The implications of societal risk management on agricultural productivity.

A report for

By Mark Swift

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Executive Summary

Over the past 10,000 years the man-hours required to produce enough wheat for the annual calorific requirements of a single person has dropped from 600 hours to roughly 10 minutes. The current progress in making food cheaper has resulted in half of the global population occupying the relatively affluent middle class and has enabled a diaspora from the fields. Agriculture's relationship with the broader community will be of crucial importance if it wishes to maintain some degree of liberty in procuring productivity gains. The gains that have been made are not largely recognised as necessary for modern society to maintain present living standards.

Agriculture may view itself as unique, but broader society is demanding industry has to meet their expectations. Many of the restrictions are not all directly imposed on the farmer but that is where they are being felt most acutely. This report has studied the diminishing chemical options that are available to agricultural producers, the restrictions that are being applied to biotechnology and the limitations that are being placed on the potential of machinery. All these areas are vital in enabling the future productivity gains of agriculture.

Protagonists developing and administering rules for agriculture need to be cognisant of the negative implications of their regulatory programs. New rules and restrictions have consequences. These consequences are not always positive and some cause greater problems than the issues they were designed to overcome. More thought is required on the implications of rules and their unintended consequences for the system to progress.

An example which highlights this has been the dealing of the live export of livestock to the Middle East and South East Asia in recent years. The supply interruptions have caused very real food security issues for Australia's trading partners and called into question sovereign risk when dealing with this country. No doubt the intentions of the interventions were good but the flow-on effects have been very long lasting, ranging from the creation of black markets for Australian livestock to a class action against the federal government by the effected parties (Penfold, 2014; Everingham & Obrien, 2014).

The trend of fear that is developing towards the systems which sustain our standard of living is concerning. There is a psychological element to this fear and it will need to be considered in the innovation process. Mechanisms are required to counter this trend because if left unchecked the risk management apparatus being implemented to quell the fear could result in sclerosis of

the systems which provide agricultural innovations. Engaging politicians and bureaucracies in a broader discussion of why innovation is necessary and where the opportunities are will be an important component in enabling continued agricultural productivity.

Concurrently entrepreneurs need to show a high degree of responsibility in their actions when researching innovations. They have a responsibility to their customers to ensure that they are not placing them at undue risk. This will require a more open process of involvement with the supply chain to ensure that significant changes are supported by the supply chain and evidence of benefits to the customer is provided. Where there are mistakes and accidents investigations will need to be undertaken to ascertain the problem. If there are serious incidents and criminal culpability is proved the innovator should be held responsible.

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Foreword

Initially this topic focussed solely on the precautionary principle. The precautionary principle is a policy tool used with the intention of limiting the potential risk associated with the commercialisation of things. "Things" ranging from resource development projects such as coal seam gas extraction, the introduction of foreign or genetically modified organisms to an environment, or the introduction of elements into the food chain where there is some degree of ambiguity to its effects.

There are a multitude of definitions of the precautionary principle but its root is derived from statements such as 'an ounce of prevention is worth more than a pound of cure'. *The **precautionary principle** or precautionary approach states that, if an action or policy has a suspected risk of causing harm to the public or to the environment, in the absence of scientific consensus that the action or policy is harmful, the burden of proof that it is not harmful falls on those taking the act.* (Wikipedia, 2013)

There is prudence in the notion. Individuals should be cautious when trying something new. There is a need for responsibility to be taken by those who are taking risks especially when the potential for harm is the burden of third parties. The practical application of this is more problematic with a range of potential interpretations from the weak to the strong.

My first experience with the precautionary principle was during the introduction of Roundup Ready Canola®. This was a term that was repeatedly used as backstop for those opposed to the technology. I was concerned what the implications of this policy were and how it would shape agricultural business and industry.

This concern was reignited by a joint Grains Research and Development Corporation and Australian Bureau of Agricultural and Resource Economics project inviting producers to comment on why productivity growth was slowing. My full interpretation of the reasons for waning productivity was delayed. I struggled with what I perceived to be a degree of hypocrisy on behalf of the questioner. Government concern for waning productivity appeared to be

shallow when it was complicit through regulations which prevented more liberal access to productive gains. I felt Governments were as responsible for the slowing as other parties, through application of their policies, including the precautionary principle in areas such as pesticide registration and biotechnology.

This initiated another line of questioning regarding safety. This was not limited to agriculture but had a broader societal context, from banning bull bars on vehicles to placing a sign on or barrier around every conceivable risk. It all appeared on the surface to be reasonable, but my concerns were that it was having deleterious effects on social well-being. Society is becoming more safety conscious, but this has a cost.

I was determined to get a better understanding of the protagonists in the discussion to gain a better perspective of their motives. Doing this proved to be a leviathan task and I have finished only to discover all I have done is learnt to ask a better question.

Researching this topic has proven to be quite an emotive exercise. The questions and positions that I have posed myself have been confronting. I do not apologise for the emotive nature in some of the discussion. There is a tendency in modern discourse to be polite and politically correct. This is something I have battled with as the implications of what I have studied are very real to the people who are on the receiving end.

I must also highlight the bias towards external forces in influencing a farmer's capacity to innovate and improve productivity. This is intentional and is not intended to abrogate responsibility in this regard. I personally believe that farmers are the most complicit group in limiting the potential of the agricultural sector. That said it is a personal choice to run a business as the proprietor deems fit. This paper is concerned with the external removal of choice from farmers to innovate and progress.

Containing the topic has proved quite problematic as there are many influences in the discussion and not all aspects could be considered. Every new realisation brought about a new line of

questioning and thinking. I am not sated but have rested on the current position as it provides a starting point for what I wish to understand. I hope that this study provides an entry point for those who wish to advance this discussion.

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This paper could not have been possible without the valuable contributions of many people and organisations. Special mention should be made to the following as they have all gone above and beyond their duty in helping organise meetings or have put me back on track after I have followed another tangent.

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My wife and family have made great sacrifices to allow me the time and capacity to undertake this leviathan topic. I hope I can repay the debts incurred.

Abbreviations

GM genetically modified

R&D research and development

GPS global positioning system

VHF very high frequency

MRI magnetic resonance imagining

HP Horse Power

Kw Kilowatts

Objectives

Innovation and progress are linked. Not all innovations are successful and many, if not all, come with a degree of risk. However even innovations that do not work do provide opportunities for progress. Risk taking is therefore a necessity for the advancement of society. A necessity because very little is learnt doing the same thing. New things are learnt by making changes and observing the results; this encompasses a degree of risk.

Progress is a subjective phenomenon depending on your personal beliefs. But it should have measureable outcomes. There are many ways in which progress can be measured in agriculture; from yields, to productivity, to nutritional content. In the context of this paper it will be confined to the reduction of time involved in producing food, as time provides a constant: it crosses borders, currencies, and languages, it is a universal measure.

Progress is not a linear process but has more of an episodic nature. This means that not every option tested will have successful outcome; each test should offer insight into the problem and move towards the solution. The nature of this process and any progression is not without risk. This process has been taking place for millennia advancing the human condition from cave dwelling hunter-gatherers to modern civilisation.

If individuals wish to maintain the trend in improved living standards then cognisance of the link between innovation and living standards is required. The standard of living now experienced has come about via a freedom to innovate. If society wishes to maintain this, acknowledging the risk involved in improving living standards will be required. Restraining the liberties required for innovation will temper progress.

Contradictory arguments are ever present in the societal and political discourse. There are expectations of improved living standards and absolute safety to man, beast and flower. For agriculture this is creating stresses. If it is to maintain its productivity trend and perpetuate its role in improving living standards then several questions require investigation.

1. What impedes agricultural innovation?
2. What is the source of these impediments?
3. What are the implications of these impediments to agricultural innovation?

This study aims to answer these questions.

Introduction

In the past 10,000 years the input of human labour required to produce the annual calorific requirement of a single person (on a pure wheat diet) has dropped from 600 hours to roughly 10 minutes. Concurrently this task has transitioned from hard manual labour to a task debatably more akin to office work. The outcome is a safer, cheaper and less resource-intensive product.

A by-product has been the division of labour enabling a diaspora from the fields encouraging people to improve their standard of living in many ways. This division of labour has come to the point where, in developed nations, only 1% to 5% of the population are directly involved in food production. This has advanced the collective knowledge held by humanity. Never before have people had such intimate knowledge of such narrow specialities.

The focus of this report is not to ask whether agriculture is getting better, but whether it could be doing so faster. There are a multitude of new products and techniques in development. Many of these would foster greater understanding of agriculture and further reduce the cost burden of food. In reality many of these novel products and practices will be limited in their availability to producers.

This study originated in an attempt to expose impacts the implementation of the precautionary principle is having on the potential of agricultural productivity. The precautionary principle, when invoked, places the burden of proving safety on the developer of a novel product before it can be released to the wider environment. In its strictest context it can be a handbrake for development and innovation as it requires an often impractical standard of “proof of safety”.

In the initial stages of this research it was evident the precautionary principle was not necessarily the problem, but rather a symptom of a larger issue. This changed the nature of the study and prompted a change in approach in order to gain a better understanding of what encourages the use of tools such as the precautionary principle. An approach was developed to study technologies currently in use or in development for mainstream agriculture that will come

under the scrutiny of the public and regulatory authorities. Three inputs to the agricultural system were chosen;

- agricultural chemicals
- biotechnology
- mechanical agriculture.

Research has been undertaken across many countries on four continents, across a range of social structures and various stages of economic development. This approach has allowed for insights to be gained, which have assisted in framing the discussion, from a perspective of developmental and cultural diversity. It has also enabled the discussion to be broadened to more cultural issues such as animal welfare and the environment. The parallels may seem tenuous but do offer valuable insights into public perceptions of agriculture. These perceptions are pertinent to the context of the discussion.

The Precautionary Principle

The precautionary principle was the impetus for this study. The scope of the study has shifted but it is pertinent that the term be placed in context and defined to assist the reader in understanding the journey.

*The **precautionary principle** or precautionary approach states that, if an action or policy has a suspected risk of causing harm to the public or to the environment, in the absence of scientific consensus that the action or policy is harmful, the burden of proof that it is not harmful falls on those taking the act.* (Wikipedia, 2013)

The Precautionary Principle's origin is rooted in statements such as *"an ounce of prevention is worth a pound of cure"* (Council for Agricultural Sciences and Technology, 2013). As such there is prudence in its origins and it is wise for individuals to pause for thought before acting. There are limits to this prudence though, if concern for potential risks gives rise limitations that stifle the will and capacity to innovate.

The precautionary principle can pose a major problem for innovators. It is usually, if not always, viewed from the perspective that a new technology will be more risky than the status quo. In this context it limits opportunities to gain experience and impinges on the liberty of entrepreneurial individuals. The outcome of this approach, if used in its strongest sense, would be continuation of the status quo indefinitely. This is due to the impractical demands that can be argued, which is due to the subjective language in the definition. This can be taken to extremes by the stronger proponents of the precautionary principle and has left the precautionary principle open for criticism.

It can be argued the criticism has altered the use of the precautionary principle. Discussions with companies and lobbyists traditionally affected by its implementation suggest overt implementation is becoming increasingly rare (Anonymous, 2013). In Europe where it originated and is most widely used, the trend is waning (Council for Agricultural Sciences and Technology, 2013). This was backed up in a meeting with an agricultural chemical company

representative in Brussels (Anonymous, 2013). The interviewee highlighted that there is a vexing situation where the use of the term *precautionary principle* is waning but the legacy of its intent remains a powerful influence.

A further criticism of the precautionary principle is its role in inhibiting experience. Without experience it is impossible to make things better. Experience is how things are learnt; not all failures can be anticipated. There is much to be learnt from mistakes, attempting to prevent them all will limit improvements.

The precautionary principle and excessive regulation are not the sole inhibitor to the rate of agricultural progress. Farmers hold the greatest role in limiting agricultural productivity. There is so much capacity to improve how agricultural business and production is conducted that industry cannot plausibly deny it is complicit in limiting productivity. However, there is an issue where producers and the industry have the capacity and will to make improvements but are limited in doing so by arbitrary rules.

Why does innovation in agriculture matter?

Historical progress in making food cheaper has enabled half the global population to belong to the relatively affluent middle class (Parker, 2009). This growth is due to economies of scale moving more people above the poverty line as food becomes affordable. The most important feature that comes from this windfall is time, allowing people to spend more time doing things they want and less time on what they need.

How is this related to the cost of food? If people have to work less for the food that sustains them they have more time to work on improving their standard of living, according to Maslow's hierarchy of needs (Wikipedia, 2012). It is a blessing to live in a time of such abundance and it is encouraging to contemplate how many of the major challenges will be overcome through the productive process.

Concurrently, there is another trend that is developing that must be rare in the timeline of humanity. Society has an abundance of idle time that has been liberated through productivity gains. This windfall is wonderful and is giving people the choice to live their lives as they wish to and enjoy what the world has to offer. However, this idleness is giving rise to a proportion of the population that are frightened of the processes which enable their standard of living. This fear is being enabled via the idle time people have to inform themselves about the processes which underpin living standards.

This is being brought about by a greater capacity to become informed about the systems which underpin society's existence. However, not all this information is palatable (or correct). Individuals now have the capacity to pursue and enable changes in these processes. Not all these whims are enacted but when the ground swell is large enough governments will bend. The live export shut-down to Indonesia in 2012 is a recent example of this. This may well be a unique point in history where a critical mass of the population now have the abundance of time to question the processes which afford them the time to ask the questions.

Cheap abundant food and energy makes everyone wealthier and better off; however, there is a proportion of society convinced this is not so. Dissenting opinions are not the problem. Historically, critics have proven a great capacity in identifying weaknesses in the development and innovation process. Constructive criticisms can, and usually do, result in a better outcome for the system, as innovators and entrepreneurs are made aware of flaws and can develop improvements. Ralph Nader's "Unsafe at any speed" is a classic example of a critic's capacity to enact industry wide changes; even if it was not adopted as rapidly as anticipated, it did initiate the improved safety standards on offer in modern automobiles (Time, 2015).

What is concerning for agriculture is that many of the critics are speaking from a position of privilege, where they do not bear the consequences of their actions in the debate and have no feasible alternatives. It was pointed out to the author in a meeting with a biotechnology company (Anonymous, 2013)

"*Most activists don't build anything; they block and destroy. They are in a base market selling fear and approach the most vulnerable as disciples who will give their time freely and advocate*

with passion. These organisations are well funded and nearly unaccountable and have attained the untouchable status of a sacred cow."

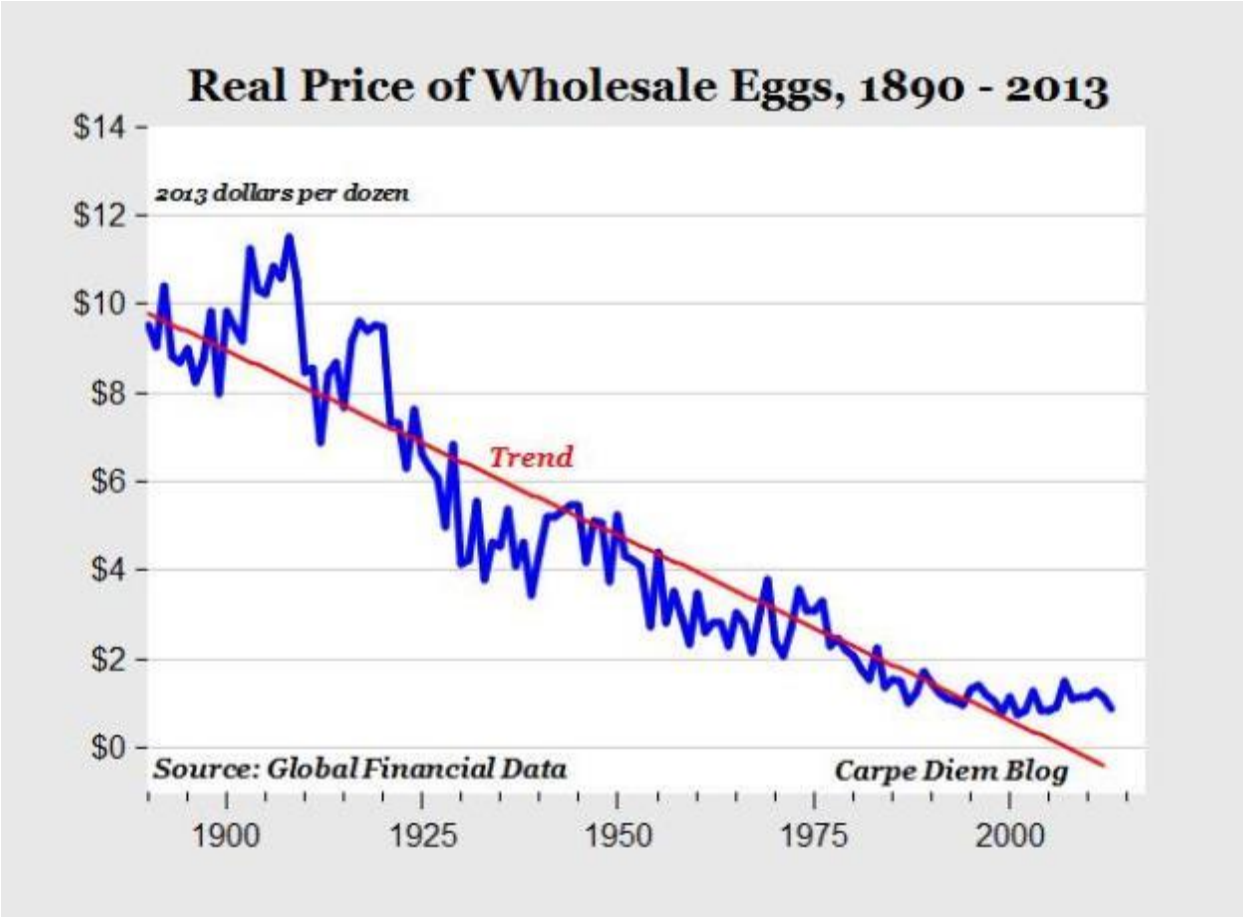
Skin in the game!

If activists work results in the banning of a product or process they are largely shielded from the effects. Mark Lynas (2014), once a vocal critic of GM technology who has since become an advocate, points out that there seems to be a widespread assumption that modern technology equals more risk. The dissent to new technology typically comes from modern affluent societies where the food is abundant and cheap. They seem to come from these nations, perhaps because there is sufficient wealth to support their destructive activism.

In relation to agriculture the effects of this activism are felt most keenly by those who are in food-scarce, developing environments. It appears modern activists have a romanticised belief in subsistence agriculture, yet there is not a single example of a prosperous nation keeping its agricultural producers in such subsistence businesses. However if agriculture can continue to produce cheaper food and fibre then the long running diaspora from the fields can continue.

If enabled it will undoubtedly contribute to even grander living standards at an accelerated rate. This should ultimately result in many of today's "major" problems being transient rather than perpetual as many of the problems of yesteryear have proven to be. If this comes to pass it will be because of the time people will have to make things better for themselves and their communities. Matt Ridley's book, "The Rational Optimist" (Ridley, 2010), provides very good examples of this process and how things are getting better. A visual example is provided in Figure 1, relating to the cost of eggs over time in the USA.

Figure 1 Inflation adjusted price of eggs in the USA



Source: http://www.aei-ideas.org/wp-content/uploads/2013/03/eggs-600x441.jpg

Why the Worry?

With living standards so good why is there a need to improve them? Progress should be further encouraged and there should be a continual striving towards improved productivity. The productivity gains that have enabled present developed world living standards will be insufficient to ensure the developing world has the capacity to enjoy equivalent lifestyles. New gains will be required to help lift the remaining proportion of the global population into the middle class.

The reality is that not everyone has the capacity to access clean drinking water; a most basic necessity, furthermore many are not capable of deriving an income which can support the current cost structure of the inputs that sustain a modern existence. Historically there are abundant examples proving the costs of these inputs can be reduced to the point where they

meet the vast majority of peoples earning capacity. The timeline of human input required to produce food discussed above would suffice but many modern day examples abound. The cost of televisions, if we only compare screen size from the 1950's to now when adjusted for inflation are roughly 11% of the price and have far more features (Haupert, 2012). Without cost reductions supported through productivity gains, many of the current items and life style choices that are taken for granted would not be available.

In 2005, the debate about access to GM technology was heated. It was a debate that had been going for many years and was far from resolution. Roundup Ready Canola® had been deemed safe by the Australian regulator, had the backing of the federal government and competitors in North America had been growing it for several seasons. Despite this it was being blocked from Australian producers. The opponents used any and all available avenues to prevent access, and at the expiration of the state-based moratoria resorted to lobbying local councils to declare themselves GMO free (Gene Ethics, 2013). If this final political act had been successful there would have been a great deal of unintended consequences, ranging in degrees of seriousness from the relatively mild; a lack of Australian cotton to wear or cotton seed oil to fry food in, to the quite serious implications for people with type 1 diabetes who are dependent on insulin derived from biotechnology inputs (Shama & Peterson, 2014).

Figure 2: Jim Watson standing on the division line between GM & Conventional Canola, Parkes. August 2008.

Source: Mark Swift 18/9/2008 Can you pick the difference?

Eventually access was granted and the first biotechnology canola crops were grown in 2008. The results were certainly encouraging, but there was frustration at not having had access earlier as North American competitors had had in the late nineteen nineties. Observations from cultivation have provided a wealth of knowledge for producers of the crop and this experience has highlighted what a useful tool the technology is in managing chemical and crop rotations.

A concern arose that this would not be an isolated incident and an appreciation was developing that the exercise had been very expensive for the industry as a whole. This led to more questions about future developments:

- How would other new products be viewed?
- What would the obstacles be?
- How much extra expense was being put into the system (this ultimately had to be digested by the food supply chain and the consumer)?

Beyond the precautionary principle

Society has expectations of how agriculture operates. This is highlighted through the political discourse and actions around sensitive issues such as animal welfare, access to biotechnology traits and the requirements for certain emissions standards in agricultural production be they dust, noise or engine exhaust fumes.

Australia is a major food exporting nation and there are a large number of markets, particularly in South East Asia and North Africa, which rely on such exports. An example of this dependence was apparent in the Middle East. There was an incident in September 2012 with a live export shipment of sheep firstly in Bahrain and then Pakistan. The decision was made by the Australian Minister for Agriculture to ban all live sheep trade to the Middle East, thereby cutting the number of sheep available in Qatar from several thousand a day, to several hundred, and creating a potential food shortage. The reality on the ground in Qatar was that the welfare of the livestock met or exceeded the standard normally experienced in Australia yet access was still being denied access to Australian sourced livestock. Figure 3 offers a typical scene at the local markets, despite the potential for accidents and escapees from the stock crate the livestock were quiet and well cared for.

Figure 3 Local livestock in Qatar

Source: Mark Swift 27/9/2012

This example highlighted our society's increasing demand for safety, be it physical, political or even that of its traded goods. Furthermore, it emphasised the potential for regulatory intervention where there is risk. This is most noticeable in more affluent societies and is coupled with an increasing cynicism towards larger multi-national businesses. For agricultural productivity, these trends are a major concern as the major companies in agricultural Research & Development are multinational. Quite possibly the most despised company in the world is Monsanto; a leader in agricultural Research & Development (R&D). This brings a unique level of scrutiny to current improvements in agricultural productivity.

Agricultural chemicals

Farmers are becoming acutely aware of the long development time and high cost of novel chemistries. The reasons for this were clarified in a series of meeting with companies operating in the agricultural chemical industry. The cost of bringing an agricultural chemical to market is between A$150-400 million and takes roughly 10 years (Guendel-Gonzalez, 2013).

The discovery phase takes roughly three years and 10% of the cost. In this phase the companies identify potential molecules to deal with a particular problem, be it disease, weeds or insects. This phase is highly efficient in testing a range of molecules across the major crops and their major diseases. Total costs in this phase ranges from $15-40 million (Guendel-Gonzalez, 2013).

Second is the development phase; trials are conducted on the molecule for agronomic use, for development of a market-ready product for producers that meets the regulatory requirements for human and environmental safety. Of the 90% of the total cost anticipated in this phase up to 40% goes to toxicology and at least 15% goes to environmental testing (Guendel-Gonzalez, 2013). The major delays occur in this phase, as this is where the majority of additional requirements are being placed by regulatory authorities. The total costs here are between $75-187 million, which must be recouped from the end-users.

The question to be posed in this process is what constitutes sufficient safety for the users, their customers and the environment. There are many chemicals being used effectively and “safely” that have not been through the current regime. Granted, these chemicals can have deleterious effects and no doubt have in the past where used inappropriately. The encouraging aspect is how few issues arise and how quickly the issues can be overcome by industry. An example of this has been drift management where industry has identified the problem and worked to minimise the issue through better application techniques and management.

The standards are so high now that many commonly used and valuable products would not pass the test, but are still considered safe enough for sale. Examples are provided in Figure 4 of the relative toxicity of many household items compared to agricultural chemicals. This highlights

the hypocrisy of the regulatory system and raises questions about the political nature, rather than scientific rigor of the process. A system which permits legacy products to be sold that would not meet the current standards under reregistration has some flaws in it. Either the new standards are too great a burden or the old products should be removed.

Figure 4 Comparison of LD 50 values for common herbicides and household items.

Herbicide	LD_{50}	Common consumer chemicals	LD_{50}
Paraquat (Gramoxone)	~100	Nicotine	9
Triclopyr	630	Caffeine	192
2,4-D	666	Bleach	192
Pendimethalin (Prowl)	1050	Tylenol	338
Atrazine	3090	Household ammonia (10%)	350
Glyphosate (Roundup)	4900	Codeine	427
Imazaquin	>5000	Table salt	3000

Source: Fishel, Ferrell, MacDonald, & Sellers, 2014. **(Note:** The LD_{50} is the dose, in milligrams per kilogram, required to kill half the population exposed). The lower the dose the more toxic is the chemical.

Many of the compounds used daily in maintenance of our health and house are considered more dangerous than many agricultural chemicals. There are risks with using any chemicals and there are incidences of misuse of agricultural chemicals. Agricultural chemical businesses are raising their own standards to ensure they deliver safe and effective products. These businesses have much at stake in their brands, their shareholder value and employees. It was highlighted that as internal standards are raised government regulations follow (Wert, 2013). This further increases the burden of reporting and auditing requirements, increasing the total product cost. Additionally, this pushes the companies to look for further standard improvements as they do not want to be seen as doing only the minimum required. (Guendel-Gonzalez, 2013)

A further impediment is the lengthening of the approval stage. This is the time after the development period, where the product is complete and final submission has been delivered to the regulating authorities. This period was taking over three years and the regulatory agency in question stated the problem was a lack of funding. In response chemical industry adopted a user-pays system and the time dropped by over 12 months. This gave the companies an additional growing season of patent protection in the market. The timeline has since started to

get longer and is back near 2.5 years (Vroom, 2013). It was little wonder that the whole process was described as *mission creep* (Vroom, 2013).

The result of this has been a dramatic reduction in new chemicals coming to market. In the 1980's one in 20,000 molecules tested had an economic market in agriculture. At present only one in 140,000 molecules will pass the test (Guendel-Gonzalez, 2013). This is despite massive advances in the identification of molecules that could be useful. It can be argued the easiest products have already been found. However it can also be argued the regulatory bar is being lifted, compounding the problem. It is now at the point where organisms are developing resistance to chemicals faster than new chemicals can be found and brought to market.

This was highlighted by a German farmer who had been informed there were no new fungicides in the pipeline and resistance was building to the products on the market (Cummerow, 2013). He offered that his only hope was that genetic improvements and farming practices could maintain productivity. With advances in conventional breeding, through knowledge gained from the biotechnology process, the odds have improved, but there is very real prospect crop yields will drop in this environment.

It is difficult to foresee a future with a long line of novel agricultural chemistries. Given this, how long can the current system of chemical assisted agriculture persist and what is there to take its place? The challenge for industry will now be to enhance the longevity of the chemicals available and start developing or relearning practices that do not require crop care chemicals. Agriculture is going to have to change its view of these inputs to the production system and view them as options in controlling problems, not the only tool for doing so. The chemical companies have been overcoming problems that agriculture managers have managed themselves into. The point has now come where the solutions are not presenting themselves as fast as agriculture can manufacture the problems. Overcoming this situation is going to be a turbulent event for an industry and businesses that have become inter-dependent.

Slower to market, more expensive but safer

The first popular concern of chemical agriculture was initiated in "Silent Spring" (Carson, 1962). There have been substantial rebuttals to this work; some which are quite blunt such as

“If man were to follow the teachings of Carson, we would return to the Dark Ages, and the insects and diseases and vermin would once again inherit the earth.” from Professor Robert H. White-Stevens, a Professor of agriculture and biology at Rutgers University, but none have ever put it to rest (Miller & Conko, 2014). This was the first popular discussion on modern farming in the mainstream audience. Potentially, if industry had been explaining why it was using chemicals and had been transparent about the impacts, the book may not have had such an impact. Industry did not learn from this experience and has failed to be proactive in managing public perception since.

A lack of new chemistries will not be the end of agriculture. There is reason to suggest that there were many very effective molecules that could have still been cheap, effective and safe as tools in future agricultural production. It is likely that a lack of communication about their role in food production and popular misleading information by concerned citizens will result in useful tools being removed from agriculture prematurely. Ultimately, alternates will have to be found or the price of food will have to rise.

Biotechnology, the next frontier

The major companies in agricultural chemicals are nearly all the same companies in agricultural biotechnology. Has this move to biotechnology been viewed as a potential way to innovate around existing chemistries as it was easier, more profitable and involved less risk than discovering new chemistries? This was possibly the case when these companies started working in this space 20 years ago but the future has proved it is not exactly a trouble-free exercise getting biotechnology gene events[1] to market.

Biotechnology: not illegal but unusable

Biotechnology in agriculture is a big business and consumes large amounts of capital. The places where this capital is being deployed are changing and understandably are being driven by risk/reward. Developed nations are becoming more hostile, increasing the cost of doing business and there is an ongoing risk of product failure through the development phase. This has resulted in Research & Development moving to regions with lower costs and risks.

Experience suggests the greatest level of concern of modern agriculture typically comes from the most urban and wealthy societies. The irony is that the advantages of modern agriculture appear to have been overlooked in the development of modern standard of living.

There is now a transfer of focus for modern agricultural Research & Development. The capital is moving to areas where there is a greater appreciation of the potential for modern agricultural production. An example of this was the announcement by a biotechnology company that it is pulling any efforts out of Europe (Dobert, 2013). The company would appear to be redeploying the effort and capital to South America where the uptake has been far more rapid and enthusiastic.

[1] Gene event; is the name used to describe the life of a new gene in the market from the day it is first released until it is no longer detectable in the supply chain.

The European Union (EU) has the tightest rules and the most open hostility to biotechnology. The EU regulatory system was described by an expatriate Belgian working in the USA as being "*designed for mediocrity".* However there are signs that the USA is moving in the same direction. A biotechnology company has had a trait (Dicamba tolerance) left in limbo due to concerns from the United States Department of Agriculture (USDA) over future litigation (Vroom, 2013).

This trait has cleared all the regulatory requirements, but fear of potential litigation from opponents of this technology has resulted in the product not being given market access. This is a novel addition to the precautionary approach, which is usually concerned with the harm a technology may pose to human health or the environment, not to the reputation and budget of a government entity (Vroom, 2013). It was further highlighted that the anti-biotechnology lobby had viewed this as a victory as it was a "no decision"; which essentially means that the product cannot be used (Dobert, 2013).

It is hard to foresee many new traits gaining approval when the regulator is fearful of being sued, even when its own requirements are met. The timeline for approval of GM products that have completed the scientific process is increasing the world over (Vroom, 2013). However this was cited as a unique example for the United States of America (USA), in denying a product that has passed all the regulatory tests access to market (Vroom, 2013).

There is every possibility the issues of biotechnology in regulation terms will be transient. The impetus will probably come due to a crisis and one industry lobbyist suggested this would be required before any change would be forthcoming (Boote, 2013). A crisis which could result in more liberal laws and some potential catalysts on the horizon to force a change in attitude include:

1. Developing countries being more open due to their price sensitivity, an example of this is the recent adoption of a GM eggplant in Bangladesh (Boote, 2013)
2. China; BT rice is already grown in China. They claim it is all for domestic use but last year there were 38 findings of this trait in the EU (Vroom, 2013).

3. Issues such as the present greening disease in Oranges in the USA, which may only be remedied via biotechnology. There are reports emerging that in the future you will either drink biotechnology orange juice or apple juice (Harmon, 2013).

Biotechnology and agricultural chemicals are the most obvious space where governments are regulating agriculture with good intentions and unintended consequences. Governments and regulators the world over need to realise that a little bit of regulation may be good but like chemicals there is a point at which the deleterious effects take over. It does not matter if that chemical is H_2O or 2,4-D.

Farmers should heed this in their future management. Research & Development companies have been very effective at delivering genetics and products that have overcome many agricultural problems. The future will require farmers to be more proactive in their management if they wish to maintain their present productive capacity.

Mechanical agriculture

There are a diverse range of inputs into the agricultural production system. This diversity is being met by society with a litany of rules to meet the demands for safety. There was abundant scope to make agricultural machinery safer for those working with it and around it. This started with improvements such as roll-over protection and has developed to encompass signalling equipment, climate controlled cabs and Global Positioning System (GPS) guidance.

Many of these have been keenly adopted, if not demanded, by the consumer but there are new requirements being demanded of original equipment manufacturers (OEM) that are coming from regulators and not the customer. These are primarily in the space of engines and emissions. Diesel engines are a large source of global emissions and farming uses a large amount of diesel fuel. With the heightened concern of the potential risk of these emissions, rules have been forced upon OEM's to reduce them.

Modern agriculture is a highly mechanised business, absorbing a large amount of capital in modern production systems. Great advancements have been made in this aspect of the industry since the industrial revolution but the rate of these advances are at risk of tapering. This was highlighted in a meeting with a major European machinery manufacturer, who stated that that they are now working to the legal limits of size with their machinery.

This was in regard to the size limitations enabling use and transportation of machinery on public roads (Nacke, 2013). This will limit the ability of manufacturers to increase the capacity of their machines and all efficiency gains must now be met within certain size limitations. These limitations will have further repercussions for European farmers. They were aware of the potential of controlled traffic to improve the productivity of their businesses but the road rules on tractor width prevented them from exploiting these gains (Thibault, 2013). This was ultimately reducing the sustainability of the farming system in Europe as there was no practical opportunity for farmers to match the wheel tracks of their tractors to their harvesters.

Despite this, at some point in the future the physical limits will be met and this is probably close to being realised in places without the more severe road restrictions, such as Australia. At some point the burden of running two smaller machines will be less than the cost of buying a single larger machine. There is potential in the near term for this point to be hastened with the introduction of autonomous control systems.

Good intentions versus thermodynamics

2008 - 2015 will see the phase-in of Tier Four emissions standards for diesel engines in Europe and the USA. These are two of the largest agricultural markets for agricultural machinery and are home to the largest manufacturers of modern equipment. This new standard is absorbing up to one third of machinery companies R&D budgets (Nacke, 2013). The first standards came in with Tier One for engines over 37KW (or 50Hp) in 1996 and they have progressed since (Dieselnet.com, 2014).

A product strategist for a large manufacturer highlighted the fact that this change in emission standards was having profound effects on their business and reducing the longevity and quality of their product (Nacke, 2013). The reasons include:

1. Engineers want to build exciting new things, not redesign old pieces of equipment to fit around particulate filters and "add blue"[2] systems.
2. Engines now have to run substantially hotter, increasing the risk of burning the machine especially in hot, dusty conditions that are typical in agriculture.
3. Research & Development that could be put into making machines better is being spent on making machines work nearly as well as they could.
4. Business competitors are emerging, selling parts salvaged from the increasing number of burnt machines.

This individual had serious concerns about the future regulatory burden for the industry. They were convinced that the standards were going to get tougher. The original regulations had unintended consequences increasing the number of particles under two microns, which are deemed dangerous to human health (American Lung Association, 2013). They were anticipating that new standards would look to rectify this and probably add CO_2 emissions. The

[2] Add blue is an additive that is injected into the exhaust system of diesel engines to reduce the emissions

impost was becoming so great that a new industry body is being developed as an attempt to counter this growing threat.

Furthermore, it was forecast that a transfer of standards being worked on for road usage would essentially be *cut and paste* to off-road machines (Nacke, 2013). This particular law is intended to reduce the fuel usage per 100km by 20% across road auto makers' fleets. If this standard was applied to agriculture the representative admitted there was some redundancy in the system (Nacke, 2013). They could remove the straw chopping and spreading systems from the harvesters they built. Figure 5 shows what a field would look like post-harvest if this solution was adopted. It was admitted this was not a practical solution, but it would enable them to reach the regulatory target despite the obvious downstream consequences.

For broad acre agriculture, if this is somehow enforced, how will stubble retention be adapted to conservation farming systems? There is an argument it may offer potential seed destruction opportunities via burning of the windrows (Hutchings, 2014). This is a potential solution but with the restrictions on burning in places such as Europe there is a possibility this option would also be removed locally in Australia. Furthermore it would exacerbate the carbon emissions which is the original target of the legislation.

Figure 5 Windrowed straw from cereal harvesting

Source: http://farmbarbie.blogspot.com.au/

The production sector needs to be vigilant on these issues as it is bearing the costs. There is little evidence in history to suggest the levers of government only work in practical sequences. These issues are having very serious practical implications for the agricultural industries and the trend suggests they will get worse. In order to prevent these issues from escalating, the machinery and agricultural industries will need to build an effective dialogue with government to highlight the consequences of the degree of regulation.

Autonomous tractors

Look no hands (or steering wheel or seat)

The concept of autonomous tractors has been around for many years and at least one major OEM has several operating in the field. There is a reasonable amount of work happening in this space and research ranges from academic development to being near market ready.

Tsukuba University Japan

The research here is aimed at finding solutions to working in extreme terrains with limited access to satellite correction. To achieve this they are working with a single laser guidance system. The environments they intend to work in are permanent plantations such as those of palm oil or bananas.

The system functions on a relative correction system using the laser system to identify obstacles. This information is then analysed via computer and the machine is guided between obstacles. There was no link to the GPS receiver mounted on the machine; it was purely for observation so they could track the accuracy. The machines they are working with are shown in Figure 6. They are very interesting and high tech but their practical application is many years away.

Figure 6 Autonomous tractors being trialled at Tsukuba University

Source: Mark Swift 10/6/2013

Dr Tofael Ahmed was the lead researcher at Tsukuba and when queried about resistance to this technology, he conceded the issue had never really been thought about. The work was still so focussed on getting a working control module that there had never been a reason to consider resistance (Ahmed, 2013).

Hohenheim University Germany

The technology and capabilities here were far more advanced and far closer to being market-ready. The system included a combination of relative guidance to avoid obstacles and an absolute guidance using satellite correction to identify where the machine is on the farm. This allows the machine to not only avoid obstacles but to also know where it is in the paddock.

Dr Hans Griepentrog, the lead researcher, highlighted that there is a level of resistance from some farmers to this technology. The concern is being driven by a fear of corporate takeover of agriculture. That fear stems from the fact that, because the farmer is no longer in the tractor, they will no longer be needed and that agriculture will all be run from high-rise offices (Griepentrog, 2013). It is unclear how widespread this feeling is, but it does highlight there are obstacles to be overcome in delivering a new product to market, no matter how good it may seem to the developer.

Both these university systems have been retrofitted to existing machines and have remote control features to allow the machine to be fitted to implements and moved to the paddock.

Figure 7 Dr Hans Griepentrog with autonomous tractor. Hohenheim University

Source: Mark Swift 15/6/2013

John Deere Illinois USA

John Deere has been working on autonomous control for several years now and they have worked on several incarnations. The fully autonomous version is pictured below and there are several of these working in orchards in the USA at the moment. Its fusion of absolute and relative control systems is similar to that employed by the University of Hohenheim.

Figure 8 John Deere autonomous tractor at Moline, Illinois

Source: Mark Swift 31/7/2013

Several years ago there were rumours in Australia that the reason these have not been released for commercial usage is for legal reasons. These rumours have been confirmed (Popescu-Gatlan, 2013). The company is still unclear on where the issue of responsibility lies in the event of an accident. Is it with the farmer who has bought and is using the equipment or is it with the software provider? Until someone has an accident there is no way of testing it in law. This standoff is a very real reason why agriculture is not getting better faster. We live in a litigious world and large companies that have the capital to invest in this research and development are limited by their risk profile. It must be noted that highly controlled environments such as dairies and horticultural packing facilities have been able to make further advancements and some early adopters have commercial operations using autonomous systems.

The visit to John Deere provided additional insights on innovation with regard to scale. In a meeting with a diverse group of employees the discussion highlighted how bureaucratic and risk averse this business is. This highlighted how the planning and development process functioned. It is very difficult for a new concept to be brought to market in under 20 years (Popescu-Gatlan, 2013).

Autonomous Tractor Corporation (ATC)

This is a small start-up business based in Minneapolis that was spawned from a think-tank. The technology is again a fusion of absolute and relative positioning but the approach is unique. A core focus has been to remove the issues in the present guidance technology, particularly concerning satellite based correction systems, such as Global Positioning System (GPS) and the issue of "drop outs." This is where signal and correction is lost due to interference. There was also discussion about the problems of the weak signal and the very busy and corruptible frequency ranges it operates in (Anderson, 2013). One example highlighted was the escaping signal from medical Magnetic Resonance Imaging (MRI) machines in hospitals. This escaping frequency severely impedes the correction signal of GPS, resulting in very limited use in areas around hospitals.

Terry's discussion of GPS reliability was pertinent to the discussion of safety of the system. He stated "At present the GPS signal is so unreliable and prone to drop outs it is highly questionable as to whether it would ever be possible to practically use the information received from it in a

fail-safe system" (Anderson, 2013). This is in accordance with the author's experience of dealing with poor reception and guidance quality when depending entirely on GPS signal.

The system being developed at ATC uses Very High Frequency (VHF) signals and is transmitted between four stationary beacons and two mobile beacons on the equipment. This system will work through trees, hills and buildings with fail-safes built-in (Anderson, 2013). The fail-safes are the true benefit of this system; each distance and angle is being continually received and the next point is being calculated. This allows the fail-safe system to function as the tractor is anticipating where it needs to be, based on this information. If the machine receives information that does not accord with where it should be, based on the distances and angles it is receiving, it will shut down. A diagram of the system is provided in figure 9.

The proprietor, Terry Anderson, is not worried about the legal issues; he has confidence in the system's ability and its fail-safes and plans to have it available to the market in two years.

Figure 9 Diagram of the ATC guidance system

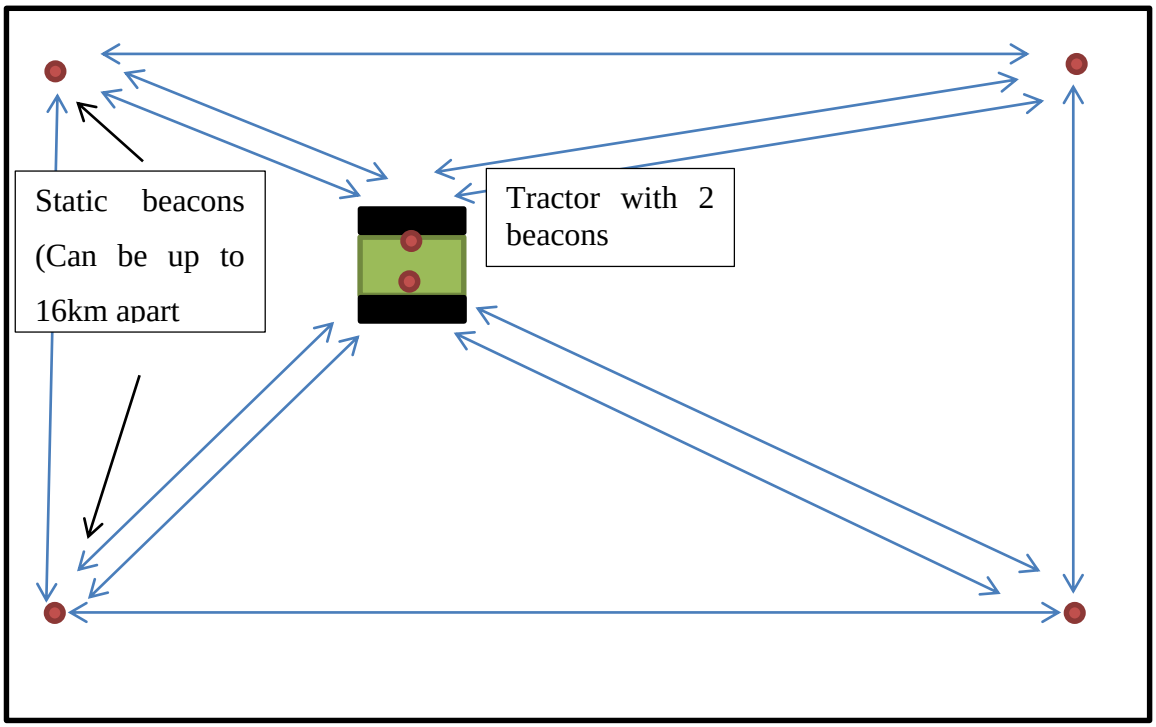


Figure 10 “Spirit” autonomous tractor with company founder Terry Anderson

Source: http://modernfarmer.com/

If the potential of these machines proves practical, this system will have a highly disruptive impact on the global machinery business and farming. The practical gaps here are monitoring of the tools that are commonly used in agriculture such as sprayers, planters and harvesters. This is the next real barrier; however, with the advances in sensing technology this should be achievable.

The question remains- how and are the public and regulators going to get involved? Given how easy it has proved for the public to involve itself in the affairs of business there is no real chance of it being left alone. A group of concerned citizens may appear from somewhere, calling for some level of restrictions, if not an outright ban. How this is managed will be of serious importance if the full potential of this technology is to be realised.

How will this regulatory exercise unfold?

Agriculture is in a unique space; working near public environments. This means it can pose a threat to the public. At some point society will have to deal with the issue of the risk posed by this technology, weighing up the potential benefits versus the threats. The discussions on this topic are highly influenced by the environment that people are familiar with. The more closely settled the area, the more concern there is about the public interaction. Nowhere is this more

evident than in Britain; with walk and bridle ways in England and the right to roam in Scotland. The right to roam is a law in Scotland allowing public access to all privately held farmland.

Farming is constantly in the news as a result of its poor safety record. Would not removing the operator from the point source of potential injury be a major benefit for the safety of farm workers? The issue seems to be in the rationalising of known, real threats with unknown, potential threats. As with all precautionary approaches there seems to be a greater sympathy with the "devil you know." It is to be hoped that a prolonged hiatus for the discussion of this technology does not prevent real progress from being made in both improving worker safety and enhancing productivity.

Agriculture and the community

There are several issues for agricultural progress. One component identified is agriculture's relationship with the wider community and how farming is portrayed in the media. There are many influences in this representation but there is a clear trend towards its increasing importance. The results of neglecting this relationship can be severe and this has been highlighted in the ongoing animal welfare and environmental debates.

Enhancing the tools we have and allowing our experience to grow

Agriculture has an intimate relationship with the community and both parties are being made well aware of this. There is a cacophony of information being provided by groups who take an interest in the spheres in which agriculture operates. The information appears to be accepted as the reality of the agricultural environment by the mainstream regardless of how sensational it is. These claims are having very real impacts on agriculture.

Sadly, agriculture all too often receives recognition for all the wrong reasons. In Western societies the general public continually receive information along the following lines:

- The environment is in decline
- The oceans, rivers and reefs are being poisoned by agriculture
- Farmers are cruel to animals
- GM foods are a risk to human health and the environment.

The public are responding accordingly by asking for greater oversight of agriculture. If agriculture wishes to maintain any autonomy there is a need to better inform consumers about current production practices. The general public is typically several generations removed from the farming process. In this time, agriculture has progressed from the 50 hp open-air tractor with full cut cultivation and low intensity livestock production to an age of increasing scale, such as:

- Genetic engineering
- GPS guided 36m spray rigs
- 5,000 sow piggeries, 10,000 head dairies, 80,000 head cattle feedlots, etc.

These changes did not occur overnight, but if the uninitiated consumer is shown a modern intensive agricultural business such as a caged egg producer, the image is certainly not of the chickens frolicking on the green hills. The public have been duped and the industry is being held complicit. The perennial marketing of a "natural" product, to maximise sales over the short term, has built up unrealistic expectations in customers. Consequently, the food sector has tricked customers into believing their food is produced via illusionary production practices for present day prices. The reality of these illusory practices glosses over the issues of yesteryear when chicken dinners were a luxury and food poisoning was far more frequent. There appears to be people who have philosophical issues with modern agriculture and they are exploiting this collective ignorance.

Agriculture employs between 1-5% of the population in developed nations and this number is largely in decline. The reduction in people working in agriculture is a good thing. It has enabled people to pursue other economic, artistic and academic avenues that have further progressed humanity. Additionally, agriculture has become safer as fewer people work in the industry and there is more competition for the available workforce. This competition is forcing improved health and safety standards not only because of regulatory authorities but also employees. The reduction in total numbers is having side effects in the current political system. Fewer people understand agriculture and as such show scant concern for the positive impacts modern agriculture has on daily life. Combine this with horrific images and narratives all too frequently depicting agriculture and it is not surprising the public ask for "someone to do something".

The "tyranny of distance" exacerbates the problem, as agriculture is typically isolated from the urban population who make up the bulk of the voting populace. This results in fewer farmers being able to articulate what they do and be available as touch points for urban citizens when there is a mainstream media reporting on agricultural issues. Additional arguments can be made that agriculture has an intimate relationship with the broader community based on the importance of food, not just a source of nutrition but also with its strong cultural ties.

Origin of neglect

Despite many attempts, there has been limited opportunity to develop an understanding of how and why these beliefs have arisen. The sole opportunity was meeting with the Soils Association of England in Bristol. The discussion was a far more pragmatic appraisal of the agricultural and food systems than was expected. Examples were provided of where the organisation were working to improve the knowledge and understanding of food and production. An example was their "food for life program" which is targeted at the large catering companies of Europe. It was highlighted that under industry self-governance that businesses were exploiting their position and being disingenuous toward their customers. One example highlighting this was sausages containing as little as 20% meat (Hockridge, 2013).

What was anticipated was far more zeal in defence of the Soil Association's charter around organic and smaller scale production. When questioned about their views on biotechnology and their campaign to ban it, they provided far less information and it was evident that pursuing that line would reduce the amount of useful information that could be gained from the meeting. There is certainly evidence this organisation has been complicit in disseminating some dubious information on biotechnology such as its ability to lock farmers perennially into using specific products and chemicals (Soils Association, 2013).

There is a high degree of entrepreneurial drive within the Soils Association. The organisation is working to create demand for their product. It is a legitimate business strategy they are pursuing to grow their business in exploiting the weaknesses in competitor products. Where the issue lies is in the political activism with a high reliance on fear and misinformation in their campaigns to move people off mainstream food. On balance their views have some merit and they do highlight some practical issues coming from the use of the present GM traits, such as resistance build up to glyphosate. The concern they show for the longevity of this agricultural chemical is difficult to comprehend given their avowed focus on organic production.

The position of this group and their contemporaries can be appreciated for the welfare of mainstream agriculture and the modern food system. There are certainly problems with the mainstream system that need addressing, such as the reliance on chemical inputs. Issues arise

however in the lengths the Soils Association go in attempting remove tools from mainstream production. Their political activism has been able to alter stories that should be good news for the mainstream into a weakness. An example is the reduction in chemical use due to some biotechnology traits; somehow this has been turned in to a place where mainstream production is having to defend itself constantly.

There is still a significant proportion of the global population who are undernourished. When these people have the wealth to choose more sophisticated options, the market for commoditised food will respond by lifting its standards to meet the demand. Until that point lifting these standards will increase the cost of food unless the system is subsidised.

Personal Responsibility

If modern agriculture maintains its present silence in the face of the legion of critics it will continue to face tighter restrictions. This silence will be met with more regulations from regulators restricting what tools are available, further limiting the capacity of farmers to innovate. If farmers wish to have influence to the point where the authorities will leave them alone, they need to change the approach to marketing their products. Industry should not believe that the present approach is working to improve its standing in the eyes of the public. If it were working, the share of organics, "natural" and free range would not be increasing and new regulations on modern techniques would be slowing.

Scrutiny of anything new is warranted. Historically the responsibility has been on the consumer under the buyer beware approach or "caveat emptor" (Mirriam Webster, 2014). Increasingly the trend is that government is removing this responsibility to the detriment of personal liberty.

People are given the responsibility to choose from the array of products that the market offers. However some products are viewed differently to others. What is the difference between a "smart phone" and the latest agricultural cure-all available in a bottle or seed? Obviously we do not eat mobile phones, but they emit and receive signals next to the most sensitive organ humans possess.

Innovative products used in agriculture seem to be viewed differently. If the market does not want food cheaper, but wishes for it to be more nutritious, then the market will move in that direction. In many modern societies this change is occurring, but the commodity market for food, which is by far the largest segment, is governed by price. The addition of arbitrary rules is falling squarely on those who can least afford it, namely those producers and consumers in the commodity market.

The commonweal is getting more involved and burdensome in transactions between informed and willing market participants. There are products and practices that allow farmers to better meet the demands of their customers, but they are being prevented from using them. The customer should be allowed to try these products and be the arbiter if they are willing to take the risk. New rules based on the good intentions of a few concerned citizens are limiting agriculture and there is little evidence to suggest they are contributing to improved living standards at a greater rate than cheaper food would. The proponents of new rules rarely feel the effects of their good intentions and there is rarely consideration of the unintended consequences. Society benefits from making food cheaper; it is troubling that limitations are being placed on the experience that ensures it continues to provide better value.

Risk in innovation

Complexity of Agriculture

In researching the case studies of chemical farming, biotechnology and mechanical agriculture, it has become evident how complex the agricultural system is. Attempting to incorporate this complexity into the information broader society receives on modern agriculture highlighted a flaw from the outset of this study. The Precautionary Principle and other tools of similar nature are society's risk management.

With new opportunities comes a level of risk and these risks are can be unknown. Rarely is change fully understood when people innovate. Many of the discoveries that have in the past taken agricultural productivity forward are serendipitous. This was highlighted in the visit to Monsanto where it was pointed out that glyphosate was originally being tested for its suitability as a coagulant when Monsanto was researching industrial chemicals. As a matter of diligence they would also cross test the chemicals in their agricultural division where they discovered the molecule was effective at killing plants (Mieure, 2013).

This serendipity was reinforced when it was highlighted how the gene utilised to provide the RoundUp Ready® trait was identified. It was discovered in an algae that had started growing in a drain that carried waste water between a production plant and a water treatment facility. An employee noticed the unusual phenomenon and sent it to the company's biotechnology laboratory (Mieure, 2013).

Where would modern agriculture be without this low cost product that has facilitated a great coup, unseating tillage as the primary weed control method in fallow management? Glyphosate has spawned the practical application of minimum and zero tillage, allowing many of the management practices presently taken for granted to be established.

Risk and reward

All innovations come with a degree of risk and deleterious effects regardless of how bullet-proof they may appear to be. An example of this is controlled traffic farming where all wheel tracks are confined and permanent. The benefits are evident to the users with better trafficability of paddocks with harder roads for the wheels and soft soils for the plants to grow in. However, there are side effects from its adoption that managers are discovering: such as tramlines (the permanent road ways) becoming very deep; severe erosion along these tramlines, and weed control issues. As these issues have arisen people have not necessarily abandoned the system but are developing techniques to ameliorate the detrimental effects. No doubt in the future managers will regret aspects of controlled traffic, as the longer-term impacts become apparent. However, with present knowledge it is the option with the least negative impacts available to many farmers.

Is there a need to treat other products or practices differently, just because they have a different acronym? Genetic improvement of crops has utilised several novel approaches to enhance the genetic potential. Many of these novel practices have been allowed to have their day in the market place when the producer has been convinced it is safe enough. There have been accidents and each new process has had its critics but overall the benefits have outweighed the deleterious effects.

The use of biotechnology is arguably safer than mutation breeding[3] of varieties in conjuring genetic alterations. There was and is very little understanding of the impacts of radiation treatment on seeds, but it has provided some very useful alterations improving genetic potential of cropping species. There is far more understanding of biotechnology and how it works, yet there has been far more resistance to it. It is now at the point where biotechnologists can place genes where they wish within the genome (Boote, 2013), yet still there are claims that not

[3] Mutation breeding is the process of exposing seeds to radiation or chemicals to generate desirable mutants (Wikipedia, 2014)

enough is known about biotechnology. Will there ever be enough evidence to sate the detractors?

Humanity would be poorer without having embraced the risks of tinkering with things. The risk is that if people cannot continue to use trial and error then the future will be poorer. It would be remiss of society to think living standards will only get better via design. The weight of evidence to prove how much better life is because of serendipity is too great.

Concurrently innovators need to be cognisant of their responsibilities. This discussion is arguing for less regulation not less responsibility. When trialling alterations there needs to be due diligence performed to anticipate the potential problems and understand the impact of these problems on other stakeholders. If there is a low probability of a high impact problem innovators should assess how they manage the trial to deal with or mitigate the risks. If there is a high probability of a high impact problem then the safe guards should provide extreme care and diligence in protecting others. If this is not possible then a personal application of the precautionary principle is defensible regardless of the potential gains.

If there is just cause to investigate an incident, common law could be used to determine whether the act is criminal and/or whether reasonable precautions were taken. In the event criminal negligence is proved in pursuit of gains, the punishment needs to fit the crime in terms of damage caused to people and property. This would place the onus back on the innovator to exercise caution as they are to be held responsible for the outcomes in front of a jury of their peers. The present regulatory system appears to deem everything illegal unless otherwise stated. This must result in many unenforceable, victimless crimes and the creation of many innovative criminals.

Psychology and risk management

It is rational that people will tend to be cautious of that which they do not understand. At some point society (or at least the ruling authorities) have deemed it appropriate that society be protected from some of the things not fully understood. Societies, particularly wealthy westernized versions, are now being “protected” from people learning about things not fully understood. The risk from this approach is evident in what may not exist if the present mind-

set / regulatory regime had been in place in the past. Would the motor car or jet engine be commercially released in the current environment?

It could be argued that only certain areas are facing this treatment. The impacts of the mobile phone on brain function and longevity are probably not fully understood and there are individuals such as respected brain surgeon Charlie Teo who claims potential links to issues such as brain tumours (Morton, 2014) but governments are not about to ban or even restrict them. What then drives this inconsistency in regulation and why does it appear certain areas come under more scrutiny?

This inconsistency is probably due to the nature of products in question. The mobile phone is a step change in communication to the end user and imparts a high degree of additional utility. Biotechnology in its current form has been a step change for the upstream users such as the farmer and breeder. But for the consumer there has been little discernible difference; in many regards biotechnology has been introduced as something for the consumer to be scared of not embraced. It may have made food cheaper but this has not been significant in the scheme of things for the developed world. The result has been a consumer left feeling they are bearing the risk with intangible benefits.

In this instance there is a lack of information to the consumer on the practices undertaken which come under scrutiny but provide a cheaper/cleaner/safer/less resource-intensive product. There is little dialogue regarding this when the debates are taking place. When food is such a small proportion of the cost of living in developed societies it probably matters very little to the consumer to ask for more safety, even if the risk is more perception than reality and it drives up the costs. The negligence in the rush to safety is the costs which are passed on to consumers in less developed markets where food is a far higher cost of living. The governing apparatus in exporting nations has a responsibility to these people as well as the more discerning customers in wealthier markets.

Agriculture's case may be special in that it is emotive and has intimate relationships with most people. It provides food for people daily and exploits the environment; and its impact on both is obvious. This is coupled with the mainstream's limited understanding of agriculture, how it functions and its role in progressing living standards by mainstream society. It is still difficult

to differentiate from the impact of mobile phones that are typically used daily, cause environmental damage in the mining of rare earth minerals for their production and that most people do not understand how they work. Granted mobile phones are not eaten, but as stated prior they do receive and emit radio signals and are used beside a highly sensitive organ.

Evidently the risks from agricultural exploitation are viewed differently as the list of rules on what is used in the daily business of producing food, fibre and timber grows further. Agriculture is not alone in this; medicine, mining and energy providers also come under particular scrutiny. Is there a psychological component as to why some industries receive special attention and does this underpin why society feels the need to use risk management tools such as the precautionary principle when dealing with them? Is there a spectrum that people fit on spanning from precaution to opportunism as illustrated below in figure 11.

Figure 11 Opinions on acceptance of innovations

Source: Mark Swift (2015)

If people do in reality fit along this spectrum the implications for inventors and entrepreneurs are profound. It would allow a greater level of thought to be put around how a novel concept is introduced to an uninitiated audience. The public do not want to be exposed to new risks, but are they as cautious of new opportunities? In agriculture these opportunities may be to enhance the nutritional value of food, reduce its environmental impact, reduce its cost or make it taste better. If a balance can be struck reducing the overly cautious responses it should assist in progressing agriculture and may improve awareness in its customers.

This balance would be assisted through developing an understanding within the key stakeholders who make regulations for agriculture. They should be aware of what agriculture has done to assist in cultivating the present standard of living and what tools have been used and how they were discovered. It may be possible to design an internal combustion engine, tractor or pane of glass and understand every component and process involved. Agriculture does

not have that luxury at present and it will take a long time to achieve it. The reality is there are many gains to be made from this lack of understanding. As people try new things new outcomes will result, this is the time for science to step in and find out what is happening.

If agriculture has to wait for scientists and regulatory authorities at every step, the progress in agricultural productivity is likely to wane further. The risk in choosing this path is that people will be consigned to live in poverty longer, increasing the environmental burden of food production and reducing the quality and safety of agricultural products. There are inherent risks in this approach and there will be consequences.

The reality is that there are many risks innate to the food system, some which no rules have yet to or will ever hope to overcome. A timely example has been the addition of melamine to children's formula as happened in China to lift the protein levels (Lim, 2014). This is a criminal act to overcome a minimum standard. Specific rules on melamine use in milk will not overcome an act like this. Potentially less sinister but not without equal magnitude in consequence are concerns regarding contamination of food with *E. coli.* This bacteria is evident in manure and easily transfers to fresh food crops which are fertilised with it. An incident in Germany in 2011 killed 50 people and resulted in the kidney failure of 3500 others where organic bean sprouts were the culprit (Lynas, 2014).

Conclusion

Agriculture's role in increasing the standards of living over the past 12 millennia cannot be overstated. The time, which has been liberated through improvements in agricultural productivity, has enriched so many lives. It has enabled an ever-increasing number of people the freedom to do what they want and not what they have to. In developed countries this is because the population has to spend so little effort attaining the food they require that they have time to spend making things better. There is an emerging trend trying to limit agriculture's access to tools that will facilitate the continued liberation of time. This trend is far more evident in societies that are more developed and have sufficient wealth and time to allow the questioning of the system that sustains their standard of living.

There is every reason to question the system that has resulted in many past failures, some of which occurred on monumental scales, damaging both the environment and the health of humans and animals. This was evident particularly in the mid twentieth century with the massive dust storms that were frequent during droughts. During these events large amounts of soil were eroded and there would have been definite impacts on the general health of the community. Despite some very long and wide-spread droughts during the early twenty-first century these events have become quite rare and this has been through what we have learnt from past mistakes and the capacity to develop new management systems and exploit new technology.

The damage is being managed and the world is a better place to be now than at any point in time. The restrictions being placed on agriculture now will have effects into the future and risk consigning people to poverty for longer than would otherwise be the case. Counter points to this argument are that the system is keeping the populace safer and healthier. The point is not without merit, but it raises a debate on which group needs the assistance more. Wealthy educated people who can afford to inform themselves and buy what they wish in developed societies versus poor people in food scarce environments who have no choice but must buy what they can afford. Questioning the agricultural system for its failings is astute. Intervening in the system without consideration for how progress has been achieved and who bears the burden, is not.

An abundance of food beyond what can be consumed leads to discerning customers. These discerning customers have choices to ensure that the food they consume is as safe as they can afford. Pricing poor customers out of the food market for safety's sake is not necessarily keeping them safe. This is particularly important for poor people in a food scarce region. The food will probably be imported and any costs that are placed on the exporting producer will inadvertently be passed on. If they cannot afford these additional costs it may result in an alternate use being found for the food, which may be as livestock food in the exporting nation. Equally, the producer may decide not to produce and substitute the production for a higher value proposition.

Mainstream society and agriculture need a better understanding of each other. Without this, society will probably continue taking agriculture's bounty for granted. To enable the remaining half of the global population to access the middle class, more tools should be on the table. Where there are opportunities to reduce the cost burden of food they should be explored. There will be consequences and lessons will be learned as has been done with countless other technologies from the steam engine to the jet plane and from the scythe to the combine harvester. Not all the impacts will be positive but history suggests the overwhelming outcome will be.

Regulatory authorities and politicians need to develop a better awareness of the implications their involvement has on complex systems; agriculture is only one such area. Despite its complexity, agriculture has a history of innovation and this has assisted in the remarkable increases in the standards of living over the past 12 millennia. Joseph Schumpeter's *creative destruction* is as potent now as it was when he first coined the idea (Wikipedia, 2014). As a result many of the issues now faced will be overcome and forgotten as new techniques and technologies supplant the current ones. If this process is stifled, then agriculture cannot play its full role in improving living standards and give all people the opportunity and time to choose.

Recommendations

- Farmers should educate themselves in the history of agriculture and its achievements and the framework it was built on. This is required to rebut unfounded criticisms of agriculture and allow better arguments to be formed when advocating for industry and why it needs the opportunity to gain experience in novel areas.
- The food supply chain requires better communication to allow broader support bases to be utilised in dealing with issues that cross over traditional sectorial barriers and reduce the competitiveness of the whole sector.
- Agriculture as a sector needs to be more proactive in advocating its successes and its role in creating the modern standards of living society enjoys, particularly to regulators and politicians. This will assist in building the argument that agriculture is a responsible industry and has provided a huge windfall to society in gaining its productivity advantage.
- Regulators need to be informed of the consequences of new rules, and how they will limit farmers' ability to adopt and adapt to the changing environments they operate in be it natural, business or legal.
- Farmers and innovation providers need to ensure they are responsible and perform due diligence when exploring novel areas to limit the damage that can come with innovation.

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Plain English Compendium Summary

Project Title:	**The implications of societal Risk Management on Agricultural Productivity.**
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Scholar:	Mark Swift
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Objectives	The objective of this report was to highlight impediments to the innovation and adoption of novel products or systems which can be utilised in agricultural production.
Background	This report was written as a response to a growing trend, where regulatory agencies become involved with and delay products which can be utilised to improve agricultural productivity
Research	This research was conducted over 22 weeks of international travel over two years to determine linkages and reasons for delays and regulations around novel agricultural products and practices.
Outcomes	• Many regulatory authorities' demands are increasing on new products being brought to market. • Society is comfortable or ambivalent about this situation. • There is little recognition that much of society's improvements in standards of living has come about without regulatory oversight. • Society is limiting its ability to continue the growth in living standards by being overly cautious of novel products and unknown outcomes.
Implications	Improvements in living standards will slow if agriculture cannot continue to make productivity gains which result in cheaper and more abundant foodstuffs. The environmental impact/footprint of agriculture will not shrink without access to innovative solutions.
Publications	