

Review

# A Future-Focused View of the Regulation of Rural Technology

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**Abstract:** There has been an explosion of innovation in agricultural technologies, but whether the anticipated benefits are fully realised depends partly upon with the institutional structures are supportive. Many types of law will shape what innovations are viable and the scale of the economic returns. Australia does not have a coherent strategy for future rural regulation that will both minimise the public risks and increase the private opportunities from future agricultural innovation. This paper addresses these issues. It considers the diverse legal issues that will affect these opportunities, and it looks particularly at agricultural robotics as an example of the many ways in which legal issues will shape opportunities from innovation. It proposes that an integrated strategy, based on a careful analysis of future issues, would be a significant contributor to Australia's agricultural sector and to its innovating industries.

**Keywords:** regulation; innovation system; robotics; risk; liability



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## 1. Introduction

The history of technological innovation is littered with examples of promising technical innovations, with exciting forecasts of the social benefits and the economic returns, which ultimately prove to be greatly optimistic. Often, it is not technological failure that creates the gap between theoretical opportunity and realised potential; it is the institutional settings that prevent that success. Unfortunately, a great deal of the literature about agricultural innovation ignores the significance of institutional supports and impediments in determining the likely outcomes of innovation. One of the significant institutional considerations is the legal context, which includes not only government regulation but also civil law such as liability and contract, and the laws that shape and govern markets.

This paper argues that maximising the productivity and social/economic benefits from the current explosion of agricultural technological innovation requires attention to the future legal context. It exemplifies these issues by reference to the potential for autonomous and robotic innovation to deliver benefits to Australian agriculture and to the investors of those technologies.

This paper considers the predicted futures for robotic and other mechanical innovations and the types of legal issues that might arise within those futures. Law essentially consists of rules that have the backing of the government. These may be created and implemented by the government or be privately created rules where the government provides institutional support through laws or organisations, such as the courts. This paper considers public (government), private, and international law, which might affect how these issues are dealt with. The method used is primarily document analysis.

Many laws affect the context for innovation by shaping incentives or by supporting, delaying, or restricting adoption. The effects of the law are often systemic. Some examples of the diverse rules that affect agricultural innovation are competition law and consumer protection, taxation and financing rules, industry development policy, intellectual property, and environmental law. Indirect considerations include how rules affect the adaptability of institutions and how rules can privilege particular interests. Legal issues partly shape the innovation capacity of industry or society [1–3].

Some aspects of our legal system impede competitiveness and farming innovation [4]. It is demonstrable that the accumulation of relatively small impediments, restrictions, and delays to the introduction of innovations can make the anticipated return on investment too low to justify that investment, with funding then redirected to other uses or other jurisdictions [1]. Different legal issues that affect innovation are relevant to plant genetics, animal genetics, chemicals and fertilisers, water systems, and mechanical innovations. I will illustrate the issues with a focus on mechanical innovations, particularly agricultural robotics and precision agriculture ([5], particularly on pp. 54–79 and pp. 88–95). In this paper, I will not discuss the broader systemic challenge to Australia’s innovation system (institutional path dependence), other than noting that legal institutional issues are among the forces that fundamentally shape any national innovation system.

As with many other areas of agricultural innovation, the laws governing robotics and automation are in a state of flux, as indeed are the technologies, and substantial change can be anticipated [6–8].

There are two broad categories of laws, which are often interwoven in practice. Public law, which is made and implemented by governments (often loosely termed “regulation”), includes international conventions and treaties, state and national statutes and the regulations for the implementation of these statutes, and administrative rules and arrangements. Government policies, plans, and programs, though generally not categorised as law, are rules that have a significant effect on rural innovation. R&D and agricultural policies are also relevant; trade and competition policy and taxation rules are among the many that can have an impact.

Non-government arrangements can acquire legal force because of the statutes and court-made laws that govern contracts (including with corporations), property rights, and liability for civil damage. Many of the rules relevant to mechanical innovation in agriculture are hybrids of public and private laws, such as those protecting: worker interests; property rights (including land, water, and intellectual property); the control, protection, and use of data; investment; and business practices, such as consumer protection and competition. Hybrid arrangements use regulation to manage some issues, but the law also creates private rights and obligations, and statute law can complement or replace pre-existing common law (e.g., worker rights and occupational health and safety rules).

Innovations that enable machines and devices to be operated remotely by humans, or to make decisions autonomously using algorithms, are expected to have a significant positive impact on agriculture, but the law will partly determine if this hope is fully realised. Remoteness and autonomy are matters of degree, ranging from (for example) pre-programmed guidance for a tractor with a driver or an automatic recording station, to a remote drone or robot that uses an algorithm to “decide” and which implements that decision without further human instruction. Laws and policies will substantially determine the extent to which remote operation and autonomy are feasible in practice. Current Australian rules restrict the remote operation of drones beyond human supervision, and some uses require users to be trained and licensed. Such rules will inevitably limit the uses of the technology, thereby putting a cap on the scale of the economic opportunity and potentially making some developments unfeasible.

Though there has been a lot of discussion about regulatory red tape in agriculture, there has been relatively little technical analysis of the legal aspects of agricultural innovation. Wiseman, Cockburn, and Sanderson [9] consider the liability issues of driverless equipment. An earlier investigation by Wiseman and Sanderson [10] focused on data issues, which I discuss later. The report by ACIL [5] considered the legal issues for robotics, sensor technologies, drones, and artificial intelligence, which are also discussed later. None of these studies has considered the systemic effects on the innovation system in agriculture.

Remote and/or autonomous operation involves technologies that capture and process data, communicate, decide (using algorithms), and send signals to equipment to operate. In this report, I have delimited my focus to the legal aspects of three technologies (noting that other embedded technologies will involve distinct issues and legal principles). These ele-

ments are equipment (machines and devices), data (capture, storage, and communications), and machine decision making.

Many regulations and other laws affect these three categories and thus are become regulatory issues for integrated systems, and all these rules shape innovation, adoption, and use. These rules are often complex and may have non-obvious effects. The rules and their implementation are also evolving, along with the technology and its applications. In the section that follows, I can only sketch the issues that are involved, because each issue involves a great deal of technical complexity beyond the scope of this paper.

## 2. Laws and Regulations Affecting Automation of Machines and Devices

Machines and devices carry out fundamental physical actions in agriculture, including monitoring, measurement and recording, transportation, harvesting, delivery of chemicals, harvesting and planting, managing animals, feeding, and sometimes transacting. This work can be done with reduced human input because machines are enabled to operate remotely from their operators, or machines are able to make “decisions” that control machine actions (such as harvesting or shearing, planting, dosing, and watering or moving things).

Some remote autonomous operations are reasonably well established—for example, automated gates or valves, or cattle weighing and dosing at feed stations—but increasingly, research envisages complex automated systems involving multiple machines and devices (e.g., automated vertical farms or “smart farm” models). An early example is the research conducted on robotic shearing, particularly during the 1970s. Robotic shearing technology involved multiple sensors, animal handling devices, responsive cutting machines, and complex informatics. Machine intelligence was relatively underdeveloped at that stage. Detailed investigations were carried out into the institutional (including animal welfare and industrial relations) challenges of shearing robotics. These developments did not progress to full commercialisation, but there is renewed interest in robotic shearing [11].

Harvesting systems that use a master device (e.g., a grain harvester) serviced by slave devices (e.g., grain transport bins) have become well established and demonstrate the potential application of remote robotic operation. Agricultural automation is driven by many things, including labour cost and availability, quality control, the need for precision, and the value of integrating processes and informatics [12,13]. Laws governing both on- and off-farm issues (e.g., worker health and safety, chemicals regulation, and the regulation of drones and autonomous equipment on farms, on public roads, or in public airspace) are likely to have a significant impact on the market for autonomous farming equipment.

The regulation of risks of injury to the environment or to third parties from “roboticised” equipment is one consideration. Automation may involve risks to the environment or third parties as machines carry out work currently performed by humans [14,15]. Of particular relevance are the risks of physical impacts, the exposure of people, plants, or animals to chemicals, or contamination of the environment. Comprehensive risk regulation exists for agricultural chemicals (Australian Pesticides and Veterinary Medicines Authority (APVMA)) or genetically modified organisms (Office of the Gene Technology Regulator (OGTR)), but new technical challenges for regulation will arise. Policies and practices to regulate autonomous on-road vehicles are being developed by the National Transport Commission and state vehicle certification agencies. The technical and legal challenges are substantial due to the radical nature of the changes and the extent of community interest or scepticism [15]. The risk issues of autonomous vehicles are discussed by Wiseman et al. [9]. Substantial effort is being directed towards designing regulatory frameworks for drones, particularly to control safety risks and privacy invasion. [14,16].

Generally, risk registration requires analysis of detailed data, with approval conditional on compliance with use restrictions, label or other warnings, and user training or license requirements. When that which is being regulated is radically different from established technologies, risk assessment is difficult [17]. The lack of historical incident data complicates risk assessment. Conventional “S-curve” models of innovation indicate evolution from a “pre-paradigmatic” stage where performance is relatively inefficient and

unreliable, through incremental improvement, to the point where the technology is stable and reliable. It is a reasonable expectation that innovations will be less reliable and efficient in their early versions (and riskier than those well-tested by use) [18].

An illustration of how new technologies involve new risks issues is the application of pesticides or herbicides via robots. This technology offers labour saving, precision, and reduced spill-overs. The weight of the instrument and the payload of robots (particularly drones) is a significant variable affecting their efficient use, which has driven the push for concentrated lightweight “nano”-chemicals (to reduce payload weight and improve battery life) that are potent with precise delivery. With autonomous remote use, chemical dosage and delivery will not be directly observed by a human operator. At least in theory, this affects the risks of over- or under-dosing, spatial misapplication, and spillages. On the positive side of this risk issue is the potential for precise automated drone delivery of chemicals to reduce the risk of misapplication, including spray drift.

Even if the active ingredient in nano-chemicals is technically equivalent to a registered version, changes to dosing and application suggest that the registration should be tailored to robotic application [16]. Labelling and other safeguards will have to be adapted to fit novel delivery mechanisms, and the usage instructions may have to be algorithmic so that they can be directly coded into the delivery device. Because machines operate differently, registrations and usage instructions will have to be modified for the delivery system—at least until there is a standardization of controls (in itself an institutional and political opportunity and challenge). If risk assessments indicate that changes to the delivery mode also changes the chemicals’ risk, then additional conditions may need to be addressed in the training and certification of workers [18,19].

In summary, the adoption of remote and autonomous systems is likely to affect the registration of chemicals, biologicals, and pesticides, and it may alter user licensing and training, on-road vehicle registration (and possibly operator training), aircraft registration, and operator qualification.

Other risk regulation issues will occur with automated animal management, particularly given animal welfare sensitivities. Animal production innovations often have animal welfare implications that lead to new rules. This is amply illustrated by the animal welfare regulations governing intensive production systems and livestock transport [20]. Many other innovations have welfare regulation implications, and there are many animal welfare laws relevant to farming [21]. Moreover, political and philosophical movements push for far stronger protection. Electronic fences within “smart farm” operations deliver a mild electric shock to animals, albeit a small and infrequent one. Automated handling, particularly in intensive animal management facilities, can lead to a perception of pain in the animal that could trigger political (and then regulatory) action. The outlawing of “shock sticks” and electronic training collars in many jurisdictions demonstrates how political sensitivity can lead to regulatory constraint. Concerns that drones can cause distress to wildlife and cattle already exist [22], and early robotic shearing and animal handling innovations raised animal welfare issues. The potential to use drones for fatal control of some pest species would give rise to regulatory complexities, legal restrictions, and other strong restrictions because it is hard to control the risks in the field. In Australia, new controls have not yet been proposed for drone-facilitated hunting (though anecdotally, it seems that drones have been trialled for scouting and for poisons delivery). Animal welfare rules are stringent, and new animal welfare regulations are likely with the increasing use of advanced animal handling and control methods.

Digital agriculture provides opportunities for more efficient supervision of agriculture and other public governance activities [23]. New administrative requirements, including reporting to the government, should be expected with remote and autonomous equipment, but advanced informatics could reduce the transaction costs of reporting. Mandatory data sharing with government agencies could also provide efficiencies for public administration, but this raises “red tape” and privacy concerns. The keys to achieving efficiencies will

be the quality of coordination and strategic planning between the public and the private sectors.

Automation raises questions about the protection of worker interests under federal and state industrial laws, awards and agreements, and occupational health and safety laws (potentially affecting civil liability, workers' compensation, and liability insurance) [24,25]. The legal aspects of workforce automation in agriculture, including industrial awards and occupational health considerations, are likely to be significant. Australian Wool Innovation investigated workforce matters relating to robotic shearing technologies, but that research is unpublished.

Increasingly, workers must have proficiency certificates from registered authorities for many specialised (or even basic) tasks. The operation of remote and autonomous vehicles will involve new skills and thus certification requirements [26]. Some relevant workforce legal issues are discussed in Diversity and innovation for Australian Wool: Report of the Wool Industry Future Directions Task Force [27] and Accelerating Precision Agriculture to Decision Agriculture [28].

Legal ownership of innovations will have a significant effect on the development, commercialisation, and use of robotics. Research and commercialisation organisations typically use intellectual property to protect their interests and potential revenue. Many innovations within remote or autonomous devices and machines will be protected under intellectual property, using patents or registered designs, copyright, or trade secrets using contracts and legal confidentiality. IP ownership is interwoven with contract arrangements, including user licenses or technology transfer agreements. The legal technicalities and practicalities of IP are complicated. Technical legal issues arise in relation to the mechanical, data, and algorithmic components of robotic systems, depending on the type of IP protection being used [5,29]. Intellectual property is technically complex. This poses a challenge for inventors, investors, collaborators, and potential adopters. The cost of legal protection is high, protection can be unreliable, and a naïve inventor can undermine their own rights (viz. by disclosure prior to applying for intellectual property protection). Aggressive legal IP tactics are not unusual in high-technology industries [30]. Robotic devices and machines may involve refinements from prior inventions, and these legacy inventions may be subject to existing intellectual property rights. This opens the door to costly disputes or negotiations. Partly because patent protection is now available for systems, as well as individual innovations within a system, the intellectual property position of systems composed of multiple technologies can be complicated.

Intellectual property issues and commercialisation can be affected by international rules for protection and trade in intellectual property, with different legal approaches used in different countries (for examples [31]). Complex data rights are discussed later in this paper. Many diverse contractual issues arise with technology funding and commercialisation agreements, technology transfers, and sale and service agreements. I point to two examples.

The first concerns sales or other agreements for advanced equipment, such as autonomous "intelligent" tractors. Traditionally, farming equipment was purchased with few conditions apart from contractual or statutory warranties under consumer protection statutes. The increasing sophistication of agricultural equipment and business models is changing these contractual relations. These can involve combinations of sales, royalties, and service agreements, with ongoing contractual obligations for the purchaser. With automation, complex issues regarding data rights (discussed later) and the "tying" of equipment acquisition to other services (notably servicing by the supplier) have emerged. A practice often seen in the automobile industry is that technology providers restrict access by possible repairers to the specialised software or equipment needed to carry out services. This limits the servicing choices of the equipment owner. Trade practices law does have provisions to limit "tying" behaviour, but the concern persists. The right to repair movement has lobbied for "fair repair" legislation in a number of states in the United States, and

some farmers have pressed for similar laws in Australia [32]. The Australian Competition and Consumer Commission has undertaken an investigation of these issues [33].

Early implementations of new technologies often involve failures or unexpected impacts, which can lead to liability or contract disputes. Many farm machines have the capacity to harm people, or their economic interests, through failure, misuse, or accidents. Accidents occur with robots in industrial situations, and Wiseman et al. (2018) [9] discuss incidents with autonomous vehicles. Mechanical or chemical injuries to workers and people visiting worksites should be anticipated. Locational errors or misapplication could cause economic or environmental harms, through mechanical impact, poisoning, or contamination. Autonomous or remote operations raise the potential for novel tort claims, such as assault or trespass by machinery. These issues are getting attention particularly due to farmers' concerns about protecting themselves from environmental and animal activist use of drones. What potential liabilities arise depends on the work that the machine is doing and the situations where the work is happening. Legal liability risks with robotic devices may lead to novel clauses in product and public liability insurance contracts and workers' compensation rules [6,9].

The potential use of technologies for regulation, administration, and policy by governments is relevant. Government agencies already make limited use of remote and autonomous technologies, for example, to obtain data about legal compliance, including satellite data, remote cameras, and in-field monitoring. An instance is the use of satellites and drones to monitor land clearing and gather evidence for prosecutions [34]. New sensing and monitoring technologies are sophisticated, for example, facial recognition of wild dogs or nano-scale detection of genetic or chemical contamination. The potential for new types of data to be combined with conventional data, for monitoring, evidentiary, and decision-making purposes, is increasing. Combining on-ground data with drone and satellite data, linked to administrative datasets, promises novel approaches to monitoring and evidence gathering [35]. Remote sensing and intelligent devices will be used to supervise compliance with legal requirements, and automated detection and reporting could reduce the administrative burdens on primary producers while providing data to government agencies. Data issues are discussed later.

Rules governing the business practices of technology and data suppliers will partly determine what opportunities become available in Australia, at what cost, and under what conditions, affecting Australian firms vying to be viable competitors. Federal competition law is designed to limit excessive market power or marketplace behaviour, and federal (and state) laws are used to protect the consumer rights of purchasers and users [36]. Powerful firms dominate relevant markets (e.g., advanced tractors) competing aggressively, and possible strategies of dominant agricultural technology firms might be unfair or anti-competitive. The Chair of the Australian Competition and Consumer Commission identified the market power of data firms as an issue for competition and consumer policy for the technology sector [37].

### 3. Data, Law, and Remote and Autonomous Machines and Devices

The potential for "digital agriculture" and "smart farming" to benefit farmers and society has been enthusiastically welcomed [38,39]. Achieving full value will involve remote and autonomous machines and devices that generate (and often require) large amounts of data, using increasingly sophisticated and precise sensors. Because information is the feedstock of decisions, "big data" has potential economic value, which creates the potential for competing interests and thus for legal issues.

Machines and devices often integrate data from different sources, for example combining terrestrial and satellite information with locational coordinates and other data. Communications, including between devices, are central to this. Identification of the potential value of digital agriculture has triggered attention to data ownership in agricultural policy sectors, but data property and user rights are not the only legal issues that could be triggered around farm data.

Sensors, stand-alone or integrated into robotic equipment, gather many types of data at a relatively low cost to improve productivity or market transactions or for governance purposes. The public sector also has an interest in “big data” in agriculture. Data from different sources inform government decisions about policy, regulation, monitoring, and enforcement by providing evidence and predictive methods [40]. The many future uses of sensed data include: the development of registration dossiers; monitoring of farm sector conditions to anticipate production, to understand land, water, or soil conditions, or to monitor compliance with rules (e.g., water extraction per Alexandra and Martin [36]); incident monitoring and management (e.g., fire, floods or invasive animals). Meta-analysis of datasets from different sources for policy purposes mainly focuses on economic analysis and intelligence, but policy uses will expand as more data and more sophisticated analysis methods become available. The potential for future legal and political privacy and data access issues has been highlighted by the intrusive monitoring of the Chinese government’s “social credit” system, and more recently with COVID-19 tracking. The need for strong privacy protection due to technological developments has been considered by the Australian Law Reform Commission [41]. Farm organisations are concerned about these issues, particularly fearing activist NGOs using new data sources to monitor farmers’ environmental management, water management, and animal welfare or as evidence for possible prosecutions [42,43].

Data ownership has received a lot of attention. The issues will be difficult to resolve, and a solution that satisfies all expectations may not be found [44,45]. Technical aspects of agricultural data rights issues are explored in Wiseman and Sanderson [10] and in the Productivity Commission [30]. Wiseman and Sanderson particularly consider ownership and data sharing, encryption, data contracts, access to research data, privacy, and trust. The Productivity Commission focused on how to improve access to and use of public and private data and proposed a “modernised legal framework”. They proposed:

- A Data Sharing and Release Act, with a National Data Custodian to govern risks and ethical considerations in data use;
- A Comprehensive Right for consumers to use their own data and to view, request edits or corrections, and be advised of the trade of their data to third parties, with a right to their consumer data.

The proposals are primarily aimed at increasing data sharing, strengthening the ability of government agents to access databases, while protecting the rights of citizens. These reform proposals do not address many issues about data in the farm sector, particularly the rights of farmers to “their” data generated by the machines that they use [46].

One starting point for debate in the farming community is the belief that farmers automatically have a right to data generated from their farms or from equipment that they own. However, data consists only of signals in different forms (notably binary signals), and ownership rights only arise once an “ownable” form of property is created (such as an image or a database with the limited protection of copyright) or assigned by a contract.

The proposal that governments should legislate new rights for farmers to “their” data may seem attractive, but there are impediments [44]. On the other side of the data ownership claims of farmers are the interests of entrepreneurs (often significant overseas corporations) who value data as the basis for new products, services, and economic opportunities (e.g., in business intelligence, new services, or commodity trading). The international TRIPS agreement limits the ability of Australia to create intellectual property rules that impede international competition in intellectual assets [32]. Australia’s 11 bilateral and multilateral trade agreements, and those under negotiation, generally promote unencumbered trade in services and intellectual property. Any attempt to provide new rights over data for Australian farmers is likely to be enmeshed in international disputes. There are important national interests at stake for countries that are positioned to benefit economically from that data.

An alternative to legislated protection of farmer interests in data may be to use Australian competition law to control the potential for abuses of market power or other

breaches of trade practices law. A binding code or standard might be a rough substitute for ownership rights. Some suppliers of farm equipment or information services do have contract terms or ethical standards that respect farmers' desires for an interest in data. A binding industry code under the federal Competition and Consumer Act 2010 may be an acceptable compromise (however, even this approach could encounter free-trade complications). Examples of voluntary and mandatory industry codes are available on the website of the ACCC [47], including the Horticulture Code of Conduct to regulate relations between producers and purchasers, the Food and Grocery Code of Conduct (a voluntary code), and the Port Terminal Access (Bulk Wheat) Code of Conduct, which is mandatory. Industry self-regulating codes and agreements may acquire some legal status under contract (e.g., as expressed or implied terms) or by co-regulation with the government. Consensus approaches have been discussed as possible alternatives to legal instruments, but political and legal technicalities will have to be navigated.

Combining large datasets can lead to new insights, such as epidemiological findings, statistics, meta-analyses, and machine-generated algorithms. This opportunity underpins the concept of "digital farming", discussions of "big data", and the Productivity Commission arguments for new law instruments. Insights from large datasets are used by government agencies or private citizens to better understand farming or farmers. New intelligent farming approaches could add to the already large amounts of agricultural data. Regulating the relationship between citizens, corporations, and government over datasets will always be complicated and increasingly strategically significant.

One "sleeping" issue is the powers of governments to access data. Government agencies integrate data when evaluating or monitoring programs or when developing policies for agriculture, such as industry development, taxation, social security, rural welfare and health, and many other topics. Public administration involves people and organisations reporting to government agencies, increasing the amount of data. Government bodies use public and restricted datasets (e.g., military satellite and intelligence data). Because dataset analysis provides cost-effective intelligence for public policy creation and implementation, legal powers that allow governments to access private-sector data are likely to remain a "hot topic" politically. Traditionally, a government's forced access to data can be part of an investigation of probable breaches of criminal or taxation law under a subpoena. Federal government powers to access private data were strengthened in 2018 with the passage of the Telecommunications and Other Legislation Amendment (Assistance and Access) Bill 2018 to provide anti-terrorism intelligence. The Productivity Commission canvassed increasing the power of the government to use private datasets and to share datasets while providing new citizen protections [48].

The use of remotely sensed data and other datasets by citizen organisations emerged as a sensitive issue for farmers with the 2019 launch of the Aussie Farms Map to provide "a comprehensive, interactive map of factory farms, slaughterhouses and other animal exploitation facilities across Australia" [49]. This is part of a campaign by animal welfare and vegan interests, envisaging individual action including activists visits to farms and other facilities where animals are kept (this purpose is inferred from the "visited: me" column on the statistics page). Civil organisations can also use "big data" methods to monitor farming for political or evidentiary purposes. Commercial databases that provide data and imagery could be used, and increasingly sophisticated drone surveillance, satellite data, and mining of databases will probably generate civil society challenges for farming. The farm sector has lobbied for stronger laws to limit data gathering (particularly drone over-flights) and has encouraged landholders to use trespass and privacy rights to protect their interests, and in some circumstances, criminal and civil law control over assault. If the Productivity Commission recommendations [48] advance towards legislation, this could trigger further debate about the facilitation or restriction of civil uses of "big data" and remote sensing.

Traditional private rights to data depend on protected intellectual property rights or contracts. Until recently, contract rights to data were of very little concern to agriculture.



However, awareness of the value of data and well-published debates about ownership have changed that. For reasons discussed above, contracts between farmers and those who want to exploit data “harvested” from robotic and other monitoring equipment are the likely path to resolve these issues. Whether this occurs through an industry-wide process to create standard terms or in an uncoordinated manner is not yet clear. Binding industry standards based on consensus could be given legal status through the Competition and Consumer Act.

Data liability issues could become more important, with “big data” permeating agriculture [44]. Datasets often contain errors, data can be distorted when imported into algorithms, and data and conclusions from data can be misinterpreted or misused. Data and analysis can be used in a misleading or negligent manner. Data and analysis failings cause wrong or unreliable decisions, with the potential for economic loss through (for example) incorrect valuation of assets or opportunities, or mistaken management decisions or opinions. This may result in deception, with potential liability under federal or state consumer protection laws, even if deception is unintended. With robotic systems, data problems could lead to the application of chemicals or the deployment of mechanical devices in the wrong place or in the wrong way, creating the potential for different types of harm and thus potential liability. Conjecture would suggest that this is only one of the situations where compensable harms for data failures could arise under tort, occupational health and safety, contract, or other laws.

The earlier discussion of control over anti-competitive practices extends to data and intelligence [45]. Information companies have become a particular concern for antitrust regulators in Europe and the United States, with anti-trust questions about Google, Amazon, and Facebook in particular. In the United States, the Federal Trade Commission has established a task force for the information technology sector, and the Australian TPCC has indicated awareness of the potential for competition and business practice issues in these industries. The EEC has fined Google almost EUR 1.5 billion for antitrust violations [46,50]. Though farm data firms are not yet mega-corporations of an equivalent scale to these corporations, their shares of their respective markets and their ability to exercise market power are still significant. It is not clear what types of abuse of market power could emerge with agricultural data, but the potential for legal issues over business practices is demonstrated by the political debates about farmer data rights.

There are also potential legal issues in agricultural data and information over digital infrastructure. An impediment to the “internet of things” aspects of autonomy and remote operation of integrated systems, and to data integration, is non-uniform data and communications formats. Standardisation can be achieved by consensus, negotiated industry standards, government standards, or legislation. A related issue is data standards and formats [48].

Claims that rural internet is inadequate, because of government policy or because of failures of internet telecommunications firms, are common. Those advocating greater use of “smart farming” technologies often point to these matters as a significant problem [30]. The legal dimensions of this issue could include community service obligations on internet providers, arguments about the abuse of market power or anti-competitive practices, and of breaches of contractual or legislated warranties. Class actions might occur when legal causes of action can be found.

#### **4. Laws, Regulations, and Agricultural Machine Intelligence**

This discussion of rules to govern machine intelligence and autonomous decision making involves conjecture, as radical changes are in the “pre-paradigmatic” stage. It involves grappling with unknowns, as the radical technology concepts challenge current paradigms of autonomous machine intelligence, potentially raising the question of who are “people” under the law and whether intelligent machines can have rights or be legally responsible. The answers to such esoteric questions are likely to have significant practical consequences well into the future.

In a world where computerised processing is ubiquitous and increasingly powerful, many machines and devices used in agriculture will acquire some characteristics of intelligence. They will take data, apply analytic rules, process the data, and arrive at a conclusion. In many cases, intelligent farm machinery will convert decisions into actions. Some will engage in conjecture as they develop predictions, and many attach values (in the form of decision rules) as part of their analysis. The more sophisticated the algorithms, and the more self-adapting the device, the more it begins to look “intelligent”. Once a machine can generate algorithms through feedback and adaptation (machine learning), then a resemblance to animal intelligence is established [51]. In the same ways we distinguish the intelligence of other animals from humans in deciding that we are humans with legal rights, the more sophisticated autonomous learning and analysis becomes, the closer “machine intelligence” comes to resembling human intelligence.

Some readers might dismiss this discussion as mere sophistry. However, the law is how society translates abstract concepts such as values, or right and wrong, into rules applied in practice. Law has proven to be capable of creating rights and responsibilities for non-human entities when humans see value in doing so. For example, can a concept have rights that can lead to legal penalties if they are violated? Yes, it can; markets are not people or organisations, but anti-trust laws penalise those who harm competition and damage markets. Do animals have legal rights? Yes, as is demonstrated by anti-cruelty laws. Do trees and other plants have legal rights? Environmental laws that penalise environmental harm *de facto* give rights to nature (or obligations to nature), which have evolved into overt legal rights. Many constitutions give legal rights to nature, and an increasing number of states declare rivers to be legal persons, with some personal rights (e.g., multiple examples are provided through the Earth Law Centre [52]). This has happened with selected rivers in India, Australia, and New Zealand. If society eventually decides that intelligent machines have rights, then society can create a legal framework.

Less esoteric but important legal questions can be asked about who has rights to an algorithm that embeds the thinking of many authors, or that has been developed using machine-learning rather than by human agents, and, conversely, who might be legally responsible if that algorithm causes harm. Jurisprudential questions concerning legal rights and responsibilities of, or at least associated with, intelligent machines are beginning to be considered. What laws emerge will be partly a matter of politics and partly a question of what legal claims and disputes arise.

Intelligent machines are moving inexorably towards passing the Turing test to distinguish between machines and man [53]. When this happens, the debate about robot legal rights and duties may move from conjecture to serious consideration [6,52].

Machines, like humans, can make mistakes. We have discussed above the liability aspects of decision errors, particularly as they relate to data. The additional liability aspect of machine intelligence is that the fault may be in the algorithm or the processors rather than the data. Where the algorithm or the computer have identifiable authors, and the fault can be clearly attributed to them, then the liability principles are likely to be a complicated extension of current jurisprudence. Where the erroneous machine has a corporate supplier and it is not possible to identify the individuals at fault, the liability of the corporation is possible. Legal liability issues are complex under common law unless it is possible to identify a causal path between human error and harm, a prerequisite for civil liability. Where a machine has autonomously generated a defective algorithm, problems will arise that will be particularly challenging, and there will be causal proof issues if the source algorithms and data come from many or unidentifiable sources. Liability issues can be anticipated in the public sector as well as in industry [54].

The workplace implications of sophisticated robotics are substantial. These include displacement (with offsetting new jobs), industrial relations, and training impacts. Workplace change through automation will have many effects that I have partly canvassed in the earlier sections [25].

Intellectual property ownership has been discussed above for some aspects of robotics, but when machines generate the valuable algorithms that are sought to be owned, complicated questions about the identity of the inventor or author are likely to arise (particularly if an algorithm is built on many inputs). Similar issues to those discussed in earlier sections of this paper will arise with contracts and agreements, but with increasing machine–machine agricultural transacting, new legal issues will arise.

Asimov’s three laws of robotics are interesting stimuli for thinking about what fundamental principles might be needed for a future legal regime for autonomous intelligent machines [55]:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

In summary, the law is not only a way of regulating relations between people, or between people and organisations. It is also a means by which to shape society, and an important aspect of society is technological innovation. Technology itself also shapes society at the same time as it delivers narrow functional benefits. The intersection of technological innovation and legal change is likely to have unexpected systemic effects, but as this paper shows, some future issues are broadly predictable. Agriculture is experiencing significant technological change, and this appears to be accelerating. This will call for new legal arrangements, and it will generate many legal problems. If the law is not pre-emptively designed to facilitate desirable social outcomes from innovation, it is possible that it will incidentally impede worthwhile changes. It is unlikely that optimal outcomes will be achieved by merely waiting to see what happens and then responding. Ideally, legal policy should reflect thoughtful predictions of the future challenges and issues that are likely to be encountered and should reflect careful consideration of the most appropriate law and policy settings. Unfortunately, it is difficult for our society to achieve this required level of sophistication when developing new policy, and so future settings are likely to be substantially reactive unless the leaders in agriculture pay serious attention to the future legal context. A simplistic appreciation of the issues as being merely about “red tape”, or the putative rights of farmers, is unlikely to serve the farm sector or the country well. As this paper has shown, there is a body of intelligence that could support a rational debate, leading to a sound law and policy strategy to position Australia to benefit from the impending technological innovations, whilst minimising the inevitable risks.

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