

# Boosting the Commercial Returns on Research – NICTA Submission<sup>1</sup>

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This submission addresses how to increase the *rate* of commercial return on research. We recognise that there are two approaches to “boost the commercial returns from research” – to do more research, and to increase the *rate* of commercial return from research done. Relative to OECD comparisons, Australia’s investment in research is low, so it is worth considering whether this investment should be increased overall. This submission, however, focuses on how to increase the *rate* of commercial return on research. We offer the following points, which also serve as a table of contents to our submission:

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<sup>1</sup> Prepared on behalf of NICTA by Robert C. Williamson FAA, with input from Phil Robertson FTSE.

## 1) There is no evidence that performance based research funding incentives work

The call for submissions lists several possible mechanisms to boost the commercial returns of research. The first (“*adjusting research funding mechanisms to provide greater incentives for collaboration between research and industry*”) is predicated on the notion that “Performance Based Research Funding” can actually materially affect the outcomes in a positive manner. However, as is explained clearly in the very source<sup>2</sup> the government quotes in its own paper<sup>3</sup>, there is *no compelling empirical evidence that performance based incentives make any positive difference in research and there is evidence they induce harm*. Thus the claim<sup>4</sup> “*To improve the commercial outcomes from publicly funded research, the underlying incentives must shift*” is not based on evidence.

As Linda Butler states on page 128 of the source cited **PERFORMANCE BASED FUNDING FOR PUBLIC RESEARCH IN TERTIARY INSTITUTIONS**

*“Assessing the impact of performance-based research funding systems is a fraught exercise, which perhaps explains the paucity of broad authoritative texts on the subject. The literature is full of words like ‘likely’, ‘potential’, and ‘possible’ but contains relatively few concrete examples that examine the impact of PRFS in detail, either through investigative data analyses or well-structured survey/qualitative investigations.”*

Later (page 130) Butler says “*It is clear that the bulk of the evidence is based on the United Kingdom’s RAE.*”

Her conclusions are clear: there is *no* compelling evidence about the efficacy; such schemes are readily gamed; and there are many deleterious unintended consequences. And this is hardly a surprise – any experienced world-class research leader knows from experience that simple-minded funding incentives are a very poor way to motivate researchers (see point 2) below on page 4). But this does not matter because there are some great ways that demonstrably work.

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<sup>2</sup> OECD, *Performance-based Funding for Public Research in Tertiary Education Institutions*, Workshop Proceedings, OECD Publishing, 01 Dec 2010, [http://www.keepeek.com/Digital-Asset-Management/oecd/education/performance-based-funding-for-public-research-in-tertiary-education-institutions\\_9789264094611-en#page1](http://www.keepeek.com/Digital-Asset-Management/oecd/education/performance-based-funding-for-public-research-in-tertiary-education-institutions_9789264094611-en#page1)

<sup>3</sup> Australian Government, Department of Education and Department of Industry, *Boosting the Commercial Returns from Research*, 2014, <https://submissions.education.gov.au/Forms/higher-education-research/Documents/Boosting%20Commercial%20Returns%20from%20Research%20%20-%2024102014.pdf>

<sup>4</sup> Australian Government, *op. cit.* page 23

Even more compelling evidence for the claim here comes from Silicon Valley and Stanford. Stanford University is unquestionably credited as the source of Silicon Valley. Stanford continues to generate vast wealth for the US through the entrepreneurial activity arising from Stanford's research. *There are no incentives at Stanford to encourage this*, apart from Stanford's willingness to offer leaves of absence to its professors. The promotion criteria<sup>5</sup> do not even mention once "*commercialization*", "*industry engagement*", "*entrepreneurial activities*". Academic promotion at Stanford is *entirely* based on excellence in research and teaching.

Thus not only is there is no positive evidence that simple-minded incentives help, but what is arguably the world's best place for achieving commercial returns on research does not try to so incentivize researchers. It is an idea wholly without merit, evidence or sense. The only explanation for its recurrent appeal to governments is well explained in James C. Scott's book **SEEING LIKE A STATE: HOW CERTAIN SCHEMES TO IMPROVE THE HUMAN CONDITION HAVE FAILED**<sup>6</sup> - states value *legibility* over outcomes – it is considered more important to be able to accurately account for things, than to achieve a good outcome; it is more important to appear to have control over a process, than have the process lead to good outcomes. The notion of exerting control over what is perhaps one of the most difficult creative acts known to humankind by tuning KPIs would be laughable if it were not so damaging.

Finally, the government's report<sup>7</sup> also claims "*Australia's research output (in terms of publications and citations) ranks highly in the OECD on indicators of research quality.*" Comparison with alternate analyses<sup>8</sup> of OECD statistics suggests this is generous. A different interpretation is supported by the analysis of Giovanni Dosi<sup>9</sup> and coauthors. They have analyzed<sup>10</sup> the "*European Paradox*" which

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<sup>5</sup> <https://facultyaffairs-humsci.stanford.edu/chapter-4-promotion-full-tenure-line>

<sup>6</sup> Yale University Press, 1999

<sup>7</sup> Australian Government, *op. cit.*

<sup>8</sup> <http://www.chiefscientist.gov.au/wp-content/uploads/OPS2-OECD-for-web-FINAL.pdf>

<sup>9</sup> If citation statistics are to be believed (and the tenor of the Government's paper suggest they are at least not entirely discounted) then Giovanni Dosi [http://en.wikipedia.org/wiki/Giovanni\\_Dosi](http://en.wikipedia.org/wiki/Giovanni_Dosi) is the most renowned scholar of the economics of innovation in the world: [http://scholar.google.com/citations?view\\_op=search\\_authors&hl=en&mauthors=label:economic\\_s\\_of\\_innovation](http://scholar.google.com/citations?view_op=search_authors&hl=en&mauthors=label:economic_s_of_innovation)

<sup>10</sup> Giovanni Dosi, Patrick Llerena, and Maoro Sylos Labini, "The relationships between science, technologies and their industrial exploitation: An illustration through the myths and realities of the so-called 'European Paradox'," *Research Policy* 35, 1450-1464, (2006).

*refers to the conjecture that EU countries play a leading global role in terms of top-level scientific output, but lag behind in the ability to convert this strength into wealth-generating innovations.*

The similarity of the European complaint with the Australian one under consideration is remarkable. Their analysis, as economists trying to understand the situation, not self-interested actors with a stake in the situation, is extremely pertinent. They distill a long history of detailed empirical economic analysis into seven “stylized facts” (page 1452), which are worth quoting at length (the many references are omitted, but can be found in the paper):

1. Contrary to the claim that scientific and technological *knowledge* can be increasingly reduced to sheer ‘*information*’, the distinction between the two continues to be highly relevant. *A good deal of knowledge is, and is likely to continue to be, rather ‘sticky’, organization- and people-embodied, and often also spatially clustered.* Related to this is the persistence of widespread agglomeration phenomena driven by top-level research.
2. *Useful academic research is good academic research. “Systematic evidence from the US shows that the academic research that corporate practitioners find most useful is publicly funded, performed in research universities, published in prestigious referred journals”* and frequently cited by academics themselves.
3. *Government funding of basic research is responsible, especially in the US, for most major scientific advances, including in the fields of information sciences and biosciences.*
4. *The proportion of university research that is business financed is very low everywhere (typically less than 10%) and lower in the US than in Europe.*
5. *The expansion of US university patenting has resulted in a rapid decline of the patent quality and value.*
6. *Increases in licensing income in leading US universities are concentrated in biotech and software, and have preceded the Bayh–Dole Act. Moreover, income flows from licensing are quite small as compared to the overall university budget; in most cases, they are unable to cover even the administrative costs of the ‘technology-transfer office’ in charge of them! At the same time, anecdotal evidence begins to hint at the ways the new appropriation regimes for public research tend to corrupt the ethos of researchers and to twist their research agendas, and in the US even “[s]ome of the nation’s largest and most technology-intensive firms are beginning to worry aloud that increased industrial support for research is disrupting, distorting, and damaging the underlying educational and research missions of the university, retarding advances in basic science that underlie these firms’ long-term future.”*

7. Interestingly, *only very rarely has a critique of the Open Science System and the public funding of basic research come from corporate users, except for peripheral countries and peripheral entrepreneurs (such as Italian ones, hoping to transform universities into some sort of free training subsidiaries). On the contrary, notably, "in the UK, where critical rhetoric is among the strongest, it comes mainly from government sources. . . In the US, companies like IBM have complained recently about the potentially harmful effects on future competitiveness of reduction in public support to academic research in the physical sciences."*

The paper concludes with recommendations which are also worth quoting:

*First, increase support for high quality basic science, through agile institutions much like the American National Science Foundation (NSF) and relying on world-class peer-review...*

*Second, fully acknowledge the differences within the higher education system between research-cum- graduate teaching universities and other forms of tertiary education discussed above. The well-placed emphasis on the role of the first type of institutions often comes under the heading of the 'Humboldt model' as pioneered by Germany more than a century ago....*

*Third, push back the boundaries between public or 'open' research and appropriable research. One often forgets that appropriability is socially justified only in so far it provides an incentive to innovation itself.*

*Fourth, develop large-scale, technologically daring missions justifiable in terms of their intrinsic social and political value and able to match in terms of size and ambition the US (often more military-oriented) programs. "Scandinavian countries and Switzerland are able to mobilize considerable resources for high quality basic research without the massive defense and health expenditures of the world's only superpower."*

All of these conclusions make perfect sense and are directly translatable to Australia.

## **2) Institutional culture matters for research results; it is known what works and there are Australian examples**

The previous point gives an example of an institution with the right culture (NICTA). In contrast to the glaring lack of evidence that simple minded incentives make a difference (see point 1), there *is* compelling, replicated, detailed empirical evidence that getting the culture right is essential for excellent research outcomes.

Renowned sociologist Rogers Hollingsworth<sup>11</sup> has made a multi-decade study of the institutional determinants of scientific success. He wanted to determine what were the institutional factors that affected whether major scientific breakthroughs occurred. That is, what makes the difference between *merely good* and *outstanding* science. This matters very much for the issue under consideration because as alluded to in Point 1), the research that has the greatest commercial interest is typically the research that makes the largest breakthrough. Hollingsworth found<sup>12</sup>

The society likely to have numerous breakthroughs is one with a weak institutional environment that permits a high degree of nonconformity and high-risk research. My in-depth, cross-national, and cross-temporal organizational study of 291 major discoveries in the twentieth century demonstrates that major discoveries have tended to occur more frequently in organizational contexts that were relatively small and had high degrees of autonomy, flexibility, and the capacity to adapt rapidly to the fast pace of change in the global environment of science.

He further found common elements to environments that hampered the making of major discoveries; his results summarised in

Table 1 below. They have been corroborated by other studies such as that by Heinze et al.<sup>13</sup> who showed that outstanding scientific outcomes typically come from small groups which

- Have high autonomy
- Have complementary variety of scientific skills (not all clones)
- Communicate widely externally
- Have “*facilitating leadership*”
- Have flexible research funding (funds are *not* earmarked)

The latter point is particular pertinent in the current context.

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<sup>11</sup> <http://faculty.history.wisc.edu/hollingsworth/>

<sup>12</sup> J. Rodgers Hollingsworth, “The Dynamics of American Science: An Institutional and Organizational Perspective on Major Discoveries,” in Jens Beckert, Bernhard Ebbinghaus, Anke Hassel, and Philip Manow, eds., *Transformationen des Kapitalismus: Festschrift für Wolfgang Streeck zum sechzigsten Geburtstag*. (Frankfurt and New York: Campus Verlag, 2006) pp. 361–380.

<sup>13</sup> Thomas Heinze, Philip Shapira, Juan D. Rogers and Jacqueline M. Senker, “Organizational and institutional influences on creativity in scientific research,” *Research Policy* 38, 610-623 (2009)

Table 1 Characteristics of Organizational Contexts Constraining the Making of Major Discoveries

|                                  |                                                                                                                                                                                                                                                         |
|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Differentiation</b>           | Organizations with sharp boundaries among subunits, the delegation of recruitment exclusively to department or other subunit level, the delegation of responsibility for extramural funding to the department or other subunit level.                   |
| <b>Hierarchical authority</b>    | Organizations were very hierarchical when they experienced centralized<br><br>(a) decision-making about research programs;<br><br>(b) decision-making about number of personnel;<br><br>(c) control over work conditions;<br><br>(d) budgetary control. |
| <b>Bureaucratic coordination</b> | Organizations with high levels of standardization for rules and procedures.                                                                                                                                                                             |
| <b>Hyperdiversity</b>            | This was the presence of diversity to such a deleterious degree that there could not be effective communication among actors in different fields of science or even in similar fields.                                                                  |

The famous economic historian Nathan Rosenberg<sup>14</sup> has argued that **HOW THE WEST GREW RICH**<sup>15</sup> was by loosening of political controls and made particular reference to the “loose” style of management necessary for advances in Science.

The psychology of *why* such loose control is necessary is now well understood. The type of person who makes the advances that create economic wealth is typically a revolutionary: As Rosenberg and Birdzell say<sup>16</sup>

*“Innovation is a form of revolt against convention, and it may be assumed innovators are more individualistic than most other people.”*

The sorts of people that create wealth by research need to be managed appropriately. As renowned management scholars Rob Goffee<sup>17</sup> and Gareth Jones<sup>18</sup> argued in their book

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<sup>14</sup> [http://en.wikipedia.org/wiki/Nathan\\_Rosenberg](http://en.wikipedia.org/wiki/Nathan_Rosenberg)

<sup>15</sup> Nathan Rosenberg and L.E. Birdzell Jr., *How the West Grew Rich: The Economic Transformation of the Industrial World*, Basic Books, 1986

<sup>16</sup> Ibid, page 261

**CLEVER: LEADING YOUR SMARTEST, MOST CREATIVE PEOPLE**<sup>19</sup>, you simply cannot inspire or lead these clever creative people by telling them exactly what to do and how they should do it, nor by setting numerical KPIs or performance bonuses. Experienced research leaders know this, and no leading groups are managed by KPIs or performance incentives; they are *inspired* to perform, not *incented*.

The creative people that generate advances are motivated primarily for *intrinsic* reasons. It is now well documented<sup>20</sup> that offering *extrinsic* rewards as a motivating factor to people that are already *intrinsically* motivated to perform a task, *decreases their motivation and leads to worse outcomes*. As Harvard business school professor Teresa Amabile has written

*Management is widely viewed as a foe of innovation. The thinking goes that too much management strangles innovation (just let a thousand flowers bloom!). But we have found a much more nuanced picture. You really can manage for innovation, but it starts by knowing what drives creativity in the people who generate and develop the new ideas that, when implemented, will become tomorrow's innovations. Unfortunately, too many managers unintentionally kill innovation because they rely too heavily on carrots and sticks to motivate employees.*<sup>21</sup> (italics at the end of paragraph added)

Deci and Amabile and others' work has assembled overwhelming empirical evidence that you simply will not get the best out of creative people by trying to manage them with KPIs and incentives. In fact you will kill the creative spark:

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<sup>17</sup> <http://faculty.london.edu/rgoffee/>

<sup>18</sup> <http://www.speakersconnect.com/prof-gareth-jones-author-anyone-led-hk-june/>

<sup>19</sup> Harvard Business School Press, 2009

<sup>20</sup> Edward L. Deci, Effects of Externally Mediated Rewards on Intrinsic Motivation, *Journal of Personality and Social Psychology*, 18(1), 105-115 (1971)

Edward L. Deci, Richard Koestner and Richard M. Ryan, A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation, *Psychological Bulletin* 125(6), 627-668 (1999)

<sup>21</sup> Teresa Amabile and Steve Kramer, "What Doesn't Motivate Creativity Can Kill It," *Harvard Business Review* 25 April 2012, <https://hbr.org/2012/04/balancing-the-four-factors-tha-1/>

*Creativity is undermined unintentionally every day in work environments that were established – for entirely good reasons – to maximize business imperatives such as coordination, productivity and control.*<sup>22</sup>

This has been demonstrated in a compelling fashion by Azoulay et al.<sup>23</sup> in the specific context of research. By comparing the long-term scientific *impact* (not mere “*excellence*”) of research funded through two different mechanisms, they showed the impact effect of autonomy. They compared results obtained via traditional National Science Foundation grants (with the sort of bureaucratic overhead and controls one sees often in Australia, which risk being increased under some of the suggestions in the Government’s paper) with those obtained via the innovative Howard Hughes Medical Investigator (HHMI) program, which bets on individuals and encourages them to take risks and follow their noses. The evidence is clear: the HHMI program leads to substantially greater impact. They also include a very pertinent anecdote about a leading researcher who did have funding from the NSF, but broke the rules, worked on something different, and ultimately made an astonishing breakthrough. Sometime after the fact, the NSF had the good grace to thank him for *not following their rules and advice!*

*The lesson is clear: if you want impact, give creative people autonomy; do not try to control them by incentives.*

Experienced research leaders know this full well. Instead they focus on the creation of a culture where the “*clever people*” will be inspired to *want* to do what the leader wishes. Again, NICTA is a shining example of how this can work. NICTA has groups of researchers rated as amongst the top 5 in the world<sup>24</sup> in their scientific area *and* engages with Australian industry to the extent that it has been estimated to add around \$1B/yr, and over \$3B NPV to 2020, to Australian GDP.<sup>25</sup>

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<sup>22</sup> Teresa Amabile, “How to Kill Creativity,” *Harvard Business Review*, 76-87, September – October 1998

<sup>23</sup> Pierre Azoulay, Joshua S. Graff Zivin and Manso Gustavo, Incentives and Creativity: Evidence from the Academic Life Sciences, *RAND Journal of Economics*, 42.3, 527-554, Fall 2011

<sup>24</sup> E.g., the independent external review using top international assessors of NICTA’s Machine Learning Group, July 2014.

<sup>25</sup> Deloitte Access Economics undertook 2 studies (in 2011 and 2012) on the impact of selected NICTA projects on the NSW and Australian economies, concluding that the potential impact from these projects alone on the Australian economy was over \$3B NPV. A further 6 case studies of projects affecting Australia’s infrastructure and transport sectors is currently being undertaken, with interim results reinforcing this scale of impact.

1. Deloitte Access Economics, *National ICT Australia: benefits from NICTA’s research to the Australian Economy*, 15 June 2012

A three-year study from the US National Academy of Engineering on “*Profiting from Innovation*”<sup>26</sup> reinforces this point. After explaining the central role of “champions” in commercialization success they explain the essence of this sort of champion and the key issue regarding their management: Champions have, similar to the scientific stars studied by Hollingsworth (*op. cit.*):

*Dedication (sometimes fanatical) to their perception of success, sometimes without management support;*

*A vision of the goal that is clear enough and powerful enough to enlist the support of others;*

*Willingness to take risks, often personal as well as professional, to reach the goal;*

*Ability to garner sufficient resources (through leadership, management insight, “reappropriation”, persuasion, luck, or intuition) to reach the goal.*

*Champion’s activities often do not conform to formal organizations or ‘orderly’ ways of doing business. Though company leaders may wish to encourage champions throughout their firm, they often fail to recognize, empower, and reward “constructive” disruptive behaviour. (Italics added)*

Conversely, getting the culture wrong is bad. As Linda Butler explains in the OECD report cited earlier (page 148), the introduction of performance based research funding decreases researcher autonomy and that directly serves to demotivate researchers; she reports claims about loss of autonomy were very common in the assessment of incentive based research funding.

Ultimately it needs to be accepted that technological innovation, and its concomitant economic benefits, is an intrinsically uncertain enterprise<sup>27</sup>, which only thrives when the best people are given the freedom to do what they want to do – and that is to truly innovate and see that innovation have an impact. They do not need to be cajoled. They only need to be gently led. They can then inspire groups of researchers around them to

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2. Deloitte Access Economics, *Contribution of NICTA to the NSW Economy*, 18 November 2011

<sup>26</sup> William G. Howard, Jr and Bruce R. Guile (editors), *Profiting from Innovation: The Report of the Three-Year Study from the National Academy of Engineering*, The Free Press, New York, 1992. See page 93ff.

<sup>27</sup> Nathan Rosenberg, “Uncertainty and Technological Change,” pages 17-24 in Dale Neef, Anthony Seisfeld and Jacquelyn Cefola (Eds), *The Economic Impact of Knowledge*, Butterworth Heinemann 1998.

make the sort of advances that are commercialisable by industry for the greater economic impact to the country.

### **3) There are Australian research institutions with the right culture – they should be preserved and replicated**

The Government's paper suggests<sup>28</sup> that Australia's poor performance in terms of the number of spin-off companies per \$US100m of research expenditure is due to a "lack of entrepreneurial culture" and goes on to conclude, on the basis of no evidence, (see the point 1) above) that this is because academic career progression is driven by research excellence.<sup>29</sup>

Contrary to the Government's claim, there certainly are research institutions in Australia with an "entrepreneurial culture" and this culture is reflected in a performance 20 times (*twenty!*) better than the Australian average on the very indicator quoted – number of start-ups per \$100m invested.<sup>30</sup> A factor of 20 utterly swamps the minor differences in the OECD reports alluded to earlier. And it is important to recognise that this entrepreneurship is not at the expense of research excellence and academic publications – rather it strengthens them.

NICTA's entrepreneurial culture arises from multiple factors, including a leadership approach informed by the issues addressed in point 2 above, giving staff and collaborators confidence that they have the freedom to innovate, and encouraging direct engagement with real industry and national scale challenges. But one other critical factor contributes heavily to the entrepreneurialism – this is the close relationship between researchers, deeply professional engineers, and user interaction designers in integrated teams with industry. This interdisciplinary engagement is fundamental to innovation and entrepreneurship.

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<sup>28</sup> Australian Government, *op. cit.* page 19

<sup>29</sup> The paper actually says "linked to citation/publication rates and grant success". While this might be true in second-rate institutions, top Australian universities follow the model of Stanford (alluded to above) and other globally leading institutions and rely on the synthetic assessment of peers rather than simple-minded counting. Such counting has been widely criticized, and many institutions, such as the Australian Academy of Science have signed the *San Francisco Declaration on Research Assessment* <http://am.ascb.org/dora/> which explicitly disavows such practices as being harmful. It would be a fine thing if the Australian Government took a global lead and made Australia the first nation to sign it!

<sup>30</sup> NICTA currently generates approximately 6 start-ups per A\$100m of research funding, which is 20× the rate of 0.3 start-ups per US\$100m of research funding that is cited as the Australian average on page 8 of the *National Survey of Research Commercialisation for 2010-2011*, published in Dec 2012 (<http://www.industry.gov.au/innovation/reportsandstudies/Documents/2010-11NSRCReport.pdf>)

Thus a simple suggestion to achieve the very goal that is mentioned is to

- a) Continue funding NICTA;
- b) Replicate NICTA in other areas (other general purpose technologies<sup>31</sup> for example).

#### **4) Absorptive capacity matters, and can be improved by better aligning public research spend with industry needs**

It has long been recognised that “*absorptive capacity*” matters for the diffusion and adoption of research-based innovations<sup>32</sup>. One extremely simple change that could be made to enhance the absorption of research-driven innovations within Australia is to better align the expenditure of public monies on research with industry need and interest. At present it is simply not true that, as is claimed in the Government’s paper<sup>33</sup> (page 9 of department’s paper) “*Australia’s research effort is focussed in key sectors relevant to our economy and society*”. The numbers quoted there contradict the assertion: private sector R&D is focussed on engineering and IT (a total of 77%). But only 11% of public funding is on engineering, and a similarly small figure on IT.

The government could vastly improve the commercial returns from research by focussing publicly funded research on areas where there is strong absorptive capacity. The counter-argument that given there is industry interest in these areas implies the government need not invest simply fails: industry does not typically undertake the long term basic research that underpins the innovations that can have a huge economic effect.

*Simply by increasing the proportion of government research funding in areas where there is absorptive capacity could very rapidly “boost the commercial returns of research.”*

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<sup>31</sup> General Purpose Technologies, such as information and communication technology, are responsible for the majority of long-term economic growth –see the book-length argument: Richard G. Lipsey, Kenneth I. Carlow and Clifford T. Bekar, *Economic Transformations: General Purpose technologies and Long Term Economic Growth*, Oxford University press, 2005

<sup>32</sup> See the comprehensive report: Don Scott-Kemis, Alan J. Jones, Erik Arnold, Chaiwat Chittravas and Deepak Sardana, *Absorbing Innovation by Australian Enterprises: The Role of Absorptive Capacity*, Report on the Project for the Department of Industry, Tourism and Resources, 2 April 2007 (304 pages)

<sup>33</sup> Australian Government, *op. cit.* page 9

## 5) There is a huge difference between generating a return for the country and appropriating the return by a given institution

From a national perspective what matters is that there is an economic return *to the country* on research. This is *not* the same as requiring the return be *appropriated* by any particular institution, especially the research institution where the research is conducted. No university in the world makes more than about 5% of their income from licencing; not Stanford, not MIT, not Berkeley. Much cannot be appropriated, but the country benefits all the same.<sup>34</sup> Appropriability of research is difficult and complex<sup>35</sup>, but if you take a national perspective, this does not matter as much.

Within Australia, many research institutions are driven by a perceived need to not only generate commercial returns, but to appropriate them for themselves. This is very counterproductive. The lesson from overseas corroborates this. As Dosi *et al.*<sup>36</sup> say

*Together, there is an increasing perception also among business firms that 'too much appropriability' hurts firms themselves. In fact, as noted by Florida "[l]arge firms are most upset that even though they fund research up front, universities and their lawyers are forcing them into unfavorable negotiations over intellectual property when something of value emerges. Angered executives at a number of companies are taking the position that they will not fund research at universities that are too aggressive on intellectual property issues. . . One corporate vice president for industrial R&D recently summed up the sentiment of large companies, saying, "The university takes this money, then guts the relationship". [But also] [s]maller companies are concerned about the time delays in getting research results, which occur because of protracted negotiations by university technology-transfer offices or attorneys over intellectual property rights. The deliberations slow the process of getting new technology to highly competitive markets, where success rests on commercializing innovations and products as soon as possible.*

There are positive examples of other models. The University of Waterloo<sup>37</sup> in Canada, famously relaxed its rules regarding intellectual property to allow it to vest

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<sup>34</sup> Richard C. Levin, Alvin K. Klevorick, Richard R. Nelson and Sidney G. Winter, "Appropriating the returns from industrial research and development," *Brookings papers on economic activity* 3, 783-831, 1987

<sup>35</sup> Emmanuel Dechanaux, Brent Goldfarb, Scott Shane, Marie Thursby, "Appropriability and Commercialization: Evidence from MIT Inventions", *Management Science* 54(5), 893-906 (2008)

<sup>36</sup> Dosi *et al.*, *op. cit.*

<sup>37</sup> Katherine A. Hoye, *University Intellectual Property Policies and University-Industry Technology Transfer in Canada*, PhD thesis, University of Waterloo, 2006;  
Allison Bramwell and David A. Wolfe, "Universities and regional economic development: the entrepreneurial University of Waterloo", *Research Policy* 37, 1175-1187 (2008)

automatically with the creators. A consequence was the burgeoning of an economically very successful industry cluster around the university. The experience of two outstanding universities in the UK provides an amazing almost controlled experiment: Oxford and Cambridge. They both set up science parks. The Cambridge one flourishes; the Oxford one does not. Cambridge had a model of just assigning ownership of IP developed by its staff to the staff; Oxford did not, and is reportedly very heavy-handed about IP.

In 2005 Cambridge changed the rules to have the university automatically acquire certain rights, but it is clear<sup>38</sup> that that the inventors still derive a large benefit. The key point is not the exact model or percentages, but the *intent* and the *spirit* – would the institution prefer a small percentage of a large economic success, or a large percentage of a small one. Institutions that seek to unduly control and appropriate the commercial proceeds flowing from research simply reduce the size of the pie.

On the other hand, as the example of NICTA shows, by behaving differently, much better outcome can be obtained. *Precisely because of the base funding provide by the Australian Government*, NICTA has been able to focus on maximising *the benefit for Australia* when commercialising the results of its research rather than the direct cash benefit to NICTA. It spins-out one company every three months and inspires its researchers to embrace a powerful and palpable entrepreneurial culture.

So yes, there is “*an opportunity to reform IP arrangements*”<sup>39</sup>. The Australian Government could require that all federally funded research institutions loosen up their rules regarding the commercial exploitation of IP to enable the creation of a bigger pie. It could also change its own behaviour in this regard: the niggardly way in which it does not even fund on the margin<sup>40</sup> is one of the drivers of the university behaviour in favour of maximising appropriability.

This is consistent with the recommendations of Dosi et al. (*op. cit.*):

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<sup>38</sup> See rule 25, page 29 of Chapter XIII of Cambridge University Ordinances  
<http://www.admin.cam.ac.uk/univ/so/pdfs/ordinance13.pdf>

If Cambridge academics do not use the in house commercialisation organisation, then they are entitled to almost all of the commercial benefits. The point of offering such a majority share of the benefits to the inventor is not really about simple monetary incentive – it comes back to *autonomy and control*, which top researchers value enormously. If your start-up exits with you controlling a super-majority of the equity, then you can retain control of the company even after successive capital dilutions.

<sup>39</sup> Australian Government, *op. cit.* page 20

<sup>40</sup> Australian Research Council grants are ostensibly just for the marginal cost of research, but they do not even do that. The rates the ARC uses, for example, for the salaries of postdoctoral researchers, is consistently below the minimum wages universities are able to pay (through their Enterprise Bargaining Agreements).

*“push back the boundaries between public or ‘open’ research and appropriable research. One often forgets that appropriability is socially justified only in so far it provides an incentive to innovation itself.”*

We thus recommend

- *Insist that research institutions focus more on growing the pie and benefit to Australia than appropriating the returns to themselves.*
- *When an institution is successful in commercialising the returns (such as NICTA) do not punish it by cutting funding. This is like a business saying that its most successful division should be cut-loose because it can look after itself and “stand on its own feet”.*
- *Focus on making Australia self-funding rather than the destructive and impossible idea of making research institutions self-funding.*

## **6) Industry sectors are the wrong way to focus research effort; technological and innovative capacity is the right way**

The Government’s innovation agenda was developed by looking at “*those industries that were already excelling in terms of trade performance*”<sup>41</sup>. Maintaining competitiveness in these industry sectors is of course critical, and this requires improving their efficiency and productivity. The primary drivers for such improvements are effective application of technology and innovation into the industry domains. This applies to incremental improvements derived from advanced algorithms and systems, through to transformative changes that change the underlying value chains and hence business models. The research itself is *performed* in ICT, materials or other technology sectors – it is *applied* in mining, transport, or other major industry sectors that underpin our economy.

This distinction is critical. History shows that industry sectors do not transform themselves – it is applying research from technology sectors that improves or transforms major industry sectors, sometimes incrementally and sometimes disruptively. This is the fundamental reason behind the industry research focus described in point 4 on aligning with absorptive capacity, and why government funded research should most heavily focus on the technologies and innovations that will change other sectors if we want to see increased commercial gains from research.

Related to this is the reality that a country’s economic base does change over time, and sometimes rapidly. Just because there is a large volume of trade now does *not* mean that

- Such a volume will continue
- The companies within the sector have a capacity for innovation

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<sup>41</sup><http://www.afr.com/p/technology/it-left-out-in-australia-future-D2nc46aBoyKbBdWZcNwPnN>

- Or even that it makes sense to focus on industry sectors at all

The major effects of technological advance are to create entire new industries; this is where large-scale long-term economic growth comes from<sup>42</sup>. There is no evidence that the current industries with strong export performance have better receptive capacity to generate commercial returns on research. In fact the idea of identifying where innovation can arise from a simple-minded sectoral approach exemplifies the forcing of facts to fit a theory so prevalent in **SEEING LIKE STATE**<sup>43</sup>

The evidence is clear:

- Big wins will come from the further advancement and adoption of general-purpose technologies, such as ICT, advanced materials, biotechnology, and nanotechnology<sup>44</sup>. These will create entirely new industries:

A missing element in the assessment of the social returns to publicly funded R&D conducted at universities, federal research labs, and other nonprofit/public institutions is the role that public R&D plays in the creation of new industries.<sup>45</sup>

- Technological innovation does not respect industry sectoral boundaries. On the contrary, there is a very complex web of ‘*technological interdependence*.’<sup>46</sup> If you want advances in human health, do not just invest in the medical sector; if you want advances in transport, then look to ICT rather than roads. If you want to

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<sup>42</sup> Lipsey *et al.*, *op. cit.*;

Chris Freeman and Francisco Louca, *As Time Goes By: From the Industrial Revolutions to the Information Revolution*, Oxford University Press, 2001;

Elhanan Helpman (ed), *General Purpose technologies and Economic Growth*, MIT Press, 1998;

Carlota Perez, *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages*, Edward Elgar 2002;

Timothy Bresnahan, *General Purpose Technologies*, Chapter 18, Volume 2 of Bronwyn H. Hall and Nathan Rosenberg (Eds), *Handbook of the Economics of Innovation*, Elsevier 2010.

<sup>43</sup> Scott, *op. cit.*

<sup>44</sup> See references in footnote 42.

<sup>45</sup> Page 105 of Albert N. Link and Donald S. Siegel, *Innovation, Entrepreneurship and Technological Change*, Oxford University press, 2007.

<sup>46</sup> Nathan Rosenberg, “Technological Interdependence in the American Economy, *Technology and Culture* 20(1), 25-50, (January 1979); and

Nathan Rosenberg, *The Impact of technological innovation: a historical view*, pages 17-32 in *The Positive Sum Strategy: Harnessing Technology for Economic Growth*, National Academy Press, Washington, 1986.

see particular products with large economic impact, expect that the underpinning sources are derived from a very wide diversity of disciplines.<sup>47</sup>

- Sticking with what currently makes a profit is precisely the “*innovators dilemma*”<sup>48</sup>, the phenomenon whereby large and successful companies fall prey to their own success because that cannot radically innovate, since such radical innovation typically disrupts their existing market successes and they cannot bring themselves to move on. Australia stands to fall prey to this well-known and easily avoidable serious error.
- It has been well documented for a long time<sup>49</sup> that *radical innovations come from outside* – a narrow sectoral approach ignores this at its peril.

*Instead Australia should organise its efforts according to where the capacity to absorb innovations is highest, and focus on those areas where the largest long terms gains are to be had (general purpose technologies).*

## 7) Improving the assessment of research systems makes sense, but that does not mean more KPIs

The Government’s paper also suggests an improvement is needed of the assessment of research systems. This is unquestionably true. At present it is entirely driven by the desire for *legibility*, not for maximising performance. This is an instance of the “**AUDIT SOCIETY**”<sup>50</sup> and “**SEEING LIKE A STATE**”<sup>51</sup> which considers it more important to measure things to three decimal places than to get something done.

The only rational reason for having a performance evaluation system is to improve performance. Any system that reduces one of the most complex human activities to a number counting exercise has utterly missed the point.

As Linda Butler observed<sup>52</sup> there are serious methodological challenges. Effort should be focussed on measuring the value of government interventions, rather than on measuring

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<sup>47</sup> See the famous “tyre-tracks” diagram in: Committee on Depicting Innovation in Information Technology, National Research Council, *Continuing innovation in information technology*, The National Academies Press, Washington, 2012.

<sup>48</sup> Clayton Christensen, *The Innovator’s Dilemma*, Harvard Business School Press, 1997

<sup>49</sup> John Jewkes, David Sawyers and Richard Stillerman, *The Sources of Invention*, St Martin’s Press, New York, 1959

<sup>50</sup> Michael Power, *The Audit Society: Rituals of Verification*, Oxford University Press, 1997

<sup>51</sup> Scott *op. cit.*

<sup>52</sup> OECD *op. cit.*

to yet another decimal place the proxy outputs of research organisations. One needs to face up squarely to the issue of causality determination (as argued by Butler). At present the performance indicators for government policy on research funding are in a much more parlous state than those for research quality and impact in research institutions.

Perhaps the most important thing to remember is this: *Silicon Valley did not arise because some government set the right KPIs and performance management system. And its continual success is most certainly not because of that either.*

If a measure is sought, then we recommend to calculate the contribution to GDP from the investment in each research activity. In NICTA's case, this is estimated as \$3B NPV to 2020<sup>53</sup>.

## 8) Research training matters, and there are Australian models of how to do it well which can be replicated

*Unquestionably* research training matters (confer page 23 of the Australian Government report). Evidence from around the world supports this:

Mike Lazaridis, founder, president, and CEO of Waterloo-based Research in Motion (RIM), the creator of the iconic Blackberry wireless device, stresses the critical human capital dimension of basic research activities:

*The number one reason to fund basic research ... is to attract the very best researchers from around the world. Once here, they can prepare Canada's next generations of graduates, masters, PhD's and post-doctorates, including the finest foreign students. All else flows from this ... If you really want to understand commercialization, all you have to do is attend convocation at your local university<sup>54</sup>*

The knowledge and skills required to achieve commercial success is largely transmitted by the movement of skilled workers<sup>55</sup>. These "*spillovers*"<sup>56</sup> are not directly manageable. The one thing you can do is to make their earlier educational experience as useful as possible.

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<sup>53</sup> See footnote 25.

<sup>54</sup> Bramwell and Wolfe, *op. cit.* page 1180.

<sup>55</sup> Bruce Fallick, Charles A. Fleischmann and James B. Rebitzer, *Job Hopping in Silicon Valley: Some evidence concerning the micro-foundations of a high technology cluster*, NBER Working paper 11710, October 2005

<sup>56</sup> See (especially *pp.19ff*) of Richard G. Lipsey and Kenneth Carlaw, *A Structuralist Assessment of Technology Policies – Taking Schumpeter Seriously on Policy*, Industry Canada Research Publications Program, Working Paper Number 25, October 1998.

For ten years NICTA has developed experience in rethinking PhD education in the ICT area. Our PhD students not only work on the leading edge internationally, but they get hands-on experience on real world projects with commercial outcomes. This is radically different to the traditional model where the student spends all of their time cloistered in the home laboratory. Our students are now contributing to the growth of the absorptive capacity in Australian industry for leading edge research. The NICTA PhD model (with its mixture of team driven projects; joint supervision; interface with commercial customers; broadening coursework; and external placements) could be replicated in all Australian research institutions to great effect.

## 9) Preservation of research funding is essential – run the country like a business

The Australian Government's paper (page 7) admired the UK Government's response to the GFC. A crucial and strategic element of the UK response was to *make no cuts to science budgets*.<sup>57</sup> This was wise and long-term *business decision* by the UK government that the Australian government would do well to emulate.

Technological advance being the primary cause for long term economic growth, it is simply a bad business decision to cut off your only source of long term growth opportunity for some short term expediency.

*If the Australian government was serious about boosting the commercial returns for research, it would not only rescind all the cuts it has made in support of research in the last year or so, but it would increase its investment in research.*

*Anything else is financially irresponsible. Australia deserves to be run like a well-managed business that plans to be around for the long haul.*

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<sup>57</sup> See e.g. <http://www.bbc.co.uk/news/science-environment-11579949>