Technology has been transformative for agriculture over the past two centuries taking the profession of food production. This has evolved from what was primarily manual labour to that which is more akin to manufacturing or office work. This transformation has made agriculture a far more productive enterprise on many metrics. On the most valuable metric available, time. The improvement has been miraculous; under manual labour production of 1 metric ton of wheat took the equivalent of 1800 man hours. With modern management and technology it takes 30 minutes and is dropping.

These gains are the result of the effort innovators who strive to improve the efficiency of food production. Some innovations are the result of ground up development to reinvent the system such as mechanical harvesting, others are more a fusion of technical capabilities that have been adopted and adapted to an agricultural setting. It has been the addition, hybridisation and occasional removal of these tools and management practices that has provided today's professional agricultural systems.

This brief paper cannot hope to cover the immense scope of this topic, but will briefly touch on all the terms of reference.

One of the more transformational contemporary technologies has been the integration of satellite guidance systems into broad acre cropping. This technology has provided myriad of productive gains resulting in reductions of labour, capital and inputs whilst also enabling improvements in soil and crop health, and operational timeliness.

These gains have come from the ability to make machinery larger reducing the duplication of equipment and the labour requirement. This has limited the overall machinery need and decreased the total capital required for crop production. The improved precision of driving has reduced overlap and minimised wastage within the system from over and under application of products. These were probably the gains the innovators had in mind when they designed these systems, however the major benefits may have been serendipitous.

One such benefit has been the broad scale adoption of controlled traffic farming which has increased water holding capacity of the soil and improved soil health with increased biological activity. In conjunction with the softer soils providing these improvements the addition of permanent road ways in the paddocks has improved the timeliness of operations. Many operations that would need to be delayed due to paddock conditions being too wet are now capable of being undertaken except under the most adverse of circumstances. All these aspects have improved crop health and yield, further enhancing the productivity of these systems.

Further gains will be produced from the use of satellite guidance such as autonomous tractors potentially resulting in the miniaturisation of equipment and the open sourcing of agricultural machinery. Such an adaption would have its own direct benefits, such as the further reduction in labour and capital required for crop production. Additionally smaller machines would reduce compaction and reinstate what are essentially roadways in CTF systems to productive land. Open sourcing would allow greater customisation of machinery, making it fit for purpose as producers can design and build their ideal machines at low cost. As opposed to the proprietary, factory built, limited option machines presently on offer that work on labour being the limiting metric.

This is a glimpse of what has happened and what potential the future holds, from looking at the single input of satellite guidance. Society should be cognizant that running in parallel to this are developments in soil water and nutrient monitoring, modern plant genetics and high resolution multispectral imagery to name a few. These are or will create their own transformations in agriculture. When all these tools are at the disposal of modern agricultural managers the results will transform agriculture once more.

Soil water and nutrient monitoring is not new but with cost reductions in sensing equipment and the additional of mobile telecommunications to areas of the rural landscape, the capacity of this technology has moved from the research arena to that of the agricultural manager. There is presently capacity to monitor soil moisture in real time in the soil profile at various depths. This is then available in real time to producers for decision making. These can be high frequency decisions such as irrigation scheduling or longer term considerations such and varietal selection or fertiliser requirements in dryland production. If sensing technology can also be developed to monitor soil nutrition levels in similar ways then producers would have very powerful information to make critical, timely decisions about crop inputs. Furthermore it would allow very quickly the impacts of soil nutrient stratification to be identified and solved; an issue which is vexing agricultural producers and researches alike.

Technology is and will continue to transform plant breeding. Modern bio technicians can now place individual genes or packets of genes precisely where they want them rather than older methods that where more trial an error to find the right place for gene expression. Technology developed for bio tech have also improved conventional breeding. New technology allows slices of individual seeds to be collected allowing their genetic code to be analysed without damaging the germ of the seed. This means the best genetics can be isolated from millions of seeds in a very short time and the most suitable candidates be reproduced. Under conventional systems such a process was time and capital intensive and probably resulted in some better genetics being discarded or overlooked.

Access to imagery is going to change agricultural management as it already has started to in some circumstances. High resolution multispectral imagery will offer new insights into crops that were unknown previously. They will offer pinpoint accuracy of crop establishment, weed competition and control efficacy. Disease and insect control may come to be managed weeks earlier than is presently capable and may reduce the need for blanket application of many pesticides. This technology is still in its infancy but offers some of the most exciting prospects on offer for agricultural managers. Presently one of the greatest impediments of this technology is data transfer speeds. Large high resolution images are very large data files. In many rural areas the fastest way to transfer these files is via Australia Post and if the NBN doesn't enhance the focus on upload speeds this will be the status quo for the foreseeable future.

There are many barriers to the adoption of technology and one simple instance has been highlighted with reference to data transfer speeds in rural areas. This issue will be as important for monitoring autonomous machinery as it is for transferring imagery. Other impediments range from the age of industry participants and willingness to embrace risk or change in years leading up to retirement, to educational requirements for adoption, lack of local technical back up, localised monopolies through exclusive importer arrangements, market risk factors and government regulatory impediments and requirements.

The age and aging of farmers is a cliché in Australia. This has practical consequences in a rapidly changing environment where many producers have had little technology change across the majority of their productive careers. Their major upheavals have been more in terms of industry structure than that of technological transformation. This situation is even more relevant in the livestock sectors where very little technology has been utilised in the mainstream.

This dovetails into the educational requirements that are necessary for the adoption of technology. There has been a move to the digital age in agriculture in many aspects. This is quite a challenge for many individuals who are largely mechanically minded to come to terms with. Many producers are used to being able to identify a problem and fix it, modern technology is facilitating a paradigm shift for many producers. Much of the technology today has internal control systems and software systems which can be quite vexing for the mechanically minded. This psychological element does impede the adoption of labour saving and productive technology. Exacerbating this issue is backup to service this equipment.

Rural Australia is sparsely populated and consolidation of agriculture has taken its toll on many service sectors the stereotypical business model is diversifying rather than specialising. Service providers are reticent to take on the risk of providing specialised service to novel products in a limited market. This is a standoff as producers wait for services to improve and providers wait for the market to grow. This lack of service is not helped by some of the common industry structures and norms.

There are a great deal of importing monopolies in Australia for agricultural equipment. These monopolies have a habit of being lazy and inefficient, the lack of competition results in limited entrepreneurial effort in providing price and service competitive business models. This is exacerbated with the limited inventory of parts that many companies house. There is little that can be done to overcome this issue as these are arrangements made between willing and informed parties. Unfortunately they do provide a significant barrier to improving the service and price competitiveness of many products. A more competitive market place would encourage uptake of novel products.

It is not only on the upstream side that market issues are occurring. The downstream consumers also pose a problem for some technologies. Biotech is good example and for many reasons. It is not just a portion of the end consumers who are concerned about GM products it is also the supply chain which gets it to market. The supply chains business model for grains typically works on thin margins and high volumes to make their system viable. In this scenario any issue could be fatal for these businesses. If an off spec shipment is found they may be operating with very limited equity and end up holding a parcel of unsaleable product. This can result in their business failure and culminate in significant losses being incurred by unsecured stakeholders upstream who have supplied product.

This scenario does not foster confidence for producers to adopt technology than can be traded at a significant discount in some markets to offset the risk to the supply chain; GM canola on the Australian east coast is a contemporary example. This unfortunate scenario was not helped by the fragmented and controversial introduction of this technology and the inconsistency of governments in dealing with its introduction.

Government intervention does not necessarily encourage the adoption of new technology or assist in reducing its cost to agricultural producers. The Ag chem industry is one sector that feels the rigors of government oversight more acutely than many sectors. This oversight is there for the safety of the consumer and user which is the state sponsored mandate of the regulator. However the concern seems a little hollow when there are many products available in supermarkets that pose a far greater risk than the chemicals commonly used in agricultural production.

Many Ag chem products have multiple uses but strict labelling requirements limit the legal utility of these products, restricting their market reach and driving up cost. I am not suggesting carte blanche in this area but many products of equivalence are used internationally for problems we face in Australia. More liberal laws need not reduce for food safety or risk tarnishing international trade where maximum residue limits are already in place. The restrictive nature of Ag chem regulation is a burden and cost that is not easily overcome for the industry. New pestilence can far more easily infect a farm or crop, than permits be can acquired to overcome it.

Technology has and will continue to transform agriculture, this should result in food, fibre and timber becoming more plentiful and cheaper whilst maintaining a profitable industry.

There are many natural impediments to adoption of new technology in agriculture that individual business operators must negotiate. These restrictions are acceptable and no producer should be forced to adopt technology due to the whims of government or bureaucracy. Regulatory agents do have a responsibility in ensuring they are not an unnecessary impediment on adoption of innovations which foster the development of a more productive and profitable industry that ensures a plentiful and safe bounty for society to consume.