Current Issues in Planning and Guiding Public R&D Investment in New Zealand: Planning under Uncertainty

Australian Agricultural and Resource Economics Society Conference,
February 13-16, 2007, Queenstown New Zealand
By Robin Johnson Consulting Economist, Wellington, New Zealand

Compared to other OECD countries New Zealand has high proportion of government funded R&D investment though a relatively low proportion of GDP as a whole. In the 1990s it was decided to re-organise the structure of R&D organisation in NZ changing government departments into government-owned research companies and allocating public funds on a contestable basis through another public agency. This paper is about models for allocating the remaining public funding to all those who apply – public and private research institutes, universities, and any other appropriate research organisation. The crown institutes have a declining share of public funding and complain that the mechanisms for public funding are discriminatory and unfair.This paper discusses the public funding mechanism from the point of view of maximising the social return to investment.

Background

Up to 1990, the major government departments involved in R&D in New Zealand were the Ministry of Agriculture (MAF) and the Department of Scientific and Industrial Research (DSIR). In conjunction with the Weather Bureau in the Ministry of Transport, the Forest Research Institute in the Department of Forestry and the Communicable Disease Centre in the Department of Health, the staff and resources were re-organised into 10 subject matter crown research institutes, AgResearch, NIWA, HortResearch, Crop&Food, Landcare, Forestry, IndustrialResearch, Geology, Social and Environmental science(ESR). As well as large staff resources, some of the institutes were allocated large farm areas which previously belonged to the government departments. These research campuses were known internationally for grassland and disease control programmes viz Ruakura, Invermay, Wallaceville, Taita and Grasslands.

The Ministry of Research, Science and Technology (MoRST) was created to take care of policy advice functions and the Foundation for Research, Science and Technology (FRST) was established to manage the contestable funds scheme. For a start, the funding mechanism was known as the *Public Good* Science Fund (PGSF) though this term has been dropped in later years. FRST seeks bids for research funds according to a list of priorities established by MoRST. In establishing major programmes of new work, the Minister sends a Ministerial Direction to FRST outlining the goals of the programme and a list of criteria for FRST to follow in judging applications for funds for the purpose identified.

This paper first outlines the structure of present-day funding system and the funds made available from central government, the allocation system for public funds, and

second, discusses whether the contestable bidding system administered by FRST, can possibly achieve some kind of `best' social return to the nation.

International Comparisions

In New Zealand total research expenditure has been being maintained at around one per cent of GDP for some years. With the reforms that have just been discussed, a declining share of expenditure has been delivered by government institutions (Table 1). Even so, Government sources still fund around 60 per cent of that total (including Vote Education-see Table 3). Private business and the universities have been taking on an increasing share of delivery as the reformers desired but public funding has varied around the 60 per cent level since 1990-91 (Johnson 2000, p.139).

Table 1: R&D expenditure as a share of GDP by major providers (%)

March year	Business	Universities	Government	Total	$m
1993-94	0.33	0.21	0.41	0.95	726.4
2003-04	0.40	0.33	0.29	1.02	1398.3*

*** MoRST estimate of expenditure on a comparable basis to earlier years. The actual survey found a sum equal to 1.16 per cent of GDP and was based on wider coverage.**
Source: MoRST (2006)

However, research interests believe that a national investment of only one per cent of GDP is a national disgrace and quote information from other OECD countries of similar size that invest double that amount in R&D (Table 2). New Zealand ranks very low among the reference countries quoted in the source. Over the whole of the OECD sample of 31 countries in 2004, New Zealand was ranked 21st for business R&D expenditure, 24th for higher education expenditure but 7th for government expenditure on R&D as a percentage of GDP. The countries with even higher government investment in the reference year were Iceland (0.74), France (0.36), Finland (0.34), Germany (0.34), Australia (0.33) and Korea (0.33). The research community believes these ratios are a measure of performance between countries (MoRST 2006). Such reasoning does not make economic sense, the alternative is to seek reasons in the area of rates of return on R&D investment and in the over-provision of some services by the state.

Table 2: Investment in R&D by providers in comparable OECD countries as a percentage of GDP 2004

Country	Business	Higher Education	Government	Total
Sweden	2.95	0.88	0.14	3.98
Finland	2.45	0.67	0.34	3.48
Denmark	1.83	0.60	0.18	2.62
All OECD	1.53	0.39	0.28	2.26
Norway	1.00	0.48	0.26	1.75
Australia	0.87	0.45	0.33	1.69
Ireland	0.80	0.30	0.09	1.19
New Zealand	0.49	0.33	0.33	1.16*

*** This is actual survey result for 2004 and supplied to the OECD secretariat.**
Source: MoRST 2006

The government authors question whether New Zealand needs to reach the OECD average for R&D performance (MoRST 2006, p.21). They suggest that NZ should be expected to spend less because of the small size of the economy, the lack of large manufacturing firms, the existing role of the CRIs and the universities, the inward flow of R&D by multinational firms, the lack of high technology industries such as aerospace, defence or automotive industries, and the dependence on primary production. On the other hand, the research providers consistently state that the overall investment is too low and the government could contribute more to R&D activity.

From the government point of view, it is clear that budget decisions have consistently lowered the government share of R&D provision in terms of GDP growth. This pattern follows the policy decisions taken in the 1990s where the burden was to be shifted to the private sector. The research industry (or the more vocal members of it) crticise both the total government funding amounts and the way it has been allocated. The FRST decision processes work by a list of qualitative criteria whose final results can only approximate to a full analytical ranking consistent with rate of return studies.

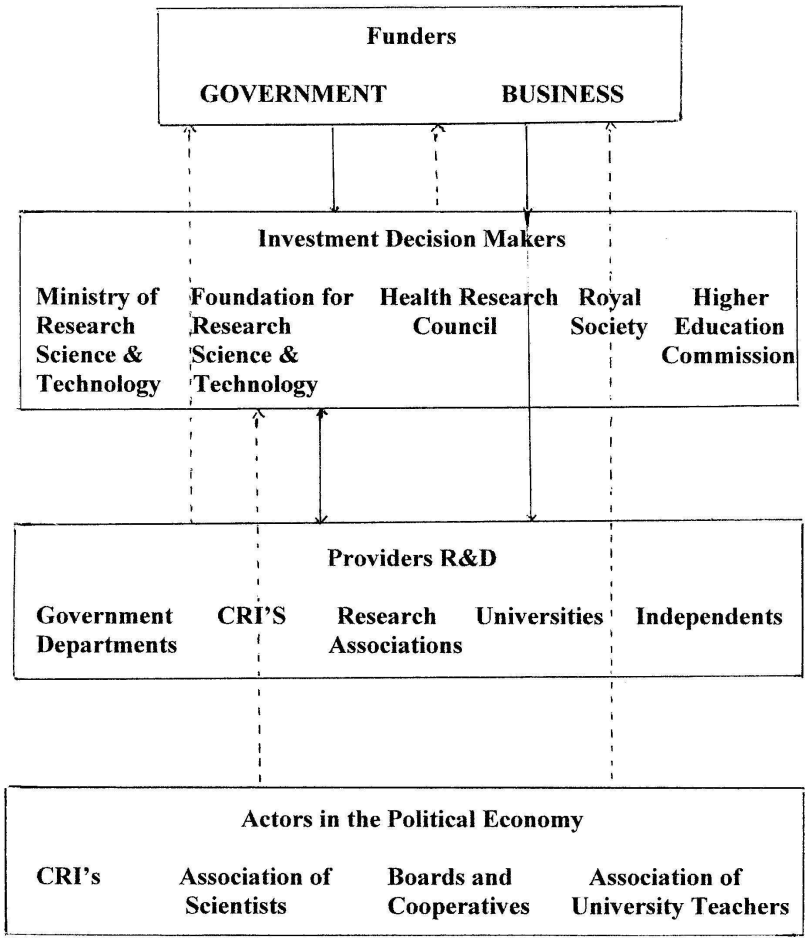
Total Public Science Funding in New Zealand

Figure 1 shows the structural relationships in the NZ public science system. According to the 1990 reforms, the roles of the funders, operators and administrators are clearly delineated . Government funding is allocated by several organisations beside FRST. MoRST only has an advisory role. The operators or providers are the public and private research institutes, the universities, some government departments and private research entities. Influential entities in the whole system are the Crown Research Institutes, the Association of Scientists and the Association of University Teachers.

The Foundation is not the only grant giving organisation in the system. Table 3 shows in more detail the structure of the system. Some of the public funding tasks have been devolved over the years to the Royal Society and the Health Research Council as well as the Foundation. The role of purchase agents was re-defined in the 1999 reforms of goals and objectives (MoRST 1999) The goals and supporting outcomes demonstrated to providers what was expected in making applications for funds. The 1999 statement said that this new investment framework will require significant changes in the nature and scope of the activities of purchase agents managing Vote RS&T investments. Purchase agents were to implement the new investment framework by managing and focussing their investments in ways that contribute to target outcomes, negotiating portfolios of RS&T programmes to contribute to each outcome and providing an

annual `strategic analysis'to the MoRST

Fig 1: POLITICAL ECONOMY OF PUBLIC SCIENCE IN NZ



Research Associations (RA's): Private sector producer groups
CRI's : Crown research institutes

One can see an agent-principal problem in that R&D grants are all based on qualitative criteria and that priorities can vary from agency to agency. Some of the possible differences may have originated in the different formation of each of the science purchasers at different dates. The 1999 reforms sought to look forward to future needs (the Foresight Project) and to make investment more enabling and less prescriptive. There had been a lot of dissatisfaction among recipients in the 1990s as to the directions that were being followed. It appears that the previous framework did not have a transparent strategic direction and was also beset by downstream

implications of changes in R&D investment with regard to staffing levels and forward planning. It is said that one in 12 applications to FRST were successful as compared with one in four in the UK (Johnson 2006).

Table 3: Structure of MoRST-funded Research, Science&Technology

POLICY ADVICE	FUNDING AGENCIES	MAJOR FUNDS	PROVIDERS
Ministry of Science Research&Technology	Royal Society of New Zealand	Marsden Fund Supporting Promising Individuals Promoting an Innovation Culture	Universities Crown Research Institutes Research Assns. Private Business
	Health Research Council	Health Research Maori Knowledge Supporting Promising Individuals	
Foundation for Research, Science & Technology	Foundation for Research, Science & Technology	Research for Industry Technology NZ Pre-Seed Accelerator Fund New Economy Research Fund Supporting promising Individuals Maori Knowledge & Development	
	New Zealand Venture Investment Fund	Venture Investment Fund	

Source: NZ Yearbook 2004, p.270.

Government spending on R&D is spread between Vote: Research Science and Technology and Vote: Education. The size of the RS&T vote has kept pace with growth of GDP (Table 4). Currently if the Education research vote is included, the combined votes are 0.60 per cent of GDP. The overall RS&T vote has increased by 35 per cent in the last six years; with innovation funds gaining share as well as Technology New Zealand (a grant scheme). Some of these provisions are for administration like policy advice and project management, but the majority of the named programmes (outputs in the jargon) are available for public tender including the crown research institutes.(Individual programme trends in the table are unreliable as there appear to be changes in the output classification over the years). Vote RS&T appears to have grown from 0.35 per cent of GDP to 0.42 per cent from 1994-95 to 2006-07. Thus central government is financing more and more R&D investment through its public good funds but its institutes and departments are getting a declining share of the funds made available. This has been the general trend of government policy direction since 1990.

The share of public funding that is contestable is called the Public Good Science Fund and is administered by FRST. As Table 3 shows, PGSF funding has declined from 85 per cent of RS&T funding over the last 10 years to 70 per cent.

Table 3: Vote Research, Science&Technology: 1994/95 to 2006/7

Output Item		94/95	99/00	00/01	03-04	06/07	01-07
INNOVATION							**+ 61.3**
Marsden Fund		-	22.8	25.8	32.8	33.9	
Support for Promising Individuals		-	8.5	10.7	14.6	18.3	
Promoting Innovation		-	3.2	3.0	2.7	4.6	
Policy Advice		-	-	5.8	7.3	13.4	
Non-specific Output Fund		-	26.8	27.4	28.5	46.6	
STAC		-	-	0.6	-	-	
Contract management		-	8.7	0.6	0.6	20.5	
Research Contracts		-	-	11.2	17.4	-	
ENVIRONMENT		-	83.4	84.0	88.6	90.2	+ **7.4**
SOCIAL							
Social research		-	3.7	4.3	8.6	5.9	+**16.5**
Maori Knowledge		-	3.5	4.0	5.5	4.9	
Health Research		-	30.4	33.4	42.2	59.0	
ECONOMIC							
New Economy Reseach Fund		-	5.6	50.8	63.9	61.6	**+21.2**
Grants to Private Sector		-	16.2	11.8		-	
National Measurement Stds		-	4.6	4.6	5.1	5.5	**+19.5**
Technology NZ		-	-	24.7	44.0	47.9	**+93.9**
Research for Industry		-	205.9	171.1	185.0	190.7	**+11.4**
MISCELLANEOUS							
Int'l Investment Opportunities		-	-	-		9.6	
Development of Int'l Linkages		-	-	-	3.0	2.5	
Advanced Networks		-	-	-		10.4	
Other		-	-	-		3.4	
Technology Partnership		-	-	-		1.9	
Pre=seed Accelerator		-	-	-	4.8	8.3	
Total Vote RS&T	$m	300.4	424.4	473.9	556.9	638.9	**+34.8**
GDP	$m	86000	108600	115000	137786	150500	**+30.9**
Vote as % of GDP		0.35	0.39	0.41	0.40	0.42	
Vote Education: Funding administered by the Tertiary Education Commission						$267.1m	
PBRF						189.7	
CoREs***						22.7	
Other						54.6	
Total of both Votes						$906.0m	
Total Votes as % of GDP						0.60	
PGSF Grouping*$m		**256.3**	**332.7**	**347.6**	**389.4**	**451.0****	**+29.7**
PGSFas % of RS&T		85.3	78.4	73.3	69.9	70.6	

* Research for Industry, NERF, Maori, Environment, Social, Health.
**2005-06
*** Centres of Research Excellence.
Sources: (www.morst.govt.nz/budgetstatements), Morst pers com (K Orr). Not all output items match previous years.

Investment Strategies: 1993 to the Foresight Project

The Ministry of Research, Science and Technology is the chief scientific advisor to the government of the day. It does not have an operational role. The Foundation of Research, Science and Technology administers the research funds although it also has a small policy role. MoRST is required to provide a Statement of Intent under its legislation setting out what the Minister sees as the general direction of science funding for each forthcoming period. FRST then administers a bidding round where all the providers submit their research plans in advance and decisions are reached through a series of referees and advisory committees. The priorities for investment are thus established by MoRST and the government in a general form but the administrative details fall on FRST.

From 1992, FRST administered the public good science fund (PGSF) system which pooled the available government funds for research and development (R&D) from a number of government departments[1]. The newly formed crown research institutes (CRIs), other providers, and later the universities, were able to draw on these funds provided they met the administrative criteria for public good research.

FRST took over a research priority system that had been devised by the DSIR. The procedure had been developed by defining a research agenda broken down by what were called 'output areas'. `Output areas' groupings were common interest research topics like sheep production and crop production. Within output areas, criteria or rules were to give guidance to final investment according to a Science and Technology Expert Panel (STEP) report to MoRST (MoRST 1992a, p.78). There were 40 output areas originally although these were later compressed to 19 main categories.

In the final report of the Panel, they raised concerns about the balance of research funding between research directly impacting on economic performance, and research underpinning areas on which economic activity depends indirectly (infrastructure research, and the social and natural sciences) (MoRST 1992b, p.11). The report noted that 68 per cent of PGSF funding in 1991-92 was allocated to the 'wealth creating' classes 1 to 19 (of the first list of output classes). They stated that this class of outputs was already well funded, but output classes 20 to 35 were more difficult to assess because the benefits they create are less direct and can be longer term. The report recommended a shift in emphasis from both the natural sciences and the production groups to what they called the infrastructural group (output areas 20 to 28). The implication was that 'underpinning' research is more of a public good than 'wealth creating' research goods.

[1] This administrative arrangement had first been suggested by the 1988 Science and Technology Committee (STAC), though it was not adopted until 1991 (Jardine 1989, p.11).

The Panel report recommended a productive partnership between the public and private sector to ensure successful commercialisation of PGSF research results. It stated that PGSF research is more likely to be successfully adopted if the research is planned with strong user involvement and is likely to have the greatest chance of producing benefits to New Zealand where users have well-established market linkages and were performing their own research. The implication was that greater co-operation and co-ordination between sectors would compensate for the low level of private sector sponsorship of research (BERL 1995, p.46).

The report recommended that the PGSF should complement successful private research activities where funds are used to promote strategic and generic research and where there is a demonstrated need for such research. Such complementarity should not displace private research funding, the report states, or support appropriable research. The Panel therefore recommended that using the PGSF to complement private funding 'should be conditional on a continuation or enhancement of funding from the private sector'. A practical problem was the state could complement private sector activity without specifying whether business was a big spender in that output area or not. Re-allocating investment away from one set of output areas created the risk that the gap would not be filled by private enterprise. In addition, the relatively high so-called private investment in some sectors was due to the fact that the industry research associations were arbitrarily classified as 'business' rather than government even though they were all established with DSIR seed money! The key challenge was whether public investment could be used to trigger further private investment in a complementary way, as well as to create conditions where the up-take of the results of all science investment was enhanced.

In the MoRST instructions to FRST dated July 1997 these objectives are reinforced by the Minister (MoRST 1997a). The Minister noted that the organisational gains made had resulted in a strong focus on small-scale purchasing of outputs, over relatively short time frames, and within a rather rigid framework of rules and procedures. FRST needed to develop a strategic, far-sighted, and pro-active strategy for focusing on the achievement of outcomes. 'It will be crucial to foster interactive relationships..... in publicly funded organisations and in the private sector that together underpin a vibrant and thriving knowledge-based society'. With respect to encouragement of the private sector, 'funding allocations should be managed in a way .....that does not diminish the incentives for, or displace investment by other funders .....'

As the 1990s proceeded, these ministerial goals were translated into fresh operational procedures by a wide consultative initiative known as the Foresight Project. The Project was a consultative process which attempted to document a vision of a desirable future and the strategies needed to get there (MoRST website: Statement by Minister Williamson). A new framework for establishing R&D priorities was designed to ensure that Government's investment would be managed in a more enabling and less prescriptive way. The new investment framework was characterised by the identification of goals and outcomes.. In summary, the science envelope goals identified were:

- An Innovation goal – accelerate knowledge creation and human capital;
- An Economic goal – creation of value in new and improved products;
- An Environmental goal – knowledge that sustains a healthy environment;
- A Social goal – knowledge of the physical determinants of wellbeing.

The science envelope goals were to provide overall direction for the public investment in RS&T. They were designed to encourage `stakeholders' and `purchase agents' to seek more effective delivery of desirable outcomes. The target outcomes were 14 future desired states envisaged by the Foresight Project that were cross-sectoral and which provided a `strategic' context for the development of RS&T portfolios, viz:

Wealth from new knowledge-based enterprises,
Innovative manufacturing and service enterprises,
Sustainable use of natural resources,
Wealth-creating food and fibre industries,
Future-focussed global intelligence,
Infrastructure for a knowledge society,
People with knowledge, skills and ideas,
Strong families and communities,
Maori development,
Vibrant culture and identity,
Health for all,
People living in safe and healthy environments,
Healthy, diverse and resilient ecosystems, and
New Zealand in the global biophysical environment

The existing purchase agents (FRST, Health Ressearch Council (HRC), and the Royal Society) would continue to purchase research `outputs' in such a way that they were structured and grouped so that they make a coherent contribution to the science envelope goals. 'Negotiation and relationship building are critical to a stable long-term purchasing environment, but contestability and fostering a diversity of ideas and approaches will remain important aspects of the purchasing strategy' (*ibid*, p.14). FRST with its responsibility for investments under several 'output classes' was expected to organise contracts with providers under each of the output classes to create portfolios of RS&T contracts that make contributions towards the target outcomes

This exercise in public management clarified the goals and strategies to be followed but changed the terminology and funding trail considerably. The role of the purchase agents was clarified (see below). FRST responded to the Foresight Project with clearer guidelines for project selection (see below). The Treasury outputs in Vote RS&T required some modification (Appendix 2 in MoRST 1999) but the total Vote for RS&T outputs thus defined did not increase markedly as the earlier GDP ratios quoted demonstrated.

Balancing Objectives: Scientists' View of Strategies at this time

An interesting question in strategy setting is where to set the emphasis on different aspects of the science process itself as compared with the Foresight consultation. This is sometimes summarised under the headings `fundamental' and `applied' science but I find recent stress on `discovery' `development' & `commercialisation' to be more instructive (Jordan and Atkinson 2003). They start with the proposition that there is a need to produce approximately ten to twenty discoveries in order to select one attractive one to take through development; that the costs of development are ten

times the cost of discovery and that commercialisation costs may be ten times those of development in the NZ situation. However, in NZ practice, the development phase is seldom publicly funded because it has no obvious saleable value. The challenge is to find development funding that will not distort activities on either side of the continuous spectrum of development and commercialisation `If this is adopted as a driving principle i.e. supporting development without draining discovery or misleading commercialisation, then NZ must invest in R&D appropriately and balance the spectrum correctly. Obtaining the right investment in the specrum parts must somehow be coordinated across the public and the private sector funding mechanisms'(*ibid*).

Applying this to the CRI situation, it means that there is a conflict between the provisions of their Act to be financially viable and the requirement to benefit NZ through science infrastructure and research output. There is no provision for CRIs to fund development. And PGSF does not support it sufficiently. But government and the private sector believe CRIs have such a development function. If money is taken from discovery, the infrastructure is run down and eventually the discovery stock is run down too. There is a parallel story in terms of failed bids to PGSF. Science personnel are lost to the system and capacity for certain types of research is run down which in turn weakens the capacity of a CRI to bid for funds in the future. The official response to this argument, as stated by FRST below, is that the CRI system was supposed to adjust to new funding circumstances through amalgamation, cooperation with other providers and seeking other funding. This has clearly proved difficult although the CRI funding story (outlined below) indicates there has been a large shift in total CRI funding away from PGSF projects. To me this seems like a lack of signals at crucial times when the new funding system was being introduced.

Project selection by strategies and house rules

The purchasing agents have to rank the bids for public research funds. For example, FRST receives Ministerial Directions from time to time as to how they are to administer funds made available under a particular Government approved programme. In addition they would be in a position to develop house rules of their own to guide their staff. These administrative decisions would require an information base, skilled staff and evaluators which an organisation like FRST would have in place. The whole process uses the language of *public management planning* and identifies outcomes, outputs and research portfolios in its documentation.

There were 4 goals and 14 target outcomes in 1999 and sector strategies that support them which were to be used as a starting point for developing research portfolios of contracted outputs within the Vote RS&T. (MoRST 1999). Each portfolio was to be designed to make an effective contribution towards the relevant target outcome. As a first step, purchase agents were to map their existing investments across to the target outcomes. Portfolio design was to be the responsibitity of the purchase agents managing Vote RS&T investments - FRST, HRC and RSNZ. At FRST, for example, current practice is for a strategy group to determine questions within portfolios which are then made available as Requests for Bids (RFBs). The portfolio is essentially an internal construction or grouping device for setting research questions in an appropriate context (S Campbell, FRST, *pers.com.*). In the FRST section below there

is a discussion of how FRST defined their strategic objectives following the Foresight project.

As an example, FRST has an `output class' called `research for industry' a $205m research programme in 2004. The outcome or goal sought is stated as `public good research, science and technology that *increases the competitiveness* of New Zealand industries and sectors' (MoRST 2004). The `outputs' identified are:
- `Research whose primary objective is to advance *food and fibre-based industries* and related sectors through innovation. Research portfolios will lead to new products, processes and services that enhance the competitiveness of these industries and sectors;
- Research whose primary objective is to advance *manufacturing and services industries* and sectors through innovation. Assists manufacturing and services industries and sectors to innovate, and includes research on the broad factors affecting business and economic life;
- Research for the development of *infrastructure* to underpin economic development. Assists infrastructure services , such as communications, energy, water and waste, to innovate cost-effectively. It also includes research on New Zealand's mineral wealth and understanding of, and responses to risks faced from New Zealand's physical hazards; and
- Research consortia to facilitate public/private research *partnerships* that provide early user engagement and increase private investment in New Zealand . Research investment will be made through user-led research consortia in partnership with research providers'.

The Government then provides in the Direction a description of the rules it would expect in administering the programme: `As it invests, the Foundation will give priority to portfolios of research that meet the following criteria:
- scientific and technological quality;
- potential benefit to New Zealand through innovation;
- contribution to boosting competitiveness of New Zealand industries and sectors; or contribution to developing a robust infrastructure to underpin economic development;
- clearly defined partnerships and pathways to implementation of the research outcomes; and
- potential to build scientific and technological capability and to increase the level of innovation within user groups'.(ibid).

There are a wide number of such outputs spread between the four goals (some of which are shown in Table 3). There is thus a hierarchy of outcomes, outputs and approved research portfolios. There is no specific mention of rates of return to the nation except for the instruction to take account of `potential benefit to New Zealand through innovation'[2]. One output class is concerned with the development of infrastructure which also includes an understanding of and response to risks faced from New Zealand's physical hazards. At this level, there is no specific indication of the risks or uncertainty that the proposed research investments posess. There is thus a

[2] There is an explanatory memo on the MoRST website "Benefit to New Zealand: Principles for Publicly Funded RS&T" which spells out a broad definition of the nature of the benefits expected. They comprise the total economic, social and environmental benefits that accrue to NZ residents from the creation and application of new knowledge generated by RS&T. The public sector should not subsidise RS&T that the private sector or others would or should do anyway but it may add to it.

weak emphasis on economic criteria in favour of strategic rules suitable for use at administrative levels[3]. In the FRST discussion below there is a recognition of the risk to funders of investments not reaching their declared potential.

If a financial risk analysis is not possible in the circumstances, then presumably a social optimum might be achieved by way of expert committees and house rules? It would then be possible to talk about the aggregate selection and choice of projects providing the best social rate of return. However, the agricultural research interests indicate that they have the view that their projects have been discriminated against throughout the process and export sector outcomes have been ignored. Some possible reasons for this are discussed at the end of the section on agricultural R&D.

The FRST framework

This section summarises FRST's portfolio investment strategy and grouping of portfolios, generic instructions for advisory groups and expert advisors and treatment of research bids. The Foundation 2006 investment framework comprises 18 distinct investment portfolios grouped within five funds (Table 5). The NERF group supports researcher-led innovation aimed at developing capability and knowledge in new areas or applications where new industries are emerging or yet to emerge, in order to underpin new high-technology business opportunities. The focus of the research is on targeted-basic research and human capital that will underpin new enterprises and new sectors. Research for Industry group focuses on research that will help sustain the value of current industries, add value through new or improved products, processes and services and to a lesser extent, create new businesses. The ERF supports public good research, science and technology that enhances the understanding and management of `our environment'. The SRF supports public good research that improves societal wellbeing and the MKDRF supports the development of research capability and knowledge for the benefit of Maori and New Zealand (FRST website).

Table 5: FRST Investment Portfolios 2006

<u>New Economy Research Fund</u>

Technologies to leverage NZ 's strengths
Creating opportunities through new physical technologies
Future human technologies

<u>Research for Industry Fund</u>
Production, quality and assurance
Sustainable production systems
Niche biological products and services
Innovation foods
High value manufacturing processes, products and materials
Optimizing physical resource use and infrastructure services
Resilient infrastructure and communities

[3] A comparision would be an investment company buying and selling shares on the stockmarket where future earnings on company shares are unknown or at least uncertain and a strategy has to be in place for dealers to follow. It follows that good management would require that the selection of high return but risky investments is balanced by investments of lower return but lower risk.

Building knowledge intensive service industries
Sustaining NZ's economic and technological development

Environmental Research Fund
Resilient, functioning and restored natural ecosystems
Maintaining environmental integrity for sustainable resource use
Building sustainable cities and settlements
Understanding and adapting to global environmental change.

Social Investmment Research Fund
Building an inclusive society

Maori Knowledge and Development Research Fund
Te Tipu Te Wananga

Source: FRST website.

Taking the primary production and sustainability investment portfolio for 2006/07, the FRST file states that $18.8m per annum is available for investing in Production, Quality and Assurance, and $2.3m is available for Sustainable Production Systems. Funds will be invested using a mix of contestable and negotiation processes. The contestable process will be held in two stages viz an initial concept phase followed by a full proposal phase for selected concepts in 2006 and 2007. The Foundation has contacted research organisations with contracts that are eligible for negotiation in the 2006/07 investment round inviting them to enter negotiation. The Foundation uses a range of expert advisors to help assess concepts and proposals for investment. These advisors make recommendation to the Foundation as to what to invest in. Members of advisory groups are posted on the Net (FRST website).

In another file, FRST sets out generic guidelines for advisory groups and other expert advisors (FRST website). Groups are instructed to make concensus decisions on assessment of individual proposals against required criteria; to recommend investments to the Foundation and advise on risks and appropriate mitigations; and to rank the proposals before them. Advisory groups are selected to ensure a balance of experience and skills. They are to score proposals against established criteria. They are to incorporate the views of expert reviewers where these are not members of the panel and take collective ownership of the Advisory group recommendations and the processes used. Information should be made available as feedback to applicants.

This summary indicates that the process is highly transparent and has built-in criteria for independent assessment of proposals. The assessment is clearly qualitative and not quantitative in nature. It seems that investment monies available are set in advance and hence are going to be important in setting funds going to different portfolios. Summing up recommendations across portfolios will bring about some form of highest social return possible depending on the initial allocation of investment funds to portfolios.

Is Optimization Possible?

The alternative to house rules for project selection is some sort of ranking based on estimated internal rates of return or other substitute criteria. I look at performance-based funding as employed in the NZ universities, literature outputs as suggested by CCMAU, and the few available studies of future internal rates of return.

Hazledine and Kurniawan (2005) report a study of efficiency in New Zealand universities using the Performance Based Research Fund (PBRF) administered by the the Tertiary Education Commission. In this case study the authors have data on performance ranking of individuals and campuses and associated costs of research and teaching which form the basis of a productivity measure comparable between universities. Such a model would permit administrators to deduce where the PBRF would be best spent among subject areas and institutions. Is this the kind of model that FRST should have in mind?

The process of measuring research performance for the 2003 PBRF round was based on:
scores for each of more 8000 academics in the eight universities (and some polytechnics and colleges);
scores were produced by 12 `peer review panels' dealing with subsets of academics divided inti 41 subject areas;
scores covered research performance over 6 years (1997-2002);
scores were weighted aggregates of 3 scores for each academic `research output' (70%), `peer esteem' (15%), and `contribution to research environment' (15%).
results were shown publicly only at the subject area and total institution level (ie not for individual staff);
funding is based only on total institution score. (ibid, p.156).

The authors arrive at a university level ranking based on total PBRF score per eligible staff member. Auckland University is at the top of the Table.

As a measure of the universities' teaching output the authors devised a weighted measure `Arts equivalent ' FTEs. This is to overcome the higher costs of teaching science and medicine. For each subject, FTE grants from government are added to to the fee payable by a student to get an estimate of per subject or per faculty teaching cost. These were then weighted by the ratio of teaching costs to Arts teaching costs to obtain total arts-equivalent FTEs cost. For the total costs of achieving the teaching and research outputs the authors use each universitys' total revenue in 2002 from government funding, student fees, research and interest income. As non-profit institutions revenues from teaching and research activities are an appropriate measure of total resources used. Two productivity measures result (Table 6 and Fig 2):

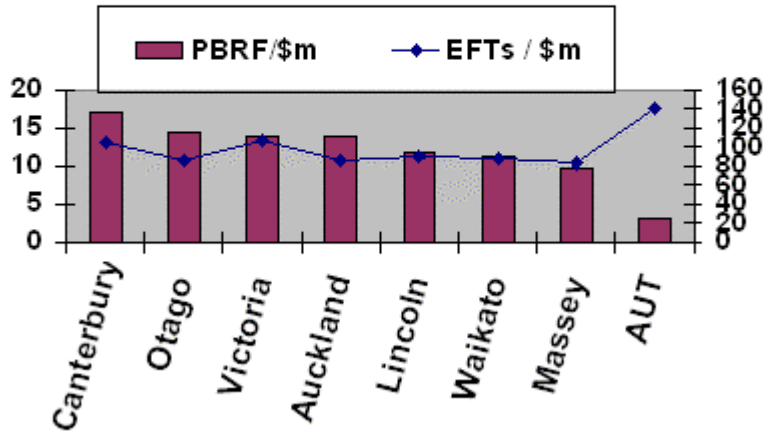
> *PBRF score per $million revenue (cost),* and
> *Arts Equivalent EFTs per $million revenue.*

Table 6: Productivity Measures for the Universities

University	PBRFscore/$m	EFTs / $m
Auckland	13.98	85.8
Waikato	11.28	87.3
Massey	9.67	83.0
Victoria	14.00	107.3
Canterbury	17.14	105.1
Lincoln	11.87	91.1
Otago	14.41	86.6
Ak University Technology	3.23	140.6

Source: Hazledene and Kurniawan (2005)

Fig 2: University Productivity



The authors then explore the possibilities of re-allocating funds between universities. The gains from re-allocation are stated to be moderate. But the study did bring out that funding universities on an FTE basis alone (`bums on seats') discriminated against high research universities (as compared, say, with polytechnics). Under the pre-PBRF scheme, universities were funded principally from student fees, partly paid by the government, and also through externally funded research grants. Low research outputs were not recognised. If enrolments fell, government grants decreased. The PBRF system recognised research outputs and put the research universities on a more even footing with the teaching institutions.

Background: Boston (2006) notes that the *formal* reasons for introducing PBRF was increasing knowledge and understanding, increasing the quality of degree and postgraduate teaching and increasing the level of knowledge transfer..The *primary* motivation driving those in the tertiary education sector who advocated its introduction was to find a politically acceptable means of securing additional public resources for New Zealand's universities and in a manner that would help protect, if

not increase, the degree of institutional and sectoral differentiation, together with the accountability of tertiary education organisations (TEOs).

According to the NZ Yearbook (1993), the present system of funding tertiary institutions was introduced in 1991. The EFTS system funds tertiary institutions *in bulk* according to the number of students and the courses those students are taking. The EFTS subsidies differ substantially across subjects based presumably on teaching cost differentials (Hazledine and Kurniawan 2005). Polytechnics, colleges of education and universities receive state subsidies for the number of equivalent full-time students in each of the course cost categories at their institution These funded places are provided by the government in advance of the funding year. The funding is inclusive of capital works. There is additional student funding called Study Right, which pays an additional tuition subsidy for those eligible.

The EFTS funding system abolished detailed central decision-making about levels of staffing, operating grants, and capital works projects. These responsibilities were transferred to the institutions themselves. According to NZYB in 1991 there were 25 polytechnics, 5 colleges of education, and 7 university institutions. There are a certain number of private training establishments also covered by the EFTS system.

Basically, the system of funding of all post-secondary education in New Zealand introduced in 1991 tended to discriminate against research activities. Education grants were paid on the basis of students enrolled, course by course, suitably weighted for heavier cost courses. This system favoured non-university institutions over university institutions and `teaching' universities (and departments) over research-oriented universities and departments. Boston notes that during the 1990s the undifferentited nature of the tertiary funding system, coupled with inappropriate tuition subsidies, and a relatively lighthanded regulatory framework contributed to a relatively rapid expansion of degree programmes outside the university sector, especially in subject areas where the tuition subsidies were relatively generous compared to the costs of provision (eg commerce subjects). This reduced the capacity of the universities to subsidise those courses for which the tuition fees were inadequate (eg in the sciences) and their capacity to encourage research activity. Out of these concerns came the move to devise a new system for the funding of research based on periodic assessments of research quality. This would ensure that degree providers undertaking research of high quality received funding while those producing little or no research were unable to access the new funds. These arrangements would thus preserve the traditional role of the full universities (`differentiation') and make them less dependent on enrolments for funding.

It should be emphasised that the PBRF scoring system helps determine the allocation from the total appropriation for TEOs to individual institutions. The allocation formula is based on qualifying staff numbers in an institution weighted by a quality rating, a subject weighting and an FTE component (B.Mischewski, TEC, *pers com*). The institutions themselves have devolved responsibility for allocating the funds received to departments and/or research topics (Bakker & Mischewski 2006).. Thus the PBRF system described above is not a formal basis of project selection but a funding mechanism that reflect quality of research, advanced degree completions and external research income.

Discussion: Can we visualise how a possible ranking scheme would work for applications for public good R&D funds? The key would be to find an equivalent measure to PBRF scores. Do peer reviews employed by FRST and other purchase agents produce quantitative scoring data? Could applicants be required to submit estimates of the implications of their projects on potential national benefits? How does one measure national benefits?. As the section on measurement of R&D returns shows, there is not a strong relationship between R&D investment and industry returns. The measures available are too aggregate, on the one hand, and too uncertain in the timing of their impact, on the other. One suggestion made before in this context is to start assessment at the micro or project level and build more aggregate results from a sampling or a survey basis?. FRST would doubtless answer that their methodology encompasses all of these points.

Measuring CRI performance

Jordan and Atkinson (2003) emphasise the role of discovery in the science system and question whether CRIs are maintaining this aspect of their work under the funding system prevailing at that time? As a measure of performance, they suggest, apparently in agreement with CCMAU, that a meaningful and comparable benchmark is international journal publication 1993-2002. This is also assessing research at an institutional level and not at a project level.

This is shown as Table 1 in their text and in some cases includes both NZ journals and international journals.. The record is not entirely complete back to 1993 but it does give some possible tends. The authors say `We note that AgResearch over ten years showed an increment in total journal publications, but the number of papers in international journals indicating competitive science, was near static, despite large revenue increases (56%) over this time. HortResearch did not report international publication separately for most of this time but showed a precipitous decline in totals and at best a static result for international publications for the last 3 years while revenue increased 24%. The publication output for IRL was spiky but near static in totals (revenue 54%).GNS was up and down (revenue 52%) and NIWA had a flat total of intenational publications in the last four years (revenue 127%). FRI showed some incease over 4 years (revenue 38%). They conclude`This is not a record of international accomplishment in science which might be expected of apparently healthily growing science institutions. Has there been a diversion of resources?'

The Foundation Responds

In 2003, the Association of Scientists published a series of papers covering allocation and sharing procedures in the science system (NZAS, 2003(2-3)). Among the essays is a perceptive contribution by FRST staff member N Allison (*ibid*, pp.84-87). The author enlarges upon the Foundation's core responsibilities.

His contention is that the performance of the system as a whole could be lifted through changes in, and improved clarity of, roles, responsibilites and accountabilities. When decisions are made in the wrong places, within the RS&T system, there is likely to be an associated failure to execute actions. Decisions need to be made by those closest to the information and who have the incentives to perform. This requires an understanding of the competencies and comparative

strength of key players in the system. FRST core competencies support its ability to develop strategic research directions, run investment processes of integrity, provide performance incentives for research providers and advise Government on investment priorities.

He notes that while research papers and international colaboration had risen in recent years, strategic partnerships between research providers remained modest, engagement with research users was typically poor, and public science providers produced a relatively small output of codifed intellectual property. There was the impression that there may not have been large spill-over benefits for the economy from Government RS&T investment. Recent changes to the system still raised concerns over the uncertainty inherent in the system. They occur in the context of low salaries for scientists relative to similar professional groups, and a perception of a lack of career development opportunities, reflected in student career choices.

FRST saw its task as meeting the Minister's 2003 Direction concerning more focus on pure ideas, driving innovation through strengthened capability, and generating investment to extract greater commercial value (Buwalda 2003). It was up to science providers to develop the culture, skills and market relationships to bring this about. FRST's task/role was to improve performance by setting long-term research directions and managing associated capabilities.

In terms of the Foresight project, the Foundation folded 120 Foresight Strategies developed by sector groups into 25 Strategic Portfolio Outlines, dissociating end-user groups from the final product. Foresight directions were then diluted through the use of 72 portfolios through which the Foundation invested funds. The strategic role of the Foundation was to initiate a continuous incremental process of setting and revising RS&T directions, which could adapt and adjust to changing opportunities and future outlook. Purchase agents had comparative information advantages and were best placed to manage continuous priority setting processes within policy parameters set by government (Allison, *op cit*). However, FRST would never glean the RS&T expertise, market knowledge and relationships to develop strategies to make specific bets on specific platforms for future research. The Foundation should set clear but high-level objectives, such as increasing the value of RS&T-based exports, use effective proposal selection criteria, and then select the winners that emerge from largely bottom-up processes as discussed earlier.

The role of the science providers in the public system would be to provide increased and balanced capability to meet policy directives for public research. In the case of redundancies, research contracts exist between the purchaser and the research organisations – not the research team. A key role of management is to ensure that exposure to risk does not fall unfairly on the shoulders of a few.`Teams might as well contacr directly with with FRST. Indeed the old audit-funding trail was a *de facto* form of such a contract, and some researchers may have seen FRST as their employer!(authors exclamation mark). Providers now have to manage their exposure to risk, although FRST does assist with making difficult transitions that result from changes in its investment'.(*op cit*).

This Foundation view of the world, in 2003, thus sees MoRST as an advisory body to Ministers on the parameters governing priority-setting processes administered by the

purchase agents; purchase agents operate incremental and continual priority setting processes in accordnce with these parameters; such parameters would include expectations relating to the management of national capabilities concerning science infrastructure, and purchase agents design investment processes to devolve decision-making to providers where there are appropraiate incentives to perform and adequate measures for accountability (*op cit*).

Now this is a clear statement of departmental responsibility and roles related to earlier discussion of the whole RS&T system. The key operatives are the portfolio strategies which are presumably not unlike the strategies quoted earlier for `research for industry'. Bureaucratic processes are still required to select investments and to balance the different requirement laid down by government. Who is to judge whether the resulting portfolio selection (in the financial sense) in any one year is anywhere near a social optimum?

Measurement of the rate of return on R&D Investment

Lillis (2006) points out that assessing the contribution of R&D to sectoral and national outcomes is most difficult, and disaggregating the contribution of R&D from those of many other inputs presents a particular challenge.He notes there is an ongoing international debate concerning the optimum role for governments in funding research, and in many nations the government 's role is primarily to address market failure, supporting long-term research that the private sector either cannot afford or from which short-term profit cannot be derived.It is debatable whether having a high proportion of scientists in the workforce underpins a strong economy, or whether a strong economy provides the means for more people to engage in blue-skies scientific work?.

When evaluating R&D outcomes, issues of causality and attribution (of outcomes to particular research investments) arise frequently. In practice, he says we face great challenges in demonstrating that particular outcomes (eg rise in GDP, increase in sector sales) arise because of particular research investments. He notes Hemlin (1999) states that there are no reliable methods for assessing direct causality between public funded research and productivity. He notes that it is usually easier to assess causality at the level of the firm or industry than at sector or national level.

Econometric studies in NZ employ industry net output or Solow type measures of net productivity as the dependent variable. Regressions are specified that include capital and labour (in the first case) and measures of stocks of R&D knowledge. The latter are defined as depreciating assets that are added to by expenditures on R&D but also subtracted from as the ideas lose relevance. It is common to separate stocks derived from public funds and those generated by private funds. The scope of these studies is limited by a lack of data on investment in R&D at the industry level. This is important as each higher level of aggregation obscures the possible underlying responses to R&D carried out.

So far these studies have identified positive relationships between net output (after a period) and private R&D investment in the total market sector and in agriculture, processing, and services. For public R&D investment there is negative relationship for the total market sector and the agriculture, forestry, manufacturing, and transport

sectors. Translated into rates of return on past investment in private R&D these results indicate returns on investment varying from 12 per cent (market sector) to 68 per cent (agriculture)(Johnson 1999).

Earlier studies have included a study by Scobie and Eveleens of the agriculture sector where fairly clear records of research and extension expenditure had been kept (Scobie&Eveleens 1986). This study related R&D expenditure to a total productivity ratio (gross return/total input) for the sector drawn from the work of B.P. Philpott (1969). The Scobie and Eveleens study of agricultural productivity from 1926 to 1984 used a model in which the observed level of total productivity in agriculture in each year was dependent on:
the weather conditions (as measured by an index of soil moisture deficits) in the previous year;
the level of spending on extension services;
the number of graduates and diplomats trained in the agricultural sciences (including horticulture, veterinary science, food technology) over the past 15 years;
the economic conditions of the agricultural sector (as measured by the annual deviation of net farm income from its long term trend); and
the real spending on agricultural research in that year, and in each of the preceding years (up to 30 years earlier).

The results showed that, on average, research results are slowly incorporated [in the case of livestock farming] into practice and their impact on productivity increased reaching a peak after 11 years and finally tailing off after a total of 23 years. In terms of research expenditure alone [i.e. holding other variables constant], $1m of research expenditure generated total benefits of $8.5m over the following 23 years, giving an internal rate of return of 30 per cent.

Cost-benefit Studies

Table 7 shows the results of cost-benefit studies on a project basis undertaken by FRST and HortResearch. While these may be possibly `successful' projects, they have longer track records that permit evaluation. The results are generally very favourable. It is not clear to me whether the methodology is always the same in each case study. There is a need to be clear about private returns and social returns to investment and whether national income conventions are being observed. The point of these results is that they are concrete evidence of the national benefit from research investment and that they do away with unwarranted criticism that research does not pay off.

Table 7: Foundation and HortResearch Cost-benefit Studies

Subject	Authors	Methodology	Results
FRST			
1. Possum Control Landcare	Outcome Management Services (M Rosevear)	Public Good paradigm Economic agents who gain or lose'.	IRR 28%
2. Mobile Radio Network Development Tait Electronics	Infometrics	Qualitative assessment Private costs and benefits	No IRR Pvt B/C 2:1
3. Post-Harvest Treatment of Carrots Plygers (Developer)	NZIER (C Nixon)	Developer's perspective Private viewpoint?	IRR 30% B/C 2.5:1
4. Vitamin B12 Deficiency Remedy Ag Research	NZIER (M Cox)	Social cost benefit `Large and diverse economic benefits'	IRR 41% B/C 10:1
5. Speedwell Cattle Vaccine (forthcoming)	N/A	N/A	N/A
HortResearch			
a. Zespri Gold Kiwifruit	MARTECH/NZIER	Comparision with next best land use	IRR 10% NPV $28m
b. Zespri Growing System	ditto	ditto	IRR 47% NPV $196m
c. Jazz Apple Cultivar	ditto	ditto	IRR 13% NPV $3m.
d. Pests on Export Apples	ditto	ditto	IRR 43& NPV 17m
e. Hop Research	ditto	ditto	IRR 8% NPV $5m.
f. Blueberry cultivar	ditto	ditto	IRR 19% NPV 0.5m.
g. Asparagus Development	ditto	ditto	IRR 53% NPV $2.1m.

Source: (www.frst.govt.nz/evaluation; www.growingfutures.com/casestudies).

Under-Investment in Agricultural R&D

In the years up to 1999, public good science effort was categorised by `industry output areas', defined as areas where major beneficiaries were located[4]. Total public good funding of investment proposals was published in terms of these classifications. Of the 19 `output areas', four could be clearly classified as `agricultural research';

[4] Output areas were categories used by the DSIR prior to the reforms. They reflected earlier attempts to identify goals and objectives for the science organisations by subject matter. Currently statistical material is set out by socio-economic objectives said to reflect the purpose of research (MoRST 2006).

namely animal research, dairy research, forage and crops, and horticultural crops research (Table 8). The extent of the subtle shift in funding over the years from 1993 to 1999 by the contestable funding system can be seen in the decline in agricultural research outputs' share of public good funding from 46 per cent to 42 per cent, with only dairy research actually bettering its share of resources. This data was discontinued after 1999. It should be noted that the above `output areas' do not exactly follow the same boundaries as those of the research institutes, and also include private providers and the universities (i.e. all sucessful applicants for public funds in these categories).

Table 8: Trends in agricultural output areas' share of public good funding (%).

March yrs	Animal Res	Dairy Res	Forage/Crops	Horticulture	Total
1993-94	15.0	3.1	8.5	19.9	46.5
1999-00	12.4	4.7	7.2	17.3	41.6

Source: Johnson *et al* (2006).

The agricultural CRIs also received a diminishing share of the the total public good funds made available through the contestable bidding process (Table 9). In the long run, there has been a gradual shift from public funding to private funding of CRIs. From 1993 to 2004, non-governmental funding rose from 37 percent of total revenue to 54 per cent across all institutes (Johnson *et al* 2006). Of these total funds, the agricultural CRIs' share fell slightly from 55 per cent to 52 per cent. Their share of public good funds fell from 59 per cent to 50 percent, and as a result of these two trends, agricultural public good funding fell from 37 per cent of all funding to 23 per cent. This confirms the trends shown up in the `output areas' analysis in Table 8.

Table 9: Trends in the share of R&D resources devoted to agricultural research institutes (%).

March yr	Agr share of total CRI funding	Agr share of public good funding to CRIs	Agr public good funding as share of all CRI funding
1993-94	54.7	58.9	36.9
2004-05	51.9	50.1	23.0

Source: Johnson *et al* (2006)

This scenario is the result of the cumulative effect of FRST administrative processes rather than a deliberate government policy instruction. CRIs were instructed to find alternative sources of income, administrators were told to involve the private sector to a greater extent. Private sector assistance was expanded and funds made available. `Agriculture' was suspect because it had previously received the greatest public support for many years. However, there is a lack of evidence to demonstrate whether the new allocation of funds is a better outcome than it was was previously. Reasons for the decline in agricultural shares of public investment in R&D include:

- a common belief that agriculture is an 'old industry' and support should be going to 'new' industries;
- the move from production output area goals to broader goals;
- constraints on public funding;
- the movement away from public providers of appropriable (profit-earning) research;
- a shift away from output areas where public good funding was 'too dominant':
- the desire for 'complementary' or supporting funding to the private sector;
- the 'crowding out' belief held in some circles (government activity taking over private sector roles); and
- the possible over-application of 'market failure' theory (too much public support for areas of under-investment).

The science reforms were carried out after the government management reforms of the 1980s. Prior to the election of the Labour Government in 1984, government policy for development had been oriented around export industries. This owed its antecedents to the 1963 Agricultural Development Conference which had focussed on improving the national balance of payments deficit. After the 1985 devaluation and the floating of the exchange rate Finance Minister Douglas had stated that exports no longer matter. Thus the science reforms came in when the export imperative was no longer operating and other reasons had to be sought for justifying higher expenditure on public R&D. Now MoRST (2006b) have published a think piece by one of its staff that re-echoes the earlier export paradigm. He concludes `Primary sector outputs should be seen not just as commodities but instead increasingly as the sophisicated products of world quality R&D. We should emphasise productivity and added value to our existing comparative advantages through strengthening and extending primary sector innovation. Enormous potential remains to add more value and build market demand for existing and new primary-sourced products'. Welcome aboard MoRST.

New developments in funding policy

The planning system had been criticised for getting its priorities wrong, for lack of transparency and for the ucertainty with regard to future support from public funds. Bidders for public good funds complained about the short-term cycles of research planning the contestable system encouraged[5]. A scientist was quoted as saying

> 'the key issue is uncertainty. Once you put in a funding application you don't know for nine months whether or not you are going to be successful. That makes it difficult to plan ahead'.

The research establishment was used to long planning horizons under the old system and were able to divert resources to new areas without upsetting staff security of tenure. Under the contestable system, some well-established projects had to be curtailed and specialist staff diverted to other projects. However, government was slow to respond to requests to modify the contestable system of allocating public resources.

The Association of Scientists expressed the view that there had been inefficient management of RS&T resources (Campbell, Lillis and Grieve, 2005).

[5] A reviewer notes that in NZ a researcher can expect to be successful with one in every twelve research proposals that he or she submits. In the UK, it is one in every four proposals.

> Inefficient management leads to excessive transaction costs on research institutions through the proliferation of funding instruments, along with excessively expensive bidding processes and reporting requirements, in tandem with excessive use of contestability, over-prescription of research and inadequate funding for excellence-based curiosity-driven research; lack of clear strategic planning and transparent funding policy around key research areas, thus reducing the ability of research organisations to plan for the future and fund equipment adequately.

It became clear that there was a need to replace short term contestable funding and move toward longer term commitment of resources to individual research providers to plan their own priorities. The agricultural research community in particular has been increasingly vocal on the role it wished to play and critical of the old contestable fund system[6].

The Minister for RS&T announced that it was now time for less contestability and more annual 'devolved allocations' to CRIs-+[7]. Research institutes needed sustainable funding to be able to maintain core competencies, finance capital works, new equipment and address the loss of researchers and inability to recruit young scientists:.

> 'Contestability is not completely the wrong answer, because it drives innovation, but it went to extremes'.

He noted that previously the aim of science policy had been to reduce funding of research of benefit to industry from the public purse, requiring industries and producers to contribute directly to appropriate Crown research institute research programmes. He also indicated it was time CRI boards were given more of the discretionary roles they were set up for, instead of the funding bodies making all the key decisions.

The Minister stated that the government would continue to sustain strong investment in RS&T, particularly on people and resources. The new Capability Fund will *replace* the former Non-Science Outputs Fund (NSOF), to assist the CRIs to maintain core capabilities.

In a later statement (Morst 2005), government confirmed that it had moved away from the competitive bidding model for R&D funding toward more long term arrangements with the science providers. Government needed to step up from simplistic *public choice* theory models of the 1990s. The needs of the industry were: long-term sustainable investment; a stable funding environment; support for high performers; a clear and purposeful R&D agenda; enhanced opportunities for collaboration, networking and technology transfer; and RS&T that is valued, trusted and supported by New Zealanders.

The aim was to provide a clear understanding of critical responsibilities of players in an RS&T system with a focus on core capabilities that deliver benefit to New Zealand so research organisations can manage better for their people and future research

[6] Devine (2003) observes that the persistent dissenting voice of the NZ Association of Scientists and the Institute of Agricultural Science contributed a more human face to the reforms.
[7] *Sustaining Strong Investment: Excellence in Knowledge and Innovation(www.morst.govt.nz)*

priorities. Alongside the multi-year budget package a one-off statement would be developed on the obligations and expectations for sectors. A series of RS&T directions or roadmaps for key science areas would be developed with relevant groups of stakeholders, key users and research organisations. There would be increased emphasis on collaboration and networking (ibid).

This re-orientation of policy is reflected in FRST's statement of intent dated April 2005 (FRST 2005a). 'To support the Government's strategies and address the Minister's challenges FRST's strategy focuses on:

- investing in areas that will help achieve measurable target outcomes where RS&T can make a real difference in improving wealth and wellbeing;
- investing in a manner that encourages improved performance in achieving these outcomes including greater devolution of decision making to RS&T providers;
- evaluating and bench marking performance to support making the right investment choices to reinforce and reward good performance;
- enhancing the Foundation's role as facilitator of an integrated and responsive innovation system'.

In a document about investment signals and requests for proposals on the website (FRST 2005b), the Foundation outlines how it will handle investment proposals for the round starting in July 2007. FRST notes that the Minister wishes to bring greater stability into the funding environment. This will involve reducing contestability in the system by devolving funding and detailed decision making to research organisations although some portfolios funds will be released for investment through fully contestable project rounds. FRST interprets this as investment *that is narrower and deeper*.

In summary, the short term system of bidding rounds, project by project, was to be superceded by a system of longer term block grants that devolve project choice on the research providers. Control passes back to the CRIs and other providers who will have prepare their longer term strategies for FRST scrutiny. There does not appear to be, as yet, a concomitant increase in the government vote for RS&T, so the future directions of research may well involve more of the same. Also, the future of agricultural public research funding lies with the FRST and not with the CRIs. As will be seen below, a fresh approach needs to be developed that establishes the primacy of agricultural research and the reasons for it.

Dividing the Cake: A view on negotiated funding

In an unpublished paper, Quigley (2006) compares the funding of the CRIs with that of the universities. `Each year the New Zealand Government makes direct investments in scientific research of around $750 million. To ensure the best return to that investment of public funds, the different allocation mechanisms rely to a considerable extent on competitive bids for the available funds, and on rigorous scientific assessment of those bids. Thus, the introduction of a "negotiated investment pathway" by the Foundation for Research, Science and Technology (FRST) represents a substantial change to public policy for a substantial part of this investment in scientific research. Negotiated investment will remove 30 percent of funding from FRST contestable pools, and may remove as much as 50 percent of

contestable funds in the medium term[8]. The objective of the policy change is to halt the reduction in the share of FRST funding being allocated to Crown Research Institutes (CRIs). Reflecting this objective, almost all FRST contracts eligible to enter the negotiated pathway[9] are with CRIs even though the value of outstanding FRST contracts held by CRIs is only around 50 percent of total investment.

`The debate around this funding change has been vigorous, but of greatest interest from the perspective of science policy has been the clear articulation of two views about why it is important to retain funding in CRIs. First, it has been claimed that CRIs have an inherent disadvantage in competing for funding against universities and private institutions because they are less able to bear the risk associated with contestable funding than institutions with more diversified streams of revenue. Second, it has been claimed that CRIs maintain critical national scientific capability in a way that universities cannot, so that when CRI scientists do not obtain funding in contestable funding pools, the social costs are greater than the social benefits obtained from the investment in the alternative university or private institution research team. This paper considers both claims before considering alternative policy responses that may be more efficient than negotiated funding.

Quigley believes that the CRIs have been slow to respond to the new competitive science policy since the 1990s. They have not adjusted their approach to sources of uncertainty which are within the purview of management and thus may be managed by the level of investment in relevant effort. He suggests they can be managed through investment in insurance, and while there is no formal insurance market available to mitigate the negative effects of failure to receive funding from FRST, there are in practice many insurance mechanisms available. The most obvious relevant insurance mechanism is the submission of multiple co-operative bids, which has the effect of allowing institutions to reduce the risk of failing to receive funding at the cost of being required to share funding for the bids that are successful.

`Another relevant insurance mechanism is diversification within the individual institution, which effectively reduces the impact on the institution as a whole of failure to receive funding for any individual activity. Technically, diversification is advantageous where uncertainty associated with one income flow (such as FRST contracts) is independent of uncertainty associated with income flows from other sources (such as commercial contracts or teaching). This diversification effect will provide universities with advantages from having alternative streams of revenue, such as for teaching. However, the suggestion that teaching revenue allows New Zealand universities to fund a pool of surplus labour which is available to compete for research funds and utilised only when it is successful seems implausible given substantial real reductions in per-student funding for teaching over the past decade.

[8] Negotiated funding is limited to 30 percent of total funding in 2007 and 2008, but given the criteria established to qualify for negotiated funding, FRST has indicated that the proportion of funding in the negotiated pathway could rise to 50 percent (Foundation for Research Science and Technology 2006a Appendix 2).

[9] Contracts eligible to enter the negotiated pathway must be single contracts owned by one research organisation that terminate on 30 June 2007, represent a continuous investment history of at least six years and two contestable bidding rounds, involve funding of more than $1 million per annum, and represent more than 7.5 percent of the portfolio to which they belong. Foundation for Research Science and Technology 2006b: 45.

`Though CRIs have sources of revenue other than FRST contracts, it might be argued that some sorts of diversification by CRIs are not feasible, and that the generation of funding streams from teaching students is one example of a diversification strategy that is not open to CRIs. But diversification does not need to be internal to the organisation, and contracts to provide teaching services to universities and polytechnics represent an obvious, and (given the strong synergies between research and tertiary teaching) desirable avenue for the diversification of CRIs.

`It is therefore unclear what weight should be placed on the view that CRIs are disadvantaged in their ability to bear random variations in outcomes in funding rounds. Much of the variation in outcomes is endogenous, and thus determined by investment in the bid. Where uncertainty is exogenous, much of it falls within the realm of normal scientific assessment of quality. Even the (likely small) purely random component can be mitigated through insurance strategies such as co-operative bidding and contracts that generate alternative revenue streams.

Recent responses from the agricultural research community

It is clear that agricultural research interests have made their position known to successive Ministers in recent years. There have been submissions from AgResearch, the major research institute, and from Fonterra, the recently formed national dairy cooperative. One key development has been the development of Fonterra's strategic framework for dairy farming's future. The purpose of the framework was to set the strategic direction for all on-farm research, development, extension and education. Fonterra needed to have a plan for increased efficiency that did not compromise economic, environmental and animal welfare imperatives, it was stated (Dairy Insight *et al* 2005).

The industry has set a goal of boosting farm productivity by 4 per cent per year. The group has already lobbied Government for a $60m boost to pastoral farming research[10]. The Chairman of Fonterra states that putting resources into 'core' agriculture is a safer bet than some less-established sectors, and that the above sum is a relatively small amount of money given the potential economic benefits to the country (*The Dominion Post*, 28.9.05). The CEO stated that the company wanted a more efficient model that makes sense for all parties involved. It wanted to avoid as much duplication in the farming sector as possible and to ensure the company was not burdened with spending money on research that does not directly benefit its value-added goals.

AgResearch announced in November 2005, that it needed $73m for buildings alone. Dr West argued that the extra $60m for the dairy industry should go straight to the crown research institutes who will then decide what to spend it on. He also argued that farmers' contributions to research investment should rise too:

> 'The $10m they contribute in levies is not much when you consider farm gate returns are $6 billion'.

[10] Government has responded to this initiative. On the FRST website, there is a draft investment scope document inviting bids for $7.8m of funds, sponsored by Dairy Insight, Fonterra and FRST, to be devoted to on-farm productivity growth.

AgResearch's strategic plan for the next 15 years was based on the country investing in its core strengths, the husbandry of plants and animals, he said.

Taken with Government showing a willingness to increase devolved funding to the CRIs there is now a marked willingness in the agricultural research sector to expand their research activities over the static levels recorded above. The agricultural research lobby has increased its public relations effort and has started to put significant research programs in front of government for public good spending. Private participation will be needed as well. While the Minister talks of investing 3 per cent of GDP (a trebling) in future years, marked increases in research spending by the government or the private sector are likely to emerge more slowly in terms of this measure.

Summary and Conclusions

The last 15 years in New Zealand has seen a significant experiment undertaken with regard to the organisation of public R&D services. There has traditionally been a fairly even split of resources between the government providers, private sector providers and university providers. Before the 1990 reforms, some commentators were of the view that the government sector was too dominant and had been creating a 'crowding-out' effect on the private sector. The erstwhile aim of the reforms was to increase private participation and to decrease the influence of the large government departments and the funding drain on the government. To this end, 10 research companies were set up to absorb the science roles of all government departments. To finance the new structures, the former departmental appropriations were placed in a government pool – known as the Public Good Science Fund (PGSF) – for allocation to all research providers on a bidding basis. Total science appropriations include other administrative functions performed by MoRST and a portion of the Education Vote that funds research in the universities..

Since the reforms began, national spending on science has kept pace with gross domestic product (GDP). In terms of provider spending there has been an increase in the share of research being performed by the private sector and the universities and a decline in the share conducted by government agencies. In terms of overall funding, there has been a parallel increase from the private sector and a decline in the government share. These changes were predicated by the reforms in the first place and could be said to have achieved what the planners set out to do. It is not clear whether this is a better outcome, apart from less drain on the fisc.

Agricultural research before the reforms absorbed about one third of all resources made available. Going by the spending by the agricultural crown institutes (Ag Research, Crop & Food Research, HortResearch and Landcare) the share of CRI resources going to agricultural research has almost been maintained (55 per cent in 1993-94 and 52 per cent in 2004-05). At the same time, the share of agricultural research funded by the government has fallen from 59 per cent to 50 per cent.

There has been criticism of the funding mechanisms and the rules which were used to choose successful projects. As a result, the government issued in 2005 the outlines of a new system of public good research funding which would be based on longer-term contracts with the research providers and devolving more of the individual project

choice to them also. This development is a return to the ways of the 1970s and 1980s when the two large departments were in sole charge of spending priorities for the public good science money.

There has been a resurgence in the agriculture research sector since 2005. The major participants like AgResearch, Fonterra, Dexcel and Dairy Insight have produced a series of reports on future developments, particularly for the dairy sector, which envisage both increased private spending and an increased contribution from the government. The industry sees all the animal and forage industries working together for the common good and with an increased commitment from public funds.

It remains clear that the public purse is to be kept tightly controlled for the immediate future and all the research interests will have to either fund more research themselves or find new sources of support. For the agricultural sector, the need is to continue to present arguments based on the close relationship between innovation and export growth. New Zealand remains dependent on a few key internationally traded primary products which, because of the distance from markets, have to be produced and shipped at lower prices than other temperate agricultual exporters. This indicates that priorities should reflect *less* social and blue skies research and *more* sectoral and product oriented research.

References

Allison N (2003), Enhancing the performance of the RS&T system, *NZ Science Review 60(2-3)*, 84-87.

Bakker L, and Mischewski B (2006), Performance-Based Research Fund Funding Flows: Initial Indications, in *Evaluating the Performance-Based Research Fund*, Institute of Policy Studies.

BERL(Business and Economic Research Limited)(1995), *The New Zealand Innovation Environment*, a report prepared for the Ministry of Research, Science and Technology, Wellington.

Boston J (2006), Rationale for the Performance-Based Research Fund: Personal Reflections, in *Evaluating the Performance-Based Research Fund*, Institute of Policy Studies.

Buwalda J (2003), Greater Expectations, *NZ Science Review 60(2-3)*, 67-69.

Campbell H, Lillis D, and Grieve J (2005), There is a better way: Eight recommendations on the science system in New Zealand, *New Zealand Science Review 62* ,80-86.

Dairy Insight, Dexcel, Fonterra and DCANZ (2005), *Dairy Industry Capability Needs Review*, Innomarc Consulting Ltd.

Devine S (2003), A systems look at the science reforms, *NZ Science Review 60*, 70-74.

Eveleens, W.M. and Scobie, G.M., ‘’Efficiency and Equity in Agricultural Research’’, August 1986

FRST (2005a), *Statement of Intent for 2005 (*www.frst.govt.nz/statements).

FRST (2005b), *Overarching Document concerning Investment Signals and Requests for Proposals,*(www.frst.govt.nz/research).

FRST (2006a). New Investment Pathways and Processes: Consultation Document. Wellington, May.

FRST (2006b). Implementing the Stable Funding Environment Initiative: Board Decision Paper. Wellington, 11 July.

Hazledine T and Kurniawan C (2005), Efficiency of New Zealand Universities and the Impacts of the Performance Based Research Fund, *New Zealand Economic Papers 39(2),* 153-179.

Hemlin S (1999), Utility evaluation of academic research: six basic prop[ositions, *Research Evaluation 7(3), 159-166.*

Jardine, V. (1989), Crisis in Agricultural R&D in New Zealand? invited paper presented to Annual Conference of the Australian Agricultural Economics Society, 6-9 February 1989, Christchurch, New Zealand.

Johnson R (1999), The rate of return on R&D Investment, NZ Association of Economists, Rotorua.

Johnson R (2000), Crowding out and resulting trends in research fund allocation in New Zealand, 1991-2000, *NZ Economic Papers 34(1),* 129-147.

Johnson R, Scrimgeour F, and Manning J, (2006), Public Investment in Agricultural Research in New Zealand, *Farm Policy Journal 31(1), 41-51.*

Jordon N and Atkinson P (2003), Development of science discoveries in the New Zealand Crown Research Institutes, *NZ Science Review 60(2-3), 91-95.*

Lillis D (2006), The role of government in R&D for economic development, *New Zealand Science Review 63(1),* 22-27.

MoRST (1992a), Long Term Priorities for the Public Good Science Fund: a Discussion Paper, (Science and Technology Expert Panel),(STEP Report).

MoRST (1992b), Long Term Priorities for the Public Good Science Fund: Final Report.

MoRST (1997), Notice to the Foundation for Research, Science and Technology (FRST): the Government's Policies and Priorities for Public Good Science and Technology, (www.morst.govt.nz)

MoRST (1999a), New Zealand Research and Development Statistics 1997/98, *Publication No 17.*

MoRST (1999b), *Blueprint for Change*, (www.morst.govt.nz/documents/blueprintforchange).

MoRST (2004), *Notice of Revocation and Replacement of the Government Priorities Under Section 7 (1) of the mmmm for Research, Science and Technology Act 1990*, September 8th 2004 (www.morst.govt.nz/ministerialstatements)..

MoRST (2005), *Picking up the Pace*, (www.morst.govt.nz/policystatements)

MoRST (2006a), *Research and Development in New Zealand: A Decade in Review*, Wellington.
.
MoRST (2006b), *Becoming More Globally Competitive, (www.morst.govt.nz/opinionpiece).*

New Zealand Year Book, Government Print, Wellington, 1991, 1993, 2004.

New Zealand Science Review 60(2-3), NZ Association of Scientists 2003.

Philpott B P (1969), Income and Expenditure of New Zealand Agriculture, Lincoln University Agricultural Economics Research Unit.

Quigley N (2006), Funding Scientific Research: Assessing Contestability, Negotiation, and Alternative Policy Responses, ***NZ** Science Review (fothcoming).*