Robert McCormick Adams, *Paths of fire. An anthropologist's inquiry into Western technology*. Princeton, New Jersey: Princeton University Press, 1996, 332 pages

Book Review by Jim Dator
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It is difficult to imagine a book more appropriate for review in a journal calling itself "Technological Forecasting & Social Change" than one which is subtitled "An anthropologist's inquiry into Western technology." And it is difficult to imagine a person who could be better qualified to undertake such an inquiry than Robert McCormick Adams, a very celebrated archeologist of urban and agricultural development in the Near East, a former Provost of the University of Chicago, and the immediate past Secretary of the Smithsonian Institution. His influence on the popular as well as professional understanding of technology in the United States has been tremendous, and this book is one he announced he was retiring to write when he left the helm of the Smithsonian.

Your reviewer, on the other hand, is none of these things--I am just an academic journeyman laboring in a pleasant, but obscure, corner of the barely-known world. I also tend to be a very bland, conflict-avoiding person, full of Aloha for almost everyone and everything. Thus, I have wrestled long and hard with how to express my judgement of this book. Bear with me here, please.

The volume is a three hundred page attempt to explain how technologies come into existence. One thing that is made absolutely clear repeatedly throughout the book is that the rise of each new technology (or its failure to rise) is a complex, interrelated process, and that anyone who believes that there is a single-factor cause (and certainly anyone who believes that technology itself is the primary cause of social change) is dead wrong.

Adams is very insistent about this point. If there is anyone who believes in a simple-minded "technological imperative" by which whatever is possible most certainly will be, then she should read this book. Adams shows that there are many complex factors, none of them commanding, none of them necessary, none of them necessarily trivial, which may lead to new and sustained technologies in one situation, but not in another. Indeed, the account of technological development in this book seems more "historical" than "anthropological" (or otherwise "social scientific"), so thoroughly does the author wish to be certain not to generalize about anything. Everything that happens does so uniquely, with nothing learned from the specific facts in terms of generalizable principles except that generalizable principles are folly, and that any principles (much less "laws") which anyone has put forward about technology and social change are certainly superficial, incomplete, subject to numerous exceptions, if not totally false.

"In any case, we are speaking here of *techno-economic activities*, which can exist only as they are deeply embedded in customs, laws, and institutions. It would surely be unrealistic to assign technology in a narrower sense a distinct and independent role, as an inanimate, extrasocietal force somehow detached from the same enveloping and supportive framework," Adams writes (p. 71. Emphasis in original)

But note another sentence, earlier on, which does get close to suggesting that once initial conditions have been established, then "causality," or at least directionality, is largely determined: "What has become known as 'path-dependence' unquestionably is a major, recurrent feature of the historical record. Initial advantages, whether

predisposing to an optimal resolution or an inferior one, has a very good chance of establishing the course that is subsequently followed" (p. 25). Indeed, this presumably is the implication of the title of the book, "paths of fire," although this is never made clear as far as I could tell.

In many ways, the book is breathtaking in its scope. After an introductory chapter, where "the idea of technological change" is presented in much of its great complexity (indeed, Adams never makes clear exactly what *he* means by "technology"), the author then turns to what surely must be his major strength: technology in "Western antiquity." He then devotes a chapter to technology in medieval Europe, a chapter to modern England, three chapters to the United States (two historical, and one in relationship to the "competitive global system" surrounding the US currently), and a final chapter on "technological change in a borderless world" which has a few hints towards the future.

Except for the fact that everything is said to be complex and interrelated, there is very little parallelism between all eight chapters. Nor is there any single theme or set of themes traced or compared from chapter to chapter. Issues which seem central to the author at one point (even for a few chapters) are not mentioned, or at least not made nearly as significant, in the later (or earlier) chapters. For example, minute (and very interesting!) details concerning the rise of "the useful arts" in the early civilizations of the Middle East do not find their counterpart or parallels when medieval Europe, or modern England, or the US are discussed. There, often very different (and very interesting!) details are presented instead which were absent in earlier chapters.

One theme that almost makes it through each chapter might be described as the question, "Which came first, science or technology?" Another contender is the question, "Push or pull? Is there first a social 'need' for which a technology is then developed to 'fill', or is there first the technology, for which someone then creates a 'need' which the technology can fill?" In either case, who or what plays the major role here--individual inventors, entrepreneurs, the market, the government, chance, or what?

At times, Adams presents evidence which seems to suggest that the emergence of new technology leads to new scientific concepts (perhaps by making observation of new phenomena possible). But other times Adams suggests the opposite. And then there are times when even the question itself seems wrong-headed. Adams sometimes seems to believe that the situation is too complex to be clearly resolved. Neither one causes the other. It is a complex interrelationship that also involves things which are not strictly either science or technology (things like personalities, cultural predispositions, accidents, and the like).

For example, Adams states that "a lengthy, largely quiescent epoch ensued after the explosive [technological] changes in the late fourth millennium that accompanied the birth of Near Eastern cities and civilizations. Later antiquity witnessed only a few conjunctures of innovation, and these seem to have had relatively narrower and much slower social impacts or concordant changes" (p. 41). "Greek and Hellenistic natural philosophy, for all of the seminal importance with which it is often invested as the source of a unilinear tradition leading to modern science, is of only marginal relevance to the history of technology"(p. 44). Even the technologies of "Archimedes and Euclid were embedded in an aristocratic and literary culture that was profoundly anti-utilitarian" (Loc. cit.).

While discussing early modern Europe, Adams in one place writes: "Thus, at best, if there was a relationship between technological innovation and market forces, it must have been not only diffuse but subject to long lags and other intervening variables" (p. 86). A page later he further stresses that "It seems, in short, that rising consumer demand was likely to provide no more than a modest and diffuse inducement at most to the technological advances that lay at the heart of the Industrial Revolution. Market 'pull,' in that direct sense, appears to have little explanatory power" (p. 87). And in conclusion on page 103 he says, "It is very difficult to identify a technological impetus that can be credited with more than a marginal influence on any of these developments. A substantially better case can be made for the reverse--for attention having turned to investing in new industrial processes and products, and to more effectively exploiting existing technologies, as new concentrations of disposable wealth appeared and the general level of economic activity increased."

But how why did wealth "appear" and economic activity "increase" if it is related to neither markets nor technology?

But why ask why? "The issue of 'push' versus 'pull' is an abstract and probably overgeneralized one. It seems to imply that causal primacy for an epochal turning point in human affairs like the Industrial Revolution lies ultimately in large, impersonal forces beyond the control, and perhaps even largely beyond the conscious understanding, of human protagonists" (p. 91). And so we are left feeling rather foolish at having been duped into believing that "push vs. pull" was an issue worthy of our paying attention to during his many pages of discussion about it. It is rather a matter of individual agency and wise investments, it seems.

But is it?

Towards the end of the book, Adams observes, "The contributions of American basic science to these accomplishments remained quite limited until the enormous acceleration of R & D activity that began in industry as well as in universities at about the time of World War II" (p. 199). It must be noted that "these accomplishments" which Adams means were "whole new industries" including "the telephone, the automobile, the airplane, electrical power and lighting equipment and appliances, radio and television," as well as "important economies of process and scale." Science had little or nothing to do with any of it, Adams says. So what did?

To be sure, Adams repeatedly stresses the inadequacy, and bias, of existing sources. Consequently, much about what happened and why is unknown, and unknowable. Moreover, we certainly know far too much about "great men" and far, far too little about everyone and everything else. And because the scientists tend to be the writers while the technologists were the doers, we know more about "great Western men of science" than we do about "technology," or any other factor, Adams comments.

Fair enough, Yet, each time the "science vs. technology" or the "push vs. pull" or the "great man vs. historical process" issue is introduced, it is treated as though it had never been mentioned in the work before. Indeed, that is one of the most frustrating things about the book: ideas, people, events which are repeatedly mentioned are brought up as though it was for the very first time However, since it seems we are not expected to have learned anything from chapter to chapter, but have just been content with the facts, we learn nothing from these repeated sequences either. Chapters 4, 5, and 6, where first England and then the US are discussed, are quite

interesting as plain historical statements of what happened. There are some good descriptive "snapshots" of various people or technologies, but not much more. We are informed, indeed, entertained, but we don't "learn" anything from what we are told.

Adams' focus on the unprecedented and rapid rise of London from a small village to the largest city in Europe in the early modern period (though Adams fails to say it was not the largest city in the world) is interesting. He suggests some of the possible consequences of that for the development of new technologies in England. And he states that while the population of England did not rise very much during the 17th century, the population of London (and no other European city) rose astoundingly. But why? He does not explain why London became a major city, which would also seem to be an important point in order to understand its role as the "puller" of technological innovation which he makes it out to be.

Adams' omissions are as fascinating as the facts he does present. For example, the role of clocks is given short shrift (p. 50f). On the other hand, he gives very great space to the various forces that led to (and sometimes away from) Watt's steam engine. Why one but not the other?

Moreover, while he does mention that the invention and evolution of writing was a complex, prolonged, and very important factor in the rise of early civilizations (pp. 39ff), he does not mention at all the equally important contribution of Gutenberg's printing press for the evolution of modern Europe. Nor does he acknowledge the prior invention of the printing press in China, and of moveable type in Korea, which, among other things would have enabled him to use that as a clear example of the complexity of the relationship between technology and social change. The invention of the printing press in Asia did not have the same impact there that it did in Europe. More importantly, it is probable that the emergence of the printing press in Europe was not an independent invention, but rather a borrowing from Asia--a point I shall return to later.

There is some mention, especially in the last chapters dealing with the present and future, of the contribution of technological change to the creation of class and social inequality (pp. 123ff). But the impact of the "enclosure movement" is not discussed at all in the chapters where it was directly relevant. This very important nonscientific and nontechnological factor is omitted. Why?

Adams does show that, contrary to what one might believe by relying entirely on prominent sources, "consumerism" was largely an upper and upper middle class phenomenon in England--especially in London--and by no means widespread among all classes. Still, the political--indeed, the human--dimension of technological change is almost totally absent in this volume.

Environmental issues only get mentioned--and only *mentioned*--at the end of the book. Yet understanding sustainability, risk assessment, and especially intergenerational equity (three terms that Adams does introduce finally at pp. 269ff) are among the key challenges facing humanity. If they were important enough at least to point out towards the end of the book, why didn't Adams set up the discussion by indicating their role--or absence--in the development of technology in the past? Once again, Adams seems content to be an "historian"--or a recording secretary--noting what is happening if and when it happens, if it appears in his sources, but drawing few implications from what he sees, much less from what is not to be seen.

While it is clear from the facts Adams presents throughout the book that the military

has an enormous role in technological innovation from the very beginning, Adams himself implies that entrepreneurial, "free market," forces are far more important. In the latter chapters (eg, the section titled "Passive and active roles of militarism and the state" [pp. 259-265]), concerning the US, does Adams at least acknowledge the over-importance of the military. Much more could and should have been made of this if one were indeed interested in exploring the major factors contributing to technological development, and its consequences, I believe:

"Fundamental to it were all of the slow and dearly won lessons of 'armory practice' that eventually gave substance to the American system of manufacture" (p. 184. See also p. 186). After Ford in the 1920s, "they did not once again fully express the levels of output of complex machinery of which mass production methods were capable, or the speed with which those levels could be reached, until the country was faced with urgent military necessities as a consequence of World War II" (p. 188).

"[T]he presence of the Department of Defense as a major R & D customer has had substantial structural effects that deserve to be mentioned. Apart from the direct stimulus of R & D funding by the Department of Defense, there are a number of more indirect military influences on industrial technology" (p. 225). "Military relevance, it would appear, is the key criterion" for federal funding of technological research, Adams concludes (p. 264). But he draws no implications from any of this.

Indeed, in discussing the 18th and 19 century in the US, the absolutely crucial role of government directed/funded activities is discredited, even when the facts he states clearly show otherwise. For example:

> "There was an occasionally aggressive (if only briefly effective) imposition of import tariffs to support infant industries, or a program of sales or awards of bountiful western lands to further railroad construction, higher education, agricultural research, and, in general, a rapidly expanding frontier settlement. Other than this, the federal intrusion into stimulating technology transfer and fostering industrial growth, by even the broadest definition, was very limited. The one major exception, again of military inspiration, was the development of elementary techniques of mass production involving replaceable parts in the federal armories. It was indeed a significant exception...." (p. 261f)

Well, yes, but the items receiving federal support listed above are pretty extensive--protective tariffs, free land for railroad construction, higher education, agricultural research, and reliance on the military for the very basis of "The American System"--interchangeable parts on an assembly-line. Indeed, what is left out of any significance here? What more could any government have done in the US in the 19th Century to facilitate industrial development?

Of course, Adams knows the story is different now: "Nothing better illustrates the crucial importance that state encouragement now has assumed than the rise to a dominant position in the US economy of an enormous complex of aerospace businesses" (p. 263). "And pioneering in virtually every successive technological breakthrough...have been military applications. Government stimulus and subsidization have played a central part.... It is safe to say that the industry would be today only a small vestige of what it has become without those ubiquitous forms of state intervention" (p. 264).

But what are we to learn from these facts? Nothing is suggested, though one of the

things which might well have been pointed out is that much of the concern with, as well as specific methods for, technological forecasting came directly from the US military experience, not only because of a growing concern with long-range threats but also because of the problematic nature of the new weapons--nuclear warheads, guided missiles, supersonic aircraft and the like--and interest in knowing what new weapons lay ahead, in scientific laboratories or technology development centers of "enemy" or of "friendly" hands alike. Most of the first specifically future-oriented methods were developed under military-related auspices in the 1950s and 60s: Delphi forecasting at the RAND, scenarios at Douglas Aircraft, and several trend-analytic methods by the US Air Force.

Entirely out of the blue appeared a section titled, "Encountering the Japanese system of production" (pp. 246-9). And here we see a fatal flaw in this book. If Adams had spent as much time surveying the history of science and technology elsewhere--such as in India, China, Japan, Korea--as he did in Europe and the US, how very much better might this book have been. Now, perhaps that is unfair. The book Adams intended to write is only about Western technology. But because he does not consider at least Asia, where sources are relatively abundant, his book is the usual blinkered Eurocentric tract, rather than the scholarly contribution I am sure he intended it to be.

At the very least, if Adams feels that it is important enough, and that he is competent enough, to discuss contemporary Japan in the final chapter, one would think he would want us to learn about technological developments in Japan well before this. Why is Japan important to us so late in the story? Is Japan's contemporary and threatening technological prowess the result of its late copying from the West (as his tardy treatment of Japan implies)? Or could it be the extension of an indigenous (or indeed regional) process that, if explicated, could help us get a more complete understanding of the true "paths of fire?" Adams' utter silence on nonwestern experiences--much less his general failure to point out nonwestern contributions to the Western experience--strengthens the Eurocentric bias of this and so much American scholarship, and brings discredit on the entire enterprise.

There is no doubt that Adams' explanation of European and American technological development would have been much different--richer and better--if he had at least traced the history of technology and society in at least Japan (since he felt he should mention Japan at the end)--and preferably much more broadly. For example, there is growing evidence to support the contention that there were (at least) two recent "industrial revolutions": the one in Europe that we know so much about, and one in Asia about which possibility most of us are ignorant. Another view is that what we call "The Industrial Revolution" was simply a later extension of an earlier Asian--indeed, global--process. None of this is of course ever mentioned by Adams--even to be rejected--and so we are left with our feelings of Western, and especially American, exceptionalism--and of the threat which the "competitive global system" in our emerging "borderless world" (about which Adams devotes the final two chapters) poses to The American Way of Life.

Towards the end of the book, Adams discusses the increasing speed of technological change, noting for example that the issuance of patents was a good measure of innovation in the early modern and modern period, but that it is not now because the time between cutting edge innovations and obsolescence in certain areas of technological change is too short for the inventors and developers to even bother applying for patents in many cases (compare pp. 88ff with pp. 243ff).

Adams also says: "It is widely claimed--by whom originally I cannot identify--that 90 percent of all the scientists who ever lived are still living today" (p. 226). It was when I read this statement that I realized what was another source of my discomfort with Adams' book.

I don't know for sure who first made this claim either, but I do know that one of the first times I read it was in Derek de Solla Price, *Science Since Babylon* (New Haven: Yale University Press, 1961), a work that Adams does not cite. I was first drawn to Price either by other writing by Price, or some other author of the time. Recollecting that, I pulled *Science Since Babylon* down from my bookshelf, dusted it off, and began reading it, cover to cover (it is less than half the length of Adams' book).

Price covered many of the same things Adams does, and many more, and generally much better, and certainly more clearly and directly (including some modest discussion of Asia and of nonwestern contributions to Europe). While Price's title says "science" and Adams' says "technology", both cover science and technology in about the same interrelated proportion. Very regretfully, I really could not conclude that Adams had contributed anything in his volume that increased our understanding of science, technology, and social change significantly beyond what Price had told us some 35 years earlier.

In any event, eventually I found the citation I was looking for. In the final chapter, ominously titled "Diseases of Science," and after a discussion of the exponential growth in the number of scientists, scientific research, and science publications from 1665 to the present (1960), Price observes:

> "To state it a little more dramatically, however, we may remark that at any time there co-exist in the scientific population scientists produced over, let us say, the last forty years. Thus, at any one time, about three doubling periods' worth of scientists are alive. Hence, some 80 to 90 percent of all scientists that have ever been, are alive now. We might miss Newton and Aristotle, but happily most of the contributors are with us still!" (p. 107).

Now, it is also the case that, in his book, Price continues his forecast on forward on the assumption that the exponential growth will continue. He concludes, "At this rate, the whole working population should be employed in the one field as early as 1990" (p. 108). Now, "the one field" Price is referring to is not science and technology in general, but specifically "the electrical engineering industry."

So, what do you think? Is Price right or wrong? Consider the place of electricity and electronics in our world today--in our homes, in commerce, transportation, manufacturing, entertainment, education, the military, and space. Who in the "working population" is not in some significant way complicit in the miracles wrought over the past 35 years by "the electrical engineering industry?" The Price is right!

Or is Price wrong, even if he was just suggesting the absurdity of--or at least the limits to--all extrapolations?

I also found that, on page 19 of *Science Since Babylon*, in a comment I dated 8/11/62, while I was teaching at Rikkyo University in Tokyo, Japan, I had written, "Maybe 'nature' knows that the survival of our species depends more on our ability to leave the earth than on our ability to adapt to the earth." What--on Earth--could have

prompted me to make that observation at that time! It certainly seems more obvious to me now than I can imagine it could have seemed then, at such a very early period in the "space race" and without that being in any way the topic Price was discussing where I penciled it in. But there it is, in my own crabbed hand.

Well, how about Adams, and all the others who continue to quote Price (without acknowledging him--assuming he is in fact the original source)?

There is mounting evidence that the number of scientists and technicians (at least in the US and Europe) seems to be stabilizing and perhaps falling, along with government grants to scientific research and universities. Is the great period of scientific/technological R & D-induced social change over? Is "Technological Forecasting and Social Change" doomed to become an historical journal, merely documenting what technology did to society, especially in the good/bad old days of the 20th Century? Are we about to enter yet another long period of scientific and technological quiescence? Or is the contribution of Asia and the rest of the world to the story of technological development about to be told, and felt? Adams does not consider any of this either.

If I have not already appeared to be uncharacteristically petty and cranky enough, I will end my review with a few more clearly cranky and superfluous comments:

1. For a publication from a prestigious university press, there are a dissatisfyingly large number of typos. Without my having tried to look for and remember any, here are three: Kondrarieff (22), aggresssively (157) "fronm" (in a quote, p. 162).

2. At the end of the preface (xvi) Adams thanks his Princeton editor: "With his help the main lines of the argument of the book have emerged with greater consistency and clarity." Since my main complaint has been with the lack of any "main lines of argument" at all, and with the considerable inconsistency and lack of clarity, would that the editor had been even more stern and insistent.

3. But the honor of being The Last Straw goes to the footnote system which is not, I presume, the fault of the author. Sources and elaboratory comments alike are indicated by conventional footnote numbers in the text. The notes themselves, however, are then arranged by chapter near the end of the volume. But full citations are not found there. For that, one must search through the bibliography printed at the end.

At the outset (xii), the author tells us that he is going to rely heavily on the work of others. Thus, perhaps more than for a work of original research, it is necessary for a reader to follow closely the author's argument by reference to his quoted sources. But, given the cumbersome layout, this is extremely difficult and annoying to do. The book did not need to offer more frustrations than are already provided by the text itself.

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