

Vaclav Smil, *Creating the Twentieth century: Technical Innovaitons of 1867-1914 and their Lasting Impact*. Oxford: Oxford University Press 2005, vi + 350 pp. ISBN:019-516874-4 (\$35.00); Vaclav Smil, *Transforming the Twentieth century: Technical Innovations and their Consequences*. Oxford: Oxford University Press, 2006, vi +358 pp. ISBN: 019-516875-5 (45.00).

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It is hard to describe in a short sentence the kind of intellectual that Vaclav Smil represents. A Professor of Geography and Environmental Science (whatever that exactly embodies) at the University of Manitoba, he has produced in the past decades an incessant stream of books on the technological developments of the modern age and their significance. Of those, my favorite is *Enriching the Earth*, in which he made the plausible case that the Haber-Bosch ammonia-producing process should be regarded as the invention that was as epochal as it was paradigmatic of the twentieth century. The ammonia process provided in abundance the food that was necessary if humanity was to be able to do other things and sustain even growing numbers at the same time.¹ Other books by him have discussed the energy revolution and the earth's biosphere. In these two volumes, Smil sums up what he has learned about what made the modern age. His scholarship mocks the boundaries that separate history from economics, geography from technology studies. He is unusually adept at combining his knowledge of how techniques actually work with his ability to illustrate their overall effects on society and the human condition.

¹Vaclav Smil, *Enriching the Easrth: Fritz Haber, Carl Bosch, and the Transformation of World Food Production*. Cambridge, MA: MIT Press, 2001.

The amount of pure learning and erudition that Smil brings to these 700 pages has to be experienced to be believed. In telling the story of modern technology since 1870 in a coherent way these 700 pages totally eclipse the competition.² Smil's writing, richly but not excessively illustrated, with a keen eye for the telling anecdote, the right illustrative number, makes his points with an eloquence and authority that has become all too rare in a world of technical scholarship in which hypothesis testing has taken precedence over a good narrative. While the narratives inevitably concerns the big breakthroughs, there are neat and cleverly presented little case studies of inventors whose names are anything but household names: George de Mestral, the Swiss inventor of velcro, or Nils Bohlin, the inventor of the car seatbelt. Yet these books are anything but coffeetable readings. They are thoughtful, analytical, even pensive at times. Smil full-well understands the environmental impact that the age of energy has had on the planet that unleashed it, and worries, like the rest of us, about nightmarish scenarios of the kind that Albert Gore has recently brought to every thinking person's home in America.

These volumes, in this reviewer's judgment, establish Vaclav Smil as another entry in a list of illustrious and erudite scholars whose main competence is in the History of Technology, yet who were able to lift themselves out of the quagmire of old gears and cogs to see a bigger picture, a picture of humanity struggling with the harshness of the environment and the niggardliness of nature, the deviousness of germs, and the sheer violence of natural disasters. Other masters in this genre, familiar to every trained economic historian are A.P. Usher, David Landes, Donald Cardwell, Nathan Rosenberg, and Arnold Pacey. The big picture produced by Smil, it should be added, is more about the immediate effects of technology than about what it did to the economy. Smil is not much interested in the standard things that economic historians do: he uses patents for illustration (and ridicule) but does not count them, he seems to have little regard for national income statistics, and he has very mixed views about our ability to measure progress through total productivity. He does not engage in social savings calculations, and his interest in the economic models that explain economic growth is rather limited. IPR's and economic incentives hardly figure in his story at all. Oddly enough, then, this is a book that gives to economic history much more than it takes from it.

There is no real *explanation* of what happened. Smil's view of technology is that it is all rather inevitable; when the ideas are there, and have been tested, "subsequent advances appear to have the inexorability of water flowing downhill (I-280)." In the context of the Western economies after 1870 this view seems to make sense, but in fact history is full of examples in which technology did indeed freeze in its tracks for long periods, to be revived only when some further breakthrough or social change allowed it do so. Smil does not stress enough, to the taste of this reviewer, that the Western World (later to include a few Asian Tigers) was a highly unusual economic environment, in which a large number of factors had come together that were absent almost anywhere else. Conditional on that environment, progress may seem inevitable. But there was nothing inexorable about the technological blast-off in the West that is described in vol. I.³ Indeed, Smil here and there

²The closest is Trevor I. Williams, ed., *A History of Technology: Vol VI, The Twentieth century, part I and II*, Oxford: Clarendon Press, 1978, 1530 pp. Ian McNeil, ed., *An Encyclopedia of the History of Technology* London and New York: Routledge, 1990.

³See Philip Tetlock, Richard Ned Lebow and Geoffrey Parker eds., *Unmaking the West: "What-If?" Scenarios*

seems to be subconsciously given to what is known “hindsight bias,” the notion that what happened had to happen. He has little interest in techniques that might have been but were not: the airship — a rather substantial technological achievement at the time — does not get a mention, presumably because it did not make it. The electric car is dismissed in one short paragraph and the steam car deserves no mention at all, even hydroelectric power barely gets two paragraphs (I-90-91). For Smil, history is definitely written backwards: start with what we have now and see where it came from. Let the economic historian who is without this sin cast the first reprint.

The two volumes here start in the late 1860s and take us all the way to the present. The first volume is dedicated to illustrate one central proposition: that the period between 1867 and 1914, the age that most of us refer to in our classes as the second Industrial Revolution and which Smil calls the “age of synergy,” was the age in which the technological foundations of twentieth century developments were laid. These two generations invented most of the technology that twentieth century growth was built upon. The second volume proceeds to tell the tale of how these seeds blossomed, in the post 1914 period, into the kind of technology that has transformed our world. Not much in these chapters will surprise a practicing economic historian teaching the origins of economic growth, but no one in our profession, I venture, is familiar with the enormous detail of technological progress that Smil provides on the sectors he is interested in. Technological progress, more than any other topic in economics, has had a certain black-box kind of nature, it is supposed to be somehow emerging as the result of the right kind of incentives and investment in human capital and R&D. It enjoys increasing returns, suffers from market failure, and in general is approximated by total factor productivity figures, patent data, and social savings computations if feasible. Smil puts a great deal of factual flesh and blood on that skimpy skeleton. Inside the black box of technological change, as he shows so richly, was a complex world of ambitious and curious creators, and greedy businessmen hoping to profit from their innovations. In the end, the consumer was the one that benefited by far the most, but, as Smil stresses, at a price.

These two volumes are not quite tantamount to a full history of technology in the second Industrial Revolution and the twentieth century. Smil is interested in energy and materials, and devotes a great deal to these favorite topics. In his picture of the world, so to speak, given enough energy and materials, we can lift the earth.⁴ He also devotes much space to information processing and communications. When all is said and done, he argues, what sets our modern age apart is its consumption of fossil-fuel burning energy, which increased from 22 EJ/year to 320 EJ/year (an EJ, as some digging will reveal, is an exajoule or 10^{18} joules, or a very large number of very small units of energy). The average American household today, he reflects, commands about 500 kW, as much energy as a Roman landlord with 6,000 strong slaves (II-260) but without the management hassles. Energy drove everything, but, as Smil reflects wistfully, it also is the Achilles heel of the entire system. There is also a long chapter on “rationalized production” in Vol. II, and the development of mass production, Taylorism, Fordism, and TPS (Toyota Production System — Smil loves acronyms, one of the few faults in his otherwise highly engaging writing style). There are some major advances that are left out, such as pharmaceuticals, genetic engineering, textiles, and civil engineering to name a few, but the areas he covers are so important and the coverage so competent and persuasive, that these are minor flaws. Underneath this improved use of energy and new materials, of course, was something deeper: better knowledge of natural processes and regularities, pure science, better mathematics, improved engineering, and networks of scientists and people of knowledge who distributed and applied a growing body of useful knowledge that made all this possible.

⁴Even in his discussion of agricultural productivity, energy dominates the story, arguing the importance of increased energy inputs rather than improved know-how in using the sun, in a section significantly entitled “potatoes partly made of oil” (II, pp. 154-56). One might object that the oil represents stored-up solar energy, and that the increased input of energy in farming was very much dependent on improved knowledge.

The two volumes are structured in similar way: the core of each consists of four chapters on specific areas of technology, preceded by an introductory chapter, and followed by two concluding chapters. The core chapters do not follow exactly the same pattern, but the overlap reflects Smil's interest and expertise. Much of the two volumes is dedicated to reproducing over and over the hockeystick effect, namely that somewhere around the end of the nineteenth century the world started to change at a high and accelerating rate compared to which the rest of human history looks rather flat.⁵ Smil's hockeystick numbers are quite mind-numbing due to his virtuoso ability to pick numbers that really illustrate his points. To demonstrate the fact that new technology was biased toward destruction, for instance, he points out that the kinetic energy of a World War I shrapnel shell was about 50,000 times that of a prehistoric hunter's stone tipped arrow but the Soviet 100 Megaton of 1961 was 140 billion times that of the shell (II-295).

In the somewhat tedious debate between "gradualists" and "saltationists" — again, a discussion that every economic historian knows well from the Industrial Revolution literature — Smil takes a firm position with the saltationists, and is not coy in actually using the term saltation. He cites H.G. Wells as noting that this was the greatest change that humanity has ever undergone, and while there was no single "shock," neither is there one at daybreak. This observation, reminiscent of the statement attributed to Edmund Burke that he could not tell when day ends and night begins, but he surely could tell one from the other, represents Smil's saltationism. His view is that between 1867 and 1914 more changed in human control over their environment and their ability to manipulate natural regularities than ever before or after, or in his own felicitous phrase, (I-13) "the pre World War I innovations tumbled in at a frenzied pace." Many of the great advances in productivity and product innovation were building on the discoveries of these two generations of miracles.

⁵Joel Mokyr, "'Hockeystick Economics,'" a review essay of Robert William Fogel, [The Escape from Hunger and Premature Death: Europe, America, and the Third World](#). *Technology and Culture*, Vol. 46, No. 3 (July 2005), pp. 613-17.

Much of what is wrong with the modern age is summarized by Smil in a citation from H.G. Wells from 1905 (I-312): “were our political and social and moral devices only as well contrived to their ends as the linotype machine, an antiseptic operating plant, or an electric streetcar, there need now be...only the smallest fraction of the pain, the fear, and the anxiety that now makes human life so doubtful in value.”⁶ In general, Smil argues, this is what bedevils the advances in technology, not the technology itself. In the closing chapters of Vol. II, his earlier techno-enthusiasm seems to have cooled. Until July 1914, it seems, the human race was on a path toward progress, but then it all fell apart through violence, destruction, and collective irrationality. However, Smil is not blaming only politics and institutions for the wrong turns that technology has taken, he also pours disdain on some private decisions. For instance, he does not like cars. If a sapient extraterrestrial civilization observed the earth they would see that “wheeled organisms, besides killing annually one million bipeds...were also responsible for very rapid climatic change and make life for the bipeds increasingly precarious” (II-266). Elsewhere he heaps scorn on SUV’s referring to them as ridiculously oversized, incongruous and wasteful machines (II-207). Above all, he notes caustically that all the technological disasters that the 20th century was supposed to have inflicted are dwarfed by smoking and excessive eating, and cites a study that notes that most supposedly negative consequences of technology are the result of lifestyle choice rather than environment factors caused by technical advances (II-294).

There are only two serious risks that the “Great Synergy” has brought about that he thinks are worth talking about, the proven risk of armed conflicts between technologically-advanced societies, and global warming. On both of this he sounds concerned, but not alarmist. At the end of the day he concedes that the energy-intensive society that the 1880s and 1890s created cannot be sustained. He does not tell us how this can and should be done, and at times he equivocates. Thus he concludes after much fascinating technical detail in his survey of the nuclear industry that the 20th century use of fission for electricity generation was a “successful failure” (II-63), technologically successful but too costly. It is hard to see it this way from Smil’s own account, because nuclear power was the only large-scale energy generation system that does not contribute to global warming, and was probably much cheaper than the solar, wind- and tidal sources that are currently discussed.

Smil is measured and balanced even when he discusses distinct technophobes like Ivan Illich and Jacques Ellul, and while he dubs Illich “an unorthodox thinker,” he does not engage Illich’s well-known neo-Luddite views. Smil himself is no Luddite, he is deeply impressed by the triumphs of modern technology as he demonstrates over and over again. He knows full well that the technophobes’ notions of the serenity of preindustrial pastoral life is a risible cartoon, and that the view that industrialization deepened, rather than relieved, human misery, is “indefensible” (I-299). But he is too smart and too learned to be a triumphalist. In the end, his judgment remains ambiguous and full of contradictions, much like the tale he tells so well.

⁶Freud, in his *Future of an Illusion*, written in 1927, said much the same thing: “ While mankind has made continual advances in its control over nature and may be expected to make still greater ones, it is not possible to establish with certainty that a similar advance has been made in the management of human affairs.”

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