Measuring Economic Impact in the New Zealand Science and Innovation System

*Kathleen M Palmer**

A paper written for:

52nd New Zealand Association of Economists Annual Conference

Wellington

29 June – 1 July 2011

Abstract

A comprehensive review of the economic impact of a decade-long billion dollar public investment in industry research will be presented. The review included grounded analysis of narrative accounts and numerical analysis through general equilibrium modelling. The multi-modal approach provided important complementary views of how Crown research institute, university and business-owned research projects have been applied to support industries and international competitiveness of New Zealand firms. A third approach, micro-data analysis, including its benefits and limitations will be discussed. The presentation concludes with a look at the value of the review in generating evidence for economic impact assessment and future policy design.

*Ministry of Science and Innovation
PO Box 5762
Wellington 6145
New Zealand
04 917 0199
Email Kathleen.Palmer@msi.govt.nz
Kathleen.Palmer@paradise.net.nz

Measuring Economic Impact in the New Zealand Science and Innovation System

*Kathleen M Palmer**

I. Economic impact of a decade-long billion dollar public investment in industry research

Industrial research as a driver of innovation and economic growth is now seen as vitally important.

The New Zealand government invested 1.422 billion dollars in 618 contracts for industry research (Food & Fibre, Manufacturing & Services and Research Consortia) between 2000 and 2008. The policy intent of the "Research for Industry" fund was to lift the international competitiveness of New Zealand industries and sectors through strategic research to develop new products, processes, systems and services.

The primary argument for the policy was that industry itself won't fund enough of its own strategic research because research is risky, the time horizon of business is too short and once the research is done, firms or farms that did not 'chip in' could also get a benefit. In other words the original policy was designed to fix 'failure in the market' and stimulate economic growth.

The method of allocation of the funding was through competition. Research organisations, mainly Crown research institutes, but also universities and independent research organisations, were invited to submit proposals, and the best were funded. This competitive approach to funding was intended to drive up efficiency in the research sector.

An important requirement of research project proposals was the ability of the researcher to get co-funding from private industry, including industry board levies. Being able to draw in private sector money was an indicator that the research was actually useful to the economy – it acted to couple science push with industry pull.

Evaluation of the economic impact of policy is a characteristic of new public management. The assessment of benefit-cost ratios and 'value for money' mark its zenith. I present an overview that illustrates support for and challenges to policy for public support of research, and note that recent changes in science and innovation thinking will make new demands on policy design and evaluation.

This paper draws from the 2009/10 review of the economic impact of industry research managed by the Ministry of Research, Science and Technology. The review was of the funding programme as a whole, not of the performance of individual research projects. My role was that of project manager including contract manager. A related 2009/10 review funded by the Foundation for Research, Science and Technology looked at policy settings and user uptake and benefits. Both reviews preceded the amalgamation of these agencies to form the Ministry of Science and Innovation.

II. Grounded analysis of narrative accounts

The investment of public funds increased the competitiveness of New Zealand industries.

A detailed account of the private and public costs of industry research and subsequent commercialisation, and current and projected benefits of each programme was made of a sample of 133 contracts from 45 distinct research programmes, accounting for just over 45 percent of the total investment. This was not a pure treatment group as all of the programmes examined received other forms of public funding. The sample programmes had received $760 million in government funding, made up of $580 million of Research for Industry funding and $180 million of other public funding.

The review established that the sample returned at least $200 million per year in measured, achieved market returns. So in very simple terms, the government investment paid for itself after four years. The economic benefit was cumulating with big numbers expected in the near future corresponding to stage one of a quadratic production function curve. These results give an empirical basis to the argument that strategic research has long time lags and substantial economic benefits.

The measured economic impact was mainly delivered though increased production efficiency ($105 m) and new or higher value products ($75 m). Improved quality of products and new networks added another $10 million each. Examples of each are provided later in this paper.

Measured benefits did not include downstream spillovers, e.g. manufacturing contracts to a local firm for specialised metal work, or internal spillovers, e.g. new behaviours and improved skills. Other studies have estimated spillovers to be four to ten times the magnitude of the first order return. Also, the benefits don't include future benefits even where the value of these can be quantified, e.g. genetic improvement to New Zealand's forestry stock that is locked in until the trees are harvested.

The benefits expressed are in terms of a counterfactual; the benefit over an above business as usual. This is the output additionality or net gain, rather than the gross gain. This approach increased the difficulty of data collection as industry representatives were far better able to state the gross value of a new technology than to identify what they would have earned in its absence.

The review found that the public investments in industry research had not crowded out business investment. Almost universally, both research providers and end-users of research stated that their research programmes would not have proceeded in the absence of public funding (or would have been significantly reduced in scope). Risk-aversion and low cash reserves meant that industry was usually unwilling or unable to become involved in the early stages of a project. Once the scientific uncertainty was resolved, and pathways to market clearer, industry involvement increased.

Research programmes reflected unique elements on the New Zealand economy and so was not duplicating knowledge that could have been gained from overseas, e.g. investigation of endemic plant species that hold commercial potential. Almost all firms reported input additionality in that they had increased their internal R&D budget. All firms reported behavioural additionality in the form of improved ability to manage research and becoming more comfortable with timescales and risks.

III. Numerical analysis through General equilibrium modelling

Very reassuring numbers – modelled New Zealand economy-wide impacts were positive.

Current impact data for five scenarios of large, long-term investments of recognised strategic importance to the New Zealand economy, and one forward-looking scenario were modelled. Infometrics Ltd used general equilibrium modelling to estimate the benefits of each scenario to the national economy. The scenarios involved an annualised investment of $25 million and impacts were expressed in terms of an average or 'steady state' year. The scenarios were selected on the basis of sufficient size and required the combining related research programmes.

Typically, government intervenes to address a market failure attributed to sub-optimal investment by businesses in research. In this analysis the benefit of the funded research to the New Zealand economy, over a lower tax rate (counterfactual) was estimated. This analysis provided an economy-wide perspective, and so the 'cost' was not simply the value of the subsidy, it was a reduction in the aggregate economic welfare that occurs when revenue is raised from taxes to fund research. The model did not capture the marginal administrative cost of collecting the tax.

The model held total employment constant so any increase in output, or gross domestic product must have come from higher productive efficiency, greater allocative efficiency or from more investment. As a result the model could but was not guaranteed to produce an increase in economic welfare which was measured as 'real gross national disposable income'.

The model was 'shocked' with different industry research scenarios. The results showed that for manufacturing research, government investment, modelled as a subsidy, was just over two times as good for New Zealanders' welfare as a lower average tax rate would have been. For the forage grass, gold kiwifruit and forestry investments, the benefit was two-fold. For sheep genomics, the benefit to cost ratio was seven-fold. There were too few scenarios, and too much selection bias to permit the positive economic effects identified being extrapolated across the entire portfolio.

The benefit-cost ratios are highly reassuring and provide good empirical evidence for government investment in long-term strategic industry research. The modelling also provides salient advice, for example, there would be a greater pay-off from research that was less focussed on highly price elastic commodities (such as milk powder); and when competition is not based primarily on price (such as gold kiwifruit) a price premium can be maintained for a longer period. These ideas could be used to design a greater return to the economy from strategic industry research and business R&D.

The approach used in this analysis involved the set up of a synthetic industry that carried out research. The premise was that the change in activity that was attributable to government investment would not occur under a business as usual scenario. A two-level standard translog specification was used which distinguishes four factors of production (capital, labour, materials and energy). The approach was relatively novel, with a similar approach having been used in an economic impact study of the Australian Cooperative Research Centre Programme.

IV. Approaches of Crown research institutes, universities and businesses

Direct funding of research organisations produces economic benefits that differ in nature and magnitude from those obtainable through direct funding of businesses.

The Research for Industry fund supported strategic, applied science. The review found that the New and Emerging Research Fund (NERF), that supports basic targeted science, worked well as a complement. Applied industry research identified more fundamental research questions that needed addressing to support the next phase in technological innovation. The more 'blue sky', basic, non-targeted Marsden research fund also supported research projects that had been identified through industry research projects. Thus, while the fund supported the more applied research stage of the innovation value chain, the review identified good evidence of the networked nature of research, and inter-relationships between different funding mechanisms.

The review demonstrated how different research organisations supported New Zealand's economic growth in significantly different ways. Crown research institutes were set up in 1992 around different productive sectors of the New Zealand economy and are required by law to undertake research for the benefit of New Zealand. This arrangement allows them to work with industry-specific strategies.

Many university researchers spoke of training skilled graduates as being the primary source of economic impact from their industry research programmes. This effect was most prevalent in high-tech manufacturing and software industries, and it increased the technical capacity of firms that graduates went on to work in. Once in industry, these graduates retained their links with other graduates and mentors, which assisted development of new industry networks and research-industry linkages. Firms engaged in the research projects reported hiring new skilled staff, and at least one firm brought highly skilled New Zealand workers back from overseas on the strength of project outputs.

Businesses reported that their research reputation was enhanced when they were involved in government–funded discretionary research projects as competition for funds was on the basis of science excellence which increased the prestige of the research project.

Throughout the study, there was close congruence between the perceptions of the government funded researchers and the co-funding businesses. Researchers generally reported that commercial and scientific goals worked hand-in-hand. There was not a big conflict between the demands of the two, and this was less so with larger programmes. Researchers also reported that as they worked more with industry, they became more proficient, and notably, improved their understanding of intellectual property issues.

V. Application of research to support industries and international competitiveness

The narrative-based investigation of a sample of industry research programmes found that research had delivered $105 million per year in increased production efficiency and $75 million per year in new or higher value products. Improved quality of products and new networks added another $10 million each. The following case studies illustrate each of these types of economic impact. They have been chosen to widen the readers appreciation of industry research and because they raise questions about established policy perspectives.

Increased production efficiency occurred mostly in the primary sector on farms, forests and orchards. New Zealand sheep farmers have made cumulative productivity gains of $600 million over the period 1998 to 2009 through the application of genetic tools developed through publicly-funded research. Much of the research investment required to generate these returns has been incremental, generated by long-running research platforms in the 1990's. Thus benefits are accruing to New Zealand from transfer of research carried out in the previous decade. The scale and time lag in the agriculture R&D system sets a challenge to economic models for valuing research outputs.

Production efficiency gains were made in the manufacturing sector though minimising waste and error in metal, plastic and composite manufacture.

Improving existing products mainly involved designing and implementing quality standards, and providing proof that goods and services met quality standards. Scientific proof of benefits of a new or niche product is an essential prerequisite for consumer acceptability. For example, cold-pressed avocado oil is a product developed in New Zealand, and Crown research institute research into its quality and health merits were instrumental in the product being stocked in foreign supermarkets. Individual firms would not have been able to appropriate sufficient benefits to justify funding the research, but the research resulted in establishment of export markets for the firms.

Research on novel sonar transducers by a Crown research institute and an electronic navigation company is an example of new product development. Research led to development of a multi beam sonar instrument that could help improve catch rates and reduce operating costs in commercial fishing and increase knowledge and safety in super yachts. There was a strong relationship between firm and researcher and the company has been able to appropriate much of the benefit of the research. The firm changed its strategic direction and focus from being an importer and on-seller of foreign technology to a developer and exporter of a high-end product. Two other firms in the case studies shifted strategic direction from on-selling to innovation-led exporting.

The question that policy must address for public purchase of research is whether it is the proper place of government to support firms that succeed in capturing a subsidy for non-appropriable R&D projects? Should government cut funding to projects where there appears to be strong capture by a few firms? What about when the research outcome is fully in line with a policy intent of promoting international competitiveness?

VI. Micro data analysis, approach, benefits and limitations

Econometric studies compare business data from firms that have had assistance with a set of firms that are similar but not assisted. Firms must be matched by difference in difference or related techniques as there is a strong selection bias in firms taking up government funds. Econometric analysis might reveal the extent to which changes in firm performance can be attributed to an industry research project. Related New Zealand work has found that this technique is technically difficult to apply. It is best done with firms that have not had a research subsidy before, as the effects of different forms of government support interact. This study found that each of the industry research projects were also funded by other streams of government support, and so analysis by micro data techniques is likely to be of little value as the effects of industry research support cannot be isolated.

VII. The value of the review for policy design and economic impact assessment

The review of economic impact of industry research aided policy design, but more gains are possible.

The narrative-based evidence from the review highlighted the different needs of participants. Small firms, large businesses and research organisations work with different time frames which has implications for measuring benefits that arise outside normal time scales for financial analysis. The churn of small firms in alloy manufacturing prevented them from setting up a research consortium in the way that established organisations had done; identifying that different rules are needed here.

Innovation that increases the competitive advantage of firms needs continual feeding. The review identified that industry research projects generated research questions that were subsequently addressed through other funding instruments (e.g. NERF and Marsden). The outputs of the more basic research was then used to both 'back fill' researchers' understanding of the innovation, and to set up for the next generation of the innovation. As a result, there is a better policy understanding on the networked nature of basic and applied research and experimental development and the importance of coherence between funding instruments.

The 2009/10 reviews of the Research for Industry fund contain information that can improve future benefits of industry research for both research organisations and businesses. The findings transcend the funding instrument itself and can help in the management devolved funding by Crown research institutes and in improving outcomes of business-government research-university networks.

Economic assessment using general equilibrium modelling showed positive benefits to the New Zealand economy, with the prospect of greater gains for one scenario in the near term. Complementary analysis through micro data analysis is likely to be methodologically too difficult.

Evaluation is a social process that includes, but is not be equated with techniques for collection or analysis of data. Looking forward there is a change in science and innovation systems that mean that even as we struggle to assess economic impact, future evaluation projects will face new demands.

IX. Bibliography

Infometrics (2009) *Evaluation of the Research for Industry Fund*. Foundation for Research, Science and Technology, Wellington, New Zealand.

Ministry of Research, Science and Technology (2010). *Economic Impact of Industry Research: A review of the food & fibre, manufacturing & services, and research consortia outputs of the Research for Industry Fund.* Ministry of Research, Science and Technology, Wellington, New Zealand.