GRAHAM CENTRE
for Agricultural Innovation

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Charles Sturt University (CSU) appreciates the opportunity to provide a submission to the House of Representatives Standing Committee on Agriculture and Industry's inquiry into agricultural innovation. As a leader in strategic and applied research in agriculture through its alliance with NSW Department of Primary Industries in the Graham Centre, CSU welcomes this review.

Charles Sturt University has a strong history of working with industry to deliver research outcomes that enhances farmer profitability. A third of CSU's external research funding comes from partnerships with industry, which is double the sectoral average. Examples of some of CSU's strong partnerships with industry include:

- Ongoing research collaborations of significant relevance to industry through the rural research and development corporations including the Grains Research & Development Corporation, the Australian Grape & Wine Authority, Meat & Livestock Australia and the Rural Industries Research & Development Corporation.
- The CSU-led ARC Industrial Transformation Training Centre for Functional Grains, which involves collaborations with SunRice, Woods Grain, MSM milling, GrainGrowers Ltd, Teys Cargill and Flavour Makers.
- The National Wine and Grape Industry Centre which is a partnership with the NSW Wine Industry Association and the NSW Department of Primary Industries.
- Farming Systems Groups, including a Partnership Agreement between Central West Farming Systems, the Holbrook Landcare Network, FarmLink Research and the Irrigated Cropping Council.
- Multinationals including Fonterra.

CSU would welcome the opportunity to provide further input into the Inquiry if required.

1. Improvements in the efficiency of agricultural practices due to new technology, and the scope for further improvements;

Productivity growth in agriculture has been underpinned by the development and use of new technology. Notable examples of large step-changes include the introduction of no-till farming (facilitated by the availability of new herbicides), which greatly reduced input costs, retained more soil moisture and improved crop yields; and the introduction of subterranean clover in southern Australian livestock systems which improved soil fertility and increased livestock growth rates and carrying capacity. Incremental improvements (through plant and animal breeding, improved management practices) have built on these large changes to result in further production gains through improved water use efficiency, stress tolerance (e.g. disease and frost), feed conversion efficiency and product quality.

ABARES, in its 2014 report on Agricultural Productivity Growth, noted slowing total factor productivity (TFP) in the past 15 years in the agriculture sector generally, and attributed this to both recent adverse seasonal conditions and a declining investment in public agricultural R&D relative to the value of production. It can be argued that much of the large TFP gains in cropping in the 1977-1988 period cited in this report were attributable to the R&D investment that allowed no-till cropping to become widespread, combined with largely good seasonal conditions allowing crops to approach their yield potentials. Much slower TFP growth in the 1999-2010 period coincided with the millennium drought and reduced public expenditure on R&D, and this has refocussed R&D efforts towards breeding more drought tolerant varieties, conservation of soil moisture (e.g. stubble retention), and practices to improve risk management (e.g. the use of dual-purpose crops which allow both a grazing value and grain yield).

There is no doubt that recent advances in technology have allowed efficiency gains. Analyses of the use of variable rate applications (VRA) of lime and phosphorus using map-based data has shown in the vast majority of cases the approach is economic. The use of sensors to adjust application rates during application is more desirable (more frequent and real-time sampling of conditions), although in most cases the sensor technology needs further development to enable widespread use.

Recent advancements in technology have permitted greater data collection on-farm. For example, yield mapping is now common, while in the beef and sheep industries electronic identification has permitted the collection of individual animal data. While there exists the potential to collect large amounts of data, with few exceptions the challenge now is how to manage this data so as to inform practices to improve efficiency. With the advent of new technology (see below) capable of generating much more data, this challenge will only increase. Effectively utilising this ‘big data’ to inform management presents a large opportunity for significant improvements in the efficiency of agricultural practices.

2. Emerging technology relevant to the agricultural sector, in areas including but not limited to telecommunications, remote monitoring and drones, plant genomics, and agricultural chemicals;

Remote monitoring provides an enormous opportunity for improvements in efficiency. For example, remote monitoring of soil moisture provides an opportunity to link yield maps to spatial variability in soil moisture. Such information will allow variable rate inputs based on land capability, leading to improvements in efficiency. Similarly, remote monitoring of moisture in crops and pastures will enable farmers to make informed decisions – e.g. to apply additional fertiliser or not, to sell livestock early, especially when combined with seasonal forecasts.

Drones may also provide significant improvements in efficiency. For example, drones used to capture in-crop conditions via spectral imagery will enable more informed decisions on whether it is economically viable to apply herbicides, pesticides or fungicides. In pastures such technology can allow identification of weed infestation zones which will allow targeted herbicide applications. While it is possible to use sensors to implement VRA of herbicides, pesticides and fungicides, further developments in sensor technology will permit the economic usage of the technology across a range of crop and pasture types.

Individual animal sensors will also allow improvements in livestock productivity. For example, through the use of electronic ID tags and walk over weighing it is already possible to remotely identify animals ready for sale. The incorporation of sensors into electronic tags will permit the collection of data leading to improvements in livestock productivity. For example, the rate of genetic gain in the wool industry is widely regarded as being slow relative to other livestock industries, and this is often attributed to the low level of pedigree recording in the industry. Traditional methods of pedigree recording are labour intensive, while DNA pedigree information is relatively expensive. The use of proximity sensors to identify parentage with a high degree of accuracy has the potential to enable widespread recording of pedigrees, increasing the rate of genetic gain within both stud and commercial operations. Furthermore, in commercial flocks, such information will also allow identification of animals with high reproductive performance (for example, in sheep, ewes consistently rearing twins), which can be used to inform decisions on animals that should be preferentially retained in the flock. The inclusion of temperature sensors may provide the opportunity to monitor individual and flock health (permitting early management intervention), while the inclusion of an accelerometer may allow behavioural patterns to be identified (through algorithms) indicative of events such as calving or predator attacks. As the cost of GPS reduces, its inclusion in ID tags will enable landscape usage patterns to be identified, informing decisions on land management, perhaps through virtual fencing.

Integrating multiple technologies perhaps provides the biggest potential gains. For example, soil sensors could be used to identify areas of the farm that need to be destocked sooner and areas that may support continued plant growth. Remote monitoring of pasture conditions (herbage available and quality) will permit livestock production to predicted, and combined with estimates of pasture growth (from soil sensor and weather data) and individual animal weights (via walk over weighing or similar) will enable predictions on turnoff weights and dates. Such data will enable producers to make early decisions on sale (or purchase) of stock, and in cases of poor seasonal conditions, prioritise animals to destock based on the additional data collected on their historical performance (e.g. animals with below average reproductive performance).

Advances in plant and animal genomics will continue to underpin rates of genetic gain. For example, gene discovery work being undertaken at DPI in Wagga is working towards identifying drought and heat tolerance genes in cereals, which will lead to more robust crops in future. In livestock, improvements in our understanding of the role of epigenetics will facilitate improvements in productivity and quality. For example, work at the Graham Centre in Wagga has shown manipulation of the diet around the time of conception can alter the omega fatty acid status of the meat from the resulting progeny, as well as the proportion of females born to those progeny. Our ability to modify the gene expression by *in utero* or early life management is a largely untapped area, and may be a cost effective way to alter productivity, without the risk of consumer concerns in relation to genetic engineering. Similarly, while the development of new herbicides is required to combat issues of resistance, fundamental work on allelopathy within organisations such as the Graham Centre require ongoing investment so non-chemical means of weed control can be further developed.

In recent years genome-editing technologies have emerged, which together with modern reproductive technologies, enable selective modification of genomes with precision. Such molecular ‘scissors’ can be engineered to target specific DNA sequences and cut out or introduce sequence elements with a high degree of accuracy. This has the potential to dramatically increase the rate of genetic progress. Moreover, since foreign genetic material (belonging to another species) is not introduced in the process, this technology is less likely to be subject to regulatory hurdles and consumer rejection. Expedited genetic improvement via genome editing has the potential to significantly improve production, production efficiency, disease resistance and animal welfare (e.g. dehorned cattle have already been produced using genome editing technology).

3. Barriers to the adoption of emerging technology

While early adopters have embraced new technology as it becomes available, rates of adoption by the majority (early and late) will likely follow the standard adoption curve unless strategies are implemented to accelerate adoption. Farmers are often cautious of adopting new technology until they see it working in practice, which can be considered as a risk management strategy. There is often good justification for this – for example the cost of new technology usually decreases over time, and the technology is improved over time as issues are identified.

A key factor affecting the rate of adoption is trust in the message and confidence that adoption will result in the desired outcome. Surveys have consistently shown that farmers are wary of information provided by individual companies, believing it to be potentially biased. When adoption requires a capital investment, farmers are more confident when robust, independent economic analyses are available. Willingness to adopt is further improved when the implication of adoption on the whole farm system is included. Involving farmers in on-farm evaluation and testing of new technology can be an effective way of developing messages that result in enhanced adoption. For example, in the recent EverGraze project (www.evergraze.com.au), farmers were involved in designing the research questions (resulting in ownership), testing some of the innovations on-farm (increasing confidence in the result), and designing the key messages from the research, including feedback on the economic analyses that addressed whole-farm implications of adoption. In many cases the economic benefit of adopting a new technology is only fully captured if modifications to the farming system are also made. Such an integrated Research, Development & Extension (RD&E) approach can result in a much greater and faster level of adoption than that predicted from the standard adoption curve.

In order to increase the adoption of emerging technologies, we consider it critical to form partnerships between the technology developers, public research organisations (independence) and next and end users. Such an approach will lead to widespread evaluation of the technology and identification of limitations (leading to technology improvements, 'fast testing'), a better understanding of the fit of the technology in and benefits for different farming systems (through independent economic analyses), and a resulting greater confidence by next and end users to adopt.

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