The Economic Case for Public Support of Science and Innovation

Submission to the Productivity Commission's study on "Public Support for Science and Innovation"

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Executive Summary

This submission examines economic arguments in favour of the public support of science and innovation. It emphasises three important points that I believe that the Productivity Commission should take into account in its study.

First, arguments of the public support of science based on the idea that basic research's economic benefits are derived from spillovers into applied research are based on a false premise of that relationship. Instead, there are strong incentives to provide use-inspired basic research that are preserved by recognising the distinct roles of pure science and commercial research as mechanisms to allocate resources to knowledge creation activities.

Second, I refute the empirical findings in a recent PC working paper on the relationship between R&D and multi-factor productivity. Empirical work is presented using data from a cross section of OECD countries that shows that the Australian domestic R&D stock has a positive and significant impact on multi-factor productivity.

Finally, I present results of the continuing study of the drivers of national innovative capacity that shows econometrically what factors – including government policy variables – impact on the domestic rate of innovation.

1. Introduction

The purpose of this submission is to offer economic arguments in favour of governmental support of science and innovation. The submission here reflects the latest economic research on the impacts of science and innovation as well as the structure of the institutions that favour it. It is intended more as a guide to key issues in the latest literature as opposed to a comprehensive re-statement of findings there. My purpose here is to identify issues and trade-offs rather than resolve them completely.

There are three important conclusions that can be drawn from recent research:

- **(Science & Innovation)** Arguments for science based on the 'linear model' of the production of innovation are false and also lead to inadequate arguments for the public support of science. Instead, recognising the deeper linkages between pure scientific research and technological innovation gives a clearer and subtler picture for support and how that support is best achieved.
- **(Innovation & Growth)** There is a significant econometric relationship between domestic expenditure on R&D and economic growth in Australia.
- **(Support & Science and Innovation)** Public decision-variables are a key driver of national innovative capacity.

In each of these cases, the argument is based on empirical findings and not mere conjecture or theorising. It is those findings that I will highlight in this submission.

The outline of this submission is as follows and is structured with the above three conclusions in mind. Section 2 considers economic arguments for science while Section 3 considers economic arguments for domestic innovation. Section 4 looks at the drivers of national innovative capacity. A final section concludes.

2. Economic Arguments for Science

The economic argument for the public support of science comes from recognising that science has the elements of being a public good (Romer, 1990). First, it is *non-rival* in that it can be widely applied without additional resource cost. Second, it is *partially excludable*. When someone makes use of science they can only appropriate a fraction of its returns (Arrow, 1962). However, actions can be taken that allow more or less excludability. These come at a cost of potentially low diffusion and hence, lower impact on economic productivity.

This is the basis for the public support of science: to correct a market failure that means that private returns from developing scientific knowledge are lower than their social value. This argument, however, does not inform us of the value of supporting science relative to other economic activities and so is an incomplete case. As we will see below (Section 3) the case for the public support of science comes from the quantitative impact this ultimately has on economic growth. That impact comes through overall R&D expenditure by business. The productivity of that expenditure is, however, driven by the functioning of science as conducted in business as well as by government and within universities. It is that linkage that I will focus on in this section.

The Case for Science is not the Case for Art

The traditional argument for the public support of science was first developed after World War II by Vannevar Bush (1945) (the director of the wartime Office of Scientific Research in the US). In *Science: The Endless Frontier*, Bush argued for a distinction between basic research (to enhance understanding) and applied research (to find use). He then stated that basic research was a critical input into the production of useful knowledge (i.e., it is "the pacemaker of technological progress"). This is the *one-dimensional linear model*: science leads to innovation leads to productivity.

In economics this is an argument for spillovers. The idea here is that the public should support science (in its purest form) because this will lead to spillovers on more economically relevant things. The problem arises when it is coupled with another idea in Bush: we need to let scientists be scientists. That is, basic research requires a hands-off approach, allowing scientists to manage their own affairs, allocate resources according to scientific merit and to make a virtue out of being insulated from considerations of immediate use.

In this respect, the case for science starts to look very much like the case for the public support of art. Art leads to 'good things' that are unmeasurable and, moreover, require personnel with particular training and experience to understand and appreciate at a first instance. Therefore, good societies support art.

The problem with these arguments – as both scientists and artists consistently discover – is that in times of fiscal restraint, they are not terribly persuasive. And much as they might lament the loss of future returns for short-run expediency, it is a continual issue.

In the case of science, however, this is as much a function of the fact that the basic core argument is incorrect even if the conclusion (long-term funding) is correct. As I will argue here, the problem lies in (a) a misunderstanding of the relationship between science and innovation; and (b) a misunderstanding of the value of pure science as an allocation mechanism for resources.

Use-Driven Basic Research

The premise of the traditional argument for science is incorrect: there is no fine distinction between basic and applied research that makes the former an input into the production of the latter. This case is best articulated by Stokes (1997). He argues that the notion of the basic scientist is a rare extreme – someone like Bohr and the development of quantum mechanics – as is the applied scientist – someone like Edison. Instead, most research takes place in a form exemplified by Pasteur: it is use-driven basic research. In this realm, the potential for use inspires the quest for fundamental understanding and so the two types of research are fundamentally related.

Once the possibility of use-driven basic research is accepted, the case for the public support of science changes. No longer is it the idea that one puts resources into basic research in the hope of spillovers to applied uses. Instead, the rationale for public support is to encourage research that is driven by use as well as understanding.

Again, this argument itself holds a temptation to another one that itself is incorrect: instead of funding basic research we should stimulate applied research. However, this only reverses the problem by reversing the linearity and supposed direction of causality.

As economists know, a supply-driven argument cannot be separated from a demand-driven one. Hence, a more careful approach is needed to understand why science deserves public support. In particular, one needs to consider science as an allocative mechanism for resources and not merely a 'type of knowledge.'

Science is an Allocative Institution

Science is a word that evokes many meanings. However, I want to use it here as a particular way of allocating resources; that is, it is an institution. This view comes from the sociologist, Robert K. Merton (1973). To put it in economics terms, science is a way of deciding which projects should be undertaken. First, it is scientist driven in that scientists propose the projects and scientists review them. Second, it has a priority-based reward system whereby there is a *commitment* to give a reward to those scientists who are first to establish a new fact or way of understanding the world. Moreover, these rewards are paid upon success through citation and academic promotion and notoriety.

Notice that market-based resource allocations do not operate quite this way. There is more sharing of rewards and the rewards themselves are more immediate: *they stand the current test of the market place rather than the test of time*. The latter is believed to be more suitable for sorting out robust facts from currently useful ones.

We do see priorities in the market place, however, these are often the result of government regulations. For instance, the patent system rewards priority with monopoly but it is a government regulation. In its absence the rewards are more diffuse and potentially effort as well.

Thus, when we talk about public support for science we are really talking about support for it as an institution. That is, do we believe that resources allocated in this manner result in superior longer-term outcomes than pure market-based allocation?

In my opinion, the answer lies in the cumulative nature of knowledge and discovery. This was captured by Newton's famous remark:

> If I have seen further [than certain other men] it is by standing
> upon the shoulders of giants

This is the idea that establishing useful scientific facts allows others to build upon that work leading to more and more understanding. It is an argument for the inter-temporal division of labour in moving the knowledge frontier: that is, that generations of scientists will each specialise in solving a new piece of the puzzle by usefully remembering and working on the work of previous generations.

Fostering cumulative innovation is a more efficient way of solving scientific problems. It allows more specialisation and less duplication of effort. Moreover, it provides a focus on the longer-term and necessarily away from immediate priorities.

It is science as an institution that allows inter-temporal externalities to be internalised and cumulative knowledge to flourish. By committing to a reward contingent upon the research's utility in allowing more knowledge to be developed (that is, citation and the judgment of future scientists) and creating a competitive race for those rewards today, better resource allocation is achieved.

In this respect, scientist concerns for the management of their own affairs and also the continued commitment to future funding (allowing rewards to be realised) are consistent with this view. The case, however, is not paternalistic but practical. Science as an institution evolved to resolve an inter-temporal resource allocation problem and to continue to be effective needs to be subject to long-term commitments to resources.

Pure Science and Commercial Research are Complementary

While science as a resource allocation mechanism does well in resolving the issue of inter-temporal externalities in knowledge accumulation, it does this at a potential cost: a lack of immediate focus on usefulness. Now, as Stokes (1997) points out, scientists are far more focused on immediate usefulness than outside perception; something that even their own rhetoric maintains. This could be for several reasons, not the least of which is that in many scientific disciplines the intrinsic rewards come from seeing knowledge as being useful but also from the pragmatic one that to justify continued funding, it helps to pursue useful knowledge.

This is where science intersects with market-based forms of resource allocation. As noted earlier, the market focuses too much on immediate use and not enough on inter-temporal issues. However, resources for scientific use – other than from the government (but sometimes there too) – come from people with their own immediate needs. The clearest example of this is students. They require knowledge to be able to have productive careers. Academic scientists provide that knowledge and take a proportion of the payment and invest it to continue scientific research. If there is too great a mismatch between that research and immediate usefulness, it becomes hard to supply useful knowledge to students and the funding can dry up.

This happened to the great American universities – Harvard and Yale. They focused on liberal arts educations in the 19th century and found themselves losing students to universities in Germany that offered more practical-based courses such as commercial science, chemistry and engineering. So the American universities changed tack, introduced new schools and attracted students back.

But similar market-based influence comes from other areas. Business research needs provide funding opportunities for basic research and so scientists wishing to further their careers pay attention to these in their selection of projects. Indeed, it has been increasingly common for academics to accept consulting arrangements with firms for this purpose. To manage that, their research projects are best more closely aligned with business needs. And universities, realising this potential, permit freedom in academic financial arrangements with business. In the end, the confluence of both systems provides for project selection akin to Pasteur rather than some ivory tower view.

It is the interaction between pure science and commercial research that leads to the selection of research projects designed to not only provide greater immediate use but also address inter-temporal concerns. The latter is supported because of the commitment to the future rewards to scientists. Those scientists who buy into that system are more cost-effective than skilled individuals who do not.[1] Hence, this is a cheaper way of funding research than might be achieved if only commercial considerations mattered.

Thus, pure science and commercial research are complementary systems. Each corrects distortions that would otherwise exist in the other. In the end, it is their interaction that allows use-directed basic research to receive priority. It is this that is the key to longer-run sustained productivity gains in the economy.

A Balanced Approach to Public Support

The complementarity between science as an institution and commercial research implies that public support needs to be balanced in its goals: neither focusing exclusively on immediate use nor on scientific independence.

But more critically it suggests the following: *it is an error to provide public support with the goal of making each system like the other*. To see this, consider first the call whereby public support for research conducted in universities comes with it requirements for its commercialisation, immediate use and intellectual property protection. What this means is that science is being asked to adjust to look more like commercial research. The cost of this is a reduction in the ability of science to function as an institution to reward cumulative knowledge. It raises costs by making scientists more concerned for immediate reward than a future payoff. It also throws up barriers to cumulative knowledge, not only by devaluing it directly, but also by creating intellectual property barriers – the 'anti-commons effect.'[2]

Similarly, when there is public support given to business R&D, there are conditions tied to this that diminish the value of intellectual property protection and also restrict commercialisation options (say, to be exclusively developed within Australia).[3] These reduce market-based returns to innovation but absent any institution in those firms for cumulative knowledge do this without a payoff. This is a lose-lose proposition. My concern here is not that the support is unwarranted but that the conditions tied to it undermine the value of the mechanism being funded.

Instead, the government needs to consider providing support free of restrictive conditions that allows each system to function as it was supposed to. This means that priority would be given to stable sources of funding for public science with committed future rewards and funding while for commercial research support should target on-going subsidies and tax breaks. For each, the government should consider required infrastructure. For science this is to support cumulative knowledge while for commerce, this is to support commercialisation.[4]

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[1] Stern (2004) demonstrates this for scientists. See also, Aghion et.al. (2005).

[2] Murray and Stern (2006) show a mild anti-commons effect.

[3] Gans (1998) articulates this argument in more detail.

[4] Stern (2005) and Duncan et.al. (2004).

I have not had the time to consider a more fully articulated set of recommendations along these lines. My purpose here is to consider a framework for understanding the value of each system and their role in an innovation system.

3. Economic Arguments for Domestic Innovation

Section 2 outlined a framework for thinking about how to give public support for science and what to expect in return. The discussion there was premised on the notion that getting the entire innovation system right and encouraging more domestic innovation was a good thing.

At a global level, the importance of innovation for economic growth is long established; theoretically and empirically. For Australia, the issue is how much support to give for domestic R&D. Thus, even if foreign R&D has an impact on Australian productivity growth, this does not necessarily mean that domestic R&D has a similar impact (or an impact at all).

The Productivity Commission released a large study into this issue as part of the investigations for the present study. That working paper by Sid Shanks and Simon Zheng, "Econometric Modelling of R&D and Australia's Productivity," took a 'warts and all' approach to investigating the econometric link between various measure of domestic R&D expenditure and various measures of productivity growth. In contrast to previous studies and a wealth of overseas experience, they found no relationship between domestic R&D and productivity growth. Specifically,

> At this point in time, there remains no precise, robust estimate of the effect of increases in domestic business R&D on Australia's productivity performance. Standard models and estimation methods, grounded in theory, tended to generate unreliable results, as well as estimates that were sensitive to seemingly modest changes in specification. A comprehensive investigation of alternative specifications and estimation techniques brought new insights, but proved unable to arrive at any definitive estimate.

This conclusion is both surprising and troublesome for those who believe that public support for science and innovation should continue. This sort of result can lead to the following conclusion: *perhaps we shouldn't support R&D in Australia at all and instead get knowledge from the rest of the world*. After all, the economy has traveled well without it for the last 14 or so years.

However, as I will argue here, it is an artifact of the particular exercise and data Shanks and Zheng were asked to work with. Correcting for that does yield a definitive estimate and I will report on those findings here.

The Problem with Single Country Analysis

Shanks and Zheng only use Australian data for their 575 page study. This means that their sample size is necessarily small (35 data points, one for each of 35 or so years). As they acknowledge, when you have a small sample size it is hard to get precise estimates. Looking for a separate and definable effect for Australian R&D expenditure (itself a small amount) is like looking for a 'needle in a haystack.' Hence, they do not find a significant relationship between Australian BRD and productivity growth measures even if foreign BRD has a positive and significant relationship.

The way growth economists have corrected for this issue has been to conduct multi-country analyses of the drivers of growth. This allows them to exploit more variation in the data across countries (e.g., allowing the experience of others to also inform on domestic effects) as well as to factor into account common macroeconomic shocks to growth across those countries. This permits more precise estimates and also allows us to isolate the Australian-factor.

Multi-Country Analysis

Appendix A provides such a multi-country analysis using 16 OECD countries including Australia from 1980 to 1998 (the data we currently have at our disposal). The main drivers of growth are consistent with the Shanks and Zheng results including the impact of foreign R&D levels on multi-factor productivity levels. However, the overall fit of our regressions as well as the precision of coefficient estimates is stronger because our sample size is far greater (a panel rather than a time series dataset).

Importantly, domestic R&D expenditure is a positive and significant driver of multi-factor productivity across this pool of countries; although the marginal impact is about ½ that of foreign R&D expenditures.

When we separate out the impact of Australian R&D expenditures on Australian productivity we find that the separate effect is either insignificant or slightly negative. What this means is that Australian R&D expenditures have about the same impact on multi-factor productivity as in other OECD countries and, therefore, have a significant and positive impact on such growth.

More worrying is that the impact of foreign R&D on domestic productivity is lower (albeit not significantly) for Australian than the average OECD country. Hence, our growth rate is relatively more sensitive to the share of R&D conducted domestically than others would be. We are less insulated from fluctuations in our own actions than other countries.

Overall, the return to a one percent rise in domestic R&D stock is a 0.11 percent increase in multi-factor productivity. This is important given the relatively small size of such expenditures as a share of GDP.

These estimates strengthen the case for the public support of domestic innovation. Moreover, they demonstrate the fallacy of any argument that suggests that we can afford to free ride on the world.

4. Drivers of Australian Innovative Capacity

Given that fostering domestic innovation can increase productivity growth, the final question becomes: what drives domestic innovation. While much has been written on this subject, a more rigorous and objective approach has been pioneered by Professors Michael Porter of Harvard and Scott Stern of Northwestern (Porter and Stern, 1999). In a project wholly funded by the Intellectual Property Research Institute of Australia (IPRIA), Scott Stern, Richard Hayes and I have been involved in updating their basic approach for specific use in Australian policy making (Gans and Stern, 2003). The approach is based on a simple idea: if we use information from a wide variety of countries, we can establish clear relationships between past innovative inputs and more recent innovative output. In so doing, we can back out a measure of a country's current *capacity to innovate*. Consequently, the resulting measure will indicate how effective the mix and level of current inputs will be in generating future innovation; providing the feedback necessary for effective innovation policy.

To this end, here is what we have done. First, we needed to pick a measure of innovative output that would be comparable across countries. As almost all innovations with substantial commercial application are filed in the US, we chose to use the total quantity of patents granted (per capita) in a given year to individuals or firms from a country by the US Patent Office as our measure of international patent output. Using this measure requires it to be lagged because the innovation environment pertinent for the patent grant is that environment that prevailed at the time of application. This lag reflects the difference between innovative capacity (innovation inputs) and the innovation index (predicted innovation outputs). Recent advice from the US Patent Office indicates that the average lag between patent application and patent grant is 2 years and this is the lag used here.

While many innovations are not patented – those intangible ones inside organisations or process innovations in service industries for example – the level of patenting is positively correlated with other measures of innovation. Remember our purpose was not to focus on this output measure but to understand it.

Second, we needed to sort out from the list of potential drivers of international patenting what were the significant drivers. R&D investments, the number of scientists and engineers, overall productivity, and education expenditures may all theoretically generate more innovativeness but they are also related to one another. So, when coming up with an index of how current inputs would drive future innovation, we needed to consider the mix of drivers that could explain most of the variation in international patenting across countries. To do this, we ran a series of regressions on potential drivers in each country and regressed them on the level of international patenting.

This allowed us to use both country differences as well as changes over time to quantify the relationship between the most significant drivers and international patenting.

What we found is that R&D activity, the numbers of scientists, as well as GDP per capita were all important. But the total expenditure on secondary and tertiary education, the amount of R&D performed by Universities (whether funded by government or not), the amount of R&D funded by industry, the strength of intellectual property protection and the general level of openness to international forces all drove higher levels of international patenting. Examined across the OECD, for each driver we could quantify econometrically its impact on international patenting. So if we took these quantified relationships, we could use this to build an index of a country's overall innovative capacity.

We present the findings on innovative capacity in Appendix B. It is useful to reiterate the 2003 Study's findings on how to nurture Australia's innovative capacity. The following extract is drawn directly from that report as I believe it is of most relevance for the PC's current study …

Nurturing Australia's Innovative Capacity[5]

Our analysis of Australia's innovative capacity indicates that macroeconomic stability, improved competitiveness in terms of cost and quality, the diversification of Australian industry away from traditional sectors and the prime examples of burgeoning clusters (e.g., wine and biotechnology) have combined to provide a sound basis for future development and innovative potential. The key question is *how to build upon this capacity to turn Australia a world class innovator?*

Here we outline an innovation policy agenda for Australia that is informed by our analysis of innovative capacity across countries. Our purpose here is to provide some principles and examples that can illustrate how Australia might move forward rather than specific policy proposals per se.

Invest in the Common Innovation Infrastructure

At its core, Australia needs to continue to invest in its common innovation infrastructure. This requires a continuation of policies that encourage macroeconomic stability, growth and effective legal and financial institutions for capital investment, and strong commitments to openness and intellectual property protection.

There is also a need to develop and invest in science and technology **human capital**. In particular, there needs to be significant increases the numbers of scientists and engineers working in Australia. Had Australia maintained its historic share of expenditure on education, its innovation index in 2000 would have been *over 16 percent higher* while achieving its peak university-based

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[5] The remainder of Section 3 is directly drawn from Gans and Stern (2003).

R&D performance would have added a further 2 percent. This would have put Australia soundly in the second tier of world innovators rather than at the clear bottom of that group.

This requires a three pronged approach. First, the 'brain drain' of top tier personnel needs to be arrested. While schemes such as Federation Fellowships assist this in the case of University research, there is an issue of differential taxation rates, exchange rate fluctuations and cost of living issues in major capital cities that impede the international labour market for such personnel.

Second, while there are scholarships in place to encourage postgraduate studies in Australia, there is a case for broadening the scheme. Our top undergraduates need to be encouraged to pursue studies with incentives not confined to Australian universities. We need to recognise that it is often the case that the best scientific and engineering training programs might be in international universities. This is something that Scandinavian countries have recognised for decades; subsidising their brightest students to pursue studies overseas and then return home. Australia could do the same, providing a competitively neutral scholarship scheme to increase our stock of human capital.

Finally, complementary to this a substantial educational investment *across* society needs to be secured. Development of universal problem-solving skills, maintenance of access to higher education and an improved commitment to postgraduate educational opportunities all have historically assisted in fostering the workforce skills required for cluster development.

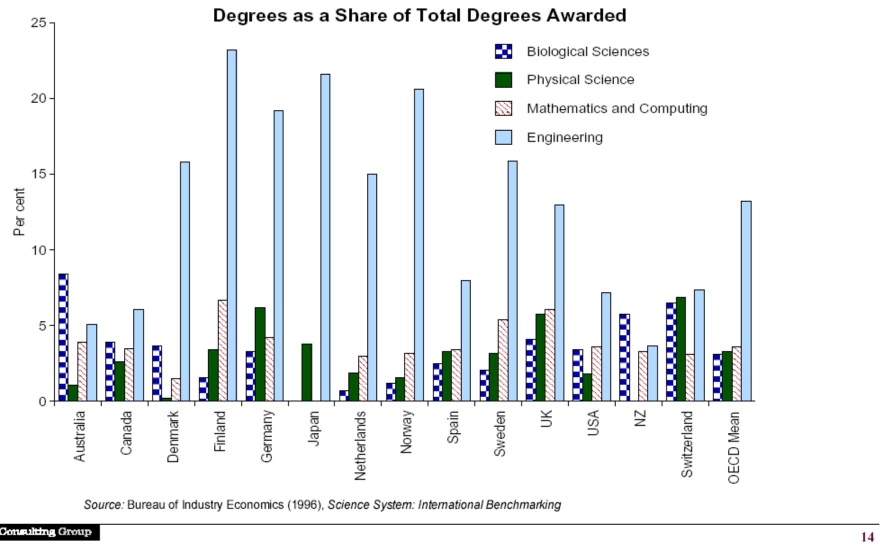
Encourage Cluster-Based Economic Growth

The basic message from research on innovative capacity is that policy-makers should be focused on developing clusters that allow for export-led economic growth. Innovative cluster development results from building on **traditional strengths**. As the textile cluster in Northern Italy and the electronics clusters in Japan and Finland have shown, traditional sectors can effectively serve as the foundation for an innovation-driven global advantage. However, the potential number of such clusters is directly proportional to the size and economic development of region. For example, the Taiwanese success in this area has built upon a deep semiconductor cluster with little diversification into other high technology areas such as biotechnology and even e-business.

In each case, the clusters grew from market-based reactions to sound government investments in innovative capacity. It is critical that governments avoid policy-traps that involve picking clusters to nurture and micro-managing industry development at a project-by-project basis. In a sense, this is the failing of recent Australian policies that have focused on picking potentially commercialisable projects rather than encouraging cluster development that exploits the local human capital resource base. *The idea is to develop the key inputs into innovation rather than the innovations themselves.* Our analysis shows that world innovation is dominated by those countries that have persistently invested in national innovative capacity and left the choice of innovative project to market participants.

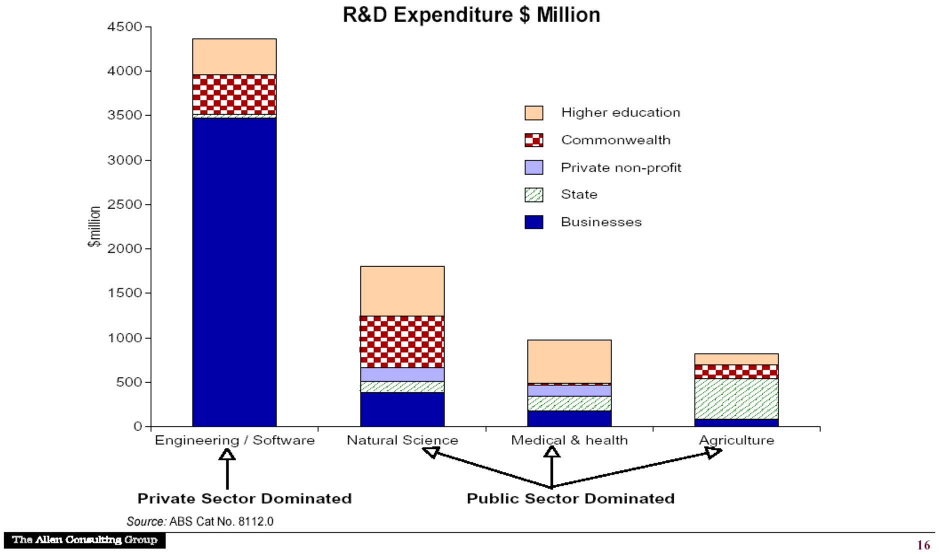
One indicator of problems Australia faces in this regard can be demonstrated by examining the allocation of R&D financial and human capital across sectors. **Figure 4-1** (compiled by the Allen Consulting Group) compares the distribution of Australian graduates across broad sectors compared with other countries. Strikingly, Australia is the only country whose graduate numbers in biological sciences dominates all other sectors. In contrast, when one examines R&D expenditures (**Figure 4-2**) a different story emerges. Expenditure is focussed on engineering and software with three areas of life sciences receiving low overall shares themselves mainly coming from public sector rather than market-driven sources. This mismatch between capital and labour is symptomatic of the problems Australia faces.

Figure 4-1



Source: Bureau of Industry Economics (1996), *Science System: International Benchmarking*

Figure 4-2



Source: ABS Cat No. 8112.0

In addition, the substantial "gap" between public and private research funding signals a systematic mismatch between assessments of opportunity and corporate strategic priorities. The key to an effective innovation system is setting the conditions for **local knowledge accumulation**.

This suggests that Australia has work to do in avoiding micro-managed allocation of R&D resources and providing a proper foundation for cluster-development. Incentives for **industrial clusters** should target the exploitation of historical strengths and foster innovation-focused domestic competition. Whereas exploiting the ICT revolution is an uphill battle, Australia has clear opportunities for globally competitive clusters in the life sciences, agriculture, and perhaps mining. Rather than continued reliance on commodities, exploit competencies and human capital developed in those sectors to foster global technology leadership.

In this regard, public R&D funds are most effective when **spurring complementary follow-on** private sector research and commercialisation investments. For example, Zmood Innovations – a Melbourne-based start-up company developing applications of Micro Systems Technology to printing systems, identification systems and medical diagnostic devices – has found new opportunities for domestic and offshore R&D precisely because of the development of complementary inputs. Their technology has potential applications in electronic systems as well as biosensors and other applications in medical devices. This start-up has been spurred on by two developments: First, another private company – MiniFAB – has invested in clean room facilities which are absolutely essential for start-ups like Zmood Innovations to use to fabricate working models of their devices. Second, the government has coordinated the Australian Synchrotron project; a key infrastructure development for scientific and technological applications in the fields of nano- and micro systems technology. All this, plus potential applications to Australia's traditional strengths in life sciences, provides hallmarks of an emerging cluster in this area with public funds establishing an appropriate framework for spurring private activity.

Foster Linkages

Finally, a key area of focus for Australian policy has to be in fostering infrastructure-cluster linkages. Universities must continue to upgrade their role as key linkages in the Australian innovation system. In leading innovator economies, the university system provides required training for a technically skilled labour force. It also undertakes "basic" research investments that serve as the **foundation** for a country's industrial clusters. Though Australian universities have been historically isolated from industry and national innovation policy initiatives (relative to the US), they are today playing a key role in one of Australia's most promising clusters in life sciences.

Current research grants that encourage linkage between industry and universities as well as Cooperative Research Centres serve to promote R&D performed by universities. However, in each case, the awarding of funds requires a micro-managed process. An alternative policy would provide a direct incentive for linkages say by gearing the R&D tax credit to have a higher return for industrial research performed by universities. This would automate the process and focus industry attention on how their R&D activities are deployed. In addition, the focus on cooperation would remove some concerns that such tax credits are being awarded to activities that are not truly innovative.

Other linking institutions can serve as facilitators of the exchange between the common innovation infrastructure and the innovation-based leadership of national industrial clusters. In particular, it has to be recognised that venture capital is more than setting up an investment fund. It is the development of highly incentivised financiers who manage commercialisation processes and build networks for the sale of ideas. In addition, industry associations can play a critical role in raising the bar with aggressive quality standards as well as openness to new technologies.

Summary

In a global economy, innovation-based competitiveness provides a more stable foundation for productivity growth than the traditional emphasis on low-cost production. Having secured a position as a leading user of global technology and creating an environment of political stability and regional leadership, Australia has a historic **opportunity** to pursue policies and investments to establish itself as a leading innovator nation. Australia must build upon a foundation of openness to international competition and the protection of intellectual property rights. However, Australia needs to focus upon the areas that appear to have become neglected over the past two decades. In particular, Australia should significantly increase its investment in:

- A **university system** responsive to the science and technology requirements of emerging industrial clusters;
- Incentives for the emergence of industrial clusters based on innovation-focused domestic competition;
- Higher education (beyond high school literacy), and, in particular, *incentives* for pursuing **science and technology-based careers** in Australia.

The direction of Australia's innovation policy needs to be towards ensuring that there is a coordinated strategy to create a favourable environment for private sector initiatives in securing innovations. This means moving away from micro-managed subsidies to projects and one time increases in key variables without plans for a sustainable growth path. It is important to recognise that this does not mean attractive high technology investments per se but investments that are in high technology functions; whatever the status of that industry in general. Securing good industrial capacity may be a goal of employment policy but it will not sustain Australia's innovation-driven competitiveness.

5. Conclusion

This submission has examined economic arguments in favour of the public support of science and innovation. It emphasises three important points that I believe that the Productivity Commission should take into account in its study.

First, I have shown that arguments of the public support of science based on the idea that basic research's economic benefits are derived from spillovers into applied research are based on a false premise of that relationship. Instead, there are strong incentives to provide use-inspired basic research that are preserved by recognising the distinct roles of pure science and commercial research as mechanisms to allocate resources to knowledge creation activities.

Second, the empirical findings in a recent PC working paper on the relationship between R&D and multi-factor productivity are refuted. Empirical work was presented using data from a cross section of OECD countries that showed that the Australian domestic R&D stock has a positive and significant impact on multi-factor productivity.

Finally, I presented results of the continuing study of the drivers of national innovative capacity that shows econometrically what factors – including government policy variables – impact on the domestic rate of innovation.

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Appendix A: Econometric Analysis of the Relationship between R&D and Productivity Growth (with Richard Hayes)

This appendix provides estimates of the effects of R&D on productivity using a basic level model. This study investigates the relationship between the level of resources devoted to R&D and the level of multifactor productivity (MFP) using a log log specification. It includes control variables for the business cycle and German unification. Country dummies and year dummies control for exogenous fixed effects for the countries and across time.

The tests were done for a panel of 16 OECD countries from 1980 to 1998. We used a data set developed and used by Guellec and van Pottlesberghe (2004). A brief description is provided in Table 1. Their paper provides a fuller description of the data measures. Sample countries are listed in Table 2.

TABLE 1: VARIABLES & DEFINITIONS

VARIABLE	FULL VARIABLE NAME	DERIVATION	GVP SOURCE
MFP	Multi-factor productivity	This is an index of multi-factor productivity of industry. It is calculated as a ratio of the domestic product of industry to the weighted sum of the quantity of labour and fixed stock. The weights used are annual labor cost share and the capital cost share. The index is normalised to 1 in 1990.	The underlying data series was derived from the OECD National Accounts database
Dom BRD	Domestic business R&D stock	The perpetual inventory method was used to calculate this, based on total business R&D expenditures in constant 1990 GDP prices and US purchasing power parities. The initial stock was calculated assuming a constant growth rate of past investments.	The series is derived from the OECD Main Science and Technology Indicators (MSTI).
For BRD	Foreign business R&D stocks	For each country this is calculated as a weighted sum of the domestic R&D capital stocks for the other 15 countries of the panel. The weights were obtained by a measure of bilateral technological proximity similar to that of Jaffe (1986). The measure of technological similarity is the frequency distribution across 50 technology classes of patents granted by the USPTO.	The series is derived from the OECD Main Science and Technology Indicators (MSTI). And USPTO patent count data.
ΔGEMP	Change in employment rate	The business cycle effect is incorporated via the change in the employment rate. That is, by measuring the change of 1 minus the unemployment rate.	GVP give no reference for the underlying data. OECD database is most likely.
G	German unification dummy	A dummy variable for the unification of Germany in 1991.	

TABLE 2
SAMPLE COUNTRIES

Australia	Finland	Italy	Spain
Belgium	France	Japan	Sweden
Canada	Germany	Netherlands	United Kingdom
Denmark	Ireland	Norway	United States

The OLS model results

Initial tests used pooled OLS and are presented as Models 1 to 4 in Table 3. Model 1 includes only domestic business R&D stock. Lagged 1 year, in addition to the controls and dummies. Model 2 adds foreign business R&D stock, lagged 1 year. Model 3 uses the lag structure used as the baseline in the Productivity Commission report Table 6.2. It has lags of 1 year for domestic business R&D and 0 years for foreign business R&D. Finally Model 4 tested another alternative lag structure of 2 years for domestic R&D and 3 years for foreign R&D.

In each model the log log specification means coefficients on the R&D stock variables have a natural interpretation as elasticities.

In all models the 2 control variables are of the expected sign and are significant. The employment rate has a significant positive impact on productivity. The German unification dummy covers the drop in average productivity in Germany in 1991, following unification.

In all models tested the elasticity of MFP with respect to either domestic business R&D or foreign business R&D was statistically significant and positive.

The preferred pooled OLS model, Model 2, indicates an elasticity of MFP with respect to business R&D of 0.17, for the sample excluding Australia. Australia's elasticity could be interpreted as 0.11, although it is not significantly different from the sample average. This model indicates an elasticity of MFP with respect to foreign R&D of 0.35, for the sample excluding Australia. Australia's elasticity could be interpreted as 0.26, however it is not statistically different from the sample average.

The elasticity of MFP with respect to foreign R&D is high compared with that for domestic R&D, indicating that foreign R&D matters more for productivity growth than domestic R&D, provided the country is capable of absorbing it.

When the effects of foreign R&D are excluded (Model 1) the Australian interaction dummy indicates Australia has a statistically significant lower elasticity for domestic business R&D than the rest of the sample average.

However the effect remains positive overall and the inclusion of foreign R&D in the other models renders this effect insignificant.

TABLE 3
ESTIMATION OF BASIC MFP AND BUSINESS R&D MODEL IN LEVELS

	Dependent Variable = ln(MFP)							
Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Estimation	OLS	OLS	OLS	OLS	FGLS	FGLS	FGLS	FGLS
Domestic lags	= (t-1)	= (t-1)	= (t-1)	= (t-2)	= (t-1)	= (t-1)	= (t-1)	= (t-2)
Foreign lags		= (t-1)	= (t)	= (t-3)		= (t-1)	= (t)	= (t-3)
Domestic BRD	0.213*** (13.5)	0.174*** (12.3)	0.183*** (12.9)	0.179*** (10.5)	0.151*** (7.5)	0.182*** (11.0)	0.211*** (13.4)	0.192*** (9.9)
Domestic BRD * AUS dummy	-0.131*** (-7.6)	-0.064 (-1.1)	-0.073 (-1.4)	-0.009 (-0.1)	-0.101*** (7.5)	-0.083* (-1.7)	-0.115** (-2.5)	-0.059 (-1.0)
Foreign business R&D stock		0.351*** (9.7)	0.381*** (9.2)	0.326*** (8.2)		0.186*** (5.9)	0.183*** (5.2)	0.181*** (5.6)
Foreign BRD * AUS dummy		-0.091 (-0.7)	-0.085 (-0.8)	-0.206 (-1.1)		-0.069 (-0.7)	-0.036 (-0.4)	-0.123 (-1.0)
Business cycle	1.41*** (7.5)	1.13*** (6.9)	1.21*** (7.3)	1.07*** (5.9)	0.704*** (7.7)	0.719*** (7.6)	0.749*** (7.5)	0.685*** (6.5)
German unification dummy	-0.078** (-2.3)	-0.069** (-2.4)	-0.072** (-2.5)	-0.058** (-2.0)	-0.066*** (-6.2)	-0.067*** (-6.1)	-0.068*** (-5.9)	-0.066*** (-5.9)
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of observations	286	286	286	254	286	286	286	254
R2	0.888	0.919	0.916	0.898				
Log Likelihood					822.0	816.7	804.1	724.4
Serial correlation[a]	237.8 (0.000)	298.5 (0.000)	250.4 (0.000)	297.3 (0.000)				
Heteroskedasticity[b]	(0.472)	(0.472)	(0.472)	(0.471)				
Ipshin[c]	-1.94 (0.024)	-2.56 (0.000)	-2.24 (0.001)	-2.05 (0.008)				
Levinlin[d]	-6.77 (0.0020	-10.49 (0.000)	-8.90 (0.000)	-8.43 (0.000)				

* Significant at 10%. ** Significant at 5%. *** Significant at 1%. t-statistics in brackets.

a Woolridge (2002) test for serial correlation in a linear panel model. Null is no serial correlation. Test statistic and p-value given.

b White test for heteroskedasticity. Null is homskedasticity. P-value given in brackets.

c Im, Pesaran and Shin (2003) t-test for unit roots in heterogenous panels. Based on the mean of individual Dickey-Fuller t-statistics for each panel unit. The null is all series are I(1). T-bar is given with p-value in brackets. Individual panel unit lag lengths selected by Ng & Perron (1995) sequential-t algorithm. To balance the panel 1998 residuals were excluded.

d Levin, Lin and Chu (2002) unit root test on regression residuals. Test statistic and p-value given. A small p-value rejects the null of I(1) behaviour. Lag lengths selected for each panel unit. Lag lengths selected by the sequential-t algorithm of Ng & Perron (1995), with successive lags eliminated until the longest lag is significant at the 10% level. To balance the panel 1998 residuals were excluded.

Robustness of the OLS results

Tests indicated the errors for the OLS models were homoskedastic.

Tests for cointegration were performed via tests for stationarity of the residuals from the models. The residuals from the OLS models were found to be stationary, allowing the overall model to provide reliable estimates of the long run effect of R&D on productivity.

The Woolridge (2002) test for serial correlation in linear panel data was done for the pooled OLS models. These tests rejected the null of serial correlation in the errors. Inspection of the residuals indicated some serial correlation for some of the panel unit residuals.

The FGLS model results

Test results using feasible generalized least squares (FGLS) estimation are presented as Models 5 to 8 in table 3. FGLS allows specification of the error structure of the model. Errors can be specified as homoskedastic across panels or not and as having a common AR(1) or panel specific AR(1) process. Given the OLS results indicated homoskedasticity this was selected for the FGLS estimation. Inspection of the graph of the OLS residuals for each panel unit suggested allowing panel specific AR(1) processes.

In each model the log log specification means coefficients on the R&D stock variables have a natural interpretation as elasticities.

FGLS coefficients on domestic business R&D and on the German unification dummy are very similar to the corresponding OLS results. FGLS coefficients for foreign R&D and the business cycle are somewhat lower than for the corresponding OLS results. It is hard to determine if the difference is significant.

The preferred FGLS model, Model 6, has an elasticity of MFP with respect to domestic business R&D of 0.18 for the sample excluding Australia. Australia's elasticity could be interpreted as 0.10, however it is not significantly different from the sample excluding Australia, at the 5% level. The elasticity of MFP with respect to foreign business R&D is about 0.19 for the sample excluding Australia. Australia's elasticity could be interpreted as about 0.12, however it is not significantly different from the sample excluding Australia, at the 5% level.

When the effects of foreign R&D are excluded (Model 5) the Australian interaction dummy indicates Australia has a statistically significant lower elasticity for domestic business R&D than the rest of the sample average. That is, the elasticity of MFP with respect to business R&D is about 0.15 for the sample excluding Australia and is about 0.05 for Australia. However the effect remains positive overall and the inclusion of foreign R&D in the other FGLS models renders this effect insignificant.

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Appendix B: Australia's Innovative Capacity, 2005 Update (with Richard Hayes)

Assessing Australia's Innovative Capacity: 2005 Update

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22nd December, 2005

Contents

Page

1 Background

Gans and Stern (2003) provided a new set of results and a focus on Australian innovation in their study of the drivers of national innovative performance. This is an update of Gans and Stern (2003); itself part of the National Innovative Capacity Project conducted by Michael E. Porter, Scott Stern and several co-authors over the past several years. The goal of these projects has been to understand the drivers of innovation across countries and use this to generate a measure of innovative performance. This update refines the empirical study further with more data, a greater coverage of years and an alternative model including the effects of specialisation. It gives us our clearest picture yet of the innovative state of the world.

This report follows our 2004 update (Gans and Hayes, 2004). Both updates complement Gans and Stern (2003). As such, we do not repeat their discussion outlining the national innovative capacity framework and its underlying history. Instead, we report only changes to some of the quantitative results and any changes in methodology and interpretation.

The report proceeds in three sections. Section 2 outlines the latest methodology used in this update while Section 3 provides the main results from this quantitative assessment. In general, despite data improvements and, a larger sample, the results of Gans and Stern (2003) are largely confirmed in both the original and the alternative model. A final section concludes reiterating the policy conclusions of Gans and Stern (2003).

2 Measuring National Innovative Capacity

The distinctive feature of the Porter-Stern approach is a clear distinction between innovation output (specifically, **international** patenting) and its drivers (infrastructure, clusters and linkages) as well as a careful determination of the 'weights' attached to each innovation capacity driver.[1] Each weight is derived from regression analysis relating the **development** of new-to-the-world technologies to drivers of national innovative capacity. This has the advantage of avoiding an 'ad hoc' weighting of potential drivers and instead using the actual relationship between innovative capacity and innovation to

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[1] See the Appendix and Furman, Porter and Stern (2002) for a more thorough discussion of this methodology and prior research in this area.

provide those weights. Thus, measures which historically have been more important in determining high rates of innovative output across all countries are weighted more strongly than those which have a weaker (though still important) impact on innovative capacity. The end result is a measure of innovative capacity that is measured in per capita terms to allow for international comparisons as well as a set of weights that focuses attention on **relative** changes in resources and policies both over time and across countries.

2.1 Measuring Innovative Output

In order to obtain the weights for the Innovation Index, we must benchmark national innovative capacity in terms of an observable measure of innovative output. In this study, we use the number of "international" patents **granted** in a given year for each country in the sample, as captured by the number of patents granted to inventors of a given country by the United States Patent and Trademark Office. While no measure is ideal, as explained by Gans and Stern (2003), measures of international patenting provide a comparable and consistent measure of innovation across countries and across time.

This update continues the practice of Gans and Hayes (2004), using patents granted in a given year as the measure of innovative output. Gans and Stern (2003) used patents granted according to the date of the patent application, primarily to take into account some missing data issues. In contrast, these updates return to the use of patents granted in a given year, as in the original Furman Porter and Stern (2002) work.

Using this measure requires it to be lagged. This is because the innovation environment pertinent for the patent grant is that environment that prevailed at the time of application. This lag reflects the difference between innovative capacity (innovation inputs) and the innovation index (predicted innovation outputs). Recent advice from the USPTO indicates that the average lag between patent application and patent grant remains at 2 years, the lag used in the 2004 update. Accordingly, we have continued to use this lag, rather than the three years used by Furman, Porter and Stern (2002).

That said, patents granted measured by date of application and patents granted measured by date of grant are highly correlated, and the use of one or the other measure as the innovation output measure does not affect the core findings of this study.

2.2 Calculating the Index

The Index is calculated and evaluated in two stages. The first stage consists of creating the database of variables relating to national innovative capacity for our sample of 29 OECD countries from 1973 to 2004. These measures are described in Gans and Stern (2003). We have obtained additional UNESCO and World Bank data allowing us to extend the time series back to 1973, versus 1978 in last year's update. This database is used to perform a time series/cross sectional regression analysis determining the significant influences on international patenting and the weights associated with each influence on innovative capacity.

In the second stage of the analysis, the weights derived in the first stage are used to calculate a value for the Index for each country in each year given its actual recent resource and policy choices. It is in this sense that we refer to national innovative capacity: the extent of countries' current and accumulated resource and policy commitments. The Index calculation allows us to explore differences in this capacity across countries and in individual countries over time.[2]

In addition to extending the work by adding new data, we have also constructed an alternative specification that reincorporates a measure of innovation SPECIALISATION, reflecting the presence and strength of industrial innovation clusters.

Both specifications produce broadly similar patterns of innovative capacity over time and countries. The econometric appendix provides further details.

2.3 Findings on Innovative Capacity

Stern, Porter, and Furman (2002) and Gans and Stern (2003) found that there was a strong and consistent relationship between various measures of national innovative capacity and per capita international patenting. The appendix details these for the expanded dataset using the original model and the alternative model featuring specialisation and largely confirms the findings of previous studies. This indicates the general robustness of this approach to measuring the underpinnings of innovative performance. As such, we refer the reader to Gans and Stern (2003) for a comprehensive discussion of these findings.

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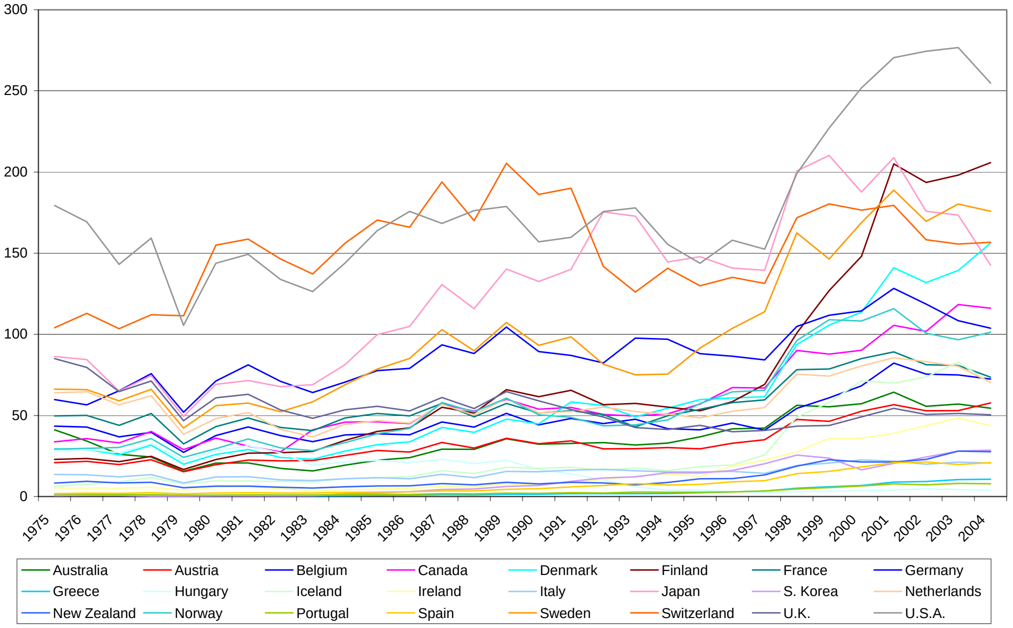
[2] Gans and Stern (2003) also used some extrapolations to forecast the Innovation Index five years in the future. We have decided not to do this exercise this year but may include it in future studies.

3 Australian Innovative Capacity

In this section, we provide updated results of the determinants of Australian Innovative Capacity. **Figure 3-1** depicts the value of the Innovation Index value for each country over time. The Index, interpreted literally, is *the expected number of international patent grants per million persons given a country's configuration of national policies and resource commitments 2 years before.*

Predicted Patents Per Million Persons



As shown in **Figures 3-1 and 3-2**, the updated Index confirms our earlier finding of three groups of nations – first, second and third tier innovators. It also reconfirms the finding of Gans and Stern (2003) that during the 1980s, Australia moved from a classic imitator economy to a second-tier innovator.

Figure 3-2: Innovation Index Rankings

Country	1975 Rank	1975 Innovation Index
USA	1	179.4
Switzerland	2	104.1
Japan	3	86.3
UK	4	85.0
Sweden	5	66.2
Netherlands	6	64.0
Germany	7	59.8
France	8	49.8
Belgium	9	43.4
Australia	**10**	**41.2**
Canada	11	33.8
Denmark	12	29.4
Norway	13	29.3
Hungary	14	27.9
Finland	15	22.9
Austria	16	20.9
Italy	17	13.7
New Zealand	18	8.4
Iceland	19	6.4
Ireland	20	5.3
Mexico	21	2.0
Spain	22	1.8
Portugal	23	1.6
Greece	24	1.0
S Korea	25	0.7

Country	1980 Rank	1980 Innovation Index
Switzerland	1	155.0
USA	2	143.8
Germany	3	71.2
Japan	4	69.2
UK	5	60.9
Sweden	6	56.1
Netherlands	7	48.1
France	8	43.2
Belgium	9	37.7
Canada	10	36.1
Norway	11	29.6
Hungary	12	28.1
Denmark	13	26.1
Finland	14	22.9
Australia	**15**	**20.7**
Austria	16	19.7
Italy	17	12.1
Iceland	18	9.7
New Zealand	19	6.4
Ireland	20	5.6
Mexico	21	2.8
Spain	22	2.3
Portugal	23	0.9
Greece	24	0.8
S Korea	25	0.6

Country	1985 Rank	1985 Innovation Index
Switzerland	1	170.5
USA	2	163.9
Japan	3	99.9
Sweden	4	78.7
Germany	5	77.6
UK	6	55.6
France	7	51.3
Netherlands	8	46.8
Canada	9	46.1
Finland	10	40.2
Norway	11	38.7
Belgium	12	38.7
Denmark	13	32.0
Austria	14	28.5
Australia	**15**	**22.4**
Hungary	16	22.4
Italy	17	11.7
Iceland	18	11.5
New Zealand	19	6.6
Ireland	20	4.7
Mexico	21	3.0
Spain	22	2.8
S Korea	23	2.3
Portugal	24	1.4
Greece	25	0.7

Country	**1990 Rank**	**1990 Innovation Index**
Switzerland	1	186.2
USA	2	157.0
Japan	3	132.6
Sweden	4	93.2
Germany	5	89.4
Finland	6	61.6
UK	7	59.0
Canada	8	54.0
Netherlands	9	51.6
France	10	51.5
Norway	11	50.4
Denmark	12	44.7
Belgium	13	44.2
Austria	**14**	**32.5**
Australia	15	32.4
Iceland	16	17.4
Hungary	17	16.6
Italy	18	15.4
New Zealand	19	7.8
Ireland	20	7.1
S Korea	21	6.9
Spain	22	4.8
Portugal	23	2.0
Greece	24	1.5
Mexico	25	0.9

Country	**1995 Rank**	**1995 Innovation Index**
Japan	1	147.9
USA	2	143.8
Switzerland	3	129.9
Sweden	4	91.5
Germany	5	88.0
Denmark	6	59.8
Norway	7	57.3
Canada	8	57.1
France	9	53.8
Finland	10	52.9
Netherlands	11	48.6
UK	12	44.0
Belgium	13	41.2
Australia	**14**	**36.9**
Austria	15	29.4
Iceland	16	18.6
Italy	17	15.3
S Korea	18	14.6
Ireland	19	12.5
New Zealand	20	11.0
Spain	21	7.6
Hungary	22	4.0
Portugal	23	2.7
Greece	24	2.4
Poland	25	2.2
Turkey	26	0.4
Mexico	27	0.4

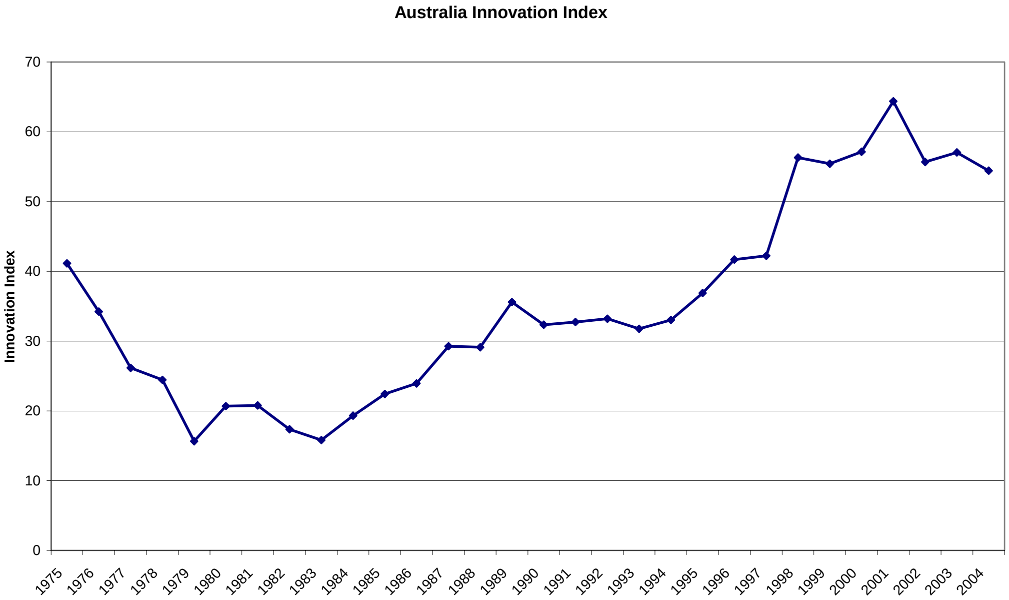
Country	**2000 Rank**	**2000 Innovation Index**
USA	1	251.8
Japan	2	187.6
Switzerland	3	176.6
Sweden	4	168.9
Finland	5	148.1
Germany	6	114.4
Denmark	7	113.6
Norway	8	108.1
Canada	9	90.2
France	10	85.0
Netherlands	11	80.5
Iceland	12	71.3
Belgium	13	68.3
Australia	**14**	**57.1**
Austria	15	52.5
UK	16	49.1
Ireland	17	35.9
Italy	18	22.6
New Zealand	19	21.4
Spain	20	18.3
S Korea	21	16.5
Greece	22	6.9
Portugal	23	6.5
Poland	24	3.6
Hungary	25	3.5
Turkey	26	0.7
Mexico	27	0.7

Country	2003 Rank	2003 Innovation Index
USA	1	276.7
Finland	2	198.1
Sweden	3	180.3
Japan	4	173.6
Switzerland	5	155.7
Denmark	6	139.4
Canada	7	118.4
Germany	8	108.4
Norway	9	96.7
Iceland	10	82.9
France	11	80.8
Netherlands	12	80.3
Belgium	13	75.0
Australia	**14**	**57.0**
Austria	15	53.1
UK	16	51.2
Ireland	17	48.6
New Zealand	18	28.1
S Korea	19	28.0
Italy	20	21.2
Spain	21	19.8
Greece	22	10.5
Portugal	23	8.1
Hungary	24	4.3
Poland	25	3.7
Mexico	26	0.7
Turkey	27	0.7

Country	2004 Rank	2004 Innovation Index
USA	1	254.7
Finland	2	205.8
Sweden	3	175.9
Switzerland	4	156.6
Denmark	5	156.2
Japan	6	142.6
Canada	7	116.0
Germany	8	103.7
Norway	9	101.3
France	10	73.6
Belgium	11	72.5
Netherlands	12	70.3
Iceland	13	70.0
Austria	14	57.8
Australia	**15**	**54.4**
UK	16	50.4
Ireland	17	43.6
S Korea	18	28.6
New Zealand	19	27.7
Spain	20	20.9
Italy	21	20.7
Greece	22	10.8
Portugal	23	7.9
Hungary	24	4.0
Poland	25	3.2
Turkey	26	0.6
Mexico	27	0.6

Figure 3-3 shows Australia's innovation index rose slightly from 1998 and has in recent years fallen back. The 2 year lag between innovative capacity (innovation inputs) and the innovation index (predicted innovation outputs) means that there have been no gains in our innovative capacity since 1996.

Figure 3-3: Evolution of Australia's Innovation Index



To understand this, it is useful to look at the drivers of innovative capacity for Australia. **Figure 3-4** presents the changes over time in the key measures used in the benchmarking analysis. It will be seen that the reasons for recent declines have been (i) stagnating R&D expenditure; (ii) a decline in IP protection; and (iii) continuing decline in education funding.

2004 saw Australia's Innovation Index record a small decline. Together with Austria's improved index this decline saw Australia's OECD ranking fall from 14th in 2003 to 15th in 2004.

What explains this fall in the innovation index for 2004? The innovation index for 2004 reflects the innovation policies and resources of recent years. Examining recent drivers of innovation reveals that the answer is not in the most direct drivers of innovative capacity, R&D spending and R&D personnel. In these areas Australia's growth rate from 2001 to 2002 was slightly higher than the average growth rate for the OECD. Although these factors do not explain the 2004 dip they remain cause for concern. Looking back beyond the most recent year, Australia's R&D spending has stagnated since 1996 and Australia's employment of R&D personnel relative to the OECD average has declined.

Some more subtle drivers of innovation rates appear to be behind the 2004 decline in the Index. Australia's impressive strides in intellectual property protection are shown. However in 2001 and 2002 there was a notable decline in the perception of intellectual property protection, which in turn has contributed to the decline in the innovation index. If the IP protection value for 2001 had even remained constant into 2002 then Australia's overall Index value would have recorded a slight increase, all other thing being equal.

The reasons for the decline in perception of Australia's IP protection may be related to controversy surrounding copyright issues, music copying and more recently IP issues highlighted by the US-Australia free trade agreement. There has been a general decrease across the OECD in the perception of the strength of IP protection, no doubt fuelled by worldwide controversy over piracy, copyright and digital IP issues.

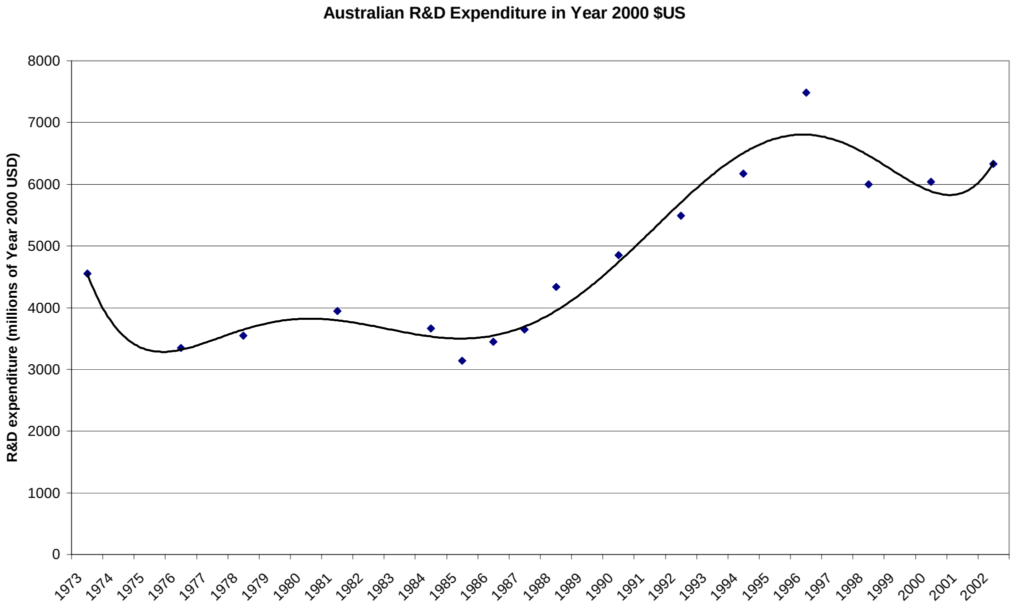
Although perceptions of IP protection also weakened across the OECD, Australia's decline was greater than the OECD average. More recent surveys indicate that this decline in perceived IP protection has continued, which will feed into future innovation index calculations.

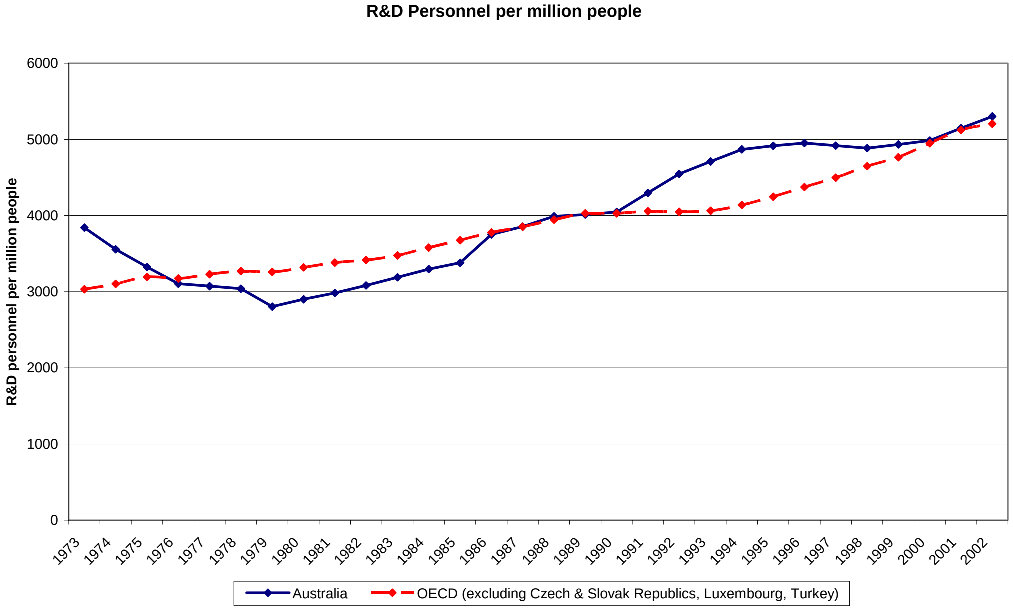
A further feature of the recent fall in the Australian Innovation Index is the continued decline in public spending on secondary and tertiary education as a proportion of GDP. This has been an area of long-term relative decline for Australia compared with the rest of the developed world. Although demographic shifts play some part in this decrease this is unlikely to explain the *relative* decline for Australia compared with the OECD average. Instead policy choices appear to have shifted public funding away from these sectors in Australia, comparing unfavourably with the persistent increases in public funding of education for the OECD as a whole.

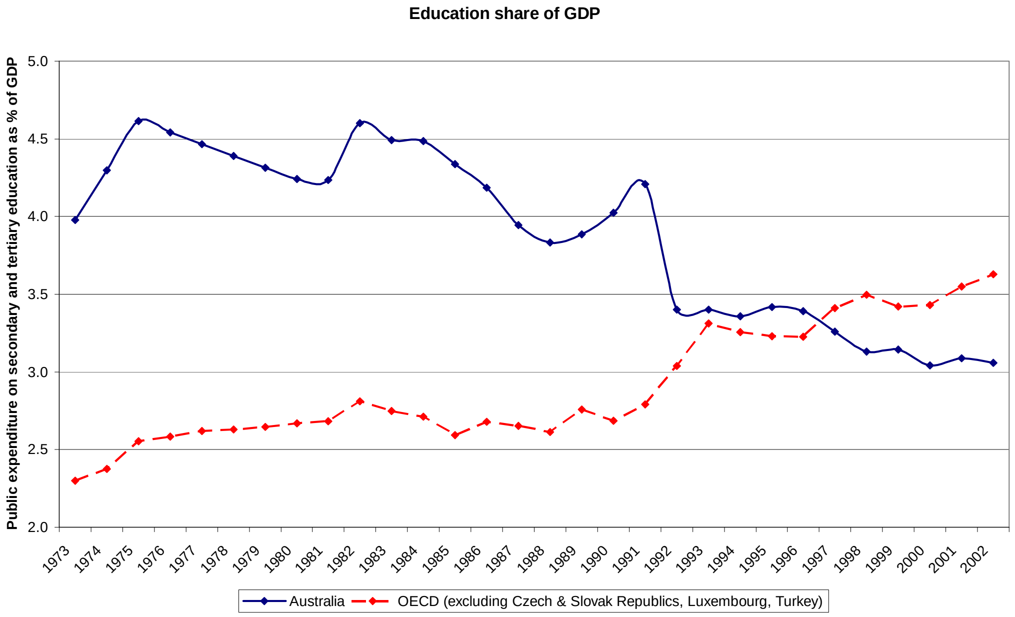
An important note is that the Index rose for only 8 of the OECD countries in 2004 despite generally increasing resource and policy commitments to innovation across the OECD. Part of the explanation for this lies in a "raising the bar" trend for new to the world technology, where increasing resource and policy commitments are needed merely to maintain innovation rates. Declines over time of the time dummy variables used in the regression support this explanation. (see Jones 1998 for further discussion of declining worldwide research productivity).

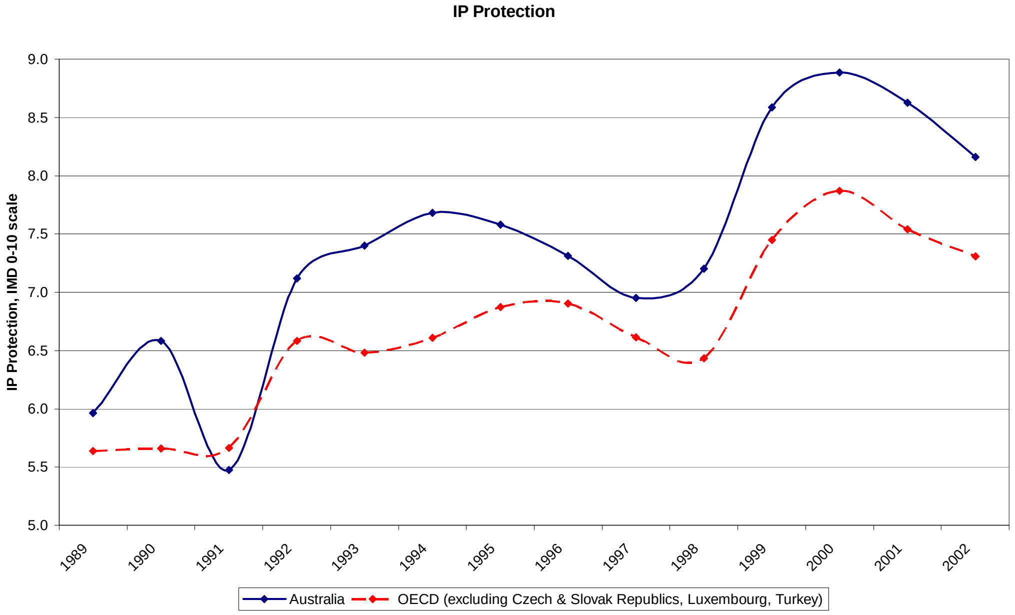
Figure 3-4: Drivers of Australia's Innovative Capacity

Common Innovation Infrastructure

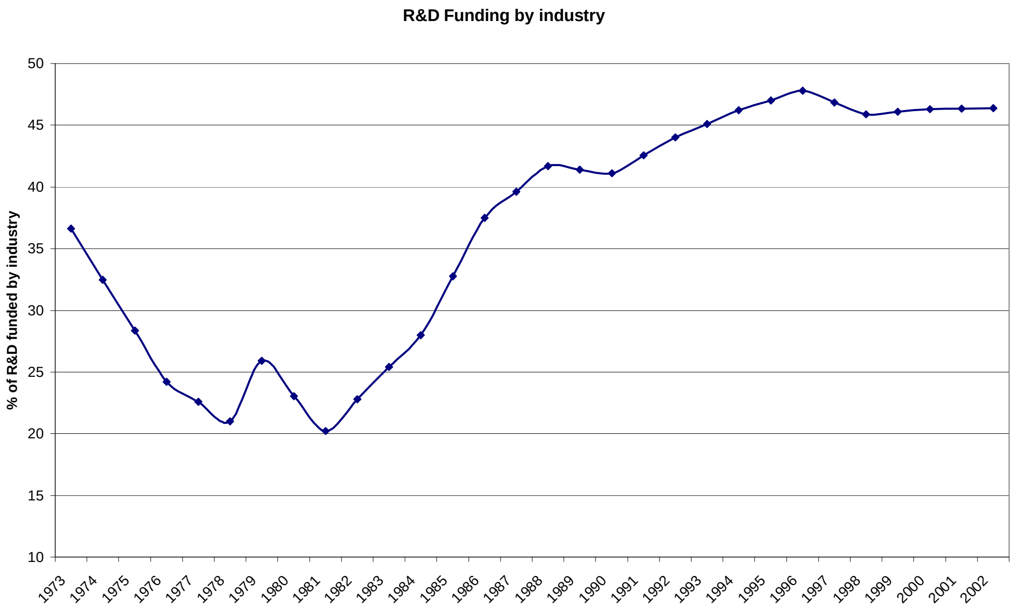




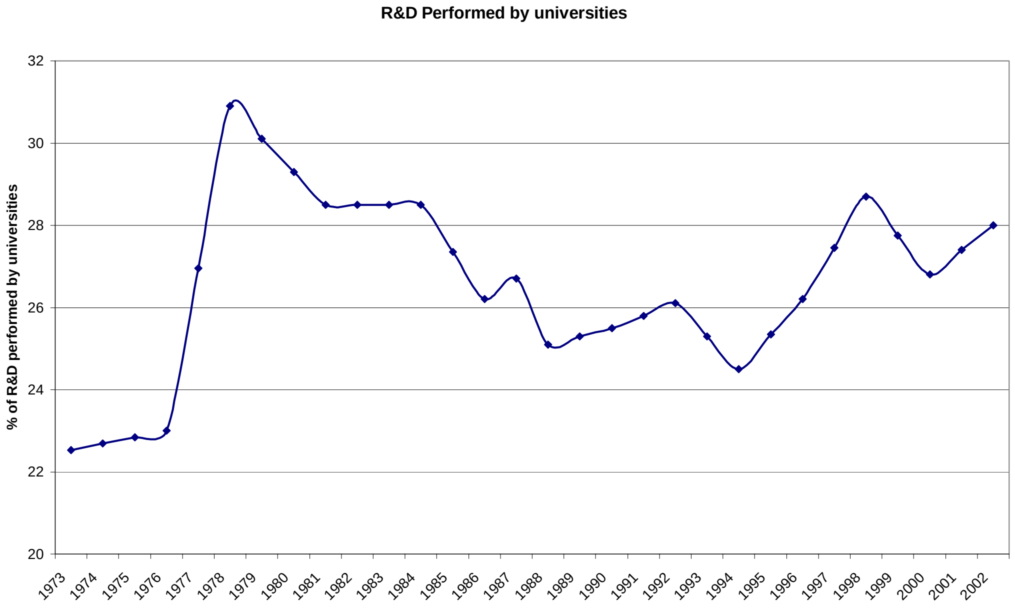

Education share of GDP
Public expenditure on secondary and tertiary education as % of GDP
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Australia
OECD (excluding Czech & Slovak Republics, Luxembourg, Turkey)


IP Protection
IP Protection, IMD 0-10 scale
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Australia
OECD (excluding Czech & Slovak Republics, Luxembourg, Turkey)

Cluster-Specific Environment



Quality of Linkages



4 Summary

Given the robustness of the conclusions of Gans and Stern (2003), it is appropriate to reiterate their policy recommendations for Australian innovation. Our expectation is that overtime, with changing policy directions, this general conclusion will change and evolve.

In a global economy, innovation-based competitiveness provides a more stable foundation for productivity growth than the traditional emphasis on low-cost production. Having secured a position as a leading user of global technology and creating an environment of political stability and regional leadership, Australia has an historic **opportunity** to pursue policies and investments to establish itself as a leading innovator nation. Australia must build upon a foundation of openness to international competition and the protection of intellectual property rights. However, Australia needs to focus upon the areas that appear to have become neglected over the past two decades. In particular, Australia should significantly increase its investment in order to:

- Ensure a world-class pool of trained innovators by maintaining a high level of university excellence and providing incentives for students to pursue science and engineering careers
- Provide incentives and opportunities for the deployment of risk capital
- Facilitate innovation as a cumulative step-by-step process
- Continue to open up Australia to international competition and investment and upgrading the effectiveness of intellectual property protection
- Maintain a vigorous yet sophisticated approach to antitrust enforcement
- Reduce barriers to entry and excessive regulation that hinder effective cluster development
- Build innovation-driven dynamic clusters based on unique strengths and capabilities
- Enhance the university system so that is responsive to the science and technology requirements of emerging cluster areas
- Encourage the establishment and growth of institutions for collaboration within and across industrial areas.

Australia's innovation policy must be cohesive in order to create a favourable environment for private sector innovation. Rather than micro-management of individual projects or short-term schemes that do not necessarily fit within the overall plan, innovation policy must be consistent and allow markets and investors to ultimately choose where to deploy resources and capital for global innovation. Indeed, in the Australian context, high-technology investments may not be in what are conventionally regarded as high-technology industries, as Australia's key strengths build on historical advantages in primary industries. Ultimately, policy should not be judged on whether a particular company or industry flourishes but on whether, taken as a whole, Australian firms are increasingly able to develop and commercialise innovation for global competitive advantage and as a source of prosperity for Australia going forward.

Appendix: Econometric Methodology

This Appendix provides a brief, more technical review of the procedures underlying the calculation of the updated Index and includes the results from our regression analysis. We proceed by reviewing the procedures associated with each of the three stages of the analysis.

Stage I: Developing a Statistical Model of National Innovative Capacity

The first stage consists of creating the database of variables relating to national innovative capacity for our sample of 29 OECD countries from 1973 to 2004. This database is used to perform a time series/cross sectional regression analysis determining the significant influences on per capita international patenting and the weights associated with each influence. Variables, definitions, and sources are listed in Table A-1. Table A-2 lists the 29 countries in the primary sample. Finally, Table A-3 provides some summary statistics.

Data choices are discussed in Furman et.al. (2002). Importantly, the data draws on several public sources, including the most recently available data from the OECD *Main Science and Technology Indicators,* the World Bank, and the National Science Foundation (NSF) *Science & Engineering Indicators*. Where appropriate, we interpolated missing values for individual variables by constructing trends between the data points available. For example, several countries only report R&D expenditure every other year; for missing years, our analysis employs the average of the years just preceding and following.

The primary measure of innovative output employed in the Index is international patent output. The data are provided by the United States Patent & Trademark Office. For all countries except the United States, the number of patents is defined as the number of patents granted in the United States. Since nearly all U.S.-filed patents by foreign companies are also patented in the country of origin, we believe that international patents provide a useful metric of a country's commercially significant international patenting activity. For the United States, we use the number of patents granted to establishments (non-individuals) in the United States. To account for the fact that U.S. patenting may follow a different pattern than foreign patenting in the United States, we include a dummy variable for the United

States in the regression analysis.[3] It is crucial to recall that patenting rates are used only to calculate and assign weights to the variables in the Index. The Index itself is based on the weighted sum of the actual components of national innovative capacity described.

We have used R&D expenditure in Year 2000 US dollars where previously we used R&D expenditure in current year US dollars. This does not affect the fundamental nature of the model due to the inclusion of year dummies.

Alternative model development – SPECIALISATION

The importance of clusters to the innovation process has strong support (see Porter (1990) for an influential account). Stern, Porter and Furman (2002) and Gans and Stern (2003) used measures of specialisation based on relative concentrations of patents across broad technological areas – chemical, mechanical and electrical. Our 2004 update and the Gans and Stern (2003) regressions did not find this variable to be statistically significant, at least partly due to irregular publishing of the underlying data.

In this update we have calculated a new SPECIALISATION measure. As innovative clusters will be associated with technologies from particular technological areas, we use the relative concentration of innovative output in individual USPTO patent classes to proxy for innovative concentration. We exclude the US because patent class information for US government and companies is not readily available from the USPTO and to avoid US raw patent numbers from dominating the specialisation calculation.

The use of 400 patent classes as the base for this measure of specialisation is considerably finer than the broad chemical, mechanical and electrical split used previously. As a result it is likely to be more reflective of genuine clusters and can also allow the identification of the clusters. The possibility of amalgamating some of these classes according to their perceived technological similarity is an option we may explore in future work.

We calculate relative concentration using the Ellison –Glaeser index used in Furman, Porter and Stern (2002), see there for a detailed explanation of the index. When a country has a lower rate of patenting it is easier to overstate its degree of specialisation. The Ellison-Glaeser index provides a correction for this effect.

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[3] The coefficient is statistically insignificant. The variable should capture any systematic effect of the asymmetry in the patent measure used, some variables being measured in US dollar terms and the calculation pf specialisation excluding the US. It remains an area for future development.

Model fitting including the specialisation variable suggested dropping the GDPbase variable, a baseline variable. This variable interacted with GDP/POP to effectively capture the effect of it being harder for bigger economies to grow their innovation rate per million people faster. It appears that the specialisation variable is instead reflecting this. Accordingly GDPbase has been dropped from the alternate specification and GDP/POP remains as an indicator of customer sophistication and the overall accumulated level of domestic technological knowledge.

In any event this measure does potentially capture the consequences of cluster dynamics and the relative specialisation of national economies in a particular area. The variable is positive and significant at the 10% level but tends to have a low net weighting on the overall index, with the slight decrease in specialisation recorded for Australia making only a very small quantitative difference to the Index for 2004. This driver of innovative capacity remains an area for future development.

Table A-1: Variables & Definitions

VARIABLE	FULL NAME	DEFINITION	MAIN SOURCE[4]
INNOVATION OUTPUT			
PATENTS$_{j,t+2}$	International Patents Granted, by Year of Grant	For non US countries, patents granted by the USPTO. For the US, patents granted by the USPTO to corporations or governments. To ensure this asymmetry does not affect the results we use a US dummy variable in the regressions.	USPTO patent database
QUALITY OF THE COMMON INNOVATION INFRASTRUCTURE			
FTE R&D PERS$_{j,t}$	Aggregate Personnel Employed in R&D	Full time equivalent R&D personnel in all sectors	OECD Science & Technology Indicators, UNESCO Statistical Yearbook
R&D \$$_{j,t}$	Aggregate Expenditure on R&D	Total R&D expenditures in millions of Year 2000 US$	OECD Science & Technology Indicators, UNESCO Statistical Yearbook
IP$_{j,t}$	Protection for Intellectual Property	Average survey response by executives on a 1-10 scale	IMD World Competitiveness Report
ED SHARE$_{j,t}$	% of GDP spent on secondary and tertiary education	Public spending on secondary and tertiary education divided by GDP	World Bank, OECD Education
OPEN$_{j,t}$	Openness to international trade and investment	Exports plus imports, divided by GDP, Year 2000 US$	World Bank
GDP/POP$_{j,t}$	GDP Per Capita	Gross Domestic Product per capita, 2000 US$	World Bank
GDPBASE$_{j,t}$	GDP in 1973	1973 Gross Domestic Product, billions of 2000 US$	World Bank
CLUSTER-SPECIFIC INNOVATION ENVIRONMENT			
PRIV R&D FUND$_{j,t}$	% of R&D Funded by Private Industry	R&D expenditures funded by industry divided by total R&D expenditures	OECD Science & Technology Indicators, UNESCO Statistical Yearbook
SPEC$_{j,t+2}$	E-G concentration index	Relative concentration of innovative output across USPTO patent classes, excluding the US	Computed from USPTO data
QUALITY OF LINKAGES			
UNI R&D PERF$_{j,t}$	% of R&D Performed by Universities	R&D expenditures performed by universities divided by total R&D expenditures	OECD Science & Technology Indicators, UNESCO Statistical Yearbook

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[4] Minor sources include US National Science Board,, Eurostat, RICYT

Table A-2: Sample Countries

REGRESSION DATA FROM 1973-2002 INDEX CALCULATIONS FROM 1975-2004				
Australia	Finland	Ireland	Norway	Sweden
Austria	France	Italy	Poland*	Switzerland
Belgium	Germany#	Japan	Portugal*	Turkey*
Canada	Greece*	Mexico	Slovak Republic**	United Kingdom
Czech Republic**	Hungary	Netherlands	South Korea	United States
Denmark	Iceland	New Zealand	Spain	

* These countries are not included in the base regression but are included in index calculations

** Czech and Slovak Republic Indexes are not calculable for base specification due to absence of GDPBASE data

\# Prior to 1990, figures are for West Germany only; after 1990 results include all Federal states

Table A-3: Regression Means & Standard Deviations

VARIABLE	Observations	Mean	Standard Deviation
INNOVATION OUTPUT			
PATENTS	647	3731	10006
QUALITY OF THE COMMON INNOVATION INFRASTRUCTURE			
FTE R&D PERS	647	196022	394527
R&D $	647	18572	40272
IP	647	6.47	1.18
ED SHARE	647	3.15	1.18
OPENNESS	647	56.4	31.0
GDP/POP	647	18529	7439
GDPBASE	647	512	963
CLUSTER-SPECIFIC INNOVATION ENVIRONMENT			
PRIVATE R&D FUNDING	647	50.2	14.5
SPECIALISATION	647	0.0132	0.0373
QUALITY OF LINKAGES			
UNIV R&D PERF	647	21.8	6.9

The statistical models draw heavily on a rich and long empirical literature in economics and technology policy (Dosi, Pavitt, and Soette, 1990; Romer, 1990; Jones, 1998). Consistent with that literature, we choose a functional form that emphasizes the interaction among elements of national innovative capacity, namely a log-log specification between international patent production and the elements of national innovative capacity:

Table A-4: Innovation Index Regression Models

Dependent variable = L PATENTS$_{t+2}$

Coefficient (Std Error)

	Base model	Alternate model – SPECIALISATION
QUALITY OF THE COMMON INNOVATION INFRASTRUCTURE		
L FTE R&D PERS	1.218 (0.077)	1.058 (0.043)
L R&D $	0.113 (0.044)	0.097 (0.043)
IP	0.108 (0.027)	0.122 (0.026)
ED SHARE	0.100 (0.014)	0.109 (0.014)
L GDP/POP	0.775 (0.064)	0.738 (0.062)
L GDPBASE	-0.183 (0.075)	
CLUSTER-SPECIFIC INNOVATION ENVIRONMENT		
PRIVATE R&D FUNDING	0.0162 (0.0018)	0.0169 (0.0018)
SPECIALISATION		0.643 (0.352)
QUALITY OF LINKAGES		
UNIV R&D PERF	0.0158 (0.0041)	0.0115 (0.0039)
CONTROL VARIABLES		
US DUMMY	0.0342 (0.0454)	0.0411 (0.0417)
YEAR EFFECTS	Significant	Significant
REGRESSION STATISTICS		
R SQUARED	0.997	0.997
NUMBER OF OBSERVATIONS	647	647

$$
\begin{aligned}
&LPATENTS_{j,t+2} = \beta_t YEAR_t + \beta_{USA} USDUMMY_j + \beta_{FTE} LFTER\&DPERS_{j,t} + \\
&\beta_{R\&D\$} LR\&D\$_{j,t} + \beta_{IP} IP_{j,t} + \beta_{EDSHARE} EDSHARE_{j,t} + \beta_{GDP/POP} L(GDP/POP)_{j,t} + \\
&\beta_{GDPBASE} LGDPBASE_j + \beta_{OPEN} OPENNESS_{j,t} + \beta_{PRIVATER\&D} PRIVATER\&D_{j,t} + \\
&\beta_{UNIVR\&D} UNIVR\&D_{j,t} + \beta_{SPEC} SPEC_{j,t+2} + \varepsilon_{j,t}
\end{aligned}
$$

This specification is inspired by 4.4 of Furman et.al. (2002). It has several desirable features. First, most of the variables are in log form, allowing for natural interpretation of the estimates in terms of elasticities. This reduces the sensitivity of the results to outliers and ensures consistency with nearly all earlier empirical research (see Jones, 1998, for a simple explanation of the advantages of this framework). Note that the variables expressed as ratios are included as levels, also consistent with an elasticity interpretation. Second, under such a functional form, different elements of national innovative capacity are assumed to be complementary with one another. For example, under this specification and assuming that the coefficients on each of the coefficients is positive, the marginal productivity of increasing R&D funding will be increasing in the share of GDP devoted to higher education.

Table A-4 reports the results from the principal regressions. The US dummy is insignificant in both models. For the base model other coefficients on the variables are significant at the 5% level with the exception of OPENNESS, which is significant at the 10% level. For the alternate model other coefficients on the variables are significant at the 5% level with the exception of OPENNESS and SPECIALISATION, which are significant at the 10% level. Consistent with prior research, the time dummies largely decline over time, suggesting a substantial "raising the bar" effect over the past 30 years (see Jones, 1998, for a discussion of declining worldwide research productivity).

Stage II: Calculating the Index

In Stage II, the Innovation Index was calculated using the results of the regression analysis in Stage I. The Index for a given country in a given year is derived from the predicted value for that country based on its regressors. This predicted value is then exponentiated (since the regression is log-log) and divided by the population of the country:

$$\mathit{Innovation\ Index}_{j,t} = \frac{\exp\left(X'_{j,t-2}\beta\right)}{POP_{j,t}}$$

To make our results comparable across countries, we included the U.S. DUMMY coefficient in the calculation. The issue of its inclusion or exclusion remains an area for closer examination in the future.

Table A-5 provides the Index value for each country for each year. The Index, interpreted literally, is the *expected number of international patents per million persons given a country's configuration of national policies and resource commitments 2 years before*. However it is important not to interpret the Innovation Index as a tool to predict the exact number of international patents that will be granted to a country in any particular year. Instead, the Index provides an indication of the relative capability of the economy to produce innovative outputs based on the historical relationship between the elements of national innovative capacity present in a country and the outputs of the innovative process.

Table A-5: Historical Innovation Index 1975-2004

Year	Australia	Austria	Belgium	Canada	Denmark
1975	41.2	20.9	43.4	33.8	29.4
1976	34.2	21.7	42.8	35.7	29.0
1977	26.1	19.8	36.8	33.2	25.8
1978	24.5	22.7	39.6	40.1	31.7
1979	15.6	15.3	27.2	29.0	20.0
1980	20.7	19.7	37.7	36.1	26.1
1981	20.8	22.5	42.9	31.1	29.0
1982	17.4	22.1	37.7	27.6	24.1
1983	15.8	22.2	33.9	41.1	23.0
1984	19.3	25.5	38.0	45.9	28.0
1985	22.4	28.5	38.7	46.1	32.0
1986	23.9	27.5	38.0	45.0	33.8
1987	29.3	33.4	46.0	57.1	42.6
1988	29.1	30.0	42.8	52.6	39.5
1989	35.6	36.0	51.4	60.0	47.8
1990	32.4	32.5	44.2	54.0	44.7
1991	32.7	34.4	48.1	54.9	58.3
1992	33.2	29.4	45.0	50.7	56.1
1993	31.8	29.5	47.7	49.6	49.2
1994	33.0	30.2	41.8	51.0	54.5
1995	36.9	29.4	41.2	57.1	59.8
1996	41.7	32.9	45.3	67.1	60.8
1997	42.2	35.0	40.9	66.9	61.6
1998	56.3	47.5	54.4	90.1	93.7
1999	55.4	46.4	61.0	87.8	105.6
2000	57.1	52.5	68.3	90.2	113.6
2001	64.4	56.6	82.3	105.6	141.1
2002	55.7	52.9	75.5	101.9	131.9
2003	57.0	53.1	75.0	118.4	139.4
2004	54.4	57.8	72.5	116.0	156.2

Year	Finland	France	Germany	Greece	Hungary	Iceland
1975	22.9	49.8	59.8	1.0	27.9	6.4
1976	23.5	50.1	56.5	1.0	29.1	7.6
1977	21.6	44.0	65.2	1.0	27.1	9.2
1978	24.8	51.2	75.8	1.2	32.7	11.6
1979	16.7	32.5	52.0	0.7	22.2	7.8
1980	22.9	43.2	71.2	0.8	28.1	9.7
1981	26.8	48.5	81.2	0.7	31.4	9.7
1982	27.0	42.7	70.9	0.7	26.9	9.2
1983	27.8	40.7	64.1	0.6	19.4	9.0
1984	34.7	48.5	70.5	0.7	21.3	11.1
1985	40.2	51.3	77.6	0.7	22.4	11.5
1986	42.4	49.7	79.0	0.9	20.9	12.4
1987	55.1	57.5	93.4	1.2	23.0	15.9
1988	51.6	49.1	88.2	1.2	20.3	14.2
1989	65.9	57.4	104.5	1.5	22.4	18.1
1990	61.6	51.5	89.4	1.5	16.6	17.4
1991	65.6	52.9	87.0	1.8	14.1	18.1
1992	56.7	50.6	82.4	1.8	10.1	16.3
1993	57.4	43.1	97.7	1.8	5.9	17.6
1994	55.2	49.9	97.0	2.0	4.0	16.0
1995	52.9	53.8	88.0	2.4	4.0	18.6
1996	58.6	57.8	86.5	3.0	3.1	19.4
1997	69.2	59.6	84.2	3.4	2.5	25.7
1998	100.8	78.3	104.9	5.2	3.1	49.1
1999	127.0	78.7	111.8	6.1	3.3	58.0
2000	148.1	85.0	114.4	6.9	3.5	71.3
2001	205.0	89.2	128.3	8.9	4.0	70.0
2002	193.6	81.2	118.6	9.3	4.8	73.7
2003	198.1	80.8	108.4	10.5	4.3	82.9
2004	205.8	73.6	103.7	10.8	4.0	70.1

* For 1975-1989, the index value is for West Germany only.

Year	Ireland	Italy	Japan	Mexico	Netherlands	New Zealand
1975	5.3	13.7	86.3	2.0	64.0	8.4
1976	5.3	13.4	84.4	2.3	64.7	9.4
1977	5.2	12.2	65.0	2.4	56.5	8.5
1978	5.8	13.6	74.6	2.9	62.1	8.8
1979	4.0	8.5	49.4	2.0	38.4	5.4
1980	5.6	12.1	69.2	2.8	48.1	6.4
1981	6.2	12.4	71.5	3.3	51.7	6.5
1982	4.7	10.3	67.8	3.0	41.5	5.8
1983	3.8	9.9	69.0	3.1	36.8	5.3
1984	4.1	11.0	81.3	3.4	44.5	6.1
1985	4.7	11.7	99.9	3.0	46.8	6.6
1986	4.9	11.0	104.9	2.2	45.4	6.7
1987	6.4	13.7	130.7	2.2	56.9	8.0
1988	6.0	11.7	115.7	1.5	50.2	7.2
1989	7.9	15.5	140.3	1.3	60.6	8.8
1990	7.1	15.4	132.6	0.9	51.6	7.8
1991	8.7	16.3	140.1	0.8	52.4	8.8
1992	10.5	16.8	175.4	1.0	55.2	8.4
1993	12.5	16.0	172.9	1..3	52.5	7.2
1994	14.0	15.2	144.6	0.8	50.8	8.7
1995	12.5	15.3	147.9	0.4	48.6	11.0
1996	18.9	15.4	140.8	0.6	52.5	11.1
1997	22.5	14.4	139.5	0.5	54.8	13.3
1998	27.6	19.2	200.6	0.6	75.5	18.7
1999	35.9	20.7	210.2	0.6	74.3	22.8
2000	35.9	22.6	187.6	0.7	80.5	21.4
2001	39.1	21.8	208.9	0.6	85.5	21.4
2002	43.8	20.1	175.9	0.7	83.2	23.0
2003	48.6	21.2	173.6	0.7	80.3	28.1
2004	43.6	20.7	142.6	0.6	70.3	27.7

Year	Norway	Poland	Portugal	South Korea	Spain
1975	29.3		1.6	0.7	1.8
1976	29.7		1.5	0.8	2.1
1977	30.3		1.1	0.8	2.0
1978	35.8		1.2	0.3	2.4
1979	24.2		0.7	0.3	1.7
1980	29.6		0.9	0.6	2.3
1981	35.5		1.1	0.6	2.3
1982	30.1		1.0	0.6	2.2
1983	28.4		1.0	0.7	2.2
1984	33.2		1.2	1.7	2.6
1985	38.7		1.4	2.3	2.8
1986	42.1		1.4	3.1	3.1
1987	58.0		1.8	4.4	3.5
1988	52.2		1.7	4.6	3.5
1989	60.7		2.1	6.3	4.5
1990	50.4		2.0	6.9	4.8
1991	48.8		2.3	9.3	6.0
1992	43.6	4.7	2.3	11.5	6.9
1993	44.2	3.5	2.8	12.2	8.1
1994	47.2	2.4	2.7	14.7	7.1
1995	57.3	2.2	2.7	14.6	7.6
1996	64.6	2.1	2.9	16.2	9.2
1997	65.6	2.2	3.5	20.2	9.9
1998	96.2	3.8	4.7	25.6	14.1
1999	109.0	3.7	5.5	23.8	15.4
2000	108.1	3.6	6.5	16.5	18.3
2001	115.8	4.0	7.7	20.5	20.9
2002	100.8	3.6	7.3	24.4	21.3
2003	96.7	3.7	8.1	28.0	19.8
2004	101.3	3.2	7.9	28.6	20.9

Year	Sweden	Switzerland	Turkey	United Kingdom	United States
1975	66.2	104.1		85.0	179.4
1976	65.9	112.9		79.5	169.3
1977	59.0	103.4		64.8	143.2
1978	66.2	112.0		71.2	159.3
1979	42.3	111.4		46.8	105.6
1980	56.1	155.0		60.9	143.8
1981	57.7	158.7		63.1	149.3
1982	52.3	146.4		53.4	133.8
1983	58.4	137.2		48.3	126.3
1984	68.8	156.1		53.4	143.9
1985	78.7	170.5		55.6	163.9
1986	85.2	166.0		52.8	175.7
1987	102.8	193.8		61.0	168.3
1988	89.9	170.0		54.3	176.2
1989	107.3	205.4		64.8	178.8
1990	93.2	186.2		59.0	157.0
1991	98.4	190.0		53.7	159.8
1992	81.6	141.9	0.5	49.0	175.6
1993	75.0	126.0	0.6	42.6	177.9
1994	75.5	140.7	0.5	41.4	155.5
1995	91.5	129.9	0.4	44.0	143.8
1996	103.7	135.1	0.4	40.0	158.0
1997	113.9	131.4	0.4	40.8	152.5
1998	162.5	171.8	0.7	43.4	199.1
1999	146.4	180.4	0.8	43.9	227.1
2000	168.9	176.6	0.7	49.1	251.8
2001	188.9	179.5	0.8	54.4	270.5
2002	169.6	158.3	0.9	50.6	274.5
2003	180.3	155.7	0.7	51.2	276.7
2004	175.9	156.6	0.6	50.4	254.7

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