Contestable Funding:

a New Deal for Research and Development in New Zealand

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A NEW DEAL FOR RESEARCH AND DEVELOPMENT IN NEW ZEALAND

Veronica Jacobsen

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CONTENTS

Foreword

One of the first substantive measures of public sector reform undertaken by the 1984-90 Labour government was the significant staged reduction in funding for the government's own research and development organisations, principally the Ministry of Agriculture and Fisheries, the Department of Scientific and Industrial Research and the Forest Research Institute. The rationale underlying the reduction was the belief that a certain, but unknown, proportion of the output of 'government science' was research that had a commercial value to private-sector users. The government's advisers took the view that, if research did have a commercial value, then making it available to the private sector without charge was an *ad hoc* and undesirable subsidy to selected private-sector parties. Over a three-year period, therefore, funding for the government's main research organisations was reduced by a substantial, but varying, proportion and they were directed to charge for research with private-good characteristics in order to offset the funding reductions.

Little research had been carried out to determine whether it was possible to appropriate any of the outputs of government research organisations, or, if so, whether the market would place a value on them sufficient to provide an economic return to the research organisations.

In essence, the government's research organisations were being told to 'be commercial' in order to raise a significant, and increasing, proportion of the resources they would need in order to maintain activity levels. No judgments had been made as to the appropriateness of those activity levels or the mix of activities they comprised. Instead, it was believed that by taking the somewhat crude approach of simply cutting back funding, organisational and market responses would over time provide the needed answers on such matters as the appropriate mix of outputs, and the value that the private sector would place on research that it had previously obtained free of charge.

That early initiative left many questions not simply unanswered but unasked. For example, if government research organisations were to compete in the market place, to what extent should they be given full commercial powers, including powers to enter capital markets, form subsidiary companies, undertake joint venture activities, and so forth? If research was to be viewed as a marketable commodity, what was the case for continuing government ownership of the major research organisations? If research outputs used by the private sector were to be seen as tradable outputs, should not the same logic apply to research outputs purchased

by the government, either for specific government activities or as the funder of public-good research?

All of these issues have been traversed, to varying degrees, in a series of reports that were prepared for the Labour government examining the role of government as a funder and provider of research and development activity. The most influential of those, that of the Science and Technology Advisory Committee published as 'Science and Technology Review: A New Deal', prompted the government to undertake a major restructuring of its science bureaucracy as a first move towards introducing some contestability for government funding and separating out the adviser/funder/provider functions.

At the present moment, however, the key questions remain unanswered. Veronica Jacobsen's very timely monograph is a clear and simply-expressed discussion of the key issues that will need to be resolved if we are to get value for money from public expenditure on research and development and create a climate that encourages private-sector investment in research and development.

Her basic premise is that expenditure on research and development is properly seen as an investment activity. She takes this approach in a way that should bring considerable comfort to the scientific community. As successive governments have addressed the restructuring issue, a major concern of New Zealand scientists has been that governments and their advisers will be insensitive to the particular nature of the scientific endeavour. Veronica Jacobsen shows that the investment approach does not require proponents of a particular project to be able to demonstrate in advance the precise results and returns the project will produce. Instead, as she makes clear, the investment approach is a particular way of thinking about outcomes, even though they may not be quantifiable in advance, that will provide a useful basis for making decisions between various research and development projects so that scarce resources can be allocated where, on balance, they are likely to give the best returns. Furthermore, as she quite properly points out, it also provides a basis for allowing governments to think about the level of their expenditure on research and development as compared with the range of other activities that they are also required to fund.

Within this basic approach, she provides a very lucid and useful discussion of a number of other important issues. These include the various responses available to the claim that 'market failure' is inhibiting investment in research and development; how the government should go about achieving an effective process for contestability of funding; the future structure and ownership of the government's own research organisations; and the pitfalls lying in the way of those who would seek to encourage more research and development by the seemingly simple

expedient of throwing taxpayers' money at the issue.

The Minister of Research, Science and Technology in the recently-elected National government has made it clear that he intends to proceed speedily with the restructuring of the government's own research organisations. This CIS monograph could well have been written as a briefing paper for the Minister and his advisers on the matters that they should take into account if they wish both to improve the quality of the government's spending on research and development and to create a climate that will provide the long-term encouragement needed to strengthen New Zealand's research and development capabilities.

Peter McKinlay

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About the Author

After a career as a computer programmer and systems analyst, Veronica Jacobsen completed a B.A. degree at Massey University and an M.Soc.Sc. from the University of Waikato. She subsequently spent three years as partner in a firm of consulting economists. She has specialised in macroeconomics and public policy analysis with an emphasis on science and natural resources and is the author of the 1991 CIS monograph *Mine by Rights or the Right to Mine? Mining Policy in New Zealand.* She is currently a lecturer in Economics at the University of Waikato, where she is undertaking D.Phil. and LL.B. degrees.

Chapter 1

The Changing Pattern of Research Funding

This monograph examines some fundamental issues related to research and development (R&D) in New Zealand. R&D is an important component of economic growth and, like many other forms of productive activity, contributes to national welfare. It exhibits all the characteristics of an investment, with current and future expenditures made in the expectation of an uncertain, distant payoff. Because resources are scarce and R&D represents only one option, investments in R&D must be made after comparing the expected returns with those from other potential investments.

Recent Changes in Government Support for R&D

In New Zealand research and development has historically enjoyed a high level of government support and involvement. However, the period 1984-85 saw the beginnings of a major restructuring of public research in New Zealand which coincided with the structural adjustment and liberalisation of the economy, together with the reorganisation of the public sector.

In 1984, the incoming Labour government introduced a series of cuts to public funding of R&D that resulted in a restructuring of research agencies, an orientation of research towards the needs of the market and a drive to increase private funding. At the same time, little overall direction was provided to science policy; nor was there a clear view of the role of government in research or the scope of public funding. A lengthy period of uncertainty and adjustment followed the funding reductions, and the belief that science was in a growing crisis was widespread in the scientific community.

From 1963 until 1986 the National Research Advisory Council (NRAC) advised the Minister of Science and Technology on science matters and resource allocation. However, NRAC was disestablished following the change in emphasis of science policy towards permitting market planning of R&D. In May 1985 a 'Science and Technology for Development Conference' was held with the aim of increasing the private sector's awareness of the importance of R&D.

Since 1986, several major reviews of the public funding and organisation of R&D in New Zealand have taken place. These include:

- the report by Sir David Beattie (1986) 'Key to Prosperity: Science and Technology', which reviewed the role of government in science and technology;
- the report by A. Bollard and D. Harper (1987) 'Research and Development in New Zealand: A Public Policy Framework' for the New Zealand Institute of Economic Research;
- the report by the Science and Technology Advisory Committee (1988a), 'Science and Technology Review: A New Deal', which was set up following the Beattie report;
- 'Report of the Working Group on Post Compulsory Education and Training', by G. Hawke (1988), which examined the funding of research in post-compulsory education and training; and
- 'Research for Health', by D. Stewart et al. (1989), on the organisation and public funding of biomedical and health research.

The Science and Technology Advisory Committee (STAC) was established to advise the government on the recommendations contained in the Beattie report, and to formulate specific proposals for the funding of research in New Zealand. It did not endorse the principal recommendations of the Beattie report for a doubling of research spending within seven years and the introduction of an 150 per cent writeoff for research expenditure. Rather, the STAC proposals explicitly recognised that some of the benefits of research can be captured by the private sector: public funding of research might therefore be limited to those areas in which the private sector was unable to capture sufficient of the benefits to warrant investment in R&D.

Following the STAC recommendations, a Ministry for Research, Science and Technology has been established, in conjunction with a Foundation for Research, Science and Technology. The foundation is charged with funding research on a contestable basis in accordance with national priorities to be set by the government. The Ministry is responsible for allocating the balance of funding to departments undertaking scientific activities.

The move from non-discriminatory public funding of research carried out by public agencies to the explicit public purchase of R&D from competitive suppliers represents a fundamental departure from traditional practice in New Zealand. The role of government has moved on from simply funding research from general revenues in response to the supposed failure of the market to invest sufficiently in R&D. In this new climate, it is expected that the government will:

- examine the causes underlying that underinvestment;
- formulate appropriate, cost-effective policies to enable that investment to occur;
- identify those areas where private initiatives are unlikely to result in private investment and which might therefore appropriately be publicly funded; and
- allocate limited public funds for research as efficiently as possible.

The challenge now facing public sector research managers at all levels is to use public funds efficiently so as to generate the greatest 'public' research benefits. Furthermore, the constraints on the performance of public research agencies in the new milieu suggest that additional restructuring will be needed to allow them to operate efficiently.

The Changing Rationale of Government Support

Governments traditionally have become involved in the funding and conduct of R&D on the assumption that private agents would invest less in R&D than would be in the best interests of society as a whole. In contrast, the reductions in public funding for R&D were, at least in part, predicated on an implicit assumption that more R&D could be privately funded. In fact, private sector underinvestment in R&D was partly due to its being crowding out by public expenditure, rather than to an inherent lack of incentives for private investment.

Furthermore, it was anticipated that reductions in public funding would improve the efficiency of research agencies. This expectation has to some extent been validated in the subsequent restructuring of public research agencies. These have become increasingly active in the private market for R&D, although they have enjoyed both the advantages and disadvantages of the public sector in so doing. It is expected that they will actively participate in the contestable market for public funding, together with private sector suppliers of research. Measures to increase their competitiveness with private suppliers, however, raise the question of the rationale for public sector supply in contestable markets for R&D, and suggest that further restructuring of public research agencies may take place.

The changes in public funding have focused attention on the degree to which the benefits of research can be appropriated. Private sector firms and industries will invest in R&D if they can capture enough of the benefits. However, investment may be constrained where the returns to the investors are reduced by 'spillovers' or leakages of the benefits to others. Appropriate government intervention in this case could involve

measures to increase the private capture of the benefits. However, if the benefits are so widely spread that no particular beneficiaries can be identified, or alternative policy interventions are too costly, then public funding of some 'inappropriable' research may be justified.

The issues of who should pay and how much should be invested have not been clearly distinguished in the period of policy change. Ideally, the overall level of investment in R&D should be determined by its rate of return relative to other options. An evaluation of the costs and benefits of R&D can assist in determining that overall level, and in allocating R&D budgets among competing R&D projects and programs. A contestable system of funding would also permit the allocation of research funds to the most cost-effective research organisation, public or private, domestic or foreign. The introduction of a contestable funding environment for public funds is likely to enhance the incentives for research organisations to develop their research management systems.

Traditionally, publicly funded and conducted research in New Zealand has not paid much attention to such matters as identifying high payoff areas, allocating budgets between competing projects, and evaluating the returns to R&D. What is needed first of all, therefore, is a better understanding of the economics of R&D, a topic examined further in Chapter 2.

Chapter 2

The Economics of Research and Development

Research and development is important because it contributes to human welfare and economic growth. Economic growth occurs in two ways. First, the stock of productive resources in an economy can grow through investment in both physical and human capital. Second, the existing stock of resources may be used more efficiently; in other words the productivity of those resources may increase.

Improvements in productivity can be reflected in either increased output per unit of input or lower costs per unit of output. These improvements may arise as a result of better education, improved health, innovations in management practices, new forms of organisation, better labour relations, better access to information and through the application of improved techniques and processes. In part these may be the product of investment in R&D.

However, to claim that R&D is a key to our future prosperity is to overstate its importance relative to other forms of investment. Research and development is only one of many instruments for achieving growth and improvements in human welfare. There simply is no linear relationship between R&D and improved economic performance. On the other hand, improved productivity is undoubtedly a source of growth, and investment in knowledge that leads to productivity gains may show a favourable rate of return both to private firms and to society at large.

The potential importance of R&D for economic growth implies that it should be undertaken as efficiently and equitably as possible. It should lead to the maximum gains from productivity growth and thereby increase the welfare of society, while distributing fairly the costs and the benefits of the investment.

The Investment View of R&D

R&D is an 'economic' problem because it involves choices about the use of limited resources such as skilled scientists, specialised equipment and capital. It has all the characteristics of any investment decision. Present and future expenditures must be made in order to generate uncertain future benefits through the payoff from increased knowledge or innova-

tions. In this sense it is no different from any other risky and long-term investment. However, it represents only one alternative for investors, and R&D investments should be made by comparing the expected net benefits with those from other investment options. This principle applies equally to private investors and to the public agencies charged with allocating R&D funding.

R&D expenditures encompass not only the direct costs of research activity itself. They also include all the ancillary activities necessary to realise fully the gains from the new knowledge generated by the investment in research. Activities such as market research, product development, extension or public education campaigns should all be seen as an integral part of the investment required to achieve adoption of the research results.

This investment view of research is by no means limited to applied research with direct effects on productivity. Basic research can also be seen as an investment that provides inputs into further research, although the nature and timing of the costs and eventual benefits are likely to be uncertain. Nor should the gains from research be conceived as narrowly 'economic'. Research and development can improve health, foster ecological awareness and increase cultural understanding. In the end, the application of these varied results of R&D to very different areas contributes to improved human welfare. The gains of all research can thus be thought of as 'economic benefits' in the widest sense.

The fundamental principle that R&D is an investment that yields future benefits enables the factors that determine both the costs and the benefits to be made explicit. Research priorities may be associated with the scientific merit or the relevance of a project or program; or research may be conducted in disciplines where there is a perceived shortage of expertise, or there are new or expanding technologies, or into areas of concern. Underlying these professional judgments is a belief, however implicit, in the ultimate benefits to be gained from the research. An investment perspective ensures that the assumptions behind those judgments are examined and made transparent, so that both the costs and the potential benefits of the research can be assessed.

A quantitative assessment of research draws on the experience and subjective judgment of a range of professionals, including scientists, extension officers and economists, to assess the potential worth of a project. It seeks answers to two fundamental questions: will the research be successful? And if so, what are the expected net benefits? It does not rely on the ability of scientists to measure precisely the costs and benefits. Useful information on which to base decisions can be obtained from estimates. Further effort in refining data may be justified on marginal or very large projects, where the benefits of improved

decisions are likely to outweigh the costs of obtaining better information.

In addition to providing decision makers with information on projects, the investment view of research provides a useful framework for those involved in R&D to consider the worth of their work. The application of quantitative assessment to research activities can subtly alter the 'culture' from that of 'doing science' to 'doing cost-effective science'.

It should be stressed that a quantitative evaluation of the costs and benefits of research supplements, rather than supplants, the informed opinions of scientists and research managers. It provides a systematic way of assembling information, much of it subjective, about researchable questions in particular areas, and the contribution that new knowledge could make if that research were to be successful. The economist's contribution is to provide a conceptual framework for viewing research as a capital investment, and to apply rigorous and systematic analytical techniques for generating measures of the performance of that investment.

The Internal Rate of Return

One such measure is the internal rate of return (IRR). This provides a convenient index of the attractiveness of an investment. It measures the yield or rate of return expected to accrue to the capital invested in the project. The higher the IRR, the greater is the expected payoff relative to alternatives. The IRR enables comparisons to be made between alternative investment options, and can be used to compare R&D investments with other uses of the funds. This concept of the 'efficiency' of R&D investment permits choices to be made about the use of scarce resources in a way that maximises the net benefit to society.

Equity

Another useful concept fundamentally associated with R&D is that of 'equity'. This refers to 'fairness' in the distribution of the costs and benefits of R&D. Expenditure is distributed equitably when those who benefit from R&D bear their proportionate share of the costs. An inequitable distribution implies that some sectors of society enjoy the benefits of R&D at the expense of others. The argument that we all benefit is not sufficient grounds for dismissing the concern for an equitable sharing of the costs and returns, nor does it alone constitute a case for the public funding of R&D.

Assessing Research

An investment view of research incorporates all stages of the process, from basic research to adoption of the results. The investment at any stage adds to knowledge, which permits improved decision making. Better decisions can increase productivity or the quality of output. The benefits of all research activity derive ultimately from implemented results. For more basic research, the achievement of such results may be further in the future, and surrounded by more uncertainty than for more applied research. The process of taking results from the laboratory to the users is an important part of R&D, and the means by which the value of research is achieved.

The design of research projects should include consideration of all the activities, such as further research, product development, education or extension, required to achieve implemented results. In assessing the value of research, the expected benefits should be taken into account, together with the costs of the research and the related activities needed to realise those gains.

An *ex ante* assessment focuses both on the critical determinants of the magnitude of the net benefits (such as the length of the research, development and adoption periods, and the rate and level of adoption) and the incidence of the eventual benefits. The degree to which the benefits can be captured by the private sector provides the basis for, and equitable sharing of, all the costs of obtaining the benefits, including development and extension expenditures, between the public and the private beneficiaries.

Chapter 3

The Rationale and Impact of Government Involvement

Government involvement in R&D may be explained by the economic characteristics of research. An investment in R&D is expected to be profitable if the future benefits exceed the costs, both measured in today's dollars. If firms value their projects in the same way as society as a whole, then the private level of R&D spending will be optimal: increased investment could not make society better off, but would drive down the return to investment below that which could be generated in other fields, so reducing national income. But firms may not value their projects in the same way as society: the anticipated benefits to the firm may be less than the costs, but the benefits to society as a whole may be greater. In this case private firms will not invest and, from society's point of view, there will be underinvestment in R&D.

Market Failure

Underinvestment in R&D is often identified as a case of 'market failure': i.e. the operation of the market does not provide adequate incentives to produce the socially optimal level of R&D. Government intervention to fund and provide R&D has generally been the traditional response to improve the allocation of resources to research. The market failure rationale emerged as the fundamental justification for government intervention in the Beattie report.

Market failure is alleged to arise

- where the cost of R&D is high in relation to the size of the industry;
- where a firm cannot capture sufficient of the benefits of R&D;
- where R&D involves long lead times; and
- where R&D is seen as a risky investment.

None of these circumstances, however, unequivocally justifies public sector intervention. There is no underlying reason why the government, rather than the private sector, should undertake research where a firm is too small to undertake research on its own. Nor is government

provision necessarily the optimal intervention where firms cannot capture enough of the benefits of research to make investment individually worthwhile. The problem may arise from imperfect property rights (where an alternative policy option is improving the institutions of property rights) or spillovers between firms (where the alternative solution could be the formation of industry groups).

Neither the long lead times nor the perceived risk associated with R&D provide grounds for government, as distinct from private, investment. Firms often make long-term investment decisions involving risk. However, if the private sector is unwilling to invest in R&D with these characteristics because the expected rate of return is too low, there is no good reason why the government should be prepared to do so. Such investment merely shifts the burden to taxpayers, without any guarantee either that the expected lag times and the perceived risk will be reduced or that the expected rate of return will be increased.

The principal drawback of the market failure rationale of government intervention is that it does not address the fundamental causes of underinvestment. It does not lead to the formulation of specific, targeted, appropriate solutions that would permit the market to function in some cases, while allowing intervention in others. The risk is that 'government failure' or 'bureaucratic failure' is substituted for the alleged 'market failure'. There is nothing to ensure that the solution advocated by this approach is any less costly than the imperfect functioning of private markets.

Transaction Costs

A more recent approach to R&D revolves around the concept of transaction costs. It has become apparent that market failure arises because of the presence of these transaction costs, which occur with every exchange of goods and services. These costs constrain economic behaviour, and can even prevent exchanges that would occur in their absence. Where there are severe costs impeding private investment in R&D, the government may have some role in facilitating such investment where the benefits of intervention demonstrably exceed the costs. Where the private sector faces high transaction costs that cannot be economically reduced by government action, the government may then have a role in directly funding R&D, subject to ensuring an adequate rate of return.

Recent economic analyses based on the transaction costs approach have focused on the degree of appropriability of R&D as a criterion for government intervention. They emphasise the importance of the appropriability of R&D in explaining patterns of investment. The extent to which the returns to research can be captured by

private investors through mechanisms such as patents or copyrights, collective action or monopoly power determines those areas of research that can be funded efficiently by the private sector.

Research and development funded by taxpayers as a response to 'market failure' has involved both 'basic' and 'applied' research. However, some firms undertake basic research where they can capture the benefits through new products or technologies. Fundamental research applied to the development of new techniques or products may be provided by the market where firms can capture enough of the benefits to make the investment worthwhile. The distinction therefore is not between 'basic' and 'applied' research, but between research that produces benefits that can be captured within the private sector, and research that provides no incentive for private investment.

Supporting the Agricultural Sector

In New Zealand the government, until relatively recently, has been involved heavily in both funding and conducting R&D. The focus traditionally was on research into unprocessed agricultural primary products, largely for export to Britain. One justification for this intervention may be that most farms were (and are) small, and could not reasonably be expected to undertake their own research. No one farmer would be willing to fund research from which other farmers would also benefit.

A further possibility is that government funding of R&D comprised a form of tariff compensation to the agricultural sector. It may have constituted a form of 'industry assistance', compensating it for the effects of protective tariffs on manufactured imports. Funding R&D is a very blunt instrument, however, for making such a transfer to the agricultural sector. Furthermore, it is potentially inequitable, since it is difficult to know who is hurt by the tariffs, or by how much, resulting inevitably in too much or too little compensation. Nor was the effect of spending on R&D related to the size, nature or distribution of the resulting benefits. The nature of R&D was not adjusted to provide explicit compensation for the negative effects of tariffs. For example, if tariffs made, say, tractors more expensive, the compensatory R&D was not designed to provide low-cost tractors.

Why the Role of Government in R&D Changed

The last five years have seen a policy of reduced public expenditure on R&D. The reductions were made in stages, with graduated cost-recovery beginning in 1985. By 1988/89, the principal recipient of public funds for

agricultural research, MAFTech, was expected to obtain over 14 per cent of its funds from external sources. It is likely that these reductions were instituted for reasons of both efficiency and equity.

The search for efficiency has two aspects: past overinvestment in R&D, and improved public sector research management. One possibility is that there was overinvestment in R&D: that other areas of spending would bring a higher return to taxpayers' dollars. A problem with this argument is that there just is not enough information on which to make such a judgment or policy decision. Such evidence as exists suggests that returns to investment in agricultural research have historically been highly satisfactory. It would be difficult to show that past overinvestment in agricultural research had driven down the rate of return below that which could have been generated by alternative uses of the public funds. In the absence of evidence that the returns to public investment in other areas of research were unacceptably low, reductions in public funding could not have been justified on the grounds of past overinvestment.

Attempts to determine the appropriate level of public funding without systematically considering the payoffs will inevitably result in an inefficient pattern of social investment. The experience of the last few years serves to highlight this problem. Merely cutting public spending was a blunt instrument for achieving improved efficiency.

However, it appears that reductions in funding were intended to improve research management by forcing research agencies to weigh more carefully the nature and extent of the benefits of their activity. Constraints on spending would sharpen the focus of research and increase productivity. Payments from users would improve the accountability of research and the transparency of research activity.

The cuts proposed by the government were apparently also, at least in part, aimed at a more equitable sharing of the costs between the private and public sectors. A reduction in funding from the public purse would reduce the burden on taxpayers and induce greater research investment from direct beneficiaries who could be identified individually (such as particular firms) or as groups (such as industries).

In addition, the size of the public sector and its deficit were increasingly seen as necessitating the search for greater public sector efficiency. A further advantage of cutting the level of government funding while encouraging the private sector to invest further in R&D was that the savings could be used to reduce the deficit without reducing the overall research effort.

Chapter 4

The Impact of Reduced Government Funding

The cuts precipitated substantial restructuring and reorganisation of research agencies, in the context of a dearth of reliable data. One of the major difficulties in assessing the impact of reduced public funding is the lack of any systematic, long-term statistical evidence on the extent, source, use and payoff of both public and private sector R&D. Without such data, the effects of policy change are not transparent.

The Effects of the Lack of Data

The compilation and publication of statistics related to R&D has undoubtedly been affected by the changes in the organisation of science. Whether the current absence of data on R&D is deliberate or an unintended consequence of the adjustment process remains an open question. The appalling fact remains that there is simply no way of determining exactly how much, or on what, public research funds are currently spent. Until this is rectified, there can be no meaningful assessment of the returns to investment in publicly-funded R&D.

Furthermore, without adequate data on spending, it is impossible to determine the rate of return to total investment in R&D let alone at the project, industry or sectoral level, even if the benefits have been identified. Without analysis of this kind, it is impossible to assess the impact of the cuts in public spending on the efficiency of research investment.

It is also impossible in these circumstances to tell whether private investment in R&D compensated for the cuts in government funding. It appears from the reaction of the previously protected public science agencies that private funding of R&D carried out by these agencies did not offset the reductions. The STAC review of Science and Technology suggested that private spending on R&D had fallen from an already low level.

Public research agencies were forced to reduce their overall expenditures through staff attrition, sales of assets, shutting down projects, forgoing new equipment and maintenance, and limiting leave for study, travel and conferences. The cuts exerted pressure on research agencies to increase their revenues to meet the new funding targets. They tended to concentrate on R&D that had visible benefits to identifiable 'users' who

would provide revenue, and research which would generate funds, at the same time reducing their commitment to long-term and risky basic research. As a consequence 'public good' R&D was reduced in favour of revenue-generating 'user-pays' research.

There had historically been little incentive for publicly-funded research agencies themselves to analyse the nature, extent or distribution of the benefits of their research. As a result, there were few objective criteria that could be used to implement cuts in spending. Confusion arose concerning what should, and what should not, be publicly-funded research. Some areas of 'public good' research may have been reduced, and some research that could justifiably be privately-funded retained. The instability reflected in changes in the organisational structure of research agencies has done little to encourage cooperative research with the private sector; a factor exacerbated by the contractual incapacity of the agencies. Furthermore, there was no national research policy to identify the goals of publicly-funded research, or the areas of highest payoff that might warrant investment.

Some Benefits and Costs of the Cuts

The cuts were not with some benefits. Along with the introduction of user fees, they have led to some improvement in research management by public agencies. Research managers have become more conscious of costs, and their accountability for the use of resources has improved. The extent and spread of the benefits of research are being examined, and some contestability in the allocation of research funds has been introduced.

The reductions in public funding were introduced without prior establishment of mechanisms to enable private funding to increase commensurately with the progressively lower levels of public funding. The cuts were carried out without first encouraging, facilitating or instituting alternative means of allowing private firms or industry groups to make up the shortfall. Nor were the private sector beneficiaries of publicly-funded research identified.

Following the cuts in public R&D expenditure, public research agencies have found themselves in an environment that combines the shackles of the public service and the challenges of the free market. The research agencies themselves were neither accustomed to, nor adequately equipped for, entering into contracts with the private sector for the provision of research. The previous administration of research had not provided scientists with strong incentives to cater to market demand.

In addition, research agencies have seen a brain drain of the brightest and best scientists, although it has to be recognised that at least

some have joined private firms or established consulting practices. Remaining scientists have often been redeployed as managers and marketers of R&D. This inefficient use of human capital, coupled with commercial, labour and bureaucratic constraints on research management, almost certainly has led to a reduction in the productivity of the public research system.

Undoubtedly, there have been real costs associated with the policy reforms to date. It is not clear that the adjustment costs were adequately recognised by those who promoted the goal of greater efficiency through cuts in public funding.

Constraints on Commercial Activity

Despite some improvement in the structure of research agencies, they lack the capacity to act in a fully commercial manner. They cannot take risks that compromise the Crown, nor can they raise equity or debt capital, or enter into joint ventures. They are also handicapped by their bureaucratic and hierarchical nature, which does not provide them with the flexibility to respond quickly or easily to change. Public sector employment practices have also dampened their responsiveness. The incentives facing employees do not encourage market competitiveness, since staff do not enjoy the benefits of their profitable activities. Nor can they be dismissed easily for poor commercial or research performance. The sale of research has been largely driven by its supply rather than by market demand.

These factors limiting the commercial activity of public research agencies have constrained their ability to emulate the performance of the private sector. However, they have also enjoyed some features of public institutions that gave them an advantage over private sector competitors. It is not clear that the capital involved in the generation of research has been fully costed. Furthermore, the net income received has not been subject to taxation. Public agencies have been able to cross-subsidise projects through their government funding, to crowd out competitors and to stifle emergent suppliers. They are able to use their research expertise, built up from past public funding, to compete with the private sector. In other words, public research agencies have been able to compete unfairly with private sector providers of R&D, reducing the overall efficiency of the nation's research effort.

Are Publicly-Funded Agencies Necessary?

One response to this would be to remove constraints on the commercial activity of public agencies and to establish mechanisms to place them on

an equal footing with the private sector. However, this diverts attention from the fundamental issue of public sector involvement in R&D. The very need to create an operating environment that parallels the private sector suggests that private firms either exist or could enter the market. If private firms could meet the needs of the market, then there would be little justification for public sector provision of R&D.

In fact, public agencies have attempted to set up consultancy services of many kinds, frequently in competition with private sector suppliers. Veterinary services, laboratory testing, water quality testing, agricultural research and agricultural policy advice are all provided by the public sector in the market. Where the private sector is an efficient producer of goods and services, it would be necessary to identify the special characteristics or circumstances justifying the retention of public sector R&D.

Certain types of R&D require a long-term relationship between the buyer and seller, and may involve specialised investment. By establishing prior contracts, they provide the seller with a certain market for the R&D, while allowing the buyer to avoid paying patent royalties to the seller. The milking machine developed by MAFTech and a commercial partner is an example of this kind of relationship. However, the enforcement mechanisms in these contracts, such as buyer investment in specific assets, can be costly, and it may be more efficient for the firm to vertically integrate its R&D effort. As a result, firms or industries may wish to take over research bodies, or those parts of them with assets that are specific to the buyer.

The internal or 'in-house' organisation of R&D also enables the appropriation of returns inadequately captured under contract. It allows a long-term relationship between the users and providers to be maintained, and aligns their common interests. The asset specificity of certain kinds of agricultural research, and the existence of identifiable clients, either as individual firms or as industry groups, makes vertical integration of parts of public sector agencies a possibility.

However, it is not clear that current institutional arrangements of public research agencies extend to permitting takeovers by private sector buyers, or indeed allowing buy-outs of facilities by groups of scientists.

At present, the Crown owns research agencies which provide public goods research and which undertake R&D on a wholly commercial basis for paying clients. Neither role would seem to automatically justify perpetuating them as public agencies.

If they are truly commercial, then clearly they will continue to flourish as business entities in their own right. If they are unable to survive as independent businesses, then they enjoy implicit subsidies from taxpayers to sustain them as apparently commercial operations. Any public

funding of commercial research has to be seen as a capital injection into the public science agencies, which must generate a return to the Crown as the shareholder. Managers would need the freedom and flexibility to ensure the successful financial performance of the agency, together with an accounting system that made clear the true return to public funding. Whether this can be achieved under their present structure, through the creation of a state-owned enterprise, through privatisation or the formation of research institutes is an unresolved issue. There are few examples of wholly independent R&D agencies in the private sector. Those that exist are highly diversified, or operate largely on government contracts in defence. Successful examples of specialised R&D laboratories are found allied closely to the industry or firm they serve.

The evolution of efficient forms for the existing agencies will require the removal of residual impediments to the formation of joint ventures, takeovers or splitting off separate commercial consultancies. Rather than trying to foresee what the structure should look like, we need to ensure that there is a flexible policy framework that allows different arrangements to emerge in response to the needs of the suppliers and users of R&D.

Chapter 5

Paying for Research and Development: the Public-Private Mix

The private sector will invest in R&D where it can appropriate sufficient of the benefits to make the investment worthwhile. In areas where these incentives are absent and public policy is unable to create them (e.g. through improving the specification of property rights) public funding may be justified.

There are three broad groups that appropriate the benefits of research: consumers, private firms and industries.

Consumers

Consumers benefit from 'basic' and 'public good' research in a wide range of R&D areas where benefits cannot be captured by private sector firms or industries. Examples include improvements in environmental quality, public health and food safety.

Government funding may also be appropriate where research constitutes one of the inputs into the provision of taxation-funded public services, for example, health or the management of the Crown's mineral estate. This research may be viewed as open to appropriation by the service agency, acting on behalf of society at large, and funded in the same way as other agency activities, such as administration. However, this rationale for public funding depends crucially on the role of the state in the provision of services of which research is only one component. Were the public provision of these services to be altered, for example through privatisation, then the basis for public funding of research would be changed, commensurate with the new institutional arrangement.

Consumers may benefit from research carried out by service agencies but which is not used directly to improve the delivery of services. Like other research that benefits consumers but which cannot be appropriated, this public good research may justifiably be publicly funded on the same basis as other research of this nature.

Consumers may also benefit from research undertaken by industry groups. An industry group may invest in R&D that is generally useful to society. Public funding of some industry R&D recognises this aspect of research benefits, since without it the industry would be likely to invest only in those areas of research where most of the benefits could be

captured directly by members. Where research is funded by industries, but also benefits consumers, then some level of public funding, related to the size of the social benefits, may be appropriate.

The benefits to consumers are less visible, more diffuse and harder to measure than benefits to firms. It is also difficult to identify the research from which consumers are assumed to benefit. One of the difficulties that has arisen during the transition period of cuts in government funding has been the lack of any guidelines defining those areas of research that benefit society at large. Once defined, these research areas may justifiably attract public funding.

Firms

Where individual firms can appropriate its benefits, incentives exist for private investment in R&D. The demand for R&D in the private sector is generally market-driven. Firms perceive the need for new products, processes or technology to increase their profitability, and the market provides sufficient incentives for investment where firms can capture sufficient of the benefits to make the investment worthwhile, and where the marginal returns are greater than those of alternative investments.

A substantial amount of R&D can be appropriated by firms and commercialised. Some research can be protected (to varying degrees) through mechanisms defining the intellectual property rights of the firm. Patents may ensure the appropriability of R&D, which can be embodied in a final product, such as machinery or pharmaceuticals, and which might otherwise be copied easily or quickly. Copyrights prevent the unlicensed copying of work. Seed and breed certification identifies the origin and genetic heritage of plants and animals, and enables firms to market certified products. Plant variety rights prevent others from commercialising varieties developed by breeders.

Other mechanisms can also emerge for capturing the returns where the costs of defining property rights are prohibitive, or ineffective in protecting the appropriability of R&D. Different mechanisms are effective for different industries, processes and products. Secrecy protects processes, chemical formulae, recipes and biogenetic inventions where the secret is not easily detected in the product and cannot be protected by patents. The intricacy or complexity of a product may prevent reverse engineering and imitation, and thereby protect the appropriability of R&D. The speed with which a project is carried out can give a firm a headstart over rivals and enable the gains of the R&D to be appropriated. Being a sole seller also enables a firm to capture the gains of R&D, as does the strong marketing and servicing of new products. The uniqueness of the firm or the complexity of the research may also enable firms to capture

the benefits of R&D. Even where R&D is process-related, and therefore apparently easily copied, it may not be readily applicable to individual firms, and so may not be easily captured by rivals. In agriculture, for example, advisory and extension services are generally necessary to 'customise' research results for particular farms or specific users.

There are several ways in which the benefits of basic research can be captured by the private sector. A firm may initiate a project that requires basic research before more applied work can be undertaken. A firm may also undertake basic in-house research where it can appropriate the benefits in several ways. Basic research can assist in training and develop the skills of research staff, and as such can aid recruitment. The opportunity to carry out basic research may form part of the reward to scientists who at other times are engaged in more applied projects. Basic research can maintain the capability of the firm to monitor and adapt overseas research developments from which it may benefit in the future.

Firms are therefore likely to invest in R&D, whether applied or basic, where sufficient gains can be captured. However, even where other groups, such as consumers or other firms or industries, also enjoy some of the benefits of the R&D funded by firms, the firm can tolerate a certain amount of 'free-riding' if it considers that the return to its investment is sufficient.

Investment in R&D may be constrained where the benefits are insufficiently appropriable. However, this private underinvestment does not, of itself, provide grounds for public funding. Rather, the underlying cause of the underinvestment should be sought and appropriate measures taken. Where an inadequate patent system deters investment, improved definition or enforcement of property rights is the appropriate solution. On the other hand, if single firms are deterred from investment where the gains spill over to other firms, then some form of collective private funding may permit investment and appropriation of the benefits by the group as whole.

Industry

When the benefits of research are spread among firms, but can be captured within the industry, the firms may collectively invest in R&D. If the industry as a whole can capture enough of the benefits to make the investment worthwhile, then a contribution of each firm to funding R&D would permit collective investment.

Industry associations in New Zealand do fund some R&D. Research associations funded jointly by the private-sector producer boards through levies of producers, processing firms and government grants, have undertaken internally-organised R&D. In addition, industry asso-

ciations may fund research undertaken by other agencies under contract. The research and development funded by these organisations is typically only one of many activities, such as marketing, which they undertake on behalf of the whole industry.

Industry funding of R&D has several advantages over public funding. The larger the size of the industry group, the larger will be the overall budget available for R&D spending, the greater the scope for R&D investment, and the greater the overall benefits. The control of the extent and nature of research that would necessarily accompany such funding would enable the industry to invest in R&D relevant to the needs of the industry and its market. Industry funding is likely to increase the private benefits of research, since members direct the investment to those areas in which they capture a large share of the benefits. Accountability would be improved, since industries could either undertake their own research or choose between competitive research agencies to undertake R&D under contract. Accountability is also likely to increase research productivity, since the industry will require measurable benefits from its investment.

The transaction costs of forming associations to fund R&D may, in some cases, be so great that some form of government action is required. However, the voluntary existence of many industry associations suggests that they form when the benefits of doing so exceed the transaction costs.

Has the Private Sector Underinvested in R&D?

Whether or not the private sector has underinvested in R&D is not clear. Nor is it clear whether changes in private spending compensated for the reductions in public spending. It is probable that some private sector investment was crowded out in the past by generous public funding. As a consequence, there was little incentive for some industries to regard R&D as an investment, or to become involved in directing and managing the research programs.

Government policies themselves have been undergoing substantial change throughout the adjustment period. Political uncertainty and an unstable policy environment discourage all forms of private investment, including investment in R&D. In R&D in particular, the lobbying of the scientific community, exhorting the government to implement the recommendations of the Beattie Report, may have added to that uncertainty and limited private investment.

The period of restructuring R&D has coincided with a period of high interest rates, and encompassed the share market crash of 1987. Private industries may not, in this period, have had the resources to invest in R&D.

The emerging venture capital market is still not fully developed, so at times it may have been difficult to obtain capital for risky projects.

Labour market inflexibility may also have contributed to underinvestment. New Zealand has been characterised by a lack of interchange of scientific personnel between institutions and with the private sector.

One common explanation for underinvestment in R&D by the private sector is that there was little incentive for industries enjoying protective tariffs to innovate, since they lacked the spur of competition. However, a firm protected from competition, whether through a monopoly or trade protection, can in fact capture larger returns from its investment in R&D than a firm in a competitive industry. Furthermore, the adjustment period has coincided with a period of tariff reduction. If the tariffs had inhibited investment in R&D in the past, then one might have expected increased R&D spending as tariffs were removed.

Finally, underinvestment can occur where a firm is unable to appropriate sufficient of the benefits. Government policy can contribute to ensuring an appropriate level of private investment in R&D by having an evolving legislative structure that recognises new forms of patenting and protection for intellectual property rights and facilitates collective action by industry groups.

Should Government Subsidise Private Sector R&D?

The perceived 'need' to increase overall R&D investment in general, and private investment in particular, has led to suggestions that the government should subsidise private sector expenditure. The Beattie Report recommended that the government introduce 150 per cent tax deductibility for R&D expenditure by industry. The main justification for this was a 'need' for tax neutrality with Australia, which at that time had introduced this level of deductibility.

The tax writeoff in Australia is applicable for a limited period and was, at least in part, intended to encourage private industry to view R&D as an investment. However, it has had some perverse consequences. Projects have been undertaken that would not have gone ahead in its absence. The time limit on the credit may also have encouraged short-term R&D at the expense of longer-term projects. The research programs of private firms have been distorted in response to the firm's need for tax concessions, rather than for any underlying research needs.

The program is also costly. Any increase in R&D must be very large before there is a net gain to society from the concessions: otherwise it represents a transfer from taxpayers to firms. Quite apart from the direct costs, a tax concession for R&D implies that some other sector of the economy is being 'taxed' to provide the subsidy. It is a fundamental

economic truth that one sector cannot be protected without 'disprotecting' another.

R&D activity may be unresponsive to changes in tax treatment, particularly when industry considers that they may be only temporary. Research involves a long-term commitment on the part of the firm, and it may be many years before it begins to pay off. Suitably qualified research staff must be hired, equipment bought, and research activities planned. A short-term policy may provide insufficient incentive to induce a long-term investment of this nature. In addition, R&D is only part of the process that leads to technological change and ultimately growth. The results of R&D must be developed into a marketable product, using plant, capital, raw materials, labour, and management and marketing skills.

Process-oriented R&D must be made known to users, such as farmers, through extension and education. These inputs are essential to translating R&D into economic growth, but themselves are not eligible for the credit. The cost of the R&D alone may comprise a relatively low proportion of the total cost of innovation, and the tax credit may represent a small subsidy on the full investment costs.

Although R&D activity may be unresponsive to tax incentives, R&D spending may increase as firms are encouraged to classify costs as 'research' for tax purposes. This tax-avoidance effect hinders the evaluation of tax credits. Even where an increase in R&D activity does occur, it is difficult to determine whether it is due to any tax credit or to some other factors such as an increased awareness of the potential returns to R&D investment, or a generally improved investment climate.

The presence of a tax concession itself creates uncertainty. The actual level of the writeoff is inevitably arbitrary, and there are incentives for lobbying to increase the amount in general, or to apply special deductions for certain classes of expenditure. This uncertainty can itself negate the very incentive to invest in R&D which the writeoff was intended to foster.

Government assistance to industry can take other forms. If industry groups do not form, then it may be appropriate for the government to assist in their establishment and in the collection of levies to fund R&D. But whether such government assistance is required, and, if so, at what level and in what form, remains unclear. Such assistance would ideally be related to the transactions costs facing firms in the formation of industry associations, and the costs and benefits of alternative policy interventions such as public funding. Such policy intervention should be preceded by an analysis of the factors constraining investment, and should seek cost-effective solutions that enable private investment to take place.

If imperfect knowledge imposes transaction costs that inhibit the formation of associations, it may be sufficient for government to recognise

the need for industry funding and to exhort industries to organise themselves to invest in their own R&D. On the other hand, where the transaction costs of ensuring the capture of the benefits of R&D by members are prohibitively high and deter investment, then legislation to ensure compulsory membership could be considered. However, if members can capture sufficient of the benefits to make their investment in R&D worthwhile, then legislation and compulsory membership of an industry association may be an unnecessary intrusion by the state into the affairs of commerce.

Associations of producers within an industry allow the members to internalise the benefits of R&D within the group. Such organisations are not limited to those within New Zealand. International groupings of firms or industry associations are a means of internalising the benefits of R&D that transcend national boundaries.

If R&D benefits are spread across industries, but limited to sectors of the economy, such as agriculture or manufacturing, then it may be appropriate for the government to levy those sectors to provide funding if sectoral groups, such as Federated Farmers or the Manufacturers' Federation cannot themselves arrange, administer and invest in R&D that would benefit all their members. This may represent a less costly policy solution than taxation-based funding of this type of research.

Government assistance to the private sector should consist, therefore, of

- the establishment and maintenance of the patent system;
- the provision of a stable policy environment;
- the development of appropriate structures for public research agencies; and
- appropriate interventions to facilitate private industry funding of R&D.

At the same time, the government may fund public good research, whether it is undertaken within the private sector or by public research agencies.

Chapter 6

Investing In Research and Development: How Much? In What? By Whom?

Recent debate on research policy has failed to distinguish clearly the issues of how much should be invested and who should pay for it. While there may have been scope for a more equitable sharing of the costs of research, the changes in science policy to date have relied on cuts to public funding as a means of improving efficiency.

How Much Investment?

The 'correct' overall level of research funding can only be determined by analysing the performance of research investment in the same manner as other investment opportunities. Investments in R&D should be compared with alternative options for expenditure, and those activities funded that offer the highest potential return after adjusting for risk. The appropriate level of investment in R&D would be reached when the returns were similar to those of other investments. Thus, if a firm or industry could obtain a greater return from its investment in, say, marketing, then it would spend its resources in that activity rather than in R&D.

This is true for both privately and publicly funded research. If the government could obtain greater social benefits from its spending in other areas than from its R&D investment, then it is likely to be over-spending in R&D and underspending in those alternative activities.

The problem is one of determining the size of the research budget, relative to other investment opportunities. An appropriate policy for R&D would not dictate a 'desirable' level of R&D investment, but would provide the guidelines and an investment climate that would permit the 'correct' level and mix of public and private expenditure to emerge. Of course, policies that encourage R&D spending relative to other activities distort investment towards R&D. Otherwise profitable investments are thereby forgone. They also drive down the rate of return to R&D relative to other activities, which become more attractive. A neutral policy environment would permit the development of an optimal level of investment in all activities, including R&D.

What R&D Should be Undertaken?

The question of 'what' R&D should be undertaken is closely related to the question of 'how much' should be done. The size of the research budget is best determined by examining the expected return to the research portfolio, and diverting funds from marginal research activities to alternative opportunities and vice versa. However, where research budgets are predetermined, the problem is one of allocating limited research budgets to achieve the maximum overall return.

Decisions on investment in R&D require a management system based on assessment of the future benefits, in order to direct research funds to those activities that have the highest expected payoffs. Measures such as the IRR, Benefit:Cost Ratio or Net Present Value enable comparisons to be made between alternative investment propositions. They can be used to compare the returns to R&D investment with other uses of funds, such as marketing; to compare R&D investments in different areas, such as agriculture or forestry; and are particularly useful in comparing alternative R&D program or project proposals.

The payoff to research depends largely on the size of the industry, the potential impact of the findings, the cost of the R&D, the probability of success and the lags in research, and dissemination and adoption of the results. Two major questions must be answered before research resources can be allocated efficiently. Will the research be successful, and if so, what will be the return? The first question can be answered by scientists with the expertise and experience to assess the scientific and technological potential of research. The second can best be answered by formal economic analysis, incorporating all the benefits and costs, and involving the judgment and expertise of people with particular experience in the area where the research will apply.

As research becomes more distant from direct application, uncertainty increases regarding the nature and timing of the results and the costs of future development. As a result there are likely to be widely differing professional views regarding the costs and benefits. However, the investment view of research ensures that the underlying reasons for these differences are made explicit in terms of the judgments made about the key factors that determine those costs and benefits.

Cost-effective research management is based on the assessment of the investment potential of alternative activities. A system based on the investment nature of research which establishes research priorities, evaluates proposals and monitors activities based on the expected payoff from the investment, will boost the return to the investment. As research proceeds, the improved information generated permits re-evaluation of the project, and early termination if initial expectations are unfulfilled.

The cost of mistaken research investment decisions is high, since it implies that resources could be better used in alternative activities and achieve higher payoffs. Cost-effective management, by gathering information, aims to minimise the costs of bad choices among research activities, and is itself an investment generating returns in the form of greater research benefits.

At its simplest, prospective research evaluation requires subjective, but quantitative, estimates of the factors that determine the costs and benefits of the proposed research. This does not imply that accurate estimates of all the variables can be quickly or easily derived. However, the informed judgments that can be made at any stage may provide sufficient information about the expected profitability of a project to permit a decision to be made without the need to refine the estimates further. However, further effort in refining estimates may be justified when the expected costs of a project rise (reducing the expected rate of return) or when initial assessment indicates that a project is marginal or negative. This further effort reduces the costs of investing funds in projects with low payoffs.

Publicly-funded research requires the explicit assessment of the potential costs and benefits. Without price signals to indicate the relative value of different types of research, it is necessary to make explicit the costs and benefits. However, many of the factors preventing private funding of research make evaluating publicly-funded research difficult. Since publicly-funded research cannot be sold, its results cannot be easily valued. Very long-term or risky research is often technically uncertain. Decisions on allocating public funds are therefore even more subjective than for private funds.

Who Should Undertake R&D?

The historical pattern of public funding of research agencies that themselves conducted research is no longer appropriate. There is no reason why the funding and the conduct of research cannot be separated. It is perfectly possible for any funding body, be it public or private, to purchase research services from other agencies. These providers of research services may equally be public or private, and may obtain funding from various bodies. Research productivity would be improved by allocating funds to the most efficient supplier. Accountability would be increased, and the transparency of the relationship between funding and the benefits of research would likewise be enhanced.

Until now, there has been no explicit mechanism enabling the government to allocate research funds to those areas promising the highest social payoff, or to those agencies that would carry out the research in the

most efficient manner. However, it is proposed that an increasing proportion of publicly-funded research will be allocated by the Foundation for Research, Science and Technology among competing research organisations on a contestable basis. This amount will reach 50 per cent of the government research budget by 1994/95. The balance of the funds will be allocated by the Minister of Science, on the advice of an ad hoc Cabinet Sub-Committee, to departments undertaking scientific activities. The potential for competition between departments makes this funding also at least partially contestable.

However, it is difficult to allocate research funds efficiently between competing agencies and projects when government institutions account for a large share of public funding. Large government institutions with political and scientific influence may capture a disproportionate share of public research funds. This result may be exacerbated when there are close links between the institutions and the funding body. In part, this is due to the large scale and the long-term nature of their capital investments, which necessitate continuous financing. The decision to allocate funding may therefore be influenced by public, political and scientific pressure, perceived scientific opportunities, the concerns of society and the quest for advances in knowledge. There is potential for those seeking their own interests to seek to influence research allocation decisions where budget allocations are made without an explicit consideration of the costs and potential benefits of research.

The rational responses of economic agents to the incentives created by the new institutional structures will involve modified forms of their traditional rent-seeking behaviour. The process of setting public research priorities will tend to be dominated by the large public providers rather than the dispersed beneficiaries. Incentives have been created to ascribe to all research proposals a high degree of public benefit in order to maximise the capture of government funds. In the absence of an effective means to identify and evaluate those areas of research with high social payoffs that otherwise would be genuinely underfunded, the new system is at risk of proliferating programs and bureaucracies rather than generating substantial gains in the efficiency and equity of publicly-funded R&D.

A system of allocating public research funds based on the perceived costs and benefits would assist in directing research into those areas that promised the greatest benefits to society. The allocation of public research funds could be further improved by research management responsive to changing needs and scientific opportunities and flexible in its system of allocating available resources. Enhancing the flexibility of the research system may require the removal of some rigidities, such as the close relationship between the large research agencies and the funding body.

Improvements in the flexibility with which scientific personnel could move between institutions and sectors would also reduce rigidity. In short, greater institutional and labour flexibility would enhance the capability of the research system to respond to changes in research priorities.

A system of competitive contracts between the government, as the provider of funds for public good research, and research bodies, would increase flexibility and the efficiency of the use of public funds. Such a system would separate the role of policy advisers to government from the provision of research services and the distribution of funds and monitoring of research performance, and increase accountability for the use of public funds. It would also focus attention on the exact nature of the research that is being funded, ensuring that public funding was in fact allocated to those areas with a high component of public good research.

There is no necessity for the research institutions competing for government funds to be limited to public or even domestic organisations. Private firms or overseas organisations could equally compete with public sector research agencies for both private and public funding. If the goal of research management is the efficient use of funds to improve the well-being of society, then investing research budgets where they yield the greatest return is the strategy by which to achieve this.

A truly contestable funding system will not place restrictions on who may enter the contest. In the past, public funds have been allocated by block votes to public agencies protected from competition by their exclusive relation with the client. The very principle of contestability implies that such barriers to entry should be removed. To exclude some potential suppliers on the grounds they are small or foreign or private is tantamount to maintaining the current system of restricted entry. Furthermore it would lead to the evolution of evasive behaviour, such as the formation of domestic disguises for foreign contestants.

In a contestable funding environment, where both private and public sector agencies are able to compete for public funding, fair competition would require that tenders from the public sector were fully costed, without cross-subsidisation from other activities financed from the public purse. At the same time however, public agencies would require managerial flexibility similar to that enjoyed by the private sector. Once more, the very necessity for these requirements brings into focus the question of the need for public sector agencies to contest funding where private sector agencies exist. It may well be the case that the present public institutional structures are not ideal in a changed funding situation, and will evolve as the funding arrangements become more established.

A mechanism for monitoring the performance of projects is essential to any system of contracting research. It permits efficient use of

available resources, shifting them to areas of the greatest payoff in response to changing priorities. Systematic *ex ante* evaluation allows the identification of research priorities and some assessment of the likely outcome of the research in terms of its scientific success, and the extent and distribution of the benefits. *Ex post* evaluation, including peer review, or performance criteria such as citation indices, serves to ensure compliance with contracts and complements *ex ante* evaluations in the selection of new projects. Monitoring ongoing research also promotes cost-effective research management. It enables funding decisions to be revised if interim assessment indicates that projects are likely to result in marginal or negative rates of return. In such cases, costs already incurred could be regarded as 'sunk', but further funding could be cancelled, and redirected towards projects offering potentially higher rates of return.

While monitoring project-related, publicly-funded research may be relatively straightforward, monitoring of more 'basic' research and the maintenance of a high-quality research capability may be more difficult. However, stringent independent review of the research undertaken remains necessary in order to prevent the development of research 'monopolies' and to ensure that funds are being efficiently used. Where the results of research are difficult to measure, and success or failure of the project hard to gauge, monitoring research performance may be more complex. Nevertheless, the very notion of accountability for research funding may improve productivity, while the possibility of the loss of funding for non-performance is also likely to enhance research efforts.

The government's responsibility for funding research extends to allocating public research funds efficiently. It implies an accountability to taxpayers that use of the research funds will be in society's short- and long-term interests. The way that the funding agency allocates its funds to research bodies, and the way that it monitors their performance all have a bearing on the efficiency with which limited public funds are used, and the benefits that they generate. The quality of public research management is as much an issue for the funding agency as it is for research agencies themselves.

Chapter 7

Managing Public Investment in Research and Development

Resources for research are inevitably limited, for both the public and private sector. The reform of public sector research is now focusing on the need to obtain the highest social return for the public research investment dollar.

Ideally, the government should allocate resources in such a way that the marginal social return from its investment in R&D is the same as its investment in other areas. However, the public benefits of research are uncertain and difficult to measure, and there is, as yet, no established methodology for comparing the worth of different types of projects on the basis of the anticipated social benefits.

Contestability and the Foundation for Research, Science and Technology

The productivity of publicly-funded research is likely to be improved by allocating monies from a central fund to the most efficient research agency to carry out research under contract to the Crown. The Foundation for Research, Science and Technology is charged with allocating funding. Under an ideal system of allocation, projects would receive funding on the basis of their expected worth ranked against other research projects proposed for public funding. All research bodies, including private firms or overseas organisations, would be eligible to compete for funds allocated by the central body. The contestability of funding would increase the accountability of agencies for the use of public funds, and the transparency of the relationship between funding and research results would be enhanced. The relationship between the funding and conduct of research would be clarified.

These changes have led to further institutional reforms in the research industry. The government's role has changed from that of an undiscriminating funder of R&D to that of a discriminating purchaser of R&D services. Rather than funding departmental organisations which then independently determine their research programs, the government will develop objectives for its funding, and purchase those R&D projects that best meet them. The design, development and implementation of

procedures to match research priorities with project proposals in order to allocate efficiently limited public research funds between competing research projects is essential to this process. Industry-specific private research funding organisations have been established in order to channel levy contributions, particularly from agricultural producers, into research that benefits the industry.

Research agencies and funding organisations, both private and public, have enhanced incentives

- to identify prospective research areas and priorities;
- to develop techniques for the routine *ex ante* evaluation of research;
- to formulate and evaluate research proposals; and
- to monitor research activities.

The development of analytical techniques for evaluation is itself an investment. The benefits of investment in research management occur in the form of increased cost effectiveness of the research programs.

Research activity may be prompted by the scientists who perceive areas of potential future benefit, or it may be induced by the needs of the community it serves. Both these approaches, the 'technology push' and the 'market led', are important in establishing areas in which research may be brought to bear. An examination of the possible gains to be made from research into different areas would assist in the planning of research priorities. The identification of those areas of the greatest potential return, and the focus of research programs on addressing problems that would enable those gains to be made, could increase the benefits from the investment of limited funds.

An active program of searching for, and identifying, areas of high potential payoff is itself an investment that should be undertaken in a cost-effective manner. Efficient search procedures can be based on assessments of the 'prospectivity' of potential research areas, in a manner akin to efficient minerals exploration procedures. An efficient search procedure would enable research areas to be established in a systematic rather than a random way, and reduce the risk of investing in areas with low potential payoffs.

Evaluation and the Investment View of R&D

The process of evaluation can also assist in identifying potential sources of funding. Evaluation can include an estimate of the benefits to particular groups, such as industries or consumers. The benefits of research are often not captured by a single group, but spill over to others. Once identified, the beneficiaries could be approached as potential sources of funding.

This is likely to be important where research results in benefits for society as a whole, but which cannot be appropriated by the private sector. In this case, applications for funding might be directed to the Foundation or the Ministry. On the other hand, the identification of, say, woolgrowers as beneficiaries would permit funding requests to be made to the Wool Board. More broadly, joint funding proposals could be developed on an objective basis.

The use of evaluation techniques internally can increase the success of applications for funding. Decisions on the allocation of research budgets by funding bodies, such as the Foundation or industry associations, can be assisted by the evaluation of research programs. The use of research evaluation techniques as a routine part of project proposals would permit funding bodies to make allocation decisions based on the expected return to the investment. The development of evaluation techniques and their systematic use in formulating proposals and in monitoring research is likely to establish their credibility and objectivity with funding bodies. The greater the compatibility of the internal evaluation techniques used by research agencies with those of funding bodies, the more successful funding applications are likely to be.

Various organisations have emerged to allocate private funds from producer levies on a contestable basis to research agencies. The allocation of private funds among competing research proposals requires a system of directing funds to areas that can be expected to generate the greatest benefits to the industry. Private returns to research are easier to quantify than public benefits and are more amenable to the use of an evaluation system that explicitly includes an assessment of the costs and benefits.

The allocation of an increasing proportion of government funding by the Foundation for Research, Science and Technology necessitates a system for directing funds to their most profitable use. However, the adoption of such a system, based on the formal measurement of the net benefits, may be hampered by the difficulties inherent in measuring the benefits of research. The Foundation is charged with allocating funds to those projects which by definition have widespread public benefits. Such benefits are difficult to quantify.

As a result, proposals for funding from a range of organisations and covering a range of diverse research areas may not all be formulated in terms of an expected rate of return. In the absence of standard indicators of the profitability of investments, other criteria must be used as imperfect proxies. Alternatively, the difficulties of comparing projects may well result in reliance on historical precedence as a basis for allocating funding.

Other Criteria for Allocating Funds

The precedence approach. Under a precedence approach, the previous year's level of funding is used as the basis for increasing or decreasing the next year's funding. The changes are typically small, and shared equally among research activities. Relative changes under this approach only occur when there is a major reform of the system. While the advantage of the precedence model is the continuity of funding, its major disadvantage is that it has no way of computing the relative worth of existing or potential research activities. Research that may have reached the limit of its productivity may continue to be funded, and it may be difficult to introduce new areas of research. This method accentuates an inbuilt inertia whereby past funding levels and areas of research tend to be perpetuated.

The fact that funding may be allocated where historical funding levels have been high is not necessarily irrational, however. Further funding of those areas of research in which there has been an accumulation of skills and experience as a result of past investment may be highly productive. On the other hand, there may be diminishing marginal returns to further investment in areas that have traditionally been strongly supported.

Were funding organisations such as the Foundation to rely on precedence as a means of allocating funds, existing levels would remain largely unchanged. However, it would preclude the opportunity for any one existing recipient to substantially increase its share. Nor would it permit the funding of new projects by existing or new agencies.

Congruence. Congruence involves the allocation of research funds across areas in proportion to their contribution to output, and may therefore be inappropriate for Foundation funding.

Ranking. There are numerous ranking methods that require individuals to compare one proposal to another or to a group of alternative proposals, and to indicate their preferences (or strengths of preferences) for the preferred option.

Scoring. Scoring models provide a simple qualitative technique to formalise the intuitive and subjective decision process involved in the choice of research areas. They evaluate projects on the basis of multiple, subjectively-weighted criteria, and from these, compute scores for competing projects. Scoring models assume that research activity can be characterised by a limited number of subjectively-chosen criteria that are sufficient to assess the relative desirability of research options. The scores are essentially qualitative and non-monetary and rely on a high level of personal judgment. While scoring models have some advantages, including low data requirements, ease of use and low cost, they also have disadvantages, involving the selection of the criteria and weights, the variability in the responses of scorers and the method of aggregating the scores. Above all, they do not assess the net benefits of research.

A system of allocating research budgets explicitly based on the expected returns from the investment would be a transparent means of choosing both research areas and agencies, and could permit research proposals in dissimilar areas to be compared. In addition, it would facilitate the comparison of the returns to research with those from other potential investments. Improved cost-effective research management would assist in the efficient allocation of public R&D funds.

Where To Now?

Government research policy since 1984 has precipitated an unprecedented examination and restructuring of the entire R&D system in New Zealand. This coincided with a restructuring of the economy, deregulation of the public sector, a reorganisation of research agencies and increased emphasis on commercial research. The uncertainty and turbulence brought about by the changes led to a widespread perception of a crisis in R&D, and calls for greater certainty regarding public science policy.

The restructuring induced public research agencies to enter the market as sellers of R&D to the private sector. The difficulties they experienced led to moves to increase their commercial powers, while the advantages they enjoyed over private competitors led to measures to ensure 'fair' competition. These changes in the nature of public good research obscure the fundamental question of public-sector involvement in private markets. Measures to put public agencies on an equal footing with the private sector suggest that private-sector sellers either exist or are willing to enter the market. Accordingly, if private sellers fulfil market needs, there may be few grounds for the public sector to provide R&D services. The monolithic public agencies that have dominated the research industry for most of this century will need the flexibility and capacity to evolve in a manner consistent with the reformed environment.

Further changes are envisaged for the public funding of research through the Foundation and Ministry for Research, Science and Technology. The separation of the functions of policy advice, allocation of funds and the provision of research services is likely to improve the neutrality of government science policy. Government purchase of public-good research from competing research organisations is likely to increase the efficiency of the use of public funds. The management of public research funds remains an area in which further developments are expected, both for funding organisations, and within research agencies themselves. While the changes in science policy to date have encouraged more efficient use of research resources, there remains scope to increase the potential benefits of research still further through cost-effective research management techniques that emphasise the investment characteristics of research.

Appendix

Estimates of Expenditure on Research and Development in New Zealand

As noted in Chapter 4, there is a serious lack of systematic and reliable data on R&D expenditure in New Zealand. The most substantial estimates are to be found in STAC's 'Science and Technology Statement 1988', which provides the following figures for 1987 (p.83):

Expenditure on R&D 1987

	Total government	Industry	Total
$NZ millions (exclusive of GST)	350	230	580
% of GDP	0.66	0.43	1.09

The Statement emphasises that these figures are 'very provisional and will include some double accounting in revenue and levies'.

The figure of 1.09 per cent of GDP in 1987 puts New Zealand 17th on the OECD scale of 22 countries, whose average level of investment in the mid-1980s was 1.64 per cent of GDP. The highest level was found in Sweden (2.93 per cent) and the lowest in Greece (0.33 per cent). Australia was 16th with 1.18 per cent.

The STAC statement emphasises the apparent decline of R&D expenditure in New Zealand in recent years. During 1984-87, government department expenditure fell by 13 per cent, and that of research associations by 15 per cent. During 1986-88 expenditure by MANFED members fell by 20 per cent.

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