

theoretical aspects can now turn to Fritz Machlup, *Knowledge: Its Creation, Distribution, and Economic Significance, Vol. III, The Economics of Information and Human Capital* published in 1984 by Princeton University Press.

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The Trouble with Technology — Explorations in the Process of Technological Change edited by Stuart Macdonald, D. McL. Lamberton and Thomas Mandeville

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One of the great contrasts within the discipline of economics is that between the awareness of the central importance of technological change to the evolution of economic systems and the difficulty with which theoretical structures struggle with the evolutionary forces of knowledge and its application.

The contributions to this volume certainly highlight this tension and, taken together, they suggest promising lines of investigation. What is clearly needed is a good base camp, from which scholarly enquiry can set forth along promising routes. To the establishment of such a starting point this set of essays may justly be said to contribute. The work is arranged around four themes — conceptual problems, theoretical dilemmas, diffusion and technology transfer, and employment and policy, but these headings do not do full justice to the subtlety of the ensuing arguments. In the space of a brief review it is impossible and inappropriate to comment in detail on each paper so it is best to identify central themes and relate them to specific contributions.

It is useful to begin with the theme of technology as knowledge, as distinct from technology as artefact and machine, for here we recognise the difficulties of treating the production and dissemination of ideas on a footing with the production and distribution of material goods. Lamberton's essay skilfully highlights this issue, and Macdonald takes this as his starting point for a critique of the linear innovation and diffusion model. The problem he identifies is that innovation and diffusion are not separable, sequential phenomena. The innovation which is diffused is rarely a fixed package of ideas, but rather a developing body of technological principle, evolving under the pressure of the diffusion environment and the rivalry from competing technologies. Stoneman's paper is a valuable review of existing diffusion literature, which is beginning to come to terms with the evolutionary viewpoint, while Gold provides a strongly argued case for extending the scope of diffusion research. He argues that the population of potential adopters is not static, that it develops with the advance of technology, and that a key to diffusion research is how different organisations come to hold divergent views

about the relevance of a particular innovation to their own activities — thus complementing Macdonald's theme.

The diffusion theme is further explored in Stout's paper on the inadequacies of orthodox theories of comparative advantage to our understanding of trade flows. In his view, crucial factor endowments are endogenous, are shaped by experience and research, may become obsolescent in a short space of time, and are linked with trade patterns by processes of diffusion; a theme also picked up by Ironmonger. Papers by Jussawalla and Welch on the transfer of technology reinforce the diffusion approach to trade; the latter being a quite splendid survey of the problems associated with trade in knowledge.

The central economic theme one may identify in all this is active competition, the struggle by firms to gain competition advantages through differentiation of technology and organisation relative to their rivals. For it is on the differences between firms that competition thrives. In studying the perennial gale of creative destruction it is important to give organisational factors their due weight alongside technology, and several papers deal with information technology in this context. Lamberton's paper is a comprehensive survey of the literature on the study of information and organisation, while Mandeville and Macdonald provide a more detailed discussion of office technology in relation to employment: emphasising the importance of quality augmenting as distinct from cost saving perspectives on new technology and the need for organisational change if the potential of the relevant technologies is to be fully realised. Labour and trade union attitudes are an important aspect of organisational response to the opportunities presented by new technology and are surveyed in an essay by Corina. Teubal's essay is of particular importance in the competitive context, for he identifies important 'intangible' elements based upon learning activity which influence the competitive performance of firms, which have intertemporal externalities, and which are not accurately captured in R&D statistics. Further work of this nature is to be warmly welcomed. The outline of our base camp now becomes clear. Any framework which purports to cope with innovation phenomena must recognise the inherent diversity across firms *qua* innovating units, and seek to exploit this diversity, not suppress it. It must recognise that competition thrives on differences between firms, drawing where appropriate on biological theory as sketched in Boulding's opening essay. Once it is recognised that competition and diversity are linked by the innovating firm, the organisational issues fall into place as do the policy problems — essentially of coping with diversity. These are ably exposed by Rothwell in his survey of policies towards innovation, and are also raised in an interesting manner by Reinecke in an essay on the language of technology and its implications for policy formulation and organisational performance.

So there are straws in the wind and fortunately they are blown in the same direction. Toward the understanding of organisations as information processing, innovating, learning structures, differentiated by their success in innovation and selected by competition as a consequence, these essays provide a valuable stimulus.

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