

Innovation in Industry *A Factor For Growth*

Innovating Industry Project

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Innovating Industry Project
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Introduction

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UNDERSTANDING INDUSTRIAL INNOVATION

Over the past few years there has been a growing concern with Britain's record of industrial innovation based upon technology. This stems from two factors. Firstly, it is increasingly appreciated that the UK's success, if not survival, as a trading nation depends upon its ability to produce and sell new products which are more advanced, more efficient, or of better design than those of our competitors in world markets. Secondly, it is clear that the UK's achievement in successfully marketing new products, whether at home or abroad, is unsatisfactory relative to that of other leading industrial nations; yet our research and development – the important first stage of the innovative process – is of a scale which is only exceeded by the USA and USSR.

This concern has been reflected in the growing discussion in press, journals, and conferences of the numerous aspects of innovation. Many different factors have been put forward as reasons for the UK's poor record (some of these are shown in Table 1). In mid-1968 many of the conclusions reached were summarized in a report of the Central Advisory Council for Science and Technology¹.

Yet despite this wide discussion it is still too often unclear just how the climate for advance can be improved. There is insufficient information in adequate detail to explain why a handful of British companies has been so successful as innovators, while British industry as a whole has such a disappointing record. Generalised remedies have been put forward in plenty; but, by and large, these lack weight due to a shortage of hard, descriptive case-study or statistical information to support them.

This shortage of information is paralleled by insufficient awareness in many government, public and industrial sectors that technological innovation is a special process and cannot adequately be understood by applying principles which relate to 'traditional' firms in conditions of static technology.

THE PROPOSAL

Against this background, the Innovating Industry Project is investigating the feasibility of establishing a new, full-time organisation which, by providing a forum for review, analysis and ventilation of the complex economic and administrative problems of industrial innovation, would work to rectify these short-falls of information and appreciation.

HOW SHOULD IT OPERATE?

The organisation should have three main terms of reference:-

- (1) to carry out a continuous review of literature and current research in industrial innovation, collating present information.
- (2) to examine in depth specific economic aspects of industrial innovation in order to –
 - (a) frame conclusions, where these can validly be drawn, and suggest policy implications.
 - or, (b) clearly identify gaps in information available, and then help, in appropriate ways, to fill them.
- (3) to publicise its work and findings; and stimulate in industry, government and public spheres interest in and understanding of the nature and role of technological innovation.

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It is envisaged that the organisation would present its findings as occasional papers, which could be given wide publicity; or as papers in specialist journals. It may on some occasions be appropriate to hold conferences or symposia for collective assessment of current situations and approaches.

Further research on specific aspects of innovation, when identified as necessary, could be carried out directly by the organisation or as sponsored or co-operative research with other institutions. Contact with University departments engaged in economic research on areas of interest will be an important requirement. Moreover, in furthering research work the organisation would be in a position to assist such departments by providing a means of contact between them and industrial firms.

As part of its continuous review of information on innovation the organisation would be able to develop a central research index to university and other current research programmes concerned with economic aspects of innovation. It would offer an information service on sources of statistics, research findings, and other references. This would help bring about a swifter and wider appreciation of results of outside research; it would also assist researchers to avoid duplication and overlap in project planning.

HOW COULD IT BE CONTROLLED?

The selection of review topics and establishment of research priorities would most appropriately be guided by a research or editorial board. This should include representatives of industry, the universities, finance, and appropriate government departments.

The basic constitution and financial structure of the proposed organisation will be decided in consultation with the first major voluntary supporters of the project.

Table 1
The Process of Innovation
some links which have been put forward as weak in the UK

RESOURCES – MONEY	<ul style="list-style-type: none"> *not effectively allocated to sectors of the economy *selection of national projects not firmly based *not enough spent on later stages of innovation
RESOURCES – MANPOWER	<ul style="list-style-type: none"> *technical education not geared to industrial needs *industry not properly using its qualified manpower *weakness of university/industry interface *qualified manpower not properly distributed between sectors
INNOVATION MANAGEMENT	<ul style="list-style-type: none"> *process of innovation rarely viewed or organised as a whole *objectives of research ill-defined *role of marketing under-estimated *good private inventions not linked to effective product management
FINANCE	<ul style="list-style-type: none"> *difficulties of raising risk-capital *investors too cautious: risk-reward relationship not grasped
PURCHASERS	<ul style="list-style-type: none"> *reluctant to try new products until they are 'standard'
ATTITUDES – SOCIAL	<ul style="list-style-type: none"> *profits and selling viewed with suspicion *institutional resistance to change *educational system fails to familiarise children with change
ATTITUDES – GOVERNMENT	<ul style="list-style-type: none"> *structure of corporate and personal incentives inhibits risk-taking *search for cheapness, as purchaser, can stultify innovation
ATTITUDES – FIRMS	<ul style="list-style-type: none"> *insufficient awareness of the importance of innovation for growth
ATTITUDES – ACADEMIC	<ul style="list-style-type: none"> *mutual suspicion between universities and industry

The Innovating Industry Project, which is publishing this booklet, has been instituted to explore the feasibility of, and to gauge the degree of potential support for, such an organisation. If wide enough support from companies and other bodies interested in the economic problems of industrial innovation can be achieved, then it is intended that the Project should give way to an independent full-time unit operating as described. This exploratory Project is financed by a grant from the Association of the British Pharmaceutical Industry.

WHAT SUBJECTS WOULD IT COVER?

The organisation's approach to innovation would be centred primarily on economic assessment. The term 'innovation' as now defined covers a broad and complex process. Table 1 lists some of the weaknesses which have been pinpointed at many stages, and it shows the sort of topics with which the organisation would be concerned. Corporate structure for innovation, the role of marketing, finance for innovation, new products and exports, prices and profits, innovation and growth, research planning and control – it is to widen understanding of these and similar topics that the organisation's blend of information review, case-study compilation and additional desk or survey research would be aimed.

THE NEXT STEPS

The main strand of the Innovating Industry Project's present work is, then, exploring the extent of potential support for this proposal. But it is also concerned to begin pilot studies to illustrate the kind of work its proposed successor might usefully undertake. Some possible preliminary studies are outlined at the end of this paper.

All organisations interested in this programme are invited to contact the Project. Early establishment of a formal unit as outlined will depend upon the foundation of a firm support base.

To provide a background to these proposals, this booklet reviews some of the key aspects of industrial innovation on which the proposed organisation might usefully focus attention. It first examines the reasons why it is important to the UK's economy and international commercial strength that the process of industrial innovation be more successfully fostered.

The Impact of Technology

The United Kingdom devotes a high proportion of its resources to research and development. It follows only Russia and the United States in the proportions of national output and of the working population which are engaged in R and D (Table 2).

9 Contrasted with this, however, is Britain's relatively slow rate of income and productivity growth. Table 3 shows that our performance compares unfavourably with that of other nations.

Our R and D expenditure is on a level which could yield a continuous crop of new knowledge capable of being commercially applied. But 'there is little doubt that we are not getting value for money because the increase in expenditure on research and development is not reflected in the economy of the country or our standard of living'². This is what leads to the questions: Are we spending the right amount on R and D? Are research resources appropriately distributed through the sectors of the economy? Are they efficiently managed by those with the responsibility for their utilisation? What are the results of this investment if they are not leading to growth? Why do some products of research not make the transition to full commercial usage?

It can be argued that there is no reason why there should be any relation between R and D and growth – the tables show that high growth rates can be obtained with relatively small R and D expenditures. Perhaps efficient labour relations and industrial policies, or growth-oriented tax structures are sufficient to yield economic growth. (It could even be that, because manpower has alternative uses, growth may be impeded by too high an expenditure on R and D³.) Equally, it is possible for firms or nations to concentrate on 'buying-in' know-how, upgrading technology by applying for licences from innovators. But in fact these options are not open to the UK, for one important reason. In order to maintain – let alone increase – our standard of living we must maintain our competitiveness in international markets. It is now recognised that for many types of technology-based products trade advantages between developed industrial countries tend to accrue to the nation with a technical lead, to a certain extent regardless of relative labour or material costs. Because technological leads are essentially temporary – competitors' developments will sooner or later whittle them away – this is known as the 'product cycle theory' of international trade⁴. Neither alternative growth policies nor a policy of importing technology would give British products this critical technological edge.

It is easily shown that for Britain, a nation with few natural resources other than brain-power, exports do depend increasingly on

Table 2
Proportion of National Output devoted to R and D

	<i>Total Expenditure on R and D as percentage of GNP*</i>	<i>Year</i>	<i>R and D Personnel per 1000 working population (1962)</i>
United States	3.4	1963/64	10.4
USSR	2.5	1962	7.3
United Kingdom	2.3	1964/65	6.1
Netherlands	1.9	1964	4.5
France	1.6	1963	3.8
Japan	1.4	1963	4.7**
W. Germany	1.4	1964	3.9
Belgium	1.0	1963	3.5
Italy	0.6	1963	1.3**

Sources: Reference 6, Table 2. *The Research and Development Effort*, Freeman and Young, OECD, pp. 37, 72.

* GNP—Gross National Product at Market Prices.

** —IIP estimate.

Table 3
Economic Growth of Nations

	<i>Average Annual Percentage Growth Rates</i>		
	<i>Industrial production indices⁽¹⁾</i>	<i>Indices of output per man-hour in manufacturing⁽¹⁾</i>	<i>Real national income per capita⁽²⁾</i>
	1957–67	1957–67	1955–64
Japan	13.8	7.1	n.a.
Italy	8.3	7.5	4.7
Netherlands	6.2	n.a.	2.9
France	5.6	4.9	3.7
W. Germany	5.0	5.3	4.3
United States	4.7	3.8	1.4
Belgium	3.6	n.a.	2.9
United Kingdom	2.9	3.3	2.1

Sources: (1) *NIESR Review* No. 45; Tables, 2, 6, 21, 30.

(2) Reference 7, E. F. Denison, p.232.

Table 4
Products and their Share of Exports

<i>Product Sectors</i>	<i>Share of total exports 1968 as a percentage of share in 1951</i>
Food and live animals	87
Crude materials	78
e.g. Synthetic rubber	1,000
Textile fibres	93
Mineral fuels & lubricants	117
e.g. Coal	27
Petroleum (products)	200
Chemicals	176
e.g. Elements & compounds	83
Dyestuffs & colours	275
Plastic materials	283
Manufactured goods	64
e.g. Rubber mfgs.	200
Textiles, yarns	25
(Cotton mfgs.	7)
Pottery, glass, etc.	234
Copper manufactures	750
Non-electrical machinery	147
e.g. Office machinery	500
Pumps	225
Excavating & earth moving	322
Textile machinery	94
Electrical machinery, etc.	178
e.g. Telecommunications	850
Transport equipment	80
e.g. Railway vehicles	18
Motor vehicles	97
Aircraft	138
Ships	65
Misc. manufactures	140
e.g. Scientific instruments; photographic	185
Clothing	78
Beverages & tobacco	123
Others	382

Note : All exported goods are distributed among the major headings.
Source : Overseas Trade Accounts, 1951, 1968.

products with a high technology or design content. Table 4 shows how products which are increasing their share of our export total tend to be those which are technology-based; while those which are losing share are older and less sophisticated.

Against this background, the following sections look at some of the factors which have been put forward as 'barriers to innovation', and point out the sort of things that we still need to know about them.

National Resources for Technology

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MONEY

The UK spent £883 million on research and development in 1966/7. (The current figure is estimated to be over £1000 million). Table 5 shows who provided this money and where it was spent.

About one-fifth of all research is performed in government establishments, and two-thirds in industry (of which about a quarter is in the aircraft industry). The government share of R and D performance is declining; that of industry is rising. As a source of finance too the government's share is declining; even so, in 1966/7 the government still paid for one-half of all research and development, either through its own establishments or supporting university, research association or industrial research programmes. The government financed 34 per cent of research carried out in private industry – though the great majority of this was accounted for by aircraft and defence contract work⁵.

The OECD has estimated that in the UK 12 per cent of total research expenditure is devoted to basic research, while 28 per cent goes to applied research and the remaining 60 per cent to development. In general in industrial countries the development stage absorbs a greater proportion of research resources than applied or basic research⁶. And compared with other countries Britain does not appear to be under-spending on development relative to other research activities. But, as the Zuckerman Advisory Council pointed out¹, it is possible that other associated inputs such as capital investment or marketing expenditure are out of line with total R and D effort. These links of the innovative chain outside R and D are now the subject of much discussion but little quantitative information exists on the relativities between them.

The OECD also attempted to split total R and D expenditure between fundamental objectives: 'big' R and D (atomic, aero-space and defence); economically motivated R and D (i.e. for a potentially commercial product or process); and welfare and miscellaneous R and D. A significant pointer from these figures is that the UK's proportion of economically motivated R and D, 51 per cent, was exceeded by Germany, Japan, Italy, and nearly all the smaller industrialised and developing countries. On the other hand, both France and the United States spent a higher proportion on 'big' R and D than the 40 per cent devoted to it by the UK. This suggests the possibility that our R and D outlays might have a greater economic impact *either* if a higher proportion was spent on 'big science', because of technological and economic 'spin-off', *or* if a greater proportion were devoted to economically motivated or directly commercial projects.

In approaching questions like these – the financing and allocation of the R and D effort across different objectives and sectors – an underlying problem is that firm judgement is restricted by inadequate knowledge. For instance, little is known of the nature and importance of ‘spin-off’, both in the usual sense of technical developments in ‘big science’ which are of application in a variety of other fields, and also as denoting the web of economic dependence which builds up round big projects through contractors, sub-contractors and agents. Similarly, single decisions can significantly affect the overall return from our national R and D outlay – the choices between ‘big’ R and D projects (e.g. space or oceanography), or between a ‘big’ project, concentrating resources, and a number of smaller projects, dispersing resources. Yet we know little about the means of assessing relative returns from different choices. To questions like these the OECD is beginning to provide background data, and results so far published may contain important lessons. Collation and analysis of different studies available in this field would help to clarify the principles by which the appropriateness of R and D resource distribution may be judged.

MANPOWER

Table 2 showed that in 1962 6 people in every 1000 of the UK working population were employed in R and D. This meant 211,000 people in all, over a quarter of whom were qualified scientists and engineers (QSE’s). There have been two recent studies on the employment of skilled manpower in Britain (the Jones Report on ‘The Brain-Drain’ and the Swann Report on the flow into employment of QSE’s). These reports reached important conclusions framed to improve the productivity of usage of technical manpower; for instance, the Swann Report emphasised the *type* of scientific training which should be given by the universities; the Jones Report called for industry to increase the representation of technical personnel at top policy-making levels. However, they did not concentrate primarily on the relativities between skilled manpower and other technological resources. M. J. Peck, who did take this approach in the Brookings Report on the British economy, suggested that the proportion of QSE’s was too low relative to total R and D manpower or expenditure⁷.

In addition to total supply, the distribution of skilled manpower between sectors is important. Of all scientists and engineers qualifying with first or higher degrees in 1966, the largest proportion, 35 per cent, took jobs in industry. As Table 6 shows, industry is therefore receiving more qualified technical manpower than any other sector. (It also

Table 5
R and D Expenditure in the UK

(a) Place of expenditure	1961/2		1964/5		1966/7	
	£m	%	£m	%	£m	%
Government						
establishments	178	27.1	193	24.9	195	22.0
Universities	32	5.0	56	7.2	62	7.0
Public corporations	21	3.3	24	3.2	31	3.5
Industry	391	59.5	468	60.7	561	63.5
Other organisations	34	5.2	31	3.9	34	4.0
	658	100.0	771	100.0	883	100.0
(b) Source of funds						
	£m	%	£m	%	£m	%
Government	378	57.5	421	54.6	443	50.2
Public corporations	23	3.5	27	3.5	35	4.0
Industry	244	37.0	285	36.9	352	39.8
Other organisations	13	2.0	39	5.0	53	6.0
	658	100.0	771	100.0	883	100.0

Source: Statistics of Science and Technology, 1968.

Table 6
Employment of Qualified Scientists and Technologists

Sector of employment	No's taking up employment	%
University research & further academic study	4369	23.3
University employment	827	4.4
Teacher training; schools & colleges	2108	11.2
Industry	6649	35.4
Central & local government	973	5.2
Employment overseas	1255	6.7
Other	2616	13.9
	18797	100.0

Note: Figures include first and higher degree qualified people; home students only; include graduates of former CAT's.

Source: Statistics of Science and Technology, 1968.

shows that the proportions of scientists and technologists entering government¹ employment and taking up employment overseas immediately after qualification are lower than is often thought).

It is generally accepted that this proportion does not represent sufficient QSE's for industry's needs. The shortage is often put down to 'the drift away from science', in other words the *overall* shortage of QSE's. But it would be surprising if the relations between industry and universities, which are occasionally still poor, bore no responsibility. Company managers claim that universities produce non-practical and narrow theoreticians who are of low value until they have received some extra industrial education; and teachers claim that industry as yet has no idea how to manage qualified manpower effectively. Both these views have some validity. Sometimes industry's image as an employer does deter qualified men. Sometimes university departments perpetuate the fallacy that intellectual challenge is lacking in industry. These misunderstandings are damaging. An American study⁸ of the complex of science-based companies at Boston has emphasised the significance of active channels of communication between universities and industry (which include a higher rate of flow of people from one to the other) in effecting the 'transfer of technology' to the commercial or real-wealth arena.

A further aspect of distribution is the type of occupation of QSE's. There is in principle an optimum balance between basic research, applied research, development, production management, corporate planning and even marketing. There is a widely-held view that a present maldistribution in this sense constitutes a barrier to more successful innovation.

Innovation in the Firm

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ORGANISING R AND D

Relative sums invested in research vary widely, from well under 1 per cent of net output in 'traditional' industries to the exceptional 43 per cent in aircraft. Firms in the high-spending research sectors are faced today with a management requirement which was hardly known as little as forty years ago – that of research management. Many aspects of research management have already been investigated. But principles are often expounded in general terms which are difficult to relate to specific circumstances. For instance:

- the research director must be the main channel of communication between his department and the other company functions, understanding and representing each to the other.

- a 'basic' research programme needs less day-to-day linking with other company activities than the short-term project aimed at improvement to an existing project.

- new techniques of capital expenditure evaluation may be applied to research according to various models.

Such observations are limited. For instance, it is quite possible for financial managers to require too rigorous an analysis of a research project's anticipated cash-flow position. Many research expenditure decisions can only be justified on a 'business intuition' basis, and at early stages in almost any project there is a degree of unpredictability about end-results, timing and competitive situations.

To clarify research-management principles studies are needed of how, for instance, research-based companies do adapt their increasingly numerate approach to management to cater for the unpredictability of some research decisions. Similarly, comparisons of different companies' approaches to project control and research department structures could provide much-needed descriptive support to the principles of research organisation.

There is a further aspect to this problem. Research in industry is not new, though the principles of research management have only relatively recently begun to be structured. What is new is the adoption by some companies of the total process of innovation – from laboratory bench to product sales – as a deliberate and unified business strategy. In this view, research cannot properly be managed in isolation. The problems are now those of innovation management. Moreover, a feature of innovation is that projects developed by one industry are often produced and marketed by another. With the increasing recognition of this pattern the strategy of innovation management may even have to transcend the confines of the individual firm or industry. It may be that a factor distinguishing successful

technology-based companies is the way in which innovation management has been conceived and its problems met.

There are many firms who are unable to carry out their own R and D for reasons of size or available resources, yet which must maintain the technological competitiveness of their product range if they are not to be left behind by the market. There are two solutions open to them. Firstly, there are certain external sources of direct research help – the research associations, government research establishments, and contract research organisations. Secondly, firms can often profitably take out licences for new products.

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The main concern of the 45 research associations is research aimed at raising the level of the common technology of their own industries. A recent study⁹ concluded that the associations were most appropriate to industries with a relatively large number of companies, not in fast-moving technological competition with each other, having a common basic research interest which is not a vital part of their own private know-how and skills. Some associations are taking on an increasing number of commercial projects sponsored by individual firms, but the RA's cannot yet be classed as a regular and recognised source of technical assistance for commercial innovation. The same may be said of the 15 government technological research establishments. They normally welcome collaborative work with industry but their numbers, size and specialisations limit the quantity of such projects.

In America, filling the need for accessible technological assistance with specific projects, is a network of commercial research contract organisations. Some of these institutes have attained great stature – for instance, the Stanford Research Institute (originally an offshoot of the University), the Battelle Memorial Institute and Arthur D. Little. During the late 1950's similar organisations began to emerge in the UK, in some cases as subsidiaries of those in the US. These were followed during 1968 by the first of the UK university industrial units which, though off to a shaky start, offer an important new potential.

All of these institutes, by part or all of their operations, provide commercial consultancy in technological fields to industry. But how effective a coverage is provided by the present institutes? Is there yet adequate technical scope in contract R and D? Or geographical scope? And are there links with other parts of the innovative chain to help firms make a commercial success of new R and D projects? Most of all, are firms sufficiently aware of the assistance which is even now available?

The alternative source of new products is through licensing. The Charpie Report¹⁰ noted that a frequent feature of technological innovation was that the invention was made outside the firm, or even industry, in which it was eventually applied. It pointed out that the 'not invented here syndrome', based on notions of pride or self-sufficiency, can lead to lost opportunities to develop and market significant inventions.

The economic possibilities of producing and marketing a new product, even if licensed from an outside source, can far outweigh the disadvantage of royalty payments. Some firms deliberately eschew domestic R and D as a source of new technology and concentrate on licensing; this can be a viable corporate policy.

In 1965 the UK's overseas technological royalty receipts were just higher than expenditure, which has favourable balance of payments implications. This reflects the fact that many British firms license overseas companies to manufacture their new products abroad. This augments relatively swiftly the firm's return on investment in the new product but is far less profitable than manufacture abroad through a subsidiary company, if that were possible. This introduces questions of capital flows and their much greater balance of payments effects. (See Multinational Firms).

It is not easy to assess the advantage of alternative policies. More information needs to be gathered on the immediate and indirect financial implications of the way in which international technological transfers are effected. Inflows and outflows of licences and royalties do not in themselves tell the whole story.

PRICING AND PROFITABILITY

The price of a product breaks down to the direct costs of making it and product contribution to overheads and profit. For a research-based firm, the costs of R and D will be an important feature of overheads; the additional capital costs of special production plant required for innovated products must also be covered; and marketing expenditures must also be allowed for. For such a firm, product contribution will inevitably be a much higher proportion of price than for other firms.

Science-based industries often grow faster than average. Industries whose output grew fastest between 1935 and 1958 were aircraft, electronics, instruments, electrical and chemicals¹¹. Today, firms operating on 'the leading edge' of technology may experience extraordinarily high growth rates.* Growth implies regular incre-

* e.g. Texas Instruments, 29 per cent average *annual* growth in turnover 1946-1965.

mental expenditures in all areas – in capital employed, on materials and labour, on marketing, and R and D. Expenditures with a ‘capital’ element, which will not generate revenue until some time ahead, impose particular demands on a firm’s cash resources. Occasionally, such incremental expenditures may be financed by ‘going to the market’. More usually they come from retention of profits earned in previous years.

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Thus, because of special expenditures associated with innovation, and because successful innovation means corporate growth, the innovating firm operates under price and profitability conditions which differ markedly from those of firms in static conditions. However, the public traditionally tends to assess value on the basis of assumed costs of production; while in business cost-plus methods of pricing are not uncommon (i.e. application over time of a given and fixed formula based on a permanent ‘proper’ margin). Because they do not allow for change, in the forms of product innovation and company growth, these approaches to pricing are not adequate for innovating firms. Their situation is more accurately assessed by a shift away from the traditional interpretation of price as the means of past cost absorption, to regard it instead as a way of raising revenue to fund future activities. This is the economic significance of the premium prices which can be charged for innovative products.

A third factor is introduced by the concept of risk. Risk is, in itself, a theoretical justification for profits of enterprise above the cost of capital. The greater the risk of failure attached to a particular commercial venture the higher must be expected profits in the event of success in order to motivate the undertaking of that risk. High-risk initial exploratory expenditures, which may have to be totally written-off, will only be undertaken if the risk involved is appropriately compensated by the level of potential reward. There is a degree of risk in most commercial ventures, but it increases for research-based projects. For each successful innovation there are many which failed at some point of the process. Thus, prices of innovated products marketed must contain an element of risk-reward which is high relative to that of non-innovated or static products.

Though an understanding of this analysis of price might help a static firm which is moving on to an innovation/growth path, its main practical implications are for purchasers of innovated products especially in cases where there is one or only a few. For instance, the absence of established principles of ‘reasonable’ price is reflected in the lengthy contract negotiations which government departments often undergo with their suppliers of technical goods. The Ferranti

and Bristol Siddeley episodes; the setting of target rates of return for nationalised industries; the PIB Reports on cement and hearing aid battery prices; Department of Health negotiations with pharmaceutical firms; the North Sea Gas price negotiations – all involve problems of pricing technology-based products.

Purchasers of such products, and particularly the government which bears responsibility for the rate of innovation across an increasing part of industry, should consider two points. Firstly, it is possible that their own long-term interest, as well as that of the supplier and the technology, will best be served by taking a long-term view – considering the implications of price for future product development. Secondly, purchasing departments may find themselves as single-purchasers for a product. While the power which this confers may never be consciously exercised it may influence attitudes towards ‘reasonable prices’.

This analysis of pricing for innovated products is essentially theoretical, for little is known about the way in which these factors are actually assessed by innovating firms. To amplify the analysis a more specific knowledge is required of the way in which prices are set by innovating firms. Company and product case-histories, the compilation of which is an objective of the proposed organisation, could throw much-needed light upon these crucial questions. Revised attitudes to the financial operations of innovation-based companies could have important implications for the success of technological innovation in the UK.

THE ROLE OF MARKETING

In Britain there has long been a certain hostility towards aspects of selling, from the Elizabethan landowner’s scorn for merchants, through the Victorian disdain towards ‘trade’, to the still unfavourable connotations of ‘profits’ and ‘selling’ today. Marketing and advertising have particularly roused intellectual suspicion, which has roots in the last century when there were many cases of unbridled publicity for products of dubious merit.

But over the past few years the increasing pace of technological development has, among other factors, had an effect on the function and nature of marketing, and indirectly on attitudes towards it. Its economic role is more widely appreciated, even if criticism still focuses on aspects of its operation.

It is not only on the consumer side that attitudes towards marketing have needed revision. Observers have frequently contrasted the marketing approach of some of British management – particularly

in small firms – with that of continental and American managers, summing up that ‘British firms sell what they can produce while American firms produce what they can sell’. The original British lead in industrial development resulted in a faith in the natural excellence of British products, and this earlier belief that British goods would sell themselves was revived by conditions of excess demand in the post-war years of the 1940s and early 1950s. Production constraints set the limits to output and it was left to other competing industrial nations to develop the marketing concept.

If properly exercised, marketing is concerned with all decisions impinging on the relationship of any firm to its market. Pricing decisions, production projections, short-term and long-range company planning, research decisions, and product range development should all depend in some degree on the advice or direct co-operation of the marketing department.

In the case of technology-based products, the importance of marketing is paramount. ‘Newness’ is always an important factor for sales. When the ‘newness’ is contained in a technological development sales-potential should be high. But the innovation must be one that consumers are known to require or one whose advantages, when presented, they can appreciate. It can be argued that a product containing a technological development of significance is, *ipso facto*, of improved quality and will therefore sell on its merits without explicit marketing. But without advertising of some kind this would be a slow process, and the competitive environment of industrial innovation – which is international – does not allow this kind of time. The company which produces a new product must take active marketing steps in order to realise its commercial potential.

This argument pervades the report of the Zuckerman Advisory Council¹. Among requirements for more successful technological innovation it put: ‘A more sophisticated marketing approach; . . . a more balanced distribution of resources between R and D, the later stages of innovation, production plant, and marketing’. It stressed the importance, in achieving this new balance, of developing the understanding that ‘the most difficult and complex problems in the process of technological innovation generally lie in . . . the final phase which includes aggressive and sophisticated marketing’.

Insufficient emphasis on marketing in a firm can have adverse effects on the research function. Developed products may be inappropriately or too slowly presented to the market and fail to achieve full commercial usage, endangering the viability of research. Also the research department may receive inadequate marketing

information, projections of consumer demand and estimates of future requirements. Without this knowledge research can become 'un-targeted' and flabby.

Marketing is not a topic which lends itself easily to quantitative treatment. A more detailed appreciation of the importance of this function requires comparative case-studies of the marketing of innovated products. It would be valuable to study, for example, structural links between marketing and research departments, the ways in which marketing research influences product development, and advertising and promotional techniques for technology-based products. From such studies a more specific recognition can be achieved of how to prevent indifferent marketing forming a barrier to innovation.

RAISING RISK CAPITAL

To achieve successful innovation requires a constant input of capital – not simply for R and D but for pilot production, plant investment, and market development. Overall, R and D may claim only one-tenth of the total cost of innovation¹⁰. Large companies generally decide to pursue a good technical idea with the knowledge that they have this money available, but few small firms or individuals with potential products are so placed. For them, the raising of capital from outside is a critical early requirement.

A feature of note here is that the finance 'industry' is itself innovating. In recent years specialist finance houses and companies have been established to concentrate on assisting technology-based ventures, either by providing loan-capital or exchanging capital for equity. They are still few in number and can carefully select the projects which they take on, the main criterion being demonstrable commercial potential.

The government also provides finance for technological development, mainly through the National Research Development Corporation. The NRDC draws its projects from a wide range of technological fields and cross-section of proposers, both individuals and institutions. From its establishment in June 1949 to 1966 only a quarter of projects submitted were accepted for progressing either to be licensed or further developed, and of these only 10 per cent (one in forty of the original submissions) had earned any revenue by 1966. NRDC has spent some £23 million and accumulatively is still £15 million in deficit, though recent and projected annual performances show a profit position.

Contrasts are often drawn between the approaches of the British and American banking institutions to the provision of venture capital. It has been suggested that the greater support provided by American banks for new ideas is one cause of the more successful US innovation record, and that the UK banks display an insufficient awareness of the commercial potential of technology. In the UK some merchant banks (and even joint-stock banks) are willing to support technical ventures, but occasional faulty selection in the past has inhibited a general acceptance of venture capital supply as a defined specialist area of activity.

If there is an overall shortage of capital it need not stem entirely from deficiencies in the market mechanism (e.g. the low number of finance houses). The caution of private investors plays a part. This may reflect a reluctance on the part of investors in the UK, compared with the USA, to indulge in high-risk investment, which in turn can be suggested to result from differing expectations of returns in the two countries. (For investors, as for companies, the rewards of success must be high enough to counter-balance the risks of failure.)

The weakness of the supply of venture capital is signified by the absence from the list of sources of the Stock Exchange. There is in the USA a thriving 'over the counter' market for stock through which the small innovator is able to float equity shares. But while the UK Stock Exchange is not at present a direct source of venture capital the growing popularity of unit-trusts in the UK and the beginnings of specialism amongst them may signify a future solution to some of these problems.

It is, however, arguable that problems of the supply of venture capital, while often thought of as fundamental, are in fact an effect of a deeper problem – that of communication between the three agents, inventor, financier, and manufacturer. Generally, only in the case of the successful going enterprise are these three one. In other cases they are split, and it is in analysing and bridging the gaps between them that much needs to be done.

SMALL FIRMS

Smaller businesses may be faced with particular problems in managing innovation. Many established small firms 'follow the market'. With small changes from time to time to keep abreast of major exogenous technical developments a position of equilibrium is maintained. What happens if a policy of company development through product innovation is adopted – whether as a result of accidental product acquisition or a deliberate change in objectives? The firm moves from

a static situation to a dynamic one. It must tackle problems of product development, marketing, and financial control – requirements which may be new to it. Previously, operational factors such as costs, selling margins, demand and manpower requirements have been in relatively fixed relation to each other. But with product innovation, the firm may expect to improve its share of its market and thus find itself in an environment of growth where sales this month are higher than last month, where output demanded by the sales department begins to bump against the ceiling of production capacity, and where previously satisfactory stock and purchasing policies begin to show deficiencies.

It is not inevitable that a firm which finds itself in this position will change its methods of operation. It could simply allow its order books to lengthen. But a company which does seize the opportunities of innovation-based growth is moving onto an ascending spiral. To keep rising and even to avoid slipping back, the firm must adopt expansionary policies. These must be based on the recognition that a new product will provide a competitive edge only for a limited length of time. So forward planning, market analysis, and new product development will also become important aspects of policy.

The small firm has special advantages as well as problems in its search for new products. Many commentators have remarked on the proportion of major developments which has occurred in small firms. The relative informality of structure, the absence of those internal systems which facilitate the control of a large organisation yet which can stifle the 'maverick intuition', and the rapid responsiveness to events have been put forward as reasons for the potential creativity of small firms. Now some large companies are deliberately attempting to build a small-company environment within their structures, and such 'venture management' units may play a significant part in the future development of innovative business strategy. Comparative studies of their management and results may provide pointers for other firms.

THE MULTINATIONAL COMPANY

The development of the internationally-based or multinational companies is increasing – particularly the growth of American subsidiaries in Europe. While American companies have been the most successful in developing a multinational base the flow is not one way. European companies have subsidiaries in America and other parts of the world as well as having cross-links with other European countries.

In many cases the growth of multinational corporations has been associated with technological development. Firstly, an innovating firm reaches a point at which direct production overseas is preferable

to exporting. Secondly, the costs of innovation rise continuously. In the major industrial growth areas of the future – metals, chemicals, computers, electronics, aero-space – the firms must have potential access to large markets to sustain future product development and recoup development expenditures. With the scale of competition, the pace of technological progress, and the sophistication of many product fields, national markets may no longer be large enough to satisfy this requirement. Multinational corporate development reflects the attempt to gain rapid access to world markets for new products, without which the viability of company operations is endangered.

In this field, questions include the extent to which we should welcome or resist overseas investment in Britain. How can overseas subsidiaries in Britain be encouraged to export from here to third markets? Conversely, how can the smaller European companies successfully break into the massive North American market? The response of UK industry to the inevitable growth of multinational business operation – a response which depends in part on governmental decision – is one of the most important, and as yet under-investigated, areas of policy determining our future international competitiveness.

INCENTIVES AND DISINCENTIVES

The government's direct interest in innovation has been mentioned incidentally at stages in this review, for instance its use of research resources and its purchasing policies. But the government activities which could possibly have greatest impact on the rate of innovation in the UK work indirectly through business incentives in tax and other policies.

Whatever economists decide to be the fundamental motive of firms or entrepreneurs there is no doubt that cash flow is important at least on a day to day basis. Taxation, corporate and personal, has an important influence on this.

The introduction of corporation tax was intended to encourage reinvestment. It has been suggested that a particular aspect of this expenditure, on R and D, requires additional encouragement and that this could be brought about by an extra tax allowance to the amount of R and D expenditure or a proportion of it. Whether or not this is a desirable step depends upon answers to the earlier questions: Is industry spending an appropriate amount on R and D already? Is there yet a balance between money spent on R and D and on the other phases of innovation, or on capital investment? The figures in Tables 2 and 5 do not immediately suggest an under-spending on R

and D. Would it be better instead to give more publicity to the tax incentives which already exist for reinvestment in technologically advanced capital goods – for instance, investment grants for prototypes?

The impact of corporation tax itself on innovation should be examined. While reinvestment should be effectively encouraged it can be argued that retained profits sometimes end up simply as more money sunk into low-yielding investment, whereas distribution would have injected into the economy extra resources which could be invested in higher yielding areas (e.g. new technological companies).

It is possible that the taxation of personal income as at present directed constitutes a more immediate barrier to innovation. Above a certain level of personal income the marginal rate of taxation in the UK is high in comparison with other countries. It has been argued that this dampens managerial ambition and effort at middle and senior executive levels and has contributed to a pervasive non-growth mentality. An implication for many small businesses of high marginal taxation may be its effect on the mobility of management. What a new technology-based business may need, beyond all else, is to attract skilled, experienced managers. But for such men pre-tax salary differentials may narrow down to progressively smaller disposable income advantages, which are out-weighed by the risks to career and family from changing jobs.

A further form of incentive which could have significant impact on personal effort is the stock option. It has widespread use in America, where it helps to establish a stronger identification between the employee's and the company's good, and acts to direct maximum energies at company growth. In the UK, the Finance Acts of the mid-60's have more or less suppressed such schemes. Whether it has been worth the sacrifice of their intangible motivational value in order to close tax loopholes may be questioned.

The personal impact of innovation must also be taken into account. Success in one field may lead to obsolescence in another. There may be a barrier to innovation if a trade union or trade association, protecting the interests of those who would most need to adapt to the change, is able to prevent the application of innovation. It is possible that more personal incentives must be devised to encourage individuals to accept the social disturbance which undoubtedly can be caused by innovation.

Whether changes in these fields could of themselves eliminate the 'gaps' – technological, managerial, entrepreneurial – which afflict industrial innovation in the UK would not be easy to establish. The

problems involve psychological as well as economic factors. But in that they would create a positive climate of reward, policy changes in these areas would valuably support other changes in management and administration fundamental to the realisation of the full economic benefit of our technological skills.

Conclusion

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The aim of this introductory booklet has been to present a review of some aspects of industrial innovation which are under discussion today. It has not attempted to treat any of the topics in depth, but has endeavoured to indicate the scope of the subject, and point out short-falls which exist in present understanding of the role and nature of industrial innovation.

The organisation which the Innovating Industry Project is proposing would be based on the premise that obtaining further knowledge and generating wider understanding of factors such as these can significantly help promote a higher return from the inventive resources of the UK.

Although many other bodies, such as the Confederation of British Industry, are concerned with questions of research and innovation in industry, none of them can concentrate exclusively on these problems in the way that the proposed organisation would do. Nor does the growing interest in academic and other institutions in the subject of industrial innovation in any way detract from the need for the proposed new unit. Indeed, this widening interest only emphasises the potential benefits of appraisal and collation of the studies and conclusions of these many centres into an organised body of knowledge which would provide a base for formulation of corporate and national policies for innovation.

As mentioned in the Introduction the Innovating Industry Project intends, while co-ordinating support for the new organisation, to commence pilot studies of selected aspects of innovation. These may include:-

- (a) the relation between R and D, profitability and growth
- (b) reaching the world market – exporting, licensing, subsidiary manufacture
- (c) the impact of taxation policies
- (d) the importance of technical and economic ‘spin-off’
- (e) the transfer of shelved projects from large firms to small.

Full details of the Project, its work and proposals may be obtained from:-

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References

1. *Technological Innovation in Britain: Report of the Central Advisory Council for Science and Technology*; HMSO July 1968
2. F. E. JONES – address to the Science and Technology Seminar of the Conservative Party Technology Committee, 12 November 1968
3. B. R. WILLIAMS – *Technology, Investment and Growth*; Chapman and Hall 1967
4. C. FREEMAN, A. B. ROBERTSON – Innovation and the World Market in New Chemical Plant; *Chemistry and Industry* 12 October 1968
5. *Statistics of Science and Technology 1968*; DES and Mintech; HMSO 1968
6. *The Overall Level and Structure of R and D Efforts in Member Countries*; OECD Paris 1967
7. M. J. PECK – Science and Technology; in *Britain's Economic Prospects*; Brookings Institution; George Allen and Unwin 1968
8. E. B. ROBERTS AND H. A. WAINER – New Enterprise on Route 128; *Science Journal*, December 1968
9. *Industrial Research Associations in the United Kingdom*; OECD Paris 1967
10. *Technological Innovation: Its Environment and Management*; US Department of Commerce 1967
11. C. FREEMAN – Research and Development: A Comparison Between British and American Industry; *NIESR Economic Review*, May 1962

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