THE UNIVERSITY OF MELBOURNE

MELBOURNE BUSINESS SCHOOL

Centre for Ideas and the Economy

Rationales and Funding Mechanisms for Innovation in Australia

Submission to the National Innovation Review

Author: **Professor Joshua Gans**

Date: 10th April, 2008

Statement of Interest: I am an employee of a higher education institution in Australia and the recipient of numerous Australian Research Council grants. I am also a participant at the Australia 2020 Summit section on productivity.

Melbourne Business School 200 Leicester St Carlton VIC 3053 **T** (03) 9349 8173 **E** J.Gans@unimelb.edu.au **W** www.mbs.edu

Table of Contents

Introduction

The National Innovation Review seeks to coordinate and rationalise the funding of innovation and science in Australia. It is long overdue.

This submission draws upon many years of research in innovation and how to promote and fund it. I take an economist's perspective. In so doing, I divide my submission into three parts.

First, I re-examine the rationale for government intervention to promote innovation in the economy. I outline the economic case but also the evidence on the impact of innovation on domestic productivity in Australia as well as evidence on what factors drive national innovative performance. It turns out that going to the data in a scientific way is informative.

Second, I examine different ways of promoting innovation both traditional and more novel. I find that there is relatively little use of market-based or demand-pull mechanisms in Australia and that these are becoming increasingly tried and effective throughout the world.

Finally, I discuss specific policies relating to mechanisms for funding innovation. I examine how market-based mechanisms could be introduced in Australia through government procurement and the encouragement of industries bodies. I then look at the interaction between open and commercial science and how thinking about this carefully suggests policies that would promote what each system can deliver both separately and together while not duplicating through government expenditure what the private sector can reasonably be expected to do. Lastly, I argue for a consideration of a coordinating and independent authority to formulate and implement innovation policy in Australia; amalgamating key functions already present in government.

Rationale for Intervention

Basic Economic Case

It is so commonplace to argue that innovation requires government intervention that it is very easy to take it as a given. However, in evaluating economic policies and approaches to innovation, it is very useful to keep in mind the economic rationale for intervention. For this reason, I will briefly outline that and, then turn to comment specifically about the value and drivers of Australian-sourced innovation.

The resources for innovation

As a matter of economics, if you want more innovation, you need to find ways of allocating resources to that activity. While each individual person and project makes up resources that add to the stock of knowledge, economics tends to conceptualise these in aggregate terms. This is to understand broad patterns rather than individual cases.

Let A represent the current stock of knowledge (in the world). We let a represent that addition to that knowledge. The amount of knowledge that is added is a function of various resources. A common representation is this:

$$a = f(KA, HA, A)$$

Here KA is the stock of capital denoted to knowledge creating activities and HA is the amount of human capital engaged in knowledge creating activities. What this equation says is that all of these factors drive innovation and having more of them (quantitatively or qualitatively) will lead to more innovation. The function, $f(.)$, describes how resources fit together and the productivity of those resources in generating innovations.

Economics has little to say about the nature of the relationship between the actual application of resources and the generation of innovations. Rather it is principally concerned about how those resources come to get allocated there. To be sure, that will be related to their productivity in the innovation process. But, critically, this will also be driven by the incentives of agents who control or own those resources and can choose what activities they are employed in.

Incentives to innovate

Consider an entrepreneur who has an idea that can be developed into an innovation. To actually generate that innovation (and so add to *A*), the entrepreneur needs to decide whether to allocate their own time to this activity but also how to attract any capital that might be required. The case for entrepreneurial attention and capital allocation is similar: **if the project is successful, what profits would accrue to those providing resources?**

One might think that this might be a fairly straightforward analysis as one might do for any business. But there are wrinkles when it comes to innovation. As Kenneth J. Arrow (1962) pointed out, innovations have specific features that make the case for resource allocation a tough one.

Uncertainty

Let's start with the most obvious: *uncertainty*. There is no guarantee that by allocating resources to innovative activity, you actually produce a useful and commercially viable innovation at the other end of the pipe. There are technical issues that need to be resolved and ultimately, it might not be clear whether the end product is of value to someone. Without either of these, no one will pay for the outcome and so not return will flow to the resources who were employed to push towards the innovation.

Once again, uncertainty pervades business and economic activity. But innovation creates a different sort of uncertainty – uninsurable uncertainty. While a business building a power plant can purchase forward contracts to ensure a certain return, the same cannot be said for innovation. If the innovation isn't successful, it is hard to tell if that was because it was a poor idea or because the resources employed did not do their job appropriately. After all, shield the entrepreneur from risk and their incentives to work 100 hour weeks to get the innovation through are diminished. This problem of moral hazard (as it is termed in insurance and agency theory) can mean that no one would want to take the other side of the insurance contract proposed by the innovator. This means that societal means of pooling for risk are not present. And it means that if innovative activity is going to take place and there are going to be those who fail and lose any return on resources allocated, the payoff from success is going to have to cover these (in expectation) as well as the project being rewarded.

Indivisibility

A second issue with innovative activity is that it is *indivisible*. For many economic goods, if you want to produce more of them you put more resources in. For innovation, doing that might improve the likelihood of an innovation being released but, more often than not, unless a certain minimum level of resources is put in place, there is little hope of realising anything of value.

As an example, consider the task of creating a new web-based word processing program. At some level, it either works or it doesn't. But if it takes a certain minimum level of resources to ensure that it works, then you had also better expect to make sufficient sales to cover that minimum level.

The profound part of this is the following. In markets, resources are often paid their marginal product (that is, the amount they actually contribute to a project). So if a project generates a certain amount of income, it is possible to ask, if a person put in a little less effort, how much less would that income be? Then you pay that person that amount. The beauty of a divisible world is that you can play this game and in the end you will end up dividing the income between different suppliers perfectly. You neither have bits left over nor are you left short.

When you have some resources where, if they don't supply a certain minimum, nothing gets produced, you have a problem. If you apply the marginal product test to those resources, they should get all of the income. And you can see what happens here: what will be left over for others? So if the market provides others with their marginal product, then those who need to supply a minimum level of effort will be under-compensated. This is a tricky issue when you allow owners of resources to choose what activities they move into. Even where there are non-market mechanisms interacting with these voluntary ones, the adding-up problem can bind. So, when it comes to innovation, attracting resources is a particular challenge.

One way to compensate for this is to make up for it at the other end and ensure that the income the innovation generates is high enough. The adding-up issue will still arise but a higher income means there is more left over for those who supply the 'minimum effort' resources. I'll note shortly how this becomes a very troubling issue in the case of cumulative innovation (that is, innovations that build upon one another).

Inappropriability

But here we run into the third and final dimension of innovation that distinguishes it from other goods: *inappropriability*. In an ideal world, the limit on the income or the reward from innovation (that is, if we could freely choose it) would be the total value accruing to consumers of the innovation. But, in reality, innovators do not come close to receiving such rewards.

First, at its core, an innovation is an idea. The problem with ideas is that they can be copied; potentially easily and cheaply. This means that if one were to place a new product in the marketplace and that product was observably successful, others could take that idea or something fairly closely related and put competing products in the market. That would be good news for consumers but bad news for the initial innovator. What is more, when weighing whether to direct resources towards innovative activity, agents anticipating such competition and any resulting rent dissipation, will likely shy away from those choices.

It is for this reason that the government (in most countries) steps in to protect innovators from such imitative competition. This is what the patent and copyright systems achieve. They offer innovators 'breathing space' from potential competition and some assurance they will have time to earn income prior to it being frittered away by competition.

The problem with intellectual property protection of this kind is that it delays the benefits that might flow to consumers. Most troublingly, the monopoly position of the innovator may lead to some consumers being priced out of the market altogether; as is the case with developing nations and pharmaceutical products.

There has been much written in economics about ways of resolving this issue more cost effectively. One such possibility has been the use of prizes as a reward to innovation. Indeed, the Australian Pharmaceutical Benefits Scheme operates a little like this. When a drug is introduced to Australia, its owner has the option of selling it under a patent in the market or doing a deal with the government. That deal has the pharmaceutical owner agreeing to a lower per unit price for the drug alongside a government subsidy to it. The end result is that the drug is distributed very widely. What is more, because the owner has the option to earn what it would have with an unregulated monopoly outcome, it must be getting more rents from exercising the government option.

A second issue to do with inappropriability is that it can be very difficult to sell an idea free of a final product (Gans and Stern, 2003a). Why might an innovator wish to do this? First of all, rather than enter a product market with a whole lot of potential competitors, selling the idea to them can minimise the profit reducing impact of that competition (for both parties). Second, many innovations do not yield value in isolation but require other complementary assets to complete them. These might be marketing or distribution resources or even other innovations. Those complementary assets can be built from scratch but they might already exist and be provided by established firms in the industry. Thus, there may be gains to dealing with those firms over commercialisation of the innovation rather than duplicating what they already have (Teece, 1986). For each of these reasons, striking a cooperative deal with established firms may secure the innovator more income than taking the product to market themselves.

Faced with these benefits it becomes difficult to imagine why an entrepreneurial firm would not contract with an established firm. One reason is, of course, that the entrepreneur might like to build an empire and keep control over their invention's progress. Another might be that the entrepreneur is far more optimistic than established firms about the invention's value in the marketplace. But even if these were issues, it would still pay for the inventor to attempt to negotiate with one or more established firms; if only to see if there are gains from trade despite these other differences. Nonetheless, it remains true that some smaller start-ups avoid approaching incumbents until their products are established in the market place.

There is a potentially good economic reason why inventors might avoid negotiations with an established firm altogether: the risk of disclosure. In order to sell an idea you have to show the potential purchaser the idea. In some situations a working model is available and its functionality is enough. In other situations, key knowledge has to be disclosed to the potential buyer. The problem is the disclosures themselves may undermine an inventor's ability to contract with unscrupulous buyers. Purchasers may claim they already knew the idea or otherwise fail to reach an agreement. They might then utilise that knowledge to develop competing products and harm the inventor's product market options. Thus, by giving key disclosures, the inventor weakens their own negotiating position to such an extent that it may be preferable to secretly go to the product market and bypass the ideas market altogether (Arrow, 1962).

This is not a pie in the sky problem. There are many documented cases of expropriation of intellectual property by established firms. Perhaps the most famous is that of Ford who was found to have violated the intellectual property of Bob Kearns, the inventor of intermittent windshield wiper. In the 1960s, Kearns solved some long-standing difficulties with developing the wiper, fitted his car with it and drove it down to the Ford motor plant in Detroit to see if they were interested. They inspected the car, employed Kearns for a short time but eventually passed on the idea. In the meantime, Kearns secured a patent only to find later on that Ford and other car manufacturers had employed his technology in millions of vehicles. Kearns eventually won a case against Ford but only after spending twenty years in a legal quagmire. Had he known, he might never have driven the car down to Ford in the first place; let alone develop this important new technology (Seabrook, 1994).

The disclosure problem is not insurmountable. One option, of course, is not to disclose the idea. This might dilute the amount legitimate purchasers might be willing to pay to purchase an invention. However, if the inventor could post a bond, they would be able to use this to give a warranty as to the invention's technical and perhaps even commercial viability. This type of assurance requires, at the very least, a well funded inventor.

A second alternative would be to use a bolder strategy. Bob Kearns might have disclosed his idea to Ford and threatened, quiet credibly, to take his invention down the road the GM if they did not strike an appropriate deal. The existence of established firm competitors can turn the potential expropriation problem on its head; with would be expropriators becoming the expropriated (Anton and Yao, 1994). This type of strategy requires boldness not generally part of most people's arsenals.

Finally, the inventor could ensure they have sufficient intellectual property protection. Expropriation can occur because of a lack of legal recourse. Having a strong patent or an established trade secret regime, allows inventors to disclose their innovations without fear that it could be used against them in the market should a deal not be forthcoming. And it is here that intellectual property serves its additional role. Patent protection not only guards inventors from imitation in product markets but also against expropriation in ideas markets. In some cases, it opens up a new profitable opportunity for entrepreneurs. In other cases, it opens up the only profitable opportunity for them.

The key message is this: **while strong IP protection improves returns in both the product market and the ideas market it makes the latter relatively more attractive than the former**. This is because IP protection actually enables ideas markets to work in an economically sensible fashion by insuring the inventor against expropriation. This makes such protection doubly important and hence, likely to encourage contracting over competition as a commercialisation strategy (Gans, Hsu and Stern, 2002).

The challenge of cumulative innovation

What each of the previous issues – uncertainty, indivisibility and inappropriability – suggest is that the private incentive to innovate and hence, the returns to deploying resources and capital in innovative pursuits, will be well below what we would want socially. If this were a once-off perhaps this dichotomy would not be an issue. But it is because innovation is cumulative that we must worry about under-production.

As noted earlier, the addition to the stock of knowledge is a function of the stock of knowledge itself. Thus, if that knowledge stock is under-produced, future additions to it will continue to lag behind. What is more, because old knowledge generates new knowledge, it is virtually impossible to divide the rents between new and old knowledge producers in a way that can assure maximal innovative activity.

To see this, consider again the role of patent protection. Patents can be set so as to increase the hurdle by which new products must improve upon old products before they infringe upon them. Obviously, increasing the hurdle rate improves incentives for the current innovations but may harm incentives for future ones. Reducing the hurdle rate, does the reverse. Indeed, it is very hard to balance incentives so that innovators share and consider the returns to future innovations.

What this implies for policy **is that long-term institutional responses are critical to stimulating prolonged periods of cumulative innovation**. Once-off interventions are unlikely to produce these results. First of all, they may fail to have mechanisms to reward innovation paths. Second, they may fail to commit to future funding in support of innovations that build upon previously funded innovations. Hence, the focus of innovation policy should be on the long-term with a vision extending decades rather than a few years.

The Matching Problem

Related to the issue of cumulative innovation is something that I will call the '*matching problem*.' Consider the following story (from Mintzberg as reported by Oliver, 2006):

> One day in 1943, Edwin Land's three-year-old daughter asked why she could not immediately see the picture he had just taken of her. Within an hour, this scientist conceived the camera that would transform his company. In other words, Land's vision was the synthesis of the insight invoked by his daughter's question and his vast technical knowledge.

This story cleanly illustrates an issue: how does need and knowledge come together?

Now when need and knowledge are held by the same individual then this is easy to see. Indeed, one vision of the entrepreneur is as an individual who sees a need and sees a potential technical solution and marshals resources to generate the actual innovation. However, this process leaves a lot to luck and serendipity. It is natural to wonder who many potential matches are not being found.

Of course, a way that serendipity can be controlled is via integration. One of the roles of a larger firm is to bring expertise, marketing and product design together to formulate needs and allocate resources internally for research and innovation to meet those needs. Indeed, this can also occur at the user level. Eric von Hippel (2005) documents many instances where users noticed their own problems and found solutions for them. Interestingly, while that was occurring, users often failed to notice how their solutions might apply more broadly.

While matching may be a problem, is there a potential market failure here and a rationale for government intervention? The issue is that for anything other than serendipity to allow needs and knowledge to be matched requires effort: mostly likely by agents on both sides of the market. Specifically, it makes sense to search for someone who can solve a problem when you know that there are people with knowledge searching for uses. Absent these then an insufficient amount of effort will be expended, not only in search, but in working out a common language, articulating problems and generalising solutions.

One way of minimising search costs and externalities is through location. When firms who have knowledge and those who have needs are located close to one another, search costs are lowered and the likelihood of profitable serendipity is also increased. This happens with various clusters of innovative activity but also in the location of entrepreneurial firms close to research-based Universities.

Other possibility is to make use of high-speed communication networks to facilitate collaboration over distances. While at their infancy at the moment, advances in conferencing technologies and collaborative tools may allow the distance factor to be limited as well as reducing search costs in assessing innovative partners.

Finally, it is useful to note that strategic issues may also form a barrier to matching. You might not want to advertise a need that also gives your competitors an idea of what you trying to do. You might not want to advertise your knowledge and skills that might be applicable elsewhere if that also advertises to direct competitors what your capabilities are. For matching issues that lead to innovations that benefits a larger range of actors in an industry, there is relatively low incentive to advertise what you currently have. A third party facilitator might be of use here and that is where governments might step in to the mix.

All of these factors suggest roles for the government in focussing innovative attention – perhaps on priority areas such as the environment, health and education where their own needs are well-defined – as well as on setting up institutions that facilitate matching in an independent and robust manner. And indeed this role has been recognised through various attempts to facilitate commercialisation (e.g., the Australian Institute for Commercialisation, InnovationXchange and the Australian Technology Showcase). The government is seen as a neutral party in such facilitation but many such functions have been outsourced in the past; something that would appear to be an inherently difficult exercise. Below, I suggest that the government's role be changed in this regard to bring together, particularly demand-side, interests and then to facilitate market-based funding mechanisms that will generate a higher return to finding good matches.

Summary

The gap between the private and social supply of resources for innovative activity is driven by many, sometimes related, factors. This means that approaches to resolving them will also likely be multi-faceted.

But it is not simply generating *more innovation* that is the goal. To be sure, conditions under which more resources will gravitate towards innovative activity will be related to the usefulness of those innovations. However, it may also be that some interventions may trade-off the returns to resources with the level of use of the innovation. When this occurs, we have to think carefully about the costs and benefits of creating more innovation of that kind.

The Case for Australian Innovation

It is sometimes argued that while there may be a strong case for government intervention to promote innovation on a global scale, the case for Australian-sourced innovation is different. The rationale is that the Australian economy benefits from innovations generated elsewhere and that to have any promotion of Australian-sourced innovation is to duplicate efforts elsewhere.

Countering this are arguments that 'it takes one to know one' (that is, if we don't innovative we can't absorb innovations from elsewhere) and 'we are big in some industries' (that is, in agriculture and mining, for example, we are world players and hence, our innovations matter here for our continued advantage in competition with the world).

Innovation Index, 2006

Country	Rank	Index
USA	1	220.3
Finland	2	180.3
Sweden	3	154.2
Japan	4	147.5
Switzerland	5	145
Denmark	6	143.3
Canada	7	111.4
Germany	8	100
Norway	9	95.8
Iceland	10	76.6
France	11	74.8
Netherlands	12	72.3
Australia	13	62.5
Austria	14	62.2
Belgium	15	61.7
UK	16	59.2
Ireland	17	39.8
New Zealand	18	28.5
S Korea	19	27.5
Spain	20	21.9
Italy	21	16.7
Greece	22	8.8
Czech Rep	23	6.9
Portugal	24	6.9
Hungary	25	4.7
Slovak Rep	26	3.6
Poland	27	2.6
Mexico	28	1.3
Turkey	29	0.3

In 2006, Richard Hayes and I set out to sort through these arguments by utilising inter-country data to **ask whether Australian productivity benefited from domestic innovation?** We found that 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.[1]

When we separated out the impact of Australian R&D expenditures on Australian productivity we found 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.

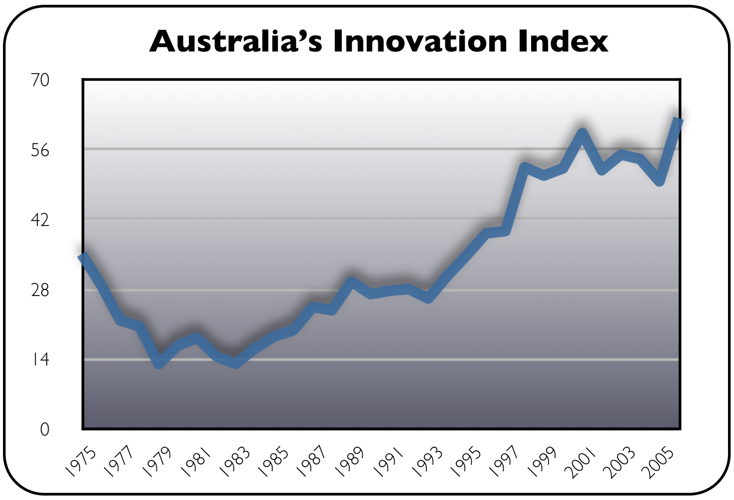
More worrying is that the impact of foreign R&D on domestic productivity is lower (albeit not significantly) for Australia than the average OECD country. Hence, our growth rate is relatively more sensitive to the share of R&D conducted domestically than others would be. We

[1] The results are contained in Joshua Gans, "The Economic Case for Public Support of Science and Innovation," *Submission to the Productivity Commission Inquiry into the Public Support for Science and Innovation*, June 2006.

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.



The Drivers of Australian Innovation

Of interest for this Review, however, is the question: **how far can Australia go when it comes to innovation?** Quite often, policy-makers express a view that Australia is small, has limited presence in 'high-tech' industries and can and has benefited from innovations coming from elsewhere. Why invest in our own innovative potential? And even if we did invest, would we really rank in the world in terms of the generation of knowledge?

A challenging task in this regard is how to benchmark our performance as an innovator? Put simply, concentrating on our own core industries -- agriculture, mining, among others -- can also make it easier to excuse poor performance elsewhere. How do we know we are performing well as an 'innovator' when we are innovating in different areas than other countries?

Other past few years, I have been involved in a project that tries to bridge the 'comparison' divide in innovative performance. It does so by looking at one common measure of innovative output -- a country's level of international patents generated per capita -- and understanding the broad drivers of that output both historically and across countries. It turns out, those drivers include elements of a common innovation infrastructure (R&D expenditure and personnel; public expenditure on education, IP protection), fostering a cluster-specific environment (industry funded R&D, specialisation and openness) and the quality of linkages (university-based R&D).

The end result of this econometric analysis is a tool -- the National Innovative Capacity Index or Innovation Index, for short -- that predicts, based on a country's choice with respect to those drivers, how well it will perform in innovation (not just in patenting but more generally) in a few years time. If we look to that measure we can see how Australia is performing over time and in comparison with other countries -- big and small alike.

The National Innovative Capacity Index

The National Innovative Capacity Index examines **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). For five years, 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 and most recently, Gans and Hayes, 2008). 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.

To emphasise, our study finds that R&D performed by Universities is a significant driver of a country's innovative capacity. This finding takes into account all of the other potential drivers of innovation by a country. Thus, **it gives us confidence that supporting innovation conducted by Universities will enhance a country's rate of innovation**.

Recent Performance

The latest update of the Innovation Index uses data available through to 2007.[2] The following figure and table summarise the outcomes as they relate to Australia. Since 1996, Australia's innovative capacity has been relatively stagnant. This is in contrast to significant growth through the 1980s and early 1990s that allowed Australia to break free of its classic 'imitator' economy status. While the last year saw some gains, these are related more to strong relative macroeconomic performance than policy decisions per se.

In comparison with our peer economies, Australia's relative position has been constant and it lies in the middle of the second tier innovator countries and well below the top tier.

While this gives a picture of current performance, this tool also allows us to consider what the impact of changes in key policy variables would achieve. For example, one of the reasons Australia's performance has been steady but not growing has been a fall in the policy variables of public expenditure on secondary and tertiary education (now at 3% of GDP) and the share of R&D conducted in universities (now at 27%). Those variables achieved historic highs around 1996 and 1997; at levels of 3.41% and 28.65% respectively. However, if we were to immediately restore those levels, Australia's innovation index would only rise by about 7% to 66.8.

This indicates that more has been lost during the past decade of degradation and policy neglect than time. Simply restoring policy parameters to historic highs will not bring Australia to a new status in innovative capacity.

On the other hand, what if Australia were to target the performance of countries in the Top 10, on these policy variables. For instance, Norway's government spends 5.18% of its GDP on secondary and tertiary education and 30.9% of its R&D is performed within universities. If Australia matched that performance, its innovation index would rise to 84.2. This would be a considerable level of growth in innovative potential as well as placing Australia in the Top 10 in the world; at least based on present day calculations.

Thus, great improvements in our innovative capacity are not beyond our means. Australia can take its place as a leading innovator in the world without 'breaking the bank' in terms of unrealistic policy goals. Hopefully, the new government will think beyond traditional innovation programs towards a widespread set of policies to put us on this path.

---

[2] The full report on the index is Joshua Gans and Richard Hayes, "Assessing Australia's Innovative Capacity: 2007 Update," Centre for Ideas and the Economy, Melbourne Business School, February 2008. It and previous reports are available at www.mbs.edu/jgans.

Promoting Innovation

Current Ways of Promoting Innovation

In this section, I review current methods governments in Australia use to promote innovation and encourage more resources to innovative activity.

Intellectual property protection

By the far the most common form of government intervention to stimulate innovation is intellectual property (or IP) protection. This protection takes the form of insulating innovators from imitative competition. The benefit of this is that it redresses potential short-falls in the ability of innovators to appropriate profits – whether it be through product markets or through ideas markets. This protection varies from the patent system that prohibits others from commercially exploiting similar products to the innovator's, to copyright which prohibits unauthorised copying of innovative works, and trade secrets which allows innovators some control over the flow of information.

However, this method of intervention comes also with a potential cost in terms of the use of the innovation. Put simply, it locks in a monopoly situation for a period of time, leading not only to higher prices but also to difficulties for others in building upon the innovation (that is, it may harm cumulative innovation).

Tax benefits and subsidies

A straightforward way of encouraging more resources into innovative activity is a tax credit or a subsidy. Such payments are made on the basis of total expenditures on research and development activities (as in Australia's R&D Tax Credit). Others might be paid based on the employment of scientists or as a tax break on capital investment.

The main issue with such open-ended subsidies is not that they do not encourage innovative activity – they do and most legitimate expenditures will claim the tax credit. Instead, the problem is that it is difficult to develop easy ways of monitoring whether a given set of expenditures is R&D related or not. Consequently, there is a concern that the subsidy extends across too many activities; costing more than it should for the innovative activity it is encouraging. For the same reason, open-ended subsidies make it difficult to budget for and leave governments exposed to fiscal risk.

What is more, in order to claim a tax credit you have to be earning income. Most start-ups do not do this or even intend to do this in the first few years of their lives. Hence, it is a policy that tends to favour big business innovation.

Competitive reforms

One barrier to innovation and, in particular, appropriability, are regulations and impediments to competitive entry. Government microeconomic reform has been largely directed at 'cleaning up' and 'freeing up' these aspects of business activity. As Gans and Stern (2003) showed, such reforms were critical in enhancing the innovative capability of Australia in terms of increased productivity brought about by innovative technology adoption and organisational restructuring.

In areas of reform that are on-going, the potential for innovation policy to support the more rapid seeding of the benefits of such reform should not be ignored. For example, in areas of health where reforms can see the reduction in waiting list through more effective patient diagnosis, the adoption of technologies in support of those activities – especially in the public sector – should be given priority. Put simply, the reform 'payoff' is likely to be delayed without recognising the need to support private incentives to adopt key innovations.

Grants

Another way of lowering the costs of innovative activity is by the use of direct contributions or grants. These differ from tax credits and subsidies in that they are targeted and not open-ended. Clearly, by providing capital directly to make up for shortfalls in expected rates of return, innovative activity can be stimulated.

Grants are not, however, without potential problems. First, there are **information problems** that arise because scientists know more about the prospects flowing from a project than do funders. They may have incentives to over-claim potential contributions to attract funding; in particular, about potential feasible use as opposed to scientific merit.

For example, Kremer and Zwane (2003) report that in relation to agricultural innovation grants:

> Many technologies developed by push program scientists have been adopted at low rates in developing countries because scientists have failed to develop products that address constraints faced by farmers. Advances worthy of scientific acclaim, such as improved cowpeas that defoliate, that have seemed promising in a controlled environment have not translated well to mixed cropping environment in which farmers actually work. (p.14)

This suggests that while grants can be useful in stimulating innovative activity, there may still be issues in encouraging follow-on investment that yields commercialisable products.

Another issue with grants is that **project selection** is difficult. In many countries, political pressures can overcome scientific and commercial merit. They involve ties that, indeed, harm continued commercial development; such as requirements that products be manufactured in their home country (see Gans, 1998). In addition, political constraints may lead to poor location decisions for innovative activities and sites and also constraints on the ability to attract quality researchers at publicly capped wages.

Given these considerations, it is safe to say that grant programs are currently most effective for more basic research. Indeed, they have been successfully been applied in University-based scientific environments. It is useful to consider why they have been more successful there.

Put simply, academic-based research can minimise the costs associated with grants. The reason for this is that granting agencies have an instrument to ensure performance: they can cut off future funding. Combine this with the career incentives of academics and you have the elements of a solid performance system.

To see this, consider the role of a funding agency. It solicits proposals from researchers but it also requires researchers to submit their track record (this is typical in the ARC for example). They then adopt rules that deny funding to researchers who have not performed on previous grants. Thus, those researchers have strong incentives to perform, truthfully reveal expectations of success and merit and other desirable things to make sure they can meet those expectations and not be excluded from future funding.

What is also true about this is that it creates incentives to self-select the most productive researchers. A productive researcher knows that they will be proposing many more projects to the agency than on unproductive ones. Hence, they have the most incentives to manage expectations. Less productive researchers have little incentives and so will over-claim (and perhaps get away with this once). If the funding agency can also ramp up grants based on an extended track record, this aspect of the system becomes even stronger.

Note, however, that for this to work requires a long-lived funding agencies. Pushes or one-time expenditures on granted projects do not create proper incentives. The funding agency needs to have a memory longer than most political institutions.

Scientific reward

Apart from monetary means and IP protection, scientific reward is the principle means of promoting research and innovation. Indeed, many grants specify conditions for open access precisely to promote scientific research and encourage cumulative innovation.

Before describing how scientific reward works it is important to dispel a preconceived notion: that scientific endeavour does and must proceed independent of the ultimate use for that research. The premise of the traditional view of 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. Thus, it is important to keep in mind that the rationale for public support of science is to encourage research that is driven by use as well as understanding.

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.

When 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.

Science works to promote innovations that build upon on another because it rewards citation and continued use. 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**.

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.

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. 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.

Moving to a Market-Based Approach

In response to issues associated with common approaches to promoting innovation, recently, some have suggested more market-oriented approaches.

The pressure for this has come from those who are concerned that current approaches, while promoting innovation, do not sufficiently promote useful innovation and its adoption. For instance, Kremer and Zwane (2003, p.14) write:

> In an effort to improve adoption rates, recent research programs, such as the Cassava Biotechnology Network, have attempted to identify attractive technological advances by interviewing farmers about their perceived needs. While this may be an improvement over research programs that have no input from farmers' responses to survey questions may depend on how questions are asked; farmers may not know the scientific opportunities and challenges, and there may be opportunities for scientists to manipulate or ignore farmers' responses.

In that situation, it was a case of simply asking potential users to articulate their needs before presuming that a potential technological advance might satisfy a need.

The newer approaches have come under the rubric of 'pull' programs that specify needs first, in contrast, to previous ‘push’ programs that specify potential solutions first.

> One of the biggest advantages of push programs relative to pull programs (other than patents) is that they do not require specifying the output ahead of time. A pull program could not have been used to encourage the development of the Post-It Note® or the graphical user interface, because these products could not have been adequately described before they were invented. Kremer (2001)

In situations where it may be possible to specify and communicate a need, then ‘pull’ programs might be effective in procuring high quality solutions to key problems that industries face. Put simply, the efficacy in ‘pull’ programs comes from a realisation that there is a potential for the government to facilitate matches between need and technical knowledge and that it is the effort in articulating needs and the search for research that might resolve those needs that is holding effective innovation back.

Here I outline some of the ways in which ‘pull’ programs might be implemented and discuss potential issues or difficulties with each approach.

Prizes

Perhaps the simplest ‘pull’ program works as follows: there is a need with a performance metric. The first research team to resolve the need and exceed that metric gets a cash payment. This is referred to as a ‘prize’ model.

There are examples of such models being sporadically tried by governments and private benefactors (most notably Google’s Larry Page, the Virgin Earth Challenge and the X Prize foundation). More recently, the US DVD rental distribution company, NetFlix, has offered a million dollar prize for a better customer information assessment system that outperformed its existing system by a certain amount (Leonhardt, 2007). The contest will run for 5 years.

Some economists favour prizes over IP protection. Joseph Stiglitz makes the case for prizes rather than patents.

> A scientific panel could establish a set of priorities by assessing the number of people affected and the impact on mortality, morbidity, and productivity. Once the discovery is made, it would be licensed.

Stiglitz notes the problem with patents for medical drugs and technologies: high price = more illness/deaths. His solution is to ensure low prices by having governments fund prizes for proven innovations. So consumers pay indirectly through the tax system.

Prizes tie the innovative reward to performance and they allow for competition in claiming that reward. It is a highly incentivised system that doesn’t actually require any money up front or for failure. However, to work the prize amount has to be high enough (there is risk being borne by entrants) and the terms have to be clear enough. What is more, the prize needs to be a credible contract as performance may take years to achieve.

So when it works, a prize system can be highly desirable. The issue is that it doesn’t work for all innovations. First of all, many attempts have been made to use the internet to set up markets whereby firms specify needs and a prize and others compete for them. However, these appear to have been rather thin markets. Second, it is sometimes hard to define performance metrics that can be immediately monitored. For instance, a prize for a vaccine might be awarded only to discover years later that the solution has unwanted side effects.

Related to straight out prizes are research tournaments. A tournament has a fixed duration and specifies a prize to the research team that makes the most ‘progress’ according to a performance metric. Tournaments are less risky for entrants because a prize will be awarded and there is no risk in terms of a threshold performance target being unrealistic. However, the other side of this is that the promoter may have to pay for whatever progress there is in any case and may not get value for money. In addition, this suffers from many other issues associated with performance metrics including the potential for politics and favouritism in award decisions. It also runs the risk of collusion amongst participants who might keep effort down. Nonetheless, the NetFlix example appears to satisfy this as it is not an award for the first team to achieve a ten percent improvement but the team that progresses the most beyond ten percent in five years. That might end up buying NetFlix lots more than it expected.

Finally, as noted earlier, microeconomic reforms have raised the returns to entry into certain industries. In particular, there are profits to be had to those who access markets quickly and effectively. One can liken this to a prize released by government for innovative entry. This has been most clearly seen in utilities industries with rushes to invest in modern infrastructure as well as in support of other government initiatives (such as the environment) but also in public firms such as Australia Post who have faced threats as a result of open access to their traditional lines of business. Finally, where governments have engaged in open tender processes, these have prize like qualities that stimulate innovation. An excellent example of this is Transurban’s development of the eTag system; largely in response to Victorian government stimulus.

Matching Grants

Another form of ‘pull’ policies involves matching grants and is commonly applied in Australia. For example, the Australian Research Council has linkage grants that require researchers to have an industry partner putting in cash or in-kind resources.

The idea of a matching grant is that it requires someone other than the public provider to find value in the research proposal. Presumably, that value arises because of an immediate need as opposed to purely scientific merit. However, its effectiveness rests on the ability of that private agent to assess the quality of those institutions and labs whom it is linking with.

Matching grants are also useful in saving the public funder from having to investigate the overall likelihood of the project’s success. It can be presumed that a private funder would engage in such investigations. Hence, so long as the matching requirement is stringent enough, poor projects will be weeded out and more good projects will be able to go ahead.

Advance Purchase Commitments

It was noted earlier that two of the main constraints on private investment in innovation are, first, that monopoly pricing may lead to under-supply of the innovation and, second, that matching issues require investments by users as well as innovators. Michael Kremer (2001b) has proposed the use ‘advance purchase commitments’ to overcome these issues in markets for vaccines.

His proposal is as follows. A government specifies what it is willing to pay per dosage for a vaccine. It writes this as a binding contract. Pharmaceutical companies then compete to, first, develop a vaccine, and, second, if there are competing vaccines, to encourage use of them. For each treatment they sell, they receive a co-payment from the government (perhaps 100 percent) in return for a fixed price to consumers. In this way, the government can set, in advance, a price based on the social value of the vaccine but it only has to pay this is a vaccine is developed. As noted earlier, the Australian PBS has some of these elements but instead of a prior commitment, it allows pharmaceutical companies the option of monopoly pricing. Kremer’s proposal goes further especially for innovations that would not otherwise be developed.

This proposal allows vaccines to be distributed widely, forces needs to be exposed, is cost effective (pay only on receipt) and encourages competition. What is more is that there is no reason why it could not apply to innovations beyond vaccines. The main requirement is that the government or industry be able to write an up-front contract to commit to purchases. While this might not hold for basic research, for much applied research, it is surely possible.

Creating a market for an innovation is similar to direct procurement. However, with procurement, the tender process identifies the supplier. With an advance purchase commitment, the procurement terms are set and the competition to create the innovation replaces the tender process. Other than that the economic considerations are very similar.

Put simply, it “might be more efficient to have problems seeking solutions than solutions seeking problems.” (Hellmann, 2007, p.626) As an MIT engineer noted:

> With university technologies you pull the technology out and you run around saying ‘Where can it stick?’ It’s probably better to say I’ve heard about these problems and I think I can solve it. But with companies coming out of MIT, it’s always the same thing, what do I do with it to shoehorn it back into industry. (Shane, 2004, p.204)

Thus, the creation of markets for innovations can turn the tables on how matches are realised.

There are three areas where advance purchase commitments would likely be most fruitful initially.

- *Dissemination of existing technologies*. Previous government expenditures have encouraged basic research and also the identification of potentially commercialisable products. An advance purchase commitment could be made for some of these products in order to encourage them to be commercialised and brought to market. In that way, the existing pool of developed technologies could be identified and exploited.

- *Technologies related to government policy*. Government policies – especially where they are areas of active reform such as health, education and the environment – often have innovative needs that are related to those reforms. As part of the reform agenda, advance purchase commitments could be set-up.

- *Supporting grant programs*: the government may wish to consider a broad-based grant program for small business innovation (such as the SBIR program in the US) but adding to it an advance purchase commitment to ensure useful results. This would provide some commercial certainty of the new solution, underwrite some initial sales (thereby enabling attraction of private sector capital - getting back to our discussion of “pulling” private capital into the innovation space) and development of skills/know how.

These areas demonstrate a role for government in creating markets for innovations. In addition, government could facilitate industry groups to match funds for this purchase and to associate to identify common needs; in this way, internalising spillovers between them.

Funding Mechanisms

Encouraging market-based mechanisms

As discussed above, demand-pull or market-based mechanisms have not been deployed in Australia as a means of promoting innovation. These mechanisms allow matching problems to be overcome but require a focus on articulating problems as well as the means of bringing the knowledge to solutions forward.

Here I describe two possible means of achieving a market-based approach: government procurement and industry bodies.

Government procurement

As noted earlier, users can be a source of innovative ideas and solutions. In some cases, those ideas have been developed and have been proven to work but simply have not been disseminated. Moreover, if an issue in generating innovations is to resolve the matching problem, then the government as a large user, can also play an active role in articulating problems that need to be solved.

At any level, governments stand out as large purchasers and users but not necessarily as entities with unique needs. This means that:

(a) governments can use their role as a large buyer to promote services that will be developed beyond intended governmental uses; and

(b) governments can specify advance purchase commitments to find solutions to existing problems they face (i.e., “fuzzy RQFs”)

Consequently, there is a direct role for the government as part of its procurement function to foster innovation in the economy.

The experience of changes in government procurement policy in the United Kingdom are informative in this regard. In a 2007 UK Treasury report on *Transforming Government Procurement*, it was noted that:

> It is much easier to evaluate the costs and benefits of a tried and tested product, rather than something that may not have previously been used in practice, or may not even exist at the time the Government first considers using procurement as a means of solving a complex delivery problem. However, if a new and

better solution is already developed or could be made available, this might provide better value for money than a tried and tested product.

And, indeed, this type of procurement of innovative solutions has begun. In the Whitehall area, an opportunity to coordinate the needs of various departments was found using a combined power and heat system. This, in particular, led to better management in order to reduce carbon emissions.

Moreover, in some areas of government in the UK, advanced purchase commitments have been utilised. For instance, in looking for more effective ways to purchase and dispose of prison mattresses, an advanced purchase commitment attracted 35 innovative solutions (including different materials to alternative recycling systems).

What this means is that **the government should take an active role in putting innovative elements into its procurement practices**. This not just a short-term role but a leverage of the government's existing role. This could be achieved by **adding a 'novelty' component (to promote new solutions to a share of government service outsourcing) and a 'spillover' component (to add explicit consideration of the benefit a government contract could yield on the provision of new innovations throughout the broader economy).**

Industry bodies

Related to the notion that government can have a role in articulating problems for which solutions might be available, industry also has that role. At present, individual firms in an industry (unless they are large relative to the industry) have little incentive to publicise problems they have that are in need of solutions. That lack of incentive impedes the ability to resolve the matching problem.

There is a role for government in promoting the use of industry bodies to gather firms together and agree upon problems that they have a common interest in resolving. The bodies could articulate these problems and also enable market-based mechanisms to generate innovative solutions: for instance, by offering prizes and advanced purchased commitments. Where government and industry have common interests, a sharing arrangement could be entered into that funds these mechanisms.

In this way, **the government could act as an honest broker in the marketplace for ideas; bringing together those with problems and those with technical know-how and the ability to find solutions**.

Linkages between science and industry

Perhaps the most challenging part of the government's role in promoting innovation is to engender linkages between science and industry. The National Innovative Capacity project has already highlighted that such linkages are a significant driver of a country's predicted innovative performance. And, as already noted, the government plays an active role in promoting science and also the commercialisation of that science. However, in so doing, both scientists and economists often fail to recognise that science is a distinct institution for directing resources to innovative activity. What I want to suggest here is how recognising that can generate alternative and useful approaches to fostering linkages between science and industry.

A Balanced Approach

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.’ Indeed, such notions suggest that not only should be not require scientists to commercialise research but, in return for receiving public funds, they may be prevented to some extent from such commercialisation; especially if it conflicts with goals of openness and the dissemination of scientific knowledge (something that I will consider in more detail below).

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). These reduce market-based returns to innovation but absent any institution in those firms for cumulative knowledge accumulation 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, at a first pass, **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.

Funding restrictions on science

Let’s begin with potential funding constraints on scientists. When a scientist receives funding from the government or from non-commercial sources, it is usually assumed that they will seek to publish or otherwise make known their research. Such openness is a fundamental characteristic of science and, that, along with a tradition of citation, gives rise to the reward system that motivates scientists. In addition, there may or may not be restrictions on patenting possibilities. In the US, prior to the *Bayh-*

Dole Act in 1980, government funded research could not be patented. Today, it can be and there was a corresponding rise in University patenting activities.

As noted earlier, one of the main goals of government funding of science is fostering cumulative innovation. **Publication** does this directly. **Patenting** may or may not do this. Specifically, while patenting involves disclosures, there is also concern that it can give rise to an 'anti-commons' problem that chills follow-on research (Murray and Stern, 2006).

A grant of government money can do various things. First, it could require publication. Second, it could prohibit patenting. Third, it could require commercialisation. The latter option can often be associated with no publication (as commercial interests seeks to keep knowledge secret) and patenting (as commercial interests seek to strength intellectual property protection). Of course, the traditional argument for requiring commercialisation is that it facilitates the application of scientific knowledge in industry.

In recent research, I have become concerned that requirements to commercialise may 'crowd out' private funding. To consider this, suppose that government funding required publication and prohibited patenting. Imagine also that there are projects being considered for funding that may have high scientific merit, high commercial benefit, both or neither. When commercialisation is restricted, private funders will be loathe to rely on government-funded research outcomes. Instead, they will see opportunities to engage with key scientists in the area and negotiate with them to 'opt out' of the government system and accept some commercialisation options. Note that when projects have both high scientific and commercial benefits, to get scientists to work with them, firms may well permit publication (as this lowers costs and motivates scientists). The end result is that scarce government funding will be allocated to projects with low commercial prospects but high scientific ones while private funding will take care of the high commercial prospects.

Now suppose that commercialisation is mandated. This makes accepting government money very attractive for firms. Consequently, some projects that have high commercial merit will now attract government funding. But the cost of this is that those projects may not be as open *and* other projects of high scientific merit will find it harder to compete for government funds. Thus, **rather than increase the pool of funded projects, requiring commercialisation actually reduces them as private funding is crowded out by government funding**. If government funding can require publication, then there may be some increase in openness but the crowding out remains.

By considering what projects might get funded by private sources when government funding rules change, **it is clear that mandating commercialisation might backfire and, instead, there is merit to focusing on requiring full disclosure through publication and, if there is patenting, an open license or other means that can ensure that patenting does not harm follow-on researchers**. I recommend, therefore, that the Review re-consider the requirements in many government grant projects for commercialisation as a condition of government funding.

That said, private funders do face risks in funding research in Universities and 'dealing with academic issues.' They may fund research only to find that the direction taken has not yielded the commercial outcomes they hoped for. They may not have as much control over an academic scientist as they would their own employees. For this reason, there may not be the level of funding for these projects than there could be.

To deal with this, the government should consider a *menu* approach to funding and funding restrictions. It could bear the risk of dealing with norms of academic freedom by funding projects that may have stronger commercial projects but imposing the restrictions on commercialisation **unless a private funder were to 'buy back' an ability to engage in unfettered commercialisation**. Thus, if it turned out that a project yielded high commercial projects that depended upon an ability to patent or some restrictions on publication, the commercial funder would come back to negotiate with the scientist for a release from restrictions tied to the project and would pay back to the government, all or part of, the payments to that project. In this way, commercial prospects could be exploited, academic risk could be borne by the government, and crowding out -- after the fact -- would be reduced.

In summary, **I recommend that government-funded projects have a default promoting openness through publication and open licensing but with a menu of options to allow those rights to be purchased from scientists/government**.

Promoting commercial funding of science

An implication of the previous discussion is that the funding given directly to scientists should be on a distinct basis from funding we would expect industry to give those scientists. That would minimise the potential for crowding out. However, that said, there is still, for reasons discussed at the beginning of this submission, a role for the government in stimulating private funding of science more directly.

At present, linkage grants and the Cooperative Research Centres are granted on the basis that there is a promotion of industry commercialisation. In that respect, I am concerned that these are substituting for capital that would otherwise be provided by private sources. That is, it is not clear that these create new linkages.

That said, each of these do target a factor that, as noted earlier, does drive innovative capacity -- that is, fostering linkages between the infrastructure of science (based in our universities) and clusters for innovation (based in some key industries). 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.

Instead, therefore, of a micro-managed process of providing funds to projects that have linkages, **we need policies that actually create new linkages where they are not or are unlikely to be**. This could be achieved by gearing the R&D tax credit to have a higher return for industrial research performed by universities. Thus, firms who engaged with scientists in Universities would receive tax breaks. 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 (after all, working with academics requires different costs imposed on firms than simply re-classifying their existing activities). Combined with alternative grants that are free of commercialisation mandates, we could be more assured that new linkages were being established.

In summary, **it is important that we structure our policies to promote commercially funded research alongside those that promote open scientific research. Recognising the different strengths and potential synergies between open and commercial science can lead to a more coherent and effective set of funding outcomes**. (It should be noted that these considerations apply equally to prizes as well as grants).

A need for coordination and commitment

Governments – both Federal and State – in Australia have engaged in a plethora of policies directed at stimulating economic growth by enhancing innovation through R&D and from scientific expenditures. In some cases, these policies have resulted in long-standing institutions; including IP Australia, the CSIRO and the Australian Research Council. For many others, the programs have been piecemeal or 'once-off' with limited long-term commitment.

To be successful in stimulating innovation where the market fails to provide adequate levels, policy commitments are required. The investments in research and development involve risk and long time horizons. To encourage private funders to devote resources to such investments and to encourage people to similarly invest in required skills and human capital, requires that any stimulus provided by government policy persists through the investment to the return stage. Moreover, as the most productive innovations are cumulative – with tomorrow's inventions building on those from the past – persistent and stable government policy can ensure that technological pushes do not fizzle but continue on in a self-reinforcing fashion.

To this end, the most successful government interventions to stimulate innovation around the world involve long-term commitments and institutions built by those governments. Moreover, because political and economic cycles differ from innovation cycles, this usually involves creating an institution that operates independently from government executives and legislatures. It has an independent budget, governance with some periodic ministerial oversight over key appointments.

Australia has recognised the importance of independent authorities in other key economic areas. The RBA and the ACCC operate on this basis. Indeed, as noted earlier some elements of innovation policy also operate with some independence, although not to the extent of the two main economic institutions.

For this reason, **I believe that the Federal government should explore creating a new Commission – the Australian Productivity and Innovation Commission (APIC) – that would fulfill this role**. It would have a lasting imprint on the Australian economic system and systematise what has been in the past periodic.

What functions would rest in APIC?

The broad goals of APIC would be as follows:

- To administer government grants (and prizes) towards science and innovation to ensure that an appropriate balance of cumulative accumulation of knowledge and immediate applicable use in industry and government is achieved.
- To ensure that government funded research is linked in with intellectual property protection in a way that stimulates private investment, appropriate commercialisation, maximum returns to innovation, diffusion and the cumulative accumulation of knowledge.
- To direct research towards areas of priority and assist government areas in procuring innovative solutions to policy and social problems.
- To facilitate the flow of knowledge between universities and industry.
- To coordinate industry bodies and collect information in a broker role.
- To evaluate the performance of Australian research – in both industry and government – and identify gaps and areas for additional stimulus.

To this end, the functions of APIC would incorporate functions currently residing in:

- IP Australia: management of intellectual property rights protection and the knowledge of the operation of this system towards business and government
- The Australian Research Council and NHMRC: provision of scientific grants and fellowships
- The CSIRO: government directed research into priority areas
- The Productivity Commission and ABARE: some of the review work with regard to policy performance
- The Higher Education Endowment Fund: the provision of research infrastructure in universities
- Other programs: the Australian Institute for Commercialisation, management of the CRCs, the remainder of Backing Australia's Ability.

This is not to suggest that these organisations would be merged into APIC (although that is a possibility that would allow synergies to be captured and managed) but that some of their functions may be transferred to it.

How would APIC be governed?

There are two possible governance modes for APIC both with a degree of on-going independence save for the appointment of top level personnel.

- Directorate + Board: This would involve a main directorate who reports to a diverse board for key decisions. This is akin to the RBA's governance structure. The Directorate and Board would be government appointed.
- Commission: This would involve a managing set of commissioners who determine all key decisions. This is akin to the ACCC's governance structure.

Given the diverse range of activities that may reside in APIC, a Commission structure would likely be more appropriate. This would allow key expertise to reside with commissioners.

In summary, **it is widely agreed that innovation policy needs commitment and coordination. It is difficult to see how this could be achieved without an over-arching, independent authority of the kind we have seen elsewhere in economic management**.

References

Aghion, P., M. Dewatripont and J.C. Stein (2005), "Academic Freedom, Private-Sector Focus and the Process of Innovation, Harvard *Working Paper*.

Arrow, K.J. (1962), "Economics of Welfare and the Allocation of Resources for Invention," in R. Nelson (ed.), *The Rate and Direction of Inventive Activity*, Princeton: Princeton University Press.

Bush, Vannevar (1945). *Science: The Endless Frontier*. Washington (DC): Government Printing Office.

Dosi, Giovanni, Keith Pavitt and Luc Soete (1990). *The Economics of Technical Change and International Trade*. New York (NY): Columbia University Press.

Duncan, M., A. Leigh, D. Madden and P. Tynan (2004), *Imagining Australia: Ideas for Our Future*, Allen & Unwin.

Gans, J.S. (1998), "Driving the Hard Bargain for Australian R&D," *Prometheus*, Vol.16, No.1, March, pp.47-56.

Gans, J.S. (2003), "The Value of IP Protection in Markets for Ideas," *Australian Intellectual Property Law Bulletin*.

Gans, J.S. and R. Hayes (2008), *Assessing Australia's Innovative Capacity: 2007 Update*, Melbourne Business School (http://works.bepress.com/joshuagans/16/).

Gans, J.S., D. Hsu and S. Stern (2002), "When Does Start-Up Innovation Spur the Gale of Creative Destruction?" *RAND Journal of Economics*.

Gans, J.S., F. Murray and S. Stern (2008), "What drives scientific disclosure?" *unpublished paper*, Melbourne Business School.

Gans, J.S. and S. Stern (2000), "Incumbency and R&D Incentives: Licensing the Gale of Creative Destruction," *Journal of Economics and Management Strategy*, 9 (4), pp.485-511.

Gans, J.S. and S. Stern (2003), *Assessing Australia's Innovative Capacity in the 21st Century*, IPRIA *Working Paper*, (www.ipria.org).

Gans, J.S. and S. Stern (2003a), “The Product Market and the ‘Market for Ideas’: Commercialization Strategies for Technology Entrepreneurs,” *Research Policy*, Vol.32, No.2, February, pp. 333-350.

Gans, J.S. and S. Stern (2003b), “When Does Funding Research by Small Firms Bear Fruit? Evidence from the SBIR Program,” *Economics of Innovation and New Technology*, Vol.12, No.4, pp. 361-384.

Hellmann, Thomas (2007), “The role of patents for bridging the science to market gap,” *Journal of Economic Behavior and Organization*, 62, pp.624-647.

Jones, Chad (1998). *Introduction to Economic Growth*. New York (NY): W.W. Norton & Company.

Kremer, M. (2001), “Creating Markets for New Vaccines – Part I: Rationale, Part II: Design Issues,” *Innovation Policy and the Economy*, Vol.1, pp.35-118.

Kremer, M. and A. Zwane (2003), “Encouraging Technical Progress in Tropical Agriculture,” *mimeo*., Harvard.

Leonhardt, D. (2007), “You want innovation? Offer a prize,” *New York Times*, 31st January.

Levin, R., et.al. (1987), “Appropriating the Returns from Industrial Research and Development,” *Brookings Papers on Economic Activity*, 3, pp.783-831.

Merton, R.K. (1973), *The Sociology of Science*, Chicago: Chicago University Press.

F. Murray and S. Stern (2006). "Do formal Intellectual Property Rights Hinder the Free Flow of Scientific Knowledge? An Empirical Test of the anti-Commons Hypothesis." NBER *Working Paper* 11465. Forthcoming at *Journal of Economic Behavior and Organization*.

Oliver, Susan (2006), “Skills, new models for the innovation economy,” *mimeo*.

Porter, Michael E. and Scott Stern (1999). “Measuring the ‘Ideas’ Production Function: Evidence from International Patent Output,” *mimeo*, MIT Sloan School.

Porter, Michael E., Scott Stern and the Council on Competitiveness (1999), *The New Challenge to America’s Prosperity: Findings from the Innovation Index*, COC: Washington.

Romer, Paul (1990). “Endogenous Technological Change,” *Journal of Political Economy*, 98: S71-S102.

Rosenberg, Nathan (1982). *Inside the Black Box: Technology and Economics*. Cambridge (UK): Cambridge University Press.

Rosenberg, Nathan and L.E. Birdzell, Jr. (1987). *How the West Grew Rich: The Economic Transformation of the Industrial World*. New York (NY): Basic Books.

Shane, Scott (2004), *Academic Entrepreneurship: University Spinoffs and Wealth Creation*, Aldershot Edward Elgar: Northampton (MA).

Stokes, D. (1997), *Pasteur's Quadrant: Basic Science and Technological Innovation*, Washington (DC): Brookings.

Stern, Scott (2004), "Do Scientists Pay to be Scientists?" *Management Science*, June.

Stern, Scott (2005), *Biological Resource Centres: Knowledge Hubs for the Life Sciences*, Washington (DC): Brookings.

Von Hippel, Eric (2005), *Democratizing Innovation*, MIT Press: Cambridge (MA).