Article

Could transforming science transform New Zealand?

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New Zealand has increasing concerns about its capacity to sustain the quality of life that we all wish to have, and rightfully so. We have seen our international rankings fall in many ways, but let me just refer to three – our relative productivity is poor; we rank surprisingly low on scales of innovation despite the national myth of number 8 fencing wire; and we have among the highest rates of teenage pregnancy and suicide. You may not see the direct link between the last and the first two, but perhaps it is there.

The world is changing at an exponential rate. Knowledge and technology are a major part of that change, and whether New Zealand remains of relevance to the rest of the world may depend significantly on transformational strategies, which will in turn depend on how we use the Research, Science & Technology (RS&T) sector. New Zealand really only has a few fundamental assets, and how we use these over the next decade will determine what we will look like for the next five decades or more.

What are our core assets?

First and foremost is our reputation, based on a stable, honest government and a physical environment that is both beautiful and relatively pristine. Secondly, we have a potentially very good education system which can generate outstanding graduates who are wanted by the world talent market across most disciplines, particularly in science and engineering. Thirdly, we have the practical and economic base on which to further develop the 'cultures' – agriculture, aquaculture, etc. – but here we must have a strategy that gets beyond the immediate to what the world will really want in 20–30 years, namely food for quality of life. We also have real strengths in the service sector, and in some aspects of high-technology manufacturing. Fifth is our umbilical cord to Asia, where successive governments have positioned us well to have effective relationships with the growth, population and economic superpowers.

I would argue that our economic future may well be particularly enhanced by seeing ourselves as an exporter of ideas, more than an exporter of widgets and food. I will describe below how we capture real value from such an approach. However, it is not an 'either–or' game – the few cards we have must be played carefully and skilfully. The bulk of this article will focus on two deceptively simple questions – how New Zealand should undertake research, and how to get better value from public investment in RS&T.

We are only four million people. This is less than in a medium-sized city in Europe, or North America, or Asia, but our obligations in RS&T to support the nation are so much more than theirs. Yet, our commitment to research is in fact much less. Why is that? Is it our history as a nation which has put relatively low value on thinking *vis-à-vis* making money or playing sport?

There is an international consensus that investment in RS&T links directly to productivity. However, our private sector expenditure on RS&T is very low and our public sector investment is relatively low – more so when one sees that the public science system in New Zealand is, in relative terms, already disproportionately directed towards the pull of the private sector when compared with other small economies, such as those of Denmark and Singapore. In my more cynical moments I wonder what we know, that the rest of the world does not, that leaves us with a very different set of attitudes to RS&T? They seem to be doing better than we are.

How should we undertake public science?

Our system is now the most competitive in the OECD, but it has a feature which looks superficially compelling – the funding system of the Foundation for Research, Science and Technology (FRST) essentially requires end-user involvement right from the start – which sounds good, but it is a system like no other in

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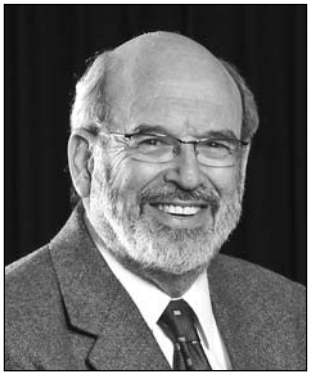
Editor



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causing more worry about a business plan than a science plan. I believe that this may at times be counterproductive. It certainly cannot guarantee quality in science, and at the end of the day, second-rate research is a waste of money.

The system is full of small buckets of narrowly defined funds, which are over-competed for. The result is that strategic decisions about what science can do and should do are often made by people who are remote from those best placed to do it. Virtually everywhere else in the world, the principle that applies is that science direction is driven by scientists, and market pull drives technology transfer. Scientists are not dumb – incentives can be put in place for them to follow market opportunities.

Our science system has many agencies involved; it is complex, it is bureaucratic, it is compliance-heavy. There is a commitment to simplification, but that simplification has to have in mind what needs to be achieved. Our science system has lost the career development focus of past generations. We have no ready way of supporting the best intellectual entrepreneurs, and the post-postdoctoral period is now a valley of death. We have a system that is so competitive that what we have done in many places is create a model where the best scientists spend their time competing for funds to support other scientists, where the focus of science has become one of institutional survival over scientific outcomes, and where we value competition at all costs over collaboration.

At the end of the day, science is about nurturing innovative minds and giving them an infrastructure and signals of direction, a high-level strategy. However, we have a system with little focus on individuals and none on infrastructure and with a tendency to micromanagement of strategy rather than having a high-level overview.

We have about 20 major research providers: the Crown research institutes (CRIs), universities, and institutes such as the Cawthron. For all of them, RS&T is a matter of survival and institutional health, not about national interest. We can end up with three groups within one CRI competing on the same science. We can also end up with eight universities and three CRIs duplicating low-level infrastructure rather than having national centres of expertise. Even where there is new opportunity we find institutions competing rather than collaborating to get to scale. The exceptions to this, and perhaps a harbinger of the future, are the Centres of Research Excellence[1] (CoREs). They delegate funds to the science community according to well defined high-level competition and under the aegis of a high-level strategy. They require non-institutional focus, exploiting the latent synergies across institutions – and they are delivering well. The MacDiarmid Centre is a demonstration of this. Perhaps the platform approach of FRST is a move in the same direction.

The other day I spoke at the Australia-New Zealand child psychiatry meeting on a topic I will return to later – adolescence. Parenthetically, one of my own research interests is the biological evolution of puberty and adolescence, and that is why I was speaking. The issue is why the period of adolescence, namely the period from biological maturation to that of acceptance as an adult, has grown so much longer over the past two generations and what its impacts are. I do not have time to go into this other than to say that adolescence defined like this is essentially a new phenomenon, and the longer the period of adolescence, the greater the risk to the individual. We know that the average age of a New Zealand girl undergoing puberty is about 12 years, and yet the pathways in her brain that control impulsiveness and confer wisdom and judgement do not mature until about 25 years of age.

There were a number of New Zealand academics and clinicians listening, each doing a rather small research project, none of which is likely to have any great impact. What if they had been put in a room with some developmental neuroscientists and social scientists, and told to identify the big questions about adolescent mental health in New Zealand and how these could be evaluated empirically? They could readily see the type of questions that might emerge. Would not that be a more effective way of New Zealand being able to go to scale in targeted ways in research?

How do we get the balance right?

While I do not have time to go into detailed explanation, over-competitive systems lead to conservative research – research that will not in itself lead to innovation. It is this matter of individual competition versus collaboration that is at the heart of the issue. We have not recognised some of the perverse incentives at play.

Because our system is so competitive, the capacity to go to scale, to develop the infrastructure and to exploit synergies is crippled. Australia sees value in national research infrastructure, but we get worried about what it will do to enhance the reputation of one institution at the expense of another.

Do we need to change some of the signals in the New Economic Research Fund[2] (NERF) and in the Performance-based Research Fund[3] (PBRF) to work better? The fractured approach just cannot work for New Zealand, given its size and geographical position.

We need to get the balance right. Peer and quality review can be based on entry in academia so that we ensure the next Paul Callaghan is identified. However, we also need to be sure that such people have a chance to flourish, and that clusters, physical or virtual, are formed. It is hard to see that happening easily in the current system. The best are leaving and we cannot afford that.

Most nations put a significant proportion of their funding through strategic allocative processes – Singapore puts about 60% in that way. The funds are allocated to what we might call super-CoREs, CoREs in the university sector, and by block-granted Institutes. However, what they then depend on is the most rigorous process of external review and evidence that there is a strategy and a path to exploitation – this is highly effective and highly accountable.

Where are strategies set in the CRIs? Their Boards have little capacity because they control little of their funding – the use of public sector funds is set by the FRST process with little buckets, and this can lead to perverse outcomes. For example, we now have little capability in ruminant physiology at the very

[1] See http://www.tec.govt.nz/templates/standard.aspx?id=586

[2] See http://www.frst.govt.nz/files/NERF.PDF

[3] See http://www.tec.govt.nz/templates/standard.aspx?id=588

time that ruminant physiology will be key to our contribution to reducing emissions. Another example is our soil science being undermined. CRIs do not have external scientific advisory boards, and ministerial letters are not based on scientific outputs or expectations.

So the challenge is how to get a better 'NZ Inc' approach. How do we get the incentives better in the science system so that it works for New Zealand? It has to if we are to thrive. How do we shift the equation so that we transform from having only 180 students in Agricultural Science but over 2400 in Film and Media?

How do we set priorities?

All this leads to another contentious question: How do we set priorities? We need some, because we cannot do everything – we need to do a few things well, but we cannot always predict where it will come from. Weta Workshop, TradeMe – any number of other outcomes – do not necessarily arise from an over-planned approach.

Priorities need definition multi-dimensionally around excellent minds, the quality of science, our competitive advantages, our particular sectoral interests (already largely defined by the shape of the CRIs), and a realistic full value chain from discovery to exploitation. Priorities should not become a long list driven by special interest lobbying.

Let me put more priorities on the table. The first is that of competitive advantage. Where we have advantage may in turn depend on how we exploit it – a matter I shall soon return to. My own bias is that small countries have one major advantage – they can work quickly across disciplinary boundaries – but the funding system needs to be responsive to this.

Secondly we should be asking the question of what futures are transformational for New Zealand, and then making sure we have the research capability and capacity to back such transformation, for one thing is certain – any transformational strategy will depend on knowledge, and science is ultimately the only way we have to gain new knowledge.

Finally any priority-setting system must be flexible and respond to rapidly emergent opportunities and ideas.

Evidential policy development

I now want to move on to the other big question: How do we grow New Zealand through knowledge? That is, how do we take science to scale, and how do we exploit it? There are multiple users of science and evidence, and each has different needs in terms of drivers.

First there is the government itself. It is a large sector of the economy. It undertakes a large amount of analytical work, but unlike the CRI and university sector, there is no oversight on its quality or value for money. Secondly, the business of government is the business of policy-based decisions, but to what extent are those decisions informed by evidence, and to what extent are interventions assessed for effect? How good is the operational research done within ministries and agencies?

Soon after I was appointed to this post I had the opportunity to meet with Lord Robert May, the first of the modern Chief Scientific Officers (CSOs) in the UK. He served during the premierships of Major and Blair and later was President of the Royal Society. I asked him what the most effective thing he had done was, and he was unequivocal in that it was putting evidence into policy. He achieved this firstly by suggesting that independent scientific input be available to every department of state —there is now a scientific advisor to every department bar one — and secondly by establishing the basis of a Cabinet protocol that requires a summary of the source of evidence and its quality to accompany Cabinet papers going forward. The role of the CSO is to monitor this. The process of evidence-based policy has recently been the subject of a House of Commons Select Committee review which confirms their importance, expresses concerns over slippage, and recommends strengthening the role of the CSO in monitoring these two related processes.

Evidence is only part of the process of policy development. Public acceptance, societal values and fiscal priorities are the other domains the politicians must judge, but without evidence we fall back on dogma and vested interest.

A demonstration project

The Prime Minister and I have agreed on a demonstration project to see how evidence might better inform policy in New Zealand. Adolescents face real challenges in their transition from childhood to adulthood, and the evidence suggests high rates of acting out behaviours, drug abuse, crime and teenage pregnancy in New Zealand relative to those of most other developed countries, with suicide being of particular note. While much focus of community angst has been on teenage crime, the psychological morbidity of early puberty and sexuality has been largely ignored. Furthermore the rate of teenage pregnancy and its impact on two generations is very high. Adolescents are at high risk of ethanol and drug abuse, with impacts on both their own health and that of society. There is a large evidence base from both the biomedical and social science literature relating to the early determinants of such concerns, and a significant component of this research is New Zealand-based.

I have asked a group of leading academics from a range of relevant disciplines to form a working group co-chaired by myself and Professor Harlene Hayne from the University of Otago. This group will review the empirical evidence in areas such as:

- The reasons and consequences of the increasing mismatch between the age of biological maturity and the age of acceptance as an adult.
- The impact of environmental and familial factors on the progress through adolescence.
- The impact of familial, social and educational factors in early life on the timing of maturation and on progress through adolescence.
- The impact of the media, the educational system, access to alcohol and so forth on adolescent behaviour.
- Context-specific factors that contribute to the particularly high incidence of risk-associated behaviour in New Zealand.

This report will put adolescence in a biomedical and social context, evaluate the evidence, and suggest strategies to improve this critical transition for young New Zealanders. I emphasise that the report will be firmly focused on the empirical evidence

base, *not* opinion. The report will separately identify those aspects where definitive recommendations are possible and identify those areas where ongoing research is desirable.

I expect it will uncover some counter-intuitive conclusions. I hope you can see the point of where this leads – let's use science properly by looking at the evidence, raising the questions, testing the questions and developing policy accordingly. Whether people are from the political left, right or centre, all governments ultimately want the best for their population. We have not used science enough in reaching where we want to be, and one can imagine how much money has been wasted as a result. I hope to look at the broader dimension of this question next year.

Knowledge transfer

There are related issues, such as the role of the media. If evidence is to be given more weight in policy formation, then it confronts the political reality that no political process can move faster than public acceptance. We have seen issues here — the situation of folate in bread being merely one example; climate change another. The quality and capacity of our media to represent science and evidence are patchy at best. Peter Griffin is doing a great job with the Science Media Centre, but the media in general are still hell-bent on reporting science as a series of breakthroughs – which it is not. They fail to adequately illustrate somewhat complex issues, and appear to want to create controversy, with a moral equivalency approach that leaves the public confused and the politician unable to act. Climate change represents a giant challenge here, and I suspect clean water will soon do so as well.

The second domain by which we use knowledge is through common good. For example, our farming strength is not primarily based on patented products, but on the strengths of knowledge of breeds, husbandry and pest control, which have come through our scientific community over several decades. That oil is now our biggest export to Australia comes because of public knowledge about our offshore shelf leading to majors being interested. That we have a sustainable fishery comes through the work of the National Institute for Water and Atmospheric Research (NIWA) and its precursors. Is our challenge of reducing pastoral emissions best done through open or closed innovation? Concerns have already emerged about the premature move towards the latter. If we have a government that sees individual responsibility as an important value, how do we transfer knowledge that leads to healthy eating and behaviours and sustainable environments?

I have left to last the issue of knowledge transfer to the private sector. There is, of course, not one private sector but many – we have a large service sector, and a significant manufacturing sector, as well as our pastoral and food sectors. While we think a lot about R&D with respect to the last two, it is perhaps in the service sector that some of the most obvious effects of basic mathematical and ICT research have come to the fore. Those interested in the service sector should look to the recently released Royal Society of London report entitled 'Hidden Wealth'[4].

[4] Professor David Rhind (Chair). 2009. Hidden wealth: the contribution of science to service sector innovation. London, Royal Society. (Available on their website: royalsociety.org)

Two cultures

As I said earlier, New Zealand has a very private sector-focused research system, but private RS&T is suicidally low in New Zealand. Clearly this has become a major focus of any government interested in improving productivity, and so it should. I recently chaired a workshop on this issue in advance of producing a report to the PM on strategies going forward. I apologise to anybody who was at the workshop for I am going to repeat some comments.

The first issue is about bringing together two cultures which in New Zealand have had little to do with each other: science and business. The incentives, expectations, and time horizons are all very different. Development is relatively linear; research is not.

We have a science application process dependent on business plans and private sector associations from the earliest stage. A project does not even have to have any preliminary data to get funded, yet after 18 years of this approach, our private sector R&D commitment remains poor. To ask some hard questions: Have we in fact simply taken the funds needed from basic research and effectively shifted responsibility away from the private sector? Do we not have the volume of basic research needed to drive innovation, or do we not have the business skills to take RS&T to scale? Or is it simply that as a country we have never really seen value in intellectualism, and that with an economy dominated by small and medium enterprises (SMEs) and short-term investment gains, the capacity and incentive to take research to scale is just not there? Other small countries do well, so size alone is not an excuse.

The cultural barriers between scientists and business are real. In contrast to what I see elsewhere, industry often comes to science just to find a late-stage solution to a problem; it rarely comes early to find what opportunities science might have. While application of most basic science may be uncertain, the reality is that such basic science of today becomes innovation in a decade, and as such, our scientists need to understand more about where exploitation opportunities lie.

Time-scales are a real issue. Few New Zealand businesses look beyond the short term. Even our largest businesses such as the farmers' collectives do not – look what has happened to the wool levy. In general, we need to recognise that early-stage RS&T is delivered by scientists; decisions about it need to be made by scientists aware of the sector, and late-stage decisions by those who understand technology transfer, business and so on. Conflating all this as we tend to have done here can be counterproductive. We should examine what happens in other small innovation-intensive economies.

It has been 50 years since C.P. Snow famously wrote about two cultures, and today we need to talk about two cultures (albeit not the same as Snow's two). How do we get the cultures of scientist and exploiter to know each other better? Is it perhaps through some programme of assistance to rotate academics, researchers and business people? Perhaps through some process of assistance to put active and or very experienced scientists on Boards? If one looks at New Zealand versus the US and Europe, one of the most obvious differences is the almost total lack of scientists on both public and private Boards here. Offshore, they need not be from the discipline or sector relevant to the

enterprise, but the scientific way of analysis has been found to add enormously and help traverse the cultural barriers. Should directorial skills become part of the career development of our most successful scientists, and would the private sector respond?

What happens in the universities – are the signals from the PBRF helpful or harmful, and can they be re-jigged to do better? Is the PBRF used as an excuse by academics to avoid the real world? Maybe it is, but in my experience entrepreneurial academics are usually also business-focused, although with this there are dangers, and damage can be done.

Supporting New Zealand talent

Twenty per cent of New Zealanders live overseas, but in terms of scientific leadership and entrepreneurship the ratio must be closer to 60% or 70%. We have to work out what to do. I opened a *New Scientist* magazine yesterday to see an advertisement from the University of Queensland for a research professor in cancer. The package included A$400,000 per annum plus a negotiable research support package which I know will be of similar size. I am prepared to lay a bet that there will be New Zealand applicants for that position. The world market for New Zealand talent is real. A similar person in New Zealand would be lucky to be making 35% of that, and yet would also be facing a much more competitive funding system.

The issues within CRIs are real and confounded by uncertainty as to whether they are competing or collaborating with industry. We have seen inappropriate closed innovation hurt whole sectors and this again suggests an immaturity of understanding of how to manage technology transfer. I worry about prematurely closed innovation. The drivers have led to the tying up of public intellectual property too quickly at the expense of what might occur downstream or through more open systems. We have to do better.

What about the business sector? Should R&D incentives be discretionary through grants like TechNZ, or primarily non-discretionary through vouchers or tax rebates? In New Zealand, we have very few companies with the infrastructure to undertake their own research, and in many cases even, development. We need a better NZ Inc approach whereby the facilities of the CRIs and universities are available – but beyond interpreters and awareness, the real issue is one of exclusion through high cost. CRIs and universities have to charge full costs, and these are substantial – indirect and overhead costs can be 150% of direct costs. Other countries subsidise these directly or indirectly. If we addressed this issue, could we incentivise universities and CRIs to go to business early and vice versa? In times like these, getting incentives which achieve what they are intended to do, rather than those that are uncertain or compliance-heavy, becomes even more critical.

Capturing value from our ideas

Perhaps one of the most difficult areas is that of technology transfer. This is not a space for amateurs, yet with exceptions, we have few professionals in this area. Should we do what Denmark has done and coalesce our expertise? Have we got the pre-seed, seed, and venture capital space right, or can we do better here? The trans-Tasman fund is an example of how we can use structured arrangements to go to scale quicker – scale in terms of sector expertise and dollars. Indeed, should we do more and recognise that going to scale might require new strategies? Such new approaches may be where we undertake international partnership from the discovery stage onwards, thereby making international funding at the transfer stage much easier. I would contend that we are better to own 50% of something large rather than 100% of something which fails because we cannot go to scale. We have obvious partners in Asia to take things to scale. In general I think that we have underestimated our capacity to be partners in ideas generation and thus in capturing value. I have a suspicion that our most valuable export will be ideas, but we need to be clever about capturing their value. It would require rethinking our science funding if this becomes a core strategy.

Conclusion

In summary I would emphasise the point that science is not a luxury – it is core to advancing the public good and the economic and environmental health of New Zealand. We are not a rich nation, but we are a clever one, and we need to look at how we invest in science and exploit it so that we can become a richer one.