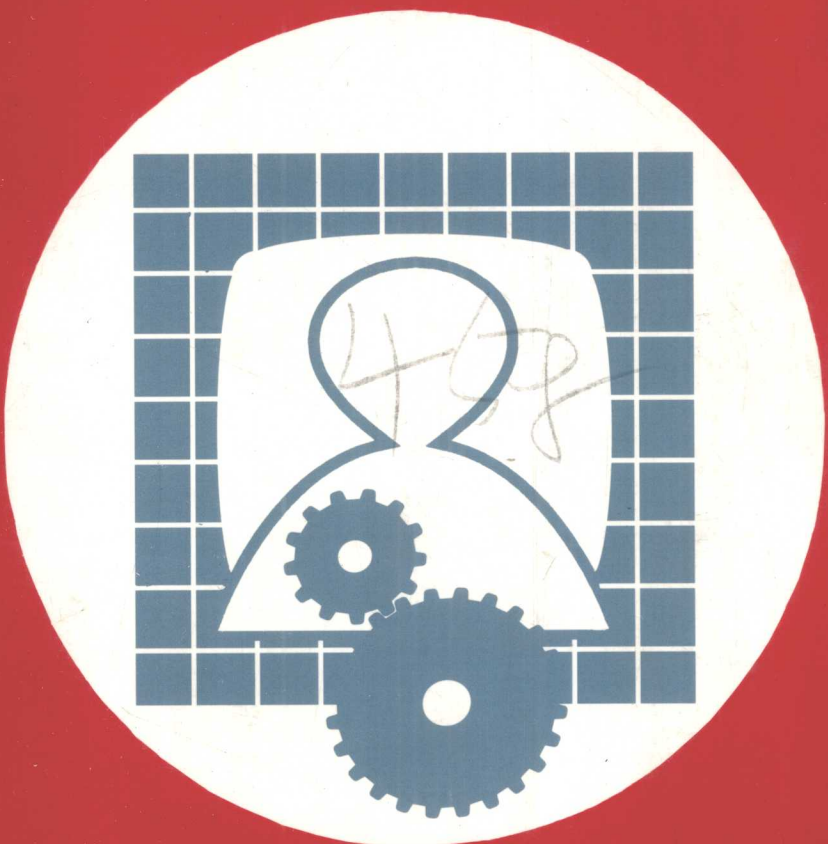
Implementing New Technologies

Innovation and the Management of Technology

Second Edition



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Implementing New Technologies:

Innovation and the Management of Technology

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NCC BLACKWELL

First published 1994

NCC Blackwell Ltd
108 Cowley Road, Oxford OX4 1JF, UK

Editorial office:
NCC Blackwell Ltd
Oxford Road, Manchester M1 7ED

Basil Blackwell Inc.
238 Main Street, Cambridge,
Massachusetts 02142, USA

British Library Cataloguing in Publication Data

Implementing new technologies: choice, decision and change in manufacturing.
1. Technological innovations
I. Rhodes, Ed II. Wield, David III. Open University
670.42'7 T173.8

ISBN 0-631.17805-8 Pbk

Library of Congress Cataloging in Publication Data

Implementing new technologies

Includes index.
1. Production management–Addresses, essays, lectures.
2. Production engineering–Addresses, essays, lectures.
I. Rhodes, Ed II. Wield, David
TS148.147 1993 658.5 85-11172

Typeset by Greenshires Icon, Exeter, Devon
Printed in Great Britain by Hartnolls Ltd., Bodmin, Cornwall

This book is printed on acid-free paper.

Preface

Although the second edition of this reader includes material on innovation in the sense of 'first commercial transaction involving new products or processes', it is more concerned with the consequences of technology diffusion and technology transfer, concentrating on the adoption within production units of technologies which are novel to the unit, even though not necessarily inherently 'new'.

The collection of readings is directed towards a concept of 'implementing new technologies' that includes study of: decision forming and decision taking (including areas like feasibility studies and pilot projects); project planning; the 'conversion' or application of plans; and consolidating the change after introduction of new technologies. The readings are also concerned with the product market, financial and other environments within which implementation takes place, and with the mediating influence of corporate strategy between these environments and individual projects.

Thus the reader adopts a multidisciplinary approach derived from production engineering and management, technology policy and management, economics, financial management, industrial relations and organizational behaviour. It includes for example, the opinions and analyses of senior managers, engineering consultants and financial strategists, as well as academics from the fields of technology policy, industrial relations, management and production engineering.

We would like to acknowledge the assistance of all those who helped with the book's preparation: Ernest Braun, Rod Coombs, Roy Rothwell, John Bessant, Peter Senker, Keith Pavitt, Alan Chatterton and Brian Small for suggesting and commenting on articles. Colleagues at The Open University, particularly Carolyn Baxter, Peter Braham, Roger Harris, Kathy Kavanagh, Systems secretarial staff and particularly Debbie Dickinson who ably demonstrated the sophisticated technological and organizational skills in multiple authored manuscript preparation.

Introduction

David Wield and Ed Rhodes

New Technologies and the Management of Technology

In much current debate, the problems of implementing new technologies are often perceived in terms of the application and management of 'new' information and communication-based technologies (ICTs). However, this focus is misleading. Some of the forms of ICT which are still being applied are now scarcely 'new' by any definition, nor are they the only 'new' technologies, particularly at the level of the individual firm. Studies of the diffusion of technological innovations (see Ray, 1983 for example) have emphasized that diffusion can be a prolonged process. This is not simply a matter of tardiness in adoption but a reflection of the very considerable obstacles that may have to be overcome to adapt them to the particular needs of the individual firm and the product market segments within which it competes. The process of diffusion is hardly ever simply one of acquiring 'off the shelf' packages of new technology. It is likely to involve progressive development and evaluation, necessitating both adaption within the workplace, and co-operative relationships with equipment suppliers. The processes of adaptation emphasize that seemingly established technologies may nonetheless be 'new' in terms of the issues and problems that are presented in the particular circumstances (such as technical, organizational and social) of the production unit. The term 'new' technology is thus not only used for the establishment of complete new production facilities, but also relates to large- and small-scale changes within established production systems which are a powerful though often neglected source of technological development.

The first edition of this book (Rhodes and Wield, 1985) was developed in conjunction with an Open University course which then formed part of a Manufacturing MSc. This shaped our focus on implementing new technologies in three respects. First, we concentrated on the application of new technologies to production processes rather than their incorporation within products – although we emphasized the artificiality of this distinction. Secondly, while we placed considerable emphasis on the various strategic and functional concerns which influence the implementation process, we did not directly address the issues of technology management. Technology management was then no more than an emerging idea, the expression of a growing awareness and discontent, particularly in the USA, at both the extent and the consequences of a neglect of the strategic issues of firm level technological performance. Since that time, the nature of technology management has been increasingly convincingly

defined, and its significance accepted – although more so on the USA side of the Atlantic than in Britain. Thirdly, our primary concern was with specific production operations in manufacturing. This was an arbitrary, if necessary, separation. Manufacturing processes have much in common with other industrial and service sectors, particularly in the introduction and utilization of new technologies. This is well illustrated by Hackett (Reading 1.2), who suggests that fully eighty per cent of all technology investments in the USA are made by service sector companies. In many of these cases, as he indicates, the problems of securing forecast improvements in productivity and other respects are, if anything, more intractable than those in manufacturing. Equally, the problems associated with the incorporation of new technologies in the form of, say, new materials or EPROM chips in product innovations are, in many respects, comparable. For example, similar issues of financial justification, work re-organization and retraining are involved. Further product innovation is, in many cases, dependent upon changes in production technologies. Similarly, in service industries, changes in the types or standards of customer service that are offered are dependent on technological change in the delivery processes – for example, in the types and range of data links, or in the uses to which these are put.

In this edition we have had the freedom to extend our concerns to the broader issues of implementation, and have done so in three main respects. *First*, we have included readings reflecting the importance of managing technology in services. *Second*, we have included a number of readings which are concerned with the general processes of 'implementation' and innovation rather than retain the focus on process innovation alone. *Third*, there is an emphasis on issues of technology strategy and management which impinge on the broad areas of implementation.

Implementing New Technologies

Our focus on 'implementation' includes a wider range of activities than is generally explicit in use of the term. Implementation has usually been taken to relate to the process of putting policy intentions – 'decisions' – into action. In the case of new technologies, the relevant activities may include: the acquisition of new equipment together with consumables; the undertaking of associated construction work – increasing floor loading, installing or upgrading services; the design of new and improved products; the development of new services; equipment installation; consultation; training; cost control; pilot production and testing; advertising; commissioning; and handover. It is this level of activity that Braun (1981), for example, describes as 'implementation'. Even in this restricted sense, he points out, the activities involved can be highly complex (depending upon the nature of the project), and can involve high levels of uncertainty. This is true even in comparatively small scale and limited examples of change such as the initial ventures into CAD described by Senker in Reading 6.1, where the complexities and difficulties are considerable. This is also true in smaller organizations with a more limited range of inside expertise and support. Not surprisingly, therefore, there is a considerable range of things

that can go wrong with new technology projects – although the precise extent to which they occur is uncertain. Hussey (1984, p. 143) has pointed out that managers appear 'to have a propensity to take personal credit for things that go right but to avoid taking personal blame for things that go wrong'.

Among the manifestations of problems are delays in project initiation that give competitors a crucial time advantage. Unit costs of production may be inflated by over-specification of project requirements. Under-specification may constrain future development and flexibility. For a variety of reasons a new technology may fail to provide all the predicted benefits or perform at specified levels and may have unforeseen adverse consequences beyond the directly affected areas of the production system. Completion may be achieved late and only after significant additional costs have been incurred. There is also the problem of non-initiation of new technology projects, for instance, because the strategic benefits of technologically based developments are poorly recognized, or because a specific projected change generates high levels of resistance from those who believe that they may be adversely affected or have doubts about their ability to cope. For example, a change in the material used to construct a major product component may threaten both past investment and established expertise.

Problems like these raise a number of issues. There is the question of why it is that things can go wrong in these ways even in seemingly competent, successful and well-managed organizations. In seeking to establish the reasons it is clear that one needs to look beyond the types of activities referred to above in terms of implementation just being the 'putting of policy decisions into action'. No amount of skills or experience in this 'putting into action phase' is likely to be able to successfully overcome the effects of policy decisions that are based upon erroneous assumptions or inadequate analysis. Similarly, in the 'active' stages of a project when purchases are committed and new equipment is being installed, it is difficult to overcome errors in the complex prior processes of planning. It is also very important to take account of events after the active stages of application. It is evident from a number of studies (see Reading 6.4 and Teubal, 1983) that, quite apart from the benefits derived from growing familiarity with new technology (the learning curve effect), there are frequently subsequent benefits from further adaptations and developments within the production unit. In order to integrate these kinds of issues and to ensure that they inform future projects, the conceptualization of implementation needs to be broad. This is to ensure sound analysis and understanding of both the problems and successes of the active phase and subsequently to identify what has been accomplished – or omitted – in fostering 'post-project' learning and improvement.

Thus, we emphasize the importance of viewing implementation as a broad change process. We divide the implementation process into four phases: an *initiating* phase which embraces the initial stimuli for technological change and the many elements of the decision-forming processes such as the development and assessment of policy alternatives; a *planning* phase; the *application* phase referred to above (which is similar to Braun's implementation phase); and a *consolidation* phase which is concerned with full completion of the many elements of a project and with the stimulation and formalization of the post-application phase. The main sets of activities within these phases are set out in Fig. 1.

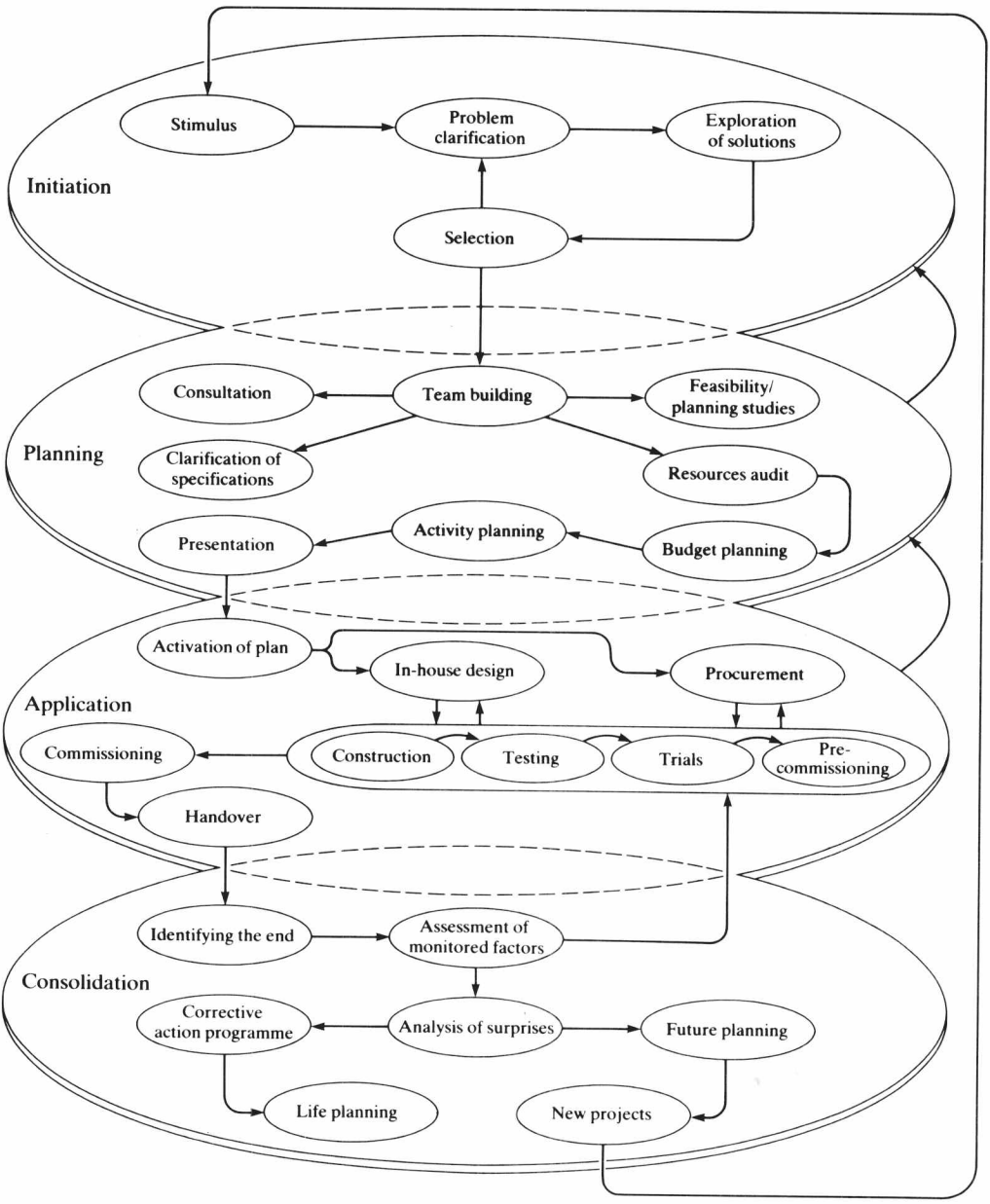

Fig 1 Main activities in the implementation process

These activities of initiation and decision forming; planning; application; and later consolidation of change are closely inter-related. This is not solely in a linear sense, although there obviously is a progression of emphasis from one set of activities to another – but in a dynamic, interactive sense since, as case studies tend to show, new technology projects, particularly when complex and extending over a long time period, are subject to some reappraisal and adaptation as new possibilities or problems become apparent. The importance of understanding and managing these interactions has been acknowledged to an increasing extent as firms have come to recognize the very substantial time, cost and performance penalties that result from projects which, although ostensibly well managed, are approached on a linear basis. This awareness has come from studies which have shown large discrepancies in the time from project initiation to completion. In product development and in the introduction of process changes, undertaking activities concurrently rather than consecutively in 'simultaneous engineering' has been found to yield considerable benefits in cost and in the speed with which the market impact of projects is achieved. However, to move towards concurrent or simultaneous engineering successfully depends upon giving greater attention to the broader setting or 'environment' in which projects are located. The implementation environment has two main dimensions. The first of these is the *internal* environment which involves the particular circumstances of the individual firm such as the extent of functional differentiation, the characteristics of production and associated technologies – for example, the degree of integration; the nature of the financial appraisal and control systems; the character of industrial relations. The *external* environment includes the characteristics of the segments of the product market aimed at by the production unit; the technological context – the rate of change and diffusion of knowledge, supplier characteristics etc.; and the broad political context, including levels of state intervention and support relevant to technology.

We emphasized above that the phases of the implementation process are interactive. Part of the interrelationship stems from the continuities provided by different groups of factors throughout the process of change. First, we can trace the broad range of issues which embrace the work force at all levels, from management to the shop floor. Whether they are involved in the initiation of proposals to change or in responding to these, ultimately there have to be processes of familiarization, integration and acculturation, all of which are dependent upon a dialogue involving all those who may be directly or indirectly affected. It is preferable that issues such as consultation are not left so late in the project that they can never be more than a dialogue of the deaf, thus contributing to alienation and jeopardizing successful project outcome. But the processes of integration embrace much wider issues than those of consultation or training. For instance, they are almost certain to involve extensive re-organization of work methods and payment systems but may also involve a fundamental rethinking of the way that decision-taking powers – and thus vertical job demarcations – are distributed. Increasingly, the trend is towards autonomous, multi-skill workteams operating with high levels of group autonomy, and it is often through well thought out changes in technology that such transitions are accomplished (Scarbrough and Corbett, 1992). Secondly,

the technical and operational issues can be traced through, from the issues involved in initial selection of equipment to decisions on the methods of utilization or adaptation during say the commissioning or post handover stages. Finally, there are the broad organizational and resource issues – particularly financial – which are likely to regulate the overall approach to change. These broad sets of factors provide an organizing framework for three later sections of this book (Sections 4, 5 and 6).

However, the identification of a general framework for conceptualizing the implementation process raises the important and fundamental issue of whether it is ultimately possible to try and understand the issues and the nature of problems at such a level. It may be felt that the factors involved in specific areas of economic activity and within specific workplaces are at a level of uniqueness that makes this impossible to achieve meaningfully. Certainly, it is important to be aware of the potential significance of such factors. At a general level, one can do no more than to point to their possible location and potential effects. At a more specific level, however, this type of framework should provide a valuable means of problem identification and clarification, and should assist in the development of solutions.

Freeman and Perez (Reading 2.2), Teece (Reading 2.5) and others are critical of much academic work in the area of innovation. This often focuses on the events leading up to the first commercial application of a larger scale innovation, such as those developed by equipment suppliers or large companies such as steel, chemicals or petroleum companies which had large in-house capacities for development of major innovative projects. More 'run of the mill' innovations, particularly relatively small scale in-house incremental innovations (such as adaptations of bought-in equipment or software) and innovations in the areas of work organization which shaped hardware utilization tended to be ignored. Innovation was sometimes seen only in terms of the diffusion of the original development, overlooking the processes of innovativeness within organizations. In-house improvement and adaptation to the firm's specific needs 'constitutes a system of continuously changing potentials and limitations' (Gold 1980). In this context, Barras (Reading 2.3) argues that innovation theories have much to learn from the study of technological innovation in the service sector. His research into study of financial and business services suggests that the process of innovation there takes the opposite route to innovation in producer goods innovators. In the latter, product innovations are often followed by radical process innovations and finally incremental process innovations. But in financial and business services Barras proposes that initial investment in new technology first produces incremental process innovations, followed by more radical process innovations, and finally new service products.

National Manufacturing Performance

We pointed out above that the nature of the environment of implementation is important and perhaps above all else its importance lies in fostering or limiting

the extent of innovativeness within organizations. But what are the elements of this environment?

In part they include factors we referred to above such as the general political environment and whether or not it supports innovativeness at firm level. In addition, factors within financial systems are likely to be of critical importance. In Reading 6.3, for example, Hayes and Garvin relate the preferred systems of financial appraisal in the USA to declining capital investment and R & D investment. The same analysis can be applied to the UK. In considering the particular problems of the United Kingdom, it is arguable that the most significant element of the environment of technological change is located at a very general, fundamental level.

Briefly, the weaknesses of UK technological performance have been reflected increasingly in the deteriorating trade balance. This is a matter not only of price competition but of product quality and other nonprice factors (Pavitt 1980). There has been a marked rise in the share of the domestic market accounted for by imports while export markets have been lost in some important sectors. British technological performance has declined relatively, a change which is in some contrast to the stable or rising pattern of some other EEC industrial countries, most notably Germany and Japan (Patel and Pavitt, Reading 1.4). The UK's remaining share of the world market has increasingly been of less technically sophisticated products. While there are some notable exceptions to this, as a tendency it has long been observable. Writing of the mid-nineteenth century, Hobsbawn refers to 'the traditional "under-developed" slant of the British economy ... a steady flight from the modern, resistant and competitive market' (1968, pp. 145–6).

The possession of the Empire was, and remains, an undoubtedly strong factor in explaining this 'underdeveloped' slant originally because it provided protected markets which, historically, were for comparatively unsophisticated products which were uncompetitive in other areas of the world market. This connection and product emphasis tended to linger on even after the colonial links were severed. The imperial legacy combined with post-1945 pretensions to great power status contributed to the comparatively large level of GNP devoted to expenditure on armaments. R & D expenditure in Britain has been relatively high, although in real terms it is now stagnant. But it has been – and remains – distorted towards military related sectors of the aerospace, research, electronics and chemicals industries. Although academically prestigious, R & D expenditure can be high risk and does not always offer acceptable commercial returns. Although the USA has also been handicapped by a similar R & D concentration, the consequences have, so far, been less serious. A greater commercial yield has been achieved because of larger market size, and possibly, by a greater propensity to innovate. Most of the other industrial nations appear to have deployed R & D expenditure more effectively by a more broadly based and more commercial orientation, particularly in sectors offering growth and high value added areas such as electronics, electrical machinery and scientific instruments. Readings 1.4 by Patel and Pavitt, 5.1 by Lane and 5.4 by Hartmann *et al* provide some important insights into the sources of European technological strengths.

Low Level of UK Innovation

The imperial legacy does not alone provide an adequate explanation of Britain's comparatively indifferent manufacturing performance. The range of other possible reasons is considerable and cannot be fully considered here, but some stand out in relation to our particular concerns. The first of these is the apparently low propensity to innovate at firm level which has been evident since at least the mid-nineteenth century. Concern at the implications of the slow rate of application of scientific knowledge to industry compared to the industrialized countries in continental Europe and the USA was expressed, for instance, as early as 1835 by Richard Cobden. Walker (1980) has shown how the UK increasingly lagged behind the Federal Republic of Germany and the USA in exploiting innovations even, in some cases, where these originated in Britain. 'The gloomy picture that emerges from the UK's economic performance after 1883 is by all standards rather familiar: a low ratio of domestic investment with, as a consequence, a declining rate of growth of productivity, slow growth of exports with rapid growth of imports of manufactures, and slow adoption of new technologies relative to competitor countries' (p 170). This was particularly evident in the newer industries of the period such as chemicals and many branches of electrical engineering.

That investment in these industries was often both limited and late was not a consequence of lack of capital for investment. The owners of capital in the UK were evidently more ready than most to look for more profitable opportunities – but in the world outside. That many entrepreneurs did not meet the challenge of new industrial competitors and took refuge in the protected but less sophisticated markets of the Empire may be felt to be ultimately a reflection of characteristics within the work force as a whole.

Work Force

For many people, reference to the work force is likely to conjure up first an image of a work force that is manual, and then one of a group that is overpaid (as Government statements constantly emphasize), unproductive and resistant to change. The 'work force' of course, embraces a much wider group of the population but the persistence of the caricature, despite all the evidence to the contrary, probably points to one of the underlying problems – i.e. managerial beliefs about the nature of work force behaviour among company directors, owners of small businesses, some media people, and politicians, rather than among the managers who have day to day contact with the pressures of the workplace. While there have been some significant exceptions – most significantly, in the pre-1980s national newspaper industry and in broadcasting – the caricature has mostly been in marked contrast to the inherent characteristics of the work force. The general experience and research points to a level of potential work force adaptability and flexibility both in the normal processes of work and where change is a prospect. Failure to realize the potential is more likely to be a matter of management approach to both the importance of consensus based change and to the choices offered by new technologies. This

is borne out by what appears to be the rather different experience of Japanese and other multinational companies using the British work force.

Similarly, while the UK's allegedly high labour costs are a continual focus of media and political noise, for a long time they have been shown to be in the middle to lower end of a distribution that also includes Japan and the countries of North America and Western Europe. As early as the 1970s Britain had become 'a country of "cheap labour" within this group of advanced countries' (NIESR 1984). Since then, labour cost surveys have shown the differential between labour costs – particularly total labour costs in the UK – to be below those of most of the other OECD countries. Yet cheapness of labour does not translate into low labour costs per unit of production, for levels of UK labour productivity are markedly lower than those of the USA, for example (Smith *et al.* 1982).

There is a link between low costs of labour and low labour productivity because the latter reduces the returns on investment in labour-saving technology. Such evidence as there is indicates that investment per employee is lower in the UK than in most other industrialized countries. This again is not a new phenomenon. Habakkuk (1962) examined the much greater readiness of nineteenth-century American employers to invest in labour-saving technologies and relates this to factor costs. But Walker (1980) shows that there was a similar readiness to adopt labour-saving technologies in Continental Europe even though labour costs were generally low.

Work Force Skills

In part, Walker relates the reluctance to invest to the comparatively low level of skill in the UK work force and to lack of management responsiveness to new opportunities. As a consequence of its pioneering role in industrialization, Britain in the early nineteenth century did have a considerable reservoir of skill and experience at all levels in the work force. But this advantage was lost as other countries industrialized and Britain failed to follow their lead in the development of a formalized system of technical and other education. Not only was Britain very late in following suit, but 'a stigma was attached to any sort of formalized scientific and technical education – or for that matter any formal education with an industrial leaning – in sharp contrast with Europe and North America where it was in high demand' (Walker 1980, p. 25).

Albu (1980) documented this in the case of professional engineers. While the British universities belatedly gave greater attention to their training, engineering has tended to remain a low-status occupation in comparison with other professional and managerial groups and in comparison with Europe. Production engineers, for example, often do not carry the weight that their counterparts in the Federal Republic of Germany or France are able to carry. This is a problem increasingly shared by the USA which also has manufacturing problems. Increasingly 'the production men' have been ignored (see Hayes and Abernathy, Reading 1.1). They see power as being increasingly exercised

by generalist or 'professional' management, the first doctrine of which is 'that neither industry experience nor hands-on technological expertise counts for very much. It encourages the faithful to make decisions about technological matters simply as if they were adjuncts to finance or marketing decisions'. Yet while marketing and financial considerations must be taken into account, technological issues cannot 'be resolved with the same methodologies applied to these other fields' (p. 16).

The issue of skill within the work force extends, however, well beyond higher education. Prais and Wagner (1983) suggest that the German work force gaining vocational qualifications did so 'at standards which are generally as high as, and on the whole a little higher than, those attained by the smaller proportion in Britain' (p. 63). A number of subsequent NIESR studies of sectors from engineering to clothing and furniture manufacture have given strong support to this view. Commenting on the shortage of intermediate-level skills in the UK population, Katrak (1982) drew attention to the work of Keesing (1968) on the ratios of skilled to unskilled workers in a working population. Applied to Britain this would predict that 'the UK's exports to the advanced industrialized countries would be intensive in unskilled labour while its imports from those countries would be intensive in skilled labour' (Katrak p. 39). During the period 1968–78 he found clear evidence of an adverse shift in this direction. This tends to bear out what he refers to as a 'low technology syndrome' in Britain which 'has been a less successful innovator, in relation to at least some of its major foreign competitors' (Katrak, p. 39). There are serious shortfalls in the standards for craft and technical skills that are required in the UK compared with other EC countries, most notably Germany. Skills shortages undermine industrial competitiveness in the UK (Senker, 1991) and similar criticisms can be directed at the USA (Kennedy, 1993, Thurow, 1993).

Taken together, factors such as those referred to above present a somewhat dismal picture and it is worth emphasizing that, nonetheless, many firms do succeed despite them. But in general, the picture is still well summarized by Pavitt's analogy (1980) of industrial Britain perceiving itself to be a First Division team while in reality it has been relegated to the Second Division in which it 'will increasingly be challenged by the newly industrializing countries recently promoted from the Third Division' (p. 13). Contrary to the view presented by government image makers, the British position has continued to deteriorate since then, according to a range of indicators. Factors such as those we have referred to represent a considerable hurdle to be overcome in responding to this challenge, let alone seeking restoration to the First Division. Yet they prompt the further question of why it is that the UK in particular has experienced such problems. As we suggested above, the legacy of the Empire must provide part of any underlying explanation, since it apparently touches so many issues, from the export of capital to the location of R & D and the historic pattern of trade.

Also at a fundamental level, and possibly related to the impact of the Empire, is the nature of British culture. The association of cultural factors with industrial performance is one that many find hard to accept, yet it is an explanation that in another context – that of Japan – seems to be readily accepted. Various writers such as Hobsbawn (1968), Wiener (1981) and Massey *et al.* (1992) have

in different ways pointed to what are in effect anti-industrial values within the prevailing pattern of beliefs and values. While lip service is often paid in political circles to the need for economic progress and technological change, writers like those referred to above have compellingly demonstrated that in most facets of society – educational (whether school or university), financial, administrative and managerial – the prevailing values do not generally favour activities associated with production. The outcome has been 'the spectacle (not necessarily all for the bad) of an industrial society led by men with "mind forg'd manacles" restraining their concepts and their actions' (Wiener, p. 10). A reflection of this is provided by Bessant and Grunt's (1985) comparison of manufacturing innovation in Britain and the Federal Republic of Germany which found that it was in cultural factors that the main differences between the two countries could be found. 'Whereas the German culture encourages many of the characteristics of technical progressiveness, the dominant UK culture tends to inhibit their development and to emphasize the stable/ short-term view.' Against this background it is perhaps not surprising that Dahrendorf was led to suggest that 'an effective economic strategy for Britain will probably have to begin in the cultural sphere' (quoted in Wiener p. 4).

We have considered these issues at some length in this introductory chapter because they emphasize the underlying nature of some of the problems and the scale of the difficulties that have to be overcome if performance in implementation and manufacturing innovation is to be improved. Ultimately, some of the issues are well outside the parameters of the individual production unit but they are, nonetheless, of great and direct relevance. What they imply is, that 'for managers in the UK to be technically progressive, they must, to some extent swim against the cultural tide' (Bessant and Grunt 1985). This may require attention to some of the more technical issues of management and control of projects. But between these micro issues, and the 'mega-macro' ones we have referred to above, there is a broad area of approach and conceptualization of the issues that needs to be considered.

We have reshaped this second edition towards all forms of production rather than focus solely on manufacturing; and we have increased its international orientation. Perhaps most of all we have underlined the need for underlying knowledge of innovation in organisations and for the management of technology to be a matter of strategic level policy and concern.. The growth in courses on the management of technology has arisen as a result of critiques such as that of the US by Hayes and Abernathy (Reading 1.1). They criticise US management as short-termist, low risk and anti-production. Arguments such as these have led to the development of Technology Management programmes to integrate management with engineering skills. Broadly, technology management encompasses the elements of management associated with the procurement of technology; with research, development, adaptation and accommodation of technologies in organisations; and the exploitation of technologies, for the production of goods and services. This includes both product and process technologies and technologies serving management functions. It includes three key competences: technological competence – the ability to dominate the particular technologies relevant to the needs of the enterprise; entrepreneurial competence – the ability to generate and implement strategies for research and

development coherently linked to enterprise strategy; and learning ability – the ability to adopt organisationally and culturally in order to accommodate technological change.

However, there is a danger of technology management being co-opted into business management teaching. This is to completely misunderstand the legacy of inadequate technological performance from which technology management has arisen. The low value attached to technological and other skills over general education and business skills in business management is part of the problem. In contrast, in Germany and Japan, managers tend to have in-depth technological experience in the areas they manage. The objective of technology management lies in building on the areas of technological expertise. The danger is that it could give generalist managers the notion that to know a bit of technology makes them competent to run a technological business of any sort. In this reader we concentrate on innovation and technology management. In particular, we identify opportunities and choices and factors shaping both technological decision-making, and subsequent attempts to realise and modify these implementation decisions.

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