Crisis In Agricultural R&D in New Zealand ?

Veronica Jardine

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1. R&D in New Zealand

In New Zealand research and development (R&D) has historically enjoyed a high level of government support and involvement. However, in 1984-85 the incoming Labour government introduced a series of cuts to public funding of R&D, together with reform of the public sector. These changes have had profound effects on the R&D industry in general. Agricultural R&D has not been exempt and it has seen a change from the traditional pattern of public sector provision and funding to one with an increased reliance on the participation of the private sector as both buyers and sellers of R&D.

The public sector reform increased emphasis on 'efficiency', 'accountability', 'contestability' and 'transparency' in government. These goals shaped many of the changes in the institutional and funding arrangements of R&D. In many areas previously the recipients of public funds, 'user pays' became a by-word.

The changes implemented by the government in 1984-85 were decisive, and aimed at a more equitable sharing of the costs and benefits of R&D, especially in agriculture. These also were intended to provide the public sector with incentives to invest in worthwhile R&D commensurate with reductions in public funding. However, they provided no clear direction for research and development. While they were intended to result in an increase in private funding and orientation of agricultural R&D towards the needs of the market, improved research management and enhanced accountability, they resulted in a period of uncertainty for the research industry and agriculture.

In 1986 a ministerial working party under the chairmanship of Sir David Beattie was set up to review the role of government in science and technology. The major conclusions of that report were for a doubling a research spending within seven years, the establishment of a Science and Technology Advisory Board, and the introduction of a 150 percent tax writeoff for R&D expenditure.

These recommendations have not been implemented, despite vocal lobbying from the scientific community seeking to continue public largesse to their industry, and the research industry has continued to flounder. There is a widespread perception among the scientific community that R&D is currently in a state of crisis. Scientists have become politicised, forming lobby groups pressing for changes in research policy, and running campaigns to persuade the public of the existence of the crisis and the need for government intervention.

A Science and Technology Advisory Committee has, however, been established to advise the government on science and technology. The Committee has recently completed a Science and Technology Review which contains recommendations on R&D policy (STAC, 1988a). It outlines the grounds for government involvement in R&D, and recommends public funding only of those areas of research which provide no incentives for private investment. It considers that the efficiency of the use of government funds would be increased by a system of contestable bidding for public funds between all research agencies, both public and private. It also recognises that the institutional arrangements for the public provision of research may not be appropriate in the anticipated environment, and foresees considerable change in those as the public provision of research is rationalised in the future.

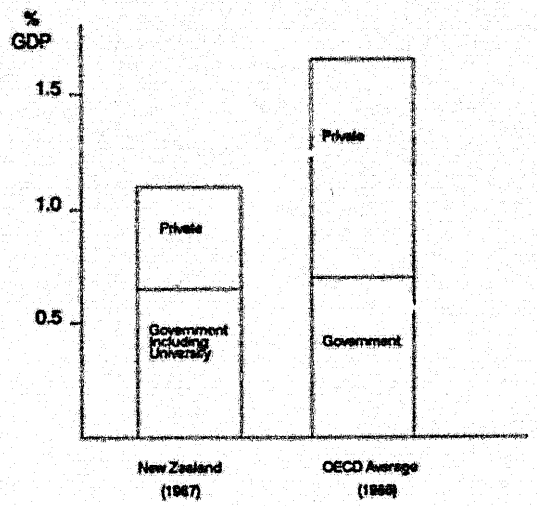
This paper considers these issues, and draws attention to some of the lessons which can be learned from the New Zealand experience in the reform of agricultural R&D.

2. Public Funding of Agricultural R&D

2.1 Level of Funding

Data on R&D investment in New Zealand in general are notoriously inadequate. There has never been an adequate system for collecting data from the private sector. Even worse, it is impossible to determine the exact amount spent by government. Using the best information available, Figure 1 shows R&D spending levels in New Zealand compared with the OECD average. Overall, New Zealand spent

Figure 1: Investment in R&D



1.09 percent of GDP on R&D in 1987. The average for all OECD countries was 1.64 percent in 1986. In New Zealand, government spending amounted to 0.66 percent of GDP, while the comparable figure for OECD countries was 0.70 percent. But New Zealand private spending on R&D amounted to only 0.43 percent of GDP on R&D, while the average for the OECD was 0.70 percent. Clearly private funding is low. In agriculture, public sector expenditure in 1983-4 (prior to the funding cuts) amounted to $77 million, $67 million of which was spent on production research. Private sector expenditure in that year amounted to $27 million, of which $9 million was spent on production research, and $18 million on processing (NRAC,1984;1986).

There is some evidence that past public investment in agricultural R&D produced a highly satisfactory 30 percent rate of return between 1926-27 and 1983-84 (Scobie and Eveleens, 1987). This result is similar to the rates of return for many countries reported in the literature (Ruttan, 1982). While part of the productivity gains may not be attributable to domestic R&D (e.g. imported machinery; pesticides developed overseas) and the magnitude of past research benefits is an imperfect guide to future gains, the results provide an indication of the investment potential of agricultural research. However, while past underinvestment in agricultural R&D may provide signals for increased investment, it provides no grounds for indicating whether that spending should take place in the public or private sectors.

2.2 Public Funding

It is likely that the justification for the historically heavy involvement of the state rested on several grounds.

One possibility is that government funding of R&D comprised tariff compensation to agriculture for protection to the import-competing sector. Funding R&D is a very blunt instrument, however, for making such a compensatory transfer to the agricultural sector. Furthermore, it is potentially inequitable, since the incidence of the costs of the tariffs may bear no necessary relation to the benefits of the compensating R&D. Nor may the incidence of benefits of the tariffs be related to the burden of

the costs of the R&D. In addition public R&D spending as tariff compensation also suffered from a lack of transparency and accountability.

Following World War II, technological development was seen as a means of achieving economic growth and political power. Increasing emphasis was placed of public funding of research to increase agricultural output and national prosperity (Douglas, 1987). The government also became an active provider of research. However, this view of R&D (perpetuated in the sub-title of the Beattie Report as the 'Key to Prosperity' as an engine of growth) overstates its importance relative to other forms of productive investment. Research and development is only of many instruments for achieving increases in agricultural output, economic growth and improvements in human welfare. There is simply no linear relationship between R&D and improved economic performance. On the other hand, this is not to deny that improved productivity is a source of growth, and the investment in knowledge, which leads to productivity gains, may show a favourable return both to private firms and to society at large. Whatever its contribution to growth, this alone does not constitute an argument for government provision of R&D.

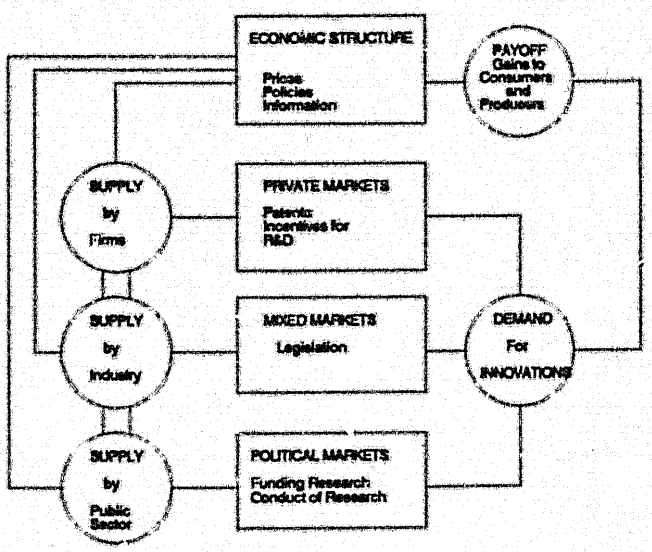
The underlying theoretical and economic rationale for government involvement in R&D has been based on Arrow's perception of market failure. This traditional view suggests that a competitive economy would not invest in the 'optimal' level of R&D due to market failure. As a consequence, the government should intervene to improve the allocation of resources to research, generally through public provision. Market failure emerged as the fundamental, simplistic, justification for government funding in the Beattie Report.

Market failure is seen to arise (a) where the cost of R&D is high in relation to the size of the industry, (b) where a firm cannot capture the benefits of R&D, (c) where R&D involves long lead times and (d) where R&D is seen as a risky investment. None of these arguments, however, provides an unequivocal justification for public sector intervention. There is no underlying reason for the government, rather than the private sector, to undertake research where the costs are large in relation to the industry. Nor is government provision necessarily the optimal intervention where firms cannot appropriate the gains from research. The problem may arise due to high transaction costs associated with imperfect property rights (where an alternative policy option is improvements in the system 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, rather than private investment in R&D. If the private sector is unwilling to invest in R&D with these characteristics, because the expected rate of return is too low, there are no good grounds why the government should be prepared to do so. Such investment, rejected by the private sector as unworthwhile, merely shifts the burden to taxpayers, without any guarantee that government investment will lessen the expected lag times or perceived risk, and increase the expected rate of return.

The principal theoretical drawbacks of this approach are that it does not seek the fundamental causes of underinvestment (which can be seen to lie in transaction costs), it does not recommend which form of intervention would be appropriate, and it does not examine the efficiency or the equity of the intervention it recommends. Not only do markets 'fail' but the government alternative this approach advocates may also 'fail'. It thus provides an incomplete argument for public sector conduct and funding of agricultural R&D in the presence of underinvestment.

A more recent approach to agricultural R&D is built on the concept of transaction costs, a relatively new development which is primarily associated with Williamson (see for example Williamson, 1979 and 1985). It has become apparent that market failure arises because of the presence of 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 frictionless markets. Where there are severe costs which constrain private investment in agricultural R&D, the government may have some role to facilitate such investment where the benefits of intervention exceed the costs. Where the private sector faces transaction costs which prevent investment, and which cannot be economically removed through government action, the government may have a role in funding agricultural R&D if the return is adequate.

Figure 2: Markets for R&D



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 (Jardine, 1986;1987a;1987b; Bollard et al 1987). They focus on 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 which can be funded efficiently by the private sector.

2.3 Users of R&D

The appropriability of research benefits enables several groups of beneficiaries of R&D to be identified.

2.3.1 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. Consumers also benefit from research which is spread so widely throughout the community that no individual or group can be identified as benefiting, for example environmental quality or food safety. Government funding of R&D is appropriate in those areas where the inappropriability of the benefits constrains incentives for private investment, and other government interventions, such as improvments in property rights are ineffective or uneconomic.

The social benefits of agricultural R&D generate a demand for 'public good' research. Private or mixed supply does not occur due to the low private and high public content of the benefits. This demand is met through political markets, with government funding (and sometimes also the conduct) of research (see Figure 2).

2.3.2 Firms

Where individual firms can appropriate the benefits, there are incentives for private investment in R&D. The demand for R&D in private markets 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. Firms will invest in R&D where they can capture sufficient of the benefits to make the investment worthwhile, and where the marginal returns are greater than those of alternative investments.

It is likely that a substantial amount of agricultural R&D can be appropriated by firms and commercialised. Some research can be protected (to varying degrees) through mechanisms which define 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 agricultural machinery, and which otherwise be copied easily or quickly. Copyrights prevent the unlicensed copying of work, and in agriculture are used to protect computer software. 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 arise 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 or products. Secrecy protects processes, chemical formulae, recipes or 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 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. Monopoly power also enables a firm to capture the gains of R&D, as does the strong marketing and servicing of new products. The returns can also be captured if the producer of R&D is also the sole seller of the goods embodying that R&D. 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, advisory and extension services are generally necessary to 'customise' research results for particular farms or specific users.

For much agricultural research, therefore, sufficient gains can be captured by firms to induce investment. Ruttan (1983) suggests that for genetics and plant breeding about half the social return is captured by the innovating firm. The figure may be similar for mechanical technology, lower for chemical innovations and even lower for biological technology.

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. Where the sufficient of the gains spill over to other firms to deter investment by a single firm, then some form of collective private funding may permit investment and appropriation of the benefits by the group as whole.

2.3.3 Industry

Where there are spillovers of research benefits between firms, but which can be appropriated by the industry as a whole, the firms may collectively invest in R&D. If the industry as a whole can capture the enough of the benefits to make the investment worthwhile, then a contribution of each firm to funding R&D would permit collective investment. Agricultural industry associations do fund some R&D. Research Associations are funded jointly by the private sector producer boards through levies of producers, processing firms and government grants, and undertake internally organised R&D. The principal organisations are the New Zealand Dairy Research Institute (DRI); the Meat Industry Research Institute of New Zealand (MIRINZ); and the Wool Research Organisation of New Zealand (WRONZ). Other agricultural industry organisations fund a certain amount of R&D from levies on

members, although overall only a small part of the levy is spent on research, with the remainder being spent on items such as marketing (Fordyce, 1986).

Industry funding of R&D offers 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 which would necessarily accompany such funding would enable the industry to invest in appropriate R&D relevant to the needs of the industry and its market. Industry funding is likely to increase the benefits of the research investment for members, since they are likely to want to invest in R&D where they can capture a large share of the benefits. Accountability would be improved, since industries could either undertake their own research (Research Associations are an example) 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 transparency of funding and the associated research and its benefits would be improved.

The trancaction costs of forming associations to fund R&D may 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.

It is the appropriability of the benefits of research, therefore, which is the decisive arbiter of whether R&D can be privately or publicly funded, and not whether the research carried out is 'basic' or 'applied'. There are a number of ways in which the benefits of basic research can be captured by firms or industries which would therefore be willing to invest in it. A firm may initiate a project (either under contract or in-house) 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 which may benefit the firm in the future.

2.4 Reductions in Public Funding of Agricultural R&D

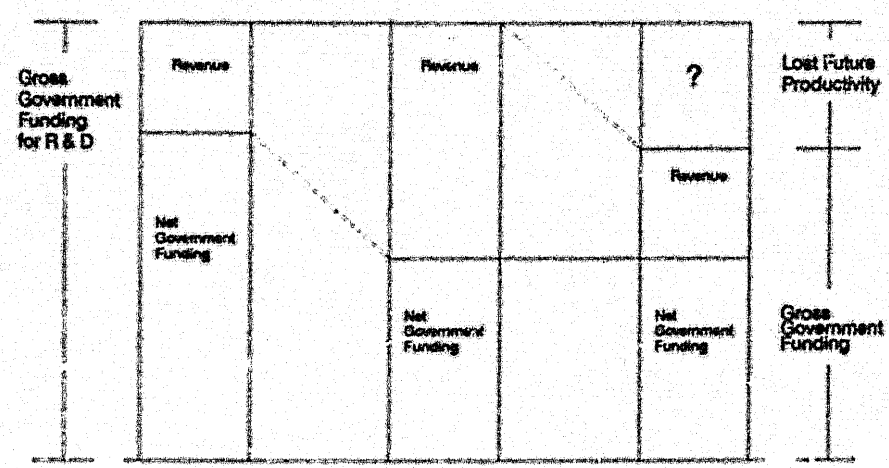
It is likely that the reductions were instituted with both efficiency and equity considerations. The search for efficiency has two aspects, past overinvestment in R&D and improved public sector research management. There is little evidence of past overinvestment in agricultural research (Scobie and Eveleens, 1987), which would suggest over investment through public funding, and future efficiency gains through funding reductions. However, reductions in funding were intended to improve research management by making research agencies consider 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 achieving a more equitable sharing of the costs, reducing the amount borne by the urban taxpayer at large in favour of a greater share from the rural 'users' or direct beneficiaries. Now too, the beneficiaries of government funded R&D could often be identified, either individually (such as particular firms) or as groups (such as dairy farmers).

In addition, the size of the public sector and the public sector deficit had increasingly been seen as necessitating measures seeking 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. The intention and impact of these government cuts is depicted graphically in Figure 2.

Initially the gross expenditure on publicly funded R&D was made up from revenue generated by research agencies themselves, and net government funding. Reductions in net funding would provide incentives to the private sector to invest in R&D where this was considered worthwhile. The inference was that if firms did not find the R&D profitable then investment from R&D agencies would fall, and private spending would not increase. On the other hand, if the R&D was worthwhile, then firms would be prepared to invest in order to maintain the overall level of R&D investment. The reductions were staged, with graduated cost-recovery beginning in 1984. By 1988-89, the principal recipient of public funds for agricultural R&D, MAFTech, was expected to obtain over 14 percent of its funding from external sources. The staged approach to the funding reductions was intended to provide funding for transitional measures (STACa,1988).

Figure 3: The Impact of Cuts in R&D



2.5 The Responses to Reduced Public Investment in R&D

The cuts precipitated substantial restructuring and reorganisation of the Ministry of Agriculture and Fisheries, coupled, lamentably, with a decline in the availability of data. One of the major difficulties with assessing the impacts of the cuts in net government funding is the lack of any long term, systematic statistical evidence on the extent, source and use of both private and public sector expenditure on R&D from which to draw conclusions or formulate appropriate policies. The compilation and publication of statistics related to R&D has undoubtedly been affected by the changes in the organisation of science. One can only speculate whether the current absence of data on R&D expenditures by public institutions reflects a deliberate attempt at obfuscation, or is an unintended casualty of the internal turmoil.

Moreover, without adequate data on spending, it is impossible to determine the rate of return to investment in R&D even if the benefits were to be identified. Without analysis of this kind, the efficiency of R&D resource allocation is difficult to assess. The lack of data does not make the effects of policy change transparent; nor can the allocation of resources or the evaluation of the benefits be seen clearly.

It is clear from the reaction of the previously protected public science sector, that the cuts have contributed to the perception of a crisis, and that private funding of R&D carried out by public agencies has not proceeded smoothly to compensate for the reductions. It is impossible to tell whether private investment in R&D overall replaced the cuts in government funding, since the data to make meaningful before and after comparisons of both private and public funding is lacking.

The STAC review of Science and Technology, however, suggests that private spending on R&D may be falling further from its already relatively low level (STAC, 1996a). It appears that cuts in public funding have not been compensated by a concomitant rise in private investment in R&D.

At least in public research agencies, the overall level of research expenditures seem to have fallen. Research agencies have been forced to reduce their overall expenditures through staff attrition, sales of assets, shutting down projects, foregoing new equipment and maintenance and limiting leave for study, travel and conferences.

The cuts have exerted pressure on research agencies to increase the short term payoff to R&D in terms of revenue to meet increasing funding targets. They have concentrated on R&D with visible benefits with identifiable 'users' and certain funding, and have reduced their commitment to long term and risky basic research. A consequence has been that 'public good' R&D has been reduced in favour of revenue-generating 'user-pays' research.

It is by no means clear that 'user pays' research carried out by public agencies such as MAFTech or private investment in research carried out within the private sector has maintained the overall level of investment in agricultural R&D. Any fall in real overall R&D spending has potentially severe long term effects on the agricultural sector, reflecting the long term nature of the investment. The current drop in real research expenditures is expected to result in a fall in future agricultural productivity.

The positive impact of the government cuts and the introduction of 'user pays' has been an improvement in research management by research 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. MAFTech has introduced contestability into the allocation of some of its public funding among various regions on the basis of competitive bidding.

Despite these efforts to allocate public R&D funds efficiently within research agencies, there has been little attempt to maximise the return to public investment in R&D overall. There was no attempt to establish a national research policy to identify both those areas of high payoff research and those that should be publicly funded. Because the overall proportion of 'public good' research was not identified, the extent of the cuts was arbitrary, and not related to any concept of what the overall proportions of publicly and privately funded R&D should be. As a result some areas of 'public good' research may have been reduced, and some research which could justifiably be privately funded, retained. The result has been confusion about what should, and what should not be, publicly funded research. A feature of the lack of a national research policy and clear guidelines on the nature of 'public good' research has been the lack of a mechanism to determine those areas which would result in the greatest contribution to human welfare, and which would correspondingly deserve the greatest funding. This is not to imply that such tradeoffs are easy to make. The argument is simply that with better information, better decisions can be made.

2.6. Private Sector Underinvestment in Agricultural R&D

Whether of not there has historically been private sector underinvestment in agricultural R&D is not clear. Furthermore, the lack of conclusive evidence of private agricultural investment following the reductions on government spending does not permit judgement of the current situation.

However, it is probable that some private sector investment has been 'crowded out' by the past generosity of public sector funding. The high level of public funding of agricultural R&D may have led

to 'dependency' in those industries which have enjoyed the benefits of public investment in R&D. A consequence of this dependence on the government has been a lack of appreciation the investment nature of R&D. Although private firms generally recognise the benefits of R&D and adopt new techniques, some are apparently unwilling to make sacrifices to obtain those benefits.

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 gone hand-in-hand with a period of high interest rates and also encompassed the sharemarket 'crash' of 1987. These factors, together with the emergent nature of the venture capital market and labour market inflexibility may also have contributed to underinvestment.

A particularly important source of underinvestment is the inappropriability of the benefits. Market forces can provide individual firms with the incentive to invest in R&D where enough of the benefits can be captured to make the investment worthwhile. Government policy contributes 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 thus enables the private appropriability of R&D benefits.

Other responses have included the recommendation of the Beattie report that the government introduce 150 percent tax deductibility for R&D expenditure by industry. The main reason for this was a 'need' for tax neutrality with Australia as it stood at that time. However, tax neutrality with Australia is not a sufficient reason for adopting this approach. A tax writeoff implies that taxpayers are subsidising private R&D. New Zealand companies wishing to undertake R&D in Australia could do so at the expense of the Australian rather than New Zealand taxpayer.

However, tax writeoffs may induce perverse consequences, drawing resources from otherwise more profitable investments and encouraging short-term projects. The research programmes of private firms may be distorted in response to the firm's need for tax concessions, rather than for any underlying research requirements. R&D spending may increase, as firms classify costs as 'research' for tax purposes. Firms may be unresponsive to measures they perceive as short term, or which represent assistance to only a small part of the total costs of innovation. The tax credit itself creates uncertainty which deters investment, since it provides incentives to lobby for additional concessions. Furthermore, any increase in R&D must be very large before there is a net gain to society from the concessions. Otherwise it simply represents a transfer from taxpayers to firms. The tax avoidance effect hinders assessment of whether tax credits actually achieve their purpose. 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.

Government assistance to industry can take other forms. If industry or sectoral groups do not form due to high transaction costs, then it may be appropriate for the government to assist in their establishment. The government implemented the cuts in public funding of R&D without first putting in place any alternative mechanisms to allow industry groups to fund research. Whether government assistance is required, and at what level or in what form is not clear, however. Possible policies range from exhortation to coercion. As with all interventions, they should be contemplated only when they improve the allocation of resources to R&D and when the benefits of the policy exceed the costs. (Bollard et al 1987).

3. Private Sector Purchase of R&D

Following the cuts in public agricultural R&D expenditure, public research agencies have found themselves in an environment which combines both the shackles of the public service and the demands of the market, while providing R&D services to both the public and private sectors.

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 did not provide scientists with strong incentives to cater to market demand, nor was it easy for the agencies to enter into contracts with the private sector. Furthermore, the subsequent structure of research agencies has not provided them with the capacity to act in a fully commercial manner. They cannot take risks which compromise the Crown, nor can they raise equity or debt capital or enter into joint ventures. This lack of commercial capacity has severely hampered MAFTech in particular, since it faced a relatively greater challenge in seeking outside funding than the other major recipient of public funds, the DSIR. They are also handicapped by their public service structure. The bureaucratic and hierarchical nature of the public sector has not provided research agencies with the flexibility to respond quickly or easily to the changes. Public sector employment practices have also dampened their responsiveness. The incentives facing public sector 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 supply-driven, rather than being led by the needs of the market. In addition, research agencies have seen a 'brain drain' of the brightest and best scientists. 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.

These factors which have limited the commercial activity of public research agencies have constrained their ability to emulate the performance of the private sector. However, they also enjoy some features of public institutions which provide them with an advantage over private sector competitors. It is not clear that the capital involved in the provision of research is fully costed. Furthermore, the net income received is not subject to taxation. Public agencies are able to cross-subsidise projects through their government funding and crowd out competitors and stifle emergent suppliers. This suggests that public research agencies are able to compete unfairly with private sector providers of R&D, reducing the overall efficiency of the nation's research effort.

The removal of constraints on the commercial activity of public agencies, and the establishment of mechanisms to ensure neutrality with the private sector is a possible response. However, it draws attention away from the fundamental issue of public sector involvement in R&D. The very need to create an operating environment similar to the private sector suggests that private sector providers either exist, or potentially can enter the market. If private firms could meet the needs of the market, then there would be little justification for public sector provision.

Where public research agencies, such as MAFTech are involved in the private market for R&D, it is possible (indeed likely) that the current structures are unsuitable and in addition are not sufficiently flexible to change according to the needs of the market. Using the transaction cost approach, it is possible to classify the structure which is most efficient for various kinds of R&D transactions (Jardine, 1986; Bollard et al, 1987). For example, laboratory testing of fibres involves transactions with a high degree of contractual certainty, and the assets of the research organisation are not dedicated to the needs of a particular buyer who can appropriate the benefits of the exchange. The sale of these routine R&D services can thus be conducted through the market.

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 public sector provides services which are duplicated by the private sector, there must be some doubts as to the fundamental justification for that provision. If the private sector is an

efficient producer of goods and services, it would be necessary to identify the special characteristics or circumstances which would make privatisation of public sector production undesirable.

Trilateral governance involves some contractual uncertainty, and moderate asset specificity for occasional contracts for R&D where appropriability is ensured by patents or warranties. The development of agricultural machinery for a client under contract would be conducted within this structure. Trilateral governance may also be appropriate for the development of innovations which may not initially attract investment, but which can be protected by patents and developed and sold to clients. However, there may be risks in choosing projects which will ultimately be successful. There is little justification for the public sector to undertake research which the private sector considers risky, and which merely transfers that risk to the public sector. Indeed, it may increase the risk for the public sector, since there are few penalties for the failure of projects. This, therefore, may be an inappropriate area for public agencies, since they lack a fully commercial structure which would permit the private financing of such 'risky' ventures. However, placing public research agencies on a commercial footing which would enable them to raise capital poses a further dilemma. If a fully commercialised public agency uses private capital to undertake pre-commercial research, what is the justification for public sector rather than private sector provision? Furthermore, if the benefits to the research can be captured through mechanisms such as royalties or licences, then the beneficiaries of the research are clearly identifiable. There would appear to be no *a priori* reason for the public sector to engage in this kind of research activity.

Bilateral governance involves a long term relationship between the buyer and seller of R&D, and high levels of contractual uncertainty and asset specificity. They involve prior contracts and provide the seller with a certain market for the R&D undertaken, 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. Sale of agricultural R&D by public agencies under contract to private buyers may continue in the absence of private competitors with sufficient research capability. However, the enforcement mechanisms in bilateral 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 parts of research bodies with assets that are specific to the buyer.

The internal or 'in-house' organisation of R&D occurs with high level of contractual uncertainty, asset specificity and uncertainty, and represents a lesser cost response to bilateral governance, enabling the appropriation of returns inadequately captured under contract. It allows the 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 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. What is required is a flexible system which will permit the most efficient structures for the provision of R&D to meet the needs of society and the market.

4. Purchase of R&D by the Public Sector

Resources for research are limited, for both the public and private sector, and are efficiently allocated in the way that maximises the return. The reform of public sector research has developed into an explicit interest in obtaining the highest social return for the public investment dollar.

Such a policy involves determining the overall level of public funding, setting goals for public sector investment in R&D, establishing a body for the allocation of the funds, selecting and funding those projects that best satisfy those goals, and ensuring that the projects are satisfactorily carried out by the most efficient research agency. The Science and Technology Committee (1988a) has made

recommendations to the government regarding the management of publicly funded research along these lines.

It is difficult to determine an optimal level of public good research. Ideally, the government should allocate resources in such a way that the marginal return from its investment in R&D is the same as its investment in other areas. However, the benefits are difficult to measure, and there is no established methodology for comparing the worth of different types of projects. In the absence of economic criteria for funding, funding decisions are influenced by public, political and scientific pressure, anticipated benefits, current and past expenditure, perceived scientific opportunities, the needs of society and the quest for advances in knowledge. STAC therefore recommends the establishment of an advisory body to advise the government on such issues as the level of funding, the objectives of funding, the evaluation of past research, and the nature of the allocation process. In order that the advice be objective and independent, its provision should be separated from that of allocating funds and of providing R&D services to the government. In fact, the provision of contestable advice from numerous sources would make several viewpoints known to government, and decrease the possibility of capture of the advisory body by sectoral interests.

STAC suggests that the government be concerned with broad goals for its investment, rather than to seek specific objectives of particular research areas, programmes or projects. Public funding should be limited to situations in which the private sector was unwilling to invest in R&D due to the limited appropriability of the benefits. STAC identifies three major areas for this funding: (a) increased understanding of New Zealand's physical and social environment, (b) maintenance of a domestic science capability to monitor overseas developments and adapt them to New Zealand conditions, and (c) pre-commercial applied research which is unlikely to be (wholly) funded by the private sector.

The productivity of public 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. STAC recommends the establishment of a National Research Council to determine priorities for the allocation of funding. The proposed method is to be analogous to that employed by Japan's Science and Technology Agency. The procedure considers priorities from a range of perspectives and enables firms to internalise the *ex ante* evaluation of projects, generating commitment to its objectives. Projects would receive funding on the basis of their expected worth ranked against all the other 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.

These proposals are likely to involve further institutional change in the research industry. The government's role will change from that of an undiscriminating funder of R&D, to a discriminating purchaser of R&D services. Rather than funding departmental organisations which then independently determine the research programmes, the government will develop objectives for its funding, and purchase those R&D projects which best meet them. The government will therefore need to design and implement procedures for the allocation of limited public research budgets between competing research projects. Systematic allocation and evaluation permits the efficient use of available resources, shifting them to areas of the greatest payoff in response to changing priorities.

Research agencies will compete for public funding in addition to the existing competitive environment for private funding. Research agencies will be faced with the research management challenge of internalising techniques for the routine *ex ante* evaluation of research, to identify priorities and assess the likely outcome in terms of scientific success and the extent and distribution of the social (and private) benefits.

The government will be involved in the essential, albeit difficult, task of monitoring projects and enforcing contracts to ensure the efficient use of public funds. *Ex post* evaluation, including peer review, performance criteria such as citation indices, and the analysis of the success or failure of completed projects and the nature and spread of the benefits serves to ensure compliance with contracts and

complements *ex ante* evaluations in the selection of new projects and the awarding of new contracts. While monitoring project related, publicly funded 'applied' research may be relatively straightforward, monitoring of more 'basic' research may be more difficult where the results are hard to measure and the success or failure of the project difficult to gauge. However, the very notion of accountability for research funding may improve productivity. The possibility of the loss of funding for non-performance is also likely to enhance research efforts.

5. A Crisis in Agricultural R&D in New Zealand?

Government research policy since 1984 has precipitated an unprecedented examination and restructuring of the entire R&D system of New Zealand. This coincided with a restructuring of the economy, deregulation of the public sector, a reorganization of research agencies and an increased emphasis on commercial research. The uncertainty and turbulence brought about by the changes has led to a widespread perception that there is a 'crisis' in agricultural R&D. That these changes have been interpreted as a 'crisis' by those directly involved in that restructuring is understandable. Structural adjustment is painful, and those who bear the costs may not enjoy a concomitant share of the benefits. The impact of the new policies on public research agencies and their scientific personnel has been severe.

The restructuring is by no means over, however. Funding reductions have induced public research agencies to enter the market as sellers of R&D to the private sector. The difficulties they have experienced have led to moves to increase their commercial powers, while the advantages they have enjoyed over private competitors have 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 to private buyers. The evolution of the structure of public agencies may see substantial change from their present public sector organisation.

Further changes are envisaged for the public funding of research. The separation of the functions of policy advice, allocation of funds and the provision of research services are likely to improve the neutrality of government science policy. The establishment of broad objectives and the government purchase of research projects which best fit those objectives from competing research organisations is likely to increase the efficiency of the use of public funds. Challenges abound in these arrangements for public funding, particularly regarding the management and evaluation of research projects.

The transition period of reductions in public funding does not appear to have provided sufficient incentives for increased private investment in R&D to meet the shortfall. Private sector underinvestment may be costly, as firms which do not invest in R&D become less competitive than innovative firms with new technologies or products. Future productivity may be reduced, and industries which do not invest in R&D to maintain their international competitiveness may see their position in world markets eroded.

Since research agencies apparently have been unable to increase private sector funding sufficiently to make up the investment shortfall, they have reduced spending in other areas. Real expenditure on 'public good' research has fallen as a result. This disinvestment in physical and human capital is likely to reduce the future productivity of publicly funded research. The long term and widely distributed nature of the foregone benefits has precluded the formation of political constituencies to lobby for their maintenance.

The government, as the agent for society, has not recognised the existence of this aspect of the 'crisis'. It has not acted to ensure that an appropriate level, quality and focus of the publicly funded research, for which it is responsible, has been maintained. Nor has it acted to preserve society's in-

vestment in the nation's public research capability. It has not managed, and is not managing, the cuts in funding to minimise the costs to society.

To conclude. Is there a crisis? Parts of the scientific community, understandably, have used this rather emotive label. Rather, the research industry is undergoing a major overhaul. There can be no doubt that government strategy to reduce public funding was, in general, soundly based. Clearly there was scope for a more equitable sharing of the costs of research. Taxpayers in general had been bearing a very substantial part of the costs of R&D. Yet there were demonstrable areas in which the primary benefits of that investment were captured by industry groups or even specific firms.

On the other hand, there was no overwhelming body of evidence to suggest that rate of return to the nation's investment in agricultural R&D was unsatisfactory. Hence, it would have been difficult to make a compelling case for cutting the total level of investment in R&D. This crucial distinction between 'how much to invest' and 'who should pay' has been lost in the 'Treasury bashing' polemic.

Private sector funding was expected to increase to supplement public funding without reducing the overall research effort. However, the way in which the transition was managed did not facilitate greater investment by firms and industries.The government adopted a long term perspective in which its role was to be to limited to the formulation of a suitable legal and economic framework in which private R&D investment could occur. Public funding for research implicitly was to be restricted to supporting those areas which generated widespread social benefits.While this policy may be appropriate in the long term, it has not provided the guidance for adjustment that research agencies and the private sector needed. Nor has it, until the recent publication of the STAC Review, included a clear role for the government in the management of public research, either during the adjustment period, or in the longer term.

Although public funding was intended to be used for 'basic' or 'public good' research, and private funding for commercial research, there were no guidelines which enabled research agencies to distinguish between the two. The way that the cuts were implemented has apparently reduced real research spending, and eroded the nation's long term research capability. Furthermore, there been no systematic means of allocating public research budgets to those areas that yield the greatest net benefit to society, or to those research agencies which would produce the desired research most efficiently. Clearly there is room for improvement in the government's management of public research. The recommendations of the Science and Technology Advisory Committee herald the formulation of a national science policy for the funding and conduct of all areas of research. What is needed is a consistent, clear and certain policy environment. This should then end the somewhat sorry spectacle and disarray which has accompanied the structural adjustment of the R&D industry to date.

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