Australian Federal Senate Economics References Committee Inquiry into:

Australia's Innovation System

This submission to the Inquiry is from my perspective arising from a 25 year international working career spent at the interface between industry and academia – developing and commercialising technology, creating new innovations that drive economic growth and social progress. Sometimes those endeavours have succeeded, sometimes not. The experiences however have taught me that Australia has the ingredients and capacity to create a world leading innovation ecosystem that would drive our economy for decades, possibly generations – but we must address fundamental obstacles to enable that outcome.

Australia's current innovation system actively discourages and dis-incentivises true innovation.

- The vast majority of Commonwealth spend on (so-called) "innovation" is actually spent supporting *invention* and a relatively lesser portion supports true *innovation*.
- **Invention** is the realm of research and discovery, basic science and the development of new ideas and knowledge. **Innovation** on the other hand is the new and successful application of those ideas to address issues. The distinction between invention and innovation is important because the blurred lines in popular/vernacular usage creates structural flaws in our innovation systems.
- Australia's academics are a significant intellectual resource. As a national priority we need them to actively drive, facilitate or contribute to true innovation at all levels of society. Australia's innovation systems however, squander this resource. Through incentives policies we explicitly encourage and manage our academics to deprioritise commercialisation of their work and to pursue instead a model governed almost exclusively by publication and citation.
- Australian industry has a very poor record of collaboration (with suppliers, customers and especially with academia) and, as a broad generalisation, consequently fails to recognise, develop or implement many progressive innovations that could otherwise result.
- Significant and frequent changes to government-driven innovation support systems available to industry greatly complicate the landscape for companies, particularly SMEs, and make it hard for them to embrace that support.
- Widespread technology literacy greatly enhances efforts to encourage innovation. We don't have this literacy in Australia – the issue arises in our primary schools and is entrenched through the secondary system. Unfortunately our schooling systems operate without a nationally coordinated strategy for the STEM subjects (science, technology, engineering and mathematics). A knock-on effect is a lack of school leavers emerging from that system with a passion for technology, which in turn for instance leaves Australia near the bottom of the OECD rankings for the number of engineers per head of population – a metric that correlates strongly with economic growth.

These issues are not unrelated. They are heavily interconnected and in many cases represent direct cause and effect. The measures to address these issues are equally interconnected.

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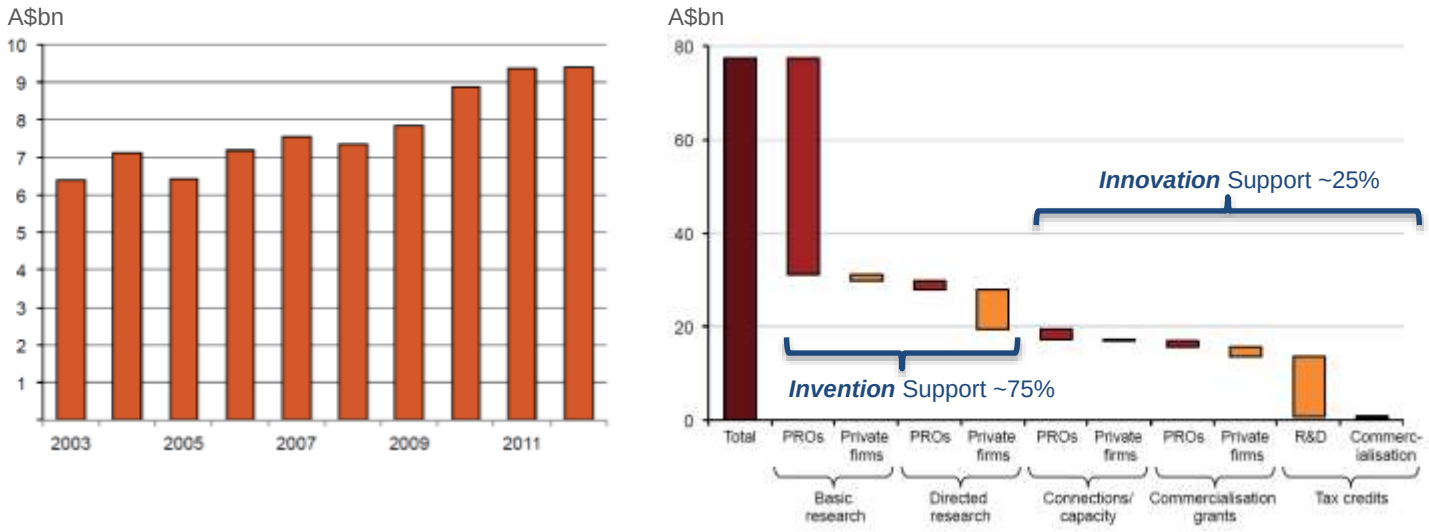
Australians have a long a successful record of inventing. Despite significant ingenuity and capacity for innovation, we have by contrast a poor record of implementing and delivering sustained innovation. Historically there are many fine examples of excellent Australian innovations, however they stand alone as isolated examples. Typically our national system and institutions strongly support and encourage *invention*, and we hope (and sometimes I think we merely pray) that *innovations* will magically arise from that. Sometimes they do. But we are yet to successfully systematise or institutionalise the transition from invention to innovation, rather we seem to rely on a presumed good fortune here in *The Lucky Country* to carry the day[1].

Innovation is not invention, and it doesn't happen by accident.

They are different. Basic research and ideas generation is invention. Australia has a good track record of invention – we encourage it, we incentivise for it. By contrast, innovation is "*ideas, successfully applied*"[2] – and this we need to get significantly better at.

Unfortunately the terms are mixed in common usage with the distinction between them often lost. For instance whilst Australian public spending on "innovation" (a term as used by government departments, treasury, etc.) has averaged the best part of A$8-9bn/year over the last decade, at most a quarter of those funds (partitioned on a very generous basis) are spent supporting actual innovation. By contrast the bulk of Australia's public spending on (so called) "innovation" is actually spent on more basic research – on invention.



(a) *(b)*

Figure 1 ***Australian Commonwealth Spending on "Innovation" 2002/3 – 2011/12***
(a) Total annual expenditure [$bn], 2003-2010 actual, 2010/11 estimated, 2011/12 as budgeted.
(b) Spending by category & recipient 2002-2012 [$bn] (PRO = public research organisation)
Source: Grattan Institute (http://grattan.edu.au/static/files/assets/128005de/901_daley_alliance_21.pdf)

With such significant commonwealth spending deployed on invention (through the support for basic research efforts) what outcomes might we expect for our money? Perhaps Australians expect a significant number of discoveries and breakthroughs and ideally significant application of those discoveries as new innovations driving economic growth. That would be great.

The reality is a little different.

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[1] And miss completely the intended irony of the title of Donald Horne's 1964 book of the same name.
[2] Dodgson M., Gann D., *Innovation: A very short introduction*, Oxford University Press, 2010. ISBN 978-0-19-956890-1

Australia's academics are world leading on any number of metrics. They discover and invent new ideas daily, and they publish prolifically. Take for instance the publication of scientific papers and journal articles – Australian academics trail only Switzerland and the Scandinavian countries on a per capita basis (see Figure 2).

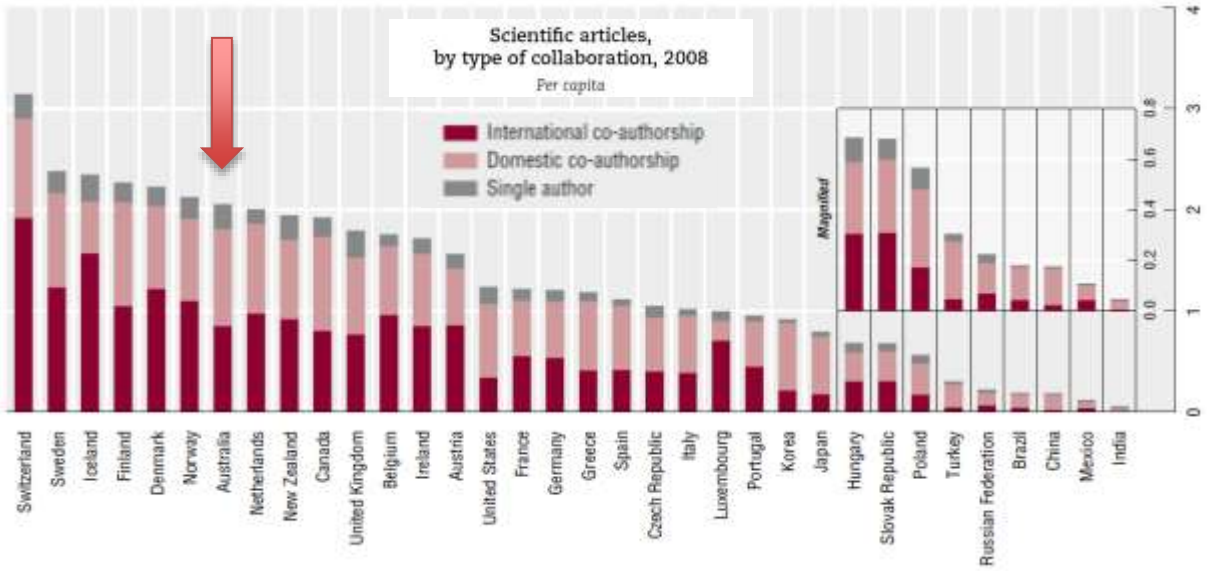

Figure 2 ***Scientific paper publication rate****. Source OECD (2010) Measuring Innovation: A New Perspective (http://www.oecd.org/site/innovationstrategy/45188320.pdf)*

By contrast with the publication rate of scientific papers, consider the capture of new inventions/IP through the patent system. Internationally PhD students are the most productive originators of new inventions. By contrast Australian PhD students (and their academic supervisors) generate patents at about a quarter the rate of their international peers: one invention disclosure per ~30 Australian PhD students compared with one disclosure per 7.4 international PhD students, as illustrated in Figure 3.

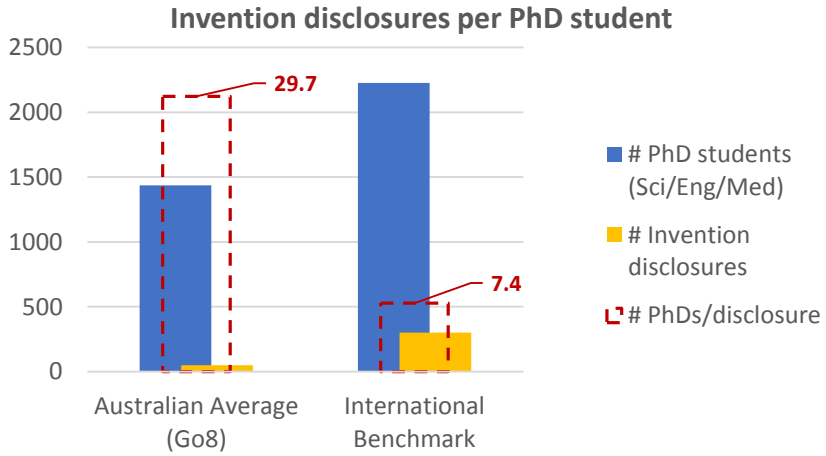

Figure 3 ***Invention disclosures (patents) per PhD student*** *(in Science, Engineering and Medicine faculties). "International Benchmark" is a selection of leading US, UK and Canadian universities.*
Source: RMIT Innovation Survey 2011

Put simply the Australian academic environment may generate many inventions, but it does not capture IP, and consequently it does not instil in its future stars a culture of creating IP that could be commercialised.

The absence of that IP capture is perhaps one reason Australia ranks poorly on international comparisons of percentage of GDP earned from licenses, patents and other IP.

Another significant element of successful innovation is collaboration. No-one has all the answers, and successful collaborative efforts are a key factor driving new innovations.

As the near term beneficiary of developing and implementing new innovations, existing industry ought to engage frequently in collaborative endeavours (with everybody/anybody – customers, suppliers, academia, etc.,) to encourage those outcomes. Unfortunately by international comparisons our companies typically do not score favourably, as illustrated in Figure 4.

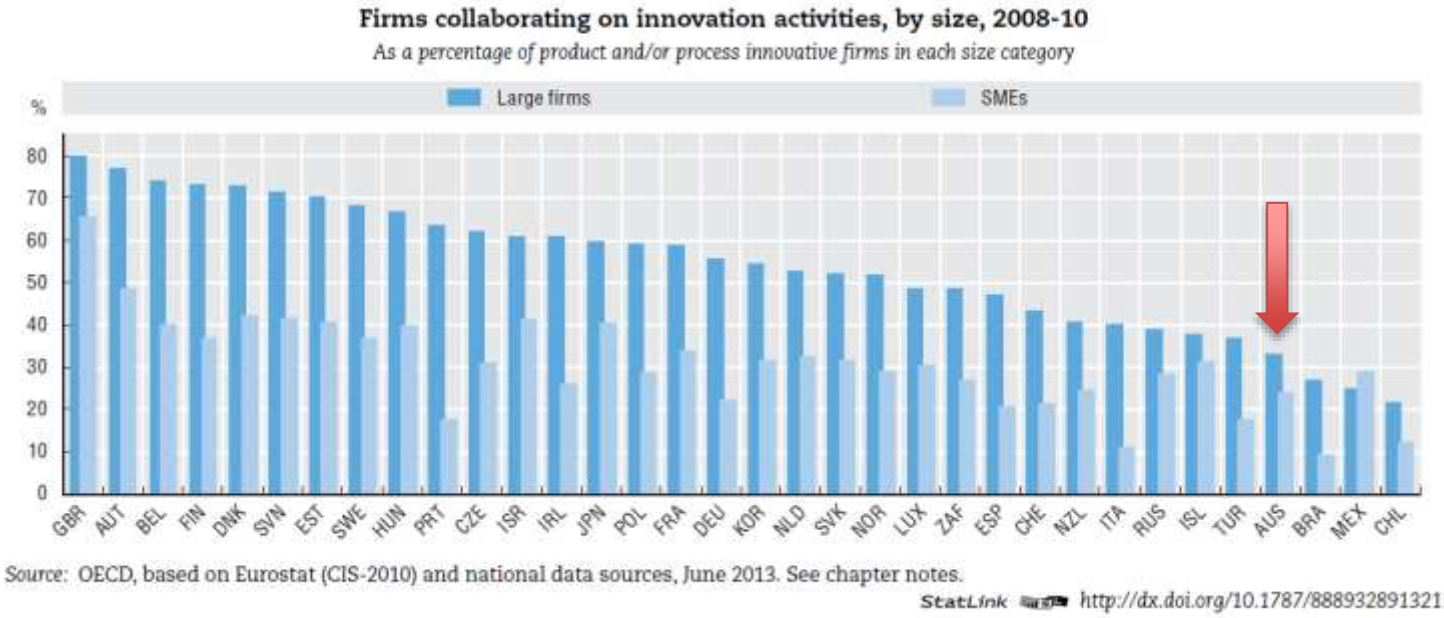

Figure 4 ***Percentage of firms collaborating on innovation activities***.
Source: OECD Science, Technology and Industry Scoreboard. 2013 http://www.oecd.org/sti/scoreboard.htm

Given the intellectual capacity of Australia's academic community one would think that industry and academia would seek to collaborate on developing new innovations to mutual benefit. But unfortunately international comparisons again show our efforts are not encouraging: - see

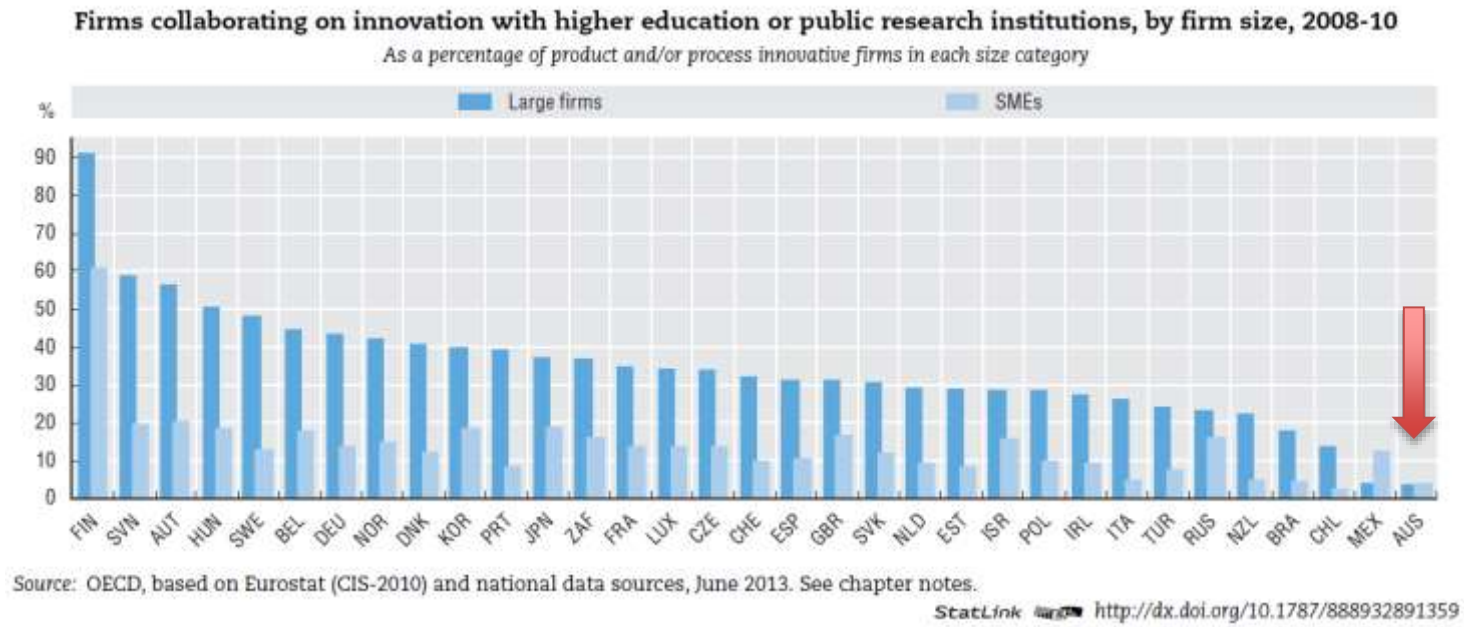

Figure 5 ***Percentage of firms collaborating on innovation activities with academia***.
Source: OECD Science, Technology and Industry Scoreboard. 2013 http://www.oecd.org/sti/scoreboard.htm

So as a generalised summary Australian academia generates significant new knowledge and inventions, chooses not to capture those inventions in patents and finds it very difficult to collaborate with industry to exploit those inventions.

Why?

Because our national innovation systems incentivise this outcome. They actively manage the processes and motivate the participants to achieve these outcomes.

Academic Career Progression

Consider for a moment the landscape from the perspective of an Australian academic. They are motivated and incentivised by a number of factors, principally:

- KPI(s) set by, and cultural behaviours "encouraged" by their employers (universities). Those in turn are driven typically by university funding models that derive significant/essential revenue from overseas student numbers, in turn driven by global university ranking metrics, in turn driven by metrics of perceived "quality of research" at the institution, in turn driven by academic publications and citations.
- Similarly the *Excellence in Research Australia* process and other ARC rules and incentives dictate an overarching focus on publications and citations.

Academic career advancement is dictated by publications and citations. The ARC rules governing academic grants and the ERA process recognise only research output. No points are awarded for commercialising an idea.

The reason publications and citations are used is more than likely simply because they are (relatively) easy to measure. Commercialisation success is hard to measure – but the difficulty of finding suitable metrics to enable its inclusion should not exclude the effort to accommodate a metric as the consequences of taking this easy option are so severe.

Intellectual Property

The typical/traditional model of intellectual property (IP) management at most Australian universities aims to derive significant revenue (well, as much as "possible") from patented IP. This is simply a direct outcome of today's university funding models that encourage/require universities to source as much additional revenue from anywhere to further the institution's core missions. There are two standard flaws in the normal approach:

- Not uncommonly efforts to exploit that IP are pursued on terms that are unrealistic for companies (especially startups, but also for existing SME and large enterprises), and more often than not the IP is not successfully used by anyone. The perceived value of the IP being licensed is often overstated, and the need to generate a financial return is too highly prioritised by the university's technology transfer offices.
- When such IP is successfully licensed to some commercialisation effort (either an existing company or a new startup), the arrangement between the university and the relevant academic(s) that were the source of the invention/IP are usually considered by the academics to be of poor net value in comparison with the time, difficulty and strain involved in negotiating the agreements. The opportunity cost for the academic is simply too high to divert them from pursuing academic research and generating research output (publications).

Academic behaviour / outcomes

Consequently, as a broad generalization, whilst Australian academics represent a major portion of our national intellectual horsepower, they are encouraged by their environment to publish their work prolifically (to attain career advancement) and are actively discouraged from attempting to commercialise their work (no career advancement and the effort involved to do it is a major ordeal).

Collaboration

Even if an invention has been captured in a patent, then as per the details above, academics find there is often little incentive to seek to commercialise their inventions. If it happens, great (*The Lucky Country* at work again!), but if not there are more important things to pursue.

From the perspective of local industry it is a commonly expressed sentiment that collaborating with academia is harder than it should be. As above – there are reasons that motivate that outcome.

From a national perspective, we have a very small pool of local enterprises (far too few) that are willing to engage and collaborate with academia – by and large Australian companies simply do not collaborate with academia.

By contrast we need a system that encourages that outcome.

To build a vibrant innovation culture in Australia we need a much bigger pool of companies that will collaborate with academia. Today's academics can/should be incentivised to form new enterprises/start-ups for many reasons, including:

- To exploit and commercialise their own existing and future inventions, ie., those ideas they have developed themselves;
- By encouraging academics to cross over into commercialisation, create a new pool of SME(s) that can and are willing to engage in collaborative effort with academia (as initially they'll be "collaborating" with themselves); and most significantly,
- To expand the number of local enterprises with positive collaboration experiences that will share their stories and encourage in others (their peers) a willingness to engage in collaborative efforts with academia

Today's academics can seed and encourage an expanded pool of willing and enthusiastic SMEs.

Innovation support schemes for industry

Over the years there have been many government schemes with worthy objectives to support innovation in industry – at federal level including AusIndustry and Dept of Industry more generally, and through many state government departmental schemes.

Unfortunately those schemes are too frequently restructured or realigned in some way - often following a change of government – and not uncommonly in response to short-term budgeting pressures.

In terms of "change" it is worth noting that the loss of continuity of those various programs is a *highly significant* factor undermining the practical innovation landscape. This is especially relevant to early-stage translational work, work that is often undertaken by small (and fragile) startups. Furthermore the loss of experienced staff that facilitate the programs within relevant

government departments, and the loss of confidence in the government's commitment to these efforts from both the innovators and importantly the small local "funding" industry (the venture capitalists, high-net-worth angels, etc.,) significantly undermines the value of the programs, the growth of the domestic funding community, and of course the very innovative commercial endeavours that we are trying to support in the first place.

Changes to these schemes are disproportionately damaging to early phase startups (the very people and endeavours we need to bootstrap our innovation system – as below), and as such they should be considered and implemented with caution and meaningful consultation.

To facilitate a vibrant innovation culture and ecosystem, governments at all levels must take a long term view in providing their innovation support programs. They must give confidence to the community (especially the 3i's: inventors, innovators and investors) of the sustainable continuity of those innovation support programs and they must avoid endless restructuring of those programs, especially when the reasons for doing so are based on merely short-term pressures. The opportunity costs are simply too high.

With regard to funds provided by the federal government to support innovation programs the government should explore options and implement a method to lock-in greater long term continuity. Those funds could be, perhaps should be, administered through an independent fund managed by an appropriate independent board.

Sustainable supply chain of skills and technology literacy

Australia needs significantly deeper literacy across the whole community on Technology and Engineering subjects – not just for professionals and practitioners in these fields, but in all members of our community. The so-called STEM subjects (science, technology, engineering and maths) constitute the basic building blocks of addressing many technology related issues in society.

Extensive research by The Warren Centre and our colleagues[3] has shown that a reliable grounding in the full breadth of STEM subjects – not just the maths and science, but also the technology and introductory engineering principles – is vital from primary school years and especially through late primary and early secondary schooling[4] to provide children with the exposure to, enthusiasm for technology and innovation. This applies NOT just in traditional "technology" careers, but equally in all commercial and economic activity across all our industries. These lessons are general – they are relevant to the whole national economy, and the importance of these subjects as grounding for the whole nation should not be understated.

In terms of enhancing and supporting a vibrant innovation culture in Australia we need our education systems to deliver a rich pipeline of technology literate graduates (from both secondary and tertiary levels), graduates that are enthusiastic about applying their knowledge and skills to address the issues they see around them.

Our national school education system currently lacks a coordinated strategy for the STEM subjects. As a generalisation Australian school education tends to focus on science and maths and deprioritise the technology and engineering subjects. In essence we teach kids the basic sciences, maths and knowledge only (the inventions), but not how to apply them, how to use them to address issues (the innovation processes) – this is like teaching kids to spell and a vocabulary but then failing to teach them how to write prose.

Broad technology and engineering literacy are widely recognised as significant factors driving innovation generally. For instance the number of engineers per head of population

[3] Details are available here: http://thewarrencentre.org.au/engineering-skills-education/
[4] the so-called "middle school" years of Years 5 through 8, approximately ages 10 through 14 years.

correlates strongly with economic growth, yet Australia ranks near the bottom of the OECD on that measure.

We need to embrace the Chief Scientist's call for a national STEM strategy to address these issues at the root cause, and be confident that the flow-on effects of those changes will lead to greater technology literacy across the community generally and in turn to a more vibrant innovation landscape.

Yes, this is playing the long game.

For further details see the recent article published in EA, and introduced here: http://thewarrencentre.org.au/warren-centre-argues-national-stem-strategy/

Kick-start a new innovation landscape

To kick-start a vibrant local innovation ecosystem we (the nation, with government leadership on this score) need to boot-strap a new cohort of (young) companies that are enthusiastic about innovation and engaging with the intellectual power resources available. Success breeds success, and we need to act today to seed tomorrow's innovation ecosystem.

Today's academics are the key to bootstrapping this, and government policies implemented through various funding mechanisms and management controls are the method by which this can be achieved.

It is the assertion of this paper that the most direct way to achieve these collective objectives is to encourage industry and academic collaboration and commercialisation by changing the incentives and barriers that currently limit their interaction.

To achieve this outcome the following recommendations are made:

1. Change the ERA and ARC's grant awarding and assessment criteria to include measures of commercialisation and industry impact for academic career advancement. Whilst these are in practice non-trivial to achieve it is crucial.
2. Require publically funded research to set aside a portion of such funds for capturing IP related to inventions generated in the research. Include metrics for invention disclosure/IP protection capture in the ARC/ERA metrics.
3. Furthermore since that research is publically funded (and should thus be for Australian public benefit) consider mechanisms for requiring that the IP/patents so generated be licensed non-exclusively to "Australian enterprises"[5] with net zero licensing fees/royalties. Universities should remain free to derive any licensing/royalty fees possible from overseas entities.
4. Encourage (perhaps require) interdisciplinary research and industry collaboration on academic grant funding applications (eg., ARC grants). There are successful overseas examples implementing such arrangements that can act as model for this.
5. Incentivise companies to innovate – the present 45% R&D tax rebate is a significant program that does help. Continue the program / expand as appropriate.
6. Incentivise companies to collaborate – consider R&D tax incentive schedules that might further incentivise collaborative effort, especially with academia.
7. Stabilise the government innovation support programs for industry. Refinement and tweaks are good – it is the wholesale disbanding and or significant restructuring on a

[5] Care needs to be taken to avoid opportunities for rorting that may arise from off-shore based companies simply shifting profits and activity through related parties. Extensive debate and some modelling work has been done on potential schemes to avoid such outcomes and such concepts should be included in considerations.

frequent basis that seriously undermines the innovation eco-system. Deliver the funds supporting innovation programs through an independent fund administered by an independent board.

8. Support the Chief Scientist's call for a National STEM strategy for our schools. Australia needs significantly deeper Encourage a broader understanding of the full suite of STEM subjects across the community – promote deeper technology and engineering literacy across the community. Australia needs a nationally coordinated STEM strategy for primary and secondary schooling

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About The Warren Centre for Advanced Engineering

The Warren Centre is an academically independent not-for-profit social enterprise located at the University of Sydney that uses robust, collaborative processes with its extensive networks in industry, government and academia to find solutions in an increasingly complex economic, technical and social environment. It is expert at leveraging its connections for optimum results, such as:

- Fostering excellence and innovation in advanced engineering throughout Australia;
- Stimulating the application and further development of new engineering technology;
- Encouraging the integration of innovation and engineering technology into Australia's public policy and wealth creation;
- Providing independent comment and advice to government and industry on relevant issues;
- Helping create competitive advantage for specific industries in Australia and overseas and viable opportunities for wealth creation.

The Warren Centre owns the process – and everyone owns the benefits.

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