ridley 1996, p. 263. Compare Prince Kropotkin 1901, giving a very similar view of an ideal town from a very different political perspective.

"radical Enlightenment" that "beginning in the 1680s northern and western Europe experienced a series of shock waves that in turn produced a new radicalism in thought both in matters political and religious. French bellicosity, the revocation of the Edict of Nantes in 1685, and the appearance on the English throne in the same year of a Catholic king threw Protestant Europe into turmoil."[29] It is her origin story, and a good one. But she and Jonathan Israel (who later carried on the argument with what Jacob characterizes with a hint of distaste as "a very different and largely idealist methodology") see the results through intellectual life, with the intellectual life then affecting the society and the economy. A more direct chain of causation would be revolutions (1642 as much as 1688, as Jacob also emphasizes; or for that matter 1568 in the Netherlands and 1517 in Germany) causing a new self-respecting by the bourgeoisie, and other-respecting for it, too—and at length the Bourgeois Revaluation. The ideas directly in support of economic change, as Jacob's colleague Joyce Appleby shows, were fruits of social and intellectual change in England during the seventeenth century, coming to full ripeness much later in French physiocracy and Scottish political economy. Joyce argues, for example, using Barry Supple's early work on the economic crisis of the early seventeenth century, that the disorders of the 1620s forced English people to think hard about a thing increasingly conceived as a separate "economy."[30]

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29 Jacob 1981 (2006), p. vi.

30 Appleby 1978, Chaps. 1 and 2. Supple 1959.

Goldstone defends the Jacobian chain of Boyle-Newcomen-Watt in which revolutionary consequences follow from the scientific discovery in England in the seventeenth century of the weight of the atmosphere (by the way, actually discovered in China centuries before, with no such practical result): "Great Britain had what no other nation on earth had, or would *for more than a generation*: a cheap and reliable means of converting heat energy (mainly from coal) into uniform rotary motion" (italics mine).[31] Note the italicized phrase, which Goldstone inserts with characteristic precision. That's right: for a mere generation or so the English coal miners and coal burners had an advantage. But a business-respecting civilization would have adopted the steam engine pronto, with coal or not. Bourgeois dignity and liberty made for quick imitation as much as ingenious invention.

Jacob noted that the very "backlash against the Enlightenment testifies to the enormous change in Western values witnessed in the eighteenth century."[32] Surely. But the change was not mere enlightenment. What finished the job was a society-wide shift towards the admiring of bourgeois virtues, supplementing the Enlightened attitude among the elite towards the creative destruction from new knowledge. Mokyr writes that "The Enlightenment affected the economy through two mechanism. One of them is the attitude toward technology and the role it should play in human affairs. The other has to do with institutions and the degree to

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31 Goldstone 2002a.

32 Jacob 2001, p. 68.

which rent-seeking and redistribution should be tolerated."[33] But such an answer to the question *Was ist Aufklärung?*" comes very close to my alleged "dignity and liberty of the bourgeoisie." An instrumental (and bourgeois) attitude towards technology gives ordinary affairs a dignity they did not formerly have. And resistance to the rent-seeking and redistribution that characterize an ageless mercantilism and, later, national economy is precisely the liberty from interference that the bourgeoisie sought—once it had been compelled to surrender its medieval attitude towards preserving the home market for itself. There's not much in the difference. I readily admit that the issue is tangled. I only suggest that one strand, without which the rope of modernity would have broken, was bourgeois dignity and liberty. Jacob herself points out, for example, that the founding rhetoric of the New Science emphasized the dignified *laboriousness* of scientific inquiry. Insight was to be achieved not by heroic gesture or God's grace but by thoroughly bourgeois works.[34] It is very Dutch, and then English and Scottish and American. And anyway bourgeois.

The Enlightenment, Jacob argues, was of Northern origin—"the beginning of the European Enlightenment can in many instances be traced to post-[Glorious] revolutionary England and the Dutch Republic," then shifted to France: "by 1750, the

33 Mokyr 2007a, p. 1.

34 Jacob 1997, p. 59.

Enlightenment had left its northern roots and become remarkably Parisian."[35] But had it stayed Parisian it probably would not have stayed at all. The production of encyclopedias and the wit of salons, if it had not worked within an increasingly bourgeois civilization led by an astonishingly innovative Britain, would have resulted (as it did in France) in hot-air balloons and military signaling systems, not steam engines and railways. The heroic engineer/entrepreneur such as the builder of the Great Western railroad and the Great Eastern steamship Isambard Kingdom Brunel (British, but the son of an exile from France) would not have triumphed. Jacob notes that "the civil engineer [of docks and canals and roads] emerged in Britain by 1750; his French counterpart was a military man. . . . standing aloof from the entrepreneur."[36] From 1747 the Frenchman graduated from the state school, *École Nationale des Ponts en Chaussées*. British engineers by contrast graduated from the private school of practice.

Jacob writes that "the Enlightenment returned to England, the land of its [1680s] birth, largely as a result of the American Revolution."[37] She means a *political* Enlightenment, since England and then Scotland never let go of the scientific and practical side. By 1750 in fact the other, British Enlightenment, of a much more practical nature, was being practiced in Edinburgh, and in 1765 in Birmingham, and

35 Jacob 1981 (2006), p. x; Jacob 2001, p. 50.

36 Jacob 1998, p. 71.

37 Jacob 2001, p. 63.

earlier even in far Philadelphia. The coal mines of Northumberland were filled with Newcomen engines by the 1740s, pumping out the water and permitting the deepest coal mines in Europe, but it was well into the nineteenth century before such wonders affected much else in the economy. Jacob asks of the engineers and inventors, "can we imagine an industrial revolution without Thomas Newcomen, Desaguliers, John Smeaton or James Watt?"[38] True, we can't. But the Bourgeois Revaluation, not high theory in Science, made the engineers. Or rather, high theory in science—and innovation in literature, in Birmingham toys, in painting, in steam, in journalism, in theology, in music, in port design, in philosophy, in constitutions—was as David Landes puts it various "manifestations of a common approach. . . . The response to new knowledge . . . is of a piece, and the society that closes its eyes to novelty from one source has already been closing them to novelty from the other."[39] The economic historian Peter Mathias wrote that "both science and technology [in the British eighteenth century] give evidence of a society increasingly curious, increasingly questing, increasingly on the move, on the make, having a go, increasingly seeking to experiment, wanting to improve."[40] The originality of Japanese color prints in the eighteenth century representing the "floating world" of prostitutes and kabuki actors betokens an openness to novelty that one sees also in

38 Personal correspondence 2008.

39 Landes 1998, p. 35.

40 Mathias 1972 (1979), p. 66.

the Osaka merchant academies of the late seventeenth century.[41] But until 1868, alas, in the face of Tokugawa conservatism, these were swallows without a spring. It is not Science that was the key to the door to modernity but the wider agreement to permit and honor innovation, opening ones eyes to novelty, having a go.

Had the Ottoman or the Qing empires so admired trade and innovation, then, they, not the Europeans, would have come first to apply science where one could, here and there—and anyway would have been the first to embark on the feverish pursuit of practical innovation in all fields from poetry to pottery that characterizes Britain and then Europe after 1700 and especially after 1800. But instead of taking advantage of their own highly developed cultures and sciences, the Eastern empires of China, India, and the Middle East, and plenty of European régimes, too (one thinks of the Counterreformation in Poland and Spain), turned in the seventeenth and eighteenth centuries, as Goldstone argues persuasively, to an intellectual conformity quite foreign to their earlier openness to ideas—just at the time the northwestern Europeans, and a few in East Prussia, awakened from their dogmatic slumbers. Yet without a radical change in attitudes towards innovation for optimistically hoped-for glory in a society newly admiring the bourgeois virtues, with a little money profit on the side, the sheer intellectual awakening in Europe would not have enriched the world. The rediscovery of analytic geometry three centuries after an Arab had invented it, the rediscovery of chemical principles known for hundreds of years in China, the questioning of religion centuries after

41 Najita 1987.

sophisticated scholars in Baghdad and Delhi and Beijing, or for that matter Athens and Jerusalem, had been doing so would have yielded no industrial fruit.

Orthodox Christianity differed from Catholic Christianity in only a few minor doctrines (*filioque;* clerical celibacy), and yet a corner of the Catholic West initiated growth while the Orthodox world stagnated. The case (which is that of the historian Lynn White) shows the drag from a rhetoric hostile to commercial values, and by contraries the importance of the Bourgeois Revaluation. The sociologist of comparative religion Michael Lessnoff summarizes with approval White's remarks on the matter: "In Greek Christianity, the influence of classical Greek culture was considerably greater [than in the West], including the philosophers' depreciation of technology, economic activity, and the active life generally. . . . Mechanical clocks, which proliferated in Western churches, were banned from Orthodox ones."[42] In the West, by contrast, Newtonian Anglicans took the clock as their central theological metaphor, and the pocket watch discovered in a field as their main argument for God's existence.

The new bourgeois society was pragmatic and non-utopian, but also a little mad—the madness that overcame European men and women once they came to believe that they were free and dignified and should have a go. Joel Mokyr cites the madness of the Montgolfier brothers and their floating of a sheep, a rooster, and a duck in a hot-air balloon in 1783 at Versailles. (Ben Franklin watched many such ascents, and at one powered by hydrogen replied to a skeptic about its usefulness:

42 Lessnoff 2003, p. 361.

"Sir, of what use is a new born baby?"). The lurching progress of innovation has never been seriously in doubt since around 1800. For a time during the Great Depression many doubted (though the economic historian Alexander Field has shown that the 1930s in the United States was in fact a technologically progressive time[43]). But the doubt was followed after the War by the greatest innovative boom since then. And world income has since further accelerated.

What was *not* routinely available in the eighteenth century was the great stock of inventions yet to be imagined, including the institutional inventions allowing cooperation among masses of people without the application of knout and sword. This is why China and India can now grow at rates inconceivable in the eighteenth and early nineteenth centuries before the inventions were well launched. Goldstone observes that human innovation until the eighteenth and especially the nineteenth centuries was "sporadic and isolated."[44] The Chinese invented the blast furnace, yes, and the Europeans much later got hold of it. Then the technology of the furnace stagnated until the British started charging furnaces with coke in the eighteenth century and then the Americans started hard driving with forced air in the late nineteenth century and then the Austrians and the Japanese reformulated the charge with the new chemistry in the twentieth. As I have said, it is a sort of madness, which now much of world outside the Bottom Billion has caught. Make your fortune

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43 Field 2003, 2006; confirmed by Alexopoulos and Cohen 2009.

44 Goldstone 2009, p. 29.

with another invention. An Indian recently invented wide and light paddle-like shoes for walking about on the water in rice paddies. Bravo.

What did happen in the seventeenth and eighteenth centuries to prepare for all this, you might think, is an original accumulation of inventive people, such as Richard Arkwright and Benjamin Franklin. But such a Great Inventor account is not quite right, either. Notions of social or spiritual capital, alleged to give rise automatically to Arkwrights and Franklins, force the evidence to lie down on the economist's bed of accumulate, accumulate. The crucial change was rather about habits of the mind and lip. Accumulated physical, human, and spiritual capital help the talk and thought, surely. If you are illiterate you are probably superstitious and conservative. But talk and thought possess a creativity that mere piling up of capital of whatever sort does not. One speaks of a "well-stocked mind," and the economist obsesses on getting "good training in the tools" of the currently fashionable formalities of his trade. Yet both of these likely as not create a mind unable to think, mechanically marshalling her knowledge of the classical languages or his tool of an econometrics over-accumulated. Thorough knowledge of Latin and Greek produced sometimes a Matthew Arnold, who could think. But sheer accumulation of learning also produced Oxford dons who almost never had an original idea and didn't publish on the rare occasions they did. The poet and Latin scholar A. E. Housman wrote in 1921 an essay against the non-thinkers in his field, "The Application of Thought to Textual Criticism." He recommended that his colleagues try thinking. Likewise in economics. Taking three of the standard graduate courses in

econometrics (as I for example did) produces usually not an economist thinking but an idiot savant good at following rules. A new dignity for innovators and a new liberty to try things out mattered more than such accumulation---although of course one needs minds minimally prepared, too. English literacy and technical apprenticeship did the job. But Japan at the time had similar levels of literacy and technical apprenticeship, without yielding an Industrial Revolution.

The other problem with the Procrustean move of forcing creativity to lie down on models of accumulate, accumulate is that people too depreciate over time. What had to happen was a change in the social rhetoric to make generation upon generation of people, educated in masses every year, *want* to innovate, and to innovate, and to innovate. There's the social or spiritual capital---but it's located in conversations. As suggested by the work of Christine MacLeod and Antonio Gramsci (an odd pairing!) the new rhetoric has to be renewed and strengthened with each new generation. Otherwise is returns to dust. The change of mind and lip was not once-for-all. What Gramsci called a "historical block" needed to be constantly renewed, as though it were a machine subject to rapid depreciation—my own book here is an example of such rhetorical investment in renewal. MacLeod argues that the "commemorative statuary [for James Watt erected in 1834] and the fundraising efforts [1824-1834] surrounding it both raised awareness of new technology and helped shape attitudes more positively towards it."[45]

45 MacLeod 1998, p. 98.

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