the frequent nostalgic looking back to a time when 'the growth of population and of invention, the opening up of new lands . . . allowed a . . . satisfactory average level of employment'.[5] (Although in an earlier book—*The Economic Consequences of the Peace*—Keynes did argue that the 'Devil of over-population, disclosed by Malthus' was one of the principle causes of the First World War.[6] Nevertheless, Heilbroner and Milberg contend, a great deal can still be learnt from Keynes, just as it can be from Smith, Mill, Marshall and others: recognition of the historical context of ideas in no way necessitates their wholesale jettisoning.

In sum, this volume is strongly recommended as an outstanding (and relatively rare) example of eminent economists taking a cold look at their discipline. I see from the footnotes that the senior author—Heilbroner—has been publishing books and articles since at least 1942!—so he is certainly well qualified to comment on the changing fashions of economic theory in line with wider societal changes. Mention of the footnotes brings me to my only criticism of this book. It is not of the authors, but of the publishers. Editorial and/or proof-reading glitches, such as references in the index to footnotes which do not in fact appear on the page indicated (as occurs in connection with the Michael Bleaney quote, above), really should not occur in the productions of a respected house like Cambridge University Press. The ravages of rampant, uncaring 'economy', it seems, have not spared even the most venerable of our commercial institutions.

Notes and References

1. M. Pusey, *Economic Rationalism in Canberra* (Cambridge, Cambridge University Press, 1991).
2. J. M. Keynes, *The General Theory of Employment, Interest, and Money* (London, Macmillan, 1936), p. 192.
3. *Ibid.*, p. 298.
4. R. Norton, 'Playing Politics with the Dismal Science', *Fortune*, September 1996, p. 44.
5. J. M. Keynes, *op. cit.*, Ref. 2, p. 307.
6. Cited in Anon., *Population Policy in Great Britain* (London, Political and Economic Planning, 1948), p. 73.

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Does Technology Drive History?: The Dilemma of Technological Determinism

Merritt Roe Smith & Leo Marx (Eds)

Cambridge, MA, London, MIT Press, 1995, xv + 288 pp., ISBN 0-262-69167-1

Some questions never truly go away. As the editor of *Technology and Culture* remarks on the back cover of this book, not so long ago the 'ideology of technological determinism' appeared to have been 'banished from academic discourse'. Now this book claims (by blurb and introduction) that it will reconsider the extent to which technology may influence social and historical process. Technological determinism (TD) is the central concern of this book, but on its return it is recognised to be a more complex and difficult beast than formerly understood. The best chapters wrestle with the meaning of the term and in the process they rework our understanding of technology and technological

determinism so that the very question 'does technology drive history?' is no longer one that one wishes to ask. The chapters are the product of individual reflection on the question of technological determinism within the authors' own specialist areas and they differ in the extent to which they define and accept technological determinism as a historical force. A collection of independently written chapters cannot amount to a coherent and measured consideration of any topic and it was therefore essential that there should be an introduction which examined whether the whole of the book was larger than its parts. With an introduction a perfunctory six pages in length the opportunity to do this was missed. I conclude that the book does not deliver directly on its promise to reconsider how technology may influence historical process, but if the reader can be bothered to do the difficult and laborious editing and chapter-comparative job for themselves such a reconsideration may be extracted from the book.

Most of the chapters were the product of a two-day workshop at the Massachusetts Institute of Technology (MIT) in 1989 (and published as this book five years later, which seems to be the usual lag for the publication of such activities) so my criticism amounts to the comment that the book amounts to little more than a bound version of the original workshop submissions. However, the quality of the chapters is high and if anyone is considering the writing of the 'last word' on technological determinism, this book will be an essential source. The authors do refer to each others' contributions and there are excellent abstracts before each chapter. My approach is to summarise the major contributions to the debate from selected chapters.

A hoary old problem in discussing TD is what is meant by technology—is it the artefact, or the artefact and associated technique, or both of these and some social context? A common accommodation with this problem is made by the use of 'hard' determinism when it is thought that an artefact determines social forms and 'soft' determinism when it is thought that both artefact and associated social context influence social forms. It was surprising that few of these chapters considered such definitions: one had to induce their understanding of technology from their use of the term and it is exactly this kind of issue that could have been debated thoroughly in the introduction. Bimber's chapter does tackle these issues directly and he attempts to categorise TD as three forms, which range from,

> positive descriptions of an inevitable technological order based on laws of nature (nomological) to claims that technology is an important influence on history only where societies attach cultural and political meaning to it (normative). (p. 81)

In addition there is what Bimber terms the 'unintended consequences' account, which focuses on the unanticipated effects of technological development. He tackles the more frequently encountered but more vague categories of 'hard' and 'soft' determinism and argues that the 'soft' is not a form of determinism at all, because it includes social structure and form in its definition of technology. Whether or not one agrees with Bimber's exact definitions and terms the argument is sound—if technology is taken to include social forms and values in addition to the artefact, then technological determinism also includes elements of the social and it is not clear that it is truly distinct from social explanations of historical and social change. However, this results in Bimber's nomological/hard determinist definition being so stringent that he admits few authors can be so classified. Even if the alternative approach of inclusion of the soft position as technologically determinist is taken, the concept is identified as having little precision or meaning. Bimber finally takes the position that the term is better not used at all and that Hughes' concept of 'technological momentum' is to be preferred.

Bimber makes good use of these distinctions when he applies them to the question of whether Marx was a technological determinist. No less than seven writers have discussed this question, of whom four decided that Marx was a technological determinist. Bimber shows that it all depends on what is meant by TD—and with his analysis, Marx is not a technological determinist.

Thomas Hughes' chapter attempts to provide an alternative concept to technological determinism for fundamentally the same reasons as given above. He extends his view that the 'technological system' should be the focus of analysis with the idea that systems acquire 'technological momentum'. Such systems are open to socio-cultural influence early in their development, but later are relatively resistant to attempts to change them; hence they have acquired 'momentum'. The term is more precise than 'technological determinism' and explicitly includes the social interests that act to advance and protect their socio-economic position linked to a particular technology.

A fascinating feature of TD is its 'spontaneous regeneration'; writers and commentators throughout history have repeatedly resorted to language which seems to privilege the artefact itself as agent of social change. In these circumstances logical argument of the above sort will not permanently suppress TD accounts. Misa contributes a chapter which shows how the micro or macro perspective of the writer influences the tendency to resort to TD accounts of history. Micro-level accounts tend to emphasise technological choices where the 'best' choice is not evident. Those whose research is conducted at the macro level are most prone to provide technologically determinist accounts of events, for the alternative technological choices are no longer apparent and the organisational debates over alternative paths are obscured by the triumph of the technologies of the present. His solution to the perspective-dependency of TD accounts is 'middle-level theory', which means the deliberate accentuation of actors, institutions and processes intermediate between the micro and the macro level. This amounts to a plea to historians of technology to change the way they investigate and write history.

Misa backs his case with examples and his chapter is worth reading just for its analysis of Chandler's famous account of the development of vertical integration by the Carnegie Steel company. He is convincing in his argument that neither some kind of 'technological logic' nor grand company strategy were important in the process of extending vertical integration in steel. Rather, Carnegie and his partners were long reluctant to buy iron ore properties and did so only when convinced by a middle-rank manager, whose arguments were largely based on the serendipitous profits that he believed would accrue to the company from the purchase of iron ore land (which had become temporarily cheap as a result of earlier company actions). The example convincingly shows the methodological flaw in Chandler's thesis; from the historical macro-level pattern of increasing vertical integration in the 1890s, Chandler attributes deliberate strategic action in search of that pattern to the actors involved. As Misa comments, 'Vertical integration proved economically rational (lower costs for iron ore plus barriers to entry) for Carnegie Steel, but it was a two-decade-long process whose rationality appeared most forcefully to later historians and not to the actors themselves' (Misa: 138). Like Hughes and Bimber, Misa recognises that the confusion over technological determinism derives from unarticulated assumptions about the meaning of technology. His summary is worth repeating in full, for it captures the message of the whole book.

> . . . a technology is far more than a piece of hardware. Properly understood, 'technology' is a shorthand term for the elaborate sociotechnical networks that span society. To invoke 'technology' on the macro level of analysis is to compact into one

> tidy term a whole host of actors, machines, institutions and social relations. To expand 'technology' on the micro level of analysis is to regain the complexity and messiness of the compacted whole. In so far as people are necessary parts of the networks, to say that 'technology' causes social change is really to say that people through the sociotechnical networks they create and sustain—cause social change. Explaining, understanding and managing these networks is the task before us! (p. 141)

One might add that not only historians are subject to see technological determinism as a social driving force, but any social analyst and commentator interested in technological change. The battle to include the less visible social constituents of technological change will never be entirely won and will continue, with particularly intense peaks of debate coinciding with periods of rapid diffusion of particular technologies—as contemporaneously, in the case of information technology.

The three chapters so far reviewed are the richest in theoretical terms. Others make similar points albeit in different language and with different empirical material. They may nevertheless be interpreted as supporting evidence for the position outlined above. Scranton demonstrates how historians have privileged the study of a select group of industries because it is thought that they exemplify the development of the 'winning weapons' (vertical integration, mass production) of industrial development. Scranton shows how the development of machine tool production in 19th-century Cincinatti attained the standardisation normally associated with mass and process production industries. This was achieved by local firms exploiting high trust relationships to advance the division of labour, knowledge and tool specialisation to otherwise unattainable levels. Scranton objects to the lack of 'an inclusive and critical history of standardisation in the US' (p. 163), a gap which has occurred because it is assumed that the process is understood. His example shows that more than one social form can enable the attainment of technological standardisation.

Perdue examines TD manifested in three accounts of development in agrarian societies; medieval Europe, 20th-century China and 19th-century Russia. His target is what he calls the 'single-factor model' of explanation of social change typified by Lynn White's account of the heavy plough's causal role for subsequent economic development in Europe. In other words, his target is a form of 'hard' determinism where the artefact is 'single cause' (although a close reading reveals this is an approximate description even of White). The interesting feature of Perdue's critique is that it does not so much destroy the role of artefact in social change, but tends to recombine social purpose and context to the artefact's role. So for example, Perdue is able to cite work which shows that other paths to urban development existed in southern Europe, where consolidation of fields gave productivity benefits even with the use of the light scratch-plough. He can also show that large open fields existed centuries before the arrival of the heavy plough in northern Europe, undermining the causal connection which would have the heavy plough making open fields at once necessary and highly productive. Hence other contextual factors and weaker hypothetical relationships are brought into the analysis. The direction of the analysis is therefore to make more complex what was once a simple and highly memorable account and this suggests another reason for the continual resurgence of TD. Reality is complex, it must be simplified for mass consumption, but the process of simplification often leads to the skewed deletion of social context and the retention of the most 'visible' parts of socio-economic change, i.e. the artefact; hence TD accounts proliferate, they are the 'default' form of historical analysis.

There are two chapters by Heilbroner, the historian of economic thought, in this volume. One is an old history of technology classic '*Do Machines Make History?*' where Heilbroner expresses the view that artefacts do indeed make history. Heilbroner's more recently written '*Technological Determinism Revisited*' marks a substantial shift away from his earlier version of 'hard' technological determinism. Several of the chapters in this volume choose to attack Heilbroner's positions, whether new or old, for he retains determinist language and concepts, in particular the neo-Marxist idea that the economic 'logic' of capitalism drives technological change and is a defining feature of capitalist industrial societies. The best example of this is Bulliet's chapter, which shows that pre-industrial societies also have an 'economic logic' which affects the character of technological change. Bulliet uses the fascinating case of the disappearance of wheeled transport in the Middle East between the 5th and 19th centuries. The displacement of the wheel was driven by the 'economic logic' of a 20% price advantage that camel transport had over cart transport. Hence 'economic logic' 'powered a long-lasting and transformative change in the economy and the technological environment of the Middle East' (p. 204); an absence of a road infrastructure, the inhibition of wheel-related craft production; the urban pattern of narrow streets accessible only by people and animals. Bulliet then argues that since economic forces have helped shape pre-industrial societies they cannot be the defining feature of technological development in industrial societies. Having established that economic forces influenced technological diffusion in the Middle East, he develops the argument that they were never the sole influence on technological change. He focuses on pre-industrial technological diffusion to argue for the importance of power, in the form of 'social groupings by class, race, educational background etc. to act as social filters for technological change, determining to a substantial degree what techniques disseminate and how rapidly they do so' (p. 205). By undermining the 'single factor' explanation of an economic logic driving technological change in society, by his inclusion of multiple social factors that influence technological change and diffusion, Bulliet's argument converges on that of his co-writers.

There are other chapters here, but they are less probing in their examination of the relationship between technology and society. A few chart the development of technological determinism as an ideology with its critics and one even touches briefly on the treatment of information technology by postmodernist writers (Leo Marx), finding that in their tendency to scepticism about the role of human agency, postmodernists tend to introduce a form of technological determinism into their analysis. However, Marx spends a bare two pages on this interesting subject. One of the problems of writings in the history of technology is the degree of relevance these have to other audiences more interested in late 20th-century processes of social and technological change. Another problem for this book is that with the partial rehabilitation of TD (it is no longer simply vilified) what should we make of the role of the artefact in social change? The nature of the book as a collection of contributions works against a progressive exploration of its theme to the point where this question can be considered. The job of writing the 'last word' on technological determinism remains unfinished in obvious ways.

The bottom line is that with its key theme as the nature of technological determinism this book has relevance and value to readers outside the history of technology. In the absence of a summary and integrative chapter, extraction of its value for the reader is a laborious task.

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