



INFOMETRICS

**Evaluation of the
Research for Industry Fund**

for Foundation for Research Science and Technology

Prepared by Infometrics Ltd

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Authorship

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EXECUTIVE SUMMARY

Evaluative questions

This report addresses the following three evaluative questions:

- How successful has RFI investment been in increasing the global competitiveness of New Zealand industries and sectors over the period under review?
- How successful have the operational policy settings been around the allocation of investments in accordance with the objectives of the funding as specified in the estimates of appropriations and Ministerial Directions and what if any changes are needed to those settings?
- What impact have other factors such as economic conditions had on either muting or enhancing the success of these investments?

RFI objectives

The Government states in its 2002 Budget Estimates of Appropriations that Research for Industry (RFI) investment contributes predominantly to the Foundation's Economic Goal, which is expected to:

- Increase the global competitiveness of New Zealand firms
- Raise the level of technology in New Zealand production
- Encourage private sector investment in research and development
- Focus on long-term strategic research, and
- Underpin production with assured standards.

Research for Industry was seen as contributing to the Economic Goal by increasing the competitiveness of food and fibre, manufacturing and services industries; and in national infrastructure such as energy and our built environment.

The main new initiative under the Government's Economic Goal highlighted in the 2002 Estimates was funding for private-public partnerships in the form of research consortia. The aim of this was to increase both rates of innovation and private sector R&D investment.

In addition to these Government goals, the Foundation received ministerial direction to increase its focus on biotechnology.

Performance of RFI investments in increasing the global competitiveness of New Zealand industries and sectors

On the basis of our evaluation it is not possible to assess the impact at a national level of RFI on the five elements outlined under the Economic Goal. This would require econometric analysis of a wider set of end-users of technology developed under RFI contracts benchmarked against end-users of (similar) non-government funded technology.



Our evaluation suggests that on average technologies developed under the 2002 RFI contracts that were the focus of this evaluation raised capital productivity, gross margins, selling prices, sales volumes, and labour productivity of end-users. **On this basis RFI investment has increased the global competitiveness of the end-users we assessed.**

Our evaluation provides anecdotal evidence that funding to research consortia has resulted in successful research programmes between research providers and end-users in terms of commercial uptake.

Biotechnology was a significant theme running through contracts we surveyed for this evaluation. Most of the research appears to be highly successful from a science quality perspective. The long lead times to commercialisation (up to 10-12 years in some cases) has meant that there is as yet little evidence of commercial uptake of biotechnology related research.

User uptake

Few researchers and potential users had a strong opinion on general barriers and opportunities to user uptake, but on balance demand is seen as the main opportunity while financial concerns are seen as the main barriers.

While we started this review with the view that the actions or inactions of researchers and users are what primarily determine the commercial success of an RFI investment, one cannot place the funding mechanism/model to one side as if it has no interaction with the actions of users and researchers. They are all intimately bound together.

Accordingly there are two ways in which the Foundation could increase or accelerate commercial uptake:

1. Greater involvement by potential users at commencement of any RFI research and as it progresses to commercial uptake; and
2. More funding available to bridge the 'valley of death' between science output and commercial usefulness.

With respect to user involvement, we observed that the consortium model has a high success rate, although some industry association led research can deliver consortia-type benefits. Mutual awareness of respective interests and objectives between users and researchers is enhanced, issues of intellectual property are more easily resolved, and the Foundation can observe a direct user stake via co-funding. The disadvantage, however, is that new entrants, whether researchers or users, may not be allowed to join an established consortium – or may not wish to. Thus some funding should be available for such groups. However, for contracts that do not involve consortia structures it would seem desirable to look at other possible mechanisms to achieve close engagement between researchers and industry.

The track record of the researcher (or consortium) in delivering commercially relevant research should be a key assessment criterion for



funding applications under RFI. Again though, some funding should always be available to new entrants without an established track record.

Preserving some funds for new entrants also guards against provider capture and the attendant negatives that may accompany the consortium model such as pricing power and the ability to play the system. It is doubtful whether an ideal allocation mechanism for centrally sourced research funding exists, but for a given set of objectives, some models seem more likely to fulfil those objectives than others.

Over time as all players become accustomed to the system there may be a need to change it again, just as the model recommended here would not have been appropriate when the Public Good Science Fund (PGSF) first came into existence.

Foundation data and interview responses show that a significant number of RFI investments fail to make the leap from successful science output to commercial viability (see Section 7 and Appendix A: Interview Results). In this sense the funding obtained under RFI, while more commercially oriented than funding under the New Economy Research Fund (NERF), is still seen by users and potential users as being too focussed on science quality and not enough on applied relevance. This is certainly not to imply that good science shouldn't be funded; rather that some of it might be better placed in a different funding pool and that funding under RFI might assist in dealing with the valley of death. That said, where there is a case for public funding in this regard there are two provisos:

1. It might be that science funding is not the appropriate source. There could be a greater role for organisations such as NZTE especially where firms are looking to develop or expand export markets.
2. There needs to be support and ideally, leadership from industry. If industry is not prepared to be involved once a technology has reached the laboratory door, then one must wonder whether it has confidence in its own future. If that is the case one would question the leverage that taxpayers and the economy as a whole can gain from such public good funding.

In a number of cases, technology developed under RFI contracts did not ultimately meet industry needs once it was developed. The risky nature of R&D means that it is inevitable that some projects will not come to commercial fruition. Those that invest heavily in R&D come to accept this. However, in several cases it was clear that failure to deliver commercially was largely due to a lack of shared understanding between researchers and industry of the objectives of the technology. This underscores again the importance of establishing arrangements that achieve this mutual understanding at an early stage.

Benefits to industry

Not surprisingly, most end-users adopt a new technology (product, process or service) with the intention of raising profits. Sometimes a new technology represents a quantum leap such as the introduction of a new



apple variety, but often it is about on-going incremental improvements to production processes, whether that be in animal feed, chemicals, or forestry.

For actual end-users it is clear that the RFI works well (in terms of user uptake) when there is a market opportunity and when the researchers and users have a mutual interest in the outcome and work together to that end. Gross margins rise by an average 5-10%, driven by either higher capital productivity or higher selling prices and sales volumes.

Implementation costs are seen as the biggest general barrier to fully realising the benefits of new technology by end-users, but for any given investment that did not become a commercial success there tended to be a unique reason. Examples include regulatory processes for trialling GE products, a lack of knowledge of markets and marketing capability, and lack of awareness by potential users.

Spillover benefits include researchers acquiring new skills that have since been applied in other organisations. New skills also extend to people involved in manufacturing, sellers and distributors who need to learn about new products and how to use them.

Factors that have enhanced or muted the impact of RFI investments

Of those end-users that did take up RFI funded technology for commercial purposes close relationships with researchers, a lack of competition in the market niche they were targeting, good underlying demand for products, processes or services, and co-funding of the research were all cited as factors that enhanced the benefits they gained from the technology.

On balance, lack of availability of skilled labour, raw material supply, financial constraints and implementation costs marginally impinged the commercial benefits end-users gained from RFI funded technology.

Contribution of operational policy settings to meeting RFI objectives The Foundation's operational policy settings with respect to RFI investment play a critical role in facilitating uptake of technology and ensuring that firms maximise the benefits they derive from commercialising it. There are several positive elements to the Foundation's RFI processes contributing to the success of RFI in meeting its objectives:

- The current approach of the NERF being used for more 'blue sky' research and the RFI fund being applied to more readily commercial research is generally approved of.
- On balance RFI processes have encouraged an increased focus on long-term strategic research among the end-users we assessed.
- Funding to research consortia has resulted in successful research programmes between research providers and end-users in terms of commercial uptake.
- Biotechnology was a significant theme running through contracts we surveyed for this evaluation, suggesting the RFI investment criteria



that were applied to the contracts we assessed were effective in favouring this area of science.

Suggestions for improvements to RFI operational policy settings

While operational policy settings as they stood in 2002 appear to have made a satisfactory contribution to meeting RFI objectives there are likely to be improvements that can be made at the margin that will enhance uptake and commercial benefits, including:

1. Greater involvement by potential users at commencement of any RFI research and as it progresses to commercial uptake;
2. More public funding available to bridge the 'valley of death' between science output and commercial usefulness;
3. More integrated cross-agency approach to supporting Foundation funded R&D;

Ideally these options would be considered in the context of the Foundation's overall objectives and framework for R&D funding to ensure that all its funding pools are complementary and do not overly duplicate objectives.

Finally, it is important that information about commercial outcomes and funding allocations among various objectives within contracts is of high quality to enable worthwhile evaluations that can inform fund performance and investment priorities.



1. INTRODUCTION

This report presents the results of an evaluation of the Research for Industry fund. The scope of the evaluation is limited to funds invested over 1998-2008 with a particular focus on the progress of specific investments in the 2002 funding year. The broad evaluative questions are:

- How successful has RFI investment been in increasing the global competitiveness of New Zealand industries and sectors over the period under review?
- How successful have the operational policy settings been around the allocation of investments in accordance with the objectives of the funding as specified in the estimates of appropriations and Ministerial Directions and what if any changes are needed to those settings?
- What impact have other factors such as economic conditions had on either muting or enhancing the success of these investments?

In answering these questions and the more detailed questions contained in the Foundation's Request for Proposal, we have established the following evaluation steps:

1. Research inputs – analyse the Foundation's contracts database to ascertain key facts and trends of relevance to the strategies and objectives of the Government and the Foundation.
2. Research outputs – analyse the specific outputs that have been developed for industry in terms of uptake, knowledge and capability.
3. User uptake – analyse the factors that positively and negatively influence user uptake of RFI funded technology.
4. Benefits to industry – analyse the benefits to industry of outputs in terms of improved productivity, reduced costs, higher value outputs, increased export revenues and access to markets.
5. Operational policy settings – assess the effectiveness of Foundation investment processes in meeting the objectives of the fund.

Section 2 gives the context for the evaluation and briefly outlines the process for it.

Sections 3 and 4 cover the insights on user uptake and benefits to industry we have drawn from Foundation reports relating to research contracts and from researcher, user and potential user interviews.

Section 5 outlines the objectives for the RFI fund as stated in the Government's 2002 *Estimates of Appropriations* and Foundation material. The effectiveness of operational policy settings in meeting these objectives is assessed.

Data and trends on research inputs and outputs and the conclusions we draw from these is presented in Sections 6 and 7 of this report.



2. CONTEXT FOR RFI EVALUATION

RFI Fund in context

For industry, research is about keeping ahead of the competition in a world where one either becomes the most efficient producer of low value commodities, or avoids low value commodities entirely and concentrates on niche high value products. Examples of both abounded in our sample:

- upmarket uses of ovine leather
- a tastier and healthier red onion
- new apple varieties
- gold kiwifruit (and perhaps soon a red one)
- better cardboard packaging
- a protease inhibitor for cataracts
- pharmaceutical and nutraceutical products from oceans and plants
- new types of rye grass that raise output per hectare
- vining peas
- using microbes instead of sprays to control fungal diseases in pinus radiata trees
- better prediction of yields in pinus radiata forests
- better prediction of tree wood stiffness for structural purposes
- genetic marker and transgenic tree technology that can help improve the quality of the pinus radiata tree stock.
- environmentally friendlier production techniques such as less use of insecticides or toxic dyes, or products with a lower carbon footprint.
- optimisation of plant in chemical manufacturing
- high value aquaculture products
- scanning devices for the meat processing and packaging industries

All research has to have a business case, even for the research providers. Seen in this context the RFI Fund generally works well, with industry support being essential. This is discussed in more detail later.

Evaluation process

Sometimes a new technology can be largely attributed to a particular Foundation contract, such as a machine for measuring cardboard stiffness, but mostly these contracts are parts of larger research programmes that span many years, encompass many strands of research, and may have many downstream applications that might not even be imagined when the research was begun. Or as was noted in the context of the use of new materials, one often cannot say which particular bits of a research programme might eventually be taken up.

This has led us to the view that from a user perspective evaluation on a contract-by-contract basis is probably not the most useful way of evaluating expenditure under the RFI Fund. Some of the technologies that have been adopted by users have been the result of research funded under RFI, NERF and TechNZ.



Selection of RFI contract sample for observation

A dataset has been prepared for RFI contracts starting in 2002. There were a relatively large number of contracts awarded in this year, which gives the opportunity to select a reasonably varied sample for more detailed analysis. The seven years that has elapsed since 2002 is also likely to give sufficient opportunity for end-users to take up the technology and see the benefits from it.

The 2002 RFI contracts provided a basis for selecting a sample of contracts guided by criteria of relevance to the evaluation. These criteria include:

- **Contract size.** The contracts with the largest total contract values and the largest RFI intermediate outcome funding amounts were chosen.
- **Representative spread across outputs.** We chose a representative spread across the three outputs within the scope of the evaluation – 7.1, 7.2, and 7.4. Output 7.1 made up the biggest share of the selected contracts, followed by 7.2 and 7.4.
- **Representative spread across research sectors.** We chose a representative spread across the main research sector institutions, namely Consortium, CRIs, Universities, Industry Associations, and Private NZ Businesses. CRIs made up the biggest share amongst research institutions because its share of total contracts dominates those of other institutions.
- **Outputs.** We chose contracts that fell outside the above criteria that either had a relatively high or low number of outputs recorded against them. We focused on outputs at the more commercial end of the spectrum such as new products, processes or services implemented and IP patents granted.
- **Co-funding.** We chose contracts that fell outside the above criteria that had either relatively high or low levels of co-funding.



3. USER UPTAKE

Barriers to and opportunities for uptake

The following barriers and opportunities to technology uptake were discussed with interviewees:

- Demand for product, service
- Competition in product, service market
- Cash flow, financing
- Skilled labour
- Ability to manage and govern implementation of new product, process, service
- Raw material supply
- Exchange rate
- Access to markets
- Other (funding model mentioned frequently)

Cash flow and finance issues were cited most frequently as the main barrier to commercialisation of research. Such issues tended to occur where industry funding is lacking due to substantial commercial risk associated with R&D, or where there are smaller commercial users such as individual farms, where establishment costs of new pasture or cultivars can be expensive.

In the consortia situation potential financial barriers are dealt with before the research is commissioned as cost is one of the factors that are taken into consideration when deciding its scope and direction. The research is funded by consortia member contributions and the technology that emerges from consortia led research is generally available free of charge to shareholders. Therefore, consortia research is affordable for its shareholders by design.

However, while cash flow issues were cited by many respondents, each new technology (products, processes or services) that had not (yet) been commercialised largely had its unique reasons, namely:

1. The technology did not work as expected at a commercial level. This was the case for example with a new technology for dyeing carpet yarn.
2. Consumer awareness: new products need marketing, for example with regard to new flavours such as manuka.
3. The existence of a substitute technology, such as an established medical procedure that can be substituted for a potential drug that is yet to be thoroughly tested.
4. Technology yet to be proven, such as in forestry where many years are required to trial new tree varieties.



5. The technology did not meet practical requirements for being applied in the field, such as meat scanning devices that were not able to meet speed, robustness and user skill requirements in meat processing plants.
6. The lack of economies of scale in producing a product that utilises a particular technology. For instance, a microbial pesticide using a polymer technology developed for a company, although commercialised on a small scale, is unable to be expanded at this stage due to the inability to apply the technology to other products in the company's portfolio. Until the polymer technology can be applied more widely fixed production costs cannot be spread to make it financially viable in the medium-term.
7. Regulatory and resource consent delays, such as the introduction of new aquaculture species.
8. Problems with supporting technology that hinder implementation. For example, a technology in the forestry industry is not being used more widely because the software used to deliver it is under-developed and complex to use preventing smaller companies with fewer resources from using it.
9. Research delivered good quality science outputs, but not the envisaged application, for example in the case of seaweed derived glycotherapeutics.

A factor that is common to most of the above to varying extents is the "valley of death", a term that describes the gap in funding that often occurs between the outputs from research and its commercialisation. In the case of drugs for example, this includes activities such as manufacturing batches of chemicals for field trials, toxicology tests, approval processes and so on. In other areas it may involve the establishment of a pilot production facilities, or seeking offshore partners to assist in distribution and marketing.

Researcher and industry relationships

A number of user and potential user contacts mentioned the importance of the relationship with individual researchers to the development and uptake of technology. In some cases the particular researcher was critical to whether a certain area of research was undertaken. In one example, a contract that started with a CRI was switched to a private research organisation when the key scientist switched to the latter institution and the main co-funder switched their contributions accordingly.

All companies interviewed mentioned that a close relationship with researchers was important to the direction of research and the transfer of knowledge between the researchers and industry. Some companies mentioned that they preferred to work with certain researchers, while there were others they preferred not to engage with. In one case the individuals on the researcher and company sides worked together to



champion a particular technology so that it got support from both of their institutions.

One company representative interviewed mentioned the importance of research organisations as “repositories of knowledge”. He made the point that staff turnover in companies was often significantly higher than in research organisations and, consequently, there was a risk of a loss of institutional knowledge in the former. An ongoing relationship with researchers in relation to a particular technology was important to ensure that knowledge was not lost as a result of turnover.

Tellingly, in at least three of the cases where the research has not been as commercially productive as envisaged, the relationships between researchers and industry were not close.

Promoting user uptake

The role of RFI

Maximising user uptake of technologies from science funded under RFI (PGSF) is not something that is affected only by the researchers and the (potential) users, but also how both of these parties interact with public science funding.

The current approach of the NERF being used for more ‘blue sky’ research and the RFI fund being applied to more readily commercial research is generally approved of – from the “laboratory to the field” as one respondent put it.

Whatever the structure, a clear message from the interviews, both from researchers and industry, is that New Zealand needs to fund research for New Zealand specific conditions. Three examples of this are research into:

- Rye grass – which is required to maintain New Zealand’s high productivity in agricultural production even though other countries may base their agriculture on completely different feedstocks such as maize.
- Wool – with one respondent citing that without RFI funding the wool industry in New Zealand will slowly expire.
- Pinus radiata – while not unique to New Zealand, is more important to the forestry industry here than it is in most other countries.

Consortium model

While industry is generally happy to be involved at the more applied or commercial end of research, much of this type of research is possible only because more basic research has preceded it. This is a view common to all the researchers we interviewed. They also commented that some businesses with a preference for more applied research did not always appreciate the substantial research that underpins it.



While 'conflict' is probably too strong a term to apply to most of these situations, there is clearly some lack of mutual empathy between researchers and users. The consortium model is proving attractive to many sectors as a way to better manage competing objectives and interests. It has a number of advantages with regard to promoting user uptake of research:

- It assists personal links between researchers and industry which, as noted above, have been important in many instances.
- It ensures that research has a strong demand-led element, while still allowing for more fundamental research further 'up the pipeline' that may eventually lead to new technologies. And it ensures that users are aware of such research. In this context it is crucial that the funding mechanism provides scientists with sustained funding.
- Co-funding is easier to achieve. This is useful to all parties, providing researchers with research objectives that they know have value to industry, while providing industry with a say in what gets researched. They also are a way for the Foundation to assess whether the research is perceived as having potential to benefit industry. WQI is an example of a well-functioning consortium, while the Leather and Shoe Research Association, which has consortia-type characteristics (as explained below), also performs well.
- A consortium representative mentioned that the share holders would only be prepared to contribute a trivial amount for R&D individually. But as a consortium shareholders are able to pool resources to fund R&D, which would not otherwise be undertaken, to the benefit of the industry.
- The view was expressed by one consortium representative that the RFI system, whereby researchers mainly retain ownership of IP developed under Foundation-funded contracts is directly counter to industry obtaining the full benefits of the research. Under the consortium model industry owns the IP, reinvesting revenue from royalties back into further research. This benefits both the researcher and the user. Plant and Food Research for example, have benefited in this manner.

A couple of the consortia we interviewed considered that under the non-consortium RFI funding model there is a heavy bias toward long-term and high risk R&D looking for big step changes in industries, whereas industry was often looking for research that results in incremental gains and shorter lead times to commercialisation.

- A consortium representative mentioned that under his consortium's arrangements with researchers there is a greater performance focus on research delivery than there would be under the non-consortium RFI approach. Researchers are given clear



achievement goals and milestones and are only paid on delivery. He mentioned that many researchers have adapted to this approach, but others have chosen to not accept this type of sub-contracting in preference for the traditional researcher-led system.

- A consortium enables better tracking of future skills supply. For example in some fields such as metallurgy there is industry concern about the age of the workforce. It was also noted though that more secure science funding (which hopefully occurs under a consortium approach) would help attract new entrants into the profession.

Industry associations with research functions, such as the Leather and Shoe Research Association and Dairy New Zealand, operate in similar ways to consortia. The research priorities of these organisations are guided by industry representatives. Specific goals are set for research and there is a high degree of end user engagement in it. In the case of Dairy New Zealand, a farming advisory support group ensures that research is tested against operational and financial realities.

It is possible for researcher-led contracts under the RFI system to be set up to achieve the key benefits of the consortia system. For example, several contracts related to the forestry and wood sector have governance arrangements that facilitate regular direct feedback between researchers and industry and promote greater industry direction of the research. Future Forest Research and the Pinus Radiata Breeders Council are two bodies set up with these objectives. Feedback from researchers and industry has been positive on the role of these bodies in getting industry engagement in research.

It is also possible to resolve IP issues through contractual arrangements, although this is admittedly a lot more difficult than if the research is led by consortia.

Start-up companies or researchers may find it difficult to either form or join an existing consortium. There is also a danger that provider capture could occur with the attendant negative effects of pricing power and obfuscation. Hence one should beware of the one size fits all model, implying that some degree of contestable funding for new entrants must be maintained. Clearly though the consortium approach can significantly enhance the probability of RFI funded research being useful to industry.

No model can guarantee that all research will lead to successful outcomes, as illustrated by the examples mentioned in this report. However, one of the keys to successfully maximising the uptake of technology and the benefits from it is close engagements and mutual understandings of objectives between researchers and industry. Consortia and industry association arrangements are one means of achieving this engagement and understanding. In contracts that do not involve these structures it would seem desirable to look at other possible mechanisms, such as formal industry/researcher engagement groups, to achieve similar benefits.



Alternatives to RFI funding

Funding through RFI was generally rated as very important to the research, with little prospect of substitute funds from other sources. Such replies are not surprising, as some element of strategic response is probably inevitable. However, whilst one might not immediately take the responses at face value, the situation is a little more subtle than a simple question and answer would suggest.

In some cases it was clear that projects would not proceed without RFI funding. In all these cases the reason given for the dependency on RFI funding was that the degree of uncertainty around the development of the technology, or the “gap to market”, was too great for it to have been a commercial proposition *ex ante*. Therefore, RFI funding effectively compensates for some of this risk, thereby bringing the project into commercial feasibility.

Most research institutions and private companies, however, have a range of potential funding sources, albeit that they are not all suited to all types of research. Furthermore, as discussed previously, any given RFI contract is frequently just one component of a wider research programme. In many cases the absence of RFI funding for a particular research project will, if the project is significant enough within the wider research agenda, be funded from other sources. These could include internal funds earned from royalties, consortia members and other PGSF funds.

However, this is not a ‘free lunch.’ When these sources of funds are used to enable a particular project (not funded by RFI) to proceed, it usually means that some other project is dropped or deferred.

Hence the net effect of a failure to obtain RFI funding is rarely that the project is not pursued. Instead it is some other project that is abandoned. This is the reality of science funding. In a strict sense, the relationship between RFI funding and the successful uptake of a particular technology is generally not one to one, but the overall contribution of RFI (or PGSF) funding in a wider sense – to the successful uptake of all technology based on scientific research – is indispensable.

As one company that is a major co-funder and user of RFI research noted, reductions in RFI funding would slow the pace of technological innovation and therefore that rate at which exports and national productivity increase. For example each 1% increase in pasture yield delivers an extra \$20-30m in exports.

This is not saying that RFI funding is optimally allocated. There are undoubtedly changes at the margin that would improve the allocation and enhance the uptake of successful technologies by business, but alternatives to RFI – in the wider context – are scarce.



4. BENEFITS TO INDUSTRY

Quantifying benefits of using Foundation-funded technology

Although companies were often confident of the benefits they received from taking up particular technologies, in most cases they found it difficult to quantify those benefits, even if in many cases (such as the Jazz apple or gold kiwifruit) quantification is theoretically possible.

One forestry company we spoke to relied heavily on a particular Foundation-funded technology to forecast yields for the purposes of scheduling operations and predicting investment returns on plantations. However, the people spoken to could not quantify what the financial impact of the use of the technology was. Similarly, another wood industry representative whose organisation had gone to considerable effort to try and identify the industry benefits of wood stiffness testing technology could not quantify exactly what the value of those benefits were.

In another example, a company adopted a new alloy because engineering research had shown it to be better than alternatives, but the cost of using an alternative was not investigated. Hence the relative benefit of the selected alloy is unquantified.

In virtually all the cases investigated, the benefits are as much qualitative in nature and are often inferred from changes in processes, or the reliance of the company or their customers on the particular end product or service.

Even if the requisite effort was undertaken to quantify benefits, we would not know the counterfactual – as with the alloy example. Or another example; to what extent an increase in sales of carpet could be ascribed to better colour consistency. Answering this kind of question requires an econometric comparison of firms who have received RFI funding with those who have not. Refer the discussion in Section 2.

Benefits to industry

The main benefit by far to companies from taking up new technologies is reported to be higher margins and enhanced profitability. Higher margins are achieved either by raising the average selling price of products or reducing costs. This had been achieved through various routes including (refer Appendix B):

- Improving the quality of existing products (8 cases)
- Producing new higher value products (6 cases)
- Raising production efficiency (13 cases).

In most cases the benefits to industry are incremental in nature. Technology allows firms to hold the line or keep up with the pack rather



than significantly forge ahead competitively, although step changes in technology do occur. The ryegrass research is an example.

In one instance a significant new farm automation technology was developed in the dairy industry to allow farmers to work more flexible hours in line with the lifestyle expectations of a modern workforce. Therefore, the use of the technology is intended to enhance the ability of the industry to attract and retain farmers, thereby improving its long-term sustainability.

The biggest barriers to achieving the full benefits from new technologies (as opposed to barriers which purely deter their uptake), include:

- Problems with supporting technology that hinder implementation (as referred to above).
- Establishing markets for and marketing the new product or service such as with respect to new health foods derived from indigenous plants.
- Finding skilled people in companies to embed and use the new technology.

These barriers possibly point to the need for a more integrated approach to Government R&D funding whereby some of the capability factors around the implementation of new technology are taken into consideration when formulating the funding package. While the consortium model should be useful in this regard, there may be a greater role for NZTE administered funding in complementing the delivery of technology funded through the Foundation.

Spillover benefits

As noted previously the development of a calpain inhibitor for application to human cataracts was not pursued, for reasons including the presence of a ready substitute procedure and the cost of toxicology tests and field trials. Thus one might see this as an example of research that has failed to deliver a commercial benefit.

However, a number of the researchers gained valuable bio-chemistry skills enabling them to move into biotechnology companies in New Zealand. Participants are still hopeful that commercial benefits will still eventuate from this particular RFI contract, albeit not where originally envisaged.

Other respondents noted that aside from researchers obtaining new skills, those involved in manufacturing (seeds, carpets, wood products, functional foods etc) also gain new skills, as do sellers and distributors who need to learn about new products and how to use them. In one case retailer certification schemes are being considered.

Note that if such spillover benefits are widespread econometric analysis of RFI would under-state its benefits, as the control group of companies would not be a pure control group. Identifying the major spillover beneficiaries would ameliorate the problem.



5. OPERATIONAL POLICY SETTINGS

Government and Foundation objectives for RFI

As the focus of this evaluation was on contracts that began in 2002, the effectiveness of operational policy settings should be assessed against the objectives set for RFI by the Government and the Foundation for that year. The RFI has predominantly Economic Goals, as indicated on page 28 of the Government's 2002 Estimates of Appropriations. The economic goal sought to "increase the contribution knowledge makes to the creation and value of new and improved products, processes, systems and services in order to enhance the competitiveness of New Zealand enterprises". Investment under the Economic Goal was expected to:

- Increase the global competitiveness of New Zealand firms
- Raise the level of technology in New Zealand production
- Encourage private sector investment in research and development
- Focus on long-term strategic research, and
- Underpin production with assured standards.

Research for industry was seen as contributing to the Economic Goal by increasing the competitiveness of our food and fibre, manufacturing and services industries; and in national infrastructure such as energy and our built environment.

The main new initiative under the Government's Economic Goal highlighted in the 2002 Estimates was funding for private-public partnerships in the form of research consortia. This was aimed at "increasing both rates of innovation and private sector R&D investment". It was expected that "[r]esearch consortia will help develop a more dynamic and entrepreneurial innovation system by providing successful research programmes between research providers and end-users, with further opportunities for commercial success".

In addition to the Economic Goals stated in the Estimates, the Foundation received ministerial direction relating specifically to its investment in biotechnology:

- Is basic or applied research that can increase the competitiveness of New Zealand's biologically-based industries through added value products or the creation of new enterprises.
- Supports a range of biotechnology platforms that:
 - will create commercial opportunities and benefits that can be captured in NZ
 - develop emerging industries and enterprises from our current sector base; or



- Focuses on 'proof of concept' applications that are novel, added-value products, processes or services.
- Demonstrates strong partnerships with industry and integrates the necessary scientific skills to increase the relevance of the research and the likelihood of its implementation.
- Leverages the Foundation's funding by co-funding with industry.
- Has clear pathways to contribute enhanced outcomes for Maori, with particular emphasis on enabling Maori to fully participate in new commercial opportunities related to indigenous flora and fauna and the seafood sector

Effectiveness of RFI in meeting objectives

On the basis of our evaluation it is not possible to assess the impact at a national level of RFI on the five elements outlined under the Economic Goal. This is because our evaluation sample is too small to draw statistically significant conclusions, and because the scope of this project does not allow the testing of counterfactual outcomes. This would require econometric analysis of a wider set of end-users of technology developed under RFI contracts benchmarked against end-users of (similar) non-government funded technology.

It was clear from our interviews and assessment of Foundation material that the technologies developed under the 2002 contracts, which were the focus of this evaluation, had generally raised the global competitiveness of end-users of technologies. This is reflected by end-users reporting generally positive effects on selling price, gross margin, capital productivity, sales volume and labour productivity, and lower production costs (see Section 6 and Figure A2 in Appendix A).

It was also reasonably clear from our evaluation that end-users had raised their levels of R&D from what they would otherwise have undertaken. Many end-users reported that they would not have undertaken certain types of R&D without RFI funding because of the high costs or uncertainties associated with it.

It was less clear from our evaluation whether end-users had raised the levels of technology in production. Although end-users had generally raised their levels of R&D we are unable to say if the technology developed as a result was additional to, or replaced, existing technology. For instance, if an organisation had not received RFI funding to develop a particular technology, we cannot tell whether it would have purchased alternative "off-the-shelf" technology to enhance its performance, whether it would have moved into a different product area that used different technology, or whether it would continue with existing levels of technology.

Several end-users we interviewed mentioned that RFI processes had helped them formalise their R&D planning and given them a longer-term focus to their research, which suggests that on balance among the



organisations we surveyed there has been an increased focus on long-term strategic research.

Our evaluation provides strong anecdotal evidence that funding to research consortia has resulted in successful research programmes between research providers and end-users in terms of commercial uptake, as discussed in Section 5. It is not possible to draw any conclusions about changes in the national rates of innovation and private sector R&D investment as a direct result of consortia funding. This is for the same reasons we cannot draw conclusions on the wider economic benefits of RFI funding as a whole.

Biotechnology was a significant theme running through contracts we surveyed for this evaluation. Biotechnology related research included:

- Development of dwarf apple trees
- Development of new pastoral grasses using genomics
- Genetic markers for pinus radiata and transgenic trees
- Microbial pesticides and anti-fungal agents
- Vegetable seed genomics
- Anti-viral and anti-cancer glycotherapeutics from aqua-cultured seaweeds.

By its nature biotechnology research is at the longer-term and riskier end of the research spectrum. Most of the research highlighted above involves long lead times to commercialisation (up to 10-12 years in some cases). Barriers for commercial implementation of biotechnology-based products are also sometimes substantial. For example, getting over regulatory, food and environmental safety hurdles. It is therefore not surprising that commercial uptake has so far not been high. On the flipside, products based on biotechnology potentially have relatively high pay-offs, often with substantial expected step changes in productivity and value-added. Several companies indicated to us that not being in the biotechnology game would create a significant risk of being left behind internationally. This is reflected in high direct business engagement in, and co-funding of, biotechnology research relative to other forms of research we surveyed in this evaluation.

Contribution of operational policy settings to meeting RFI objectives

Based on our assessment of the RFI contracts in this evaluation and interviews with end-users we have identified the following factors that can have a significant influence on meeting RFI objectives:

1. Researcher and industry engagement

One of the keys to successfully maximising the uptake of technology and the benefits from it is close engagement and mutual understanding of objectives between researchers and industry. Industry engagement needs



to occur at early stage so there is understanding on both sides of the research “pipeline” toward commercialisation of technology.

Consortia funding is one way to achieve this engagement. Industry associations also often have consortia-type characteristics that facilitate researcher and industry engagements.

Consortia representatives we interviewed suggested that in some circumstance CRIs turned down joining their consortia or being involved in consortia-led research because of their preferences for non-consortia funding. A move to a greater proportion of consortia funding under the RFI would help to mitigate this issue by making it harder for CRIs to opt out of the consortia model. A balance needs to be struck, however, as too much consortia funding could present a significant risk of provider capture by consortia, with the attendant negative effects of pricing power and obfuscation.

There are other reasons why it will not be appropriate for all funding to be directed through consortia, as outlined in Section 3. However, with non-consortia funding, it would be worth considering whether the establishment of formal researcher/industry engagement groups can be facilitated.

2. Better identification of commercial outcomes

One factor that has hindered the insights from this evaluation is the lack of well specified commercial outcomes from RFI contracts. In many cases the outcome information is vaguely specified or not specified at all. This contrasts with the generally excellent science quality reporting, which specifies in detail science findings, papers published, and workshops and presentations.

We acknowledge that it is difficult to quantify commercial outcomes, as our interviews with end users illustrate. This is largely due to technology being made freely available to industries and the contracted researchers having little or no incentive for a direct relationship with the ultimate end users to assess the value obtained from the technologies.

However, for evaluation and accountability purposes good quality outcome information is arguably the most important information to collect. There is likely to be considerable extra benefit from increasing the effort to derive better information in this area. Good quality commercial outcome information would improve the surety of any benefits that materialise and help with the Foundation’s RFI funding prioritisation decisions.

3. Identifying funding associated with specific outcomes

Often single RFI contracts are associated with the development of multiple technologies. For instance, one 2002 contract was associated with a variety of different scanning technologies, which would potentially be applied for different purposes in different industries. Some of the devices developed are more significant in terms of economic value than others. Yet, in the contract information there is little indication of the shares of the funding that were utilised for developing each product.



For accountability and evaluation purposes it would likely be desirable to identify what share of contract funding is associated with each outcome delivered under the contract. This information would be also valuable for evaluating prioritisation within contracts.

4. Making funding available to bridge the gap to market

There are factors that can prevent successful science from making the jump from the laboratory to a successful commercial product, process or service, whether it is field testing or implementing new plant and machinery. If the objectives of RFI are to develop science with a heavy emphasis on commercial uptake, as the name of the fund suggests, it may be desirable to make more funding available within RFI to help bridge this “gap to market”.

Within current funding allocations there are three possible ways more funding could be made available to bridge the gap to market:

1. Widen the criteria for RFI funding to include funding for certain types post-research activities such as field trials and implementation of new plant and machinery.
2. Confine RFI to deal almost exclusively with consortia based research.
3. Disestablish RFI and split its funding between NERF where direct commercialisation prospects are low and TechNZ where high involvement by individual companies is more likely to lead to commercial uptake.

It is apparent that RFI sits between more long term research funding of the type covered by NERF and research that is more directly linked to commercial prospects as covered by TechNZ. The latter usually deals with specific companies, the former with researchers, while RFI joins the two together – researchers and broader industries (not usually individual companies).

Where RFI has failed to deliver commercial successes, two of the main causes are lack of industry input into the research and RFI not funding the stage between the research output and the marketable product. Funding for the latter is more appropriate from TechNZ, while research that has little if any co-funding from industry belongs in the NERF.

Of course this raises the question as to whether such a split would leave a gap by failing to address true industry-wide research, but not company specific research, that is currently the domain of RFI, especially under the consortium approach. It would be bad policy to discard a successful model.

Ideally these options would be considered in the context of the Foundation's overall objectives and framework for R&D funding to ensure that all its funding pools are complementary and do not overly duplicate objectives.



5. More integrated cross-agency support of R&D funding

Once a new product, process or service has reached commercialisation stage the biggest barriers to leveraging the benefits are factors such as lack of marketing capability, difficulty in undertaking consumer research, accessing markets and developing distribution channels,

Funding is available from NZTE and other agencies to assist with these types of capabilities. However, a number of companies we interviewed reported that it was often confusing and burdensome to apply to different funding sources. There appears not to be a holistic view of R&D beyond the initial commercialisation stage.

If there is a desire to make the most of a commercialised RFI technology, then there may be a case for taking a more integrated cross-agency approach to R&D funding, from the lab to the market and in the market. A one-stop-shop model may be one that could be investigated. Another alternative is to have a government agency sponsor for individual projects over a certain value, with the sponsor responsible for maximising contributions for all relevant government agencies to ensure commercial success of the research project.

6. Timing of RFI funding

One of the farming based research organisations indicated that it had problems in the past with breeding research because the timing of RFI funding decisions (October) is out of sync with the start of the breeding season (July). Research would need to start before RFI decisions related to it were known. Industry co-funders were often reluctant to take the risk that RFI funding would not materialise. This resulted in research either not going ahead or being delayed.

For agricultural or horticultural research that is dependent on seasonal factors there may be a case for greater flexibility about the timing of funding decisions.



6. RESEARCH INPUTS

Infometrics utilised the Foundation's RFI contracts database for the period 1999-2008 to ascertain key facts and trends of relevance to the strategies and objectives of the Government and the Foundation. In particular, the key insights we sought to bring out include:

- The RFI investments that have been made in dollar terms on an industry and sector basis by each of the outputs Food and Fibre, Manufacturing and Services, and Research Consortia.
- The dollar magnitude of annual RFI investments in each specific sector relative to the other sectors.
- Whether there are any apparent sector imbalances in the pattern of investments. These will be judged against stated Government and Foundation sector objectives, the existing R&D intensity of the sector, and previous success of RFI investments in the individual sectors.

Investments by output

Table 1: RFI investments by output 2000-2002

	Total IO funding	Proportion of total
Food & Fibre	\$ 606,140,737	70.5%
Manufacturing & Services	\$ 106,981,694	12.5%
Innovative Infrastructure	\$ 119,672,600	13.9%
Research Consortia ¹	\$ 26,486,243	3.1%
TOTAL	\$ 859,281,274	

1. Code introduced in 2002

Table 2: RFI investments by output 2003-2008

	Total IO funding	Proportion of total
Food & Fibre	\$ 1,041,743,123	64.3%
Manufacturing & Services	\$ 227,487,682	14.0%
Innovative Infrastructure	\$ 319,569,568	19.7%
Research Consortia	\$ 32,273,595	2.0%
TOTAL	\$ 1,621,073,967	

As Table 1 and Table 2 show, RFI investments have been skewed predominantly toward the Food and Fibre category. In the five years to 2008 the balance has shifted slightly away from Food and Fibre toward Manufacturing and Services, and Innovative Infrastructure.

The balance of investments between the output categories no doubt reflects the priorities of the Government and the Foundation since 1999. Primary industries, which make up the bulk of the Food and Fibre category, are responsible for around 38% of New Zealand's exports. In



addition, value-adding innovations in this area are most likely to be led by scientific developments.

Countering the weight of RFI investments in favour of Food and Fibre is the fact that manufacturing and service industries make up the largest portion of the economy, with manufacturing consisting of around 14% of the economy and services consisting of around 52%. Primary industries, in contrast, account for around 7% of GDP.

Manufacturing's relatively high share of the economy compared to primary overstates the weight of RFI investments in favour of Food and Fibre somewhat as a large proportion of production is due to downstream processing of New Zealand's primary production. Therefore, RFI investments in Food and Fibre encompass both primary and manufacturing industries.

The area that stands out in terms of the balance of RFI investments is services industries. The services sector is not only the largest sector of the New Zealand economy, but has also been growing its share of the economy.

Any growth enhancing developments within services will have a significant impact on New Zealand's overall growth. Without further investigation, it is not clear to us whether these opportunities will be facilitated through higher R&D, better management and marketing strategies, or a better regulatory environment. However, if higher overall growth is an objective for RFI, then it would seem desirable to assess on an ongoing basis whether there are any significant value-adding R&D opportunities in the services sector that might benefit from government assistance.

We recognise that increased involvement in services would need to be balanced by not spreading RFI too thinly across sectors, thereby diluting the leverage that might be obtained from concentrating on a narrower set of industries. Therefore, increased involvement in services would need to be justified by the significance and relative certainty of the opportunities together with the scope for reprioritising RFI funding from lower value-added areas.

Research consortia span both Food and Fibre and Manufacturing and Services. Discussion of its share of RFI investments is more relevant in the context of research sector shares of funding, discussed below.

Investments by research sector

Table 3 shows that the majority of RFI funded research is led by CRIs. This is a product of the science system currently in place where CRIs are the dominant science providers.

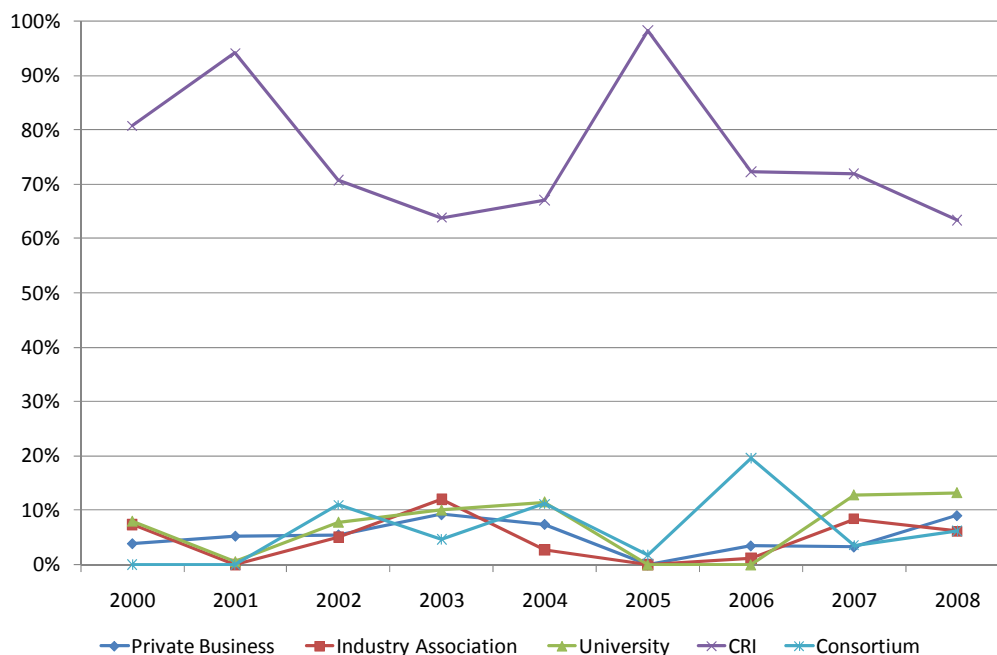


Table 3: RFI investments by research sector 2000-2008

	Total IO funding	Proportion of total
Private NZ Business	\$ 156,886,428	6.3%
Industry Association	\$ 158,723,642	6.4%
Education - University	\$ 253,293,161	10.2%
Education - Other	\$ 1,140,000	0.0%
CRI	\$ 1,732,715,576	69.9%
UNK	\$ 12,390,625	0.5%
Local/Regional Government	\$ 1,600,000	0.1%
Consortium	\$ 163,605,809	6.6%
TOTAL	\$ 2,480,355,241	

Figure 1 shows that the share of RFI investments going to contracts led by CRIs has been declining since 2005, from almost 100% of the total to 63.4% in 2008. Since 2005 RFI funding to industry associations, private businesses, universities and consortium have generally increased. The investment shares of non-CRI research institutions, however, remain substantially below that of CRIs.

Figure 1: RFI investment shares by research sector 2000-2008



Given the history of science funding, the weight of investments toward CRI led contracts is understandable. The greater emphasis of the Foundation on consortia funding is reflected in the rise in the share of investments in contracts led by this type of structure.

With the Foundation seeking more private sector engagement in science delivery and end-user uptake of Foundation funded technology, we would expect investments through private sector, industry association and consortia to increase.



RFI outputs consistency with official statistics classifications

As part of analysing research inputs we assessed whether it would be desirable to move Foundation RFI output classifications closer to ANZSIC classifications. In principle, having consistency between the two would be helpful in analysing the relationships between Foundation and private sector investments in R&D, and between Foundation investments and industry growth. It would therefore be potentially useful in evaluating the effectiveness of Foundation investments in R&D in promoting innovation and growth at a macro level.

The practicalities of classifying Foundation information according to ANZSIC are unlikely to make it feasible. RFI contracts often span a number of different research areas with potential applications in various industries. In some cases it is not possible to predict with certainty in which ANZSIC area a particular technology will be applied. Although in some cases it would be possible to identify application of a particular research area in an industry of primary use, thereby allowing ANZSIC classification of that research area, this is not likely to be the case for the majority of research areas.

Classification of research inputs and outputs according to ANZSIC classifications would require knowledge of the ANZSIC system by Foundation staff and interpretation of information provided by researchers according to that system. This would require significant time and investment by the Foundation, which may not deliver tangible benefits given the uncertainty around the classifications as mentioned above.

We therefore suggest that it is not worth pursuing the application of ANZSIC for the purposes of classifying RFI investments at the contract commencement stage.

This does not preclude, however, the application of ANZSIC codes to new technologies once they have been adopted by particular companies. In effect an ANZSIC code only makes sense for a new technology when that technology is actually used by a company, at which point the ANZSIC code for the technology is defined to be the same as the ANZSIC code for the company. As an example, as part of our interview process we discussed with a researcher various applications of plant genomics and breeding technologies that have potential application in many industries, but one particular one – dwarf trees – has already been adopted by apple growers. Apple growing has an ANZSIC code.

The value of this ex post classification of technologies is that it allows firms that have adopted technologies with (some degree of) RFI funding to be econometrically compared with firms that do not have those technologies. The longitudinal Business Database held by Statistics New Zealand makes such analysis possible. We strongly recommend it as a complementary way of assessing the performance of the RFI investment portfolio.



7. RESEARCH OUTPUTS

The RFP asks what specific outputs have been developed for industry in terms of:

- Uptake: the development of intellectual property, technological skills and specific applications that can be actively used to enhance wellbeing;
- Knowledge: a body of research, scientific or technological knowledge that can potentially be used to enhance wellbeing; and/or
- Capability: the ongoing development of scientific, research and technological capability that can meet current and future RS&T needs.

Data on 192 contracts started in 2002 were given to us by the Foundation from its RFI database. There are two significant issues associated with the 2002 RFI contract outcome data: there is no outcome data listed for 110 (over half) the contracts; and the outcome data that is supplied is binary in nature (i.e. there is an outcome or there is not an outcome, with no values applied). These factors mean that care should be taken in interpreting the success or failure of 2002 contracts based on the Foundation RFI outcomes data alone.

With the above qualifications, Table 4 addresses the three questions above.

Table 4: 2002 RFI contract outcomes

	No. of contracts [#]	
	Outcomes delivered	Outcomes not delivered
Uptake ¹	39	43
Knowledge ²	50	34
Capability ³	81	0

[#] for some contracts there is more or less data on some aspects of outcomes than others (i.e. there are 82 contracts with data on uptake, 84 with data on knowledge, and 81 with data on capability).

Notes:

1. Uptake is defined as new products, processes, or services implemented by end-users
2. Knowledge is defined as any codified IP or product, process, or service developed but not yet commercially implemented by an end-user.
3. Capability is defined as the recording or transfer of science knowledge such as through journal publication, workshops, seminars or presentations



With the qualifications mentioned above, the following observations can be made about the 2002 contracts on which we have outcome data:

- Almost half have recorded tangible commercial outcomes.
- Around 60% have recorded knowledge that can potentially be used to enhance wellbeing in the future.
- All have recorded some form of knowledge transfer or recording.

Although it is difficult to ascertain the success of 2002 RFI investments based on the above data, the results are not inconsistent with several key findings from our interviews with end-users and researchers, namely:

- There was a reasonably good success rate in terms of commercialisation of technologies.
- There were a significant number of contracts where there has been no commercialisation of technologies (Section 3 outlines the key reasons for this and Section 5 outlines some changes to RFI processes to enhance the commercial uptake and benefits of RFI funded research).
- Science quality is generally regarded as high, reflected by the large number of papers published and demands for dissemination of science results.

Finally, the incompleteness of the outcome data highlights the desirability of more comprehensive quality information on RFI contract commercial outcomes. This point is made in more detail in Section 5.



APPENDIX A: INTERVIEW RESULTS

Not all of the interview results are amenable to tabulation and of those that are, there were many non-responses. Those where some useful quantitative information can be compiled are summarised below.

Questions for Researchers and Potential End-users

1. Expectations of pay-back period for implementation

Far too long	11%
Comparable with other investments	56%
Extremely good	33%

2. Expected selling price of new products, processes, services

Too low to be profitable	10%
Allow normal margins	30%
Lead to high profitability	60%

3. Expected costs for new products, processes, services

Too high to be profitable	0%
Allow normal margins	38%
Low, leading to high profitability	63%

The unsurprising message from the above three questions is that most research is undertaken because a pay-off is expected, either via higher selling prices for outputs or lower costs of production.

The reported cases of the pay-back period being too long or output prices too low are misleading – they do not relate to expectations at the start of the research. Rather they relate to a single case where a new technology, namely the calpain inhibitor to treat human cataracts, did not proceed to trialling and testing beyond the laboratory because of expected lengthy testing times and uncertain results. At the outset of the research, however, expectations were high.

4. Expected acquisition and embedding of new knowledge and skills

Substantial new knowledge/skills	55%
Some new knowledge/skills	45%
No or minimal new knowledge/skills	9%



5. Expected barriers to and opportunities for implementation

The ratings available to respondents were:

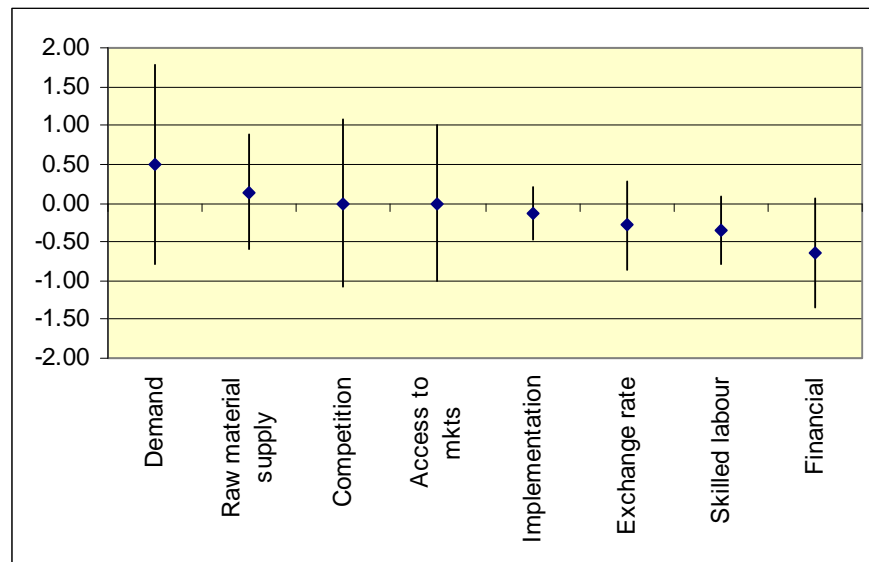
- Significant barrier
- Mild barrier
- Neither a barrier nor opportunity
- Mild opportunity
- Significant opportunity.

For the purposes of calculating a weighted average rating we assign these qualitative ratings numerical values of (-2, -1, 0, 1, 2) respectively. Note that this assumes approximate linearity in the ratings which may not be valid.

Further, we assign a score of zero to all non-responses, on the assumption that no response meant that the factor listed was not an issue. This will give a more accurate picture than ignoring the non-responses. For example if one respondent cited the exchange rate as a significant opportunity and no other respondents rated that factor, ignoring the non-responses would overstate the overall importance of the exchange rate.

In Figure A1 below the average factor scores are shown ranked from highest to lowest, with the error bars denoting ± 1 standard deviation¹ of the factor scores.

Figure A1: Barriers and Opportunities to Implementation



No factor scores highly as a barrier or opportunity, but on balance the demand for the product or service, and the availability of the required raw materials are seen as opportunities. The main barriers are access to skilled labour and financial, including the exchange rate, although where

¹ Another way to interpret a ± 1 standard deviation range is that there is around 68% probability that responses will be within that range.



the exchange rate was cited as a barrier, it was the US/NZ cross rate that caused most concern.

6. Relationship between researcher and potential end user

Close	64%
Moderately close	36%
Little relationship	0%

Close relationship between researchers and potential end-users are a dominant characteristic of RFI contracts.

Questions for End-users

1. Company a co-funder

Yes	77%
No	23%

2. Relationship between researcher and end user

Not close	8%
Moderately close	15%
Very close	77%

3. Effects of the new product, service or process on various input and output measures

Effect sizes were classified into:

- Down by more than 25%
- Down 5-25%
- No major change, $\pm 5\%$
- Up 5-25%
- Up by more than 25%

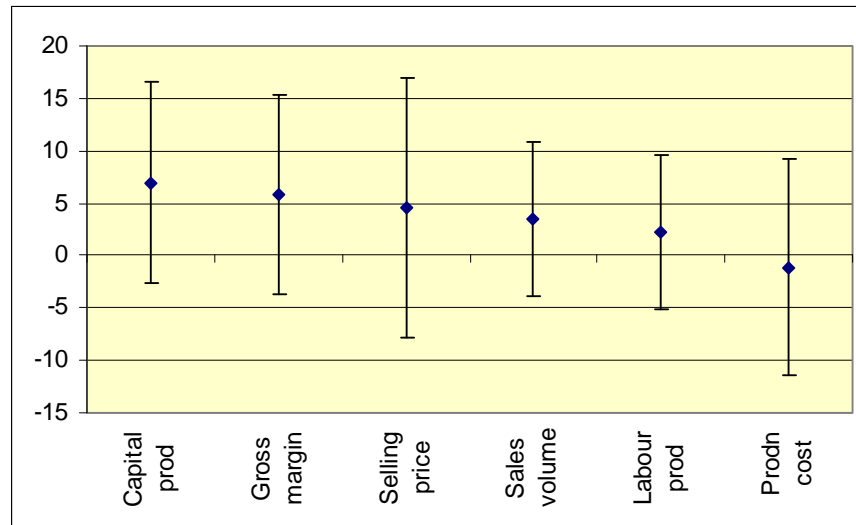
For the purpose of calculating weighted averages we define these as (-30, -15, 0, 15, 30). Figure A2 shows the mean effects and ± 1 standard deviation.

Consistent with the expected benefits reported by researchers and potential users, there are clearly pronounced effects on gross margins, stemming from greater capital productivity and higher selling prices. Higher sales volumes also contribute. Examples of increases in capital productivity are higher land productivity from dwarf fruit trees, improved



rye grass leading to healthier animals, less plant down-time with regard to cardboard manufacturing, asset models that optimise replacement and maintenance schedules, and tree growth prediction models

Figure A2: Effects on Inputs and Outputs



4. Benefits met expectations

Not met	8%
Met in most respects	58%
Exceeded expectations	33%

The sole case of 'not met' is the report on distribution channels for tourism which, as far as we can establish, had no user uptake. The calpain inhibitor for cataract treatment is included in the 'researchers and potential users' category as although it has not delivered commercial results, there is still the prospect of it doing so.

5. Expected barriers to and opportunities for implementation

The ratings available to respondents were:

- Significant barrier
- Mild barrier
- Neither a barrier nor opportunity
- Mild opportunity
- Significant opportunity.

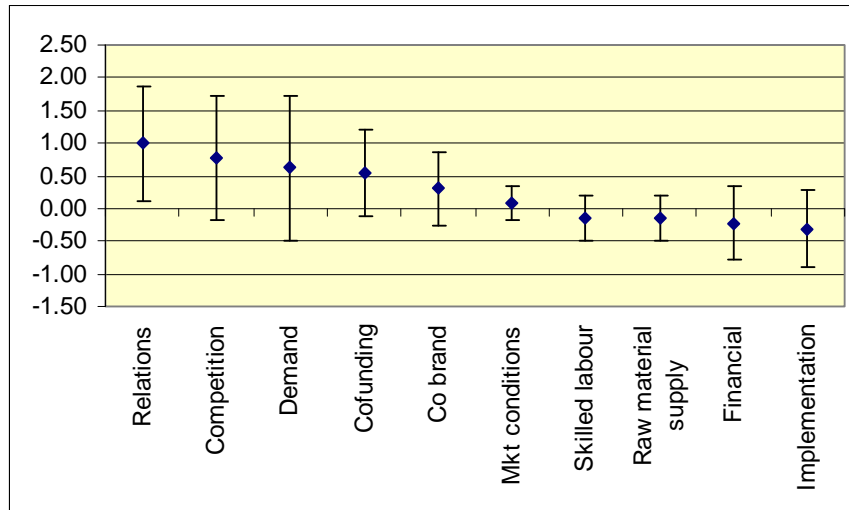
As above, for the purposes of calculating a weighted average rating we assign these qualitative ratings numerical values of (-2, -1, 0, 1, 2) respectively. Figure A3 shows the mean scores \pm 1 standard deviation.

The average scores are higher than for the 'researchers and potential users' – the benefit of hindsight presumably. Two external factors; competition and demand, rank second and third amongst opportunities,



while two internal factors; relations between researchers and users, and co-funding, rank first and fourth. We infer therefore that RFI works well in terms of user uptake when there is a market opportunity and when the researchers and users have a mutual interest in the outcome and work to that end.

Figure A3: Barriers and Opportunities to Implementation



In successful cases the various barriers have been sufficiently overcome (by definition). Unsurprisingly therefore the barriers did not receive strong ratings. However, implementation costs and financial issues are seen as the biggest barriers, suggesting that there is still some degree of funding difficulty between research output and successful commercialisation.

On the whole though there is little consensus on why new technologies did not deliver commercial benefits, with the reasons cited being:

- Inadequate demand, encompassing the existence of substitute products and lack of consumer awareness.
- Technology not working as expected or needing complementary technology.
- More research needed into commercial applications.

6. Implementation issues that needed to be resolved

Yes	23%
No	15%
Don't know, no response	62%

7. Ex post review of the product, process or service

Yes	38%
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No	8%
Don't know, no response	54%

8. Post contract development

Yes	38%
No	8%
Don't know, no response	54%

The above three questions were not well answered. Either the interviewee was not working at the firm at the time of implementation, or responsibilities for implementation, review and further development were with different people.

9. Consider the implementation a success

Yes	77%
No	8%
Don't know, no response	15%

10. Availability of alternative sources of funding if no FRST

Probably not	38%
Perhaps	23%
Almost certainly	0%
Don't know, no response	38%

The main source of possible alternative funds is the user, perhaps via an industry consortium or association. This was far from certain, however, and would be less likely to fund basic research, as well as probably leading to other research projects being deferred or cancelled.

Again the 'don't know' responses are significant here as research funding decisions are often not within the domain of the people responsible for implementation.

Common to many RFI investments is that they are initiated by researchers. Thus the CEO of a likely end user tends to be less involved than occurs with say TechNZ (TBG) investments. This is reflected in the answers to Questions 6-10, suggesting that RFI is not securing quite the degree of interface between research demand and research supply that would be required to meet the RFI objectives of increasing the global competitiveness of New Zealand firms and raising the level of technology in New Zealand production.



11. Shared new technology with other firms in same industry

Not much	23%
A little	0%
A lot	54%
Don't know, no response	23%

There is an interesting dichotomy in the responses to this question. Firms in an industry association or consortium naturally shared the new product, process or service, while those who acted alone (albeit with a researcher) tended to keep the benefit to themselves. In many cases though (for example product varieties and pastoral genomics) it was noted that eventually other firms catch up so it is important to maintain the research effort in order to keep ahead.

12. Do competitors have similar technology

Nothing similar adopted	38%
Adoption of somewhat similar	15%
Widespread adoption of similar	0%
Don't know, no response	46%

In retrospect this question had the wrong focus. Most respondents emphasised that while at any given point in time they might be ahead of the competition with regard to a particular technology, competitors would also be engaging in research and innovation to gain market advantage. Thus research and development needs to be a continual process to either keep up with or stay ahead of the game.



APPENDIX B: INTERVIEWEES

A total of 29 organisations were interviewed – a mix of researchers, consortia, potential end users and actual end users. These organisations were involved with 24 RFI contracts, which covered 27 new technologies (products, processes or services).

Contract	Organisation	Improve quality of existing products	New higher value products	Raise production efficiency
BIDX0201	PF Olsen			1
C01X0207	NIWA		1	
C02X0202	PGG Wrightson	1		
C02X0203	Enza Zaden		1	
C04X0203	Kaingaroa Timberlands	1		1
C04X0205	Visy			1
C04X0207	Rubicon and Scion	1		
C06X0205	ENZA and Plant & Food	1		1
C08X0201	WQI	1		
C08X0211	Aquaculture NZ		1	
C08X0217	Meat NZ			1
C08X0219	Contact Energy and Methanex	1		1
C10X0203	PGG Wrightson and AgResearch			1
C10X0233	Ballance		1	
DRCX0201	Dairy NZ			1
DRCX0202	Dairy NZ			1
LINX0205	Douglas Pharm and Lincoln University		1	
LPHM0201	Fonterra		1	
LSRX0201	Leather & Shoe Research Assn	1		1
VICX0202	Tourism Industry Assn			1
VLAC0201	PGG Wrightson			1
WQIL0201	WQI	1		
WROX0201	Cavalier Bremworth			1
		8	6	13