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LUCAS HEIGHTS

EFFECTIVE RESEARCH AND DEVELOPMENT IN THE GOVERNMENT SECTOR

by

R. SMITH

Keynote Address to the

AIM (Melbourne Branch) Residential Conference on

EFFECTIVE RESEARCH AND DEVELOPMENT

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FOREWORD

This report is a summary of the keynote address on "Effective Research and Development in the Government Sector" presented to the AIM (Melbourne Branch) Residential Conference on "Effective Research and Development" held at Warburton, Victoria on August 10th and 11th, 1972. The aims of the address were two-fold; first to give a perspective of applied R and D in the government sector in relation to the broad objectives of government research in Australia, and secondly to comment on the factors which need to be considered if applied R and D is to be effective in terms of objectives appropriate to government.

In the remainder of the session, a number of case histories were considered and the arguments presented in this address provided a basis for comparison.

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1. INTRODUCTION, ASSUMPTIONS, SCOPE

I assume we believe in general, as do Governments and the public, that a direct relationship exists between scientific and technological progress and economic well-being. We note the marked economic growth of countries like the USA and Japan, and the ever-increasing gap between the prosperity in technologically-advanced countries and that in technologically-barren, developing nations - and our belief is broadly confirmed.

We also believe that an important operative link* in this relationship is "technological innovation" - which is achieved through the chain of processes from research and development through capital investment, production, marketing and sales culminating in the use by customers of something new or improved which has commercial and economic impact. Technological innovations can be classified[(1)] into (a) those which bring about productivity gains (b) those which represent new contributions to existing products, processes and industries and (c) those which express themselves in the spectacular creation of completely new industries.

From the title of this Conference I assume our scope is limited to applied R and D leading to technological innovation. I assume also that we are interested to discuss where Australia stands in relation to the above beliefs; does the above cause-effect relationship apply here? To what extent does Australian R and D lead to local innovation; what examples are there? To what extent should public funds be directed towards R and D for technological innovation? Is there any Government policy or even a concensus of opinion? What sort of technological and economic needs exist which might be met through innovation of local R and D; how does the innovation process work, and how is the R and D process made meaningful and effective in this context? What is effective R and D? What benefits do we expect from our R and D in relation to our objectives and at what cost? Are our objectives worthwhile in relation to the cost in men, money and materials? Is there an alternative route? Should we purchase the know-how instead? When we relate these questions to R and D in the government sector we still have a fairly broad scope for this session.

In passing, and before we become too materialistic in our thinking, it is worth noting that there are some who would question whether continuing technological and economic growth through technological innovation is wholly desirable for the benefit of mankind. Here we will ignore this argument and

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*Other important factors which affect this relationship include fiscal and tariff policies, management skills, and industrial relations.

assume that the technological progress we are discussing is well considered and worthwhile. We must note, however, that in affluent societies, R and D purely in pursuit of economic goals without proper consideration of undesirable social costs, as in the last decade, is not likely to be acceptable in the present decade[(2)]. Also in these societies we must note a re-orientation of social needs - and probably R and D objectives in the government sector - away from material goods towards community services such as health, education, transportation, waste treatment etc.

2. CLASSIFICATION OF RESEARCH

There are many ways of classifying research either in terms of objectives, who pays, time scales, outcomes etc. At the risk of getting involved in a discussion of semantics, the classification I choose to use is:

I Pure Research* - research motivated by curiosity, unconstrained except by the facilities available to the research worker and supported as Science to produce new knowledge - a cultural activity, mainly confined to Universities, and closely tied to educational goals.

II Oriented Basic Research* - concerned also to produce new knowledge but oriented towards a particular technology or mission and supported to provide the technical base and expertise required, for example, as a source of informed advice, a basis for exchange of information, or a source of scientific capital to support an applied programme.

III Project Research - research with defined objectives, which can be further sub-divided into;

- A Mission Oriented Research - where the defined objectives are other than strict technological and economic goals although there may be some economic impact e.g. objectives such as a cure for cancer, the prediction of weather, fire prevention, provision of national standards, or ecological surveys.
- B Applied Research - concerned with practical applications and technological innovation as classified in Section 1. Thus applied research incorporates development as well as consideration of all other aspects of the innovative process. Conversely by this definition R and D is synonymous with applied research.

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*These two categories provide "the reproductive mechanism of science (and technology) and are essential for the maintenance and continued revitalisation of the whole" (OECD - Science Growth and Society - A New Perspective).

I assume that in this discussion we are primarily concerned with applied research as defined above, although in Australia most of the Government-sponsored research is justified and funded on the basis of II and IIIA.

3. THE ROLE OF GOVERNMENT IN RESEARCH AND DEVELOPMENT

Apart from the support of pure research for cultural reasons or as part of the educational cycle, and research related to defence, Government-sponsored research in Australia appears to be carried out for one of the following reasons:

1. To provide a body of informed opinion on matters of importance to government, industry, and the public e.g. meteorology, health, water resources, land usage, soil, mineral resources, forestry etc. (c.f. many of the Divisional Titles in CSIRO).
2. To meet a central co-ordinating regulatory role or statutory obligation e.g. specification of standards for such things as physical units, foods, pharmaceuticals, safety, discharge of pollutants etc.
3. To stimulate or control an established future product need which affects public consumers, e.g. electric power, water desalination, telecommunications, etc.
4. To provide sufficient incentive where innovative research could lead to new or improved products or processes affecting a wide sector of industry but where there is currently insufficient incentive, interest, or resources in any one private organisation or industry e.g. development of techniques for bore-hole logging, new properties in woollen products, techniques for on-stream analysis in the mineral industry.
5. To meet end-objectives related primarily to social welfare and improved amenities e.g. development of radiopharmaceuticals, reduction of air and water pollution, improved transportation etc.

All these are, of course, interdependent.

Although examples can be quoted of innovative R and D carried out in the public interest, it has generally been accepted, at least until recently, that it is not a prime function of a Commonwealth establishment to set out to develop and exploit an invention in commercial and industrial fields.

4. ORGANISATION OF GOVERNMENT FUNDED RESEARCH

Government funded research is carried out in its own Government laboratories or by contract in Universities or Industry, and it is funded through a number of bodies responsible to a number of Ministers. In the Commonwealth, some of these related to non-primary industry are:

Minister for Education and Science

Australian Research Grants Committee, National Standards Commission, CSIRO.

Minister for National Development

Bureau of Mineral Resources, Geology and Geophysics; Forestry and Timber Bureau; National Coal Research Advisory Committee; Australian Water Resources Council; Australian Atomic Energy Commission; Snowy Mountains Hydro-Electric Authority.

Minister for Trade and Industry

Australian Industrial Research and Development Grants Board.

Minister for Health

National Health and Medical Research Council, Commonwealth Serum Laboratories, Commonwealth X-ray and Radium Laboratory, Dental Materials Laboratory, Acoustics Laboratory.

Minister for Supply

Weapons Research Establishment, Defence Standards Laboratory, Aeronautical Research Laboratories, Antarctic Division.

Minister for the Interior

Commonwealth Bureau of Meteorology.

Minister for Works

Commonwealth Experimental Building Station.

Of these the largest research organisation is the CSIRO which in 1970/71 spent approximately $60 million; four-fifths of this came directly from the Commonwealth Government and the remainder from customers in particular industries. Within this organisation, as with others, project objectives are largely defined by scientists in the research units (e.g. Divisions) to satisfy broad national objectives laid down by the Research Bodies and Government. Funding is approved ultimately by the Minister and provided through parliamentary appropriations, but delegations are provided down the organisational line.

Probably there is no common plan for direction and control of research within the different research bodies, and the responsibility for planning and organisation rests largely with the head of each identifiable "homogeneous" research unit. At the AAEC Research Establishment, project proposals covering objectives, programme, time-scale and budget are prepared for all new projects by a process of argument up and down the line; these are then submitted to the appropriate delegate for approval (usually the Commission). During the course of the project, it is reviewed in terms of its objectives, to consider its future implications, and as necessary to arrange for further approvals or cessation. Each project leader is expected to account for his expenditure in relation to the approved objectives and programme at least once a year.

5. THE CUSTOMER-CONTRACTOR PRINCIPLE

The situation in Australia as outlined above can be compared with that in the UK which has been carrying out a rather agonising re-appraisal of the framework for Government research and development. In the UK, there has been a deep concern in recent years to provide a framework and policy whereby applied R and D can be used effectively to assist economic growth.

Lord Rothschild, in his recently published and controversial report on 'The Organisation and Management of Government R and D in Britain' discusses the type of arrangement which we have in Australia and dismisses it as having little or no bearing on the conduct and management of Government R and D in the 70's (in fact he denounces the "Haldane Principle" formulated in 1918 which is the basis for the Australian type of arrangement). He stresses the accountability of scientists in government-sponsored R and D, with the ultimate test of accountability (and effectiveness) being whether there is a customer prepared to pay for the R and D. His basic principle is that "applied R and D, that is R and D with a practical application as its objective, must be done on a customer-contractor basis. The customer says what he wants; the contractor does it (if he can): and the customer pays". This principle has been welcomed by the British Government; it is perhaps worth considering in the Australian context during discussion.

His other category of research is basic, fundamental or pure research and for this the end product is an increase in knowledge, and it has no analogous customer-contractor basis.

6. INNOVATIVE RESEARCH

Coming at last to the main topic of this meeting, the previous sections should have made it clear that, with some exceptions, Government research in Australia is not specifically geared to carry out applied research and development intended to lead directly to innovation in industry and commerce, although it is expected to provide scientific and technological capital which industry can use for its own innovations. Many would argue that this is far too passive an approach, that it does not lead to effective interaction with industry and that it is not effective in ensuring that research results are used, or that research is matched to practical problems. In recent years there has been a trend in some laboratories to be more active in technological innovation; this would have to become more marked before Government research could have any large scale direct impact.

Notwithstanding the above comment, (and as shown by the case histories which follow), ideas, inventions and discoveries of possible industrial significance do arise from Government research in some areas both by intent and as a spin-off. When this happens, it is accepted that there is a responsibility actively to promote innovation in Australia's interest. Cases can be quoted in which ideas and inventions have been taken through the innovative cycle to be of significant commercial and national value; others can be quoted which have been failures even with an equivalent amount of expenditure and effort.

Let us now examine what is involved in discharging the responsibility for carrying out effective R and D leading to technological innovation within the framework of a Government research laboratory. The questions to be considered are similar to those in an industrial research laboratory, but will differ in several significant ways.

Evaluation. This begins with the determination of plausible objectives and should be followed by an analysis of each postulated objective to establish the costs and benefits associated with its realisation. Alternative routes should be explored even if they do not involve R and D. Finally the probability of attaining the benefits should be considered in the light of the resources, capability, and degree of commitment of parties involved in the chain of innovation; and the objectives should then be refined. In all these steps as outlined by Jones[4], there is a considerable margin for error in estimates and judgement, but it is certainly less than that which exists when relying solely on intuition, and it does allow a strategy to be drawn up for R and D and exploitation. The details of the actual approach to evaluation depend very much on the case and are most easily considered in terms of case studies (usually in retrospect).

What are the objectives? Often projects are not effective simply because there is no clear appreciation of the objectives of applied R and D projects. Thus in an example given by Nicholson[5], applied research on a new extrusion process is not done "to find a new extrusion process" but "to find a way of converting material from one form to another at a lower cost than provided by alternative methods present or future". Similarly, there is no intrinsic benefit in developing a nuclear pace-maker for hearts, when alternative devices are available; the objectives must be related to economics. In setting objectives considerable attention has been given in recent years to techniques of "technological forecasting" which when taken together with market surveys and cost/benefit analysis are considered valuable aids[6].

<u>What benefits are we looking for?</u> As pointed out by Nicholson[5], effectiveness can only be gauged against the benefits and we must be clear from whose viewpoint we are calculating the benefits. A contract research laboratory is interested in commercial returns from sponsored work, royalty payments and licensing fees. An industrial company is interested in profits, growth, and defence of existing business. A best decision from these viewpoints may not be the best for the industry concerned or for the consumers as a whole. A Government Establishment should be interested in assessing costs and benefits from the broadest national viewpoint combined with pragmatic appreciation of the benefit to the company responsible for realising the innovation.

Ideally this requires an estimate of the benefits to

- the primary exploiting company(s).
- the industries and consumers down the chain through their taking advantage of the innovation. For example, if the innovation means a reduction of 10¢ per lb in the price of uranium concentrates, what benefit does this mean to the consumers of nuclear power? Alternatively any innovation may lead to a general gain in efficiency or production through improvements in communication or reductions in injuries or ill-health.
- the economy as a whole (if appropriate) e.g. a favourable change in the balance of overseas payments or an undesirable alteration to the employment pattern.
- individuals of the public in terms of social and amenity costs or benefits e.g. reduction in noise nuisance or pollution, or ill-health. Compare, for example, the public and industrial health costs of a fossil fuelled power industry, from mining to waste disposal, with that of nuclear power on the same terms.
- the Treasury in terms of licensing fees and royalty payments, particularly from overseas exploitation.

<u>What is the route for commercial exploitation and innovation?</u> Although in the past it was commonly argued that ideas, inventions and research should be published in fairness to the public so that everyone could have an equal opportunity for making use of them, this is now accepted as unrealistic and irresponsible, because it seldom leads to any return at all. It is now agreed that innovation with a "best" return to the public is best achieved by securing industrial property rights (patents) and exploiting these rights through direct negotiation and co-operation with industrial companies. Further, although a

fairness principle would suggest that licensing agreements should be non-exclusive, in practice, experience has shown that it is invariably essential to give exclusive licences to avoid splitting the market, reducing incentive and thereby inhibiting innovation.

The time at which industry should become involved varies with the example. Ideally the involvement and co-operation should begin at the ideas stage, but usually this is not possible; it is difficult to license a patent at the ideas stage, particularly if it relates to more novel technology. Usually it is necessary to carry out Government R and D to develop the idea further to a demonstration pilot plant, or prototype instruments or products, before becoming involved with an industrial partner[7], at which stage potential value can be more clearly identified. The scientists are then accountable in retrospect, which is a point of conflict with the Rothschild philosophy.

7. QUESTIONS FOR CONSIDERATION IN CARRYING OUT EFFECTIVE RESEARCH AND DEVELOPMENT

We will assume that we have identified the idea, innovation or discovery either by accident or by a period of research. Some of the factors that must then be considered are given below.*

- What is the technological advance in relation to prior or alternative arts? Is it significant?
- Do we need it and what are its implications - social, technical and economic?
- How significant is the Australian market? the overseas market?
- What benefits can be expected within Australia? Overseas?
- What return could be expected by an individual firm taking up the exploitation?
- What Australian firms have competence in this area?
- What extra effort is required to demonstrate technical and economic feasibility? What will be involved in manufacture? Is there a target figure for price which cannot be exceeded?
- What is the relevance of the proposed developmental work to the programme of the laboratory? Do resources exist?
- Is the invention patentable in relation to prior art? When would it be advisable to take out the provisional application? What are the claims which would need to be protected? In which countries should

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*In the lecture, these factors were illustrated by using the case history of the exploitation of isotopic X-ray sources for on-stream analysis in the mineral process industry.

you apply for a patent? How much will this cost? and who will pay?

- How should you go about seeking an industrial partner? Should you consider non-exclusive licences to promote innovation or would this be better achieved by an exclusive licence?
- How will you exploit the overseas market? Can this be done by an Australian firm?

All these questions need to be considered by the government research organisation before deciding to go ahead with the project on a developmental basis. Generally this consideration cannot be done properly by the 'inventor'/ scientist and he will require advice and assistance from a person experienced in industrial innovation and patenting. Since at present there are few such experienced people in Australia there is a case for relying on one Government unit such as the one set up by CSIRO.

8. PROCEDURES FOR EXPLOITATION

Planning the strategy in exploitation should also be the responsibility of a professional innovations officer. Some of the main actions involved are:

- Discussions with selected industrial companies to seek assistance in assessing the commercial value - if necessary under an agreement on non-disclosure of information.
- Preparation of a provisional patent application usually about six months before enough information is available for preparation of the complete specification. This will include a review of prior art to clarify what claims are to be emphasised.
- Promotion of the research and development phase of the work either 'in house' or under contract elsewhere in order to demonstrate feasibility.
- Advertising for industrial partners and choosing one or more on the basis of an assessment of their capability.
- Negotiation of licensing agreements which ensure an equitable return to Treasury while at the same time ensuring best prospects for innovation.
- Filing of patents both in Australia and overseas, with follow-up action to watch that modifications to meet examiners' objections are not detrimental.

9. CONCLUDING REMARKS

No attempt has been made in these notes to provide a formula for effective R and D in the Government sector because none exists. Rather emphasis has been placed on stressing the complex inter-relation of the factors which need to be considered, and which must be considered properly if wise decisions are to be made. But it should not be forgotten that the R and D can only be effective if there are experienced entrepreneurial research managers available to make the decisions and good scientists interested in and committed to following the work to a conclusion through all the difficulties which inevitably arise.

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