GOVERNMENT POLICIES FOR THE STIMULATION OF TECHNOLOGICAL INNOVATION

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PREFACE

This paper was written by Professor Ernest Braun, head of the Technology Policy Research Unit at the University of Aston, UK, during a visit to IIASA in September 1979. The work was part of the Innovation task of the Management and Technology Area, and the paper was presented at the Workshop on "Innovation Policy and Firm Strategy" held at IIASA in December, 1979.

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INTRODUCTION

It has become an article of faith in all technically developed countries that technological innovation is the major therapeutic agent for current economic ills (e.g. Hauff 1979). The pillars of this faith are many and only a few need be listed here.

It is believed that flagging economies of the developed countries can be revived by opening up fresh avenues of economic activity (e.g. Mensch 1977, Freeman 1979). It is further believed that each economy must retain or achieve a competitive advantage over newly industrialized countries and over its technically developed competitors by producing ever new sophisticated products by ever new efficient methods. The saturation of markets for some goods, such as television receivers, also supports the belief that new goods, which create new needs, are required. Finally, it is considered that unless the spectrum of products is constantly increased, productivity advances in old products will erode the employment market; yet innovation is also often undertaken to ease bottle-necks in the availability of labour. Thus for a wide variety of reasons technological innovation appears to many economists, industrialists and politicians as the answer to their prayers.

A recently strengthened motivation for the search for new and improved products and processes is the necessity to save energy, mainly imported energy, and to substitute abundant raw materials for scarce ones. Hand in hand with the growing awareness of requirements for energy and raw materials conservation, grew an awareness of requirements for environmental protection and for improvements in the quality of life. These new requirements impose limits on the consumption of some old established goods, but at the same time call for new goods and processes and therefore reinforce -- from a different angle -- the call for technological innovation.

The variety of results desired from innovation can only be achieved by a variety of types of innovation. Many classifications have been proposed, both to describe the importance of the innovation (from minor improvement to fundamentally new) and the area of activity, e.g. product innovation, process innovation, and manufacturing innovation. Product innovation produces new or substantially improved products and thereby opens up new markets and/or maintains market shares. Process innovation improves the efficiency of use of natural and human resources by substituting new ways of achieving similar results - although new processes often result in somewhat altered products and sometimes in entirely new products. Manufacturing innovation is aimed at increasing productivity and can improve the quality of the working environment. Essentially it uses new control mechanisms to make old products by old processes (Braun et al. 1980).

As the importance of technological innovation became more widely recognised, so the literature on the subject grew. By now there exists a large number of textbooks and some reasonable degree of agreement as to the important steps through which an invention must proceed to become an innovation (e.g. Freeman 1974, Mansfield 1968). There also exists, to a lesser extent, some agreement on sources of ideas which may become innovations (e.g. Jewkes et al. 1958). All governments have policies designed to stimulate innovation and those must of necessity make some assumptions on how innovation proceeds. We shall therefore very briefly summarize a plausible theory of the process of

technological innovation, in order to relate possible and actual government action to such theory.

All innovation starts with an idea. Whether or not the idea is a result of scientific research, it is plausible to assume that ideas arise most readily in a creative atmoshphere of interchange of thought. Ideas are most likely to be new and fruitful if their originator is well informed, especially on potential feasibility and potential need. The highest probability of an idea to give rise to innovative action is achieved when it can be well articulated and communicated to collaborators. Thus the plausible image of an inventor is a well-informed articulate person in lively contact with current knowledge and current needs.

The idea, however, is only the beginning--and, alas, more often than not also the end of the story. For an invention--and an invention really is only a particular category or form of idea--for an invention to become an innovation a series of actions must happen. The number of steps--and the difficulties of taking them--depends entirely on the kind and magnitude of the innovation. In very simplified form, the sequence of events, or the stages of the innovation, may be as follows:

The inventor must build or have built a prototype model. Usually, unless the invention is a very simple one, this step cannot be completed without many modifications and, more often than not, will require further research work. To accomplish all this the inventor will require a lot of money and a lot of persuasive power. The latter he needs not only to obtain the former, but also to persuade the appropriate decision makers that his invention can be realised and, if realised, can be profitably marketed.

The stage from idea to prototype can be long, convoluted and expensive. It may require a great deal of research, a great deal of personal commitment by a 'product champion', complex facilities, and access to technical and commercial information

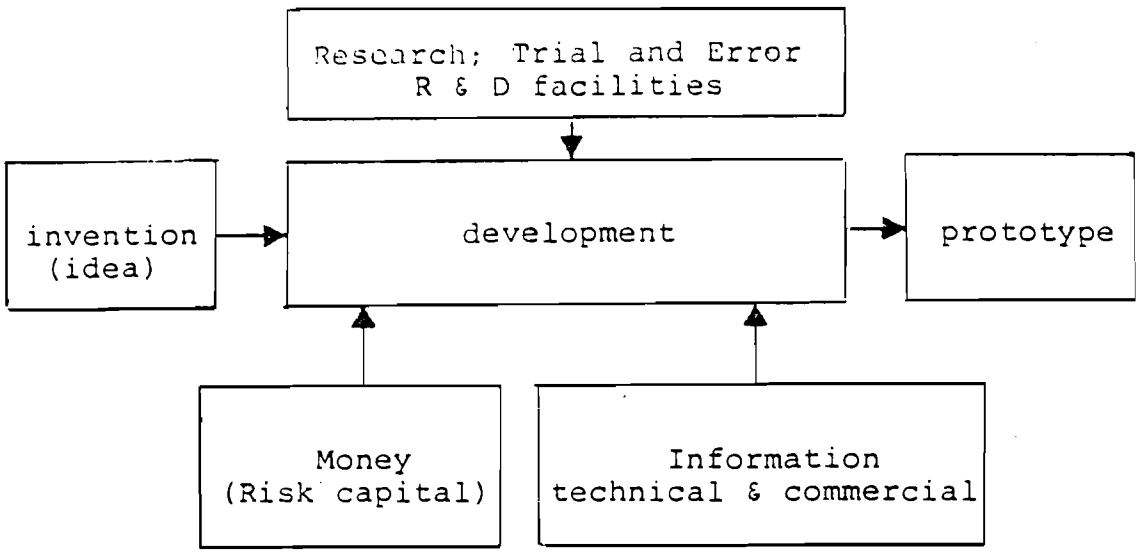

Fig. 1

Even our simplified scheme shows some of the many difficulties and complexities that may be encountered on the way between idea and working prototype. Indeed often the obstacles prove insurmountable and the idea may be abandoned at any stage before or during development. There is often considerable feedback between research and development and the distinction between the two activities--though in principle quite different--becomes blurred.

If and when a 'final prototype' emerges, that is a prototype which the developer considers satisfactory, the penultimate stage of the innovation process may start. A decision on whether or not the invention--now in prototype form--should be put into production is made and, if the decision is positive, production facilities must be designed and built or otherwise obtained. The crucial consideration in the decision is simple: can the product be marketed at a reasonable profit.

No matter whether the innovation is a new product, a new process, or a new production technique. In all cases somebody has to buy and use it for the innovation to become a reality. Thus from prototype to innovation there is also a difficult--perhaps the most difficult--transition. The innovator must be satisfied that the innovation can not only be manufactured but also be marketed successfully.

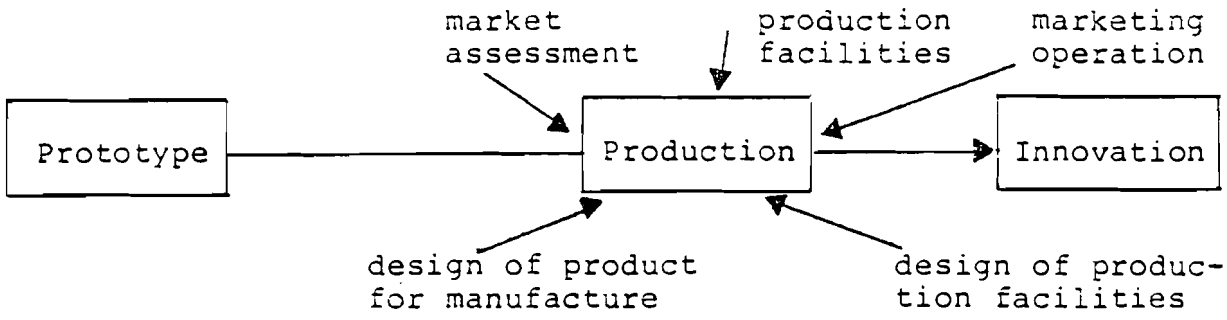

Fig. 2

PUBLIC POLICY OPTIONS

As indicated above, most governments now feel that it is their duty to support the innovative process by suitable policies and indeed most governments have instigated a number of measures designed to stimulate innovation. Before reviewing some of the measures that have been or are being used, we shall attempt to describe what one might call the operational freedom of governments--i.e. define what measures are, in principle, available to government. There are, of course, many possible classifications and we shall not explore all of these. It may be useful to distinguish between measures which

a) influence the general environment in which innovators operate,

b) influence industrial performance (either specific sectors or industry in general),

c) stimulate innovation in general,

d) stimulate specific innovations.

Bearing these distinctions in mind, we can list classes of possible measures--though some overlap is difficult to avoid--and give some examples of each class. This is done in Table 1.

Some of the examples listed can fall into all or several of the categories (a) to (d), others fit only into one of these. A more elaborate matrix of possible measures could be devised and undoubtedly the level of generality and of abstraction could be increased, though it is doubtful whether the utility of the scheme would increase in proportion.

Table 1.

Type of measure	Examples
Financial	Grants, loans, conditional grants, subsidies, financial sharing arrangements, loans and gifts of equipment, provision of free services, provision of buildings.
Taxation	Company-, personal-, indirect-, payroll-taxation, tax allowances.
Legal & regulatory	Patents, environmental regulations, health regulations, inspectorates, protection of designs, arbitration services, monopoly regulations.
Educational	General education, universities, technical education, apprenticeship schemes, continuing and further education.
Procurement	Defence purchases, central government purchases and contracts, local government, public corporations, R & D contracts, prototype purchases.
Information	Information networks and centres, libraries, radio and television, freedom of information, advisory services, statistical services, government publications, data bases, museums, exhibitions, liaison services.
Public enterprise	Innovation by publicly owned industries, setting up of new industries, pioneering use of new techniques by public corporations, correction of imbalances by public enterprise, participation in private enterprise.
Public services	Purchases, maintenance, supervision and innovation in health service, public building, construction, transport, consumer protection, telecommunications.
Political	"Atmsophere", honours system, planning, regional policies, innovation by decree.
Scientific & Technical	Technical standards, research laboratories, testing stations, support for research associations, learned societies, professional associations, research grants.
Commercial	Trade agreements, tariffs, currency regulations.

Perhaps it ought to be emphasized that policy measures can act at any point of the innovation process. Invention itself can be encouraged by educational and information measures, by financial rewards and by esteem given to inventors. The research and development phase can be eased by a widely available research and technical information system, by financial grants, contracts or loans, by liaison services, etc. Decisions about innovation can be eased by government risk sharing, by procurement promises, by market information services. The stage between prototype and production can be aided by loans, grants, purchases, provision of manufacturing facilities, tax incentives, advisory services, etc.

Thus policy measures can not only be specifically designed to stimulate innovation, they can also aim at removing difficulties at specific points of the innovation process. Hence an understanding of the process--or theory of innovation--is an integral part of innovation policy.

In a recent OECD report (1978) a different classification of policies for the stimulation of innovation (PSI) was proposed. The report distinguishes three types of PSI:

a. Specific measures

(i) Instruments aimed at establishing and/or maintaining an interface. Examples are (p.34):
"- instruments for promoting research associations
- brokerage instruments either combined with or without technical or financial aid, etc."

(ii) Instruments based on loan or subsidy procedures, providing direct financial aid to innovation.

b. Non-specific measures

(i) Measures connected with science policy, especially involvement of government laboratories both in setting standards and directly aiding innovation.

(ii) "Measures combined with instruments of industrial policy"

(iii) "Measures grafted onto regulations for controlling relationships between various economic transactors"

these measures include patents, licensing, consumer protection, procurement, taxation, etc.

c. The final class of measures is (pp.35-36) called 'complex measures' or 'major programmes' and these are often "leading instruments of sectoral policy".

The German Federal Minister of Technology and Research, V. Hauff (1977) simply classifies instruments according to the market at which the innovation is aimed. In this view, the set of stimulation policies can aim at innovations for the private purchaser, the industrial purchaser, and the public purchaser. The first set of measures will essentially aim at new or improved consumer goods, the second at capital or investment goods and the third will aim to arrange procurement in such a way as to stimulate innovative activity.

An alternative classification of mechanisms by which governments can stimulate innovation is given by Allen et al. (1978). These authors list 12 mechanisms by which government can influence technological innovation and these fall into three categories:- initiating mechanisms, sustaining mechanisms, and restructuring mechanisms. Into the first category fall activities such as "reducing the probability of technical or commercial failure". In the second category we find measures such as "increasing transfer of technical knowledge between institutions" and in the third category we find measures "influencing labour's receptivity to technological change and internalising the human costs associated with innovation activity".

In summary, government has several tools for the stimulation of technological innovation at its disposal, ranging from fiscal and legal measures, to direct industrial participation. These tools can aim principally at four different target areas: the general 'environment'; industry; general technological innovation; specific innovations. All tools are, or may be, interrelated and so may be the target areas.

Although many more classifications at various levels of abstraction are possible, it might be more useful to turn our attention to a brief review of a sample of policy measures undertaken by various governments in recent years.

SAMPLE OF RECENT POLICY MEASURES

To give a complete list of measures undertaken by the governments of the developed countries would be difficult and unhelpful. Instead, a short selection of some characteristic measures will be given, together with literature references, although these are not exhaustive.

The list does not include general climate measures - it is taken for granted that all developed countries have a complex structure of elementary, intermediate and higher education; a network of government laboratories; patent and other legislation; a web of standards; regulations and inspectorates; and that all these governments make substantial purchases ranging from paper clips to computers and from policemen's helmets to fighter aircraft. It is further assumed that all these countries have developed transportation and communication systems, including road, rail, air, telephone, telex, radio, television, etc.

Amongst the more specific measures for the stimulation of innovation we shall look at only a few countries and use the previous classifications (Tables 1 and 2).

Financial

An example of a financial support programme aimed at general innovative activity, perhaps with special emphasis on small and medium sized enterprises (SME) is the Erstinnovationsprogramm of the Federal Ministry for Economic Affairs (Hagedoorn and Prakke 1979, p.54). In this programme the Ministry pays 50% of R & D and pre-production costs for "important programmes of high risk, which would not be launched without aid or would progress much more slowly". If the project is commercially successful, the grant has to be repaid within 10 years.

Table 2

Measure \ Target	General ambience	Industrial policy	General innovation	Specific innovation
Financial		Investment in regional factory building	Making venture capital readily available	Supporting specific R & D programmes
Taxation	Supporting entrepreneurial spirit	Making investment allowances	Allowances for innovative investments and R & D expenditure	
Legal & regulatory	Patent laws monopoly regulations	Factory legislation	Health & safety regulations	
Educational	General educational provision support for higher education	Technical training schemes		Training schemes in specific new areas
Procurement	Level of public expenditure	'Buy at home' policies	Procurement specifications	Orders for specific new equipment
Information	Libraries, broadcasting, government statistics	Technical information services	Liaison services	
Public enterprise		Active regional policies	Participation in new ventures, innovative policy in state industry	Public enterprise in new technology Use of specific innovations
Public services	Transport & communications			Use of specific innovations
Political	Access to information Public opinion Government laboratories		R & D availability from public source	
Scientific & Technical	Technical standards		R & D availability from public sources	Specific R & D support

In a somewhat similar scheme by the Federal Ministry for Research and Technology, and aimed purely at research and development contracts placed by small firms with external organisations, the Ministry will pay 30% of the cost up to DM120000 per enterprise, per year (Förderfibel 1979). The measure is to promote ".. R & D contracts which aim at obtaining technically new or improved products or processes and which contribute to an improvement in the economic performance of the enterprise". The scheme is an instrument of public policy in that it supports innovation, but excludes R & D contracts "... which run counter to the public interest..."*.

In the UK technology policy armoury there is a whole range of financial measures but only a few will be mentioned here (see e.g. Hagedoorn and Prakke 1979). The first instrument of policy is apparently a result of the Rothschild report of some 8 years ago. Many Departments of Government now have their own chief scientist who supervises the work of Research Requirement Boards. These boards have a number of industrial and other independent members. In the Department of Industry there are nine such Boards for different industrial sectors. "Their objective is to improve the technological base of the industry by helping to fund R & D projects carried out by companies and research organisations, including research associations".

The Boards generally prefer to fund projects in direct support of the government's industrial strategy, i.e. they give preferential treatment to projects in support of technologies singled out by the Department of Industry as of high priority. Generally, projects should "yield financial returns and improve the manufacturing performance in terms of international competitiveness, added value per employee and energy conservation". What more could one ask?

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* The phrase 'counter to the public interest' does, of course, beg the question of determining what the public interest is. Without the hidden assumption that government is the guardian of public interest and therefore can find ways and means of determining this interest in each case, all public 'policy-making' would collapse. Although these problems are crucial to any debate about public policy, they are well beyond the scope of this paper.

Quite large sums are dispensed in this way. For example the Mechanical Engineering and Machine Tools Requirement Board has an annual budget of £10 million.

The financial schemes mentioned so far are aimed at aiding the process of innovation at the R & D stage. Several schemes go further than that. For example the UK Product and Process Development Scheme of July 1977 provides 50% government funding from the design stage up to the point of commercial production (Dept. of Industry, 1978). The scheme allows either for grants of up to 25% of qualifying costs of for a 50% contribution coupled with a levy on sales. Furthermore, the Department of Industry can buy prototype equipment and lend it to an industrial user. The user has the option of buying on favourable terms or returning the equipment after a certain period.

Many of the schemes described so far attempt to provide finance mainly for research and development*, with limited further help. They fall into the category of general financial help for innovation, although there is some limited vetting and priority allocation and, in that sense, the schemes aid specific innovations. There are, however, much more specific schemes. One only needs to think of all the nuclear energy schemes, financed almost entirely from public funds, or of innovations like supersonic transport aircraft. Under the same category fall schemes like the recent British programme for the promotion of microelectronics. Most other governments have similar programmes.

The microelectronics programme is a deliberate and many-pronged instrument of policy. It aims to promote the strengthening of production and applications (with some stress on the latter) of a particular new technology - in this case microelectronics. The instruments used fall into many categories: an information campaign; grants and loans for research projects; financial help with the launching of new products; founding of a public corporation for the manufacture of microelectronic components. The overall hope is to increase innovative activity in products using microelectronics as control elements. The public involvement in the manufacture of components is less an instrument of

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* Indeed Gerstenfeld (1977) estimates that the Federal Government pays for about 50% of all industrial R & D in the BRD.

innovation policy and more one of industrial strategy, although motivations in this area, as in most others, tend to be mixed (Dept. of Industry 1979).

An important aspect of financial help for innovation is public provision - or public support for private provision - of venture capital. In the Federal Republic of Germany the Government has provided a venture capital corporation, the Deutsche Wagnisfinanzierungsgesellschaft, financed by a consortium of banks, with a 75% guarantee against losses for the first fifteen years of its operations.

In the U.K., the National Research and development Corporation has the provision of venture capital as one of its aims and is allowed to borrow directly from the Department of Industry for this purpose (NRDC, undated).

Tax Incentives

Again, just a few examples of the kind of policies that have been used will be mentioned. In the U.K. for example, capital expenditure on plant and machinery used for R & D purposes is completely tax-deductable in one year. Similarly, revenue expenditure on R & D wages etc. is deductible and costs of licence fees and patents may be written off over a number of years (Hagedoorn and Prakke 1978).

In the BRD research and development facilities receive a tax-free subsidy of 20% of allowable costs up to DM500000 and 7.5% for further costs. For investments which are aimed particularly at energy savings there is an additional subsidy of 7.5% (Förderfibel, 1979).

Patents, Liaison and Information Services

In the Federal Republic of Germany there are four sets of measures specifically designed to increase the utilization of patents (Hagedoorn and Prakke, 1979, pp 30-31). The Patentstelle für die Deutsche Forschung provides a consulting service and credits for inventors to patent their work and to find industrial sponsors.

The Max Planck Gesellschaft owns Garching Instrumente GmbH, which mediates the licensing of patents and develops and sells prototypes of equipment invented in MPG laboratories. There are two further patent information centres: the Arbeitsgruppe Patentverwertung is establishing a system to inform industry about patents resulting from government funded projects, while the Technologieverwertungsstelle der Grossforschungszentren aims at selling patents resulting from research at major laboratories.

The Patent Office itself offers to produce, at a cost, surveys of patents existing in any specified area of technology even for companies not seeking to patent an invention.

In the U.K., one of the tasks of the NRDC (National Research and Development Corporation) is the patenting and patent management of inventions originating in the public sector, particularly in government research laboratories and in universities.

A very large variety of other sources of technical information are generally supported from public funds. A Central Office of Information pamphlet (1978) lists: General library services, British Library, National Reference Library of Science and Invention, National Central Library, National Lending Library for Science and Technology, Information services provided by the Department of Industry, the United Kingdom Atomic Energy Authority (e.g. Technology Reports Centre, Ceramics Centre, Non-Destructive Testing Centre,) etc. etc. The only item missing from the list is an information centre on information centres.

One of the widely quoted success stories of a mainly advisory and information system is a special working party set up by the German Federal Ministry for Research and Technology (BMFT), the central 'applied science' research organisation (Fraunhofer Gesellschaft), the user industry, trade unions, and manufacturer's organisation to advise the clock and watch industry on technological change. Assistance has been given to firms on the watchmaking, clockmaking, sensor, weighing machine and office and sales equipment areas. Services available under this scheme include advice on applications and diversification, technical advice and provision of know-how, preliminary assessments of development projects, and advice on the availability of public funding. 50% cost-sharing

Table 3. (from Hagedoorn and Prakke) Government funds available for innovation in current prices

Millions of national currency units

	1972	1973	1974	1975	1976	1977	1978	1979
Germany F.R.								
Patentstelle für die Deutsche Forschung	0.5	0.6	0.7	0.9	1.1	1.2	1.5	
Technologieverwertungstellen der Gross-forschungszentren							±1.0	
Deutsches Patentamt	95	101	104	117	123	125	131	
R.K.W.	30	32	34	40	41	42		
Fraunhofer Gesellschaft	62	68	82	90	108	126	138	
Technological Advisory Services to SMEs						0.5	2.6	3.0
VDI Technologie-Zentrum						0.7	0.7	1.0
R&D manpower grant programme								300
BMFT-Projektförderung					1269	±1500	±1500	
Vertragsforschung							6.0	10.0
Wagnisfinanzierungsgesellschaft						0.8	1.8	5.5
Erstinnovationsprogramm	3.9	7.2	6.0	7.3	9.9	12.1	16.0	19.5
United Kingdom								
N.R.D.C. (revolving fund)	4.46	3.84	2.49	3.17	4.14	4.39	6.48	7.03
Low Cost Automation Centres	0.10	0.10						
Industrial Liaison Services Centres	0.50	0.20						
Small Firm Information Centres	0.03	0.5	0.5	0.38	0.5	0.5	0.42	0.43
Research Associations	2.90	2.8	3.2	4.7	6.6	8.0	11.0	11.5
Small Firm Counselling Service					0.03	0.05	0.34	0.35
Manufacturing Advisory Service						0.23	1.86	1.64
Requirement Boards		0.30	0.70	1.80	2.00	2.20	10.00	11.00
Collaborative Development Contracts	4,496	8.416	10.388	10.141	10.343	11.125	14.862	16.571
Pre-production Order Assistance							0.38	
Product and Process Development Scheme							0.27	0.6
Software Products Scheme	0.033	0.057	0.114	0.310	0.273	0.200	0.400	
Micro-electronics Support Scheme						0.210	6.0	6.0

in R & D and innovation projects is also available under a BMFT scheme (Hagedoorn and Prakke 1979, p.37) Table 3, reproduced from Hagedoorn and Prakke shows the funds available over the years in the U.K. and the BRD for projects identified by the authors as policy measures in support of technological innovation. These funds are exclusive of the very large sums spent on general industrial policy schemes and in government procurement schemes.

The total spent by governments in support of innovation can only be guessed at. Pavitt and Walker (1976) have neatly summarized estimates of the ratio between total U.K. government expenditure on industrial support and on industrial R & D. The figures give an indication of the relationship between general direct support and R & D support for industry. (See Table 4).

Table 4. R & D and Total Government Financial Aid to Manufacturing Industry in the U.K.

	R & D (1970-71)	Other (1969-70)	Total
Chemicals	0.2	14.8	15.0
Metal manufacture	0.1	8.5	8.6
Engineering	7.1	10.4	17.5
Vehicles (inc.aircraft)	16.3	20.7	37.0
Textiles	0.1	4.6	4.7
Other	1.2	16.0	17.2
Total	25.0	75.0	100.0

Source: Pavitt and Walker 1976.

The Position in the Socialist Bloc

Everything that has been said so far is directly applicable only to basically unplanned economies. The full innovation policies of the socialist countries cannot be reviewed here in an adequate way. Certainly the support and management of technological innovation is an acknowledged task of the planning organisations and the various ministries concerned. A network of exchange and collaborative arrangements also exist. Perhaps the position can be summed up in the words of an economist from the DDR

When we consider the development of technological planning up to present time we may state that the actual experiences have refuted the initially widespread view of the impossibility of planning scientific-technological progress. Even inventions are being planned today though the actual time and concrete way of solving the problem cannot be forecast exactly. The practicability of central technological planning has also been sufficiently proved though its forms did not meet all the requirements already in the beginning. Actually we should be aware of perfectionistic ideas and bureaucratic distortions. This may also be said of long-term prognoses and the strategy of science and technology. Its necessity and its appropriateness are undisputed but it does not in every case save us from erroneous calculations. Flexibility of planning should therefore be given great consideration. (Haustein)

Figure 3. summarises,in the words of the author, "the most important steps of planning of innovations...."

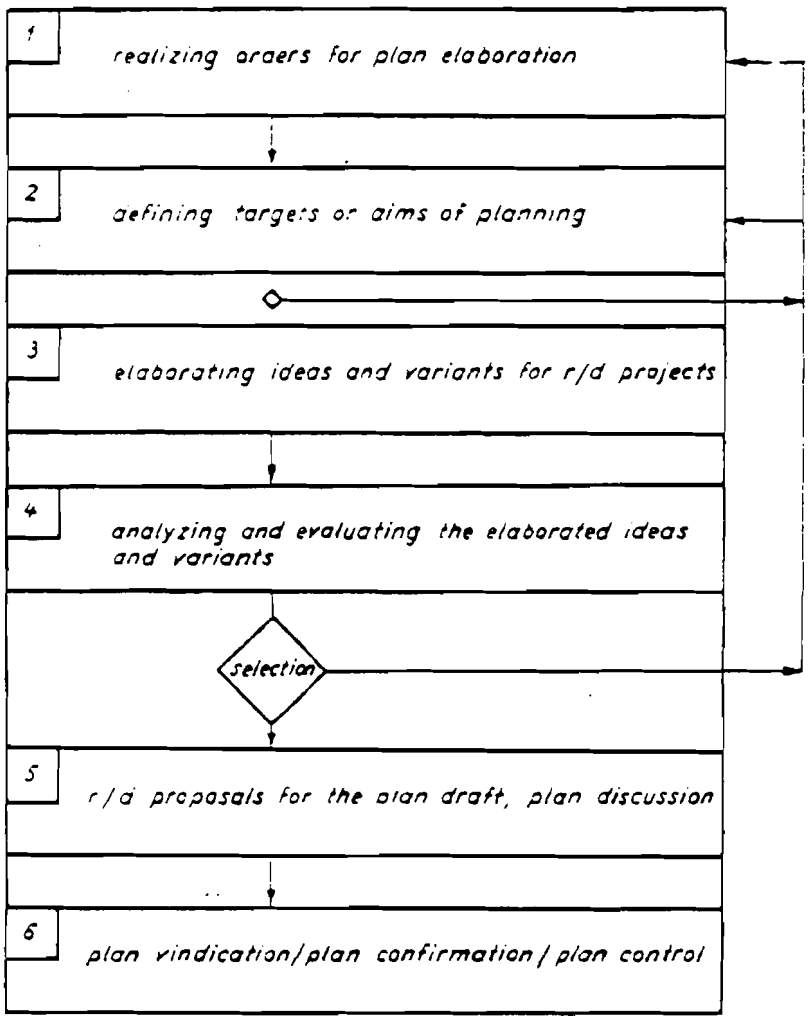

Figure 3. Planning of innovations.

Source: Haustein.

The present review cannot, and is not intended to, give a complete list of individual measures taken by individual governments for the purpose of fostering technological innovation. All that can be achieved is to give a few characteristic examples of current measures in two countries which illustrate the most common features of such measures. Perhaps it should be said, without apology, that most real measures contain a mix of theoretically possible tools and do not fit neatly into single pigeon-holes of our classification. Many government measures consist of packages containing more than one tool and many try to fulfil several aims at once. The classification may nevertheless be a useful tool for analysis and understanding.

SOME CRITICAL EVALUATIONS OF POLICY MEASURES

It is a truism to say that no policy measures escape criticism, but it may be worth remembering that the criticisms can be aimed at two fundamentally different aspects. It is possible to criticise a policy because of disagreement with its aims or because of doubts about its effectiveness in achieving these aims. Additionally policies attract criticism because of unintended, unwarranted or unforeseen effects which they may cause.

The simplest and most devastating criticism of innovation policies has been made by Gaudin (1977). "As a civil servant managing research contracts, I can tell you that most work in economics of innovation is completely irrelevant and useless".

In fairness, not so much a criticism of innovation policies as of the theories they might be based on. Gaudin goes on to criticise the assumption that research is the prime mover of innovation: "...most innovations are not the result of research ...". Here, again in fairness, it needs to be said that most recent theories of innovation do not identify research as the sole source of invention but only as a component of the innovative system. Most case studies of innovations support this view (see e.g. Braun and MacDonald 1978, Langrish et al. 1970).

Many critical views question the thesis that innovation is desirable, or if desirable, whether it is taking the right course. Some critical views question both the desirability of innovation,

or, at any rate, a forced pace of innovation, and the ability of government to influence it greatly. A characteristic comment, critical of both aims and efficiency of innovation policies comes from R.G. Noll (1977).

> ....literature does not establish either that too little innovative activity takes places, or that government can be particularly effective in devising cost-effective strategies to promote more R & D...

However, in the same publication Lederman (1977) writes about

> Persuasive evidence that R & D and technological innovation have had a significant positive effect on growth of productivity...

and that the U.S. is

> probably underinvesting in civilian R & D.

Much controversy surrounds the question of whether government aid for specific technological innovations is more or less effective than general measures to stimulate industrial or innovative activity. A characteristic comment on these issues is:

> ....data presented in this report have strongly suggested that general measures (e.g., tax, safety) have a greater impact on industrial innovation than R & D specific measures. It seems that, unless the general social and economic environment is favourable, specific R & D innovation related measures will have only a limited impact... (Rothwell and Zegveld 1978).

Leaving aside fundamental criticisms and essential doubts about innovation in general and innovation policies in particular, a number of recent reports have concentrated on proposals for improved innovation policies. All these proposals are firmly based on opinions, and all too often the opinions closely reflect the sectional interests of those who express them.

A recent report by the Advisory Council for Applied Research and Development (1978) makes, inter alia, the following specific recommendations:

(i) increased tax incentives for a limited period for investment in new manufacturing plant and machinery,

(ii) money additional to the science budget for a build-up in Science Research Council programmes in support of manufacturing technology,

(iii) an expansion of the Department of Industry Manufacturing Advisory Service,

(iv) provision of financial and other support to Research Associations and the appropriate Engineering Institutions for the study, research, and publicising of the sciences supporting highly efficient, internationally competitive manufacture.

Much emphasis is put on the role of the small firm in innovation. Although there is certainly no unanimity in the matter, there is a large body of opinion which believes that some innovations are most efficiently carried out by small entrepreneurial firms (see e.g. Rothwell and Zegveld 1978). This view is reflected in the ACARD report and some of their recommendations.

> The Government should do more to foster the special contributions which small firms make to industrial innovation by providing additional support through:
>
> (i) arranging that any losses from small business enterprises be allowed against the personal tax liability of the shareholders,
>
> (ii) reducing capital gains tax on the appreciation of founder's holdings,
>
> (iii) examining the feasibility of setting up special tax arrangements which might make it attractive to large companies to spawn or help to support small businesses.

One of the hotly debated issues of the day is the role of government regulations in innovation. As regulations concerning safety, environmental pollution, working conditions, descriptions of goods, etc. became more ubiquitous, so their opponents began to argue that so much money had to be spent by manufacturers on complying with regulations, that none was left for innovation. On the other hand it is argued that the need to comply with them gives a fillip to new products and processes. While dispassionate writers like Lederman (1977) say that no consensus exists on whether, on the whole, regulations are beneficial or detrimental

to innovation, many members of a recent U.S. Domestic Policy Review of Innovation (1978) were extremely critical. Amongst the recommendations of the subcommittee on Industry Structure and Competitors (p.4) are :

> Each regulatory agency should issue a long range statement of regulatory intent... Where a company has related compliance requirements controlled by more than one law, consultations must occur between the agencies.

No doubt, some confusion and changes of direction can cause difficulties. The main thrust of the argument, however, is directed against regulations which prescribe solutions instead of prescribing performance standards.

> Innovation is negatively impacted by regulating the means rather than the ends. (p.6)
>
> Regulations should only prescribe the standards of performance to be achieved, not the means by which they are to be achieved. (p.7)

Small firms again become the subject of special pleading

> Smaller firms, historically the source of significant contributions to innovation, suffer disproportionately greater injury from the overall costs of regulations than do larger firms. (p.21)

The sub-committee on Federal Procurement Policy makes similar points in relation to procurement policy. The recommendations of this committee on general policy include the following:

a. Express needs and program objectives in mission terms and not equipment terms to encourage innovation....

b. ....allow competitive exploration of alternative system design concepts....

Different sub-committees of the same Domestic Policy Review of Innovation view obstacles to innovation and the role of the state very differently. The Labor Advisory Committee states "The best stimulus to innovation comes from a healthy full employment economy--not from weakening protections". The Sub-Committee on Public Interest, on the other hand: "We do not accept the widely held industry assumption that regulations impede innovation" (p.2). "Moreover, job security is a fundamental aspect of innovation. Frightened workers, worried about whether another job

will be available if a specific new idea is implemented, often oppose innovation" (p.4).

These are just a few examples of statements and recommendations made by various interest groups in what is obviously a political issue. Interested groups clearly have a different view not only of what influences innovation and how the mechanisms operate, but also, mostly implicitly, of what direction innovation should take. Only one group, however, states this: "From the public interest perspective, the rate of innovation is subservient to the question of the direction of innovation" (Sub-Committee on Public Interest, p.6).

So much then, for opinion; but what about actual research findings on the efficacy of government policies for the stimulation and direction of innovation? The paucity of knowledge in this field is considerable. One of the few serious attempts to investigate these questions (OECD report, 1978, p.80 ff.) used the method of questionnaire addressed to government officials administering the various schemes identified by the report. The conclusions are somewhat confused, but on the whole officials either felt unable to answer certain questions or answered in a spirit of rosy self-satisfaction. The questions were directed, in the main, at the attainment of intermediate, rather than final, objectives.

Allen et al. (1978) investigated 164 innovation projects in several industries and several countries. They found that nearly half the projects were affected by Government policies, but found no indication that success or failure was influenced. Projects involving a response to regulations tended, on the whole, to have an above average rate of success.

Rubenstein et al. (1977) investigated management perception of the role of government incentives to technological innovation in England, France, West Germany and Japan. On the whole, they found that managers tended to regard government incentives with great scepticism, although Japanese and German managers less so than their British and French counterparts.

James and Willett (1977) discuss the difficulties in evaluating the costs and benefits of government laboratory research and information services. On the whole they believe these services to have positive outcomes, but find a rigorous examination of all costs and benefits too complex to be cost-effective.

CONCLUSIONS

The conviction that technological innovation is a powerful driving force which gives dynamism to an economy is still widespread. Considerable controversy centres round issues of what directions innovation should take and how government should stimulate it. There can be no doubt that the process of innovation is extremely complex and varied and therefore any simple prescription or description is likely to be widely off the mark.

Government has a large range of measures in its armoury by which to influence different aspects and stages of innovation. The efficiency of the various measures is, however, largely unknown.

The stimulation of technological innovation undoubtedly forms an important part of any government's industrial and economic policy and much more thought must be given to questions such as:

(i) what kind of innovation is desirable;

(ii) what rate of innovation is optimal;

(iii) what government measures are most effective to achieve the objectives resulting from answers to the above questions.

It is certainly impossible to obtain complete answers to the above questions, but perhaps it is worth trying to come a little closer to approximate and partial answers.

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