Wool to Weta

Transforming New Zealand's Culture and Economy

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Beyond the Farm and the Theme Park

PAUL CALLAGHAN

Over my lifetime New Zealanders' lifestyles have changed in many ways. In the 1950s men died in their fifties of heart attacks, teenage girls disappeared for nine-month periods to stay with distant relatives and people who had travelled abroad were regarded, at least in my Wanganui East street, as slightly scary. Food was meat and three veges and drinking coffee was something risqué and done at night in darkly lit places called coffee bars. Life was good but a bit boring, and I couldn't wait to escape New Zealand. You certainly couldn't be an international scientist or a concert pianist with New Zealand as your base. All that has changed, remarkably. But most of the world has moved on as well, and New Zealand is not the only place where the coffee is great and the food sophisticated. Our measures of life quality tend to be formed relative to those around us, and so our children will make comparisons not with the world of their parents' childhood, but with the world of today, a world that offers them global opportunities.

When I was a child, the New Zealand dollar was always worth more than the Australian and our gross domestic product (GDP) per capita was higher than Australia's. Now our family members head across the Tasman for a better standard of living. New Zealanders like to think that we enjoy a good quality of life, and in many ways we do. But we see that our roads are, by First World standards, poor, and that people die unnecessarily. Auckland is congested, and we don't know how to afford

to build Wellington's new northern motorway through Transmission Gully. Pharmac can't afford to provide the pharmaceutical treatments that Australians and Canadians take for granted. We can't help but notice that many of our houses are dilapidated. In fact, our national housing stock, when it comes to insulation and interior warmth, is substandard given our cool and damp climate.

Even if you are prosperous and think that you can avoid all these problems, there is another reason to be worried. Our children go to London or Sydney or New York, and they like the lifestyle, they like the high salaries and they have plenty of Kiwi mates on hand. Our diaspora is around one million. Of course there are plenty of people with brains and talent who want to migrate here to exchange places with our kids. There are plenty of countries on the planet less prosperous than our own. But when our grandchildren are growing up on the other side of the world, when we have to Skype to read a bedtime story, we feel a pang of grief. Our prosperity gap, and especially our prosperity gap with the English-speaking world, causes a disconnect from children and grandchildren. Prosperity matters to families.

The graph below shows how our per capita GDP has changed, relative to the United States, Australia, Finland and Ireland, over the last 35 years. It is not surprising to see that the US is the richest country. However two small countries, Finland and Ireland, turned their economies around and built significantly higher levels of prosperity in the space of a decade.

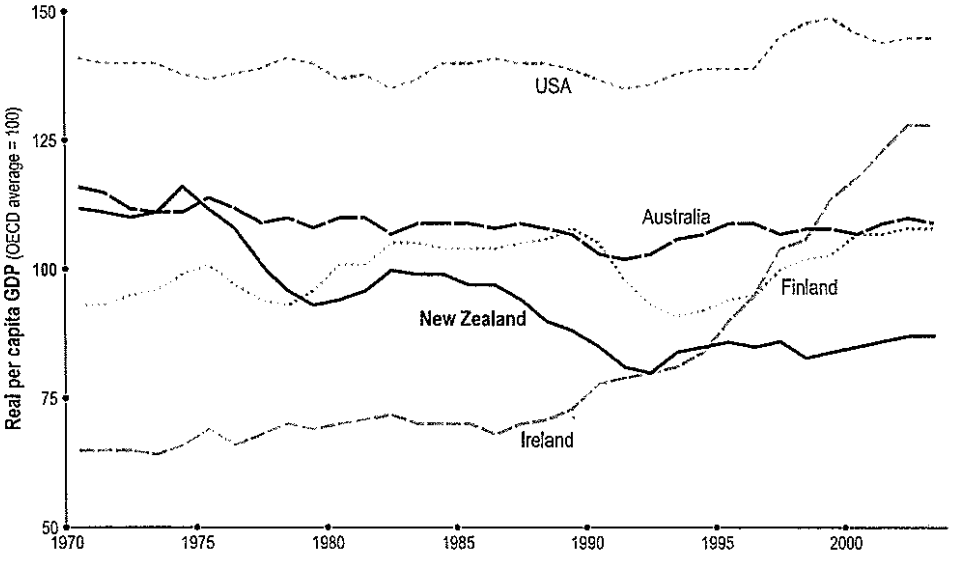

FIGURE 1 Per capita GDP normalised to the Organisation for Economic Co-operation and Development average. SOURCE: OECD

Australia has maintained a GDP per capita of around 110 per cent of the Organisation for Economic Co-operation and Development (OECD) average since 1970, while New Zealand has declined, improving its performance over the last few years, but by now significantly poorer than Australia. The gap between us and Australia, the extra amount that we would have to earn annually to match Australia's level of prosperity, now represents US$30 billion, around five times Fonterra's export earnings. That is the scale of our problem. And while we are dealing with OECD rankings, we compare poorly in quality of life measures such as imprisonment rates (24th worst out of 30), life expectancy (16th worst) and infant mortality (22nd worst). Are these social factors related to prosperity? I don't know for certain, but I can't see how a declining per capita GDP ranking can help.

It is not as if we don't work hard in New Zealand. In fact we work very hard indeed, compared with most OECD countries, as the graph below shows. Only Icelanders work harder than we do, although that work rate didn't protect Iceland from becoming one of the first casualties of the 2008 global credit crisis. By contrast, the French manage to work fewer hours per person than most OECD citizens. But look at what the French earn per hour. They are at the top, while we are near the bottom. Understanding this comparison is central to understanding New Zealand's recent economic predicament.

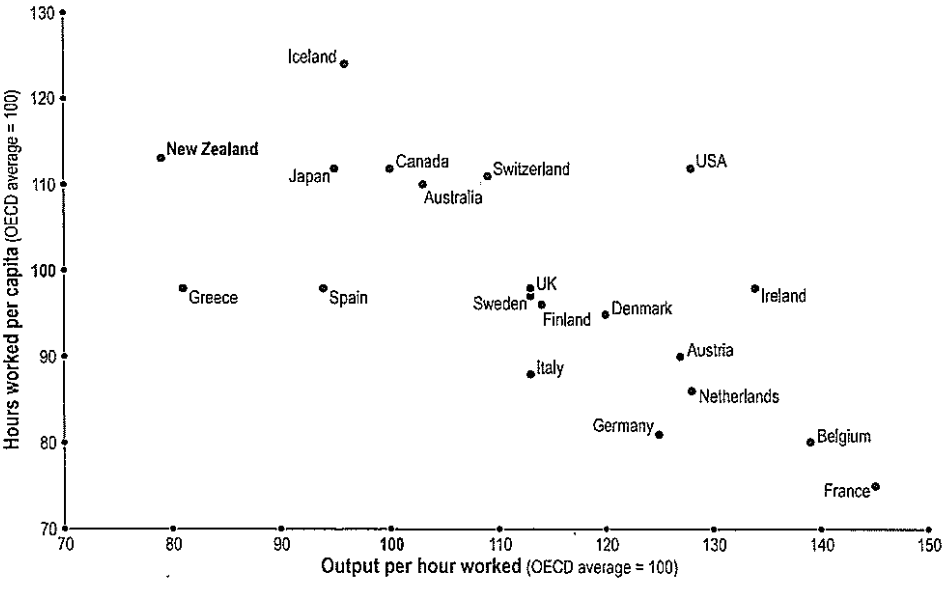

FIGURE 2 Hours worked per capita versus output per hour. New Zealanders are hard working but work in low-wage activities. SOURCE: GRONINGEN GROWTH AND DEVELOPMENT CENTRE AND THE CONFERENCE BOARD, TOTAL ECONOMY DATABASE, AUGUST 2005

Does it really matter? Do we really want to be as prosperous as our Aussie neighbours? Perhaps the answer to that question depends on where we want our children and grandchildren to end up living. But I want to start from the premise that it does matter, and that we would like to bridge the prosperity gap in a sustainable manner that preserves all that is best about New Zealand. I am going to make the assumption that we would rather be wealthy than poor, although we are aware that there are measures of a nation's well-being that cannot be expressed in per capita income.

What follows are my thoughts, illustrated from time to time with data. Mine is only one perspective. The interviews I have held with the other New Zealanders who appear in this book offer other perspectives, some which align with my own, and some which diverge. What we all have in common is a passion for this country and a desire to see it rise to a greater level of prosperity.

FOUNDATIONS OF PROSPERITY

I am interested in economic history and in what makes nations wealthy or poor. A widely held view is that the keys to prosperity are effective markets, legal frameworks, property rights and an honest work ethic. But those factors, in themselves, are not enough. If they were, then New Zealand would be one of the most prosperous countries in the world, since few countries can better us in our openness of markets, legal transparency, hard work and lack of corruption. Since 1984 New Zealanders have debated the roots of economic success. The economic liberals, as they like to call themselves, say that all we need is a level playing field. With low taxes, minimal government involvement in the economy and deregulation, the markets would work their wonders and we would all prosper. But strangely, for over two decades, we have watched ourselves slip behind countries that are less pure, less economically virtuous than we are; countries like Finland or Sweden or Ireland or Israel, places where governments meddled.

Like Harvard economic historian David Landes, who has looked at the way societies prosper or fail,[1] I think that effective markets, legal frameworks, property rights and an honest work ethic are essential to prosperity, but they are not in themselves enough. Landes explains how innovation, based on science and technology, substantially lifts prosperity.

In his book, *The Wealth and Poverty of Nations*,[1] Landes cites the case of Nathan Rothschild, the richest man in the world in 1836, who developed an abscess on his lower back and died at 59 years old from streptococcal septicaemia. Why? There were no antibiotics in those days. To quote Landes, 'The man who could buy anything died of a routine infection, easily cured today for anyone who could find his way to a doctor or a hospital or even a pharmacy.' In that sense, the poor of today's world are richer than the richest person alive in 1836. That is how Landes sees prosperity, not so much dependent on exploiting resources as in using knowledge, especially scientific knowledge. I am interested in the New Zealand side to that story. In the New Zealand context, technological innovation has progressively transformed our lives, improved our standard of living and broadened the scope of our lifestyle choices, with particular local benefits driven by science, from refrigerated shipping and pastoral farming to, most recently, the internet and cheap air travel.

THE EFFECTS OF SCIENCE

Part of the story I want to tell is about science and technology, and their place in our society. First and foremost the role of science is cultural. When Galileo built the first telescope he observed the moon and found it was not a perfect sphere but had mountains and craters. He observed the phases of the moon, as well as the phases of Venus, and he realised the universe was not earth centred but that we were in orbit around the sun. And looking at Jupiter he saw its moons and realised that orbits took place around many different points in the universe. For that heresy, he was silenced by the church. For similar apostasy, Giordano Bruno was burned at the stake. But despite efforts at suppression, the enlightenment had begun and the old earth-centred universe was finished.

Thomas Hooke used lenses to observe the micro-world and a plethora of living organisms was discovered. Humanity learned that most of life was microscopic, single celled and unfamiliar. Charles Darwin gave us an extraordinary new insight regarding the origins of life on earth and from Ernest Rutherford's understandings of radioactive decay, we learned that our planet was not thousands of years old but 4600 million years old. From the X-ray diffraction work of Rosalind Franklin and Dorothy Hodgkin, we learned about the structure of DNA and proteins. The age of biological insight began, insight that enabled New Zealand geneticist

Allan Wilson to discover the links between humanity, using the method of mitochondrial DNA tracking. We now know that the average genetic difference between people of different races is insignificant compared with normal genetic diversity in any single monoethnic group. We are all part of a closely related human family.

The place of planet Earth in the universe, the origins and nature of life itself, the connectedness of humanity, these are our philosophical insights from science. But in economic terms science has also driven a rise in prosperity that has permitted the human population to grow. Let me give you just a few ways in which the real wealth of nations has been immeasurably changed over the past five hundred years. Optics gave us the eyeglass and, through Galileo and others, its further descendants the telescope and magnifying glass. Nothing has so increased human productive potential as the ability of those beyond forty to use eyeglasses to continue to apply their skills and contribute to their craft. The telegraph, radio waves, the science of electromagnetism, due to Faraday and Maxwell, gave us modern communications and allowed New Zealand to move from isolation to sudden connection to the world. The discovery, by Fritz Haber, of how to fix nitrogen from air enabled the synthetic manufacture of fertiliser, allowing the world dramatically to increase food production and negate the Malthusian prediction of mass starvation. Fleming and Florey's discovery of penicillin gave us the science of antibiotics and the means to counter the many diseases caused by bacteria. The discoveries of the electron by J. J. Thomson, the atomic structure by Rutherford, the laws of quantum physics by Schrödinger and others gave birth to chemical understanding. This was followed by the later discovery by Bardeen, Brattain and Shockley of the transistor, leading to modern electronics and the computer age. The development of the contraceptive pill completely changed social relationships, empowered women and gave a new impetus to our productive potential. Contraception has allowed us to manage fertility so that we have the capacity to achieve a levelling of human population on the planet.

Of course we still face issues of sustainability, issues that we will need the power of science to address. That is a subject for another essay. Here, I want to stake my position as a humanist – one who believes that we should not leave nature alone but instead harness science and technology so that humans may prosper, while living in harmony with nature. Those who seek to return to some mythical, Arcadian, pre-industrial past better reckon on reducing the world's population to 100 million and being

prepared for a brutal, precarious existence. Unless we relish the thought of some sort of Armageddon where 98 per cent of humanity will be struck down, we humans have no choice except a future based on science and technology.

NEW ZEALAND'S ECONOMIC BASE

If you go to the Rangitikei district of the North Island you can go on a tour of stately homes. Many were built in the early 1900s when New Zealand's poor economy went through a rapid growth in prosperity. Newly wealthy families developed delusions of grandeur. The growth was brought about by the science of thermodynamics and the development of the refrigerator. Refrigerated shipping lifted New Zealand from subsistence trade to relative wealth. When I was a schoolboy we all learned the name of the ship that carried New Zealand's first refrigerated cargo, the SS *Dunedin*. New Zealand children have no longer heard of it.

Agriculture became New Zealand's source of wealth generation. To achieve this we converted most of our forest into greenhouse gas, giving us an abundance of grass. This use of our land has been a springboard for present prosperity. Jared Diamond[2] writes of the importance of a biodiversity buffer of indigenous forest – about a third of a country's

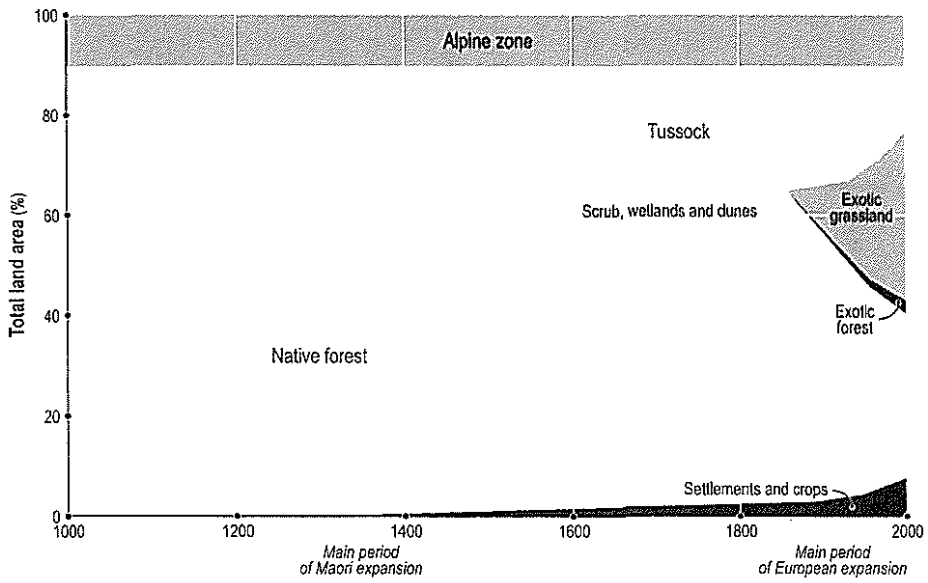

FIGURE 3 The history of New Zealand land cover. SOURCE: 'THE STATE OF NEW ZEALAND'S ENVIRONMENT 1997', MINISTRY FOR THE ENVIRONMENT WEBSITE, WWW.MFE.GOVT.NZ/PUBLICATIONS/SER/SER1997

land area is necessary to be effective. On that basis, and given that we no longer cut down our native forest, we seem very balanced at present. However, we cannot claim the moral high ground in telling developing countries that they shouldn't cut down their rainforests or use their coal resources.

The story of our bedrock, land-based industries is an impressive one. Our science innovation gave us world-class agriculture, so that, by the time I was born, New Zealand had one of the highest per capita incomes in the world. We have become a big international player in agriculture and we are a 'superpower' in dairy exports. And of course, our absolute prosperity has increased as we all share the fruits of international science and technology discoveries. So why has our per capita income relentlessly slipped behind countries we used to better? Why do we work harder for less than the rest of the developed world?

To understand that problem we need to go back to some historical indicators. We export commodities and recently that's been a pretty good thing to do. But look at the long-term trend for commodities from *The Economist* (below).[3] There are localised peaks when times are good, but the overall trend is relentlessly down. To illustrate the point we need look only at the ratio of meat exports to pharmaceutical exports, the number of sheep carcasses needed to buy a quantity of aspirin or chemotherapy treatment. Forty years ago our meat exports paid for our pharmaceuticals

FIGURE 4 Industrial commodity-price index, 1850 to 2007. Real dollar terms adjusted by US GDP deflator. SOURCE: *THE ECONOMIST*

bill eighteen times over. Now it pays for it four times over. Even in the past few years, while we have enjoyed a commodity boom, that ratio has stayed fairly flat. The long-term prospects are clear: relentless decline.

EXPORT OPPORTUNITIES

Why then do we have a US$30 billion per annum GDP per capita shortfall *vis-à-vis* Australia? In part, the Australians are lucky. All they have to do, when they are feeling poor, is to dig another hole and sell the uranium or bauxite that they find to China. Or at least, that's how our myth goes. But of course the truth is more complex. Their productivity is better than ours, in large part because of a better superannuation savings record and consequent investment over the past decade. They seem to have managed their economy better and of course they have greater economies of scale. But their large market is ours as well, thanks to the Closer Economic Relations (CER) agreement.

So where might we earn another US$30 billion per year in foreign exchange? Ideally we would earn it from additional exports. We are just 0.2 per cent of the world's economy. Our local market is very small, and much of what we want to buy is made offshore. What that means is that our extra productive capacity will need to be directed to exports. Everything we want from offshore, whether pharmaceuticals or iPods, we can buy only if people elsewhere in the world want to exchange their dollars, euros or yuan for our goods, our land or our dollars. For a while, we can sell them land or businesses, but one day we will run out of assets to sell. We can, for a while, sell them our New Zealand dollars on the basis of high local interest rates, but eventually those multinational banks and Japanese housewives will want to bring back their earnings, and probably their principal, to New York or Yokohama. That is exactly what happened in late 2008 with the sudden drop in the New Zealand dollar when the Reserve Bank lowered the official cash rate.

And how do we earn our living via exports? The relative export dollar fractions as indicated by the latest Department of Statistics data (Figure 5), show that tourism is now number one, with manufacturing close behind. Dairying continues to be a great New Zealand success story. Adding US$30 billion per year would mean, on the face of it, multiplying our dairy exports by five, or our tourism by four. Of course there are economic multipliers at work that deliver additional 'downstream' benefits for

every extra dollar exported. But we do get a measure of the scale of our problem by the ratios I am quoting. And even if we could increase dairying or tourism, there are problems. The limits to dairy's growth include environmental impact and methane contribution to greenhouse gas. Dairy is also vulnerable to negative international perceptions of 'food miles'. Tourism is extremely successful but has limits as well. Indeed, we may have already reached the limits to 'eco-tourism' in some areas. I doubt that it would be feasible to double Fonterra's production, let alone increase it by a factor of five, and I doubt whether we would want to quadruple the numbers of tourists visiting New Zealand each year, from 2.5 million to 10 million. Milford Sound already has 10,000 visitors per week, and if you walk the Tongariro Crossing on a fine day you will share the track with hundreds of people. Of course, we could just have more of the higher-paying visitors, the sort of people, for example, who will pay $8000 to shoot a deer in an enclosure. But, even if there were enough rich tourists for us to service, a doubtful proposition at best, is that really how we see ourselves as a nation? Is servicing that trade what it means to be a New Zealander?

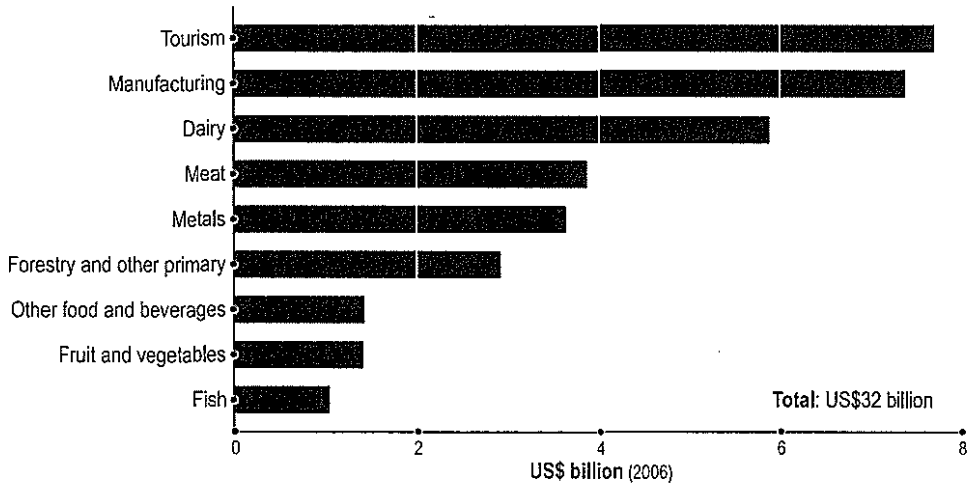

FIGURE 5: New Zealand foreign exchange earnings by sector (2006). SOURCE: NEW ZEALAND EXTERNAL TRADE STATISTICS, WWW.STATS.GOVT.NZ

I want to suggest another model for New Zealand export business, and one that has few downsides. To start with, I present an analysis of some international businesses, in terms of two particular metrics per annum: revenue per employee and profit per employee. Figure 6 shows a list of companies, many in what I would call the 'science/technology'

Company	Type of Business	Employees	Revenue (per employee)	Net Profit (per employee)
Apple	Computer	16,820	$1,335,871	$128,016
Microsoft	Software	61,000	$1,170,862	$333,131
Genentech	Biotechnology	9,500	$1,126,214	$217,148
Nokia	Cellphones	58,874	$1,109,395	$116,213
Samsung	**Consumer electronics**	**123,000**	**$1,026,095**	**$135,064**
Hewlett-Packard	Computers, electronic instruments	150,000	$977,054	$27,020
Garmin	Global positioning systems	986	$912,779	$395,865
Pfizer	Pharmaceuticals	106,000	$780,554	$123,022
Sony Corporation	Consumer electronics and entertainment	158,500	$646,596	$10,685
Varian Semiconductor	Semiconductor instruments	1,518	$638,042	$76,501
Intel	Semiconductor devices	99,900	$626,853	$139,882
Varian Medical	Medical imaging	3,600	$619,444	$92,742
AstraZeneca	Pharmaceuticals	64,900	$595,209	$96,526
Boeing	Aviation, military	153,000	$578,168	$27,114
Raytheon	Military, communications	80,000	$441,411	$17,560
Northrop Grumman	Military, aviation	123,600	$400,890	$18,269
Agilent	Electronics test equipment	21,000	$394,700	$25,115
Sigma-Aldrich	Fine chemicals	6,849	$392,334	$60,758
Tektronix	Electronics test equipment	4,334	$386,665	$34,238
Newport	Optical devices and sensors	1,870	$347,594	$10,005
Fisher & Paykel Healthcare	**Medical technologies**	**1,250**	**$232,000**	**$75,840**
McDonald's	Fast food chain	447,000	$73,826	$9,389

FIGURE 6 Comparison of international companies by revenue and profit per employee per annum (in US dollars) with Fisher & Paykel Healthcare Ltd. SOURCES: HOOVER'S DIRECTORIES, WWW.HOOVERS.COM/BUSINESS-DIRECTORY/; NZX DATA

sector and one, for comparison, in retailing of food. Revenue per employee and profit per employee are not perfect indicators of wealth generation, but they are interesting. Of course, one needs to look at the assets of a company to get the full picture. What did it cost to build the asset base to allow that industry to function? In the case of high-tech companies, the asset base is mostly brains and knowledge, whereas for an energy company it may be large-scale construction along with brains or fewer brains, depending on the particular company. But looking at largely brain-based business, it does seem, overall, that high-technology companies come out quite well. There are several companies, in the United States especially, where US$1 million revenue per employee is not uncommon. Of course large revenue will be most interesting, from a wealth-generation perspective, when it arises from a low input value of raw materials or a low input value of supplier product (and a low capital asset base). Examples are the writing of valuable software, the discovery and production of a valuable chemotherapy drug or the turning of silicon from sand into integrated circuit electronics. In this regard, Samsung, which makes its own chips and consumer electronic products, is close to that ideal. Samsung produces about three-quarters of New Zealand's GDP with 123,000 employees. That's a sobering thought. By contrast,

McDonald's, a well-known and presumably profitable business for its owners, has extremely low revenue and profit per employee. McDonald's, like most of New Zealand's economy, is in the low-wage business.

Among New Zealand's top earnings performers, it seems that Meridian Energy (US$3.0 million per employee) and Auckland Airport (US$1.0 million per employee) also make a large amount per employee, but they have large physical infrastructure as capital assets, and there is a cost to capital.

OUR TECHNOLOGY STARS

What is high technology? In short, products that embody relatively intensive research and development (R&D) inputs, either at the final manufacturing stage or through the components used in their production. One British definition includes 'processes which could be carried out in a residential area without detriment to amenity'. So what are our high-technology businesses, the ones that turn ideas into valuable products? These are the companies whose assets are the brains of their team. No dams, no windmills, no runways and airbridges, but talented people who create employment for other talented people, who might have computers, some machine tools, some circuit-manufacturing capability and some plastics-moulding equipment. We have a handful of such companies in the $100 to $200 million per year revenue category. These include Rakon with global positioning systems (GPS) on a chip, Fisher & Paykel Healthcare with hospital technology, Tait Electronics with radio communications equipment, HumanWare with technologies for the blind and Gallaghers with security equipment and electric fencing. None of them beats Fonterra in terms of revenue per employee (around $300,000 per annum), but let's consider for a moment their big advantage. Rakon, Fisher & Paykel Healthcare, Navman, Gallaghers, Alphatech, Vega Industries, HumanWare, Weta Workshop and Weta Digital all needed no new resources to start except brains and market understanding. Unlike Fonterra (or Meridian Energy), they need practically no land. They incur no significant costs of transport across the world, because their products are worth tens of thousands of dollars per kilogram or, better still, weightless. They consume little energy. They do not emit significant greenhouse gases or dump nitrates in our lakes. The Resource Management Act is no bother to them at all, and, as their

products are valuable, they are perfectly happy with a high New Zealand dollar value. And these businesses reside in perfectly attractive buildings and surroundings. In short, they are sustainable, environmentally and socially benign and there is no limit to the numbers of such companies which we might enjoy, except to the degree that our brains and enterprise make such businesses possible.

There are many innovative New Zealand companies, such as Icebreaker and 42Below, which are doing a brilliant job building export-led business. But my particular focus is on those companies where exceptionally high scientific or technological knowledge is central to the business model. Our star performers, Rakon, Navman, Fisher & Paykel Healthcare and Tait Electronics, have built on a platform of physical sciences and engineering capability, and they have shown that knowledge-rich physical technology platforms can be competitive from New Zealand.

Clearly New Zealand would benefit if many more such 'knowledge businesses' were to form, but what can we do to seed that process? The reason that each of these companies started, the nucleus of each subsequent growth, is not widely understood, although in several cases researchers have examined their pathways to success. Anecdotal evidence suggests a central role was played by inspired individual entrepreneurs, few of whom came from a formal, research-based scientific background, but all of whom have extensively employed high-level R&D capability. To quote from Angus Tait:

> In those days (30 years ago), a radio was designed by one person and it took hundreds of people to manufacture it. Nowadays, you almost need no one to manufacture it, but it takes hundreds of people to design it . . . . so right now we are looking at what we have to do to give highly creative engineering people and software people an environment . . . . which enables them to be creative . . . . we have done a lot of work on a career path for technical people.[4]

HOW DO WE GENERATE MORE?

I don't think that it is sufficient for us merely to create a macro-economic environment conducive to business, and especially export business, and then to hope that seed nuclei will form. My interest is in expanding the

seeding process and helping companies take the first steps to market. One obvious place to look for such seeds is in the large body of publicly funded scientific research, especially in those areas of science where commercial opportunities abound. Our prior success stories suggest that physical sciences may be our best hope.

I am speaking here of spin-out companies. A spin-out or spin-off company is 'formed through the transfer of technology from an R&D company, which is completely independent of the parent (R&D) company, and involves the transfer of human capital'.[4] Given that there are no suitable pre-existing vehicles for commercialisation, the spin-off strategy is, in many cases, the only viable option for the parent owner of the essential ideas, the so-called intellectual property (IP). Examples of such recent spin-offs are: Southern Photonics Ltd (optical pulse analysers) from the University of Auckland, Whisper Tech Ltd (Stirling cycle engines) from the University of Canterbury, Magritek Ltd (magnetic resonance technology) from Victoria University and Massey University, Australo Ltd (nanomanipulation of DNA), which has grown out of prior University of Otago research, and Photonic Innovation Ltd (laser detection of gases), also from the University of Otago. In the biotechnology sector, we have Proacta, a United States company which has commercialised cancer drug intellectual property of the University of Auckland, and Protemix, a University of Auckland spin-out company developing drugs to treat diabetic heart failure. Both show considerable promise, but have not yet generated a significant income stream. Therein lies an interesting issue.

New Zealand's Growth and Innovation Framework (GIF), established by the government in 2002, identified four sectors, including creative design, information and communications technology (ICT) and biotechnology, worth focusing on. Later economic strategies highlighted these and other candidates. This sort of 'guessing where our talents lie' is inherently dubious. It is true that ICT is indeed an area of high technology where we can get to market quickly and where we have shown that we can be successful. But consider for a moment the case for biotechnology. The government-funded Foundation for Research, Science and Technology (FRST) particularly targeted biotechnology as an area for R&D investment. Biotechnology is an ill-defined descriptor, encompassing pharmaceutical development, genetic engineering and human reproductive technologies at the most valuable end of the spectrum to new methods of food and beverage processing or

technologies which assist agriculture at the other end. Clearly New Zealand has some natural advantages in agriculture, horticulture and certain food industries, so that technologies aimed at enhancing their performance can produce real benefits. But for the rest, for the high-value activities, biotechnology is one of the most difficult areas in which to get products to market and to generate income streams. With biotechnology it is often hard to find a way to turn ideas into real products, to deal with complex regulatory requirements and to develop sufficient scale. While we are clearly good at agriculture, the assumption that this will translate into other areas of biotechnology is an heroic act of faith.

While we have not been particularly effective at turning scientific intellectual property into business, especially in the more valuable aspects of biotechnology, in contrast we seem to be good at doing it in another high-value area, the so-called physical platform technologies. Given our capability in physical sciences and engineering, I think that we could generate many more start-ups of the Rakon/Navman variety, and if a fraction of them succeed we may do far better than via the biotechnology route favoured by government. One of our main funding instruments for building a platform for high-technology spin-outs has been the New Economy Research Fund (NERF). A report on this fund, commissioned by the Ministry of Research, Science and Technology and undertaken by United States firm Abt Associates in 2006,[5] suggests that New Zealand disproportionately invests in biotechnology yet the outcomes, in science, intellectual property and business activity, have been significantly poorer than those for physical sciences and engineering. Worse, there has been an 'investing in predetermined boxes' approach to New Zealand's funding of scientific research, based on a presumption that our small size requires us to focus our investment effort – focused of course where public servants deem that we might be successful. The biotechnology gamble appears to be based on an observation that we are good at farming.

In my view we should invest in platforms where we have capability and talent, and, being the small country that we are, we would be most unwise to plan in advance where these capabilities and talents are likely to arise. No public servant has the prescience needed to make pre-selected allocations or to micro-manage our research. It would not be difficult to change the way we manage New Zealand's science funding instruments. We certainly need more investment in physical sciences and engineering, but we need it to be allocated to people with good ideas and enterprising

intent, rather than bundled up in prepackaged boxes. It may be that we have talents in biotechnology, but we certainly have great potential for wealth generation in physical technologies. We should remember that the nuclear physicist Rutherford and polymer chemist MacDiarmid did their Nobel Prize-winning work in physical sciences (abroad, of course). And we should note that the overwhelming majority of New Zealand's successful technology start-ups are in physical technologies.

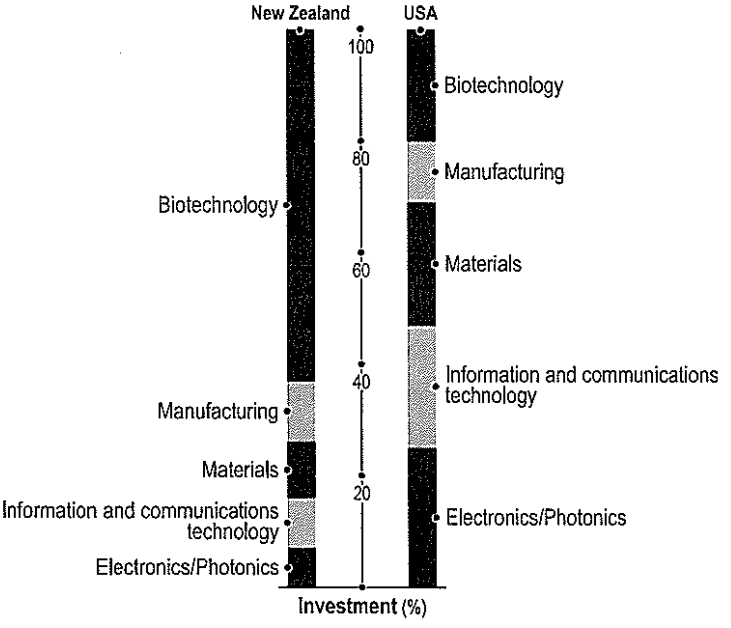

FIGURE 7 Comparative New Economy Research Fund research investment profile of New Zealand (left) and United States Advanced Technology Program (right; percentages represent investment to date). SOURCES: ABT ASSOCIATES, BASED ON SURVEY RESPONSES, PROJECT DESCRIPTION AND FRST CONTRACT INFORMATION; ATP ECONOMIC ASSESSMENT OFFICE

I am not advocating spending less on biotech research. But I am suggesting that we shouldn't apply blinkers, that we do have a track record of producing great businesses out of physical sciences and engineering and that we have the potential to do a great deal more. Most importantly, we should realise that we probably won't get results on the cheap. We invest less per capita in R&D than the OECD average (Figure 8), and our industry research investment rate is extremely poor. Despite that, our per capita rate of science publication is high, on a par with the best in the world (NZ has 1.0 scientific publication per annum per 1000 population compared with 1.4 for Finland and 0.9 for the US). But where we perform badly is in the generation of intellectual property per capita (NZ has 0.03 US patents per annum per 1000 population compared

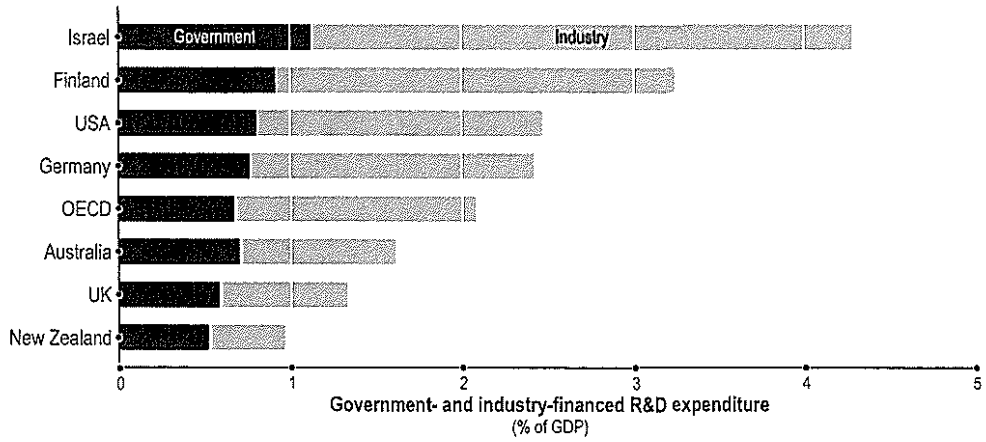

FIGURE 8 Comparison of New Zealand research and development investment per capita with other OECD countries. Data is from 2005 or latest available; New Zealand data is from 2003. SOURCE: OECD

with 0.15 for Finland and 0.26 for the US). Why is that? Perhaps in part it reflects the nature of business in New Zealand, and in particular the low-technology character of much of our manufacturing. But I also believe that it is because of the lack of an enterprise culture among many of our scientists. For example, in some Crown research institutes (CRIs), boards and management are loath to share the benefits of intellectual property with research staff. By contrast, there are fewer excuses for poor performance in the universities. Staff are entitled to a one-third share of benefit. At least one report suggests that our commercialisation rate from university research exceeds the United States average, but we should remember that many US universities are weak in research, and that they are more than compensated by the spectacular success of institutions of the commercialisation calibre of Stanford, Caltech or MIT.

INNOVATION AND SCIENTIFIC RESEARCH

Being a scientist, I naturally look to science to contribute to New Zealand's economic development. But at the same time, a degree of caution is needed. While science and technology have driven improvements in prosperity and quality of life in a global sense, there is no guarantee that a small country will be able to commercialise the scientific research carried out within its confines. Further, when we look at our own successful high-technology companies, we find that many emerged through the genius of

entrepreneurs rather than as outcomes of home-grown science research. The case of Neville Jordan founding MAS Technology is an example of the former; the development of Fisher & Paykel Healthcare humidifiers from the work of a Department of Scientific and Industrial Research (DSIR) scientist, Alf Melville, is an example of the latter. In many cases, the science that underpins our successful businesses was developed abroad, as in the case of the chip technology of Rakon. Examining our successes, we see that the fundamental driver is entrepreneurial vision coupled with effective innovation.

Good-quality science research is not a necessary condition for successful high-technology commercialisation and most certainly it is not a sufficient condition. However, scientific research, when carried out with intent to innovate and with a keen awareness of commercial potential, brings three major benefits to an economy. First and foremost it provides a source of skilled employees for the high-technology sector. Secondly, it provides a source of intellectual property and potential seeds for innovation. Thirdly, it raises the significance of science and technology in the country and increases the motivation for the young to pursue an education in science and engineering. But the drive for innovation, and the ability to learn from markets, as well as underlying scientific and technical skills will be the key determinants of whether new science-based businesses can emerge. I explore this magical combination of factors in the following interviews with those who have helped create our export business success stories.

I have argued here against an attempt to pick winners, against the belief that because New Zealand is small we must necessarily focus our ambitions within the science and technology sector. The crucial determinant of funding direction, for economically focused tools such as NERF, should be the quality of the proposals, the science excellence, the potential for innovation and the entrepreneurial capabilities of the team.

THE NEED FOR CULTURE CHANGE

Frankly, New Zealand science needs to do a whole lot better. That is where Centres of Research Excellence can contribute. One of these, the MacDiarmid Institute for Advanced Materials and Nanotechnology, was founded in 2002 and is a partnership involving scientists from across New Zealand. We have tried in the MacDiarmid Institute to create a culture

of entrepreneurship among our graduate students, to share with them the experiences of their fellow graduates who have gone into business and to bring them seminars from the world's leading technology entrepreneurs. Among this group we have outstanding human research capability in physical sciences and engineering. Our challenge is to turn that capability into manufacturing industry, to get people to 'make things that the market wants'. We have to fire up our young scientists so that they see starting their own business, or joining a start-up team, as the most exciting prospect for working in New Zealand.

Part of our culture change will be to encourage a marriage of physical sciences and engineering. Ultimately, when we come to make products to sell to the world, we will need the skills of the engineers and designers. And New Zealand performs badly in this regard. We have a disjoint between engineering and physical science that borders on hostility in places. We have far too few students enrolling in engineering courses in our universities and far too few learning the necessary maths and physics at high school. But the solution, I believe, lies in the hands of the present science and engineering generation. When we create the exciting high-paying jobs in the New Zealand high-technology sector, smart kids will cotton on fast.

My personal journey from science into entrepreneurship is quite recent. It grew out of geophysics research funded under a global climate change programme of the Foundation for Research, Science and Technology. It had a myriad of causes, many of which were to do with physicists and electronics engineers working together in an Antarctic adventure. It was encouraged by the Foundation for Research, Science and Technology twisting our arms in the direction of enterprise. We had started by developing robust, cheap, portable magnetic resonance spectrometers that could be used in Antarctica to measure the brine content of sea ice, but that work led to international interest in the use of these spectrometers for university teaching purposes, and then to their use in analytical research environments. So began the export company Magritek, and a stream of new products based on magnetic resonance technologies. The company took off because we had a brilliant and unconventional young entrepreneur with a PhD in magnetic resonance who could act as CEO. It grew out of the principle that technology and science are intertwined. I can't be certain that Magritek will make it, but it is performing, with revenue of around one million dollars per annum, nine employees and a minimal asset base.

A WAY FORWARD

So how do we boost the high-technology sector in New Zealand? First, and foremost we should do the easy things. We should discard the myth that because we are good at farming, our best high-technology future lies necessarily in biotechnology. Our best high-technology future will lie where are skills, our talents and our enterprise are apparent.

The Foundation for Research, Science and Technology needs to disentangle the process of encouraging wealth generation from the process of maintaining stability of funding for Crown research institutes. The NERF fund in particular needs to be freed up to all-comers, with funds being allocated where the science, engineering and enterprise capability is exhibited, and not in pre-labelled packages invented by FRST officials. We should be prepared to be surprised, to find talent in unexpected places and in unexpected science platforms.

We need an injection of new public funding in research. We cannot expect to reach the technology-based economic performance of countries we aspire to equal when we invest in R&D at a much lower rate, both in business investment and in government investment. We have it in our power to do something about the latter. But new money should be invested wisely. I am not convinced that the government's Foundation for Research, Science and Technology is the best vehicle for that investment, unless it allows open and free competition from across the research sector, thus unleashing New Zealand's research capability. Whatever route is chosen, such additional funding will need to seek ingenuity, intelligence, enterprise and commercialisation intent.

More funding and more effective investment instruments are relatively easy to achieve. What is harder to achieve is a culture in which scientific and technological enterprise is valued, where business seeks to innovate, where scientists regard business as a valid outlet for their talents and where children aspire to be scientists, technologists and engineers. We need our universities and institutes to champion world-class New Zealand science research where only the best will do, attracting the world's best to New Zealand, and enabling New Zealanders to be world-class scientists working in New Zealand. We need to build a science platform that is internationally connected, wealth generating and a focal point for society, raising the status of science in New Zealand. And most importantly, perhaps, we need to educate a new generation of scientists

who are excellent, entrepreneurial, communicative and socially aware, a generation who wish to stay in and contribute to New Zealand.

We need to build active links with the Kiwi diaspora, along the lines of the important work carried out by Stephen Tindall and the Kea network. New Zealand has an opportunity to recruit new migrants and returning Kiwis of exceptional enterprise and scientific/technological talent, in a world that looks increasingly tense and unstable. To be successful we need to be viewed internationally as more than a 'farm and theme park'. A major cultural shift towards greater emphasis on science and technology may generate new high-technology enterprises through this multiplier effect. Perhaps even more important is creating urban environments in which people of talent and enterprise will want to live. Arno Penzias,[6] Nobel laureate and, until 1998, CEO of Lucent Technologies (Bell Laboratories), has said that successful technology business clusters tend to form in the vicinities of excellent universities where the environment is conducive to graduates wanting to continue to live in the vicinity, the San Francisco Bay area, Boston and the Raleigh-Durham triangle being examples. If we are to attract the best scientific and technological entrepreneurs to base their business enterprise here, if we are to attract talented expatriate Kiwis home and retain the best of our own, then we need not only a vibrant science and technology culture, but great urban environments and a stimulating intellectual climate.

We need to acknowledge the heroes of New Zealand's high-technology sector, such as Neville Jordan who built microwave communications company MAS Technology from scratch. It was the first New Zealand enterprise listed on the NASDAQ. Jordan sold it at premium value and went on to found a New Zealand venture capital company, Endeavour Ltd. We need to tell the stories of Peter Maire, Gary Paykel, Rod Drury, Ken Stevens, Russell Smith and Angus Tait, amongst others. They have done in business what Peter Jackson and Richard Taylor have done in the film industry. The kids know about Weta and the Jackson studios. But they don't know the stories of the remarkable individuals who began our high-technology sector.

We need to remember that small countries can do astonishing things. Finland, with a population of four million, produces Nokia cellphones. Sweden, with a population of nine million, makes Saab jets, Volvo motorcars and Ericsson cellphones. It manufactures pharmaceuticals and, in Ikea, sells kitset furniture to the world. One single family, the

Wallenbergs, donates 200 million New Zealand dollars a year, mostly to science research. That's five times our Marsden Fund. Sweden runs the Nobel Prizes; the Swedes decide who get the top prizes in science for the world. That's pretty impressive.

Swedes aren't any better educated than us. They aren't more ambitious than us. It's just that they expect to innovate with science, while we see ourselves differently. We overachieve brilliantly in sport, but we underachieve in creating large sustainable businesses that can ensure our prosperity. It doesn't have to be that way. We have the capacity to do a lot better. We have the brains, the education system, the inventiveness. But we do need to resist our occasional little-mindedness, our parochialism, our tendency to divide amongst ourselves, our tendency to be suspicious of each other. We have business suspicious of government, engineering suspicious of science, Wellington resenting Auckland, the University of Auckland pretending the other universities don't exist, CRIs jealously protecting research grants from universities, the Ministry of Research, Science and Technology disjointed from the Ministry of Education, the Foundation for Research, Science and Technology disconnected from the Tertiary Education Commission. We just can't afford it. We live in a wonderful but small country. Our population is no bigger than Manchester or Philadelphia, but no smaller than Finland – where people seem a whole lot better at co-operation. My plea is that we believe in ourselves and work hard to discover the business models that work for us. My plea is for a 'New Zealand Incorporated' perspective, where we build links with our talented diaspora and all the other fellow-travellers in the great Global Village who love this country

I started by praising economists – my contribution to overcoming little-mindedness. I cannot be certain that we can lift our per capita GDP performance via the route I am suggesting. But I think it is worth a serious try. Further, by enhancing the role in New Zealand society both of science and, more importantly, of the values of science, we better prepare ourselves for a future where science and technology will play an increasing role in all our lives. Science is (or should be) about honesty, persistence, striving for excellence, scepticism and seeking consistency with what we know. I suspect that some or all of those values lie at the heart of most effective economies.

Let me finish this chapter by quoting Landes again.

Rich economies must defend themselves (ease but not eliminate the pain) by remaining on the cutting edge of research, moving into new and growing branches, learning from others, finding the right niches, by cultivating and using ability and knowledge. Much will depend on their spirit of enterprise, their sense of identity and commitment to the common weal, their self-esteem, their ability to transmit these assets across the generations.

In this world, the optimists have it, not because they are always right, but because they are positive. Even when wrong, they are positive, and that is the way of achievement, correction, improvement, success. Educated, eyes-open optimism pays; pessimism can only offer the consolation of being right.

The one lesson that emerges is the need to keep trying. No miracles, no perfection, no millennium, no apocalypse. We must cultivate a sceptical faith, avoid dogma, listen and watch well, try to clarify and define ends, the better to choose means.[1]

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Our World-class Success Stories

MICHAEL CHICK, MIKE DANIELL, PERI DRYSDALE AND RICHARD TAYLOR

In starting these conversations, I begin with people who give us cause for optimism. This chapter tells the story of four remarkable New Zealand businesses, each focused on the global marketplace with world-class products, each employing designers or engineers or scientists, each built on a knowledge base in which creativity and excellence are the engines of success. Fisher & Paykel Healthcare creates high-technology medical products, Tait Electronics designs and builds sophisticated radio transceiver systems, Snowy Peak turns natural materials into sophisticated fashion apparel and Weta Workshop is a five times Academy Award-winning company that offers creative services to the movie and television industries.

These are not the only New Zealand companies excelling in the knowledge game, but they provide a nice set of examples. Fisher & Paykel Healthcare and Tait both have a long genesis from small beginnings, one a publicly listed company, the other a family trust. The rise to success of Snowy Peak and Weta Workshop has been more rapid and both of these businesses are as much about creativity in design and the role of the arts as they are about science and technology. The individuals I interview also play different roles. Michael Chick and Mike Daniell are both CEOs, responsible to a shareholding governance structure, while Peri Drysdale and Richard Taylor are founding CEOs of their respective businesses. But