Powering Innovation

Improving access to and uptake of R&D in the high value manufacturing and services sector

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EXECUTIVE SUMMARY

Rapid development of the high value manufacturing and services sector (HVMSS) has the potential to generate a step change in the economic growth and social wellbeing of New Zealand. The country already has examples of highly successful firms in this space and the number is growing. The traditional contribution of our food and fibre based sectors will remain critically important for our future, but international experience shows that growth of the advanced technology industry sector[1] offers a pathway to higher productivity and a means to reverse our relative decline in living standards. This sector can also increase the diversity and overall value of our exports and contribute to the growth of new skills and capabilities nationally.

This report presents recommendations from a review by an independent panel, which was set up by the Ministry of Science and Innovation (MSI) upon a request from the Minister of Science and Innovation, to advise how the Government can better facilitate the development and growth of the HVMSS through enhancing the level of access to and uptake of research and development (R&D) services. This includes lifting the number and quality of successful commercialisation ventures from university and Crown Research Institute (CRI) research.

A number of challenges must be met if this vision is to be realised. Notably, there is a relatively low level of investment in R&D by New Zealand business (0.54% of gross domestic product (GDP) in 2010, compared with the Organisation for Economic Co-operation and Development (OECD) average[2] of approximately 1.5%), and similarly a relatively low level of overall expenditure on R&D as a percentage of GDP (1.30% in 2010 compared with the OECD average of 2.33%). OECD economic development statistics show the correlation between R&D investment and GDP growth. The report identifies other barriers to innovation and experiences from the innovation systems in other countries that support recommendations for action.

The Terms of Reference defined the scope of the review to cover the HVMSS including the following:

- Firms across sectors that include biotechnology, processing, electronics and embedded systems, mechatronics and robotics, sensing and scanning devices, medical technologies, advanced materials and manufacturing technologies (including plastics), marine technology, pharmaceuticals, agri-technologies, digital technologies and information and communication technology (ICT).
- The application of technology developments to the more traditional manufacturing sector including, for example, meat processing, wool processing and related agri-technology activities.
- The role of public research organisations involved in this sector.

[1] In this document, the phase "advanced technology industry" has been used interchangeably with the "high value manufacturing and services sector".

[2] The term "OECD average" used here strictly refers to the value calculated for the whole of the OECD, that is, the OECD total value as opposed to an average across all countries (see http://stats.oecd.org/glossary/detail.asp?ID=1885).

- Actions that can be taken to address the opportunity for the HVMSS to increase New Zealand's GDP and labour productivity.

This Executive Summary first gives an overview of barriers that were identified to access to and uptake of R&D then, following brief comment on aspects of the innovation systems in other countries, presents recommendations for initiatives that have the potential to boost development and performance of the advanced technology industry sector in New Zealand.

Barriers to innovation

From the submissions to this review, generic barriers were identified in four thematic areas, namely: Structure/Infrastructure, Capability, Investment and Culture.

A group of barriers was identified around the structure of the sector and the infrastructure in which it operates. Factors that were considered included:

- the effectiveness of CRIs, most importantly Industrial Research Limited (IRL), in meeting industry demand for R&D services;
- infrastructure that goes beyond roads and high-speed broadband and includes the networking of R&D capability, the location of large R&D equipment and how the transfer of technology should best occur.

Another key group of barriers identified in responses fell under the general category of capabilities and included those classified under knowledge and human resource. Access to knowledge for the industry sector and mobility of staff between the research sector and industry were significant capability issues. This barrier was found to exist across all levels of human resource and in all organisations, both private and government, of the sector.

The third main generic barrier identified was investment. The Panel considered New Zealand's low private investment rate as well as how the public investment could be best used to assist the sector. The Panel also considered barriers throughout the funding life cycle, from idea generation to product. Recommendations were made accordingly.

Finally, a group of barriers was classified as "cultural". These included those relating to New Zealand's national culture and the perceived lack of and need for a national innovation strategy. Cultural barriers also included differences in organisational culture, for example, between research organisations and business, challenges around relationships, management of intellectual property (IP) and barriers that have their genesis in business culture. These barriers tend to affect the innovation system capability and long-term strategic direction, and have led to recommendations in those areas. Because an innovation culture is nurtured by potential actions under each of Structure/Infrastructure, Capability and Investment, culture-related recommendations appear under these three headings and under a fourth "The Big Picture – How to Make an Even Greater Impact", which focuses primarily on long-term strategic issues.

International experiences

The report outlines experiences from other countries that are relevant to New Zealand and analyses responses and interview feedback from New Zealand research institutions, government agencies, industry and industry representative bodies. This information assisted the Panel in the identification of generic and specific barriers to growth in innovation. More importantly, there were lessons from overseas countries on structures and initiatives that had been successfully implemented to enhance knowledge flows, and connections between R&D capability and industry, and which appear to have driven higher economic growth rates.

The Nordic countries – particularly Norway, Denmark and Finland – have programmes, institutions and policies that are worthy of study, likewise Israel and Queensland (Australia). The Panel reviewed innovation strategies for small- to medium-sized jurisdictions, which share with New Zealand not only a desire to grow innovative business sectors, but also other characteristics. Denmark, for example, operates effective industry-focused R&D institutions with a focus on industry-led development projects rather than basic research. Finland has adopted a centralised and coordinated approach to the development of their innovation ecosystem, with the establishment of an overarching Research and Innovation Council, which is chaired by their Prime Minister. This has allowed Finland to take a holistic view of their innovation ecosystem and drive more effective innovation strategies.

To improve the flows of knowledge at the researcher–industry interface, a number of overseas jurisdictions such as Finland, Denmark and Queensland have introduced support schemes, analogous to New Zealand's Technology Fellowship scheme, which place researchers in industry. The outcomes of such initiatives can be impressive. An example is the "Industrial PhD Programme" that is funded by the Danish Council for Technology and Innovation. Companies that hosted industrial PhDs out-performed in profit growth, and the industry PhDs had greater earning power and were more likely to reach top level jobs than non-industry based PhD students.

Countries such as Finland and Denmark are currently reviewing their innovation systems. This gives New Zealand the opportunity to incorporate aspects of their findings, where appropriate, into our policy thinking. The Research and Innovation Council of Finland has identified a number of things that must happen in order to develop the innovation system, for example, *"structures will be reformed and organisational, operational and regional fragmentation will be reduced".* Strategic development policies have been developed to improve the flexibility of organisations, raise their profile and integrate complementary organisations.

Towards recommendations

MSI does not have policy and operational oversight of the entire New Zealand innovation system. For example, universities and polytechnics are partially funded by the Tertiary Education Commission (TEC), and other research organisations are funded by industry. In order to make effective change to the innovation system, all of these institutions need to be engaged in the change process. Therefore, the Panel has, in taking a holistic view of the innovation system, made some recommendations that are technically outside the scope of the report. These are intended to engage other players in potential changes that, collectively, could power the innovation system further and faster, thereby benefitting the economy of New Zealand.

The report makes recommendations on changes that relate to roles, responsibilities and structures of key research institutions in the sector, notably a significant restructuring of IRL and the establishment of a new organisation that focuses primarily on industry demand-driven development projects while retaining IRL's established strengths. The Panel recommends the new institution be based in Auckland, Wellington and Christchurch and exist on a scale appropriate to the needs of the sector, now and in the future. To move away from research institute connotations, the Panel has suggested that this new organisation be called Advanced Technology New Zealand (ATNZ).

The Panel also recommends a variety of changes or incentives to enhance knowledge access and R&D activity in the high value manufacturing and services sector. Other key recommendations relate to: enhancing commercialisation activity from research institutions, providing incentives for mobility of R&D capability between research institutions and industry (including establishing new technology-based companies) and enhancing R&D access for market-led product and business developments.

The Panel makes recommendations on setting the national innovation strategy, including top level political leadership of an enduring innovation agenda through the establishment of a new Science and Innovation Council. International experience is that the development of the innovation system requires the highest levels of government support. The Panel suggests that the new Science and Innovation Council be led from a very senior ministerial level in Government. Recommendations also include potential changes in the education sector that are seen as essential in growing innovation capability that will underpin a national innovation culture.

Progressive increases in Government investment in R&D are recommended over an extended period, ideally to arrive at an outcome where New Zealand's overall R&D investment at least matches the OECD average, and is underpinned by a continued commitment to basic research. The key aim of such changes is to better leverage the Government's investment in R&D with investment from the private sector. The report recommends an increased focus on the Physical Sciences and Engineering, while recognising that a successful innovation system depends also on science-aware graduates in Business, Creative Arts, Design, the Humanities, Law and the Social Sciences.

Some recommendations at the end of this Executive Summary have been abridged. The full wording of the recommendations is included in Chapters 3 and 4.

The recommendations in this report are a call to action that the Panel sees as essential to achieve out-performance in the national innovation system. These recommendations sit in a wider macroeconomic context and there are ongoing imperatives on the Government to address factors such as incentives to develop a strong savings and investment culture in New Zealand, broader and deeper capital markets, and creation of a more attractive environment for foreign direct investment. Such developments will be essential if the desired growth in private sector engagement and investment in R&D is to be fully realised. Based on the recommendations in this report, the Panel has suggested a set of priority actions that are outlined in Chapter 5 to set the stage for constructive change.

Finally, the Panel notes that earlier well-researched reports, notably those of the Institution of Professional Engineers New Zealand (IPENZ) and the New Zealand Institute,[3] present recommendations in the subject area for this review. The Panel hopes that this report reinforces previously recommended actions and proposes new initiatives that will, if adopted, place New Zealand on a path of much more rapid growth and development in its high value manufacturing and services sector.

[3] Institution of Professional Engineers New Zealand: *Catalysing Economic Growth: Boosting Innovation Expertise in the Private Sector*, 2011 (available at www.ipenz.org.nz), and New Zealand Institute: *Standing on the Shoulders of Science: Getting More Value from the Innovation Ecosystem*, 2009; *A Goal is Not a Strategy: Focusing Efforts to Improve New Zealand's Prosperity*, 2010; and *Plugging the Gap: An Internationalisation Strategy*, 2010 (available at www.nzinstitute.org.nz).

Recommendations

1) Structure / Infrastructure – driving connectivity

Recommendation 1:

Develop a strategic and structured approach for connectivity between research and development providers and the high value manufacturing and services sector.

Recommendation 1.1: IRL should evolve into a new "Platform for Industry" organisation, as "Advanced Technology New Zealand" (ATNZ), which would focus primarily on industry demand-led research and development contract work and would deliver expertise across a selected range of advanced technology platforms. This development should involve:

(i) ATNZ extending its industry development project support activities and downsizing its basic research projects.

(ii) Consideration being given to moving selected research platforms from IRL to one or more universities or, possibly, to other CRIs.

(iii) The significant majority of professional staff as engineers and those with applied science skills.

(iv) Two additional sites for ATNZ, one in Christchurch and one in Auckland. (Detailed recommendations on roles and funding appear as **Recommendations 19 and 20.**)

Recommendation 1.2: Government should give consideration to combination, rationalisation or coordination of related research themes, operating structures or other business arrangements for closely related research organisations. This should be done where it would enable these organisations to exchange knowledge, better allocate funds for incoming projects, use human resources more effectively and run commercialisation units that have more scale and effectiveness.

Recommendation 1.3: In certain sectors (for example, agri-technology and other service sectors) where many small- to medium-sized enterprises (SMEs) are generically similar, the Panel recommends developing an industry engagement strategy for more effective outreach by CRIs, and other research institutes and associations to ensure better uptake of technologies. These activities could take place in cooperation with industry bodies.

Recommendation 1.4: The establishment of further university–CRI–industry research consortia should be explored in advanced technology sub-sectors.

2) Capability and Commercialisation – Enhancing the Innovation Culture

Connectivity, Staff Mobility and IP Benefits

Recommendation 2:

Enhance connectivity between research organisations, tertiary education institutions and industry, through more flexible arrangements for employment, IP rights and benefits, and incentives for staff mobility and engagement in commercialisation. Promote R&D awareness and knowledge access schemes.

Universities:

Recommendation 2.1: Introduce more flexible university employment and IP benefits incentives to encourage staff, subject to meeting agreed teaching and research duties, to:

(i) Undertake paid consultancy work with business and industry.

(ii) Take on joint appointments or substantial secondary paid employment with business and industry at a level that enables New Zealand to match overseas income levels for sought-after academics.

(iii) Facilitate leave of absence for working in industry for periods of up to two years.

(iv) Engage in commercialisation and industry relationships, by adopting a more flexible and generous policy towards the percentage of the researcher share in the commercialisation revenues and ensuring that full national and international patents are given credit for academic promotion.

Related incentives are recommended for the polytechnic sector where a staff member has technological knowledge that is in demand from industry partners.

CRIs:

Recommendation 2.2: Introduce incentives for CRI staff to:

(i) Move into industry after a period of employment in the CRI sector to transfer R&D capability to advanced technology industries.

(ii) Engage with commercialisation, by adopting a standard policy that allows a share of IP benefits in the form of a performance bonus or royalty share to researchers who are actively involved in successful commercialisation initiatives.

More Flexible Approaches to IP Rights

Recommendation 2.3: To maximise the potential for successful new technology innovations, develop more flexible approaches to IP rights under which university or CRI IP or specialist knowledge may more easily be transferred to an industry partner or to a spin-out venture funded by external investors. Seek more flexible share-of-benefits arrangements that may not necessarily be equity or royalty arrangements, but could be success-based funding of staff positions or of student scholarships.

R&D Awareness and Knowledge Access

Recommendation 2.4: To enable MSI to introduce R&D awareness to and gain engagement from industry sectors, and improved access to knowledge:

(i) Create an R&D analogue of the NZTE Better by Design programme.

(ii) Promote the existing TechNZ Global Expert scheme and link this to the networking and industry advisory capability embedded in the proposed ATNZ (see Recommendation 1.1).

Increasing Commercialisation from Universities and CRIs

Recommendation 3:
Individual commercialisation units should continue to develop or increase capability both through embedded skills and through networked activity, to deliver high quality screening of IP opportunities and increased good quality commercialisation deal flow nationally.

Recommendation 3.1: Build on current networks of commercialisation units to link all universities and CRIs, and create the planned National Network of Commercialisation Centres (NNCC). This network should also enhance linkages to industry partners.

Recommendation 3.2: Provide an NNCC coordination office that would deliver support to the networked commercialisation offices by facilitating administrative services, database management and connections to wider investor and technical expert networks.

Recommendation 3.3: University and CRI commercialisation units should develop or increase embedded capability to deliver high quality screening of IP opportunities and increased deal flow, through:

(i) Appointment of directors with international business experience, and business development managers with the necessary technology backgrounds to identify and effectively screen commercialisation opportunities, existing competition and prospective connections to similar technologies and strategic partners in New Zealand or overseas.

(ii) Governance or advisory boards that bring to the commercialisation decision process a wide range of knowledge of, and expertise in, international markets.

(iii) An actively managed database of accessible technical and business experts across a range of technologies who can be summoned to give additional advice on potential technology opportunities.

(iv) The services of the best (international) patent lawyers, aggregating demand if possible across several institutions and/or commercialisation centres to obtain services at lower cost.

Recommendation 3.4: In addition to the enhanced access to investors enabled through the NNCC, university and CRI commercialisation units should enhance their linkages to angel investors and investor syndicates and seek to establish serial successful commercialisation venture partnerships.

International Recruitment of Skills

Recommendation 4:

Implement a study to determine where the professional skills gaps are in the New Zealand research organisations and advanced technology industries. Then launch an international talent attraction campaign including repatriating talented New Zealanders through a dynamic "Bring Back our Brains" programme. The programme would aim to attract top scientists, engineers and business people who are working overseas, but also to create a "buzz" in New Zealand during the process. Implement this programme by expanding the existing Royal Society of New Zealand Rutherford Foundation initiatives, using a talented and creative advertising firm, and encouraging the universities, CRIs and industry partners to run talent search campaigns at the same time.

Enlarging the Talent Pipeline

Recommendation 5:

In order to meet the demand for skills that are and will be required by New Zealand's high value manufacturing and services sector, current education policy settings and initiatives should be revisited.

Recommendation 5.1: Review policy on tertiary education tuition subsidy limits, which has led to capping of enrolled student places, with the aim of enabling universities to enrol students in the areas of Sciences and Engineering that are in demand, without penalising other disciplines.

Recommendation 5.2: Reinforce initiatives to engage under-represented groups in the science innovation system through secondary and tertiary education (for example, women remain under-represented among engineering graduates and Māori and Pasifika are under-represented more generally in the science disciplines).

International Collaboration and Agreements

Recommendation 6:

The Panel recommends that New Zealand should research and subsequently increase the number of international research and development collaboration agreements in strategic areas for the high value manufacturing and services sector, in both large research

infrastructure and areas of basic and applied research that support capability development in this country. R&D collaborative agreements between specific companies and overseas partners should also be encouraged.

Recommendation 6.1: Pursue targeted bi-national and company-to-company agreements in science and technology areas that support the high value manufacturing and services sector.

Recommendation 6.2: Pursue continued and new membership in mega-research infrastructure projects in order to participate in advanced international scientific research that requires shared infrastructure investment.

Raising Awareness in Business

Recommendation 7:

Increase visibility and awareness of technology developments and the value of innovation and the successes achieved by the sector through networking and promotional events.

Recommendation 7.1: The formerly TEC-funded Priorities for Focus (PFF) technology showcase events currently hosted by university research, and commercialisation offices should be extended to continually increase mutual awareness of R&D capability and innovation opportunities between the university, polytechnic, CRI and industry sectors.

Recommendation 7.2: In the case of CRIs, tertiary education institutions and other research organisations, the senior organisational leadership should increase the promotion of and publicity for successful business–industry partnerships and technology commercialisation from research, to motivate their organisations to move towards a more outward-looking innovation culture.

3) Investment to Catalyse Innovation

Prioritising and Driving Value from Government Investment

Recommendation 8:

While maintaining sufficient investment capability to foster serendipitous discovery and innovation, MSI should select a number of advanced technology platforms as a focus for TechNZ funding of R&D. In order to achieve scale in particular industries, New Zealand should concentrate on niche areas, for example, biotechnology, processing, electronics and embedded systems, mechatronics and robotics, sensing and scanning devices, medical technologies, advanced materials and manufacturing technologies (including plastics), pharmaceuticals (only to early IP licence stage), agri-technologies, digital and ICT technologies. The basic research focuses of Recommendation 14.1 would service these platforms.

Recommendation 9:

The investment in TechNZ grants, including Technology Development Grants and Technology Transfer Vouchers and the Pre-seed Accelerator Fund, should be increased as programmes become established and industry demand increases. Such grants should continue on a partner co-funding basis. In future policy design, the Government should consider models that provide for repayment of a proportion of a grant where the funded project has led to commercial success, to allow for reinvestment back into the TechNZ investment fund.

Recommendation 10:

Maximise early stage international market intelligence input into technology development funding. MSI should continue and enhance its collaboration with NZTE to provide better market information, in parallel with MSI, early in the investment process. This will inject additional high quality market input into the decision process around development support for advanced technology projects at as early a stage as possible.

Recommendation 11:

Continue the move towards collaborative investment in large research infrastructure, as exemplified by the planned investment in High Performance Computing. New high-cost physical and/or communications infrastructure that is required for clusters of industries and university research groups should be established on a cooperative basis and located to best serve the community of researchers (in universities, CRIs and industry) and on the basis of co-funding where appropriate by partner industries.

Expanding Private Sector Investment in R&D and Innovation

Recommendation 12:

Leveraging private sector investment is a key factor and important for all government investment in private companies, but consideration of a graduated scale of co-funding may provide an incentive for engagement of new players.

> Recommendation 12.1: Industry co-funding should continue to be used for all government investment in private companies, with the level of the matching customised for each programme of support.
>
> Recommendation 12.2: Government should continue to collect and use for future investment decisions statistics on commercial success of companies that have received government funding.

4) The Big Picture – How to Make an Even Greater Impact

Oversight and Leadership

Recommendation 13:

Form a Science and Innovation Council, led from a very senior ministerial level in Government, with representatives from the university, public and private research organisations and from industry. Members should represent a wide range of science and technology themes, including the social sciences. The role of the Science and Innovation Council should be to establish a national innovation strategy and advise on science and innovation policy and priorities.

Reinforcing the Basic Research Platform

Recommendation 14:

The Panel recommends that New Zealand maintain its commitment to basic and applied research through MSI and other government science funding, but, as funding increases allow, give more emphasis to engineering and the physical sciences.

Recommendation 14.1: Along with investments in life sciences, New Zealand should prioritise areas of research in engineering and the physical sciences that are essential for innovation in advanced technology, including computer science, mathematics, neural-computation, mechatronics, robotics, smart devices and embedded systems, information and communications technologies and media.

Recommendation 14.2: Maintain, in real terms, the existing level of funding for basic and applied research through MSI and other government science funding agencies. This funding should be part of a wider long-term agenda to increase funding levels into the tertiary education and CRI sectors to provide world-class facilities and enable the appointment and retention of top staff from the international talent pool.

Education – Creating the Next Generation of Innovators

Recommendation 15:

Introduce initiatives to produce a new generation of young people inspired to move into creative and entrepreneurial careers in the Sciences and Engineering.

Recommendation 15.1: In order to begin filling the funnel at an early age, launch a major national campaign encouraging young people to choose science and engineering career paths. This campaign should include success stories of start-ups in the media, science programmes on television, school advisors connecting science education with technology advances, sustainability and nature conservation, presentations in schools, and, for example, role models presenting to groups of science-gifted girls, Māori and Pasifika.

Recommendation 15.2: Establish new government funds for PhD scholarships in the priority areas of Applied Sciences and Engineering (see also Recommendation 15.3) for R&D capability building. These scholarships should be larger than the usual type of university PhD stipend. They should be prestigious and competitive.

Recommendation 15.3: Increase funding into the existing MSI capability-building schemes (such as the current Technology Fellowships) to enhance the level of knowledge transfer into industry sectors and capability building through:

(i) Industry-based and co-funded Masters and PhD programmes in applied science and engineering. Universities would build partnership programmes with industries in their region. Students would spend the bulk of their time in the company under joint supervision of the university and the industry partner.

(ii) Industry co-funded employment of graduates in science and engineering. This is a partnership scheme in which recent graduates or postgraduate students work on an industry-based problem where the supervising academic and industry partners give joint oversight to the project-based employee.

Recommendation 15.4: Develop a new generation of graduates with international business skills that address the shortage identified by various commentators[4] by ensuring that New Zealand has a premier international business school, probably based in Auckland. This should evolve through enhancement of present programmes at one of the existing business schools or as a collaborative venture across two or more.

Academia Engagement with Business and Industry

Recommendation 16: [5]

If the TEC Performance-Based Research Fund (PBRF) continues in (or close to) its present form after the 2012 PBRF Quality Evaluation, introduce a separate but similarly performance-based fund that:

(i) Recognises excellence in innovative work in the areas of applied sciences, architecture, design, engineering and technology.

(ii) Would likely be linked to business and industry co-funding for postgraduate students and/or partnered projects.

[4] New Zealand Institute: *Standing on the Shoulders of Science: Getting More Value from the Innovation Ecosystem*, 2009*; A Goal is Not a Strategy: Focusing Efforts to Improve New Zealand's Prosperity*, 2010*;* and *Plugging the Gap: An Internationalisation Strategy*, 2010 (available at www.nzinstitute.org.nz).

[5] **Note:** As Principal Moderator for the 2012 PBRF Quality Evaluation and potentially involved in the 2018 PBRF Quality Evaluation design, the Panel Chair felt it necessary to stand aside from this recommendation.

Making and Incentivising Investment in Advanced Technology Businesses

Recommendation 17:

The Panel recommends that the New Zealand Government should take proactive steps to lift the level of local and foreign investment in the New Zealand advanced technology industry sector.

Recommendation 17.1: The Government should "court" multinational companies to establish local industry collaborations and establish R&D facilities in New Zealand. Ideally, such initiatives should be led from the highest political level (in some countries this has been the Prime Minister) and should include incentives for foreign direct investment.

Recommendation 17.2: The Government should take steps to attract international venture capital to invest in new start-up companies, and other foreign direct investment into established industries, by raising ongoing awareness of the opportunities in New Zealand and considering other incentives.

Recommendation 17.3: The Government should encourage the investment of a small proportion (for example, 1%) of the New Zealand Superannuation Fund and Accident Compensation Corporation Fund in advanced technology companies in New Zealand.

The Goal of Increased Investment – Both Private and Public

Recommendation 18:

Set a target of matching OECD average public sector investment in R&D within 10 years and using increased investment to leverage private sector investment. This recommendation addresses the country's long-term investment in R&D and should be the subject of a follow-up project.

Recommendation 18.1: Increase public funding by 2.5% per annum or more in real terms over a 10-year period to place public investment in research and innovation at least at the OECD average level. The Panel believes the eventual target should be above the OECD average in order to drive performance in the innovation sector.

Recommendation 18.2: Use the increased public funding to leverage significantly increased innovation investment from the private sector. The target for the private sector investment increase should be much higher. It is instructive to note that for the private sector to lift its investment to the OECD average in 10 years would require a 30% per annum increase.

Roles and Funding of ATNZ – the Future of Industrial Research Limited

Recommendation 19:

ATNZ Business Model: Operating Structure and Roles

The Panel recommends that the ATNZ should have an operating structure and roles as follows:

(i) ATNZ would be a Crown-owned company, operating on the basis of reinvestment of any operating surpluses and driven by industry needs rather than blue-skies research.

(ii) The emphasis for ATNZ would be on "development" rather than "research" but it would retain some embedded science and engineering research capability and would link strongly to universities and other research organisations as well as to industry.

(iii) ATNZ science and engineering staff would be engaged primarily in market-led industry projects in both technology and market identification and characterisation roles.

(iv) ATNZ would be geographically located at key sites in Auckland and Christchurch, but with continuation and transition to the new focus at the Wellington Gracefield site. Establishment of the two new sites would begin as soon as possible.

(v) Ideally, the ATNZ sites will be collocated with technology start-up companies and, possibly, specialist technology research centres.

(vi) ATNZ would be framed around a series of advanced technology platforms that relate to its industry sector focus which are not covered by sector-specific CRIs.

(vii) Technology platforms for ATNZ could include:
- Microelectronics and embedded software systems (a generic field covering medical technologies, electronics, mechatronic devices and others)
- IT & Telecommunications
- Electro-optics
- Alternative energy systems
- Advanced materials and nanotechnology (including plastics)
- Advanced manufacturing technology
- Marine technology
- Future: Nano-bioelectronics.

(viii) At the time of the creation of ATNZ, consideration should be given to moving selected research platforms from IRL to one or more universities or to other CRIs.

(ix) Some R&D specialisations that currently exist in other CRIs could be considered for transfer to ATNZ, or vice versa, if this contributes to creating relevant critical mass of related R&D activity.

(x) ATNZ would provide a location for shared use of high technology R&D equipment and IT services.

(xi) ATNZ would offer a portal for information or specialised knowledge enquiries from the industry sector, also providing connections into more sector-specific research institutions and associations.

(xii) The ATNZ sites would offer a hub for industry–institute (including CRIs)–academia networking, joint project activity and for connection with other R&D service providers.

(xiii) ATNZ would aim to create an internal culture that encouraged the mobility of staff to feed talent into industry sectors.

(xiv) The ATNZ should work in association with the Metro Group[6] of polytechnics, to provide staff consultancy to industry on product and/or process development and on production problem-solving projects on a subsidised basis. For example, projects could be effectively co-funded through a partial in-kind contribution of staff and student time.

Recommendation 20:

ATNZ Business Model: Governance and Investment

The Panel recommends that the ATNZ should operate under the following governance and funding framework:

(i) ATNZ would have an independent Governance Board appointed by the relevant Ministers with a majority of business appointees (including the Chair). The Board would include representatives from the applied science/engineering research sector as well as international members.

(ii) ATNZ would receive core government funding but would be tasked with leveraging government funding with at least equal funding from industry-linked contracts. It is expected that the level of industry contribution to project funding would range from half to two-thirds of the total contract value.

(iii) The Panel foresees an effective target size of between 600 and 1,000 professional full-time equivalent (FTE) staff (current IRL staff 320) across the three sites. The significant majority of the professional staff should be engineers and those with applied science skills including those in new and emerging areas of interest to business.

(iv) ATNZ and its industry partners should be able to use project funding flexibly across project costs, including labour, financial and legal services, equipment and consumables, subject to meeting independent external audit requirements.

(v) Among key performance indicators for ATNZ, the following, if able to be clearly linked to ATNZ interventions, would help show that ATNZ was succeeding in its partnerships with industry:

- Revenue growth and export market development of project partner companies.
- Employment growth in existing companies or in new companies that are created through ATNZ–industry partnerships.
- The number of new product launches as a result of project partnerships with existing partner companies.

[6] The Metro Group consists of: Christchurch Polytechnic Institute of Technology, Manukau Institute of Technology, Otago Polytechnic, Unitec Institute of Technology, Waikato Institute of Technology and Wellington Institute of Technology.

- The amount of new foreign investment secured by companies as a result of project partnerships.

CHAPTER 1: Introduction

1.1 Background and Context for the Review

New Zealand is a self-described nation of innovators and entrepreneurs, with a strong scientific publishing record, and capability in low cost product development. However, there is evidence that the New Zealand high value manufacturing and services (HVMSS) sector is under-developed, and could contribute substantially more to the economy than it currently does, particularly through growth in high productivity advanced technology industries, thereby lifting gross domestic product (GDP) per capita and our position in Organisation for Economic Co-operation and Development (OECD) rankings.

The productivity gap is due to a number of factors.

Overall, there is a relatively low level of investment in research and development (R&D) by New Zealand business and to a lesser extent the public sector. In 2010 this country invested 1.3% of GDP in R&D, compared with the OECD average of 2.33%, and considerably less than other economies similar to that in New Zealand.[7] New Zealand also lags well behind the OECD average in labour productivity and, over the past 10 years, has fallen further behind Australia.[8]

The structure of the sector in New Zealand has also had an impact.

In terms of the number of employees, New Zealand's (HVMSS) consists principally of small- to medium-sized enterprises (SMEs), many with little or no history of engagement in R&D. This limits their capacity to implement new products and processes that are generated through research. Unlike other sectors important to the economy, such as agriculture, the HVMSS is exceptionally diverse and fragmented: it is composed of a large number of technology sub-sectors that are not unified by an overarching and guiding national strategy or vision.

The landscape of R&D capability across the sector is by no means uniform. In this sector, small technology start-ups, such as those that spin-out of university research, may be R&D intensive to the exclusion of other skills that are necessary for successful entrepreneurial or international growth. Larger companies, such as Fisher & Paykel Healthcare and Rakon, have embedded in-house R&D capability but have difficulty meeting the demand for additional skilled professionals or special "one-off" research needs.

Despite these characteristics, the New Zealand HVMSS includes many firms that have achieved global leadership positions in specialist niche markets and there is some evidence that this group is expanding. For example, of the 116 firms where joint Ministry of Science and Innovation (MSI) and New Zealand Trade and Enterprise (NZTE) service plans were completed, for 2008–09 total turnover increased by 14.4% to \$11.15Bn, and total exports increased by 18.9% to \$7.83Bn.[9]

Recent efforts to grow this sector further include the introduction of new Technology New Zealand (TechNZ) mechanisms aimed at accelerating the expansion of SMEs and larger

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[7] Statistics New Zealand Research and Development Survey: 2010 (available at www.stats.govt.nz).

[8] *OECD Economic Survey for New Zealand*, Volume 2009/4, April 2009.

[9] The Terms of Reference for the review are included as Appendix 1.

companies, the intended National Network of Commercialisation Centres (NNCC), and the actions recommended by the Crown Research Institute Taskforce.

It is intended that the recommendations in this report will offer additional mechanisms by which the Government can accelerate the process of growth of the HVMSS and further drive the New Zealand economy. Such mechanisms include R&D assistance to businesses in the HVMSS, commercialisation and technology and knowledge transfer initiatives, and the role of research organisations in improving the access to and uptake of R&D by the sector.

1.2 Scope and Objectives of the Review

Upon the Minister's request, MSI assembled an independent panel to conduct this review. Terms of reference for the Review and a list of the Panel members are given in Appendix 1.

The broad objective of the Review was to make recommendations on how the development and transfer of R&D knowledge, know-how and technology can facilitate the growth of companies that develop, provide and/or utilise high value manufactured goods and services.

The scope of the review included the following:

- Firms across a range of advanced technologies, including biotechnology, processing, electronics and embedded systems, mechatronics and robotics, sensing and scanning devices, advanced materials and manufacturing technology, marine technology, medical technologies, pharmaceuticals, agri-technologies, digital technologies and information and communication technology (ICT). These are hereafter referred to as the "Advanced Technologies".
- The application of technology developments to the more traditional manufacturing sector including, for example, meat processing, wool processing and related agri-tech activities.
- The role and funding of public research organisations involved in this sector.
- Actions that can be taken to address the opportunity for the HVMSS to increase New Zealand's GDP and labour productivity.

Specifically, the Panel was asked to:

- Analyse the primary barriers to technology and knowledge transfer from research organisations to the HVMSS in New Zealand and provide options to overcome those barriers.
- Provide an analysis of overseas models for assisting and driving growth in the HVMSS that have the most relevance to New Zealand, analyse the key lessons and practices from these models and explore what their implications would be for the roles, responsibilities and funding structures of key research institutions in the sector.
- Provide options for the roles and functions and funding of research organisations in the sector.

1.3 The Review Process and Extent of this Report

Prior to the Panel convening, eighty-seven representative individuals or organisations key to the HVMSS were invited to make written submissions to the Review Contributions to the Review were also invited through the MSI website and MSI distribution lists. Forty-six submissions were received.

Following written submissions, during 21–29 March 2011, over 30 face-to-face and teleconference interviews for up to one hour were conducted with individuals either representing themselves or their organisations. Interviews were conducted in Auckland and Wellington. Those interviewed were variously chief executive officers, managing directors, business managers and other senior staff.

Barriers for businesses in the HVMSS to access and uptake R&D were identified in the submissions and interviews. A detailed discussion of these is included in Appendix 2.

A number of countries of similar size to New Zealand have successfully implemented programmes to develop the scale of their high value manufacturing and services capability and have, subsequently, seen an increase in contribution to economic growth. Research of overseas models was supplemented through teleconferences (held before and during 21–29 March) with individuals at international research institutions in Australia, Korea, Finland and Denmark. Appendix 5 contains a commentary on aspects of the innovation systems in selected overseas locations.

The report includes commentary on the New Zealand innovation system (Chapter 2), and its funding and experiences from New Zealand organisations and key countries to which New Zealand seeks to compare itself (Chapter 3).

Recommendations are presented with supporting discussion in Chapter 3.

Chapter 4 gives specific recommendations about a future structure for Industrial Research Limited (IRL), and Chapter 5 some suggested priorities for action.

The Panel was provided with extensive background material assembled by the MSI support team. Public domain material not otherwise referenced in footnotes is listed in the bibliography (Appendix 6).

Despite a short timeframe for its completion (essentially the months of March and April 2011) every effort has been made to produce a report that responds to the terms of reference.[10] This report is not quantitative in regard to funding levels to meet recommendations for investment, or specific in some of its analysis and recommendations. However, efforts have been made to link comments to relevant pre-existing reports and analyses carried out in New Zealand and overseas.

This report was submitted in draft to the MSI steering group on 5 April 2011 and in final form on 28 April 2011.

[10] The Terms of Reference for the review are included as Appendix 1 to this report.

CHAPTER 2: The Innovation Ecosystem

This report focuses on science and technology-based innovation. However, growth of an innovation culture also involves broader questions around the breadth and depth of secondary and tertiary education, entrepreneurship education, the development of a more science-aware society across all professional disciplines and the creative connection of talented minds across discipline boundaries. A future innovation culture in New Zealand will be characterised by a vibrant design and creative arts community, and by the innovative contributions of professionals in business, law, the humanities and social sciences. These important broader influences, and that of the challenge of long-term sustainability of our society, were acknowledged by the Panel as it focused on the more confined scope of this review.

New Zealand's innovation ecosystem has been shaped over the years by government policy, the domestic and global economic climates and other factors, rather than having been led by a long-term national innovation strategy.

The innovation ecosystem is often seen narrowly as a "pipeline" or "food chain", in other words a linear commercialisation model that goes from idea to full market establishment with stages in research, proof-of-principle development, prototype, product beta-testing in trial markets and market launch. This scenario may be true for "technology push" projects that emerge from publically funded research organisations, but, innovation typically begins not with a discovery but with the identification of a market need that triggers industry-led innovation, which represents the large bulk of science and technology innovation in New Zealand.

It may also begin with lateral thinking that takes an existing technology and puts it in a new application or applies a technology to different markets. Innovation also emerges from partnerships between R&D institutions and industry, where work on a project produces spin-off ideas that produce new and often unexpected developments.

In reality, the innovation ecosystem has interactions at many levels and may involve iterative organic processes rather than a simple linear model. There are often difficulties, in particular, as products traverse the "valley of death" where many stall due to a lack of development capital as they pass beyond the early commercialisation stage. It is important that, between investments from the Government and the private sector, all innovation pathways and stages of the commercialisation process are funded, but based on sound market-led decision making.

The Panel notes that although most successful technology companies in New Zealand have not emerged from university or CRI spin-outs, in many cases the knowledge needed for the advanced technology development has been obtained through polytechnic programmes, university education (undergraduate and postgraduate) and from CRI and university research experience. Ongoing investment in the tertiary education system, therefore, is a key element for the generation of high value companies and the economic growth these can deliver. Moreover, an investment environment that encourages partnerships between publicly funded R&D organisations and industry appears to stimulate the level of innovation in the industry sector, as evidenced by international examples.[11]

[11] For example, a report released by the Danish Ministry for Science, Technology and Innovation entitled *Business R&D and Innovation in Denmark* (2010) states (p 3) that "…additional analysis of the Danish innovation consortia programme which supports research-

2.1 The Current New Zealand System

2.1.1 Industry

Because of its location, and long-term focus and dependence on primary industries, New Zealand has developed an advantage over other countries in some fields. While the country should, without doubt, continue frontier research in agriculture, oceanography, water, aquaculture, geology, bio-ecology and veterinary science, it should not allow the focus on these areas of expertise to become a barrier to success in other areas, for example, in sciences that do not need major (or costly) equipment investment but that have the potential to deliver advanced technology products.

New Zealand industry is characterised by a relatively large number of very small companies in the SME sector. However, contrary to popular perception, New Zealand has a slightly lower proportion of employees in SMEs, with 19 or fewer employees, than the OECD average (Figure 1). New Zealand has a similar proportion of people employed in large firms (250 or more employees) to the OECD average, although the number of very large firms in New Zealand is less than the OECD average.

Low productivity in New Zealand does not seem to relate to its high proportion of small companies. Denmark, for example, has similar proportions of SMEs but a much more productive economy measured as GDP per capita (Figure 2).

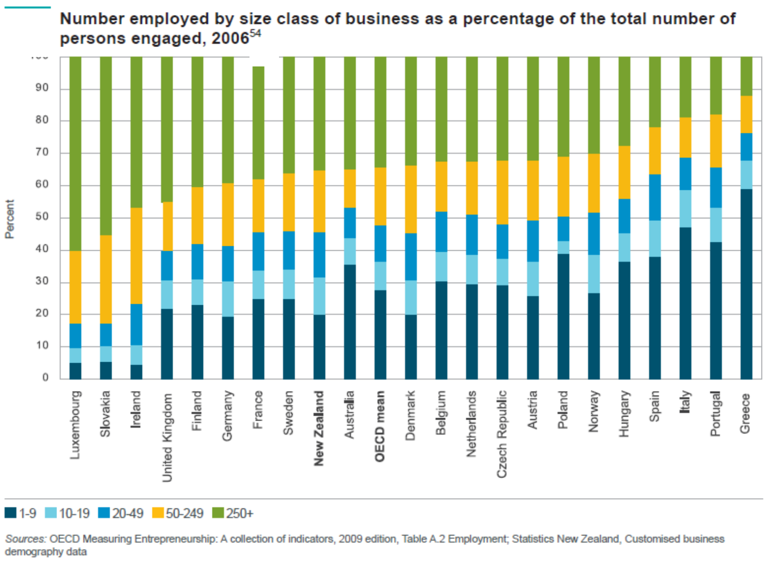

Figure 1: International comparisons of numbers employed by size class of business

While a substantial number of companies are involved in advanced technology business exports, the bulk of export earnings come from relatively few. For example, in the year ending March 2010, the top 100 TIN100 companies[12] had combined revenues of $6.7Bn, of which

business collaboration shows that 400.000 EUR invested by a company in public-private research partnerships yield 2–3 millions EUR in gross profits".

[12] TIN100, Industry Analysis, New Zealand, 2010, Sixth Edition.

$4.9Bn were exports involving 24,000 staff. The next 100 companies had total revenues of $508M and employed 2,900 staff.

The small number of high-technology companies (and there are many others that act as second-tier support to these) does not reflect the full potential in New Zealand. There has been an encouraging trend of increased R&D expenditure in the business sector over the period 1998–2010, as shown in Figure 2 below. Although New Zealand is considered to have high value for investment made, the fundamental problem is that there is not enough investment by the private sector.

New Zealand's macroeconomic environment has been identified in a range of other studies as not being as supportive as it could be to investment in the private sector and innovation.[13] Specific actions taken to develop the HVMSS must be accompanied by ongoing changes to the macroeconomic environment to support innovation.

2.1.2 Research and Development Organisations that Access Public Funding

The primary R&D organisations in New Zealand are its eight universities and eight CRIs. In addition, there are a number of industry-supported private sector research associations and organisations that draw upon government funds for specific types of research. The polytechnics, particularly the Metro Group, also have the capacity to offer technology development services to industry. A full summary of the R&D organisations and a map of their geographic locations are provided in Appendix 3.

These organisations form a network of capability in terms of researchers, engineers and business development managers. They also provide the underpinning physical R&D infrastructure.

A characteristic of the New Zealand science and technology research and innovation system is that resources are spread throughout the country, and individual institutions often lack critical mass in either staff capability in particular research themes or in research equipment. To a limited extent, this has been successfully addressed through the Centres of Research Excellence (CoREs) where the formation of virtual teams with shared research infrastructure has accelerated performance in certain research areas. The MacDiarmid Institute for Advanced Materials and Nanotechnology is an excellent example of such an organisation.

The universities and CRIs focus on basic and applied research, as well as some consultancy activities with business and industry. The CRIs engage more with strategic and tactical research as well as consultancy that supports specific industry sectors (for example, AgResearch, Plant and Food Research, Scion, IRL) or public good objectives (ESR, GNS Science, Landcare Research, NIWA). Other R&D organisations tend to be more narrowly industry focused (for example, BRANZ and the Heavy Engineering Research Association (HERA)).

Of the industry-focused CRIs, IRL is most directly involved with the HVMSS. However, because of the diversity and fragmented nature of the sector, IRL has a very diverse portfolio of

[13] University of Canterbury: *Innovation in New Zealand: Issues of Firm Size, Local Market Size and Economic Geography*, Hong Shangqin, Philip McCann and Les Oxley, 2009 (available at www.econ.canterbury.ac.nz/RePEc/cbt/econwp/0904.pdf); Ministry of Research, Science and Technology: *Becoming More Globally Competitive*, Peter Morten,2006 (available at www.morst.govt.nz/publications/a-z/b/becoming-more-globally-competitive/).

activities that probably lack the depth to be as effective as they need to be in supporting advanced technology innovation. Examples of current IRL capabilities are shown in Table 1.

General Area Domain	Possible Key Technologies	Examples of Relevant IRL Programmes
Electrical and power systems	Smart-grid and micro-grid, including eventually HTS (High Temperature Superconductors); sub-themes of current and voltage detection; networking; automation; power system modelling and prediction; energy efficiency; power quality; dielectric conducting and wear materials.	Communications (embedded intelligence, networks); spintronics (current detectors); HTS conductors; HTS accelerated development (transformer) cryogenic refrigeration; micro-grids (interface with smart grids); and wave energy.
Primary Measurement Standards	Maintenance of New Zealand's Measurement Standards, international liaison to ensure acceptance of New Zealand manufactured products, measurement advice and training to New Zealand users, measurement advice to regulators, calibration laboratories and industry.	Funding agreement for the Measurement Standards Laboratory providing funding for Measurement Standards.
Medical Equipment	Medical devices (not diagnostics).	Real-time imaging; advanced skin imaging; nanomaterials for energy (nanorod arrays as transducers and receivers, nanopores for bioseparation); photonic imaging and sensing; fast fluidic microanalysis; and 3D medical ultrasonics.
Natural Products and Ingredients	Supercritical fluid extraction, enzymatic processing technologies, fermentation and complex lipid chemistry are all technologies to assist New Zealand companies produce high value food products and ingredients.	High Value Lipids (HVL) programme targeted at a range of product opportunities and overcoming processing and engineering.
Industrial automation	Imaging and sensing with intelligence; automation and vision guided robots.	Communications (embedded intelligence, networking); fast content creation; integrated optical devices; and gradient coils.
Agri-technology	Imaging; sensing; security; traceability.	Communications (embedded intelligence, networking), spintronics (magnetic sensors); photonic imaging and sensing (THz sensing, strain and biosensing).
GPS/GIS, Communications and Optics	Product extensions and applications; developments in miniaturisation and optoelectronics.	Communications (embedded intelligence, acoustics); integrated optical devices (optoelectronics); advanced sonar technologies; and high resolution spectrograph.
AR, VR, Games and Film	Fast 3D imaging, model building and real time rendering, VR and AR technologies.	Communications (embedded intelligence, acoustics); fast content creation; digital artefact cloning; and augmented humans.
Appliances	Energy and water efficiency, thermal management, and environmental footprint.	Communications (embedded intelligence) and cryogenic refrigeration (thermal engineering).
Structural and Functional Materials	Specialist materials, in particular composites, and micromanufacturing.	High performance ceramics; multiscale modelling (computational materials analysis to support bio-ceramics), cements for extreme environments and acoustically efficient buildings.
Industrial Chemistry and Pharmaceuticals	Organic chemistry and bench to GMP (Good Manufacturing Practice) chemical synthesis with a strategic focus on new therapeutics for gout and cancer, renewable ingredients, chemical manufacturing.	Glycotherapeutics and New Synthesis Methodologies (drug discovery and manufacturing processes through the Carbohydrate Chemistry Team and GlycoSyn); CarboNanotechnology (vaccine adjuvant); Renewable High Performance Coatings (with Resene Paints); Chiral Pharmaceuticals to generate manufacturing technologies and IP that differentiate New Zealand industry from other low-cost manufacturing nations.

Table 1: Examples of Advanced Manufacturing Technology Capabilities within IRL (Source: IRL)

IRL has spun out companies from its basic research. However, the abandonment of BioPharm in 2006, and the slow path to market of HTS 110,[14] indicate that there are opportunities for improving commercial outcomes from this CRI. IRL has been hindered by a lack of breadth and depth of science and engineering capability to fully engage with the wide range of industries in the HVMSS. There is an opportunity for IRL to become more market driven and better aligned with short- and long-term industry needs.

While IRL is the obvious CRI to consider for structural change, consideration also needs to be given to science and technology areas covered by other industry-linked CRIs, to strengthen sector focuses and ensure alignment with market demand for their R&D services.

[14] HTS 110 was launched to commercialise IRL's high-temperature superconducting technology. A part of this entity was recently bought by the New Zealand-based company Scott Technology.

2.1.3 Investment Levels in R&D, Funding Channels and Initiatives

The link between investment in R&D and GDP growth is clearly seen in OECD data.

The *OECD Science, Technology and Industry Outlook 2000* (Annex 1) contains a comprehensive summary of the empirical links between innovation and economic performance. Based on a large number of studies evaluating the rates of return on R&D investments, it finds the direct (private) rates of return are typically between 10% and 20%, making investments in R&D ultimately a profitable undertaking. Rates of return typically show considerable differences across sectors, with R&D in research-intensive sectors having higher returns.[15]

A comparison of GDP per capita versus national R&D expenditure (GERD) per capita, over time in US dollar equivalents (Purchasing Power Parity US dollars), for New Zealand and various other countries confirms that increased investment in R&D does correlate to increased GDP (Figure 2). While this correlation may be one of diminishing incremental return, this return may be worth seeking, in terms of the expected absolute GDP per capita growth achieved.[16]

The average OECD total R&D expenditure in 2008 was 2.33% of GDP. New Zealand falls well short of this, running at approximately 80% of OECD average in total of government and education sector expenditure and about one-third of the OECD average for the business sector.

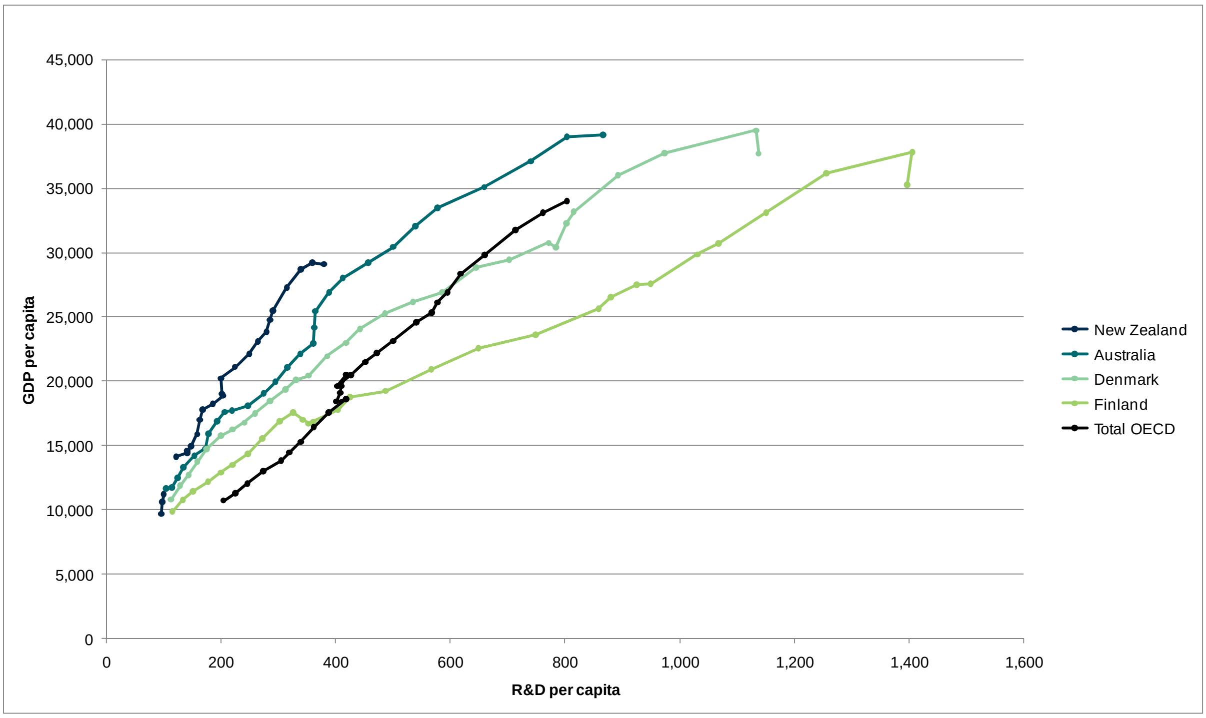

Figure 2: Comparison of GDP per capita, 1981–2009

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[15] *OECD Science, Technology and Industry Outlook 2000* (available at www.oecd.org).

[16] *OECD Main Science and Technology Indicators 2010–12* (2011); Statistics New Zealand; Ministry of Science and Innovation.

In 2010, New Zealand invested the following amounts in research and development:[17]

Business	$1013M	0.54% GDP
Government (excluding higher education)	$ 629M	0.34% GDP
Higher Education Sector	$ 802M	0.43% GDP
Totals:	**$2444M**	**1.30% GDP**[18]

Although expenditure from the business and government sector has increased in the past 10 years (Figure 3), these figures are still below the OECD average.

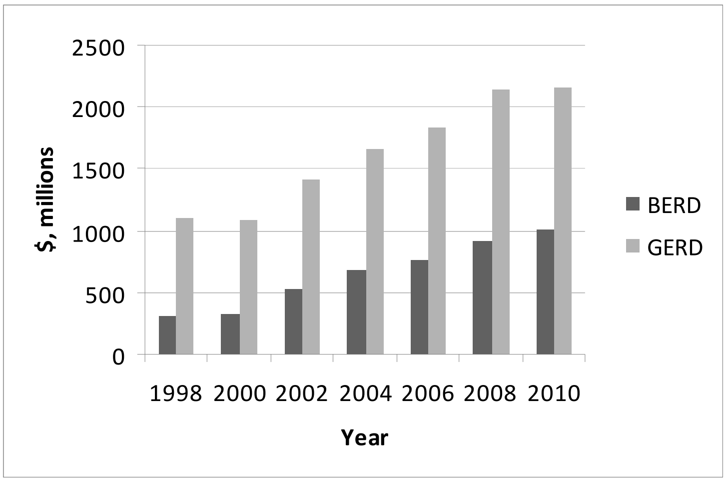

Figure 3: Gross Expenditure on Research and Development (GERD) and Business Expenditure on Research and Development (BERD) as a Function of Year (Source: Statistics New Zealand) [19]

Figure 4 shows that New Zealand SME expenditure in 2007 on R&D was 0.26% of GDP, relatively high on OECD comparisons. This was half of total New Zealand business expenditure on R&D, but was significantly due to the lack of larger companies in the New Zealand economy.

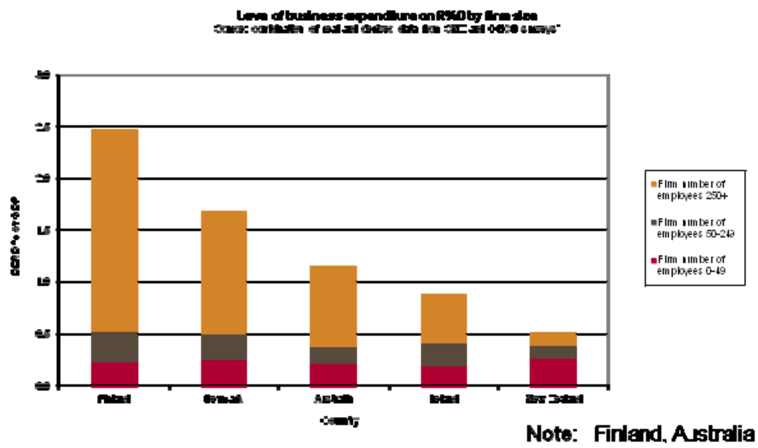

Figure 4: Level of Business Expenditure on R&D (BERD) by Firm Size

[17] Statistics New Zealand Research and Development Survey: 2010 (available at www.stats.govt.nz).
[18] Due to rounding, some figures may not add to stated totals.
[19] The information for this section and graphs has been compiled from a variety of sources: Statistics New Zealand; OECD data.

It is estimated that the HVMSS[20] comprises approximately 5% of New Zealand's economy (as measured by the contribution to New Zealand's GDP), produces approximately 12% of total exports and attracts approximately 18% of R&D investment. In comparison:

- The primary sector comprises approximately 8% of New Zealand's economy, produces approximately 51% of total exports and attracts approximately 16% of R&D investment.
- The wider manufacturing and services sectors comprise approximately 55% of New Zealand's economy, produce approximately 49% of total exports and attract approximately 34% of R&D investment.

It is not possible to make precise inferences from these figures as there is some overlap, for example, where the HVMSS adds value to primary sector products. High value manufacturing and services are also diverse and less mature as an industry sector than the primary sector.

Investment in science and technology activities occurs through a number of government agencies such as MSI ($745M) and MAF $56M (through the Primary Growth Partnership scheme). These budget figures for 2010 included spending in areas other than science and technology, and MSI also supports innovation in social, environmental and economic systems and organisations. The Ministry has been charged with leading a leaner and more responsive support system for New Zealand's scientists, entrepreneurs and exporters.[21]

Funding levels in 2010 for various MSI priority areas are shown in Figure 5, which shows distribution of funds from Vote Science and Innovation across different areas such as high value manufacturing and services, environment and biological industries.[22]

All of these funds are invested by MSI apart from:

- the Marsden Fund and Talent Development (which are invested by the Royal Society of New Zealand)
- Health and Society (the majority of this is invested by the Health Research Council).

Investment that is business facing, that is "direct business support" in Figure 5, is achieved through a number of investment vehicles.

- Technology Development Grants: designed to assist firms that conduct significant amounts of R&D. The grants cover 20% of project costs to a maximum of $2.4M. Grants are for three years but and are not tied to a particular project, giving the firms certainty and flexibility.
- TechNZ Project and TechNZ Capability: provides 1:1 matching funding for discrete projects and capability development.
- Technology Transfer Vouchers: designed to give firms that lack existing R&D capacity access to research organisations. The voucher provides 50% matching funding of projects, with a minimum total contract value of $60,000.

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[20] Sources: Statistics New Zealand; Ministry of Science and Innovation; TIN100, Industry Analysis, New Zealand, 2010, Sixth Edition. In order to calculate the GDP contribution of the high value manufacturing and services sector, the following assumption has been made: for 2010, TIN200 is 80% of the high value manufacturing and services sector.

[21] Prime Minister Rt Hon John Key, Statement to Parliament, 8 February 2011.

[22] Note that this diagram does not reflect the changes in funding distribution due to CRI Core Funding changes.

A key characteristic of these funding schemes is for the partner research organisation or industry to co-fund, as a motivator for commitment to succeed.

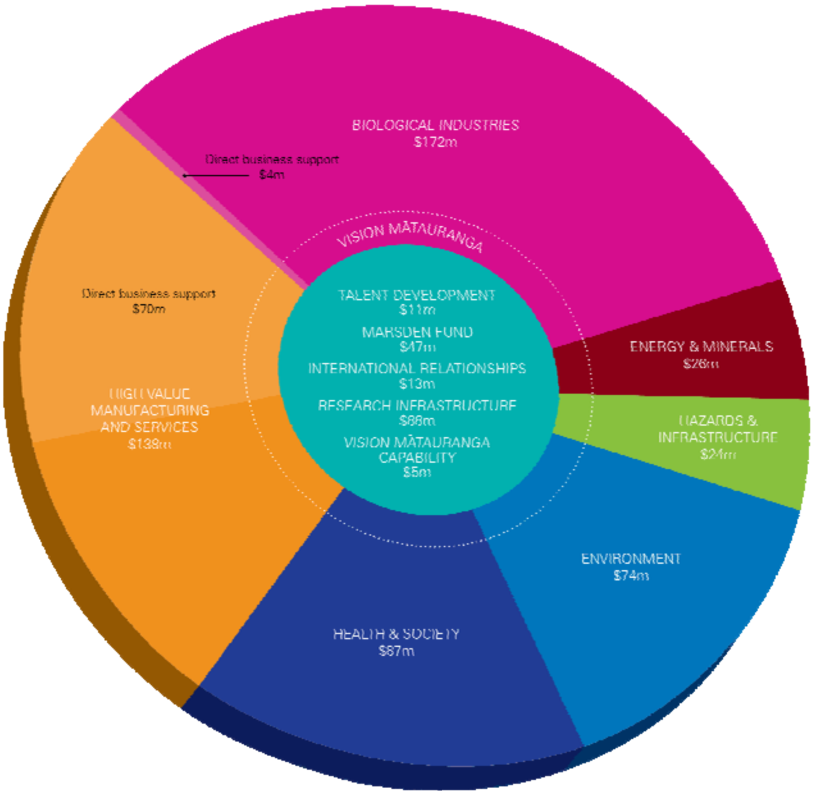

Figure 5: Overview of MSI Investment (Source: MSI)

2.1.4 Commercialisation and Knowledge Transfer

Each New Zealand university and CRI has a commercialisation office or company associated with its operation. In some cases, these are wholly owned companies such as Auckland UniServices, AUT Enterprises Ltd, WaikatoLink Ltd and Otago Innovation Ltd. Others operate more as offices linked to the research management function, sometimes linking to regional incubators (for example, Massey University links to the Bio Commerce Centre in Manawatu and the e-Centre in Albany) or with other institutions, as in Canterbury with a cooperative arrangement between the University of Canterbury, Lincoln University, Canterbury Development Corporation, the Canterbury Innovation Incubator and Powerhouse Ventures.

Incubator performance data[23] demonstrate that, on average, while resident companies are more successful, companies that graduate and become independent deliver a high return on the investment (by NZTE and host organisations) for the New Zealand economy.

In general, there is a lack of scale and insufficient breadth of technical and market know-how in most university and CRI commercialisation units. Recognition of this lack of scale is already

[23] www.incubators.org.nz/about/incubation. For example, in 2007, figures for the industry showed that, on average, resident companies increased their turnover by over 200% and combined they employed an additional 303 people. The total capital raised by incubated companies in 2007 alone was over $25.3M.

leading to greater networking and collaboration between commercialisation units (see Unicom below).

Of all of the commercialisation organisations, UniServices has the greatest scale. It has a similar business model to UniQuest at the University of Queensland, handling contract research, staff consultancy and commercialisation of IP. The first two provide positive cash-flow and this cash-flow, along with a proportion of royalty or dividend income from earlier commercialisation activities, supports the commercialisation of IP. While UniServices' revenue was $114M in 2010, most of this was from research contracts, not IP commercialisation revenue. Further discussion on research sector commercialisation units and handling of IP rights and benefits can be found in Chapter 3.

Three organisations exist to support cooperative activity in IP commercialisation (see Appendix 4):

- University Commercialisation Offices of New Zealand (UCONZ): A forum for the directors of the commercialisation offices to share best practice and promote joint initiatives.
- UniCom: A consortium of five New Zealand universities that collaborate to maximise the commercial potential of public sector research.
- Incubators New Zealand: A strategic network and forum for managers of incubators.

2.2 Lessons from Overseas Models

There are a number of countries and regions throughout the world where there are good examples of growth being driven from the HVMSS and how improvement has been achieved in access to and uptake of R&D.

The Panel reviewed innovation strategies for the Nordic countries – particularly Norway, Denmark and Finland – who have programmes, institutions and policies that are worthy of study and consideration, likewise Israel and the Australian state of Queensland. These small to medium size jurisdictions are also working to grow innovative business sectors. Notably,

- Countries such as Finland, for example, have adopted a centralised and coordinated approach to the development of their innovation ecosystem, with the establishment of an overarching Research and Innovation Council which is chaired by their Prime Minister.
- Denmark, in particular, has had success with R&D institutions working closely with industry.
- Finland, Denmark and Queensland have introduced support schemes, analogous to New Zealand's Technology Fellowship scheme, which place researchers in industry. The outcomes of such initiatives can be outstanding, such as the "Industrial PhD Programme" funded by the Danish Council for Technology and Innovation.

New Zealand may be able to incorporate into policy aspects of findings of other countries, such as Finland and Denmark, who are also currently reviewing their innovation systems. The Panel was aware that adopting portions of a particular country's innovation strategy does not, however, guarantee success.

Information drawn from other countries' experiences is related to barriers to R&D in New Zealand in Chapter 3. A more in-depth commentary on features of the innovation systems in these countries and others is included in Appendix 5.

2.3 Is the New Zealand Innovation System Fit for Purpose?

In relation to the country's population, New Zealand's science and technology innovation system is well underpinned by research organisations and commercialisation offices or companies. However, many research organisations lack the scale to support the required advanced technology R&D platforms, and commercialisation units generally lack the scale to bring the necessary international market knowledge and experience to bear on IP commercialisation projects. This limits the innovation system capability. There is a clear need for much greater networking of capability and of access to knowledge and R&D infrastructure to drive greater effectiveness and efficiency from a modest-sized resource.

In regard to investment levels, Section 2.1.3 has shown that there is an imperative for New Zealand to move closer to OECD average R & D investment levels to drive an increase in its HVMSS performance and grow its innovation system.

The Panel's brief examination of the relative proportions of Government expenditure on R&D, to support the primary sector and HVMSS respectively, was not in sufficient depth to suggest outright that a higher proportion of Government R&D investment should be used to grow the advanced technology industry sector. However, the relationship between investment and industry sector contribution to GDP should be assessed accurately and the case for relatively higher investment in the HVMSS determined accordingly. Proactive moves to grow this sector would likely require a disproportionate investment over a period of years. Recommendations around investment follow in Chapter 3.

CHAPTER 3: Barriers to Innovation and How to Overcome Them

This chapter explores barriers to innovation under generic headings, and presents comments that are drawn from the submissions to the review, the interviews and the Panel's investigation of innovation system models overseas. It draws on this information and, on particular issues, the Panel members' experience, to present recommendations on how to overcome the identified barriers to innovation.

MSI does not have policy and operational oversight of the whole innovation system, which, for example, includes universities and polytechnics that are partially funded by the Tertiary Education Commission, and other research organisations funded by industry. In order to make effective change to the innovation system, all of these institutions need to be engaged in the change process. The Panel has, therefore, made some recommendations that, while technically outside the scope of the report, are made for the purpose of informing and engaging other players in potential changes to the innovation system.

From the 46 written submissions to the Review, primary barriers to access to and uptake of R&D by the HVMSS were identified as listed below. The first response was the most frequent; others are listed in random order:

- lack of connectivity across research and industry networks to provide necessary scientific or technical input
- focus on short-term cash flow and survival; lack of company capability and absorptive capability – absence of R&D culture and lack of information about how to engage or undertake innovation
- availability of risk capital for R&D led innovation, especially for small companies
- overseas ownership leading to use of New Zealand operation for manufacturing only and therefore an absence of drive for innovation
- relevance and depth of research capability in research organisations manifested as a lack of available researchers to develop technologies needed by the company
- not being able to find the right business or commercialisation partner
- lack of infrastructure to develop technologies
- communication – researchers and industry drivers and expectations not aligned
- low levels of private sector investment
- national culture – anti-intellectual, do-it-yourself
- cost of engagement (research, compliance, relative to international providers)
- lack of critical mass and scale in commercial research services and research commercialisation units attached to research organisations
- university staff performance incentives not aligned to industry R&D engagement
- concerns that leakage of IP will occur from research organisations under contract to industry.

Following analysis of written submissions and interviews (detailed in Appendix 2), these barriers and recommendations to overcome them were categorised into four high level areas. These were:

- **Structure/Infrastructure – Driving Connectivity**
- **Capability and Commercialisation – Enhancing the Innovation Culture**
- **Investment to Catalyse Innovation**
- **The Big Picture – How to Make an Even Greater Impact**

Sections that follow address each of the four areas in turn, outline evidence from overseas initiatives (detailed in Appendix 5), suggest how these may be adapted to New Zealand, and make recommendations for action.

Section 3.4, "The Big Picture – How to Make an Even Greater Impact", presents recommendations that tend to be outside the scope of the Terms Reference, but raises a number of critical long-term issues around leadership, the education system and investment. In particular, this section underlines the importance of a national innovation strategy with leadership from the highest political level. It also emphasises essential underpinning actions such as maintaining investment in basic research, educating tomorrow's innovators and increasing long-term investment in the innovation system.

3.1 Structure/Infrastructure – Driving Connectivity

The environment in which the HVMSS operates was mentioned as a barrier by many.

Multiple responses highlighted a lack of networking and collaboration between organisations (including between research organisations throughout the country). This relates to the lack of critical mass of individual institutional R&D capability in particular research areas noted in Section 2.1.2. A number of submissions noted as a barrier that research organisations in New Zealand that service the needs of the HVMSS had insufficient depth to deliver this service effectively.

One commentator said, "*…none of the CRIs see it as their main role to visit companies to assess their needs and sell R&D services to them"*. One investor suggested that the overall structure of research organisations was a primary reason for the barriers. It is important, this person said, to have organisations (for example, IRL) structured around research areas of strategic importance.

An industry research association submission stated, *"Publicly funded research organisations are set up as industry independent research providers and are not generally linked to a particular niche manufacturing sector or particular companies. Therefore there is little networking and/or interaction and companies do not identify with those organisations as being 'their' research providers."*

Many responses also identified as a barrier the lack of, or poorly developed, industry clusters. One industry organisation said that institutions are not always placed in locations for easy access to the necessary expertise, and many submissions suggested that the fragmentation of capability through geographical spread of companies and research organisations was a barrier through lack of proximity.

The core public good research function of CRIs distinguishes them from other private or industry-funded research organisations. Most CRI research is ostensibly close to end-user needs and serves as a technology support to primary industries and other public good science domains (such as farming, food, forestry, public health systems, geology, energy, environment).

However, public funding of CRIs has been marked by a high level of contestability. This has made them vulnerable to loss of research funding streams and therefore the disappearance of research platforms and capability. CRIs have competed for additional funds and industry contracts in order to meet financial targets set by their Act and to maintain staffing levels. This has shifted their priority from public good R&D to R&D with market value. While R&D with market value is to be commended, many CRIs lack the capability to do both well. Industry-linked contracts are likely to remain a major portion of CRIs' revenue, even with an increase in core funding following the Crown Research Institute Taskforce recommendations.

The IRL submission to the Panel noted that the "What's Your Problem New Zealand?" programme was heavily oversubscribed. This is symptomatic of the present inability of IRL to fully engage with industry as broadly and deeply as it could. The present balance between scientists engaged in basic research and engineers engaged in industry-led consultancy and development contracts appears not to be serving the innovation system well. IRL is also relatively small and has to work across a highly diversified and fragmented industry sector.

Many of the countries (and regions) examined by the Panel have institutes that work successfully with industry. In particular, the Panel considered the Australian Institute for Commercialisation (AIC), the Danish GTS-network[24] (specifically DTI, DTI stands for Danish Technological Institute) and the professional development programmes at Taiwan's Industrial Technology Research Institute (ITRI). Our study of these institutions suggests that they tend to be successful because, among other things, they:

- are industry led
- concentrate on complex development issues rather than blue-skies research
- are highly customer focused
- concentrate on technology commercialisation
- are of sufficient scale to make a difference in the economies in which they operate.

A recent analysis of the return from private R&D investments in Denmark show that R&D-active business enterprises, which cooperate with universities and other research institutions, experience on average 15% higher productivity per employee compared with R&D-active enterprises with no cooperation with research institutions.[25]

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[24] GTS stands for Godkendt Teknologisk Service.

[25] Danish Ministry of Science, Technology and Innovation, *Business R&D and Innovation in Denmark*, 2010 (available at www.icdmuenchen.um.dk/NR/rdonlyres/28ACB41B-2EB0-4EA7-86DC-7B849A80BC7E/0/RDandInnovationinDenmark28april2010finalreport.pdf).

New Zealand is not alone in its review of its HVMSS. Other countries are currently undergoing similar reviews and reorganisations. For example, Finland is set to significantly overhaul its science and education system. Among other things, its Strategic Centres of Excellence (SHOKs), set up in the early 2000s as public–private partnerships, will be reviewed by 2013. The activities of the SHOKs are expected to be strengthened and the funding expanded. In addition, the Research and Innovation Council of Finland has identified a number of things that must happen in order to develop their innovation system, for example, *"structures will be reformed and organisational, operational and regional fragmentation will be reduced".* Strategic development policies have been developed to improve the flexibility of organisations, raise their profile and integrate complementary organisations.

The Danish GTS Institute System has already undergone international review. The 2009 review found that while the GTS system "*has done well in meeting its target groups' national and even international needs for technological services…the world is changing around it, so GTS must adapt as needs evolve"*.[26]

Denmark, a country widely respected for its innovative approach to R&D, has an elegant innovation policy. Many of the tools within it already exist in New Zealand and would benefit from expansion or enhancement.

Having the facilities to conduct great R&D is just one piece of the puzzle. Letting users and the public know about it is another vital component. The fourth action of the Queensland Research and Development Investment Strategy is to *"Connect researchers, end users and investors"*.[27] Commitment to outreach is imperative in a modern system.

The Panel makes no recommendations on structure/infrastructure specific to the universities and polytechnics, and this lies outside the scope of the review. Clearly, the tertiary education sector will be better able to engage productively with business and industry and help advance growth in the HVMSS if Government funding levels in the sector enable ongoing investment in top-quality staff and in research infrastructure that supports internationally competitive advanced technology industry sectors.

In relation to CRIs, the Panel generally agrees with findings of the Crown Research Institute Taskforce and makes the following additional recommendations for non-university research institutions and associations that relate to effective operations and commercialisation.

Recommendation 1:

Develop a strategic and structured approach for connectivity between research and development providers and the high value manufacturing and services sector.

[26] Danish Ministry of Science, Technology and Innovation: *A Step Beyond: International Evaluation of the GTS Institute System in Denmark*, 2009, p 48 (available at www.teknologiportalen.dk/NR/rdonlyres/43A17153-8159-4FD5-83BB-67D33F650897/3647/AStepBeyond_web_2.pdf), ISBN: 987-87-923-7280-2.

[27] Queensland Government: *Queensland Research and Development Investment Strategy 2010-2020*, 2010 (available online at www.chiefscientist.qld.gov.au)

Recommendation 1.1: IRL should evolve into a new "Platform for Industry" organisation, as "Advanced Technology New Zealand" (ATNZ), which would focus primarily on industry demand-led research and development contract work and would deliver expertise across a selected range of advanced technology platforms

(v) Assuming its new form, ATNZ would extend its industry development project support activities and downsize its basic research projects.

(vi) Consideration should be given to moving selected research platforms from IRL to one or more universities or, possibly, to other CRIs.

(vii) The significant majority of the professional staff should be engineers and those with applied science skills, including those in new and emerging areas of interest to business.

(viii) Two additional sites for ATNZ should be established, one in Christchurch and one in Auckland. The relative size and scope of these sites would be based on the likely demand and industry sectors in these locations. The universities in each of the three cities where ATNZ is located would collaborate on this initiative and help, where needed, in the transition and establishment phase by facilitating such aspects as joint appointments and possibly with temporary physical facilities. (Detailed recommendations on roles and funding appear as **Recommendations 19 and 20** in Chapter 4.)

Recommendation 1.2: Government should give consideration to combination, rationalisation or coordination of related research themes, operating structures or other business arrangements for closely related research organisations. This should be done where it would enable these organisations to exchange knowledge, better allocate funds for incoming projects, use human resources more effectively and run commercialisation units that have more scale and effectiveness.

Recommendation 1.3: In certain sectors (for example, agri-tech and other service sectors) where many SMEs are generically similar, the Panel recommends developing an industry engagement strategy for more effective outreach by CRIs and other research institutes and associations to ensure better uptake of technologies. These activities (for example, industry sector advisor programmes) could take place in cooperation with industry bodies.

Recommendation 1.4: The establishment of further university–CRI–industry research consortia should be explored in advanced technology sub-sectors, with matching funding by government and industry. Each consortium should include at least two research organisations and two industries submitting a joint proposal under a competitive process, on a project initiated by the industry partners. The associated IP commercialisation framework would be designed to incentivise industry to participate.

3.2 Capability and Commercialisation – Enhancing the Innovation Culture

A group of barriers identified in written submissions and interviews fell under the general category of capabilities: knowledge and human resources. Many of these barriers, which exist across all levels of the sector, appear to be cultural in nature, either from the point of view of national culture or business culture.

3.2.1 Connectivity, Staff Mobility and IP Benefits

Barriers to the innovation system at universities and, to some extent, the polytechnics partially relate to the level of government funding for the tertiary education sector. These institutions are funded, per equivalent full-time (EFT) student, net of student loans, at well below Australian levels. This limits their ability to make sufficient capital investments in research infrastructure, pay salaries that will attract top academics from the international market and operate with low teaching contact hours to free up staff time for research and/or industry or community engagement. While these issues lie outside the scope of this review, they impact on the ability of universities to engage effectively with industry and need to be considered in relation to recommendations below that address incentives to increase staff engagement with the business and industry sectors.

Access to Knowledge and Staff Mobility

Access to knowledge by industry, and transfer of knowledge from the R&D sector to industry, were frequently raised as barriers in submissions and interviews. A number of respondents said, "*Small industries don't know what they don't know*". Therefore, the question arises as to how to increase the connectivity to SMEs that are either not R&D-active or lack information on a local or international level that is essential to their development and enhanced performance.

The difference in alignment of university, CRI and company cultures is a barrier to R&D collaboration, knowledge transfer and alignment of objectives in partnered projects. While businesses necessarily focus on cash flows and short time horizons for product development, universities are driven more by teaching and basic longer term research, this being less time constrained. CRIs are better positioned to support industry, but the industry parties interviewed commented that there needed to be better alignment of CRI objectives with industry needs.

A related barrier is the lack of mobility of R&D staff between universities, CRIs and industry that contributes to a shortage of R&D capacity in industry, and lower levels of knowledge transfer than could otherwise be achieved. Moreover, while a number of industries are partnered in one way or another with research institutions, there is generally a lack of mobility of industry staff into specialist university or CRI research centres and vice-versa.

A further barrier is created by the performance measures against which staff are judged for promotion. While professional engagement with business, industry or the community does sit within the basket of performance measures in most academic institutions, it does not generally seem to be given significant weight during promotion processes.

It was evident from interviews that many larger companies in New Zealand have internalised their R&D function and capability. These companies employ science and engineering graduates, but said that they struggle to attract the numbers needed from the local population of university graduates. Attraction of top employees from overseas is a challenge because of New Zealand's low income levels, in some cases compounded by a higher cost of living, compared with similar positions overseas. The same problem exists in university staff recruitment.

At least three firms commented that the main barrier to using R&D from research organisations is that their R&D requirements are in very niche areas. New Zealand companies that look for specialised support from university staff or research laboratories cannot always find it, because a dedicated specialised service from the research partner may not be practical or affordable for a university department. This also leads to internalising of research expertise in companies, which take on graduate trainees to meet this need, or look overseas for more specialised research advice. Where specialisation is developed through long-term research partnerships with universities, it tends to focus on more distant horizon research.

The Panel's study of overseas practices found that, to improve the flows of knowledge at the researcher–industry interface, a number of overseas jurisdictions such as Finland, Denmark and Queensland have introduced support schemes that place researchers in industry.

The Panel notes that Queensland's Smart Futures Commercialisation Fellowships are aimed at "researchers-in-residence". These fellowships aim to improve industry uptake of new technologies and cross-pollination of ideas by placing a researcher in-house. The fellowships

- include grants of up to $100,000 per year
- are available to industry and businesses to engage an innovation-focused researcher (PhD or equivalent) for a minimum of six months and maximum of two years on either a full-time or part-time arrangement
- must be matched by a sponsor cash contribution of 1:1, and
- require researchers to be retained and sponsored for the term of the fellowship by a Queensland-based SME.

Reciprocal fellowships, which bring industry staff into universities or research institutes, are also available.

Finland has identified that it under-utilises schemes such as sabbaticals for researchers to work in companies and tailored postgraduate and research programmes at its higher education institutes. One of its strategic development policies is that incentives for business cooperation are created for higher education institutions.[28]

ITRI, in Taiwan, encourages staff to cycle through and gain experience and then move into industry. Professional development of staff is part of the institute's culture, and it is expected that staff will leave ITRI and join (or form) a company.

[28] Research and Innovation Council of Finland: *Research and Innovation Policy Guidelines for 2011–2015*, 2010, (available at www.minedu.fi/export/sites/default/OPM/Tiede/tutkimus-_ja_innovaationeuvosto/tiedotteet/RIC_press_2010.12.21_Linjaus.pdf), ISBN: 978-952-485-998-1 (pdf).

New Zealand has some examples on the home front that have worked well in the business environment and which could be adapted to enhance R&D uptake in the HVMSS. For example, NZTE's Better by Design business mentoring programme is based on the idea "*Design unlocks better business – better thinking, better approaches, and better customer connections*". This has helped New Zealand companies increase their international competitiveness by integrating design principles and thinking right across their business. By using an analogous approach to development of an R&D culture, many companies in the HVMSS should be able to enhance their prospects for growth.

Control of IP Rights

Barriers exist around IP policies in universities and CRIs, and around tensions over IP ownership. Historically, the New Zealand commercialisation system has been marked by universities and CRIs controlling IP rights, sometimes to the detriment of investment deal flow and potential downstream benefit to New Zealand. Businesses perceive that universities and CRIs want to own IP rather than assign it to a start-up company, or enter shared IP ownership arrangements with technology development partners at the early stages of the R&D process.

Much CRI IP is difficult or inappropriate to protect with patents and belongs in the public domain. Many of their commercialisation initiatives are undertaken with industry based on know-how and cultivation of knowledge in major industry sectors.

A Relative Lack of Incentives for University (or CRI) Staff to Engage in IP Commercialisation

A perceived barrier to innovation is the lack of financial incentives to CRI staff to commercialise IP. Although universities share some financial benefits of commercialisation with staff and students, CRIs have been less flexible and benefit sharing is rare in the CRI system.

University staff members in New Zealand are typically entitled to a one-third share (sometimes more) of the financial benefits from a commercialisation project. Allocation of benefits can be used as both a carrot and stick to ensure commitment of researchers to the commercialisation process. For example, a start-up company may allocate founder shares that are redeemable proportionally over the first five years if the researcher leaves the project.

As with staff mobility between research institutions and industry, neither universities nor CRIs appear to attach importance to commercialisation activities in relation to staff career advancement. In New Zealand universities, the registration of an international patent is generally given equivalence in some fashion to the publication of a paper. However, academic promotion to the Associate Professor or Professor levels normally relies largely on international refereed journal publications.

IP Partnerships with Industry

A focus on internally generated "technology push" IP is common internationally and is a necessary part of the commercialisation office's role. Parties interviewed noted the importance of industry–sector relationships and enduring partnerships for commercialisation to facilitate the "market pull" approach. This was particularly evident in a relationship between a research institute in the agri-food sector and its partner industries. In this example, long-term industry partnerships for product development and commercialisation were seen to be more effective than the alternative of technology-push from IP arising from university-sourced ideas.

Recommendation 2:

Enhance connectivity between research organisations, tertiary education institutions and industry, through more flexible arrangements for employment, IP rights and benefits, and incentives for staff mobility and engagement in commercialisation. Promote R&D awareness and knowledge access schemes.

Universities:

Recommendation 2.1: Introduce more flexible university employment and IP benefits incentives to encourage staff, subject to meeting agreed teaching and research duties, to:

(v) Undertake paid consultancy work with business and industry.

(vi) Take on joint appointments or substantial secondary paid employment with business and industry at a level that enables New Zealand to match overseas income levels for sought-after academics.

(vii) Facilitate leave of absence for working in industry for periods of up to two years.

(viii) Engage in commercialisation and industry relationships, by adopting a more flexible and generous policy towards the percentage of the researcher share in the commercialisation revenues and ensuring that full national and international patents are given credit for academic promotion. In some cases, a researcher share of IP benefits of 50% or higher may be justified.

Related incentives are recommended for the polytechnic sector where a staff member has technological knowledge that is in demand from industry partners.

CRIs:

Recommendation 2.2: Introduce incentives for CRI staff to:

(iii) Move into industry after a period of employment in the CRI sector to transfer R&D capability to advanced technology industries.

(iv) Engage with commercialisation, by adopting a standard policy that allows a share of IP benefits in the form of a performance bonus or royalty share to researchers who are actively involved in successful commercialisation initiatives.

More Flexible Approaches to IP Rights

Recommendation 2.3: To maximise the potential for successful new technology innovations, develop more flexible approaches to IP rights under which university or CRI IP or specialist knowledge may more easily be transferred to an industry partner or to a spin-out venture funded by external investors. Seek more flexible share-of-benefits arrangements that may not necessarily be equity or royalty arrangements, but could be success-based funding of staff positions or of student scholarships with or without an equity or royalty component. Look for long-term partnerships to achieve long-term benefits.

R&D Awareness and Knowledge Access

Recommendation 2.4: To enable MSI to introduce R&D awareness to and gain engagement from industry sectors, and improved access to knowledge:

(iii) Create an R&D analogue of the NZTE Better by Design programme, which helps New Zealand companies increase their international competitiveness by integrating design principles across their business.

(iv) Promote the existing TechNZ Global Expert scheme and link this to the networking and industry advisory capability embedded in the proposed ATNZ (see Recommendation 1.1).

3.2.2 Increasing Commercialisation from Universities and CRIs

International comparisons in a UCONZ report[29] show that New Zealand has an efficient commercialisation system in terms of patents granted and companies started per dollar invested in R&D. However, the absolute number of high technology company start-ups from the university and CRI system is small and this currently limits the impact of this sector on the innovation system.

This statistic is also influenced downstream by the cultural barrier of risk averseness. New Zealand companies' attitude towards risk was mentioned repeatedly in submissions to the Review. One response described New Zealand business culture as: "*a traditional culture that concentrates on volume rather than value, that focuses on short term gains rather than long term advantage and that has little appetite for risk*". Other submissions echoed the sentiment and described the barrier as business having a "*short term focus*", "*risk averse"* or driven by short term profits. One submission identified New Zealand business as having "*conservative corporate management"* and said this was a barrier to the uptake of R&D.

An additional barrier for New Zealand SMEs stems from risk averseness to and inexperience in international business. They are commonly not interested in developing export markets, and are reluctant to go to international sources for technical or business advice. Failing to address the potential of international markets inclines such firms to be less innovative as they see only a small local client base. This may appear either as a commercialisation barrier or simply a business growth barrier.

Another factor that may limit commercialisation activity is that some New Zealanders still consider an "exit" (business sale) to an overseas buyer solely as a loss of knowledge and future local business activity rather than as a successful commercialisation outcome and/or the potential beginning of a new R&D collaboration. On the other hand, one barrier identified by respondents is the pattern for high tech start-ups to be sold overseas with a subsequent relocation of operations – and, importantly, innovation decision-making – overseas. This suggests that the way in which New Zealand companies exit overseas is important. If exits provide further opportunities for innovation or investment then that is most likely positive. If all value exits then that is probably negative.

[29] See www.universitiesnz.ac.nz/files/u2/NZVCC_Uni_ResearchFIN_1C59D.pdf; the following is also interesting www.otago.ac.nz/entrepreneurship/docs/Qual%20report_31%20August%202010.pdf.

The foregoing factors around risk averseness and lack of engagement with international markets are not addressed through a specific recommendation. In the wider commercialisation context it is important that smaller companies, in particular, seek access to NZTE programmes that assist in familiarisation with and launching into international markets.

Further to contributory factors identified above, the following factors identified by the Panel have worked against the institutional commercialisation system being able to deliver as effectively as it could:

(i) Lack of capability to take projects through the early commercialisation stage

CRI and university commercialisation offices or commercialisation companies commonly lack sufficient capability and experience to identify and screen IP opportunities effectively against market needs and competing products. Most also have limited ability to handle the number of opportunities coming forward. Larger commercialisation offices follow a rigorous stage gate process, but there has been some evidence across the sector of non-competitive business attitudes and ineffective commercialisation decision-making processes. On a more positive note, commercialisation advisory boards increasingly have members experienced in business across a range of technologies and with international markets. This trend should be reinforced because new high technology products will almost certainly be addressing global markets.

Submissions to the Review also noted limitations in the ability to attract investor interest, early stage commercialisation funding and/or business partners, and to negotiate deal flow. This arises through a lack of contacts and relationships and/or a lack of familiarity with the product domain.

Further to the above, interview discussions highlighted the importance of aligning the commercialisation strategy, for example, early trade sale of IP versus licensing for royalty versus formation of a start-up company, to the nature of the product being developed. For example, licence agreements are more likely in biotechnology and pharmaceuticals than in IT or smart devices.

(ii) Loss of market opportunity through not investing in international patent services

High performing international patent lawyers have a high relative cost, but not using them on commercial prospects presents a barrier to commercialisation.

Recommendation 3:

Individual commercialisation units should continue to develop or increase capability both through embedded skills and through networked activity, to deliver high quality screening of IP opportunities and increased good quality commercialisation deal flow nationally.

Recommendation 3.1: Build on current networks of commercialisation units to link all universities and CRIs, and create the planned NNCC. This network should also enhance linkages to industry partners.

Recommendation 3.2: Provide an NNCC coordination office that would deliver support to the networked commercialisation offices by facilitating administrative services, database management and connections to wider investor and technical expert networks.

This would include:

(i) Networking to Economic Development Agencies (EDAs), angel and venture capital investor groups, technical experts, national and international IP lawyers and other businesses.

(ii) Creation and management of databases for technical expertise, investor contacts and so on.

(iii) Connection through the ATNZ hubs (see Chapter 4) to businesses and industries needing commercialisation advice.

(iv) Assistance for individual research organisation units to obtain expert input to IP commercialisation decisions or to connect to similar technologies under commercialisation in a different organisation in New Zealand or overseas.

(v) Encourage and support networking activity and the operation of regional cross-sector groups in each of Auckland, Wellington and Christchurch.

(vi) Administrative support for network operations such as meetings, travel, database maintenance, Pre-seed Accelerator Fund (PSAF) contract expenditure monitoring and reporting.

<u>Recommendation 3.3</u>: University and CRI commercialisation units should develop or increase embedded capability to deliver high quality screening of IP opportunities and increased deal flow, through:

(i) Appointment of directors with international business experience, and business development managers with the necessary technology backgrounds to identify and effectively screen commercialisation opportunities, existing competition and prospective connections to similar technologies and strategic partners in New Zealand or overseas.

(ii) Governance or advisory boards that bring to the commercialisation decision process a wide range of knowledge of, and expertise in, international markets.

(iii) An actively managed database of accessible technical and business experts across a range of technologies who can be summoned to give additional advice on potential technology opportunities.

(iv) The services of the best (international) patent lawyers, aggregating demand if possible across several institutions and/or commercialisation centres to obtain services at lower cost.

<u>Recommendation 3.4</u>: In addition to the enhanced access to investors enabled through the NNCC, university and CRI commercialisation units should enhance their linkages to angel investors and investor syndicates and seek to establish serial successful commercialisation venture partnerships.

3.2.3 International Recruitment of Skills

New Zealand is competing worldwide for top talent and must have a strategy to succeed in attracting it. There has been frequent anecdotal and media comment on the shortage of professional skills in business and advanced technology. It was clear to the Panel from submissions (see Section 3.2.1) that New Zealand lacks world-class capability in various areas of science and engineering. These areas need to be clearly identified, as a shortage of skills presents a barrier to R & D uptake and innovation.

The Panel's view is that New Zealand companies should seek the best talent regardless of nationality. This problem may be tackled through cooperative arrangements for services with overseas institutions and individuals, but a more robust and sustainable approach is to attract international talent to come to work in New Zealand. In this context, there should be opportunities to attract New Zealand professionals back to New Zealand.

Other countries are also trying to attract top international skills. For example, one of the Research and Innovation Policy Guidelines for 2011–2015 for Finland is: "*The recruitment practices of education, research and innovation organisations will be made more transparent to attract international students, researchers and experts. Research places should be allocated to foreigners under flexible terms, and, where necessary, quickly. Residence and work permits, social security and the student financial aid scheme will be developed so that they support the recruitment of students, researchers and experts to Finland."* Another guideline begins, *"An active employment and skills-oriented immigration policy will be formulated along with the legislation to support it…"*[30]

<u>Recommendation 4</u>:

Implement a study to determine where the professional skills gaps are in the New Zealand research organisations and advanced technology industries. Then launch an international talent attraction campaign including repatriating talented New Zealanders through a dynamic "Bring Back our Brains" programme. The programme would aim to attract top scientists, engineers and business people who are working overseas, but also to create a "buzz" in New Zealand during the process. Implement this programme by expanding the existing Royal Society of New Zealand Rutherford Foundation initiatives, using a talented and creative advertising firm, and encouraging the universities, CRIs and industry partners to run talent search campaigns at the same time.

(i) For universities: the programme would include creating new paid positions for or co-funded by the Government for three years (including a start-up research grant) and subsequently paid for by the university.

(ii) For the private sector: introduce the programme to create new positions co-funded by the Government and the company for the purposes of a new R&D programme within the company. This could take place as a part of current TechNZ funding, for a defined period, for example three years.

[30] The Research and Innovation Council of Finland: *Research and Innovation Policy Guidelines for 2011 – 2015*, ISBN 978-952-485-997-4 and ISBN 978-952-485-998-1 (pdf).

3.2.4 Enlarging the Talent Pipeline

It is evident that industry has a current and anticipated future shortage of skilled manpower in science and engineering for advanced technology industries. In particular, there appears to be a shortage of mechanical and quality control engineers, electrical engineers and software engineers, physicists, mathematicians and computer scientists.

In relation to the supply of engineering graduates, the 2010 Institution of Professional Engineers New Zealand (IPENZ) National Engineering Education Plan (NEEP) report[31] states:

> *"In 2008 there were 1500 engineering graduates with these (degree) qualifications. This number was only half the OECD average of 12% of tertiary graduates having engineering qualifications. The Governing Group estimated that New Zealand needs 2000 - 2750 new graduates each year. The lower number estimates the graduates needed if New Zealand continues on a 'business as usual' basis. The higher number estimates the graduates needed in an innovation-led economy with engineers participating in building innovative businesses."*

This shortage has a number of downstream consequences: it prevents companies from growing and this causes existing successful companies to consider relocation to other countries. It can also lead to a short supply of prospective founders of start-up companies.

Submissions to the Panel indicated that New Zealand industry does not seem prepared to attract foreign engineers by paying them internationally competitive salaries (higher than the local engineers) as is done in other economies (for example, Korea, Taiwan and Russia). This was due not only to financial constraints, but also to perceived equity issues between the international and domestic employees.

OECD statistics[32] also underline the dominance of sciences graduates and undersupply of engineering graduates in New Zealand. In New Zealand, engineering graduates make up 5.4% of total bachelors' graduate numbers across all disciplines as against 12.5% in sciences. Interestingly, the same picture can be painted for Australia. The numbers of engineering graduates tend to be proportionally higher in Europe. For example, 20.6% receive degrees in engineering and 8.1% in sciences in Finland. A similar trend is present for PhD graduates, which are weighted more heavily towards the sciences in New Zealand. For example, engineering PhDs make up 8%, and sciences 32.8%, of total PhD graduates in New Zealand, compared with 22% engineering PhDs, and 21.9% sciences PhDs in Finland. Across the total OECD the figures are 15% engineering PhDs and 25.3% sciences PhDs.

The general shortage of engineering (and to some extent science) graduates stems from cultural and education system issues in New Zealand, notably:

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[31] Institution of Professional Engineers New Zealand: *National Engineering Education Plan*, 2010, Prepared for the Tertiary Education Commission by the NEEP Project Governing Group (available at www.ipenz.org.nz).

[32] OECD: *OECD, Science, Technology and Industry Scoreboard 2009* (available at www.oecd-ilibrary.org/science-and-technology/oecd-science-technology-and-industry-scoreboard-2009_sti_scoreboard-2009-en).

(i) Many young people prefer to drop mathematics, physics and chemistry early in their secondary schooling, and too few teachers lack the specialised knowledge to inspire students about science and engineering innovation.[33]

(ii) Under present tertiary tuition subsidy limits, it is not possible to significantly increase enrolments in engineering and the physical sciences without penalising other disciplines. Universities have been reluctant to do this and the lack of a more flexible approach to meet the demand for graduates is a barrier in the innovation system.

(iii) Industry submissions to this review indicated that there are too few PhD students in industry-linked research projects. Both government and university funding initiatives to support such projects appear to be insufficient to meet demand.

Worldwide, countries are recognising the need to increase attention to science and technology education, and that innovation needs a highly educated workforce. As the country moves out of recession, New Zealand must be prepared to increase the supply of able and motivated graduates to become the intellectual powerhouses for advanced technology companies.

US President Obama's 2011 State of the Union address focused on innovation and the United States of America maintaining its leadership in research and technology. He also addressed the need for scientific and mathematics education, saying "*we need to teach our kids that it's not just the winner of the Super Bowl who deserves to be celebrated, but the winner of the science fair".*

The Queensland Research and Development Investment Strategy 2010–2020 lists five actions. The fifth is to engage the community:

"*A scientifically engaged community will enable Queensland to capitalise on technological opportunities to address the environmental and social challenges of the future, whether they be climate change, genetically modified foods or new materials. A community that can critically understand and evaluate the role of science and research and development in almost every aspect of our lives will help raise the number of children studying and graduating in science, increase business uptake and diffusion of new ideas and technologies, and better inform our decision makers*."[34]

Other countries have developed special recruitment programmes to breakdown cultural and behavioural choices and encourage under-represented groups into specific areas of study. For example, girls and women have been traditionally under-represented in engineering in Israel, and programmes to recruit females to engineering were developed to counter that trend.

In addition to the two recommendations below, there are further recommendations on this subject in Section 3.4.

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[33] Office of the Prime Minister's Science Advisory Committee: *Looking Ahead: Science Education for the Twenty-First Century: A report from the Prime Minister's Chief Science Advisor*, 2011, pp 6 and A35 (available at www.pmcsa.org.nz), ISBN 978-0-477-10377-4 (pdf).

[34] Queensland Government: *Queensland Research and Development Investment Strategy 2010–2020*, 2010, p 26 (available at http://www.chiefscientist.qld.gov.au/research-and-development/assets/queensland-r-and-d-investment-strategy-2010-2020.pdf).

Recommendation 5:

In order to meet the demand for skills that are and will be required by New Zealand's high value manufacturing and services sector, current education policy settings and initiatives should be revisited.

Recommendation 5.1: Review policy on tertiary education tuition subsidy limits, which has led to capping of enrolled student places, with the aim of enabling universities to enrol students in the areas of Sciences and Engineering that are in demand, without penalising other disciplines.

Recommendation 5.2: Reinforce initiatives to engage under-represented groups in the science innovation system through secondary and tertiary education (for example, women remain under-represented among engineering graduates and Māori and Pasifika are under-represented more generally in the science disciplines).

3.2.5 International Collaboration and Agreements

In the global science and business environment, international collaboration is essential to maintain cutting-edge research and innovation. This is relevant in all parts of the innovation ecosystem, for production and for marketing. International collaborations need to be wider and deeper for the HVMSS to fulfil its potential to help drive the New Zealand economy.

Some New Zealand manufacturers tend to consider only the local market and do not establish partnerships with big R&D companies overseas. Submissions to the Review identified the lack of natural international partners as a barrier to growth of the HVMSS. It was stated that New Zealand should be working with partners in other countries who know how to sell to the world and who are small, smart and have networks with people with *"real money and capital"*.

Government initiatives and schemes that promote the engagement of New Zealand researchers in the international arena and encourage individual collaboration (scientist-to-scientist, company-to-company) exist in basic and applied science areas with countries such as China, Japan, Korea, France, Germany and the United States of America. However, these are largely without government funding other than in relationship facilitation. Bi-national endowments for industrial R&D collaboration and national membership in mega-scientific infrastructure, such as the European Organization for Nuclear Research (CERN) Large Hadron Collider, are limited. Participation in the European Commission Framework Programme is minimal. These are all barriers to the growth of this sector.

Internationalisation of the education, research and innovation system has been identified as a priority for Finland. It has partnerships and agreements with other countries in the European Union (EU), and in its 2011–2015 plan has emphasised the need to participate in programmes closely related to its areas of expertise and interest. However, it also identifies a prioritisation of making bilateral agreements with countries outside Europe in areas of strategic importance.

Israel is perhaps a good example for New Zealand in terms of bi- and multi-national research agreements and funds. A small country, with limited human resource and equipment, Israel has Free Trade Area Agreements (FTAA) with the United States of America, the European Economic Community (EEC) and European Free Trade Association (EFTA). However, in addition, it has developed research programmes with many countries, and research funds with Canada, Croatia, EU, France, Germany, India, Japan, Russian, Singapore, South Korea, the United Kingdom and United States of America. The structure of the funds require collaborative work between researchers in Israel and the other countries.

Recommendation 6:

The Panel recommends that New Zealand should research and subsequently increase the number of international research and development collaboration agreements in strategic areas for the high value manufacturing and services sector, in both large research infrastructure and areas of basic and applied research that support capability development in this country. R&D collaborative agreements between specific companies and overseas partners should also be encouraged.

> Recommendation 6.1: Pursue targeted bi-national and company-to-company agreements in science and technology areas that support the high value manufacturing and services sector. Bi-national agreements for co-funded research projects could be pursued with countries where there are existing (largely unfunded) cooperation agreements such as China, Japan, Korea, France, Germany, and the United States of America, but also others such as Australia, Taiwan, Israel and Singapore. This should include continuing negotiation for improved access to international organisations like the European Commission Framework Programme for Research and Technological Development.

> Recommendation 6.2: the Panel recommends continued and new membership in mega-research infrastructure projects in order to participate in advanced international scientific research that requires shared infrastructure investment. Examples of existing participation include the Australian Synchrotron project and the CERN Large Hadron Collider. Priorities for such memberships should be reviewed every five years.

3.2.6 Raising Awareness in Business

The lack of experience in using R&D, and the lack of understanding of what R&D can do for an organisation, becomes its own barrier. As one research organisation commented, it can be a daunting step to take.

"New Zealand has had 100 years of undervaluing intellectual development. There is a disconnect between different parts of the system and a lack of global understanding relating to competitive advantage. The number of New Zealanders who understand how technical R&D works is small." (New Zealand commentator)

Some respondents said that businesses don't see the need to engage in R&D or that they don't have a vision of what R&D is or what it can do. This was echoed by a CRI that said businesses failed to grasp the benefits that can come from innovation. While this could be classified as a cultural barrier, an industry research association echoed these sentiments, and explained that the majority of businesses wouldn't have the innovation skills required to be competitive in export markets, and that part of this skill set is being able to understand the role R&D plays in being innovative and competitive.

Recommendation 7:

Increase visibility and awareness of technology developments and the value of innovation and the successes achieved by the sector through networking and promotional events.

Recommendation 7.1: The formerly TEC-funded Priorities for Focus (PFF) technology showcase events currently hosted by university research, and commercialisation offices should be extended to continually increase mutual awareness of R&D capability and innovation opportunities between the university, polytechnic, CRI and industry sectors.

Recommendation 7.2 In the case of CRIs, tertiary education institutions and other research organisations, the senior organisational leadership should increase the promotion of and publicity for successful business–industry partnerships and technology commercialisation from research, to motivate their organisations to move towards a more outward-looking innovation culture.

3.3 Investment to Catalyse Innovation

Investment, funding or the continuity of funding was mentioned in some form in every response. This relates not only to availability of investment funds but also to how the investment of government and private sector funds is prioritised.

3.3.1 Prioritising and Driving Value from Government Investment

Setting Investment Priorities

Section 3.4.1 discusses the urgent need for a national innovation strategy led at a very senior political level. A national strategy should aim to overcome a barrier identified by a number of commentators: the lack of identified niche areas on which the HVMSS should focus. One submission to the review noted the lack of integration in the sector and the "*lack of focus on unique products and processes to improve international competitive advantage*". While Recommendation 14.1 identifies areas of basic research that would support the HVMSS, the country must also focus on niche advanced technologies where it can compete internationally.

Science and innovation is dependent on government investment. To optimally support uptake of R&D in the HVMSS, it is critical that:

(i) Advanced technology industry sectors are identified for prioritised investment.

(ii) The limited financial resources in this sector are spent as efficiently and effectively as possible and, in principle, that the prevalent use of matching funding by industry should continue to be used to help drive value from government interventions.

Prioritisation of specific areas for R&D has become a common theme for countries and regions that are committed to driving growth through their innovation sectors. For example, Finland has strong linkages between researchers and firms but has identified the need to increase the number of R&D start-ups. The Finnish Research and Innovation Council released its guidelines in 2010 stating, "*It is important that Finland make choices that support specialisation in competitive areas of strength. It is vital for Finland to be able to identify promising research, competence and business areas*."[35]

Industry-oriented research in strategic areas was also identified in the innovation plan for Norway: "*In addition to a general stimulation of research and innovation in Norwegian industry, the Government will continue to support industry relevant research in strategic areas. This includes five areas where Norway has developed specific competences or has other competitive advantages. These are: the marine sector, tourism, the maritime sector, energy and the environment.*"[36]

Closer to home, Queensland's Research and Development Strategy identified five areas for action, one of which is to "*focus on needs and strengths*". Enabling sciences and technologies is one of the priorities in this strategy, with its objective to support capability development in these areas. Smart industries is another priority, and within it fall four objectives including to build Queensland's knowledge-intensive industries, enhance productivity, create new value-adding products and services in Queensland's food and fibre industries, and support safe, sustainable and competitive energy and resources industries.

While it can observe and learn from these other countries, New Zealand must determine its own areas for investment priority.

Access to Government Investment Funding

Lack of money available to research and commercialise ideas was mentioned by business, research associations, universities and CRIs, angel and venture capital investors and industry organisations. Comments ranged from "*There is no money for initial research or idea generation*" to "*When businesses or individuals (including scientists) have an innovative idea, they often lack the expertise and financial backing to take it to the next level*." Commentators said that this situation can occur in a growing business or in a garage start-up. While angel investors were quite active, taking commercialisation to the next level was an issue because of the lack of depth of venture capital markets and a lack of subsequent expansion capital.

This difficulty in access to developmental capital was raised in submissions as a barrier to innovation, particularly for existing and start-up SMEs. This is symptomatic of a small-scale economy that lacks industrial breadth and depth, has limited advanced manufacturing infrastructure, and thin capital markets that are short of foreign direct investment.

MSI and NZTE both support industrial innovation at different but overlapping stages of the pathway from concept to market. A barrier identified in submissions was that, in some cases, there appears to be a lack of alignment around the investment decisions that support companies or industry sectors. However, it was acknowledged that MSI and NZTE were working to solve this problem.

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[35] Research and Innovation Council of Finland: *Research and innovation policy guidelines for 2011–2015, 2010*, p 1 (available at www.minedu.fi/export/sites/default/OPM/Tiede/tutkimus-_ja_innovaationeuvosto/tiedotteet/RIC_press_2010.12.21_Linjaus.pdf).

[36] Norwegian Ministry of Education and Research: *Climate for Research* (Summary in English: Report no. 30 to the Storting (2008–2009)), p 3 (available at: www.regjeringen.no/upload/KD/Vedlegg/Forskning/climate_for_research_final.pdf).

The following areas were identified in a number of submissions as barriers in relation to government investment in R&D:

- The low level of R&D investment by government
- Small firms do not necessarily qualify for grants that require 50% co-funding and/or are seen as risky by research providers.
- R&D grants favouring big companies, not "cash-strapped" young companies.
- The high-entry threshold for the Technology Transfer Voucher: more than one submission suggested freeing up the 50% co-funding requirement and considering in-kind as well as cash contributions.
- Complexity of the process around funding: one respondent noted the large number of intermediary organisations (such as NZTE, TechNZ, Business New Zealand, EDAs, Chambers of Commerce), The lack of integration among the public sector resources, and the high turnover of staff in these organisations.

Recommendation 8:

While maintaining sufficient investment capability to foster serendipitous discovery and innovation, MSI should select a number of advanced technology platforms as a focus for TechNZ funding of R&D. In order to achieve scale in particular industries, New Zealand should concentrate on niche areas, for example, biotechnology, processing, electronics and embedded systems, mechatronics and robotics, sensing and scanning devices, medical technologies, advanced materials and manufacturing technologies (including plastics), pharmaceuticals (only to early IP licence stage), agri-technologies, digital and ICT technologies. The basic research focuses of Recommendation 14.1 would service these platforms.

Recommendation 9:

The investment in TechNZ, Technology Development Grants, Technology Transfer Vouchers and the Pre-seed Accelerator Fund should be increased as programmes become established and industry demand increases. Such grants should continue on a partner co-funding basis. In future policy design, the Government should consider models that provide for repayment of a proportion of a grant where the funded project has led to commercial success, to allow for reinvestment back into the TechNZ investment fund.

Recommendation 10:

Maximise early stage international market intelligence input into technology development funding. MSI should continue and enhance its collaboration with NZTE to provide better market information, in parallel with MSI, early in the investment process. This will inject additional high quality market input into the decision process around development support for advanced technology projects at as early a stage as possible.

<u>Recommendation 11</u>:

Continue the move towards collaborative investment in large research infrastructure, as exemplified by the planned investment in High Performance Computing. New high-cost physical and/or communications infrastructure that is required for clusters of industries and university research groups should be established on a cooperative basis and located to best serve the community of researchers (in universities, CRIs and industry) and on the basis of co-funding where appropriate by partner industries.

3.3.2 Expanding Private Sector Investment in R&D and Innovation

Section 2.1.3 has presented information on current levels of R&D investment in New Zealand. While the overall level of investment in the science and innovation system is too low, under-investment by the private sector forms the most significant barrier to innovation-led economic growth. A key outcome sought from this review is that the level of business investment will increase.

One research association said that a barrier to R&D is the tendency by business to see R&D as "*something that can be downgraded in the drive to hold up margins*" and that when business is operating in a tough economic environment, R&D other than for necessity, will "*take a back seat*". Another submission said that businesses are challenged to see R&D cost as investment.

The lack of co-investment models between public and private enterprise was seen as a barrier by at least two respondents. Many identified the lack of incentives to business to invest in R&D. One research association said that during the previous R&D tax credit scheme, there was an increase in the number of companies expressing an interest in R&D, including some that had never engaged in R&D before. This, the respondent said, was a step change which has since disappeared.

The private money that goes into R&D is mainly composed of in-house funds of the approximately 200 existing globally focused technology companies.[37] Universities have reinvested commercialisation profits in their commercialisation units but, in most cases, unprofitable operation means that annual financial support for the commercialisation units has to be reintroduced over time.

International evidence suggests that this barrier is most successfully addressed by smart co-investment of government funds to significantly leverage private sector investment.

Different countries and states have unique programmes to encourage private investment in R&D, but co-investment is the norm. For example, funding in Queensland's Proof-of-Concept project-based fund is to be matched by a cash contribution of 1:1. There is a total Queensland government contribution of A$20,000 to A$50,000 per project for eligible expenditures over 12 months. Denmark's DTI innovation voucher scheme (est. 2008) for business–research partnership projects involves two types of vouchers with state co-funding ranging from 40% to 70%, and with goals of transferring research to SMEs or solving current problems of industry.

[37] TIN100 Industry Analysis, New Zealand, 2010, Sixth Edition.

Recommendation 12:

Leveraging private sector investment is a key factor and important for all government investment in private companies, but consideration of a graduated scale of co-funding may provide an incentive for engagement of new players.

> Recommendation 12.1: Industry co-funding should continue to be used for all government investment in private companies, with the level of the matching customised for each programme of support. To engage new participants in schemes such as the Technology Transfer Voucher, a graduated scale of co-funding should be explored, which could provide, for example, a more substantial government funding component for small companies on their initial project engagement.

> Recommendation 12.2: Government should continue to collect and use for future investment decisions statistics on commercial success of companies that have received government funding. Among other things, this can be used as a public relations factor – to attract more private funding to R&D and to assist future government funding allocations.

3.4 The Big Picture – How to Make an Even Greater Impact

Actions that can be taken to enhance the access to and uptake of R&D by the HVMSS should be part of a long-term national innovation agenda that aims to embed an innovation culture in New Zealand's society. Such an innovation culture would seek a high standard of living for its citizens, but in a sustainable industrial and environmental context. Features of this would be:

- a high level of capability in research organisations and industry supported by an outstanding education system delivering creative people into careers in business, the creative arts, the Sciences and Engineering
- organisational structures that support innovation in the HVMSS as well as the traditional food and fibre based industries
- a strong government investment framework successfully leveraging private sector investment.

An innovation culture would be reflected in the frequent and public celebration of creative achievements in the arts, sciences and technology, in academia and industry. These public celebrations could complement and enlarge on pre-existing achievement awards. One commentator noted that in New Zealand we do not celebrate leadership in the applied sciences and identified this as a barrier to innovation. It was suggested that the Royal Society of New Zealand Science Excellence Awards – a major driver of behaviour in the science arena – give equal emphasis to those working in the applied sciences.

To establish an enduring innovation culture in New Zealand, the Panel has made a number of recommendations in foregoing sections. To underpin these and draw together the overall set of recommendations, the Panel makes further recommendations in this section that address more strategic long-term issues around leadership, maintaining our basic research platform, initiatives in the education sector and, finally, investment. These broader recommendations tend to lie outside of the immediate scope of the review.

3.4.1 Oversight and Leadership

New Zealand's innovation ecosystem has developed over a long period of time and has tended to evolve organically rather than be led by a long-term, consistent, national innovation strategy. This has had a particular impact on the HVMSS because of the sector's diversity and fragmentation, and the predominance of SMEs. This has led to the sector being unable to draw together its own vision or long-term strategy.

As one submission said, "*We do not have a well-articulated national vision that establishes our leadership aspiration in national markets*." Another said we need something we can all aspire to and another said "*the Government needs a clear goal related to the sector*". A university stated that a barrier was that "*New Zealand has not had a coordinated approach to development, implementation and management [of] science and innovation strategy across government. This has been shown internationally to be a barrier to innovation impact*." Finally, one commentator said that we have been "*caught up with the micro-management [of individual organisations] and not thinking big…things become focused on trivial matters but we need to have a vision of what New Zealand can really do".*

Innovation doesn't occur in a vacuum. It is part of a national system that is influenced by macroeconomics, geography, culture and, in many cases, history. The Nordic countries, for example, have, for the most part, adopted a systemic approach to innovation and have relied on the relationships between industry, research organisations, sources of investment and funding. These countries also take a more holistic approach to business (for example, design-led business is not new in Scandinavia), and their science and innovation policies go beyond the Ministry or department directly responsible for their execution.

Many of these countries have a high-level centralised council that advises other ministries. For example, in Finland the Research and Innovation Council is chaired by the Prime Minister and it advises all ministries on related matters.

The State Government of Queensland has also developed a broad strategy for science and innovation, discussed in detail in Appendix 5. It is of interest that it is a state goal – not just a Ministry of Science goal – to see a 50% increase in the proportion of Queensland businesses that undertake R&D or innovation.

Recommendation 13:

Form a Science and Innovation Council, led from a very senior ministerial level in Government, with representatives from the university, public and private research organisations and from industry. Members should represent a wide range of science and technology themes, including the social sciences. The role of the Science and Innovation Council should be to establish a national innovation strategy and advise on science and innovation policy and priorities.

3.4.2 Reinforcing the Basic Research Platform

New Zealand has a solid foundation in basic research. This is an essential platform for any advanced economy and requires ongoing investment to ensure that research and research capability aimed at fundamental discovery is well supported and not sacrificed to meet short-term goals. The country must take a long-term view when building its innovation system and ensure that basic and applied research are able to underpin near-to-market development and commercialisation projects and thereby offer a robust platform for success.

Section 3.3.1, "Prioritising and Driving Value from Government Investment", noted the importance of identifying niche areas where New Zealand can compete internationally and of setting priorities for government investment in advanced technology R&D, within a national innovation strategy. It is vital that investment is also maintained (if possible increased), in the underpinning science research system, again prioritising investment in basic research that supports the HVMSS as well as the traditional food and fibre industry sectors.

<u>Recommendation 14</u>:

The Panel recommends that New Zealand maintain its commitment to basic and applied research through MSI and other government science funding, but, as funding increases allow, give more emphasis to engineering and the physical sciences.

<u>Recommendation 14.1</u>: Along with investments in life sciences, New Zealand should prioritise areas of research in engineering and the physical sciences that are essential for innovation in advanced technology, including computer science, mathematics, neural-computation, mechatronics, robotics, smart devices and embedded systems, information and communications technologies and media. New Zealand should prioritise areas of the sciences where it is capable of playing a leading role given its capital and capability base and where there is the potential to deliver advanced technology products. For example, the application of computer science and mathematics in neural-computation or mobile health products, media and cyber security, are areas that offer the potential for high value exports. Advanced research in, for example, agriculture, oceanography, water, aquaculture, geology and forestry and bio-ecology, should continue at both the basic and applied levels. Among other factors, these are essential to ensuring long-term sustainability of our living environment.

Funding support would be through:

- individual grants and scholarships
- collaboration grants (for researchers from different universities, CRIs)
- interdisciplinary and emerging technologies grants (for cross-disciplinary research)
- Centres of Research Excellence (CoREs).

<u>Recommendation 14.2</u>: Maintain in real terms the existing level of funding for basic and applied research through MSI and other government science funding agencies. This funding should be part of a wider long-term agenda to increase funding levels into the tertiary education and CRI sectors to provide world-class facilities and enable the appointment and retention of top staff from the international talent pool.

3.4.3 Education – Creating the Next Generation of Innovators

The scientific community in New Zealand is productive and efficient, as measured by the standard metrics,[38] with a publication rate that compares well internationally based on numbers of researchers by country: 0.7% of the scientific publications in the world have a New Zealand author. However, approximately 75% of New Zealand's scientific publications are in the life sciences and related fields (such as agriculture, ecology and medicine). New Zealand has relatively few researchers in engineering and the physical sciences, even though many opportunities to create new technology start-up companies are in these fields. It is a barrier to innovation that New Zealand has not identified priority areas of study to ensure that research that drives contemporary innovation is well-represented in New Zealand's basic science research.

Danish studies have shown that companies that host industrial PhDs see, on average, increasing patenting activity. They are also characterised by high growth in gross profit, and more positive developments in gross profit and employment growth than companies in a control study group.[39] Not only did the companies benefit from this programme – it was also found that: industry PhDs had greater earning power (7% to 10%) than non-industry PhDs; they were more likely to be found at the top levels of their organisations' hierarchies compared to those with normal PhDs; and they were more likely to be found in positions requiring high-level specialist knowledge than regular university graduates.

<u>Recommendation 15</u>:

Introduce initiatives to produce a new generation of young people inspired to move into creative and entrepreneurial careers in the sciences and engineering.

> <u>Recommendation 15.1</u>: In order to begin filling the funnel at an early age, launch a major national campaign encouraging young people to choose science and engineering career paths. This campaign should include success stories of start-ups in the media, science programmes on television, school advisors connecting science education with technology advances, sustainability and nature conservation, presentations in schools and, for example, role models presenting to groups of science-gifted girls, Māori and Pasifika. It should include social media campaigns as well as traditional media. Growth in numbers of graduates ultimately moving into careers in the sciences and engineering must be balanced by many choosing careers in business, design and the creative arts to ensure that a vibrant innovation culture continues to evolve.
>
> <u>Recommendation 15.2</u>: Establish new government funds for PhD scholarships in the priority areas of Applied Sciences and Engineering (see also Recommendation 15.3) for R&D capability building. These scholarships should be larger than the usual type of university PhD stipend. They should be prestigious and competitive.

[38] Ministry of Economic Development, Treasury, Statistics New Zealand: *Economic Development Indicators: 2011*, 2011, p 51.

[39] Danish Agency for Science, Technology and Innovation: *Analysis of Danish Innovation Policy – The Industrial PhD Programme and the Innovation Consortium Scheme*, 2011 (available at www.dasti.dk).

Recommendation 15.3: Increase funding into the existing MSI capability-building schemes (such as the current Technology Fellowships) to enhance the level of knowledge transfer into industry sectors and capability building through:

(i) Industry-based and co-funded Masters and PhD programmes in applied science and engineering. Universities would build partnership programmes with industries in their region. Students would spend the bulk of their time in the company under joint supervision of the university and the industry partner. A flexible approach to IP rights should go hand-in-hand with this scheme, with agreement at the commencement of projects on the allocation of financial benefits that would follow successful commercialisation.

(ii) Industry co-funded employment of graduates in science and engineering. This is a partnership scheme in which recent graduates or postgraduate students work on an industry-based problem where the supervising academic and industry partners give joint oversight to the project-based employee.

Recommendation 15.4: Develop a new generation of graduates with international business skills that address the shortage identified by various commentators[40] by ensuring that New Zealand has a premier international business school, probably based in Auckland. This should evolve through enhancement of present programmes at one of the existing business schools or as a collaborative venture across two or more schools. Student international business entrepreneurship projects would be integral to the academic programme. It should involve successful New Zealand international business entrepreneurs in guest teaching, mentoring and sponsorship of academic positions and scholarships in the school.

3.4.4 Academia Engagement with Business and Industry

A number of submissions and interview responses referred to the TEC Performance-Based Research Fund (PBRF) as a barrier to engagement by tertiary education institution staff in R&D project partnerships with industry. The PBRF is essentially teaching component funding that is aimed at research training and lifting research capability in the tertiary education sector. It is not, by definition, research funding, although some of it is applied to the execution of research projects. Since its introduction in 2003, it is generally agreed that PBRF has had the effect of increasing research involvement from academics and has had a positive effect on the number and quality of research publications produced.

However, feedback continues from the business sector that the PBRF discourages a proportion of academics from engaging in research and consulting with business or industry as this activity is seen to be less valuable for PBRF rankings. As the PBRF, like research quality evaluation systems in other countries, was not designed at the outset to enhance industry engagement,

[40] New Zealand Institute: *Standing on the Shoulders of Science: Getting More Value from the Innovation Ecosystem*, 2009; *A Goal is Not a Strategy: Focusing Efforts to Improve New Zealand's Prosperity*,2010; and *Plugging the Gap: An Internationalisation Strategy*, 2010 (available www.nzinstitute.org.nz).

the solution to this issue may not necessarily lie with redesign of the PBRF system, but a positive alignment of the PBRF objectives with a national innovation strategy should be sought.

<u>Recommendation 16</u>:[41]

If the TEC Performance-Based Research Fund (PBRF) continues in (or close to) its present form after the 2012 PBRF Quality Evaluation, introduce a separate but similarly performance-based fund that:

- **(i)** **Recognises excellence in innovative work in the areas of applied sciences, architecture, design, engineering and technology.**
- **(ii)** **Would likely be linked to business and industry co-funding for postgraduate students and/or partnered projects.**

3.4.5 Making and Incentivising Investment in Advanced Technology Businesses

Submissions to the Panel cited instances where large multinational companies that have taken over New Zealand companies then move their R&D activity overseas and run the New Zealand subsidiary as a production-only operation. This has been notable, for example, in the forestry sector. This was identified as a barrier to innovation and growth in the New Zealand operations.

Conversely, in the past, multinationals (for example, Motorola) have considered placing an R&D facility in New Zealand. Incentives offered were not sufficient to attract this important kind of foreign direct investment. This is a key barrier and a major issue for the New Zealand Government to address as part of a national innovation strategy.

The level of foreign investment in new technologies in New Zealand in return for equity and/or licensing is low. Such investment may be seen as a major innovation success, but it is not uncommonly seen as a threatening dilution of the founder's equity. Complaints against "*loss of knowledge"* and "*loss of a business ownership from New Zealand*" were heard. Foreign direct investment in companies beyond start-up stage and in our larger companies does take place but the incentives for a greater level of such investment should be reviewed.

Incentives for local capital investment in advanced technology industries should be considered. Ideally, New Zealand will, with stronger capital markets in the future, have an acceptable mix of sales to overseas interests (exits), and of businesses expanding to include overseas investors and markets with majority ownership remaining in New Zealand (including New Zealand majority-owned businesses operating overseas).

[41] **Note:** As Principal Moderator for the 2012 PBRF Quality Evaluation and potentially involved in the design of the 2018 PBRF Quality Evaluation, the Panel Chair felt it necessary to stand aside from this recommendation.

Recommendation 17:

The Panel recommends that the New Zealand Government should take proactive steps to lift the level of local and foreign investment in the New Zealand advanced technology industry sector.

Recommendation 17.1: The Government should "court" multinational companies to establish local industry collaborations and establish R&D facilities in New Zealand. Ideally, such initiatives should be led from the highest political level (in some countries this has been the Prime Minister) and should include incentives for foreign direct investment.

Recommendation 17.2: The Government should take steps to attract international venture capital to invest in new start-up companies, and other foreign direct investment into established industries, by raising ongoing awareness of the opportunities in New Zealand and considering other incentives.

Recommendation 17.3: The Government should encourage the investment of a small proportion (for example, 1%) of the New Zealand Superannuation Fund and Accident Compensation Corporation fund in advanced technology companies in New Zealand.

3.4.6 The Goal of Increased Investment – Both Private and Public

Chapter 2 of this report has noted New Zealand's low overall level of investment in R & D, and OECD data showing the correlation between R&D investment and GDP growth. If New Zealand is to out-perform in the HVMSS sector, the country's long-term vision should not be simply to match the OECD average in both government and private sector expenditure but to exceed it.

In the international context, it is worth noting that Denmark, which has a national innovation strategy, has data to show that R&D investment makes a difference. A recent analysis of the return from private R&D investments in Denmark shows that R&D-active enterprises, which cooperate with universities and other research institutions, experience 15% higher productivity per employee on average compared to R&D-active enterprises with no cooperation with research institutions.[42]

Recommendation 18: Leveraging private sector investment

Set a target of matching OECD average public sector investment in R&D within 10 years and using increased investment to leverage private sector investment. This recommendation addresses the country's long-term investment in R&D and should be the subject of a follow-up project.

Recommendation 18.1: Increase public funding by 2.5% per annum or more in real terms over a 10-year period to place public investment in research and innovation at least at the OECD average level. The Panel believes the eventual target should be above the OECD average in order to drive performance in the innovation sector.

[42] Danish Ministry of Science, Technology and Innovation, *Business R&D and Innovation in Denmark,* 2010 (available at www.icdmuenchen.um.dk/NR/rdonlyres/28ACB41B-2EB0-4EA7-86DC-7B849A80BC7E/0/RdandInnovationinDenmark28april2010finalreport.pdf).

Recommendation 18.2: Use the increased public funding to leverage significantly increased innovation investment from the private sector. The target for the private sector investment increase should be much higher. It is instructive to note that for the private sector to lift its investment to the OECD average in 10 years would require a 30% per annum increase.

CHAPTER 4: Implications for Key Research Institutions in the Sector and Detail Recommendations for ATNZ

The extent to which implications of the Panel recommendations exist for key research institutions depends on the policy or funding decisions that may follow the review. The following brief comments assume that MSI and other organisations will make changes that act on the recommendations of this report.

4.1 Universities

(i) Universities would have more flexibility, in the capped funding environment, around enrolment of students in science and engineering disciplines to meet industry demand.

(ii) Universities would have enhanced R&D connections with CRIs, business and industry. These will be facilitated by more flexible employment contracts, joint appointments and by TechNZ and other R&D funding mechanisms that are reinforced and shaped to incentivise connections.

(iii) Universities should see an increase in revenues from industry-linked research and consultancy contracts.

(iv) Universities should see increases in commercialisation revenues through more effective commercialisation offices and networked connections to other institutions.

(v) Depending on the detail that emerges in new innovation funding initiatives, universities could perceive funding to be more tightly tied to support for national economic development initiatives than in the past. The Panel emphasises that the ability of universities to carry out basic and applied research independent of industry- or market-led innovation objectives should increase over time and not be weakened by their engaging more strongly with business and industry.

4.2 Crown Research Institutes

(i) CRIs that carry out mostly public good research (for example, GNS Science, NIWA, ESR, Landcare Research) would see relatively little change as a consequence of the Panel's recommendations.

(ii) CRIs that have a major focus towards industry sectors would, in some cases (particularly in the case of IRL, see 4.4), see a change in the balance of work moving more towards industry- and market-led projects that support innovation in the HVMSS and less basic research projects.

(iii) In some cases, stronger connections with other CRIs would result; there would be more focusing of objectives if there is any rationalisation of research themes across the CRI system.

(iv) Working partnerships with universities and with industry should increase and strengthen.

(v) Motivation to participate in technology innovations, normally partnered with businesses, would increase if creative forms of new employment contracts emerge that encourage staff to push for success in innovative projects and/or to move on to high potential industry positions as a successful new technology ventures gather momentum.

4.3 Polytechnics

Polytechnics would be more comprehensively engaged with industry, providing technical and business problem solving and product and process development support. This will have benefits not only for the industry partners but also for polytechnic students and staff through maximising their involvement with advanced technology companies and maintaining the currency of their own industry knowledge.

4.4 Roles and Funding of ATNZ – the Future of Industrial Research Limited

The Panel recommends that IRL evolve into a platform for industry whose work would focus on market-led project demand from the HVMSS. For the moment we have called this “Advanced Technology New Zealand” (ATNZ).

The vision for ATNZ is that it would be characterised by being commercial, disciplined, timely, creative, ambitious, energetic, trusted by business, transformational through relationships, deeply connected and respected nationally as well as internationally with superb translational capability.

The Panel considered different project models and scales under which ATNZ would engage with industry in R&D. The expectation is that ATNZ would engage more in near market industry development support than IRL currently does, and less in basic research. The Panel’s initial ideas for these models are illustrated in draft form in Figure 6.

Model 1: Support for product or process development

Customer Need	Typical Engagement/ Product/Services	Funding Type	Critical Connections
Relatively Defined	1 to 2 companies	Vouchers	Polytechnics
Small – Medium 'D'	Short term 1 day to 6 months	Fee for service	NZ universities
	0800-TECHNOLOGY	> $100,000 per engagement	Global expert
	Global expert		Internal ATNZ resources
	Regional technology partners		Industry research organisations
	Internships/ fellowships		Other industry players
	Internal ATNZ resources		

Model 2: Support for more major development requiring some research

Customer Need	Typical Engagement/ Product/Services	Funding Type	Critical Connections
Less Defined	1 to several companies	TechNZ funding	NZ and international universities
Big 'D' Small 'R'	Medium term 6 months to 3 years	Fee for service	Global expert
	Internships/ fellowships	Other joint-funding models for multiple projects	Internal ATNZ resources
	External resources	< $5 million per engagement	Industry research organisations where appropriate
	Relatively standardised governance		International industry players and investors

Model 3: Long horizon advanced R&D for future product or process

Customer Need	Typical Engagement/ Product/Services	Funding Type	Critical Connections
Less defined	1 to several companies	Complex platform funding	NZ and international universities/ research institutions
Small 'D' Big 'R' research	Longer term 1 to 10 years	Bespoke negotiation	Internal ATNZ resources
	Multiple players NZ and offshore	> $5 million per engagement	International industry players and investors
	Bespoke governance		

Figure 6: Project Engagement Models – ATNZ

Recommendation 19:

ATNZ Business Model: Operating Structure and Roles

The Panel recommends that the ATNZ should have an operating structure and roles as follows:

(i) ATNZ would be a Crown-owned company, operating on the basis of reinvestment of any operating surpluses and driven by industry needs rather than blue-skies research.

(ii) The emphasis for ATNZ would be on "development" rather than "research" but it would retain some embedded science and engineering research capability and would link strongly to universities and other research organisations as well as to industry.

(iii) ATNZ science and engineering staff would be engaged primarily in market-led industry projects in both technology and market identification and characterisation roles.

(iv) ATNZ would be geographically located at key sites in Auckland and Christchurch, but with continuation and transition to the new focus at the Wellington Gracefield site. Establishment of the two new sites would begin as soon as possible.

(v) Ideally, the ATNZ sites will be collocated with technology start-up companies and, possibly, specialist technology research centres.

(vi) ATNZ would be framed around a series of advanced technology platforms that relate to its industry sector focus which are not covered by sector-specific CRIs.

(vii) Technology platforms for ATNZ could include:
- Microelectronics and embedded software systems (a generic field covering medical technologies, electronics, mechatronic devices and others)
- IT & Telecommunications
- Electro-optics
- Alternative energy systems
- Advanced materials and nanotechnology (including plastics)
- Advanced manufacturing technology
- Marine technology
- Future: Nano-bioelectronics.

(viii) At the time of the creation of ATNZ, consideration should be given to moving selected research platforms from IRL to one or more universities or to other CRIs.

(ix) Some R&D specialisations that currently exist in other CRIs could be considered for transfer to ATNZ, or vice versa, if this contributes to creating relevant critical mass of related R&D activity.

(x) ATNZ would provide a location for shared use of high technology R&D equipment and IT services.

(xi) ATNZ would offer a portal for information or specialised knowledge enquiries from the industry sector, also providing connections into more sector-specific research institutions and associations.

(xii) The ATNZ sites would offer a hub for industry–institute (including CRIs)–academia networking, joint project activity and for connection with other R&D service providers such as specialist research centres, the NNCC, incubators, research associations and private research laboratories.

(xiii) ATNZ would aim to create an internal culture that encouraged the mobility of staff to feed talent into industry sectors. Most scientists and engineers would be expected to remain in ATNZ for not longer than 10 years and would be subject to incentives to move into industries.

(xiv) The ATNZ should work in association with the Metro Group of polytechnics, to provide staff consultancy to industry on product and/or process development and on production problem-solving projects on a subsidised basis. For example, projects could be effectively co-funded through a partial in-kind contribution of staff and student time.

Recommendation 20:

ATNZ Business Model: Governance and Investment

The Panel recommends that the ATNZ should operate under the following governance and funding framework:

(i) ATNZ would have an independent Governance Board appointed by the relevant Ministers with a majority of business appointees (including the Chair). The Board would include representatives from the applied science/engineering research sector as well as international members.

(ii) ATNZ would receive core government funding but would be tasked with leveraging government funding with at least equal funding from industry-linked contracts. It is expected that the level of industry contribution to project funding would range from half to two-thirds of the total contract value.

(iii) The future size of ATNZ would depend on the available investment envelope and industry demand and co-investment but the Panel foresees an effective target size of between 600 and 1,000 professional FTE staff (current IRL staff 320) across the three sites. The significant majority of the professional staff should be engineers and those with applied science skills including those in new and emerging areas of interest to business.

(iv) ATNZ and its industry partners should be able to use project funding flexibly across project costs, including labour, financial and legal services, equipment and consumables, subject to meeting independent external audit requirements.

(v) Among key performance indicators for ATNZ, the following, if able to be clearly linked to ATNZ interventions, would help show that ATNZ was succeeding in its partnerships with industry:

- Revenue growth and export market development of project partner companies.
- Employment growth in existing companies or in new companies that are created through ATNZ–industry partnerships.
- The number of new product launches as a result of project partnerships with existing partner companies.

- The amount of new foreign investment secured by companies as a result of project partnerships.

4.5 The Path Forward for ATNZ

The Government needs to consider how to progress the implementation of the ATNZ, subject to the necessary funds being available. The Panel has given this only brief consideration and provisionally recommends the following steps:

(i) Assemble an ATNZ Implementation Task Force with representation from MSI, the research sector and business.

(ii) Determine the structure and governance model.

(iii) Decide on physical locations, whether and how these could collocate with other R&D organisations or centres of specialist R&D capability.

(iv) Decide on the sequence of investment to establish sites additional to or replacing the present IRL sites.

(v) Decide on the optimal split of advanced technology platforms and phased growth of expertise for each of the Auckland, Wellington and Christchurch sites in conjunction with other CRI roles, and specific industry sector group needs such as plastics industry and others, including existing IRL technology platforms.

(vi) Design the networking arrangements to build wider innovation hubs at each of the ATNZ sites, including possible partnerships with industry, local government, tertiary education institutions, other research organisations and government agencies.

(vii) Plan the change process to enable transition for existing sites, particularly the Wellington Gracefield site, to fit the new character and work focus of ATNZ.

(viii) Map out costs and timelines for individual site implementation based on available investment budget.

(ix) Appoint a transition management team.

CHAPTER 5: Looking Forward – Priority Actions

This report has made a number of recommendations for action, which the Panel believes are necessary to build a strong R&D culture in the HVMSS. While these recommendations are focused around the Sciences and Engineering, the wider innovation system is dependent on a vibrant creative culture and a tertiary education system delivering, across all disciplines, science-aware graduates who are attuned to entrepreneurial behaviour and a commitment to the economic betterment of New Zealand.

All of the recommendations made in Chapters 3 and 4 are considered important to give an integrated suite of actions that would drive change across different groups and sectors that contribute to New Zealand's innovation system. A number of the recommended actions require significant investment. Others are more about behavioural change – working for greater connection between the research sector and industry, helped by greater flexibility in employment arrangements and a broader view of what constitutes outstanding performance.

The Panel proposes the following priority actions that set the stage for constructive change.

<u>Priority 1</u>:

1. Commence the reshaping of IRL as ATNZ. (Recommendations 1.1, 19 and 20).
2. Set up dialogue within government on reviewing the policy on tertiary tuition subsidy limits, in relation to meeting industry demand for graduates in areas of the Sciences and Engineering. (Recommendation 5.1).
3. Proceed with the National Network of Commercialisation Centres, concurrently promoting stronger commercialisation units in the research organisations. (Recommendation 3).

<u>Priority 2</u>:

4. Set up a joint MSI–MoE Innovation Task Force with universities, CRIs, polytechnics and industry representatives to work towards:
   - More flexible employment and performance incentive arrangements to enhance R&D collaboration, staff mobility and knowledge transfer.
   - More open IP management strategies to better support national economic development. (Recommendation 2)
5. While remaining open to serendipitous advanced technology opportunities, determine priority investment areas based on the NZTE market input and identified advanced technology platforms for industry, and focus new investment more heavily in these areas, increasing investments in partner co-funded grant schemes such as Technology Development Grants, Technology Transfer Vouchers, Pre-Seed Accelerator Fund, Global Expert, and Technology Fellowships in the priority areas as budget allows. (Recommendations 8, 9, 10 and 15.3)

Long-term Strategic Priorities:

6. Form a Science and Innovation Council, led from a very senior ministerial level in Government, and develop a long-term science and technology investment strategy. (Recommendations 13 and 18)

7. Working across MSI, MoE, MED, implement:
    - A campaign to attract international and New Zealand-citizen talent from overseas to New Zealand to fill essential capability gaps.
    - A major "young brains into science and engineering" campaign, supported by scholarships.

    (Recommendations 4, 15.1 and 15.2)

CHAPTER 6: Conclusion

The Panel for the Review of Access to and Uptake of R&D by the High Value Manufacturing and Services Sector has completed a rapid, high level process that involved:

- An intensive review of numerous sources of information on the innovation system in other countries of similar size to New Zealand, the New Zealand research and manufacturing sectors, current relevant government policy and funding mechanisms, and submissions to the review.
- Interviews with parties from the research and industry sectors, and from Government ministries and organisations.
- Identification of barriers to innovation across generic themes of culture, capability, funding and investment, and structure and infrastructure.
- Development of a number of recommendations to lift R&D engagement and innovation in the sector, presented in Chapters 3 and 4 of this report.

While some of the recommendations lie outside the initial scope of the report, the success of the HVMSS, and the wider innovation system, is dependent on many influences that lie outside the generation of a higher level of engagement with and investment in R&D in the industry sector. Actions that lie with other ministries, tertiary education organisations and businesses are necessary in order to develop a strong national innovation culture, and to fully enable the rapid development of the HVMSS, this having the potential to stimulate a step change in the economic growth and social wellbeing of New Zealand.

The traditional contribution of our food and fibre based sectors will remain critically important for the future of the country, but if we are to reverse our relative decline in living standards then this traditional strength must be bolstered by the development of the HVMSS. This sector will increase the diversity and overall value of our exports and contribute to the growth of new skills and capabilities in the country.

The Panel has recommended that public sector R&D investment be increased to at least the OECD average over a 10-year period, with this investment leveraging a more rapid rate of growth towards the OECD average in the private sector. New Zealand must invest to achieve the potential growth in advanced technology industries and services, but many of the Panel's recommendations are around cultural change that can be achieved through leadership of a strong national science and engineering innovation agenda, and a more flexible, collaborative approach to knowledge transfer and commercialisation. Education, and the choices made by secondary school students, remains pivotal in driving a strong national innovation system.

The recommendations in this report are a call to action that the Panel sees as essential to achieve increased performance in the national innovation system. These recommendations sit in a wider macroeconomic context and, consequently, there are ongoing imperatives on the Government to address factors such as incentives to develop a strong savings and investment culture in New Zealand, broader and deeper capital markets, and creation of a more attractive environment for foreign direct investment. Such actions are essential if the desired growth in private sector engagement and investment in R&D is to be fully realised.

The report has not specified dollar investment figures in recommending particular actions. The duration of the review was too brief to reach this level of detail, which in any event would be expected to be addressed in the development of the MSI forward investment strategy, and those of other ministries or organisations in relation to out-of-scope recommendations.

Finally, the Panel notes that earlier well-researched reports, including those of IPENZ and the New Zealand Institute,[43] present recommendations in the subject area for this review. The Panel hopes that this report reinforces previously recommended actions and proposes new initiatives that will, if adopted, place New Zealand on a path of much more rapid growth and development in its high value manufacturing and services sector.

[43] Institution of Professional Engineers New Zealand: *Catalysing Economic Growth: Boosting Innovation Expertise in the Private Sector*, 2011 (available at www.ipenz.org.nz), and New Zealand Institute: *Standing on the Shoulders of Science: Getting More Value from the Innovation Ecosystem*, 2009; *A Goal is Not a Strategy: Focusing Efforts to Improve New Zealand's Prosperity*, 2010; and *Plugging the Gap: An Internationalisation Strategy*, 2010 (available at www.nzinstitute.org.nz).

Appendices

Appendix 1: Review – Terms of Reference

Improving the access to and uptake of R&D in the high value manufacturing sector including high tech and related services

Terms of Reference
28 February 2011

Purpose

These are the Terms of Reference for an independent panel to advise on how the Government can better facilitate the development and growth of the high value manufacturing and services sector (including high-tech and related services) through creating and transferring research and development (R&D). The focus is therefore upon the process by which knowledge, know-how and technology is transferred from relevant research institutions to firms. The panel's report is expected to outline what experiences from other jurisdictions can be applied to New Zealand and, if applied, what this would mean for the roles, responsibilities and consequently funding structure of key research institutions in the sector.

Background

It is a widely held view that there is potential for the New Zealand manufacturing and services sector to contribute more to the economy than currently. There is a relatively low level of business investment in R&D by New Zealand firms (0.5 %), and similarly a relatively low level of expenditure on R&D as a percentage of GDP (1.2 %). These ratios are considerably less than in economies that have some similarities to New Zealand's.

Data on labour productivity in the manufacturing and services sector also reveals New Zealand as lagging well behind average OECD performance. Over the last ten years our performance has lagged well behind countries such as Australia and Denmark.

The high value manufacturing and services sector in New Zealand is principally made up of a large number of small to medium sized firms. This factor limits their absorptive capacity for implementing new products and processes that are generated by research. Unlike other sectors, the high value manufacturing and services sector is disparate without an overriding strategy due to the large number of technology sub-sectors.

Despite these barriers the New Zealand high value manufacturing and services sector does include firms that have achieved market leadership positions in specialist niche markets, and there is some evidence that this group is expanding. For example, in 2008/09, in the 116 firms where joint Ministry of Science and Innovation (MSI) and New Zealand Trade and Enterprise (NZTE) service plans have been completed, total turnover increased by 14.4 % to $11.15 billion, and total exports increased by 18.9 % to $7.83 billion.

Government has backed the idea that grant support for R&D can assist and accelerate this expansion in the number and size of these firms, and has recently approved new monies for low threshold grant programmes targeted at existing and successful R&D intensive firms.

In addition, there are a number of related Government initiatives which will affect the development of the high value manufacturing and services sector including:

- the Crown Research Institute (CRI) Taskforce – which seeks amongst other objectives to improve connectivity between firms and CRIs
- the creation of the National Network of Commercialisation Centres (NNCC) – which is an initiative designed to improve commercialisation of public research organisation intellectual property and related knowledge and technology transfer to firms
- an evolving Economic Growth Agenda by the Ministry of Economic Development which has highlighted the opportunity for high value manufacturing and services sector to increase New Zealand's GDP and labour productivity

It is likely that these developments will impact on all public research organisations that work in the sector, often in specialised areas.

A number of countries of similar size to New Zealand have successfully implemented programmes to develop the scale of high value manufacturing and services capability and their contribution to economic growth (including South Korea, Denmark, Finland, Israel, Queensland and Singapore). However, it still remains unclear as to exactly how these experiences are relevant to New Zealand. A key component of the proposed review is to commence a more structured process of learning from these experiences.

Objectives

The broad objective for the independent panel is to make recommendations on how the Government can better facilitate the development and growth of the high value manufacturing and services sector through creating and transferring of R&D. Specifically the panel is asked to:

- provide an analysis of overseas models for assisting and driving growth in the high value manufacturing and services sector, that have the most relevance to New Zealand
- provide an analysis of the key lessons and practices from those models that have significant relevance to New Zealand
- explore what the implications of these models would be for the roles, responsibilities and funding structures of key research institutions in the sector
- provide options for the roles and functions and funding of research organisations in the sector
- analyse the primary barriers to technology and knowledge transfer from research organisations to the high value manufacturing and services sector in New Zealand
- provide options to overcome those barriers.

Scope

It is expected the report will assist officials in any further development of policy initiatives relating to the provision of R&D assistance to businesses in the high value manufacturing and services sector, commercialisation, technology and knowledge transfer initiatives and the role of research organisations to enable this.

The report is to include commentary on experiences from the key countries that New Zealand seeks to compare itself to. Specifically:

- the relevance of this experience to the Government's role in the development, oversight and funding of innovation in the high value manufacturing and services sector

- possible new initiatives or organisational arrangements including funding that could be implemented in New Zealand in regard to supporting the growth of R&D by the high value manufacturing and services sector, and the wider manufacturing and services sector generally
- the potential role of public research organisations in assisting this.

The scope of the review covers the high value manufacturing and services sector including the following:

- firms across the biotechnology, processing, manufacturing of electronics, robotics, sensing and scanning devices, medical devices, drugs, agritechnologies,[44] digital and ICT technologies
- the application of technology developments to the more traditional manufacturing sector including for example meat processing, wool processing and related agritech activities
- the role of public research organisations involved in this sector.

Out of scope

The focus of this review is about how the development and transfer of knowledge know-how and technology can facilitate the growth of firms which develop, provide and utilise highly technological manufactured goods and services. Firms and sectors outside this definition are excluded from the scope of the review.

The scope of the review is primarily focused on the interface between research organisations and firms or businesses. The funding of research organisations is within scope, but the role of central government agencies, including policy agencies, is out of scope.

The review will be relatively high level and likely to be directional and not prescriptive. As noted the study will assist officials in considering the need for further policy and the report will be used to support any policy development.

Engagement with the Sector

This review is likely to receive considerable interest from both the research organisations involved in supporting the high value manufacturing and services sector, and from the high value manufacturing and services sector itself. As noted the panel will be interacting with key stakeholders.

Panel

The independent panel will include three members, with combined experience in manufacturing and services, technology and innovation in New Zealand and internationally.

One appointee will be selected to coordinate the panel's activities. The panel members will be contracted to MSI and paid on a time incurred basis.

The members of the panel are:

Professor John Raine
Professor Mina Teicher
Phil O'Reilly.

[44] "Agritechnologies" includes agriculture, horticulture, forestry and seafood technology businesses.

Governance and support provided by officials

The independent panel will report to an officials' steering committee comprising initially the Chief Executive of Ministry of Science and Innovation (Chair), Chief Executive of New Zealand Trade and Enterprise, a representative of the Ministry of Economic Development and another senior official from Ministry of Science and Innovation. The process will be overseen by the Chief Executive of Ministry of Science and Innovation and the final report will be forwarded to the Minister of Science and Innovation, by the steering committee.

Secretarial and administrative assistance will be coordinated by officials from MSI. A writer will be supplied if the panel requires it.

Process

The work of the panel is envisaged to comprise the following components:

- the development of a background paper on the models followed in similar jurisdictions to New Zealand and how the key issues are linked to the New Zealand context
- consultations with key industry users in the high value manufacturing and services sector, key researchers in the sector, key commentators and Government officials
- analysis of the lessons learnt and a report outlining the key lessons and the recommendations of the panel.

Outputs

A short high-level summary report with recommendations is to be completed by April 2011 (TBC).

Consultation required

It is a requirement that the panel undertake consultation with the main participants in the sector. This will include interactions with IRL, universities and CRIs with relevant research contracts, their respective commercialisation offices, independent research organisations such as BRANZ and HERA, representatives from the angel investor and economic development agencies, a representative sample of firms from the high value manufacturing and services sector, and Government officials in relevant ministries and agencies. MSI will assist in setting up these consultations.

Deliverables and Timeline

Deliverable	Indicative Timelines
Interviews with representatives of international organisations	Week 14–18 March TBC
Interviews with key New Zealand stakeholders	Week beginning 21 March 2011 TBC
Report writing	24th March 2011 TBC
Report completed and presented to Ministers	April 2011 TBC

Independent Panel Members

Professor John Raine (Chair) is the Head of the School of Engineering and Pro Vice Chancellor – Innovation and Enterprise at the Auckland University of Technology. John has had long term involvement in setting up university commercialisation operations, and was co-founder of WhisperTech Ltd, the Canterbury Innovation Incubator and the HITLabNZ. He has been a member of the MED Design Task Force, and the Governance Boards of the MacDiarmid Institute for Advanced Materials and Nanotechnology, and of IPENZ. He is currently chairs REANNZ Ltd, the Crown owned Company managing the KAREN advanced broadband network, and is Principal Moderator for the 2012 TEC Performance Based Research Fund Quality Evaluation.

Professor Mina Teicher is the Director of Emmy Noether Research Institute for Mathematics at Bar-Ilan University. Mina has previously held post of Chief Scientist at the Ministry of Science Culture and Sport and Director General at the Ministry of Science and Technology with the Israel government. Mina is currently a member of the Uniservices Stage Gate Investment Management Committee. Mina is widely credited for the development of the innovation sector in Israel.

Phil O'Reilly is the Chief Executive of Business NZ, New Zealand's largest business advocacy group, representing thousands of businesses of all sizes. Phil chairs the Capitalising on Research and Development Action Group (CRAG) and the Government's Green Growth Advisory Group. Phil is a member of the MSI Innovation Board and was previously a member of the Board of the Foundation for Research Science and Technology. He is also a member of the Council of the Royal Society of New Zealand. Internationally, Phil represents New Zealand employers at the International Labour Organisation (ILO) and is a Board Member of the Business & Industry Advisory Council to the OECD.

Appendix 2: Barriers to Access and Uptake of R&D in the High Value Manufacturing and Related Services Sector – As Identified by Responses and Interviews

Representative individuals and organisations key to the high value manufacturing and services sector were invited (87 invitations) to make written responses on how R&D can better support New Zealand's high value manufacturing and services sector. This invitation was also extended to interested stakeholders via the MSI website and established electronic distribution channels. From this process, a total of 46 written responses were returned (Tables 2A and 2B show additional detail).

The list of invitations was segmented as follows: providers of R&D (CRIs, universities, polytechnic institutes and independent research organisations); research consortia and associations (such as the Building Research Association of New Zealand); commentators; angel and venture capital investors; fifth, companies in the sector; and representatives of sector bodies.

Individuals and organisations were asked to answer the following three questions:

1. What are the primary barriers for business to access and take up R&D expertise available in research organisations in the high value manufacturing and services sector. What is the most important one?
2. What are the primary reasons for these barriers – for example, organisational structure, responsibilities or funding of the research organisations?
3. What do you see as the main initiatives to overcome these barriers?

Following written submissions, over 30 face-to-face and teleconference interviews were conducted during 21–29 March with individuals either representing themselves or their organisations. Face-to-face interviews were conducted in Auckland and Wellington. Those interviewed included chief executive officers, managing directors, business managers and other senior staff. The interviews usually lasted from 45 minutes to one hour.

Following analysis of written responses and interviews, barriers around the access to and uptake of R&D in the high value manufacturing and services sector could be categorised into four high level areas:

1. **Structure/Infrastructure**
2. **Capability**
3. **Investment/Funding**
4. **Culture.**

What follows is a discussion of the barriers as cited by those responding (written and oral) to the review.

1. Structure and Infrastructure

The environment in which the high value manufacturing and services sectors operate was mentioned as a barrier by many who made submissions. Factors considered were infrastructure that goes beyond roads and hi-speed broadband (though these were mentioned) and includes where, throughout the country, large equipment is located and can be used. The structure of the sector is also included in this set of barriers.

At least two submissions said the low level of **investment in infrastructure** (one specifically suggesting more fabrication facilities) was a barrier.

The scale of New Zealand businesses was mentioned numerous times as a barrier. In particular, numerous submissions highlighted a barrier in that the high value manufacturing and services sector in New Zealand is diverse and lacks scale or critical mass with very few companies and researchers working in the same fields.

One research association identified New Zealand's **low-volume economy** as a barrier. This commentator said that companies may be more likely to import an innovative product rather than develop it themselves; the companies may not see a profit or wide application beyond the small New Zealand market.

Multiple submissions highlighted a lack of networking and collaboration between organisations (including between research organisations throughout the country) as a barrier; members across the groups making submissions said that having no research organisation in New Zealand focused on servicing the needs and issues of the high value technology-based manufacturing sector was a barrier.

Multiple submissions also identified the **lack of or poorly developed clusters** (of the sector) as a barrier. Institutions are not always placed in locations for easy access to the necessary expertise, said one industry organisation and many submissions suggested that the geographical spread of companies and research organisations was a barrier (lack of proximity).

One university said that many of the firms lack the expertise to initiate and manage R&D projects and to embed the results in the operation of the company. "*To successfully manage this process*", the submission said, "*requires an innovation strategy, the technical knowledge to guide the development of the product, service or process and the management resource to operationalise it within the business. Many small to medium enterprises lack the resource and the sector is sufficiently* ***fragmented*** *to make it difficult to achieve this collectively*."

One respondent identified the large number of intermediary organisations (such as NZTE, Technology New Zealand (TechNZ), Business New Zealand, Economic Development Agencies, Chambers of Commerce and so on) and the high turnover of staff in these organisations as a barrier. Another submission identified the **lack of integration among the public sector** resources as a barrier.

One commentator said, "*…none of the CRIs see it as their main role to visit companies to assess their needs and sell R&D services to them*." One investor suggested that the overall structure of research organisations was a primary reason for the barriers; it is important, this person said, to have organisations (for example, Industrial Research Limited) structured around areas of strategic importance.

"Publicly funded research organisations are set up as industry independent research providers and are not generally linked to a particular niche manufacturing sector or particular companies. Therefore there is little networking and or interaction and companies do not identify with those organisations as being 'their' research providers."
(Industry research association)

One submission identified a lack of government procurement requirements that encourage the early adoption of high tech products as a barrier. "*There is a relatively narrow focus on price and quality according to the needs of the purchasing department(s) whereas a more 'holistic NZ Inc' view would help encourage local businesses to engage more in R&D.*"

International exits were identified as a barrier by more than one submission. One barrier identified by two submissions is the pattern for high tech start-ups to be sold overseas with a subsequent relocation of operations – and, importantly – innovation decision making, overseas.

Other commentators identified the lack of natural, international partners as a barrier, citing that we should be working with partners in other countries who know how to sell to the world and who are small, smart and have networks with people with "real money and capital".

2. Capability

A group of barriers identified in submissions and interviews fall under the general category of **capability**: knowledge, alignment and human resource and depth thereof. Capability barriers occur both in the research organisation and the business sides of the equation.

At least three firms commented that the main barrier to using R&D from research organisations is that their R&D requirements are in very niche areas. In these cases, the firm, not an external supplier of research, had the most expertise. Consequently, a lack of skill at the research organisation level can be interpreted as a barrier to uptake of R&D by business. One firm said that they failed to find internationally competitive **research expertise** in New Zealand. Another firm said that New Zealand research organisations did not have the regulatory expertise needed to support the businesses' needs.

"We must have world class capability to engage. Try not to be average."
(New Zealand university)

Business and at least one research association mentioned that the knowledge in New Zealand research organisations was mismatched to meet the needs of businesses in the sector.

Lack of available scientists and engineers moving to industry was seen as a barrier by at least two respondents. These submissions identified a need for an increased transfer of R&D workers between research and business. Multiple research organisations identified a lack of incentives for people to migrate between research organisations and industry as a barrier. One industry body identified a barrier in the lack of encouragement that *permanent* transfer to business is a good thing for researchers to advance their careers; others suggested a secondment programme or temporary arrangements would be worth considering. An inadequate integration between education, training and R&D support was also identified as a barrier in more than one response.

The lack of individuals who act as "translators", who bridge the gap between business and providers of research services, was identified by one university as a barrier.

Insufficient support for students who work with industry was identified as a barrier by one university. Another university identified student quota/capacity numbers (capping) as a barrier. Research students add to the university's total numbers; one of the barriers, then, is in human capital provision. Universities would like to have the ability to accept more students without penalty.

Barriers were also identified in business, including at the management level, with a lack of expertise using high-risk R&D at the board and CEO level; a barrier was identified that there are too few people (overall) in business with experience using R&D. The lack of experience using R&D becomes its own barrier. As one research organisation expressed, it can be a daunting step to take.

"New Zealand has [had] 100 years of undervaluing intellectual development. [There] is a disconnect between different parts of the system and a lack of global understanding relating to competitive advantage. The number of New Zealanders who understand how technical R&D works is small."
(New Zealand commentator)

"Inexperience can also lead to unrealistic expectations, both in terms of timeframes and the amount of attention that needs to be paid to R&D projects to ensure success."
(New Zealand research organisation)

Some respondents said that businesses don't see the need to engage in R&D or that they don't have a vision of what R&D is or what it can do. This barrier was echoed by a CRI that said a barrier was in businesses' failure to grasp the benefits that can come from innovation. While this could be classified as a cultural barrier, an industry research association echoed these sentiments, and explained that the majority of businesses wouldn't have the innovation skills required to be competitive in export markets and that part of this skill-set is being able to understand the role R&D plays in being innovative and competitive.

One university described a barrier in the **lack of technological appetite** within business. This, too, reflects on the skill-set of those in the business. Another university identified "*technological literacy and the ability to evaluate R&D investments*" as a barrier.

"This is sometimes referred to as the low absorptive capacity of businesses — i.e., a company 'doesn't-know-what-it-doesn't-know'. Unless a company has an 'R&D/technology champion' in a key decision-making role, they are unlikely to embark on any form or R&D or technological improvement; or, if they do so, it will often take the form of simply purchasing a new technology 'off-the-shelf' rather than a de-novo development. Hence, most companies do not even consider accessing R&D from research organisations in the first place. The critical challenge therefore is how to instil this culture/appetite into more businesses in the HVMS."

At least one company and one university mentioned that businesses **lack suitable personnel** to initiate and manage the initial contact and the ongoing cooperation with research organisations as a barrier to collaborative work. The company also said that pressures on its in-house R&D programmes meant that it has no extra capacity in terms of time or resources to dedicate to further R&D activity. The ability to absorb new technologies was also identified as a barrier by at least one organisation, and one commentator said that a barrier to outsourcing comes later: if a business outsourced R&D, it needs the capacity to bring the solution in-house.

A lack of engineers and students interested in engineering was identified as a barrier, as was a lack of programmes for young students to engage them early in their education. One commentator suggested the UK junior engineering programme to develop extra-curricular streams for involvement in high school. Another commentator suggested that there is a barrier early on: children don't have a clear vision of what science is available to them.

3. Investment/Funding

In one form or another, investment or funding, the continuity of funding, was mentioned as a barrier by nearly every submission.

The cost of R&D comes in different forms and the affordability for R&D was mentioned as a barrier by many. The initial cost of the research, the cost of implementation, the cost of accessing the support mechanisms (applying for grants and so on), the ongoing cost of R&D to the business as it grows, were all mentioned as barriers by one or another submission.

Lack of money available to research and commercialise ideas was mentioned by business, research associations, universities and CRIs, angel and venture capital investors and industry organisations. Comments ranged from, "*there is no money for initial research or idea generation*" to "*when businesses or individuals (including scientists) have an innovative idea, they often lack the expertise and financial backing to take it to the next level*". This situation can occur in a growing business or in a garage, the commentators said; either way, the individual may not have the ability to test and develop the idea. Another comment was that there was a discontinuity between angel and venture capital investment; while angel investors were quite active, taking commercialisation to the next level was an issue because of the lack of depth of venture capital markets.

Small- to medium-sized enterprises (SMEs) with one to 10 staff do not have the capacity to fund research, said one firm. "*They are full of great ideas, but no money*."

At least two firms said that it was a barrier when research organisations were not cost-competitive by international standards. This could be due, said one, to the high cost of supplies in New Zealand as well as the high overhead charged by research organisations. One said it was a barrier when research organisations were not "*structured to perform contract or commissioned R&D in a commercially competitive manner*"*.* The firm explained that this included the research firm lacking a competitive focus, dedication, full-time staff, capital equipment and other resources (admittedly, this could be interpreted as a cultural barrier but this submission identified the result as a cost barrier).

Two universities identified a barrier in that companies were unwilling to pay going rates for R&D. One university pointed out that because most businesses have little or no experience investing in R&D, they perceive the cost of contract R&D in New Zealand to be high where, in actuality, it is relatively low by international standards. A research association echoed this and said that industry tends to believe R&D services are expensive.

Government Research Investment

The low level of R&D investment by government was identified as a barrier in a number of submissions and interviews across stakeholder groups. Commentators also identified the way government funding is structured is a barrier.

At least three firms said that it is a barrier to R&D that small firms do not necessarily qualify for grants that require 50/50 funding and/or are seen as risky by research suppliers. One said that the R&D grants favour big companies, not "*cash-strapped*" young companies. The high entry threshold for the technology transfer vouchers was identified as a barrier. More than one submission suggested freeing up the 50/50 ratio and considering in-kind as well as cash contributions.

One commentator suggested that Foundation for Research, Science and Technology investment has been orthogonal to where companies are operating and that this mis-investment has resulted in long-term research being misaligned to the needs of New Zealand industry (this, then, becomes a cultural issue).

Business submissions and interviews appreciated that research organisations may not have the funding in terms of adequate resourcing that is necessary for R&D that is applicable to specific industry needs.

One commentator, who identified that funding was a barrier, suggested that making funding to the CRIs contestable with private sector organisations also doing R&D to support their commercial aims, and measuring outcomes directly in terms of money spent for economic outcomes achieved, would be worthy of consideration. This would encourage a sharper focus on commercial reality, they said. A submission from a CRI countered this view and said that a barrier was in the "*overly contestable system versus a more collaborative mind set*".

One submission identified, as a barrier, that innovation support has been narrowly defined and targeted at technical innovation; focus on invention alone is not sufficient.

One university suggested that the lack of relevant research to industry was due to funding projects rather than people. This submission suggested that shifting the model to one that funded people who focused on quality research in supporting disciplines might break down the barrier of irrelevant research.

In addition to the level of funding, submissions criticised the **process around funding** as being a barrier.

One submission identified a barrier as the "*…level of cynicism/distrust of Government funding mechanisms, arising from negative experiences around onerous processes, compliance rules and conditions that limit the practical effectiveness of the support*".

One commentator suggested that a barrier is that fast-growing technology companies have the inclination to look "further out" and would benefit from longer-term investments. This commentator identified a barrier being the management of long-term R&D funding being done by MSI and they suggested it should be done by the CRIs in the sector. An industry organisation suggested that a barrier was the processes around the voucher system and that these not be managed by MSI but that the bulk of the innovation/voucher funding be entrusted to the research organisation(s) that would then partner and negotiate appropriate ratios of co-investment.

One business said that a barrier was that the research application process is viewed as being a "*pain-in-the-neck*" (filling forms, locating supplier invoices, accounting for hours and so forth) for grants of only \$20–\$30K. Another firm said that the contract negotiation process was a barrier. Another organisation said the lack of clarity around the R&D funding process and the perception of bureaucracy and complexity around it was a barrier. Another submission identified the funding streams as "*a tangled web*" and that it was difficult to know what support was available from what agency (MSI versus NZTE). One university identified the cost of going through the processes of getting funding to be a barrier and suggested that to reduce the cost of investment on both sides would be beneficial.

One university identified a barrier in that universities "*get paid to do teaching and research but engagement with industry and commercialisation activities are largely underfunded*".

Commentators identified the **lack of private funds and investment** to take projects from idea to commercialisation and complete the value chain as a barrier. Lack of risk capital was mentioned as a barrier in submissions and interviews across the categories.

One research association said that a barrier to R&D is the tendency by business to see R&D as "*something that can be downgraded in the drive to hold up margins and that when business is operating in a tough economic environment, R&D for anything other than necessity, will take a back seat"*. Another submission suggested that businesses are challenged in seeing the cost of R&D as "investment" as compared to "cost".

The lack of co-investment models between public and private enterprise was seen as a barrier by at least two respondents. Many identified the lack of incentives to business to invest in R&D. One research association said that, during the previous R&D tax credit scheme, there was an increase in the number of companies expressing an interest in R&D, including some that had never engaged in R&D before. This, the respondent said, was a step change that has since disappeared.

Barriers were also identified by one commentator around the "*unpredictable nature of the exchange rate*".

4. Culture

When asked what the primary barriers were for the uptake of R&D expertise by businesses in the high value manufacturing and services sector and the reasons for these barriers, a number of the specific barriers mentioned can be grouped under the general heading of "culture".

Some of these cultural barriers are around **national direction**. As one submission said, "*we do not have a well-articulated national vision that establishes our leadership aspiration in national markets"*. Another submission stated that a barrier is the lack of integration in the sector and the "*lack of focus on unique products and processes to improve international competitive advantage".* Another said we need something we can all aspire to, and another said "*the Government needs a clear goal related to the sector*" and a university stated that a barrier was that "*New Zealand has not had a coordinated approach to development, implementation and management [of] science and innovation strategy across government. This has been shown internationally to be a barrier to innovation impact".*

Finally, one commentator said that we have been "*caught up with the micro-management [of individual organisations] and not thinking big…things become focused on trivial matters but we need to have a vision of what New Zealand can really do"*.

Part of a national strategy could overcome another barrier identified by a number of commentators: the lack of identified niche areas on which the sector could focus.

One commentator pointed out that the majority of the barriers are "social science" in nature (because human behaviour and interactions between groups and organisations are crucial considerations) and yet we do not invest in and/or involve social scientists in the discussion. This, then, became another barrier that sits in the national culture area.

Another barrier, identified by a CRI, was that the sector has no leading agency. Another commentator identified a barrier that we do not appreciate leadership in the applied sciences and suggested that it would be good if the Royal Society of New Zealand – a major driver of behaviour in the science arena – awarded medals and put equal emphasis on those working in the applied sciences.

An **overall lack of engagement between business and research organisations** was identified on a number of submissions as a primary barrier. This barrier, of course, spans a wide range of issues and warrants further dissection.

While some companies are spin-outs of universities and, consequently, have relationships with them, typical manufacturing firms do not interact with research organisations; consequently, the lack of personal connections was identified as a barrier. Many respondents – across the stakeholder spectrum – accepted that businesses are **unfamiliar** – on a philosophical or practical level – with what knowledge and expertise resides in research organisations or is under development. One firm said that it had historical relationships with a few research organisations and, consequently, understood what kind of work was under way at those particular places. However, it said that it was unaware of what work other research organisations were doing that could be beneficial to the company.

Many of the firms mentioned that a barrier to the uptake of expertise was in not knowing who – by means of the individual – to contact at a research institution when they had an R&D need. Companies expressed concern that there may be a "*limited targeted promotion"* by suppliers of research services.

One barrier identified by a research organisation is that, historically, the system has been "passive" rather than proactive, explaining that companies needed to go "*hunting for help"*, rather than the research organisations making their skills and expertise known to the industry. When new relationships needed to be formed for R&D needs, the onus was on the company to do so but, companies said, without a "*one-stop-shop"*, it is difficult to find the researcher with the capacity and capability to do the required work. One CRI agreed, saying that a barrier was that there was no mechanism or central point of contact to link expertise with the R&D need. One research association said that a barrier was due to the lack of good science communication from the scientists to the industry.

One firm said that there is a perception that New Zealand research is all based around agriculture and there is no one "*to help me with my business".*

One of the investors commented that while communication and understanding may be a barrier, **relationships** are two-way streets and business must also make an effort and approach R&D institutions. One CRI suggested that the barrier was a lack of a process to partner scientists and industry who could exploit new ideas coming out of research. Another commentator added that there needs to be more "true" partnerships; that research organisations should be doing work "with" not "for" business.

Even after a business and a research provider find each other, another group of cultural barriers occurs that was tagged by one university as a "**lack of alignment**" between R&D provider and business expectations.

Some barriers were mentioned that are **differences in organisational culture** between research organisations and business.

Surveyed businesses reported that they perceived research organisations to **lack understanding** of business needs. Business submissions identified a barrier in that those employed by research organisations are focused on the academic rather than the business potential of their work. One representative sector body explained the barrier to be that research workers (who do, in fact, interact with business) are insufficiently conversant with business, its language, processes and drivers. The providers, the submission said, do not understand companies' strategic planning processes. One university said that a barrier is the lack of motivation in researchers to engage with business or to do so "*in a business-friendly*" way. Other submissions noted that those in business need to become smarter with technology, to know how research works and the benefits that R&D can bring to business. One respondent wrote that it was a **suspicion** in the manufacturing sector that "*research organisations are **bureaucratic** and staffed with academic types with little or no commercial perspective".*

Another organisation said, "*…[research organisations] lack recognition that business and industry is indeed an appropriate recipient of the output of these institutions and organisations"*.

There were many submissions that discussed barriers that resulted from a difference in motivation of researchers in research organisations versus people in business. One company said that research organisations historically developed IP in isolation, which led to solutions to problems that didn't exist; this company congratulated a shift in behaviour it had witnessed in at least one research organisation that had engaged businesses by proactively asking how it could help solve business problems. Other submissions echoed the problem of **"tech push"** from research organisations and suggested that research investment be made to projects that aligned to industry needs (market pull).

"[W]e have found that very little of the R&D expertise in New Zealand research organisations is directly focused on delivering targeted output to business and industry."
(New Zealand business submission)

Another firm said that a barrier to the uptake of R&D existed because of a "*valley of death*" between research findings and having something that New Zealand businesses can afford to take up. In other words, the research is at too early a stage for commercialisation by the sector.

Business reported that much of the research conducted is based on what is academically interesting to the researchers rather than what business and industry requires; that is, researchers are more interested in publishing and with developing their research careers. This is due, said submissions from business and commentators, to researchers being rewarded based on publication numbers and New Zealand placing priority on publication in international peer-reviewed journals. A commentator noted that staff in the CRIs also held the view that their primary role was investigator-led research.

When considering research organisation culture, two business firms identified a barrier in the area of research organisation mission statements. One barrier comes from organisations setting research goals and programmes to work in with its mission; the other barrier was around a lack of consistency in mission. This company sympathised with CRIs, which at times were expected to pursue research and commercialise it and, at other times, were asked to assist industry without having deep competence and were therefore unable to provide value to business and industry customers.

Barriers between the organisations and business don't end with individual researchers; more barriers were identified when business submissions addressed the **commercialisation arms of organisations**. One firm said, *"[They] see themselves as a sales force for researchers' ideas rather than [as] a team that seeks to understand the future needs of businesses and connects this with relevant expertise…these organisations overvalue the idea and undervalue the commercialisation and market entry costs*."

An industry commentator suggested that a barrier is that the commercialisation offices cannot provide the needed level of service because of the scale in New Zealand and "*the lack of market and tech savvy people with the depth of knowledge to provide real support for scientists".* Business submissions said that where industry connections had been explored by research institutions, it had been on the basis of the research organisation seeking a business to commercialise an idea or concept rather than to deliver something that business is looking for. One business said, "*There seems to be a prevalent view within New Zealand research institutions (universities and CRIs) that they produce ideas and insight and that business simply exists as a factory to manufacture and deliver something based on their innovative talent (and from which they earn large royalties) and this is only after they've explored and discounted their own start-up commercialisation options.*"

One research organisation suggested the barrier was the poor understanding of technology transfer. "*There seems to be a view that tech transfer only occurs when there is a commercial transaction and that measurement should be focused on a transactional basis. In fact tech transfer occurs in many forms both explicit and tacit. It may take the form of formal publication or oral presentation (conference of seminar), student lecture, confidential report, licence or IP sale, informal discussion, representation on an industry board or group etc. There is a need for a broader understanding and definition of tech transfer and the resourcing that is supporting it*."

Difference in **timeframe** expectations around "*getting the job done"* was another organisational cultural barrier mentioned by business and research organisations. One CRI said, "*Small high tech firms are usually at an early stage and their focus is getting a product to market and getting cash flow. They* ***need answers fast*** *and they have very little money available. Public research organisations rely on getting paid or funded to do longer term research programmes, so there is not a good fit between the needs of both parties."* Another submission said, "*It is unreasonable for business and industry (or Government) to expect 'instant domain expertise' from research organisations. The matching of fundamental research to growth needs of business and industry requires a long-term partnership, which is generally lacking in the New Zealand high value manufacturing and services sector*." Another submission explained that it is unrealistic for an R&D organisation to be able to allocate 100% undivided attention to a particular project – it is a barrier for business to think this is will be the case.

There were a number of responses that identified cultural barriers around **IP**.

At least six respondents said that concern around IP was a barrier to companies using research organisations for R&D. IP protection, ownership and terms of licensing were all concerns. Negotiating the licensing agreements was also stated to be tricky and could become a stumbling block.

Companies expressed concern that any R&D produced on their behalf would also be available to domestic or international competitors (IP leakage). Firms feel more comfortable minimising risk of IP leakage by having in-house teams working on R&D.

One company responded that "*research organisations prefer to retain at least some IP ownership in order to build a large portfolio of 'background IP' but often require business to fund the cost of protecting newly generated IP. Businesses then face the challenge of paying for the protection of IP that they don't own*." On the other hand, one CRI said that there is a lack of understanding about IP ownership and that they do a lot of "*fee-for-service"*, in which case, the IP belongs to the client. A research association said that there is a perception that largely publicly funded research providers make the owning of IP costly. This perception often accompanies the argument that the providers are receiving the funds from the public and industry and therefore should make the IP available at no cost.

One firm said that the contract negotiation process was a barrier, explaining that expectations of royalty payments and ownership of generated IP versus relative investment by each party has sometimes been irresolvable.

One company expressed concerns that non-New Zealand staff employed in research organisations might return to their country of origin and commercialise the IP without regard to its confidentiality and ownership.

A **lack of or a low level of incentives** for research staff was mentioned by business and universities as a major barrier to collaboration.

Incentives can come in many forms and written as well as oral responses covered the range. Many submissions and interviews identified a negative connotation (to one's career) of working with industry as a barrier to R&D (there is little or no incentive for a researcher to spend time working within a business, for example). Many of the people interviewed mentioned the need to balance a Performance-Based Research Fund score with working collaboratively with industry. One business said that "*In nearly all cases, a secondment to industry would be damaging to an academic's career, and thus would be discouraged by peers. There needs to be a structure which rewards such interactions (through promotion, access to facilities, etc)…"*

Commentators suggested that researchers' "*share of the pie"* was too low and this presents a barrier. One interviewee said that CRIs have a "*we own it, you get no benefit"* mentality and that universities are too rigid in their one-third (university): one-third (department): one-third (researcher) ownership and reward model.

Other submissions expanded on the views expressed above and said that there is no financial incentive for research *organisations* (as compared to individual researchers) to up-skill the industry; they do not get an appropriate share of the reward, said one submission. Other commentators simply stated that there is no incentive for research institutions to be entrepreneurs.

At least two commentators turned this barrier around and said there is no incentive for business to engage with research organisations, "…*it is quicker, cheaper and better to do it yourself by using existing in-house staff and/or recruiting talented R&D-capable graduates"*. One CRI said that there is no incentive for the two to work together, from the earliest stage of the research process.

"To be fair, both parties can undervalue and under appreciate the other party's potential contribution. Industry is often looking for instant expertise and answers, and commercial arms of research organisations are looking for rapid commercialisation returns and market access. Neither of these is possible without long periods of investment."
(New Zealand company)

Business Culture

The barriers around organisational culture do not solely fall in the lap of the research organisations. Submissions and interviewees also identified barriers that have their genesis in **business culture**.

New Zealand companies' **attitudes towards risk** were mentioned repeatedly as a barrier. One submission described New Zealand business culture as: "*a traditional culture that concentrates on volume rather than value, that focuses on short term gains rather than long term advantage and that has little appetite for risk"*. Another submission echoed the sentiment and described the barrier as business having a "*short term focus*". Others described New Zealand firms as "*risk averse*" and driven by short-term profits. Others said business look for "guarantees" and that R&D wasn't a sure thing. Following on from attitudes towards risk, one submission identified New Zealand business as having "**conservative corporate management**" and said this was a barrier to the uptake of R&D.

Another cultural barrier was identified by one of the investors who explained that some businesses are happy where they are; they are happy with the *status quo* and do not realise that R&D could take their business to the next level. One university summed up the barrier simply: that New Zealand's small companies are unaware of the *need* to invest in R&D.

A submission from a research association identified a barrier as a New Zealand national culture that "*denigrates seeking expert assistance until it is absolutely necessary, especially when it is expensive*". One university echoed this barrier, saying that business complacency was a barrier.

"*Some businesses…are making annual surpluses and perhaps achieving organic growth, but are neither looking to step up the size/growth of their businesses nor looking forward to mitigate future marginalization of their business activities."*
(New Zealand university)

One university said that businesses believe they can go it alone and their lack of familiarity with the R&D process creates fear, which generates a barrier. Another university summed up the barrier that business sometimes lacks inspiration, explaining that they tend not to *"think big"* and are focused on fixes and incremental improvements. One organisation suggested that a barrier was the modest sharing of innovation between businesses. Another research organisation echoed this, suggesting the barrier was about "*protecting the home territory and not looking at the bigger picture*".

One business suggested that, in a way, **business is its own barrier to innovation**. It described business as looking through its unique lens and being limited by its knowledge, way of thinking and working. This results in business approaching solutions from the same angle each time rather than trying new perspectives; the result is an adaptive rather than transformational approach to innovation.

Organisation/Affiliation	Number of Representatives
International	
Australian Institute of Commercialisation (AIC), Queensland, Australia	1 (by phone)
Danish Technological Institute (DTI), Denmark	3 (by phone)
Electronics and Telecommunications Research Institute (ETRI), Korea	1 (by phone)
VTT Technical Research Centre, Finland	1 (by phone)
New Zealand	
Crown Research Institutes	
Scion	2
Industrial Research Limited (IRL)	13
Universities	
Dodd-Walls Centre, University of Otago^	1
University of Waikato and WaikatoLink	2
Riddet Centre, Massey University	1 (by phone)
University of Auckland and UniServices	3
Lincoln University, Commercialisation Office	1
University of Canterbury	2 (video link)
Polytechnics	
MetroPoly Group	4
^ joint interview – Southern Photonics and Dodd-Walls Centre	

Table 2A: Interviews with Representatives of the New Zealand Manufacturing and Services Sector

Organisation/Affiliation	Number of Representatives
Research Association	
Heavy Engineering Research Association (HERA)	1
Commentators	
New Zealand Institute	1
Better by Design, NZTE	1
Others	3
Angel Investors	
Angel Investors	3
Companies	
Southern Photonics ^	1
FPHcare	1
Tait	1
RAKON	2
Gallagher Group	1 (by phone)
Representative Bodies	
Manufacturers and Exporters Association (MEA)	1
Plastics New Zealand	1
Institution of Professional Engineers New Zealand (IPENZ)	2
Government Departments	
Ministry of Science and Innovation (MSI)	5
New Zealand Trade and Enterprise (NZTE)	5
Ministry of Economic Development (MED)	3
^ joint interview – Southern Photonics and Dodd-Walls Centre	

Table 2A (continued): Interviews with Representatives of the New Zealand Manufacturing and Services Sector

Manufacturing R&D Sector	Nos.
CRIs	**4**
Industrial Research Limited	
Scion	
GNS Science	
Plant & Food Research Limited	
Universities	**11**
University of Auckland	
University of Canterbury	
Victoria University	
Otago University	
Massey University	
University of Waikato	
Lincoln University	
Lincoln University – Lincoln Ventures	
Lincoln University – Commercialisation Office	
AUT University	
Dodd-Walls Centre (Otago University)	
Polytechnics	**2**
Metro Group	
Wellington Institute of Technology (WelTec)	
Research Associations	**3**
Building Research Association of New Zealand (BRANZ)	
HERA	
Cawthron Institute	
Research Consortia	**1**
Solid Wood Innovation	
Total	**46**

Manufacturing R&D Sector	Nos.
Commentators	**7**
Angel Investors and VCs	**3**
Companies	**8**
Tait Radio	
Temperzone	
Southern Photonics	
NZTP, A.G. Frankham Ltd (ATP)	
Gallagher Group	
Fisher & Paykel Healthcare	
Rakon	
Douglas Pharaceuticals	
Representative Sector Bodies	**7**
IPENZ	
Building Industry Federation	
Economic Development Agencies New Zealand (EDANZ)	
Medical Technology Association of New Zealand (MTANZ)	
New Zealand Institute of Mathematics & its Applications (NZIMA)	
Plastics New Zealand	
ISEPAG Policy Group	

Table 2B: Written Feedback from the New Zealand Manufacturing and Services Sector

Appendix 3: New Zealand R&D Organisations that Receive Public Funding

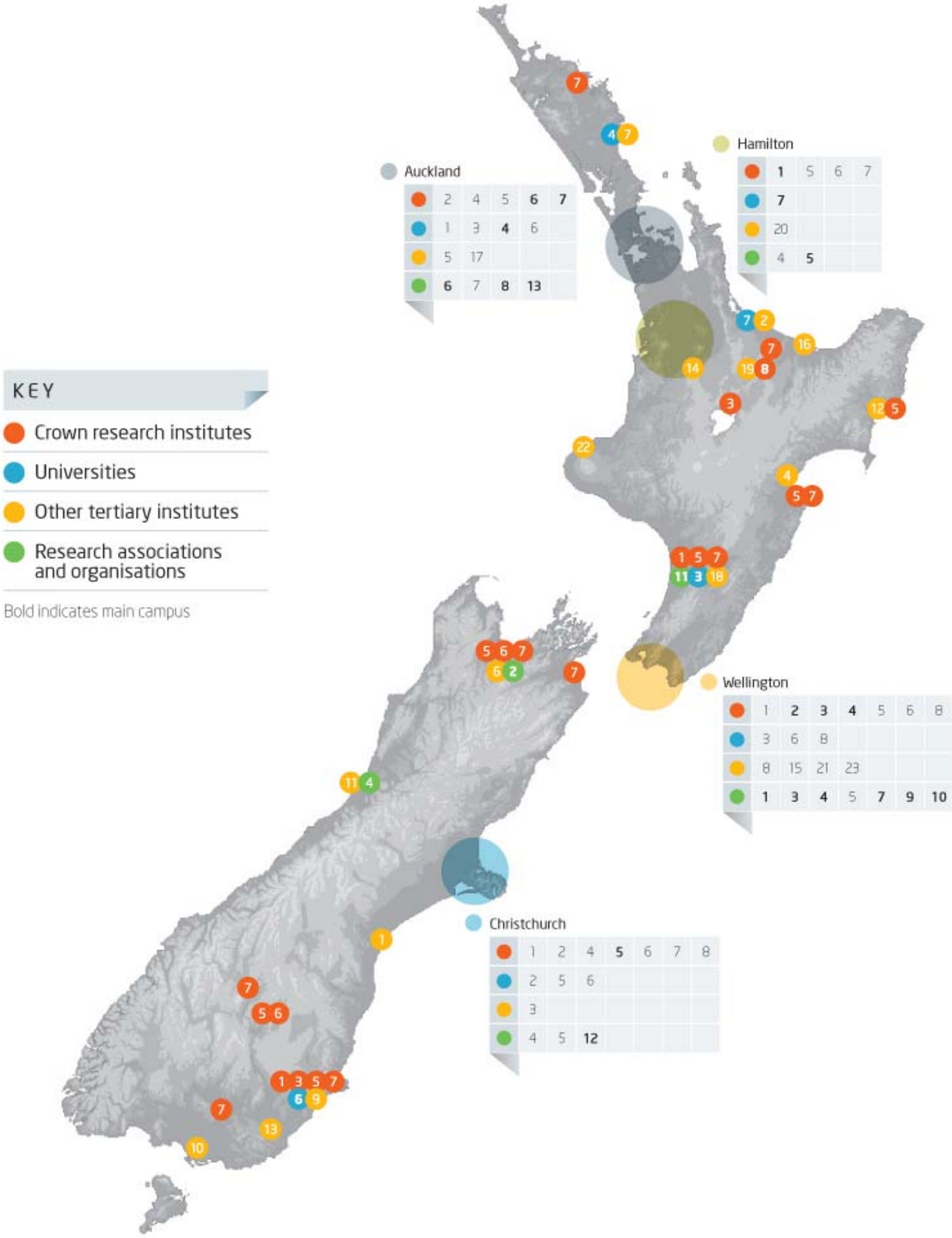

Figure 3A: R&D Organisation Locations

The numbers assigned to each of these organisations correspond to those in the text. For example, GNS Science is a CRI and is number 3.

The following discussion refers to Figure 3A wherever applicable.

1. Crown Research Institutes (red dots on the New Zealand map)

Eight CRIs were established in 1992 as government-owned businesses with a scientific purpose. Each institute is based around a productive sector of the economy or a grouping of natural resources. These eight CRIs are:

1. AgResearch – A life sciences research organisation with an increasing emphasis on product development and commercialisation. Its expertise in modern biotechnologies is founded on a legacy in the biological sciences of agriculture.

2. Institute of Environmental Science and Research Ltd (ESR) – Provides specialist science solutions related to public health, environmental health and forensic science. Its particular capabilities are in chemical and microbiological contaminants and surveillance of diseases and hazards.

3. GNS Science (Institute of Geological and Nuclear Sciences Ltd) – the New Zealand Crown-owned research institute that focuses on geological resources, environmental and industrial isotopes, and natural hazards.

4. Industrial Research Ltd (IRL) – Undertakes science, development and technology commercialisation in areas of communication, information and electronic technologies, advanced materials and performance, intelligent devices and systems, biochemical technologies, energy technologies, complex measurement and analysis.

5. Landcare Research – Research focuses on six areas: biodiversity and ecosystem processes, greenhouse gases and carbon storage, sustainable business and government, biosecurity and pest management, rural land use and urban environmental management.

6. National Institute of Water and Atmospheric Research (NIWA) – Provides a scientific basis for the sustainable management and development of New Zealand's atmospheric, marine and freshwater systems and associated resources.

7. Plant and Food Research – A science company formed in December 2008 through the merger of HortResearch and Crop & Food Research. Provides R&D that adds value to fruit, vegetable, crop and food products.

8. Scion – Provides research and technology solutions to all levels of forest and wood products industries, including biomaterials science, alternative species and plantation resources. Scion has recently extended its focus beyond wood to meet the growing consumer demand for renewable materials and products from plants.

2. The New Zealand tertiary sector

Tertiary Research Funding

Tertiary Education Commission (TEC) – a Crown entity responsible for funding post-compulsory education and training. While the Ministry of Education sets policy for the Performance-Based Research Fund and CoRES, the TEC administers the Performance-Based Research Fund, and allocates funding to institutions based on the quality of their research, and funding for the Centres of Research Excellence (see below).

2.1 Universities (blue dots on the New Zealand map)

1. Auckland University of Technology
2. Lincoln University
3. Massey University
4. University of Auckland
5. University of Canterbury
6. University of Otago
7. University of Waikato
8. Victoria University of Wellington

2.2 Centres of Research Excellence

The role of the eight Centres of Research Excellence (CoREs) is to support leading edge, international standard innovative research that fosters excellence and contributes both to New Zealand's national goals and to knowledge transfer. Each CoRE is hosted by a tertiary education institution. Funding for the CoREs is administered by the TEC.

Allan Wilson Centre for Molecular Ecology and Evolution
Maurice Wilkins Centre for Molecular Biodiscovery
Ngā Pae o te Māramatanga (Horizons of Insight) – the National Institute of Research Excellence for Māori Development
The MacDiarmid Institute for Advanced Materials and Nanotechnology
National Research Centre for Growth and Development
National Centre for Advanced Bio-Protection Technologies
The Riddet Centre – foods and biological
New Zealand Institute of Mathematics and its Applications

2.3 University Research Commercialisation Services

UniServices (Auckland University) www.uniservices.co.nz
AUT Commercialisation (Auckland University of Technology) www.aut.ac.nz/commercialisation
Canterprise (Canterbury University) www.research.canterbury.ac.nz/about.shtml
Lincoln Ventures Ltd (Lincoln University) www.lvl.co.nz
Massey eCentre (Massey University) www.garagetoglobal.com
Otago Innovation Ltd (Otago University) www.otagoinnovation.com
VicLink (Victoria University) www.viclink.co.nz
WaikatoLink Ltd (Waikato University) www.waikatolink.co.nz

2.4 Whare Wānanga (yellow dots on the New Zealand map)

There are three Crown funded Māori tertiary education institutions called whare wānanga. (The Education Amendment Act 1991 refers to them simply as wānanga.) Their purpose is to create a significant entry point for Māori into tertiary education by providing education services and curriculum tailored toward Māori aspirations and needs.

The whare wānanga all enjoy key relationships with iwi, hapū and whānau and with other education and research providers including the universities.

14. Te Wānanga o Aotearoa
15. Te Wānanga-o-Raukawa
16. Te Whare Wānanga o Awanuiārangi

2.5 Polytechnics (yellow dots on the New Zealand map)

The Metro group:

3. Christchurch Polytechnic Institute of Technology (CPIT)
5. Manukau Institute of Technology (MIT)
9. Otago Polytechnic
17. Unitec Institute of Technology (UNITEC)
20. Waikato Institute of Technology (WINTEC)
21. Wellington Institute of Technology (WELTEC)

Other polytechnics:

1. Aoraki Polytechnic
2. Bay of Plenty Polytechnic
4. Eastern Institute of Technology
6. Nelson Marlborough Institute of Technology
7. Northland Polytechnic
8. Open Polytechnic
10. Southern Institute of Technology
11. Tai Poutini Polytechnic
12. Tairāwhiti Polytechnic
13. Telford Rural Polytechnic
18. UCOL – Universal College of Learning
19. Waiariki Institute of Technology
22. Western Institute of Technology at Taranaki
23. Whitireia New Zealand Polytechnic

3. Research Organisations and Associations (green dots on the New Zealand map)

3.1 Primary Industries

2. Cawthron Institute – marine, freshwater and aquaculture research
4. CRL Energy Research – energy and environmental consulting company
5. DairyNZ – industry body funding R&D and technology transfer
6. Fert Research – the New Zealand Fertiliser Manufacturer's Research Association
10. Beef and Lamb (formerly Meat and Wool) New Zealand – funding for R&D and technology transfer activities
11. New Zealand Leather and Shoe Research Association
12. New Zealand Plant Breeding and Research Association

3.2 Medical

9. Malaghan Institute of Medical Research
The Liggins Institute

3.3 Construction and Engineering

1. Building Research Association of New Zealand – company supplying research, testing, consulting and information to the building industry
3. Cement and Concrete Association of New Zealand
8. Heavy Engineering Research Association (HERA)
13. Transport Engineering Research New Zealand

3.4 Information Technology and Communications

7. Harmonic – New Zealand's Information and Communications Technology Research Institute

3.5 Peak body for non-governmental research organisations

Independent Research Association of New Zealand

Appendix 4: Organisations Supporting University Research Commercialisation

Three organisations exist to support cooperative activity in IP Commercialisation.

(i) University Commercialisation Offices of New Zealand (UCONZ)

UCONZ is an association of university commercialisation offices that provides a forum for commercialisation directors to share best practice knowledge and to interact with government funding agencies on matters of common interest, for example, the former TEC sponsored Priorities of Focus (PFF) programme of events to create stronger university business relationships.
(http://uconz.wellcomhosting.com/2010-12-hi-tech-r&d/).

(ii) UniCom

UniCom (www.unicom.co.nz) is a consortium of five New Zealand universities that collaborate to maximise the commercial potential of public sector research. The UniCom consortium is made up of WaikatoLink Ltd, the commercialisation office of the University of Waikato, and those of the Auckland University of Technology (AUTEL), Lincoln University, University of Canterbury and Victoria University of Wellington (VicLink).

The mission of UniCom is to encourage collaboration rather than competition between public research institutions, aiming to maximise commercial benefits to New Zealand, facilitate broader collective expertise, sharing of commercial and development networks and an overall improvement in commercial capability and outcomes. UniCom's goal is to bridge the gap between knowledge generation and the progression of technology to market readiness. The UniCom consortium approach is underpinned by an investment committee whose members have a strong commercial background and provide a robust decision-making process around investor engagement and financial support for projects under commercialisation, for example, in decisions involving the allocation of the Ministry of Science and Innovation Pre-Seed Accelerator Fund.

Working with Unicom and other commercialisation groups, the intended National Network of Commercialisation Centres (NNCC) should assist the delivery of breadth and depth in commercialisation services by networking with commercialisation offices, investors and technical experts, to maximise the available expertise and prospects of deal flow.

(iii) Incubators New Zealand

Incubators New Zealand (INZ, www.incubators.org.nz) has 14 incubators, mostly in the high technology area, that assist more than 100 resident companies. Members of this group are:

AUT Business Innovation Centre: www.aut.ac.nz/innovationcentre
Canterbury Innovation Incubator (Cii): www.cii.co.nz
Creative HQ: www.creativehq.co.nz
Dunedin Fashion Incubator: www.dfi.co.nz
e-Centre Massey: www.e-centremassey.org.nz
The Icehouse: www.theicehouse.co.nz
Soda Inc: www.sodainc.com
WaikatoLink Limited: www.waikatolink.co.nz
Upstart: www.upstart.org.nz
The Bio Commerce Centre: www.biocommerce.co.nz.

Appendix 5: Commentary on International Models and Experiences

Overseas Models

There are a number of countries and regions throughout the world that offer good examples for how others might drive growth in their high value manufacturing and services sector and more specifically improve the access to and uptake of R&D in these areas. The Nordic countries – particularly Norway, Denmark and Finland – have programmes, institutions and policies that are worth study and consideration; likewise Israel and the Australian state of Queensland. These aforementioned locations are small to medium in size and share a desire to grow innovative business sectors.

Other locations, such as Singapore, the United States of America and the United Kingdom are remarkable in their successes in growing innovative companies and sectors. While New Zealand can learn from all these experiences, the domestic environments of these countries are significantly different than New Zealand's and this makes a one-on-one translation of models problematic.

Innovation doesn't occur in a vacuum. It is part of a system that is influenced by macroeconomics, geography, culture and, in many cases, history. Consequently, while parts of one system or another may look appealing, adopting one portion of a particular country's innovation strategy does not guarantee success. Likewise, picking and choosing pieces from many must be done in a considered manner. The Panel reviewed the following countries and regions and incorporated initiatives and learning from these in the recommendations chapter.

Norway

The Norwegian R&D system is close to New Zealand's with historically low total national investment in R&D (at 1.7% of gross domestic product (GDP) in 2008, it was slightly lower than the Organisation for Economic Co-operation and Development (OECD) average but slightly higher than New Zealand's 1.3% of GDP). Most R&D in Norway is conducted by the public sector; institutes play a key role as collective centres of applied R&D expertise. Norway has public research organisations similar to New Zealand's CRIs. All R&D organisations in Norway compete for funding from the Norwegian Research Council, which is part of the Ministry of Knowledge.[45]

In the 2008 OECD Reviews of Innovation Policy, the OECD identified that a main weakness of Norway's innovation system was its "*comparatively low level of R&D/innovation in some parts of the Norwegian business sector, especially in manufacturing".*[46] The authors explain that the concern is not that it reflects "*backwardness*" but that it reflects "*the need to restructure towards more knowledge-intensive industries while building strength in existing ones"*. It is not surprising, then, that in the OECD Science, Technology and Industry Outlook 2008 report, it states: "*innovation surveys show that Norwegian firms are less innovative than firms in several other OECD countries, especially in the services sector*".[47]

In 2009, the Norwegian Government published a white paper, Climate for Research, in which it stated that it aimed to increase R&D spending to 3% of GDP.[48] The government plan included encouraging business R&D, through loans, grants and R&D tax credits, especially for SMEs. The Research Council of Norway, responsible for the development and implementation of the national research strategy, has five divisions: Science, Energy, Resources and the Environment, Society and Education, Innovation and Administration. Following a reorganisation in early 2011, the division for Innovation now has a greater

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[45] Peter Morten, *The Role and Value of CRI-Type Institutions Overseas*, The Hague, February 2008.
[46] Organisation for Economic Co-operation and Development: *OECD Reviews of Innovation Policy: Norway*, OECD, 2008.
[47] Organisation for Economic Co-operation and Development: *OECD Science, Technology and Industry Outlook 2008*, OECD, 2008.
[48] Norwegian Ministry of Education and Research: *Climate for Research*, 2009 (available at www.regjeringen.no/upload/KD/Vedlegg/Forskning/climate_for_research_final.pdf)

focus on research in and for industry and is tasked with integrating innovation with industry and technology.

A number of programmes are available to industry:

- funding of R&D (funding for user-driven innovation projects up to 50% of the approved project costs; up to 80% funding for knowledge-building projects with user involvement that are submitted by research institutions in cooperation with trade and industry)
- tax deduction for costs related to R&D
- industry PhD scheme (companies may apply for support for a three-year period for an employee seeking to pursue an ordinary doctoral degree and the doctoral research project must be relevant to issues related to the company's long-term challenges)
- a new programme for commercialising R&D results is being set up to replace FORNY (a joint programme between the Research Council of Norway and Innovation Norway), which was set to end in 2010. The programme to be outlined will be for the development of business ideas that come from research from universities and the goal is to start a new company or to use the technology or business idea in an existing company or industry. FORNY worked through a national network (jointly funded by Research Council and Innovation Norway)
- Centres of Research including the Centres of Excellence (for long-term, high quality basic research); Centres for Research-based Innovation (to establish or strengthen research groups working together); Centres for Environment-friendly Energy Research; and Centres of Expertise (for industry innovation on a regional context). These centres work collaboratively with companies, researchers, university colleges and the public authorities. The scheme is established in cooperation with Innovation Norway and SIVA (the Industrial Development Corporation of Norway).

Norway offers New Zealand an example of a country faced with similar challenges and one that has very recently developed systems, plans and mechanisms to meet them. With such recent introduction of schemes and very recent reorganisation of a government department, it is difficult to know the impacts of the initiatives.

Finland

Finland ranks second in the OECD in R&D investment (3.45% of GDP). Company-based R&D investment is mainly in the areas of electronics, and NOKIA accounts for almost half of overall business R&D. Traditional industries (wood and metal) account for less than 16%. According to the OECD report, the country has "*very few R&D-oriented start-ups, partly owing to a lack of risk capital*".[49]

The Finnish Science Policy released in 2009 included plans and mechanisms to encourage growth and business innovation. These included an increase in R&D investment to 4.0% of GDP. This was reiterated in the Research and Innovation Policy Guidelines for 2011–2015, which explained that Finland aimed to "*strengthen its position among the top knowledge and competence-based countries*".[50]

As outlined in the following diagram (Figure 5A), the Finnish Research and Innovation Council is chaired by the Prime Minister and advises ministries; science policy is carried out by the Ministry of Education (education and science policy) and the Ministry of Employment and the Economy (industrial and technology policy). Funding is distributed through the Academy of Finland, Tekes (the main Finnish

[49] Organisation for Economic Co-operation and Development: *OECD Science, Technology and Industry Outlook 2008, Science and Innovation: Country Notes: Finland*, ISBN 978-92-64-04991-8.

[50] The Research and Innovation Council of Finland: *Research and Innovation Policy Guidelines for 2011 – 2015*, ISBN 978-952-485-997-4 and ISBN 978-952-485-998-1 (pdf).

public funding organisation for research, development and innovation) and Sitra (the Finnish Innovation Fund).

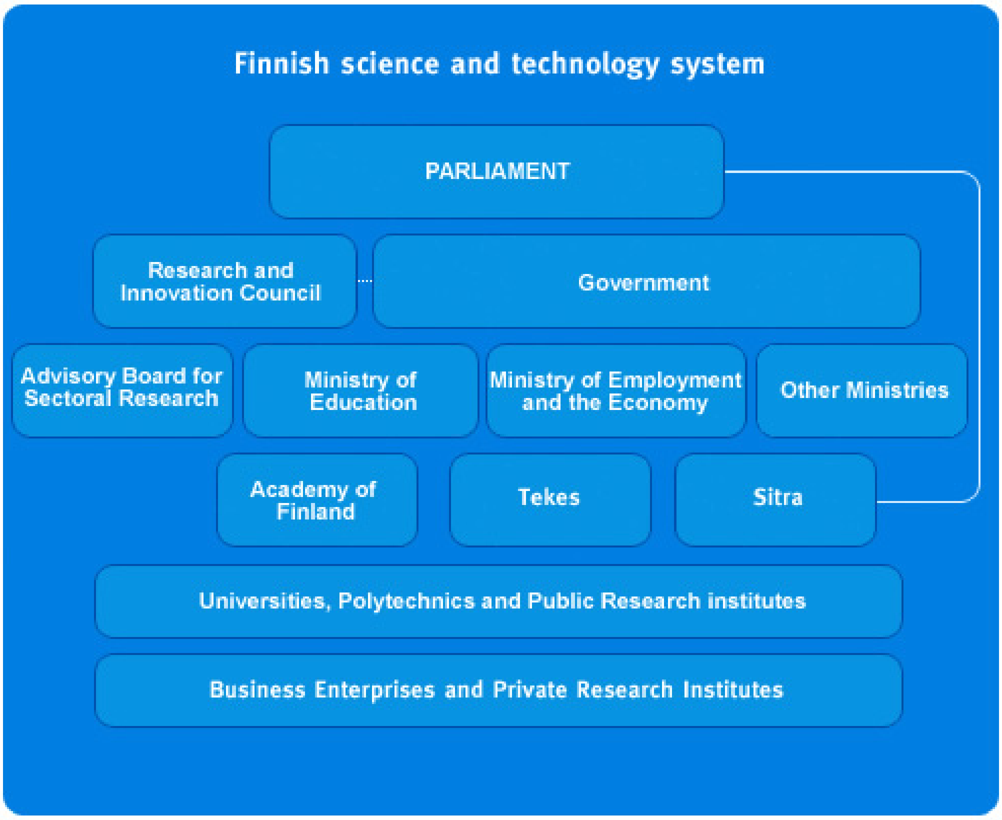

Figure 5A: The Finnish Science and Technology System (Source: Finish Science and Technology Information Service)

The press release attached to the 2011–2015 guidelines said, in part:

"Succeeding in an open and dynamic operating environment requires new ways of working and the development of structures, as well as experiments and risk-taking. It is important that Finland makes choices that support specialisation in competitive areas of strength. It is vital for Finland to be able to identify promising research, competence and business areas. Grand challenges must be taken into account in a more systematic manner. The operating culture of the public sector must be changed in a way that serves the implementation of overarching development actions."[51]

It is not surprising, then, to see that Finland has set on a pathway of significant overhaul in its science and education system. (Only those bullet points that directly relate to this review are included here. The reader is encouraged to further study the information provided by the Finnish government.)

Areas of development

- Incentives will be created for higher education institutions to engage in co-operation with companies, and the effective exploitation of competencies will be advanced.
- Non-technological and social innovations must be created and partnerships, users and customers will play a key role in making this happen.

[51] The Research and Innovation Council of Finland: *Research and Innovation Policy Guidelines for 2011 – 2015*, ISBN 978-952-485-997-4 and ISBN 978-952-485-998-1 (pdf).

- An R&D tax incentive scheme for companies will be introduced.
- The regulatory framework and steering systems will support the exploitation of research and innovation activities and experiments.
- The funding and steering of education, research and innovation activities are being developed to support internationalisation.
- Finland will adopt a proactive approach to the reform of the European Union research and innovation policy.
- The international evaluations of Tekes and the Academy of Finland as well as those of Strategic Centres of Excellence in science, technology and innovation (SHOKs) will be carried out by 2013.
- The steering and funding of higher education institutions and research institutes will be reformed in a way that supports improving the quality of education and research, internationalisation, the utilisation of research outcomes and specialisation. The role of polytechnics within the innovation system will be clarified.
- The strategic steering of public research institutes will be strengthened.
- At the beginning of the next term of government, the structural development of the public research institutes will be outlined. An action plan extending to 2020 on the development of the public research institute sector will be drawn up.
- The operating model for the Centres of Expertise Programme (OSKE) will be revised.
- The activities of the SHOKs will be strengthened and their funding base will be expanded.
- The level of education of the population will be raised.

Funding

- Finland's objective is to maintain the R&D funding share of GDP at 4% in the 2010s. Public investment should be 1.2% of GDP.
- The most important funding targets are research infrastructures, basic R&D of tenure tracks for researchers, fields of education, research and innovation activities of the highest international level and other selected focus areas, SHOKs and internationalisation.
- The priority areas for innovation funding include safeguarding the competitiveness of, and innovation in, areas of strength in business and industry as well as companies, the promotion of demand and user-based innovation activities and experiments supporting it, and supporting growth businesses.

Research Centres

Finland's SHOKs were established in early 2000s through Tekes funding and are public–private partnerships tasked with speeding up the innovation processes and boosting private sector initiated research done in partnership with publicly funded research. There are six centres, based around particular areas of industry:

- forest cluster
- information and communication industry and services
- metal products and mechanical engineering
- energy and the environment
- built environment innovations
- health and well-being.

(In addition to government initiatives, the Technopolis Group is a publicly listed (NASDAQ OMX Helsinki) company that owns and operates scientific and industrial parks in Finland, Russia and Estonia. Facilities and business development services are available to companies and organisations clustered in the parks).

Denmark

A recent analysis of the return from private R&D investments in Denmark shows that R&D-active enterprises, which cooperate with universities and other research institutions experience (on average) 15% higher productivity per employee compared to R&D-active enterprises with no cooperation with research institutions. An additional analysis of the Danish innovation consortia programme (which supports research–business collaboration) shows that 400.000 EUR invested by a company in public–private research partnerships yields 2–3 million EUR in gross profits. Analyses of the return from private R&D investments in Denmark show that R&D-active enterprises have a 15% higher average productivity per employee compared to non R&D-active enterprises. Further, innovative enterprises have a 6% higher average labour productivity than non R&D-active enterprises.[52]

The Ministry of Science, Technology and Innovation is responsible for the following policy areas: research, information and communication technology (ICT), innovation, telecommunications, university educations and internationalisation of education and training in Denmark.

Funding and advice for research and innovation comes through five foundations and councils as illustrated below in Figure 5B.

Figure 5B: The Danish System

Main policy initiatives of the Ministry around innovation are administered by The Danish Council for Technology and Innovation (established in 2002). It is charged with promoting innovation and dissemination of knowledge between knowledge institutions and enterprises.

Innovation policy initiatives fall under four main priorities:

1. collaboration between business and research
2. access to high skilled workforce
3. research commercialisation
4. Approved Technological Service – the GTS-net.

[52] Danish Ministry of Science, Technology and Innovation: *Business R&D and Innovation in Denmark*, 2010, p 3 (available at www.icdmuenchen.um.dk/NR/rdonlyres/28ACB41B-2EB0-4EA7-86DC-7B849A80BC7E/0/RDandInnovationinDenmark28april2010finalreport.pdf).

Danish innovation policy

According to the Danish innovation policy, the fields of focus of Innovation Denmark 2010–2013 are:

- developing new innovation-promoting and collaboration-promoting instruments for small and medium-sized enterprises
- providing increased opportunity for initiatives generated by enterprise demand
- developing approved technological services for small and medium-sized enterprises
- ensuring more highly educated staff are employed in small and medium-sized enterprises
- focusing on the service sectors' need for innovation
- focusing on the production sectors need for R&D promotion and good framework conditions
- promoting good frameworks for, and increasing investment in, knowledge dissemination and private research, development and innovation
- strengthening the commercial use of public research; promoting innovation in Danish businesses, and knowledge dissemination in society through increased international cooperation and knowledge from abroad
- strengthening the public sector's opportunities to support enterprise innovation.

Tools of the Danish Council of Technology and Innovation

- Innovation consortia scheme
  - This is a framework for collaboration between companies, research institutions and non-profit advisory parties. It is not set up as a scheme for product development for a particular company; instead it is meant to use high level innovation and research into generic content that will be relevant to a wide group of companies. Close collaboration between partners is a requirement of projects (which should last two-to-four years) and company input is required to ensure that projects are based on the needs of Danish companies and that company input (knowledge/competence) is used in the project.
- Competence and Innovation Networks
  - A network or cluster with a flexible framework set up for collaboration between companies, research institutions and non-profit advisory/knowledge dissemination parties. Networks are designed to be inclusive of SMEs, are national in nature, are open to new members and provide entry to the national innovation system.
- Industrial PhD programme
  - In the three-year Industrial PhD programme, a student is enrolled in university and hired by a Danish company. The company receives a wage subsidy and the university's expenses are covered. The student gains experience in both academia and industry; the research project (which the student works on full-time) integrates academic research into the business environment.
- Knowledge-pilot scheme
  - This scheme subsidises the employment of university graduates for SMEs that would otherwise not hire graduates and also allows for SMEs to apply for "knowledge vouchers" to purchase education or services at universities and research institutions.
- Innovation Voucher Scheme
  - Established in 2008, the scheme is for business-research partnership projects. There are two types of vouchers ranging from state co-funding of 40% to 70% and with goals of transferring research to SMEs or solving current problems of industry.
- Danish Technological Service System (GTS-net)
  - The nine approved research and technology organisations in the GTS-net (Godkendt Teknologisk Service) are the GTS-institutes. The organisations are approved by the

Minister for three years at a time; approval is based on technological and financial performance and organisational solidity.
- o The institutes are independent, not-for-profit and profits are reinvested in R&D.

The core function of the GTS-network is to deliver technological know-how to companies and public institutions in order to increase innovation and competitiveness of the Danish industry and society.[53] The Government does not financially support the services of the GTS-institutes - the institutes market their services on a commercial basis. They also collaborate in R&D with universities, companies and research institutions in Denmark and internationally.

Institutes are able to apply for government performance contracts to finance applied research to develop new knowledge and/or transform and communicate existing knowledge. Of the nine GTS-institutes, at least seven offer services to companies in what MSI would consider the HVMSS (including high tech and related services).

In 2008, the Danish Ministry of Science, Technology and Innovation commissioned an international evaluation of the GTS Institute System. The authors acknowledged that the system:

"*…is doing a good job in its national context, serving the industry needs of Denmark and eliciting great satisfaction from its customers. It plays an especially important part in supporting SMEs, which tend to acquire technological services a little at a time in small projects, to be reluctant to pay what they often see as high prices and to need a lot of introductory help and after-care. These hard-to-serve customers are very unattractive to the private sector but looking after their needs is vital to the health of the substantial SME sector in Denmark*."[54]

The authors went on to say that the focus on services to customers:

"*…means that Danish industry tends to get a lower amount of R&D-related, knowledge-intensive support from its institutes than does industry in other countries. This is reflected in the comparatively low proportion of PhD-holders among the GST staff and the comparatively low rate of scientific publication and linkage with universities among GTS staff.*"

The authors support that while the networks primary role of "de-risking" innovation through services of R&D beyond the internal capabilities of companies should not be abandoned, the GTS-institutes should increase their R&D capacity, increase their proportion of PhD staff and build closer relationships and links with universities, perhaps through reciprocal placements as well as collaborative research projects. Further, the authors recommended that the institutes increase their international connections and partnerships; they recommend an increase in core funding to the GTS-institutes is a necessity.

Mikkel Agerbaek (Director of DTI, one of the GTS-institutes),[55] reported that making links and working in close collaboration with universities and SMEs has been a focus of DTI's strategy for the last few years. The key enabler of the collaboration with the universities is the infrastructure and equipment that the universities own; the key driver for the collaboration is investment in further, expensive equipment. DTI will also work with universities which have a piece of technology that they have not been able to commercialise but that has commercial value; if DTI can see an industrial application, it will build a consortia agreement to do so.

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[53] This delivery of technological know-how is being done in close corporation with Danish and foreign universities. The GTS-network develops competencies, know-how, methods and technological services, which are strongly relevant for Danish industries and which are not available in the private sector. The GTS-network thereby ensures that the newest knowledge and know-how is available to the Danish industries.

[54] Danish Ministry of Science, Technology and Innovation: *A Step Beyond: International Evaluation of the GTS Institute System in Denmark*, 2009, p 9 (available at www.teknologiportalen.dk/NR/rdonlyres/43A17153-8159-4FD5-83BB-67D33F650897/3647/AStepBeyond_web_2.pdf), ISBN 987- 87-923-7280-2.

[55] Ministry of Science and Innovation panel interview, 22 March 2011, Mikkel Agerbaek, Lars Germann (Director of Productivity and Production, Danish Technological Institute) and Annaliese Germaier (Danish Technological Institute).

Agerbaek et al explained that to fund research DTI must get competitive grant money; R&D at DTI is very much industry-focused. "*We need to see the product at the end before we start any research. We need to be sure there are companies interested in things we are developing*." DTI may research an area where it is unsure of the outcome, but if it is heading in a particular direction, it will be in discussion with companies to ensure there is industry research.

Collaborative funding is available through the Ministry to improve the connections between the GTS-institutes and universities. The universities are funded to conduct research that has industrial application; the industries collaborate in this work. DTI's role is to bridge the gap between the work done at the university and the actual need.

Agerbaek says that, in Denmark, universities tend not to be well-connected with industry and they are driven to collaborate with the GTS-institutes in order to gain this connection. Challenges for industry, says Agerbaek, are that companies may find it difficult to follow academic discussions. However, he says, the project success is reliant on the company being involved in the discussion.

Coupons through the Innovation Voucher Scheme are redeemable at the GTS-institutes. The DTI panel explained that companies match in time and/or labour and that DTI has completed several hundred projects in the past two years. It is a very efficient way for a company to get started in R&D, the panel said, adding that the purpose of small grants was not always about R&D as much as to introduce the SMEs to knowing what they can get out of working with R&D partners and universities.

Queensland

Queensland has roughly the same population as New Zealand; traditionally it has been a commodity exporting economy.

Queensland's economic output (expressed as real gross state output in 2007 constant prices) rose from A$93,172M to A$200,805M in the period from 1989 to 2007. This compares with the change in New Zealand's real GDP (in 2007 constant prices) in the same period from A$75,616M to A$144,676M. In percentage terms, Queensland's real output exceeded New Zealand's by 23% in 1989 and, by 2007, this excess had grown to 39%. Williams reported that a key contributor to the economic growth differential was Queensland's mining industry and that up to 30% of the business expenditure on R&D was attributable to mining.[56]

In 2009, the Queensland Government developed "Toward Q2: Tomorrow's Queensland".[57] This plan identifies five ambitions for the state to achieve by 2020: to make Queensland strong, green, smart, healthy and fair. Of note is that one of the main goals of the state's plan is to see a 50% increase in proportion of Queensland businesses that undertake R&D or innovation.

Subsequent to the state plan, the Queensland R&D investment strategy 2010–2020[58] was developed to ensure that that state's investment in R&D was aimed at the same five ambitions; it identified five areas for action and coordination across government, each with specific mechanisms (some are highlighted here, all are available in more detail in the cited report).

- Focus on needs and strengths
    - Define and invest in R&D across six priorities and 14 objectives.
    - Apply clear investment criteria, conditional on meeting priorities and objectives.
- Build critical mass

[56] *Queensland-New Zealand Comparative Analysis of Economic Growth Differential and Contribution of Science in Economic Growth*, Julian Williams, MoRST, April 2010

[57] Queensland Government: *Toward Q2: Tomorrow's Queensland*, 2008 (available at www.towardq2.qld.gov.au/tomorrow/library/pdf/Towards_Q2_Tomorrows_Queensland.pdf)

[58] Queensland Government: *Queensland Research and Development Investment Strategy 2010–2020*, 2010 (available at www.chiefscientist.qld.gov.au/research-and-development/assets/queensland-r-and-d-investment-strategy-2010-2020.pdf).

- Invest in collaborative R&D precincts to co-locate research, industry and education. In 2007, *Smart Cities: Rethinking the City Centre* was released, outlining how Brisbane can best use its "knowledge corridor".[59]
  - Facilitate national and international research partnership networks.
- Skill the workforce
  - Deliver quality science, technology, engineering and mathematics education and training.
  - Attract outstanding researchers.
  - Provide a rewarding research environment.
- Engage the community
  - Coordinate state and national engagement activities.
  - Incorporate research engagement activities into R&D investments.
- Connect researchers, end users and investors
  The Queensland Government aims to increase technology transfer rates. To do so, it must more closely connect researchers to end users and investors. The Queensland Government has developed three main mechanisms.
  - Facilitate end user access to research through organisations like the Australian Centre for Commercialisation (this is discussed in detail below).
  - Translate research to application
    - Co-locate research, education and industry facilities.
    - Support education and extension activities for business as well as the development of entrepreneurial skills of researchers and innovators. This is done in part through Commercialisation Fellowships and other vehicles:[60]
      - Researcher-in-Residence Fellowships
      - Entrepreneur-in-Residence Fellowship.
      - Innovation Investment Exchange Fellowships:
        Grants available for Queensland-based venture capital fund managers to engage in one-way or two-way exchange in programmes with overseas venture capital firms to strengthen Queensland's links with the international investment community.
      - The Queensland Wide Innovation Network (Q-WIN) assists businesses with innovation through services such as innovation coaches, regional innovation support funding and the online Innovation Toolbox.
  - Attract investment into innovation
    - Proof of Concept Fund.[61]
    - Programme based.
    - Project based.

Australian Institute of Commercialisation

The Australian Institute of Commercialisation (AIC) was established in 2002 to help grow commercial success and increase the number of innovating SMEs. It covers a number of different knowledge and technology sectors including bio-medicine, nanotechnology, engineering, ICT, agriculture and tourism. It operates in both product- and service-based industries.

[59] Queensland Government: *Smart Cities: Rethinking the City Centre*, 2007 (available at www.premiers.qld.gov.au/community-issues/smart-state-council/council-reports/assets/smart-cities.pdf).
[60] Queensland Government: Smart Futures Commercialisation Fellowships (available at www.sd.qld.gov.au/dsdweb/v4/apps/web/content.cfm?id=10387).
[61] Queensland Government: Proof of Concept Fund (available at www.industry.qld.gov.au/funding-and-assistance/504.htm).

The AIC operates across all states of Australia with international engagement in Malaysia, Korea, China, Singapore, Canada and some US states. AIC is a limited liability company; it is its only shareholder and operates as a not for profit but also as a not for loss. Its current annual budget is A$4M; this has moved between A$3.9M to A$5.3M. The AIC was seeded by the Queensland Government for the first five to seven years, with diminishing funds per annum. This is the first year without government funding. The AIC has achieved a fully sustainable model. AIC runs a combination of programmes on behalf of government and also does fee-for-service work; it generates around A$300K by consulting in innovation. It has 25 staff.

Programmes have been developed by AIC to aid the market. The organisation aims to bring stakeholders together so all players know where they fit into the value chain and to accelerate the commercialisation of the technology they create

Some of the programmes of AIC are:

- TechFast (linking companies with the right people and organisations to help them solve their issues; identify technical capability and new growth opportunities)
- innovation coaching programmes (in 2010, 28 SMEs had 11 week in-depth coaching)
- hands-on work with SMEs across all sectors to help businesses innovate
- researchers in business.

Knowledge brokering

AIC also assists university commercialisation offices by providing business intelligence and making connections. Universities recognise AIC as an organisation that provides industry representation for them. The Techmark programme is based on AIC going to industry and identifying needs, problems and opportunities and then going back to the research sector to farm the IP. AIC then has the knowledge and connections to introduce the two players. The AIC suggested a one-stop-shop where industry could take problems, opportunities and needs, a single point of entry that could then be farmed-out to appropriate research organisations.

Taiwan

The Industrial Technology Research Institute (ITRI) was founded in 1973 from the merger of three research organisations. In 2006, it was reorganised into six core laboratories, five focus centres and five linkage centres. Since ITRI was launched, its three goals were to expedite the development of new industrial technology; aid in the process of upgrading industrial technology techniques; and establish future industrial technology. Upon reorganisation, the goals became more focused on integration, exploring new technology trends and leading new opportunities for industry.

ITRI has an extensive career development programme and encourages employees to cycle through it and gain experience in different areas as well as further their formal education. The organisation subsidises Master's and PhD tuition fees and has grants for collaborative work with other research organisations including universities. The ITRI College offers courses for employees and members of the industrial (and general) community. A six- to 24-month leadership training programme is offered for those identified as future leaders in R&D.

The organisation's website states that, as of 2006, over:

"*160,000 alumni have graduated from ITRI with more than 140,000 of them currently employed in the business community…more than 60 of our alumni are current domestic corporations CEO. ITRI believes we are not only providing revolutionary technological research, but we are also preparing* *individual talents for their various future endeavours, preparing them to be Taiwan's next generation of industrial pioneers*."[62]

Israel[63]

A young country of just over 7 million people, Israel is recognised as one of the most innovative nations in the world, its creativity and originality spurred by the challenging environmental pressures placed upon it. To appreciate Israel's culture of innovation, it is important to start with its history. Sixty years ago, Israel was a new country with very little land and cut off from the food sources of neighbouring countries. Into it came a flow of refugees from Europe, the Middle East and North Africa. The country's respect for high quality education was engrained from its time under British rule and three universities already existed.

The new country's first goal was to grow enough food to feed the population. Because of the acute shortage of land and fresh water, agriculture needed to be very efficient; consequently, the Israelis developed highly sophisticated and innovative agricultural systems. Today, the country produces almost all of its own food although it does not grow wheat or rice and imports produce that is more competitively grown elsewhere.

An independent national research institute for agriculture was established and, within it, researchers were given the freedom to conduct basic, applied and product-oriented research. Research into genetic modification, for example, is funded by the Government and the results/information is distributed directly to the farmers. The IP generated by these researchers cannot be protected and consequently has no commercial value. The institute developed a tutor or mentoring programme where institute researchers take their research findings directly out to the farmers. The Government funds research that the farmers need and it is delivered at no cost. The Agricultural Research Organisation is administratively part of the Ministry of Agriculture.

Other government research institutes were established in public benefit areas including geology, geophysics, oceanography and health (specifically social and public health, health systems, preventative medicine and genetic syndromes/medicine).

All other research is conducted in universities and at private R&D companies and organisations.

Israel's universities offer study and research in all areas. Research is curiosity-driven with no government mandate or prioritisation of topic. Israeli researchers enjoy strong connections with researchers in other countries that include individual research collaboration. Some are funded by bi-national endowments (those with Germany and the United States of America are the largest of such foundations), partnership in the Framework Programme of the European Commission and so on.

Israel started as a shattered country but, by the 1970s, was self-sufficient with its food production and started to develop its innovative approach. The Government did not drive this transition; it was market driven, from the bottom up, based on past government investment in the education system and in defence R&D. With government encouragement through the investment in defence R&D (electro-optic, cryptography, computer vision, applied mathematics and so on) civil applications are initiated. Every year more global-oriented technology-based start-ups companies are created.

A number of factors facilitated the development of Israel into the innovative nation that it is today:

[62] Industrial Technology Research Institute: www.itri.org.tw/eng.
[63] Personal communication, Professor Mina Teicher.

- The universities are of high quality. Three existed before the country was established and investment into the tertiary education system is high. Now there are seven research universities that are very competitive and the system is well-connected internationally.
- There is significant investment in public domain research and a high regard for innovation.
- At the early stages of the computational revolution, young people came out of the army with considerable knowledge in computation, computer vision, algorithms, and related areas and development skills. These people translated their technology skills into market products. Success stories started to flow and other young people wanted to enjoy the same success when they came out of the army. The Israel Defence Force became the place for networking: where young people learned skills and also met other young, talented entrepreneurial thinkers.
  - When the Government realised the great potential of the innovation system, it boosted it with innovation engines such as pre-seed funds and "incubators" where start-ups learn about R&D, business, marketing, doing business worldwide and so on.
  - The start-up companies return the Government investment – in case of success.
  - Multinationals (for example, Digital, IBM, Intel, Microsoft and Google) set up R&D centres in Israel.
  - The Government set up initiatives to ensure that the high market demand for skilled manpower continues to be met. There is a national goal to boost the number of engineering and science students. This initiative has resulted from forecasts that suggest that the future demand for scientists and engineers will increase.
- The higher education system is open so that anyone who wants to attend can do so. Tuition is set at a reasonably low rate and fellowships are available for low-income students. The quota is the budget for each student and many universities go above the quota (easily done for students who do not require experimental facilities) and just accept the tuition fees. Universities will go over the quota in science because of the prestige associated with scientific achievement.
  - In addition to the universities, about 30 Israeli colleges can also award BSc degrees. These institutions do not carry out research. Some of these colleges have very high standards for their BSc and engineering. This has arisen because of their strong linkages to industry.
  - Girls and women have been one of the neglected sectors represented in engineering. Special recruitment programmes have been developed to breakdown cultural and behavioural choices to encourage more girls and women to enrol in engineering.

Appendix 6: Bibliography

General Background

The Panel was provided with a number of documents that outlined New Zealand's R&D investment and, in particular, the investment schemes pertaining to R&D in the manufacturing sector.

These included:

- 2010 Crown Research Institute Taskforce Report: How to enhance value of New Zealand's Investment in Crown Research Institutes: Report of the Crown Research Institute Taskforce
- CRI Statements of Corporate Intent (SCI) and Statements of Core Purpose (SCP)

Ministry of Science and Innovation (MoRST)

- Ministerial Direction – High Value Manufacturing and Services Research 2010
- Collaboration Criteria for Companies – NZTE/MSI
- Request for Proposals for the Technology Development Grant – August, 2010
- Applying for the Technology Transfer Voucher – What you need to know
- Request for Proposals: Commercialisation Centres – 2011
- MSI investment Processes: Technology Development Grant and Technology Transfer Voucher
- Global Expert Fact Sheets: Capability overview, Project, TechNZ Investment – What we look for

New Zealand Trade and Enterprise

- New Zealand Trade and Enterprise – The Basics

Ministry of Research, Science and Technology

- 2010 MoRST New Zealand RS&T Scorecard
- 2010 MoRST Report – 2010 Impact of the New Zealand Science System

Foundation for Research, Science and Technology (FRST)

- 2009/10 Foundation for Research, Science and Technology Annual Report
- Ministerial Direction – New Economy Research Fund – November, 2008
- Ministerial Direction – PreSeed – August, 2007
- Ministerial Direction – TechNZ – June, 2008

General

- 2007 Contestability and Contested Stability: The Life and Times of CSIRO's New Zealand Cousins, the Crown Research Institutes – Davenport and Bibby
- 2006 Whither the Crown Research Institutes? Funding Issues - Johnson

Innovation in New Zealand

A number of reports outlining perspectives on innovation in New Zealand, both public and those tabled with government ministries, were provided to the panel, these included the following.

Evaluations

- 2010 MoRST Economic Impact of Industry Research
- 2009 Foundation for Research, Science and Technology – Evaluation of TechNZ
- 2009 Foundation for Research, Science and Technology – Evaluation of Research for Industry Fund

MoRST

- Policy Instruments to Support Private Sector & PRO (Public Sector Research Organisation) innovation in New Zealand: Some Options and Analysis

Ministry of Economic Development (MED)

- 2011 MED Economic Development Indicators Report

The Institution of Professional Engineers New Zealand (IPENZ)

- 2011 Catalysing Economic Growth*:* Boosting Innovation Expertise in the Private Sector
- 2010 National Engineering Education Plan

New Zealand Institute

- 2009 Standing on the Shoulders of Science: Getting More Value from the Innovation Ecosystem
- 2009 Lifting Innovation Ecosystem Performance
- *2009* New Zealand's Innovation Ecosystem
- 2010 Plugging the Gap: An Internationalisation *S*trategy

Miscellaneous Reports

- Management Matters in New Zealand*:* How does manufacturing measure up? – April, 2010
- Baseline Review of Angel Investment in New Zealand – November, 2007
- SME's in New Zealand: Structure and Dynamics – July, 2010
- School of Government – Harvard – 2004: Growth Strategies

New Zealand Manufacturing Sector

Documents and information outlining the New Zealand manufacturing sector were provided to the Panel, these included the following.

Ministry of Economic Development

- Economic growth opportunities – EGA High Value Sector – Definitive Version
- 2010 Innovation and the City: Review of the Auckland regional innovation system

Miscellaneous Reports

- New Zealand Economy and the Manufacturing Sector
- 2009/10 New Zealand Global Competitiveness Report
- 2009 Policy Watch: Economic geography, globalisation and New Zealand's productivity paradox
- 2009 Industry Snapshot for the Auckland Region – the manufacturing sector
- University of Auckland – Faculty of Engineering – Innovation in Manufacturing and Materials
- 2008 Business Expenditure on R&D in New Zealand – future potential and future industries
- National Targets for R&D expenditure
- 2008 Innovation and the New Zealand Manufacturing Sector – PhD Thesis – The Role of R&D in Productivity Growth
- 2006 The Case of Agriculture in New Zealand: 1927 to 2001
- 2005 The Economics of Knowledge: What Makes Ideas Special for Economic Growth?
- 2005 The Growth & Innovation Framework Sector Taskforces: Progress with Implementation
- 2004 R&D in the Economy: The Impact of R&D on Economic Growth

International reports and information

Reports and documents pertaining to innovation and public investment in other countries were provided to the panel, these included the following.

OECD Reports

General

- 2010 Measuring Innovation: A New Perspective OECD
- 2010 Ministerial Report on the OECD Innovation Strategy – 2010
- 2007 Analysis of Investment in Knowledge Inside OECD Countries
- 2001 The Driving Forces of Economic Growth: Panel data evidence for the OECD countries – OECD Economic Studies no. 33
- 1997 Does Government Support Stimulate Private R&D? – OECD Studies no. 29

Countries

- 2009 OECD Economic Surveys for New Zealand Vol. 2009/1
- 2008 OECD New Zealand Innovation Profile
- 2008 OECD Reviews of Innovation Policy – Norway
- 2008 OECD Norway Innovation Profile
- 2008 OECD Sweden Innovation Profile
- 2008 OECD Finland Innovation Profile

Scandinavia

Norway

- A Nordic Innovation Strategy – Innovation Policy Structures of the Nordic Countries

Finland

- Finnish Paradox – The curious absence of high-growth entrepreneurship in Finland
- Rationales and Instruments for Public Innovation Policies

Denmark

- 2006 Private Sector Interaction in the Decision Making Process of Public Research Policies – Country Profile: Denmark
- 2009 A Step Beyond: International evaluation of the GTS Institute System in Denmark

Sweden

- 2009 Strategy Proposal 2009-04-17 Sweden – Research, Development, and Innovation: Strategy Proposal for Sustainable Growth

Australia

- 2011 Australian Government – Innovation Policy Report – February, 2011

Queensland

- Advanced Manufacturing Sector – Action Plan
- Queensland Research and Development – Investment Strategy 2011–2020
- Centres of Excellence – Building Queensland's R&D Capacity in a National Framework – Discussion Paper
- Queensland–New Zealand: Comparative analysis of economic growth differential and contribution of science in economic growth

Asia

Singapore

- Singapore's Manufacturing Sector as Engine for Economic Growth: Past, Present and Future – Role of Government

Taiwan

- The ITRI Experience: Innovation Engine of Taiwan's High Tech Industry – K Wang

United Kingdom

- 2011 Europe's Innovation Hub Finally KICs Off – February, 2011
- 2011 UK Government Releases Plans for Fraunhofer-style Centres – January, 2011
- 2010 Sourcing Knowledge for Innovation: The International Dimension – May, 2010

United States

- 2010 Technology Transfer and Commercialization Partnerships – National Science Foundation