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Mick Keogh.

Will humans be redundant in Australian agriculture in the future?

There is no doubt that Australian agriculture is facing an era of unprecedented technological change, and a case could be made that humans will largely become redundant in the sector in future.

However, we are not the first generation to experience major changes due to the impact of technology, and nor is agriculture the first sector of the economy to experience such changes.

So before answering that question, it is worth considering what history and the experience of other economic sectors can teach us about the impacts of technological change.

The head of the World Economic Forum, Klaus Schwab[1], proposes that what we are currently anticipating and just starting to experience is actually the fourth major industrial or technological revolution.

In his book "The Fourth Industrial Revolution" he notes that the agrarian revolution that occurred ten thousand years ago, when plants and animals were domesticated and food production increased dramatically, enabled the mass migration of people into major urban centres.

This led to the specialisation of labour, and then the first industrial revolution which occurred from 1760 to 1840, triggered by the development of the steam engine and railways.

The second industrial revolution occurred in the late 1800s and early 1900s when electricity and the development of the assembly line by Henry Ford made mass production possible.

The third industrial revolution began in the 1960s with the invention of mainframe and later personal computers, which made the rapid processing of large amounts of information possible. This was later augmented by the development of the internet, which enabled the instantaneous exchange of information globally.

Now, Schwab argues, we are at the start of the fourth industrial revolution, which has been facilitated by the rapid development of data storage and processing capacity, and its application in combination with telecommunications, machine learning, sensors, robotics and automation through virtually every sector of the global economy.

Implications of Intelligent Automation.

What this "Intelligent Automation" revolution will mean for the future of economies, sectors like agriculture and individual workers is the subject of a lot of conjecture.

No doubt this was the case when mechanisation first occurred, and horses and human muscle were replaced by machines. Those involved in the horse industry at that time, or those muscular labourers who were highly sought after to do all the heavy lifting would have become concerned about their future employment.

The same would have occurred when Henry Ford introduced the first assembly line in Michigan in 1913. All the highly skilled tradesmen who trained for years to achieve great proficiency in building

[1] Klaus Schwab (2016). "*The Fourth Industrial Revolution*." World Economic Forum, Geneva, Switzerland.

cars from scratch suddenly found their roles reduced to that of assembly-line workers doing simple repetitive tasks who could easily be replaced.

The changes resulting from the third industrial revolution were much more widespread, and have impacted on jobs as varied as postmen, telephonists, secretaries, lift operators and bank clerks.

Whether workers in those occupations understood the potential implications of the changes that would be wrought by the introduction of computers is doubtful, as even Thomas Watson - the head of IBM at the time - thought there was a world market for only five computers.

Schwab and others argue, however, that the so-called fourth industrial revolution which has now commenced is different.

The scale and scope of Intelligent Automation means it will impact much more widely and rapidly than the past three revolutions, and it has the potential to not only displace workers from manual jobs, but also to displace workers from a wide range of professions.

As MIT Principle Research Scientist Andrew McAfee[2] has written, "*Digital technologies are doing for human brainpower what the steam engine and related technologies did for human muscle-power during the first Industrial Revolution*."

By that, he means that we are now observing the automation of knowledge acquisition, learning and decision-making, something that has been the exclusive domain of the human brain up until the present day.

In addition, these technologies are able to interact with humans using voice recognition. The very rapid emergence of smart devices in homes that can respond to speech reinforces the view that the technology capable of replacing many of the professions is already available.

Important milestones in this regard include the 1997 victory of IBM's chess-playing computer Deep Blue over then world champion Gary Kasparov.

Other notable developments have included the victory of IBM's question-answering computer Watson in the TV game show "Jeopardy!" in 2011, and the emergence of fully-autonomous self-driving vehicles – such as the Uber self-driving truck that delivered a cargo of Budweiser beer from Fort Collins to Colorado, a distance of over 200 kilometres, in October 2017.

The emergence of Intelligent Automation was considered to be of such significance that one of the last major initiatives of the Obama Presidency was to commission a number of detailed reviews of its potential impacts on the US economy.[3]

Those reviews concluded that the implications of these technologies are really only just starting to become apparent, and reported some projections that suggest that up to 50% of current occupations are likely to be either partially or wholly replaced by machines with cognitive intelligence over the next two decades.

Numerous examples were cited throughout these reports of robotic technology coupled with advanced computer processing capacity capable of 'machine learning', which have achieved performance levels that are superior to human practitioners.

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[2] Andrew McAffee and Erik Brynjolfsson (2014). "*The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*." MIT Initiative on the Digital Economy.

[3] Executive Office of the President, 2016. "*Preparing for the future of artificial intelligence."* and "*Artificial Intelligence, Automation, and the Economy."* Reports prepared for President Obama by the Council of Economic Advisors and National Science and Technology Council.

An example was cited of the use of technology augmented with Artificial Intelligence in pathology laboratories which has now matched or exceeded the accuracy of human pathologists in detecting cancer in cell samples.

A specific focus of both the Presidential reviews and Schwab's book was what these developments are likely to mean for the economy and people in the future.

Is a dystopian future likely in which machines prove more adept at learning than humans, and consequently replace them?

Or will it be that the quality of human life will be enhanced and enriched by Intelligent Automation, in much the same way the lives of labourers were improved when machines took over some of the more gruelling manual tasks during the first industrial revolution?

The jury is still well and truly out on this question, although some trends are available that provide useful insights for the future. The following are some projections from Klaus Schwab, with these sentiments also echoed in the reports produced for President Obama.

Schwab observed that "*Many different categories of work, particularly those that involve mechanically repetitive and precise manual labour, have always been automated. Many others will follow, as computer power continues to grow exponentially. Sooner than most anticipate, the work of professionals as different as lawyers, financial analysts, doctors, journalists, accountants, insurance underwriters and librarians may be partially or completely automated."*

He projects that "*In the foreseeable future, jobs at low risk of being replaced by automation will be those that require social and creative skills; in particular decision-making under uncertainty and the development of new and novel ideas."*

He further projected that "*Employment will grow in high-income cognitive and creative jobs, and low-income manual occupations, but it will greatly diminish for middle-income routine and repetitive jobs."*

On the question of future workforce requirements, there was a consensus about the need to develop workforces that are equipped to work with, and alongside, increasingly capable, connected and intelligent machines.

Implications for agriculture.

What these developments mean for the future of agriculture, and more importantly what these developments mean for the future knowledge and skills that will be required by those working in, and managing agricultural businesses is the focus of this conference.

These questions are important, not only for the future growth of the sector, but also for those currently embarking on a career in the sector, and those charged with the responsibility of educating and training the sector's future managers and workers.

It is arguable that the changes now underway in other sectors of the economy due to Intelligent Automation are really not relevant to agriculture, because agriculture at its heart involves biological and environmental interactions that are modified by a wide range of different factors, the successful management of which requires knowledge, skills, experience and insights that are not easily codified or automated.

I think this argument has some truth if we are thinking about the short-term – the next three to five years – and particularly over that period for some sectors of agriculture such as broadacre livestock and dryland cropping.

However, I think it would be strategically irresponsible to limit our consideration to this timeframe, and hence to dismiss the potential significance of Intelligent Automation for the future of the agriculture sector.

I say this for two reasons. First, those young people currently thinking about a career in agriculture – especially as professionals and managers – are contemplating a five to ten-year intensive learning and training period during which they will obtain the qualifications and knowledge that will provide them with a rewarding career, and the sector with the vital human resources that will be needed for Australian agriculture to remain competitive and expand in the future.

This means that our agricultural education and training systems already need to be equipping industry entrants for the work environment they will experience a decade into the future.

Secondly, while it is true that the complex environmental factors inherent in plant and animal production are not as easily monitored and converted to objective digital information as is the case for an assembly line or a bank, technology is already developed to the stage where the key question is the economics of monitoring and collecting the relevant agricultural data, not the technical capability of doing so.

As can be observed from other presenters at this conference, there are few if any of the factors of production associated with an agricultural enterprise that cannot now be monitored and translated into the digital information that will be necessary to successfully implement Intelligent Automation.

It is currently possible, using existing technology, to reliably monitor in real-time all the soil, water, atmospheric, plant and animal conditions necessary to manage an agricultural system using computer processing capacity and machine learning, and to do so at a much greater level of precision than even the best human manager can achieve.

In fact, this is already occurring in some intensive livestock and protected horticulture businesses, which have almost completely computerised control systems, and the manager is relegated to little more than monitoring a computer screen.

However, the current limiting factor, particularly in the less intensive production sectors, is the economics of such monitoring systems, and to some extent the ability to connect these in a network.

Due to the rate of development of technology, the cost of these systems is rapidly falling, and it will be economically feasible to establish these integrated monitoring systems in even the extensive sub-sectors of agriculture within a decade.

To those of you who might think that projection fanciful, I remind you that it is just two weeks shy of 11 years since the first smartphone was released, and there are now 2.53 billion of them in use world-wide – a reminder of how quickly these technological changes can occur.

If it is accepted that the development of Intelligent Automation is already underway in agriculture, and likely to be much more widespread within a decade, what are some of the lessons we can learn from other economic sectors that have already experienced this transformation?

The first lesson for me is that the very detailed technical knowledge that many of us spent years learning in disciplines such as chemistry, agronomy and animal physiology will be of decreasing value to the next generation of agricultural business managers and will soon only be relevant to a very small group of specialist researchers.

The reasons that I think this is the case are multiple. Firstly, the ubiquity of Google and other search engines means that all of this information is instantly and universally available, and there is no longer a need to commit it to memory.

In fact, memorising the chemical reactions involved in photosynthesis will be about as useful to a person in the future, as memorising times tables is now in an era of universal access to calculators and smartphones.

Secondly, as Intelligent Automation systems develop, relevant technical information will simply be coded into software systems and incorporated into the outputs provided to operators.

And thirdly, in situations where uncertainty remains, machine learning based on access to large volumes of relevant data will overcome the need for a detailed technical understanding of the precise nature of the physical and chemical interactions involved in a production system.

I was made acutely aware of the diminishing value of detailed technical knowledge about agriculture several years ago during a visit to a major agricultural technology company in the USA. The CEO informed me that he had just one plant physiologist on his staff, along with about ninety computer programmers and IT specialists.

I believe that this observation applies equally to different businesses throughout the entire supply chain from farm to consumer, and not just to those directly involved in agricultural production.

By way of evidence you just need to consider how many current car drivers know how their car engine works, or how to fix it in the event of a breakdown. Knowledge that was considered essential for drivers just a generation ago has been made largely redundant due to the computer processing capacity now incorporated into motor vehicles.

It will be more important for the future agricultural workforce to be able to adapt continuously and learn new skills, than it will be for workers to have an understanding of the scientific underpinning of the production system they are involved in.

The second lesson we need to consider is that knowledge of how software systems interact and how connectivity can be achieved and maintained across a business enterprise, and between enterprises, will be of critical importance to the future sustainability of agricultural businesses.

This is already the case in agricultural businesses that are at the forefront of the adoption of Intelligent Automation. For the manager of an intensive poultry or irrigation farm which has integrated computerised control systems, a failure of a computer can be just as critical as the failure of a major pump or electric motor.

Having skilled staff or service providers available who can overcome such challenges will be essential to future business success.

This applies equally to interactions between businesses along a supply chain. Efficient future supply chains will enable information to be transferred seamlessly between participants as necessary, especially in the case of supply chains that are reliant on provenance and credence claims as a significant component of product value.

For a beef producer who wishes to integrate cattle genetic and performance information with NLIS compliance data, DEXA carcase feedback, and then integrate some of this with Breedplan, send some information to the bank, and make some of this available to consumers, the challenges of data integration and management are readily apparent.

Having either staff or service providers available with these skills will better equip any agricultural businesses to transition towards the increased application of Intelligent Automation that is inevitable in the future.

A third observation that is available from many of the reviews and studies of the potential implications of Intelligent Automation, is that the so-called soft or people skills will become significantly more important for managers of these businesses in the future.

The observable trend that have occurred in those sectors of the economy already impacted by Intelligent Automation is that it has displaced staff in the mid-skill ranges – especially those involved in carrying out relatively repetitive tasks – but that employment is predicted to grow in high income cognitive and creative jobs, and in low income manual jobs.

Manual agricultural tasks that are not easily automated, such as fruit picking or shearing, are already carried by contractors or casual labour, and it is unlikely that this will change in the foreseeable future.

However, at the high-skill and managerial end of the agricultural workforce it seems there will be an increasing trend towards the use of specialist service providers and professional contractors, with the business manager acting as coordinator, rather than a supplier of these skills to the business.

The critical skills needed by future agricultural business managers are therefore going to be people and communication skills, and more than one of the reviews of Intelligent Automation have noted that such skills are generally considered to be more prevalent amongst females, rather than males.

This suggests that the future leadership of agricultural businesses will have less gender imbalance than has been the case in the past, and that those involved in training the future managers of agricultural businesses will need to place a much greater emphasis on people and communication skills.

Conclusion.

In conclusion, all the available evidence about the potential implications of artificial intelligence and automation for a sector such as agriculture points to some seismic shifts in the way that businesses will operate as the technology is adopted, and further indicates that the timeframe associated with likely changes will be measured in years, rather than decades.

It can be confidently predicted that within a decade it will be economically feasible to digitally monitor most if not all the factors of production in most agricultural businesses.

Intelligent Automation will also mean that in ten years, many of the more routine tasks will be capable of being carried out by machines, although I still have some doubts about automated shearing!

By that time, integrated computer software systems will be capable of doing much of the decision-making, and will become progressively better than humans at doing this due to their machine learning capability.

Some of the jobs that currently provide employment for people in the sector will undoubtedly disappear, and people employed in these roles will become redundant.

It probably doesn't matter whether we think this is a good or a bad thing, as such changes are largely inevitable, and can be readily observed in other sectors of the economy.

No doubt many people previously employed in the car manufacturing sector were opposed to the job losses arising from robots on assembly lines, but the adoption of that technology was inexorable, and the national car sectors that resisted the changes experienced the greatest losses, as they became uncompetitive and were shut down.

The most logical response strategy for the agriculture sector in Australia is to gain as many insights as possible from the experience of other sectors of the economy that have already encountered these changes.

Armed with that information, the most urgent immediate task is to review current agricultural education and workforce training systems, to ensure that the future agricultural workforce will be well equipped to operate in a work environment that will be very different from the current one.

More generally, participants in the sector need to engage in discussions about these changes and their possible implications with research agencies, policymakers and the wider community, to ensure the changes are facilitated, rather than resisted.

This conference is a good example of this process, and further similar efforts will be required.

At the start of this presentation, I posed the question of whether humans would be redundant in Australian agriculture in the future.

I think the answer is that humans will certainly be redundant from some of the tasks and roles they currently perform in the Australian agriculture sector, but there will be a lot more redundancies if the sector fails to embrace the opportunities for improved global competitiveness that Intelligent Automation is providing.

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