from McCloskey, *Bourgeois Dignity* (2010):

Chapter 38

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 sixteen. 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. Early on, in 1960, Hayek questioned “our habit of regarding economic progress chiefly as an accumulation of ever greater quantities of goods and equipment.”[[1]](#footnote-1) In 2010 the economic historian Alexander Field reinforced the original insights of the 1960s from calculations of productivity change in the United States that technology was it, not capital accumulation; and in 2006 the economist Peter Howitt had arrived at a similar conclusion from cross-country studies.[[2]](#footnote-2)

So: the Great Fact was not caused by capital accumulation, as desirable as was an Interstate Highway System valorized by the invention of the automobile and motor truck. Nor was it any such thing, such as the accumulation of educational capital. These are supplied if the innovation demands them. Nor was it the better allocation that comes with better institutions, or commercialization. Nice though efficiency is, it is not the main point. Innovation is. Even many good economists have not been able to grasp that static allocation is not the key to the success of market societies. As it is not. The inefficiency of social democratic regimes such as that of France, therefore, is a pity, but it has not yet been a catastrophe either politically or economically. France is very rich and very free. A generous social provision has *not* led down the road to serfdom, which is why Western Europe’s moderate version of socialism has proven viable, such as Sweden after 1960.[[3]](#footnote-3) True, 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 of the bourgeoisie.

It could be, conceptually, that the nature of man under the other, more rigorous socialism—central-planning, zero property, first-shoot-all-the-bourgeoisie socialism—would result in such a rise in public spirit, say, or such a reduction of alienation, that desirable innovation would flourish. 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. Ant-farm 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, however, 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 to exorcise the remote devils of European and Japanese imperialism, and constructs great dams that will silt up in twenty years.

All right. Again: what does then explain innovation?

New thoughts, new habits of mind and lip, 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.[[4]](#footnote-4) 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.”[[5]](#footnote-5) Mokyr and Goldstone and Jacob and Tunzelmann and I and some others would go one step further, to ideas. It was ideas about steam engines and stock markets and light bulbs and grain storage that made northwestern Europe rich, and then much of the rest of the world, not buildings or BAs accumulated from savings—which were merely induced by the ideas. As Nicholas Crafts writes: “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.”[[6]](#footnote-6) The new society was one of innovation. Many scholars with whom I agree on many other points, though, think that it was in particular the ideas of the Scientific Revolution that caused the innovation.[[7]](#footnote-7) Lay people (not the scholars to whom I refer) speak loosely in a portmanteau phrase of “science-and-technology” making us better off. As it did. But the phrase makes it possible to ignore the political and social change—what I call the Bourgeois Revaluation—that put the science to work. There’s some politics in it. With “science-and-technology” as the explanation of the modern world, you can sit comfortably on the left, for example. Contrary to the opinion of Marx and Engels, you will not need to admit that the bourgeoisie has created more massive and colossal productive forces than have all preceding generations. Or you can sit comfortably on the right, and admire the aristocratic genius of the great scientists—and disdain 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, and much of the present. It justifies for example a worshipful attitude toward expensive sciences such as astronomy and theoretical physics, which have no economic justification. The phrase needs to be broken in two. Science. Technology. To which, as Mokyr and Jacob have stressed, one must add *enlightenment*.

In one respect I am inclined to agree with the science-did-it scholars, and even the science-and-technology lay people, and certainly the enlightened, because the impulsive force is then ideas rather than matter alone. Mokyr declares that “engineers and mechanics such as Smeaton [breast waterwheel], Watt [separate condenser for steam engine], Trevithick [high pressure steam engine], and G. Stephenson [locomotive with high pressure engine] learned from scientists a rational faith in the orderliness of natural phenomena and physical processes; an appreciation of the importance of accuracy in measurement and controls in experiment; the logical difference between cause and correlation; and a respect for quantification and mathematics.”[[8]](#footnote-8) But these were rhetorical and ideal forces, as Mokyr would agree. Remember Richard McKeon’s claim that “the [technical] power to modify the heavenly laws” was in the late seventeenth century increasingly vouchsafed to human agency—by human agents, for example, in the form of merchants and projectors. 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.”[[9]](#footnote-9)

But of course one problem that has to be faced by advocates of science as a cause, and to some degree even by the advocates of the Enlightenment as a cause, is that Chinese, and at one point Islamic, science and technology, separately and together, and their humanistic scholarship, were until very lately superior to Western science and enlightenment in most ways, and yet resulted in no industrial revolution. Koreans invented moveable type, yet had no great scientific conversation. Another problem 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 very 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 by 1890 and yet industrial might, and Japan, ditto, by 1970.[[10]](#footnote-10)

Agreeing with this last point, 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.[[11]](#footnote-11) Sometimes. “Cheap steel,” for example, is not a scientific case in point. True, as Mokyr points out, it was only fully realized that steel is intermediate between cast and wrought iron in its carbon content early in the nineteenth century, since (after all) the very idea of an “element” such as carbon was ill-formed until then. Mokyr claims that without such scientific knowledge, “the advances in steelmaking are hard to imagine.”[[12]](#footnote-12) I think not. 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.”[[13]](#footnote-13) My own early work on the iron and steel industry came to the same 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 and a half.

The economic heft of the 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 the science-dependent telegraph was useful to keep them from running into each other); the improvements in engines to pull the trains; the military organization to maintain schedules (again so that the trains would not run into each other: it was a capital-saving organizational innovation, making doubletracking unnecessary); elevators to make possible the tall reinforced concrete buildings (although again science-based electric motors were better than having a steam engine in every building; but, the “science” in electric motors was hardly more than noting the connection in 1820 between electricity and magnetism—one didn’t require Maxwell’s equations to make a dynamo); better “tin” cans (more electricity); asset markets in which risk could be assumed and shed; faster rolling mills; the linotype machine; cheap paper; and on and on and on.[[14]](#footnote-14) Mokyr agrees: “It seems likely that in the past 150 years the majority of important inventions, from steel converters to cancer chemotherapy, from food canning to aspartame, have been used long before people understood *why* they worked. . . . The proportion of such inventions is declining, but it remains high today.”[[15]](#footnote-15) 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 numbers of employees. 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 “scientific” decades only a little faster, by a factor of 2.88.[[16]](#footnote-16) The 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 its economic heft *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 eighty-year factor of an astounding 5.5. The results are similar for the United States, though as one might expect at a still more feverish pace: a factor of 3.25 in per capita real income from 1820 to 1900, 4.54 from 1900 to 1980, and after 1980 about the same frenzy of invention and innovation and clever business plans as in Britain.[[17]](#footnote-17)

Mokyr argues that what was crucial was the *belief* in science (in line with his conviction that the Enlightenment ideology was the crux) because it eventually paid off—perhaps a little even in the second half of the nineteenth century, the Age of the Dynamo as Henry Adams called it, but certainly in the twentieth century. “The belief that systematic useful knowledge and natural philosophy were the keys to economic development,” Mokyr argues, “did not fade as a consequence of such disappointments” as the evident uselessness of most seventeenth-century science and the very slow progress during the eighteenth century of extending it in useful ways. “Yet the research continued, unshaken in its belief that at the end of the process there would be economic benefits, even if these were not yet known.”[[18]](#footnote-18) Physical and biological science, Mokyr argues, eventually prevented diminishing returns to mere engineering tinkering. “Without the work of natural philosophers, who would infuse it with new knowledge and connect different industries, an artisanal economy would eventually revert to a technologically stationary state*.”* “On its own,” Mokyr continues, “artisanal knowledge would be insufficient.” Highbrow science, he is saying, prevented economic growth from running into diminishing return.

Mokyr persuades, but not entirely. The immediate objection would be that such an effect was important only in the late nineteenth century, and hardly at all in 1800. We would be enormously richer now than in 1700 even without science. But one can start to see Mokyr’s point as the twentieth century proceeds. Had we lacked German organic chemistry, we would have no artificial fertilizer, and would have experienced diminishing returns in agriculture. Had we lacked American agronomy and genetics, we would have had no Green Revolution, with similar results. Yet without the first Industrial Revolution and its nineteenth-century denouement, which depended hardly at all on science, we would also have lacked the universities and the other riches to apply chemistry and physics and soil science and biology. Like imperialism and trade, science was more a result of economic growth than a cause.

All this remains to be shown, a tricky counterfactual. But understand the main point here: even today, as the calculations show, 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, such as cell phones, but uses also a great many merely *technology*-based technologies (“artisanal” in Mokyr’s vocabulary) free of much input from science—I offer again reinforced con-crete and military organization of railway workforces. And the international spread of growth has intensively used the social “technology” of bourgeois dignity and liberty.

I do not deny that economic growth nowadays depends to some degree on scientists. 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; or astronomy, which is splendid, yet, for all the romantic talk about the High Frontier in aid of better funding for space telescopes, less useful per dollar even for the human spirit than poetry or Assyriology). But I do deny that modern enrichment by an unprecedented and Malthus-denying factor has been crucially dependent on the physical and biological sciences. It was certainly not so until 1900, and the asserted scientific contribution to economic growth in the twentieth century needs to be calculated, not merely indignantly asserted because one admires physical and biological science. Just as Britain in 1850 was far from exclusively a steam-driven cotton mill, so the world even 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 be poorer, of course, but still it would be very much richer than the world of 1800—so long as the Bourgeois Revaluation had taken place. And there’s the use of *economic* science.

Tunzelmann notes further that Britain was not “particularly conspicuous as a leader in science,” which is to say that it was not conspicuously leading in propositional as against applied science, and especially as against applied technology. Scientific advance from Copernicus to Carnot was pan-European, and in the late nineteenth century became strikingly German. Yet the Industrial Revolution of the eighteenth and early nineteenth centuries 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: the military tank, penicillin, jet planes, radar. It is conventional to observe 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 nonetheless very significant tinkerers and muddlers through. Technologists. Bourgeois.

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.[[19]](#footnote-19)

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 upscaling 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, science in Europe had been pursued mainly as a hobby, and on the Continent it was pursued as disproportionately an aristocratic hobby. “For science to develop on a wide base,” Grantham argues, “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.”[[20]](#footnote-20) Like music, it came to be supported massively by the bourgeoisie. “From an intellectual standpoint,” he 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,” after (I would add) the Bourgeois Revaluation.[[21]](#footnote-21) That’s why the science important for our economic welfare started mattering much only after 1900.

The relative price of bourgeois standing changed long before 1900, and made for large and non-science-based innovation in total. In doubting with Tunzelmann and Grantham 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, the Dutchman resident in England 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.”[[22]](#footnote-22) Until 1871 the universities at Oxford and Cambridge excluded Jews and Catholics, of course, but also 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 hatred of business, or favor retirement into studying the argument from design or the three forms of indirect speech in Attic Greek. From around 1700 the Scottish universities by contrast 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.”[[23]](#footnote-23) Theology itself in Britain joined 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 toward the Scottish discovery of economics.[[24]](#footnote-24)

Celestial mechanics and anticlericalism, in other words, could not by themselves have revolutionized Europe, any more than China and the Muslim world were revolutionized by the great lead they had in science until 1600 or so. 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 of course quite impossible to imagine our worldview 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 and Antikytheran 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 (the Comte de Buffon), retaining a glorious and axiomatic impracticality imparted first by Descartes. As Jacob emphasizes, “The aristocratic character of French scientific institutions” was in sharp contrast to the workmanlike and practical tone in Britain.[[25]](#footnote-25) Science in the Anglophone world depended much more on bourgeois, working, experimental figures like Newton or Franklin or Priestley or Hutton or Davy or Rutherford.

And scientists 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 sometimes became virulent enemies of economic innovation, and often virulent enemies, too, of the freedom to have children or the freedom to speak one’s mind or the freedom to live outside a concentration camp. Upper-class socialists like the great economist Joan Robinson, writes the economist and priest Anthony Waterman, who was her tutee at Cambridge, exhibited a “patrician disdain for capitalist acts between consenting adults.”[[26]](#footnote-26) Consider 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 the atheists—the two are not the same—are not automatically the best friends of human dignity and liberty, and therefore not automatically the best friends of the modern world.

The crux around 1700 was not the new sciences about anatomy and astronomy (neither of which 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 [there’sthe scientific attitude], and give all their attention to what they are about.”[[27]](#footnote-27) And especially what matters is that the rest of the society honors and liberates such people.

Jacob and Mokyr would reply that such active people of whatever class merged increasingly 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.”[[28]](#footnote-28) In the English-speaking world, however, such practical savants attended to applications, not scientific theory, 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 civil-ian machines, and gives rise by 1606 to “engineers” and their flourishing in England and Scotland and America and France toward 1800. It climaxes in the lives of the engineers, devoted to useable projects of industrial design, experimental madness, such as Isambard Kingdom Brunel’s Thames Tunnel, Great Western railway, and Great Eastern steamship

Robert Allen correctly observes that the connection between Mokyr’s “industrial Enlightenment” of the fancier sort and many of the inventors was tenuous. Occasionally it was close, like Watt’s friendship with Black. But Wedgwood the potter and member of the Lunar Society was not elected to the Royal Society until he was fifty-three.[[29]](#footnote-29) The experimentalism that accompanied invention, Allen continues, was anyway necessary for any innovation, and “had precedents running back centuries.”[[30]](#footnote-30) Or millennia, in every part of the world. Doubtless some anonymous Romans “experimented” to invent the Roman arch, and food is an ancient and obvious case of experimentation—without “science” in the modern English sense of the word.

1. . Hayek 1960, p. 42. [↑](#footnote-ref-1)
2. . Field 2010; Howitt 2005, p. 7 in the Brown University preprint. [↑](#footnote-ref-2)
3. . Berman 2006. [↑](#footnote-ref-3)
4. . Hayek 1960, pp. 42–43. [↑](#footnote-ref-4)
5. . Easterlin 2004 , p. 8. [↑](#footnote-ref-5)
6. . Crafts 2004 (2005), p. 10 of manuscript. [↑](#footnote-ref-6)
7. . 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. [↑](#footnote-ref-7)
8. . Mokyr 1990, p. 168. [↑](#footnote-ref-8)
9. . Easterlin 1995, p. 99. [↑](#footnote-ref-9)
10. . Rosenberg 1978, pp. 282–283; compare Rosenberg 1982, p. 13. [↑](#footnote-ref-10)
11. . Mokyr 2007a, p. 30. [↑](#footnote-ref-11)
12. . Mokyr 1990, p. 169. [↑](#footnote-ref-12)
13. . Tunzelmann 2003, p. 86. [↑](#footnote-ref-13)
14. . See for example Prentice 2008,. [↑](#footnote-ref-14)
15. . Mokyr 1990, pp. 169–170. [↑](#footnote-ref-15)
16. . Maddison 2006, pp. 437, 439, 443, in 1990 international Geary-Khamis dollars, uncorrected for improved products à la Nordhaus. [↑](#footnote-ref-16)
17. . Maddison 2006, pp. 465, 466, 467. [↑](#footnote-ref-17)
18. . Mokyr 2010, p. 61. [↑](#footnote-ref-18)
19. . Goldstone 2002b, abstract. [↑](#footnote-ref-19)
20. . Grantham 2009, p. 13. [↑](#footnote-ref-20)
21. . Grantham 2009, p. 5. [↑](#footnote-ref-21)
22. . Allen 2006, p. 14 of manuscript, quoting Mandeville 1705, 1714, vol. 2, p. 144 (“Third Dialogue”); also in Allen 2009, p. 251. [↑](#footnote-ref-22)
23. . Durie 2003, p. 458. [↑](#footnote-ref-23)
24. . The economist and theologian Paul Oslington has argued so to me. [↑](#footnote-ref-24)
25. . Jacob 1997, p. 108. [↑](#footnote-ref-25)
26. . Waterman 2003. [↑](#footnote-ref-26)
27. . Mandeville 1705, 1714, vol. 2, p. 144 (“Third Dialogue”). [↑](#footnote-ref-27)
28. . Mokyr 2003, p. 50. [↑](#footnote-ref-28)
29. . Allen 2009, p. 247. [↑](#footnote-ref-29)
30. . Allen 2009, p. 257. [↑](#footnote-ref-30)