Inquiry into and Report on Agricultural Innovation

Terms of Reference

The Committee will inquire into and report on the role of technology in increasing agricultural productivity in Australia. The inquiry will have particular regard to:

- improvements in the efficiency of agricultural practices due to new technology, and the scope for further improvements;
- emerging technology relevant to the agricultural sector, in areas including but not limited to telecommunications, remote monitoring and drones, plant genomics, and agricultural chemicals; and
- barriers to the adoption of emerging technology.

Submission

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A Personal Background

My principal research field for many years has been Australian regional economic development focusing on non-metropolitan locations. In recent years, I have attracted many competitive research grants dealing with that topic and also changes in the agricultural sector and their implications for small town economies dependant on primary industry. Sources of funds have largely come from the ARC, CRCs, and RDCs. In parallel with this work, I have a strong interest in technological change and the impact that it has on economy and society, which has led recently to many invitations to address meetings, whether academic, business or government, both in Australia and overseas. Overseas destinations in that regard have included universities in Portugal (Evora), UK (Oxford), Japan (Nagoya), and Romania (Bucharest), and USA (Missouri (at Columbia), North Texas (at Denton, Dallas)). I have also worked, both this year and last, with the organisers of Armidale's TechFest to deliver that organisation's inaugural address and, two weeks from writing this, convene sessions on rural venture capital finance. Technology has long fascinated me and I programmed my first computer in 1967, almost 50 years ago! Finally, I am an avid proponent of the free market, a collaborator with Sydney's Centre for Independent Studies, and a private stock market investor through our family's SMSF.

B Emerging Technologies

I am reversing the terms of reference to what I think is the correct order – giving technologies pride of place. The list of emergent and very often transformative technologies that are relevant to agriculture goes far beyond those listed. But before documenting those, I'd observe that most futurists conclude that we are on the verge of a huge and accelerating surge in technological capacity that will rewrite dramatically nearly every aspect of economy and society within as little as ten or twenty years: products and services; their production methods; machinery and equipment; range of inputs and their sources, including especially energy; downstream processing; market destinations; and logistics. Interestingly, the

literature sees this surge as being driven not just by individual technologies but also through their combination through processes variously described as blending, fusion or integration. Such combination makes technological forecasting particularly hazardous because unintended and unexpected uses suddenly emerge for technologies. For example, GPS systems suddenly found application in many different dimensions of precision agriculture. Likewise, the internet of things is rewriting everything from production systems to everyday family living. And now we're seeing the emergence of artificial general intelligence (AGI), which – connected to the internet of things – is starting to threaten the jobs and livelihoods of many professional people including lawyers, accountants, doctors, academics, and – who knows – farm managers. Moreover, merge AGI with robotics and the whole recent debate about back-packer taxation takes on a new twist because many backpacker jobs may be replaced by robots – for example in the orchard sector. Most of us know about Moore's Law, which forecast the doubling of semiconductor power every 18 months to two years, and proved more or less accurate for decades leading directly to modern computers. Many analysts now see the processes of blending fusion and integration extending Moore's Law into many other realms of technology – a huge technological acceleration. Putting all this together we are on the verge of what has variously been termed "the Second Machine Age" (Brynjolfsson and MacAfee) or the "Third Industrial Revolution" (Rifkin).

So what transformative technologies might be about to envelope agriculture? Here's a *short* list and some qualifying notes:

Technological Arena	Notes
1. Enhanced ICT	The internet of things
2. Quantum computing	Ever faster and more complex information processing
3. Big data / information storage / expert systems	Large data sets and relevant processing algorithms
4. Robotics / Artificial General Intelligence (AGI)	Learning machines able to collect, analyse and make relevant decisions unaided by humans – multiple on farm use envisaged
5. New materials	Light weight, high strength, anti-corrosive, good malleability, etc. materials like graphene and stanene – implications for construction
6. Automated design and construction techniques	Look up DIRTT in Calgary (Canada) for an example of leading modular design and construction
7. Smart everything	Farms, cities, homes, vehicles, leisure, work
8. 3-D Printing	E.g. Printing spare parts for machinery

9. Human augmentation	Wearable ICT, plus surgical implants as foreseen by Kurzweil (2005)
10. New Foods	E.g. synthetic meat printed on 3-D printers; chemical cuisine (or Note-by-Note cooking); synthetic milk (developed in Boston by muufri); protein from harvesting insects Note, too, potential urban production. Competition for existing rural output
11. Bio-medical	Drugs or other treatments for many common diseases; GM advances; pharmaceuticals; chemicals
12. Transport / logistics	E.g. drones, driverless cars and trucks, Elon Musk's vacuum tubes, and aerospace
13. Renewable or alternative energy generation and storage	Wind, solar, wave, geo-thermal, micro-nuclear [and localisation of production]
14. Water management	Irrigation techniques / storage / recycling
15. Environmental monitoring and regulation	Soils, vegetation, wildlife, ecologies – identification of stress points and remediation
16. E-tailing, e-governance, e-society	
17. Educational technologies	Advances in knowledge learning systems, ability to understand and develop ideas, critique and integrate information, plus developing imagination and creativity
18. Changing demographics and lifestyles – consequent on many other technologies	Ageing, length of working lives, family structures, lifestyle preferences, working arrangements, work-social balances, social networking, etc. Lifestyles, for me, are a form of technology
19. New financial technologies	Especially fintech, venture capital arenas
20. New business management strategies	E.g. Pixar – reported by Catmull, (2014). Pixar has a flat structure to generate new ideas – which tend to come from below, not above – rather than a typical hierarchical business organisation
21. Improved business / social networking platforms + protocols / techniques	See Pentland's work on social physics and its centrality to business innovation

Under these conditions just about every aspect of farm production could experience radical transformation over the medium to longer term – from inputs to production management, harvesting and delivery to end use.

Improvements in the Efficiency of Agricultural Practices

Although the technologies noted here will undoubtedly have a large impact on agricultural productivity, it is almost impossible to calculate precisely their effects numerically for a large range of interconnected reasons. These include:

1. Variations between commodities: livestock, coarse grains, cotton, horticulture, etc.
2. Variable economies of scale – by commodity, region; bulk vs niche production
3. Export vs domestic focus
4. Corporate vs family operations
5. Strength of local labour market skills / knowledge … modified perhaps by use of fly-in fly-out labour
6. Access to capital markets – probably easier for large scale operations
7. Differences in productivity leverage between each branch of technology
8. The cost, complexity, and ease of spread of each technological innovation
9. Likelihood of blending / fusion / integration between technologies
10. The networking capacity of producers, which might be easier in more densely settled rural regions rather than remote ones
11. Ability of producers to grasp the sharing economy, as proposed by Jeremey Rifkin who has been advisor to, for example, the Obama (USA) and Cameron (UK) administrations
12. Quality of the agricultural environment: soils, water, seasonal conditions
13. Quality and cost of essential infrastructure: internet, transport media, energy supplies, etc.
14. Quality of farm management: production decisions (what and how much), timing, innovation capacity, management of workforces, etc.
15. Effectiveness of producer organisation (often commodity based)
16. Effectiveness of government-led organisations dedicated to disseminating technological advances

In conclusion, we know little in advance about the future, which will continue to ambush us at an ever increasing rate backed by a constellation of transforming technologies. This understanding is crucial for my next set of remarks about handling fast-moving uncertainty for the benefit of the farm sector, and position it for world leadership in commodity production.

Barriers to the Adoption of Emerging Technology

To start with, this term of reference omits a crucial dimension. It is not enough to ‘adopt’ a technology. The adoption has to be effective and for that to happen people engaging with a particular technology have to understand its strengths and weaknesses, the opportunities and threats it presents, how to dovetail it into current operations to best effect, and

imagine how it might be developed further by the processes of blending, fusion and integration, perhaps with other distinct technologies and, more likely, with current procedures or processes. All of this entails sound technological knowledge and, in addition, the capacity to learn and experiment quickly and fluently with considerable imagination and creativity. And all the contemporary literature on these themes stresses that these tasks are unlikely to be executed effectively by lone wolfs. Rather it is the task highly networked teams of talented and creative individuals sharing ideas about the application of technology, mentoring and supporting each other, and reporting the success or failure of individual technological experiments they have undertaken.

Another preliminary observation here is that the locations on this planet that excel in technological invention and adoption – such as Silicon Valley (or Santa Clara county), Seattle, Boston, Tel Aviv, London and New York – all exhibit similar behavioural cultures and it is difficult to see why they do not or should not apply to rural Australia in general and the farm sector in particular. Here are nine behavioural qualities to consider for accelerating innovative and adaptive futures:

1. Funding (money makes the world go round)
2. Risk acceptance – recognition of the risk of failure (in Silicon Valley 85% of start-ups fail!) but accepting that risk because it carries little adverse stigma
3. Talent – knowledge, ideas, decision-making capacity, etc.
4. Support – from funders, other businesses, community groups or institutions, private mentors, government agencies etc.
5. Mindset – imagination, creativity, originality and willingness to break with tradition, urgency, sense of purpose
6. Trendsetting – willingness to go out on limb and do something completely new
7. Diversity – forget group-think, new ideas best emerge from the clash of ideas (but debated with civility); disregard anyone who says we must all agree to a plan and stick to it
8. Amenity – quality of infrastructure and environment, coupled with access to cerebral culture (theatre, opera, etc.), and
9. Optionality (as conceived by Nassim Taleb) – constant review of options and selection of those whose assessment is the likely the most profitable over a given, probably medium term, time-frame.

Each of these dimensions is interconnected and, preferably, the task of businesses (farms in the current case), communities and governments alike is to energise the complete package. And, yes, the work to be undertaken is heavily psychological as well as scientific and technological: it's culture shifting.

Governments have typically been poor at psychological management, yet psychological issues are now at the core of modern economics thanks to the work of people like Daniel Kahneman (winner of the 2002 Nobel Prize in economics and author of a brilliant book I'd recommend to all business leaders, politicians and bureaucrats entitled "Thinking Fast and Slow"), Richard Thaler, Nassim Taleb, Bob Prechter, Jeremy Rifkin, and Alex Pentland. Basically, many of the assumptions under-pinning conventional economic theory are no longer sustainable! Econs, as Thaler calls them – i.e. *Homo Economicus* – simply don't exist and markets cannot be deeply rational. Two of the above analysts, Taleb and Prechter, should know, because the made fortunes by trading on the New York Stock Exchange and

surviving its vicissitudes and uncertainties. This understanding of real humans and markets enabled Taleb to forecast the 2007/8 global economic crisis before the event in his book "The Black Swan" which unsurprisingly became a New York Times best-seller.

Sometimes governments innovate psychologically and with tremendous effect to shape citizens' behaviours. One such instance is the strategy of "nudging" advocated by Thaler and adopted in various advanced democracies. Sweden for instance has used the technique in the healthcare arena. And the UK's Cameron government appointed a Behavioural Insights Team six years ago. One of the outcomes in the UK was to dramatically increase organ donation for medical purposes in the UK, just as the Swedes had also done. The Obama government is also in the nudging game. So perhaps Australian government strategies to increase the **effective** and **rapid** uptake of new technologies for agricultural production should involve elements of nudging.

Now, in a way, this is what farm field days – of the kinds organised by State departments of primary industries or research organisations like CRCs or RDCs – were all about. They sought, typically, demonstrate new or improved farming techniques. Moreover, they provided opportunities for networking (Pentland's social physics) for producers who are often spatially separated.

But could various other strategies help to do something that has in my view no parallels on earth: nudge the farm sector into behaving like Silicon Valley, which is the global pinnacle of technological progress? For me this is the core issue. Many of the technologies likely to impact farm practice and profitability seem to lie outside of farm-oriented research and development and firmly in the private commercial arena. Moreover, such technologies have potentially global sources that are way beyond any Australian government control. For me, the name of the game is to capture everything on offer and to use it to best advantage. In many respects, this is little different the problem of contemporary regional development strategy. And I've immersed myself in this via membership of the local digital economy implementation group which in turn nominated Armidale in 2015 for the Intelligent Community of the Year Award run from New York. Of the 450 entries world-wide Armidale made the first cut of the Samrt21 in company with major world cities like Taipei and Kaohsiung (Taiwan), San Diego (California), Montreal, Ottawa and Winnipeg (Canada) and many others. Armidale was much the smallest place to make the cut and testimony to how the right attitude and other ingredients in a remote and small community could be highly innovative and globally competitive.

So how can we develop strategy not just to create new technologies (which is still important to some extent) but accelerate the rapid acceptance by agricultural producers of all relevant technologies (from whatever source) and help early adopters to make the most of their opportunities? Here are some thoughts on that subject, developing the nine themes presented earlier, although we need far more in-depth consideration of all policy possibilities connected with each theme:

Theme	Commentary – Possible actions
1. Funding (money makes the world go round)	Develop venture and other risk capital funds focusing on the up-take of new technologies / new commodities in the farm sector.
2. Risk acceptance – recognition of the risk of failure (in Silicon Valley 85% of start-ups fail!)	Legislate to enable failed entrepreneurs to start-up new farm enterprises quickly
3. Talent – knowledge, ideas, decision-making capacity, etc.	Establish on-line forums documenting all new technologies relevant to agriculture and others where (a) producers can swap notes on how those technologies can best be implemented and (b) explore what strategies / tactics work or fail and why those outcomes result. Internet based systems stand to overcome the tyranny of distance suffered by widely scattered producers
4. Support – from funders, other businesses, community groups or institutions, private mentors, government agencies etc.	This aspect might also be developed by on-line means, but could also benefit from communities developing strong future-oriented mutual support systems locally. One example is the Enactus program at the University of New England where business students work with local enterprises. However, strong leadership from chambers of commerce, local governments or key business leaders would also help. In the USA, some universities have vibrant programs for technology transfer, but Australian universities tend to lag in this respect. Two years ago Carnegie Melon University in Pittsburgh spun of no less than 36 start-up enterprises in one year.
5. Mindset – imagination, creativity, originality and willingness to break with tradition, urgency, sense of purpose	This is served by intense networking of people with ideas and the literature claims that major cities are the fount of such networking. The task is to translate this to rural society. Some cities like Las Vegas regularly stage technology festivals and perhaps Australia should mount an annual event (possibly rotating between major regional centres) that goes much further down the technological path than fairs like AgQuip staged at Gunnedah. Perhaps, too, we need regular rural TED type conferences. On another front, we need perhaps a national web-site documenting agricultural innovations documenting and explaining innovations that both work and fail. This would especially help achieve theme 6.
6. Trendsetting – willingness to go out on limb	

7. Diversity – forget group-think, new ideas best emerge from the clash of ideas (but debated with civility)	Again, many of the networking protocols mentioned above would likely bring disparate points of view into debate about the future and provide platforms for public dissent about what the futures holds here and how to reap its potential benefits. I think it important that such opportunities not be based in Australia's large cities, but as far as possible be taken to rural locations.
8. Amenity – quality of infrastructure and environment, coupled with access to cerebral culture (theatre, opera, etc.), and	We also need much better forums on necessary infrastructure for Australia's rural regions: especially IT, transport systems, energy, research institutions, data bases. I have already contacted the Minister for Agriculture proposing the establishment of a "big data" centre for all relevant information on agriculture and the environment. This would mirror the AURIN data hub established with Federal funding at the University of Melbourne (AURIN = Australian Urban Research Infrastructure Network and was funded to the tune of $24 million). Such a data base would be the fount of innumerable research projects into the problems and prospects of Australian agriculture.
9. Optionality (as conceived by Nassim Taleb) – constant review of options and selection of those whose assessment is the likely the most profitable over a given, probably medium term, time-frame.	Optionality as a business tool is a state of mind that can only infiltrate practice by constant repetition by responsible organisations like business schools, the Productivity Commission, Reserve Bank, Accountants, Business organisations of various kinds. It depends heavily on Kahneman's system 2 analysis of complex analysis rather than system1 heuristics which often yield wrong analyses based on inaccurate rules of thumb.
Source: the author	

The conclusion I arrive at from this table is that we could do much better at developing a focus on technological innovation and its speedy and effective implementation. In some respects traditional research activities focusing on agricultural production have been effective by global standards over many decades and their implementation via the likes of field days have been exemplary. But my fear is that the impending rush of transforming technologies extending far beyond on-fam production could swamp our existing ways of doing things.

I think, too, that there are some major additional implications emerging for farm enterprises from my story. On the one hand, it seems likely that large corporate-style farm enterprises could benefit from the impending technological tsunami much better than small producers

because of (a) their better access to the heavy capital requirements implied and (b) their ability to hire in all manner of professional services to advise on best use of technology. In this regard, large farms are becoming more like automobile assembly plants in that they purchase in all manner of production components and are better able to tune technologies to their needs. On the other hand it is possible to envisage all manner of fast-moving and opportunistic start-up farm enterprises occupying new niches stimulated by the constellation of technologies. In these regards the farm sector would be mimicking the business environment of, say, Silicon Valley where the interplay of start-ups on the one hand interfaces with the big boys like Apple, Google, Microsoft and Tesla. There the large companies are rathe liker vacuum cleaners sucking up successful start-ups. It would be great in my view if we could more easily shoe-horn disruptive young start-up farmers into the industry, and link them equally disruptive advisors of various kinds. This outcome could also boost the sector's focus on innovation. Many analysts have argued that large players in any industry sector often tend to be corporate dinosaurs, though this diagnosis is obviously unfair for the likes of Apple and Google.

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