Re-setting science and innovation for the next 20 years

Science, innovation and business

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Introduction

I would like to talk to you about two cultures within the field of R&D – on the one hand, the culture of scientific research, and on the other, the culture of technological development for industry. These two activities and their associated cultures are not the same, nor indeed are their underlying purposes. This disparity of purpose flows through into the motivations which drive those who engage in each activity, and should be reflected in the excellence criteria used to assess performance. In New Zealand we have for many years confused these two activities, their purposes, their cultures, and indeed our systems of recognition for achievement in them. Much of this confusion has come from within the research community itself, stemming in some cases from unfamiliarity with the other field, in others from self interested promotion of one activity at the expense of the other, and in the worst cases intellectual snobbery and condescension reinforced by the review of peers unevenly selected from one culture or the other. Unless we are able to address this confusion here in New Zealand we will continue to have an innovation system which under-performs and an economy which does not meet our expectations.

The two cultures

I make no apology for the anecdotal character of my remarks. In my own career I have moved back and forth constantly between these two worlds – one perhaps best typified by the ethos and culture of the Marsden Fund, and the other the customer-focused and applied research world of the independent Research Associations.

The culture of scientific research

I will not labour a description of the culture of scientific discovery. I was recently privileged to attend the 350th Convocation of the Royal Society (of London). This was a celebration of the intellectual contributions of some of the most important scientists ever to have lived and recognition of the contribution which collective international effort has made to our understanding of the universe. The culture underlying this achievement is not only internationally consistent, but it is also altruistic and inspirational in its ambition. Its ambition is to progress human knowledge – arguably one of the most difficult and important tasks we can set ourselves. Progress is made using the scientific method first refined by the Royal Society's membership in London over 300 years ago. It involves the proposing of hypotheses and theoretical models based on observations and analysis, the testing of these propositions with experiments, and, when hypotheses are disproved, proposing new ones, and so on. Progress is recorded through open publication, and recognition is based on priority in publication dates, the impact factor of journals which agree to publish the research after peer review, and how frequently publications are cited by subsequent researchers. Whilst these widely used metrics are often criticised as favouring one discipline over another, or as being insensitive to the separately judged impacts of individual discoveries, any international peer review panel set up to assess science achievement will place at least some reliance on these globally accepted measures.

The culture of technological development for industry

Why on earth then, given the inspirational character of discovery in science, would any young person with a brilliant mind, lower themselves to target what might appear to be the lesser or even more tawdry goal of technology development? To answer this question, I have had to reflect on why I have personally chosen to devote so much of my own career to this apparently lesser challenge, and especially as I became more experienced in the latter stages of my career. Is it because I was unable to make a useful contribution to the challenging world of global science? This is undoubtedly to some extent true, but maybe there are other motivations too.

The answer I have come to in the end is that I began to find technology development more interesting, more immediately relevant to the competitive advantage of our own small economy here in New Zealand, and requiring a more complex mastery of a broad range of skills. So what actually do I mean by the phrase 'technology development for industry'?

I can perhaps best answer that by saying that I don't mean translation of research outcomes into commercial solutions, or technology transfer, or the commercialisation of research. The use of these phrases reveals a linear mindset of the application of science which is not how skilled technologists actually do

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Garth Carnaby spent the first twenty years of his career researching the application of mathematics and physics to the industrial utilisation of the New Zealand wool clip. In 1992, he became Managing Director of WRONZ (Inc.), now the Textile Science & Technology Section of AgResearch, and led the organisation through twelve years of continuous profitable growth. His involvement in seeking commercial applications for science in the wool and textile industries resulted in 2000 in his election to the role of World President of the Textile Institute, based in Manchester.

Throughout his career, Garth's interests have covered a very wide span, from the most basic science to the application of science in industry. His strong support for the vital role of basic research has been evidenced by his two spells on the Marsden Fund Council, first as Chair of the Physical Sciences Panel and then as Deputy Chair and Chair.

Dr Carnaby was elected a Fellow of the Royal Society of New Zealand in 1992, and in 2009 he was elected its President.

development. What I do mean is the practice of responding to industrial or market needs through a deliberate process of technology development in order to meet those needs. It has more in common with design, product development or engineering than science *per se*, but of course it might require the application of science to solve the problem – and certainly it will involve the scientific method or something like that. There may even be publications, but that is not the purpose of this activity – indeed there may not be any journals in the field in which to publish and almost certainly none of significant impact factor so as to enable the researcher to build a scientific reputation.

Indeed there are many cases where scientific knowledge is not the key component of the solution at all. Some might argue that what I am describing is not science and they may be right. They might disparage it by describing it as only a glorified form of consultancy. However, it certainly is an extremely creative activity which may involve the application of old science to a new problem of local relevance, or to the establishment of patents and/or the achievement of other demonstrably original and innovative contributions.

Although the solutions found may be of broad benefit to mankind, the primary motives for this activity are proprietorial, either at the national level or even at the level of the individual inventor. It is that unashamed proprietorial character that is the key to the wealth creation and capture which is aimed for.

Summary comparison of key features

Previously I've suggested some excellence criteria which could be used to assess the performance of those engaging in these two distinct cultural activities (Carnaby 2009). Table 1 summarises these, together with some associated characteristics describing the activity.

Implications for New Zealand (Inc)

Failure to fully understand and value both of these cultures in New Zealand will in my view lead to a sub-optimal innovation system. I don't think we can point the finger here at the government or government agencies. In fact they have developed a range of public intervention vehicles, from Marsden Fund to Technology New Zealand, which reflect the necessary values and which fund the most promising proponents of both scientific research and development for industry. What we have not done, however, is reach a consensus amongst researchers over the prioritisation of these activities. Nor have we achieved an acceptance of the need for co-existence, nor have we achieved a differentiated system for assessing excellence via peer review.

I believe it is important that we make progress on these matters within the New Zealand research community. I think it is important for New Zealand. We are a small community remote from the markets to which we are capable of successfully supplying only an alarmingly small number of commodities. The number of companies capable of exporting at scale is low. If we are to improve this situation, the case for more technological development to support both the successful industries we do have and to create new ones which we do not, is in my view compelling. I do not personally believe that putting all our eggs into the basic research basket, the results of which will be openly published in international journals, is the optimal strategy. We do seem to be under-investing despite the existence of some wonderful examples of market-led technological development. An example of such an opportunity is represented by the 'Placemakers Lab' on the Boulder Bank in Nelson, where the Cawthron scientists have cloned the breeding life-cycle of our major shellfish species. This will enable selective breeding of improved stock to commence, and hence a competitive advantage for the country to be created. This won't lead to papers in *Nature*, but it could add $1 billion to aquaculture exports from New Zealand. We could also cite the Fonterra ingredients team at Palmerston North, or the HortResearch efforts in the sensory science of New Zealand wine.

Whilst Government has developed differentiated funding streams which do reflect these differing cultures, the Govern-

Table 1. Criteria to assess performance of those engaging in the two distinct cultural activities (Carnaby 2009).

	Activity	**Value proposition for use of New Zealand taxpayer funds**	**Excellence criteria**	**Frequently levelled criticisms**
Basic scientific research	Discovery of new scientific knowledge	Serendipitous discoveries	Novelty re literature	Limited direct economic return on investment
	Engagement with global science	Informs Tertiary Education	Publication	No direct pathway to New Zealand outcomes
	Intellectual stretch	Informs applied science	Citation	Self-indulgent lifestyle choice
	Individualistic	Cultural imperative	Peer review	
		Step changes in economic activity		
		Market failure		
Technological development and applied research	Application of existing knowledge to new New Zealand problems	Competitiveness of New Zealand enterprises	Clarity of need	Poor science
			Novelty	Industry should pay
	Needs driven by the potential user	Export growth	Economic impact	Takes resources away from basic science or public good science
		Market failure without State leverage	Peer review	
		Large irreversible short-term gains		Private benefit capture

ment investment in applied research such as the Research for Industry area has often been looked down upon by academics as being unworthy of their attention.

Others have a part to play too. Let's start close to home with the Royal Society of New Zealand. The Society has made a clear decision that its Academy will embrace a relatively broad church. It now includes scholarly research in the humanities alongside traditional science disciplines as well as applied science and technology. However, do its committees who elect the fellowship really apply a multidimensional set of excellence criteria in selecting its fellowship or does it continue to place an over-reliance on traditional research scholarship? For a number of years now I have berated the Academy on this issue – I have suggested that we try to elect say a couple of new fellows each year whose research has created a $100 million sector in the New Zealand economy. Surely these people exist, can be identified and their contributions measured and assessed – or is Fellowship the wrong accolade – perhaps it is, and for this reason I have recently been promoting the enhancement of the status of special medals such as the Pickering, and by giving out a couple of special President's awards.

I have also been very pro-active in lobbying the Tertiary Education Commission so as encourage them to make the Performance Based Research Fund excellence criteria more permissive of development as well as the more traditional areas of research and scholarship. Not all academics want to engage in development, and nor should they be forced in this direction. Their main job is to produce graduates whose education has been informed by current research. However, some academics – maybe 15-20% – do enjoy development, and would engage more actively in it if their career reward incentives placed higher store on it, and were permissive of the time so expended. In my view, graduates coming from a more entrepreneurial research and teaching environment might well be expected to be even more valuable to the country. This is not to mention the country achieving greater direct economic benefits from our large Vote Education contribution to academics salaries.

Fortunately, too, we have a unique opportunity in implementing the CRI Task Force recommendations to refine the role in the New Zealand innovation system of the CRIs. The CRIs, the independent industry-controlled Research Associations, and private companies are the key to our progress in technological development.

The CRI Task Force clearly signalled the need for the CRIs to become better focused on delivery of results to their sectors for the benefit of New Zealand. The CRI Act requires the CRIs to carry out research. In the context of this presentation, what does 'research' mean and how will the Boards of the CRIs be instructed or expected to interpret that? By research, do we intend them to behave as if they were 'student-less universities' with large platforms aimed at 'science discovery' with international publication as the main objective? I hope not.

It is widely believed in the international science community and indeed accepted by economists that science discovery often precedes technological development and that more investment in it might fuel faster technological growth. However, whilst I personally would agree with this in general as it pertains say to, say American scientists and the US economy, or even British scientists and the British economy, the issue is more subtle for New Zealand. I would certainly agree that open publication of New Zealand science in US journals might stimulate the US economy too, but will it stimulate ours? I think we have to ask more searching questions of our CRI investments and the benefit capture mechanisms they propose to use.

Nearly all CRIs are likely to have an objective of 'science excellence'. If so, which criteria would be used to assess it – academic research criteria or technology development criteria? The recent budget signalled a great deal of new funding available through the primary growth partnership or for business-oriented research. This represents a major new opportunity for New Zealand-based scientists to engage with business and to win new resources for their research teams. However, the culture required to succeed in this will be different. It will require a service mindset. It will insist that scientists meet with the leaders of industry and listen to what it is that industry needs from science. I hear scientists say that industry leaders need to listen to scientists, too, but that's beside the point – they are unlikely to do so because they have many demands on their time and for their discretionary capital. It is my view that it is the scientists who need to do the listening for needs, not the other way around.

It will require the services of generalists who are capable of linking science expertise to the needs identified. It will also require a willingness on the part of scientists to drop what they are doing in order to respond to the issues identified.

Some members of the science community may regard what I am saying today as heresy, but what I am talking about is nothing other than excellence in applied research. We don't need every scientist in the country doing applied research. But we do need an army of scientists doing it if we are going to close the standard-of-living gap with Australia. The CRIs in particular need to take the lead in this. Industrial Ressearch Ltd made a start last year with its competition, 'What's your Problem, NZ'. We must avoid denigrating those scientists who do devote their careers to the application of science to New Zealand issues. Often this will be the application of old science to a new problem. The results might only be relevant here. The New Zealand science journals published by the Royal Society of New Zealand are often avoided now because they have low impact factors. However, they were developed as a vehicle for communicating what matters to us, not to the audience for a prestigious US journal.

If we are not to denigrate these applied scientists, our Academy and our institutions will need to learn how to assess them and do better at recognising them. We simply must recognise their creativity, their energy, and their intellectual contribution. Their contribution will typically integrate across a broader skill-set of expertise and normally combine this with a pronounced focus on leadership. Just as all of us would love to see one of our basic scientists win a Nobel prize whilst working in New Zealand, so too wouldn't it be good if we could equally celebrate someone whose ideas and creativity have led to the development of an extra $1 billion per year of wealth in our economy and enabled us to enjoy the standard of living to which our community aspires.

Reference

Carnaby, G.A. 2009. 'The' New Zealand Science System – An approach to evaluating structure. *New Zealand Science Review 66(4)*: 131–135.