December 2016

THE CASE FOR CUTTING RED TAPE ON DRONES

Darcy Allen
Research Fellow

Institute of Public Affairs

Institute of Public Affairs
THE VOICE FOR FREEDOM
ESTABLISHED–1943

This page intentionally left blank

THE CASE FOR CUTTING RED TAPE ON DRONES

Darcy Allen, Research Fellow

About the author

Darcy Allen is a Research Fellow at the Institute of Public Affairs and is in the final stages of a PhD in economics at RMIT University, Melbourne. His research focuses on the economics of innovation, entrepreneurship and regulation, and has been published in peer reviewed academic journals, book chapters and conference proceedings. Darcy has submitted evidence to and appeared before state and federal Parliamentary inquiries. His research, opinion pieces and comments have appeared on the pages of *The Australian, Australian Financial Review, The Age, Sydney Morning Herald, The West Australian* and *The Weekly Times*. Darcy holds a first class honours degree in economics and finance.

Helpful research assistance was provided by Jake Fraser.

This page intentionally left blank

Contents

Executive Summary 1

1. Introduction 2

2. The potential of drone technology 4

3. Current drone regulation in Australia 7

4. The case for cutting commercial line-of-sight restrictions 11

5. Adopting a permissionless innovation approach 13

6. Conclusion 17

References 19

Appendix 23

This page intentionally left blank

Executive summary

- From videography and construction, to the age-old primary industries of agriculture and mining, drones hold remarkable potential to revolutionise many Australian industries.

- From 29 September 2016 regulatory changes by the Civil Aviation Safety Authority (CASA) cut red tape on drones by removing burdensome license requirements for low-risk operations and carving out an exclusion category for drones on private property.

- While these changes represent a reasonable trade-off between community safety and flexibility, they have not escaped political debate from various interest groups. This paper contributes to this policy discussion by placing it within a broader context of the regulation of new technologies.

- Two further reform recommendations for drones in Australia are made:

    1. Remove the regulatory requirement for drone operators to be within visual line-of-sight (VLOS) for commercial drones. Cutting this red tape and enabling beyond visual line-of-sight (BVLOS) flights will help stimulate investment in new business models.

    2. Adopt a permissionless innovation approach. Rather than precautionarily regulating based on hypothetical future harms, a permissionless approach allows innovation by default, and waits for harm to be demonstrated before intervening.

- Adopting these recommendations will ensure the Australian drone industry is able to flourish by remaining at the frontier of global drone regulation best practice.

1. Introduction

Remotely Piloted Aircraft ('RPA'), or drones, look to revolutionise many Australian industries: from the sometimes dirty and dangerous work of mining and agriculture, to new techniques in videography, construction, and transportation of goods.

But the development of drone technology has come into tension with existing aviation law. Indeed, as with all new technologies, developing effective and flexible regulations for drones is an uncertain and moving policy target because the future evolution of drone technology is unclear. The task of policymakers is to determine the appropriate trade-off between community safety, on one hand, and the freedom for the industry to grow, on the other.

The central contribution of this paper is to this drone regulation conversation by drawing on the history and lessons of the economics of regulation and entrepreneurship, and understanding this policy question is a comparative institutional one.

Australia already sits near the frontier of global drone regulation best practice. To ensure the industry continues to grow here, we must maintain regulatory flexibility, and constantly review rules in line with the development of the technology itself.

Achieving minimally effective drone regulation is important not only to stimulate investment and economic growth as this multi-billion dollar industry grows, but more importantly to enable this technology to raise Australian living standards and make us more prosperous.

The debate over drone technology is a microcosm of a broader challenge facing the Australian economy. As a nation we are already facing an enormous red tape problem, recent Institute of Public Affairs research, for instance, estimating that the cost of red tape to the Australian economy is at least $176 billion each year in foregone economic output.[1] Part of this lost output inevitably comes from the over-regulation of new technologies—rules that stymie development with little understanding of the indirect costs.

The regulation of new technologies should be centred on the concept of *permissionless innovation*. Regulators must avoid precautionarily restraining the technology based purely on hypothetical future harms (e.g. public safety). Put another way, drone innovation and use should be permitted by *default*.

The burden of proof for heavier regulation sits on the government, and must be based on logic, reason and evidence, not hypothetical fears. This is because the risk of over-regulating the early stages of drones, as with all new technologies, can be substantial and ongoing:

1. Restrictive regulation delays and diminishes the application the technology for human need, and therefore lowers long-run benefits of the technology and how it improves our lives; and
2. In world of competitive mobile capital investment, Australia must maintain a flexible, stable and certain policy environment, in order to develop a domestic drone industry.

1 Novak, Mikayla. "The 176 billion tax on our prosperity." *Institute of Public Affairs Occasional Paper* (2016) http://ipa.org.au/portal/uploads/The-176-Billion-Tax-On-Our-Prosperity.pdf

In understanding this, the present paper proceeds as follows.

Section 2 outlines some of the current and expected applications of drones in Australia, including the various estimates of the value of the industry globally. Collecting data from the CASA website on the number of licenses held for drone flight suggests that the industry is rapidly growing.

Section 3 then lays out the regulation of drones in Australia, with a particular focus on the recent changes by the Civil Aviation Safety Authority (CASA) that cut red tape around low-risk uses and for commercial use over private land. These changes are welcomed and encouraged.

Section 4 recommends that CASA should remove the visual line-of-sight (VLOS) restrictions for commercial flights. Flying beyond visual line-of-sight (BVLOS) is a significant comparative advantage of the technology, and restricting this ability may substantially curtail its development.

Section 5 recommends the adoption of a permissionless innovation approach to the regulation of drones. That is, drone innovation should be enabled by default, rather than adopting a stifling precautionary approach.

Section 6 concludes.

2. The potential of drone technology

Drones are unmanned aircraft that range in size from tiny hobbyist rotary-based micro drones to large fixed wing options.[2] While drones were originally developed for the military—given their capacity for autonomous and remote operation—they have increasingly moved into the private sector.[3]

Because Australia is a resource-rich and vast country the potential scope of application for drone technology is broad.[4] Further, given our comparative advantage in primary industries, such as mining and agriculture, we are placed well as a future hub of drone development.[5]

Particularly in agriculture, monitoring remote parts of large properties can be difficult and expensive.[6] Indeed, drones have been described as the "biggest new ag technology in 20 years."[7] Drones can not only collect new data in order to improve yields, but also spray crops and track the health of native flora and fauna to better inform biodiversity decisions.[8] For miners, drone technology can not only lower costs, but also improve safety in exploration and prospecting, and help efficiently survey and map existing open mines.

What's more, drones have the potential not only to reverse recent productivity declines in our primary industries—assisting landowners to manage their land in difficult, unsafe, or cumbersome roles—but even help achieve conservation objectives necessary to meet regulatory requirements, such as the inspection of equipment and environmental hazards including erosion.[9]

---

2 Villasenor, John. "What is a drone, anyway?" *Scientific American*, 12 April 2012 https://blogs.scientificamerican.com/guest-blog/what-is-a-drone-anyway/

3 Newcome, Laurence R. *Unmanned aviation: a brief history of unmanned aerial vehicles*. AIAA (2004)

4 For some of the examples of broad uses of drones, see:
The Parliament of the Commonwealth of Australia. "Eyes in the sky: Inquiry into drones and the regulation of air safety and privacy." House of Representatives Standing Committee on Social policy and Legal Affairs (2014): Chapter 2 http://www.aph.gov.au/Parliamentary_Business/Committees/House/Social_Policy_and_Legal_Affairs/Drones/Report
Handwerk, Brian. "5 surprising drone uses (besides Amazon delivery)" National Geographic, *2 December 2013* http://news.nationalgeographic.com/news/2013/12/131202-drone-uav-uas-amazon-octocopter-bezos-science-aircraft-unmanned-robot/
Atmel Team. "18 awesome ways drones are being used today." Atmel Bits & Pieces, *8 August 2014* http://blog.atmel.com/2014/08/08/18-awesome-ways-drones-are-used-today/

5 e.g. see Brann, Matt. "Agricultural drone jobs taking off in northern Australia." ABC News Rural Online, 13 December 2016 http://www.abc.net.au/news/2016-12-13/agricultural-drone-jobs-taking-off-in-northern-australia/8103834

6 Similar arguments over the importance of drones have agriculture have been made, for instance, in Texas in the United States. See: Linn, Andy. "Agriculture Sector Poised to Soar with Drone Integration, but Federal Regulation May Ground the Industry before It Can Take off." *Texas Tech Law Review* 48 (2015):975

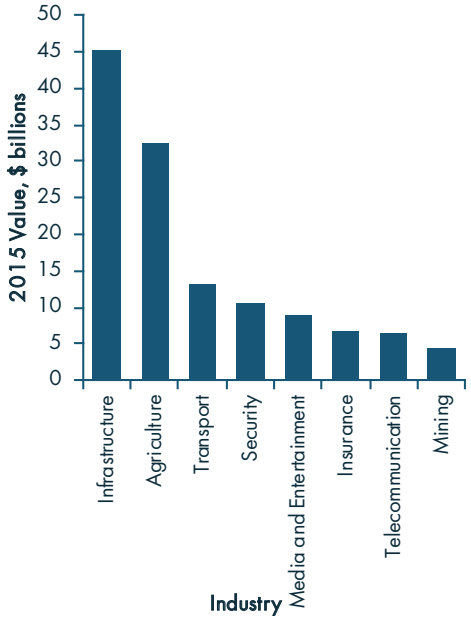
7 Gunders, Jodie and Hough, Cassandra. "CASA develops new regulations for drone operation." 1 April 2016 http://www.abc.net.au/news/2016-04-01/new-drone-regulations-to-benefit-farmers/7293392

8 See, for instance, the growth in precision agriculture. See: Zhang, Chunhua and Kovacs,John M. "The application of small unmanned aerial systems for precision agriculture: a review." *Precision agriculture* 13, no. 6 (2012):693-712

9 e.g. Sandbrook, Chris. "The social implications of using drones for biodiversity conservation." *Ambio* 44, no. 4 (2015): 636-647

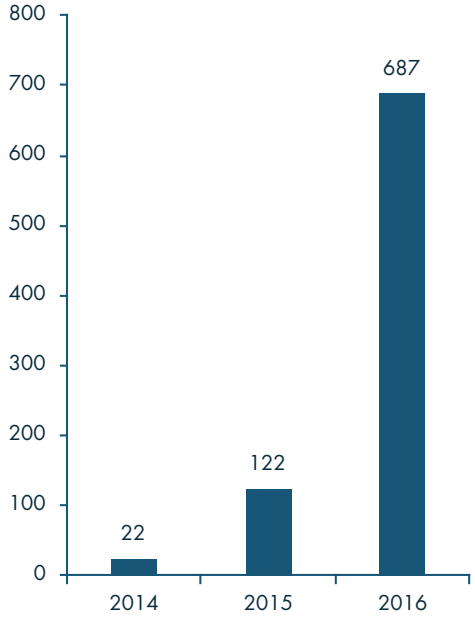
The global drone industry is on the cusp of taking off. A recent report by PwC Poland, for instance, estimated the value of the drone market exceeds $127 billion USD globally, which is broken down by industry in Figure 1.[10]

Figure 1: Estimated Value of Drone Applications by Industry



Source: PwC Polska (2015):4

Figure 2: Total UAS Certificate Holders



Source: IPA, CASA (2016):4

Goldman Sachs also recently estimated the worldwide drone market to soon approach $100 billion.[11] Another proxy for the growth of the industry—the number of licenses handed out by the aviation regulator—suggests a substantial increase in interest in the technology over recent years.[12] Institute of Public Affairs research, based on the number of licenses listed on the CASA license database, are outlined in Figure 2 and 3.[13] This demonstrates a nearly five-fold increase in license holders from 2015 to 2016 alone.

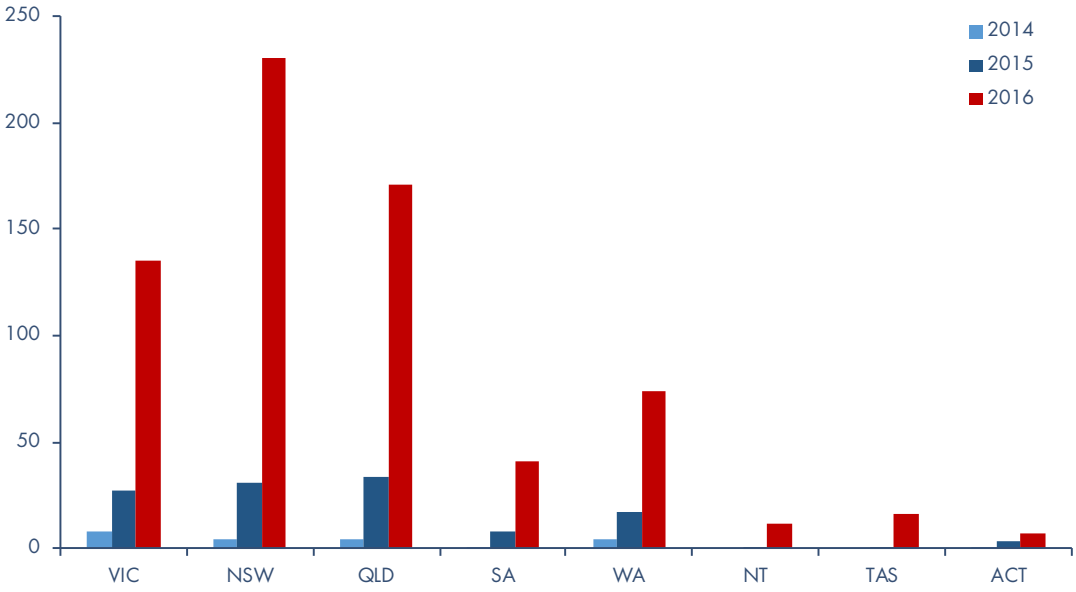
10 PwC Polska. "Clarity from above: PwC global report on the commercial applications of drone technology." May (2016) https://www.pwc.pl/pl/pdf/clarity-from-above-pwc.pdf

11 Goldman Sachs. "Drones: Reporting for Work." Goldman Sachs (2016) http://www.goldmansachs.com/our-thinking/technology-driving-innovation/drones/

12 As at 29 November 2016 the number of UAS certificates was 816. See Australian Government Civil Aviation Safety Authority "UAS Certificate Holders" https://www.casa.gov.au/aircraft/standard-page/uas-certificate-holders

13 See Appendix A.

Figure 3: UAS Certificate Holders by State



Source: IPA, CASA

But the potential of drones as a general purpose technology (GPT)—alongside other GPTs such as electricity and the car—remain nascent. The full suite of applications of drone technology remains shrouded in uncertainty.[14] The entrepreneurial discovery process that solves this problem, however, inevitably comes into tension with existing law.

The history of new technologies demonstrates that continuing regulatory tensions are unavoidable—a narrative no different for drones.[15] Regulatory barriers are cited alongside a range of other factors as barriers to drone adoption and diffusion:

> There are several bottlenecks that are hampering more rapid adoption of drones, including regulatory and enforcement clarity and lag, cultural perceptions or misconceptions of what drones are and what they can do, as well as significant challenges that can be thrown up by a more rapid proliferation of drones.[16]

Situated within this context, the main aim of this paper is to contribute to the important conversation on the principles of the regulation of drone technology.[17] How can Australia establish a regulatory system that both protects the public from harm, but also enables entrepreneurs the opportunity and freedom to apply drones into the economic system, thereby realising its full potential?

---

14 See Lipsey, R. G., Carlaw, K. I., & Bekar, C. T. *Economic transformations: General purpose technologies and long-term economic growth: General purpose technologies and long-term economic growth.* Oxford: Oxford University Press (2005)
Or more recently, Cantner, Uwe, and Simone Vannuccini. "A new view of general purpose technologies." *Jena Economic Research Papers* 54 (2012)

15 e.g., Holcombe, Randall, G. "Integrating Drones into the US Air Traffic Control System." *Mercatus Centre at George Mason University Working Paper*, Arlington, V.A. October (2016)
See also: Hall, Abigail R., and Christopher J. Coyne. "The political economy of drones." *Defence and Peace Economics* 25, no. 5 (2014):445-460

16 Rao, Bharat., Gopi, Ashwin Goutham and Maione, Romana. "The societal impact of commercial drones." *Technology in Society* 45 (2016):89

17 Note other barriers to the spread of drone technology, including, for instance, public perceptions. See: Lidynia, Chantal, Philipsen, Ralf and Ziefle, Martina. "Droning on About Drones—Acceptance of and Perceived Barriers to Drones in Civil Usage Contexts." In *Advances in Human Factors in Robots and Unmanned Systems*, Springer International Publishing (2017):317-329

3. Current drone regulation in Australia

In Australia, aviation laws are maintained by the Civil Aviation Safety Authority (CASA), including the regulation of drones. On the 29 September 2016 amendments to the *Civil Aviation Safety Regulations Part 101* came into effect.[18] Most generally, the changes relaxed the requirements for a license on low risk commercial drones under 2kgs and excluded some other categories from burdensome regulation.[19]

The term Unmanned Aerial Vehicles (UAV) was redefined to Remotely Piloted Aircraft (RPA), which sits in line with International Civil Aviation Organization (ICAO) terminology.[20] Further, drones were redefined into four main categories based on weight, as are outlined in Table 1 below.[21]

Table 1: Weight Classification of drones. Source: CASA

Classification	Drone size
Very small	100g > 2kg
Small	2kg – 25kg
Medium	25kg – 150kg
Large	> 150kg

Based on these new weight classifications, CASA introduced the concept of an 'Excluded RPA'. The main rationale of the changes was the principle of risk. Excluded RPAs (drones) require less regulatory oversight than those that are not excluded because they pose fewer risks.

18 Bingemann, Mitchell. "CASA sets out regulations for use of drones." *The Australian*, 1 April 2016 http://www.theaustralian.com.au/business/aviation/casa-sets-out-regulations-for-use-of-drones/news-story/4f876cccc1fe97b3c7d015ed97f5d85b
Civil Aviation Safety Authority. "Part 101 Amendments." (2016) https://www.casa.gov.au/aircraft/standard-page/part-101-amendments-cutting-red-tape-remotely-piloted-aircraft

19 Civil Aviation Safety Authority. "New Drone Rules Cut Red Tape" 28 September 2016 https://www.casa.gov.au/media-release/new-drone-rules-cut-red-tape

20 Note that the previous major changes to the regulation of drones were in 2014. The key proposals at that time were to: "Key Proposal 1: Bring the terminology in line with ICAO. Key Proposal 2: Clarify the current requirements for remote pilot training and certification. Key Proposal 3: Remove redundant requirements and simplify the process for approval. Key Proposal 4: RPA of gross weight of 2 kilograms and below, operating under standard RPA operating conditions will not require CASA approval to operate." See: Civil Aviation Safety Authority. "Notice of Proposed Rule Making: Remotely Piloted Aircraft Systems." NPRM 1309O S, May (2014)

21 The nature of defining drones by weight relates to the theoretically clear correlation between weight and danger on impact.

Operators flying 'very small' drones for *non*-commercial purposes are 'excluded' and do not require the two main drone licenses: the RPA operator's certificate (ReOC) or the controller's remote pilot licence (RePL). They are, however, required to follow the standard operating conditions stipulating how an RPA is permitted to be flown:[22]

- Within *visual line of sight* of the person operating the RPA;
- At or *below 120 metres*;
- *Not within 30 metres of other people*;
- *Not within 5.5 km of airports*;
- *Not over 'populous areas'*;
- Where there is a *public emergency situation*; and
- Only *one RPA is being operated at a time*.[23]

The *commercial* operation of 'very small' drones similarly does not require a license, and must follow the standard operating conditions, but must also abide by a new notification system. Specifically, very small commercial operation requires an Aviation Reference Number (ARN), and through it supply broad information about intended operations 5 days before flight.[24]

Flying drones over the 'very small' category generally requires obtaining licenses, including the RePL and a ReOC. The cost of obtaining these licenses can be substantial, because it includes registration fees and also potential training:[25]

> To be certified, you need an RPA (remotely piloted aircraft) operator's certificate, which costs about $6400 overall. CASA charges $1400 to assess your application and you'll spend about $5000 on a training course if you don't have a pilot's licence.[26]

The other major changes by CASA are for commercial-like flying with drones under 25kgs over *private land*. Where an individual is flying a drone under 25kgs over their own land, the operator is excluded from obtaining an ReOC or RePL license.[27] In this scenario, the other standard operating conditions outlined above still apply (i.e. including visual line-of-sight) and the operator must not receive remuneration for the work. These changes are likely to be important for the use of drones for commercial purposes in industries such as mining and agriculture.

22 Civil Aviation Safety Regulations 1998, Part 101.238 https://www.legislation.gov.au/Details/F2016C00889/Html/Volume_3

23 There are significant penalties associated with operating outside these standard operating conditions.

24 Civil Aviation Safety Authority. "ARN Applications" Accessed 6 December 2016 https://www.casa.gov.au/standard-page/arn-applications

25 Civil Aviation Safety Authority. "Commercial unmanned flight - gaining your remote pilot licence (RePL) and RPA operator's certificate (ReOC)." Accessed 6 December 2016 https://www.casa.gov.au/aircraft/standard-page/commercial-unmanned-flight-gaining-your-remotely-piloted-aircraft-pilot

26 Griffith, Chris. "Certified drone operators left up in the air over the new rules." *The Australian,* 8 November 2016 http://www.theaustralian.com.au/business/technology/certified-drone-operators-left-up-in-the-air-over-new-rules/news-story/112be92d7038ff6039522a7b52453300

27 Civil Aviation Safety Authority. "Flying over your own land - excluded RPA." Accessed 6 December 2016 https://www.casa.gov.au/aircraft/standard-page/excluded-remotely-piloted-aircraft-flying-over-your-own-land

The new rules for drones are summarised in Table 2 below.

Table 2: Amendments to Part 101. Source: CASA (2016)

Operation	Require a RPA remote pilot licence (RePL)?	Require a RPA operator's certificate (ReOC)?
Very small RPA (<2 kgs) *commercial*	No	No
Small RPA (2-25 kgs) *private landowner*	No	No
Medium RPA (25-150 kgs) commercial	Yes	No

These changes, however, have not escaped controversy. Resistance has built from various stakeholder groups including pilots and commercial operators.[28] There have been calls for a 'disallowance motion' in the Senate to reverse the rules.[29] Many of the criticisms are based on safety concerns. These calls were partly driven by criticisms of the rules from industry groups.[30]

To be clear, those who are calling for the reversal of the rules are those who have the most stake on maintaining the status quo.[31] Indeed, the political economy of regulation suggests not only a supply of regulation in the 'public interest', but also that there is a demand for regulation in the 'private interest' largely driven in search of the supernormal profits of regulatory protection.[32]

Good public policy understands the potential for rent-seeking, and therefore proceeds in an attempt to disentangle the entire constellation of possible benefits or costs emerging from regulatory intervention from the private interests of stakeholders. These same issues are currently being faced in other industries across Australia.[33]

Media attention around the regulation of drones is unhelpful in this regard, given that it often focuses on major but extreme incidents, and in particular the costs or potential costs of these incidents, with little understanding of the underlying costs of attempting to correct them through pre-emptive regulation.

28 Bingemann, Mitchell. "Drone pro Andrew Chapman challenges CASA over safety regulations." *The Australian,* 8 April 2016 http://www.theaustralian.com.au/business/aviation/drone-pro-andrew-chapman-challenges-casa-over-safety-regulations/news-story/df877029fdc26d85f0c236e906620466

29 ABC News. "Senator Nick Xenophon moves to bring down 'dangerous' drone rules recently introduced by CASA." 6 October 2016. http://www.abc.net.au/news/2016-10-06/xenophon-moves-to-bring-down-dangerous-drone-rules/7908070

30 e.g., Australian Certified UAV Operators Inc. "Disallowance" (2016) http://www.acuo.org.au/industry-information/disallowance/ ibid. Griffith (2016)

31 e.g. see Bingemann, Mitchell. "Drone operators demand tougher legislation." *The Australian,* 1 July 2016 http://www.theaustralian.com.au/business/aviation/drone-owners-demand-tougher-legislation/news-story/9138645fdd96a7b7b25a7540562e6a62

32 For the demand and supply of regulation, that leads to rent-seeking, see:
Stigler, George J. "The theory of economic regulation." *The Bell journal of economics and management science* (1971):3-21
Peltzman, Sam. "Toward a more general theory of regulation." *National Bureau of Economic Research Working Paper 133.* (1976):1-52

33 e.g. see previous Institute of Public Affairs research on the 'sharing economy': Allen, Darcy and Berg, Chris. "The sharing economy: How over-regulation could destroy an economy revolution." *Institute of Public Affairs Occassional Paper* (2014) http://ipa.org.au/portal/uploads/Sharing_Economy_December_2014.pdf

Policymakers should be cautious of regulating drone technology predicated on such a debate. The lure of 'public safety' is often rallied in order to achieve coercive benefits from the state. This problem is exacerbated given that recent coverage of drone incidents have been even outside of the new rules, but are used as calls to increase the rules, based on hypothetical worst-case scenarios.[34]

In light of the recent CASA changes outlined above, a new Senate Standing Committee was launched to review the regulations, and whether the laws will maintain airspace safety.[35] This is despite the fact the new rules were already subject to a consultation process, that the reasonable standard operating conditions remain, and that the new rules were welcomed by business and industry.[36]

To contribute to this debate, the following two sections contain recommendations for achieving further reform in drone regulation. The first, in Section 4, is a specific recommendation of removing restrictions on commercial beyond visual line-of-sight (BVLOS) flight. The second, in Section 5, recommends the adoption of a principled policy position towards drone regulation known as permissionless innovation. That helps to frame debates not only about contemporary regulations in Australia, but the regulation of technology more broadly.

34 Ironside, Robyn. "Aviation watchdog turns up heat on recreational drone use." 8 November 2016 http://www.news.com.au/technology/gadgets/aviation-watchdog-turns-up-heat-on-recreational-drone-use/news-story/221203c6e46c866f9490cac32a6ebeb3

35 Parliamentary Senate Standing Committee. "Regulatory requirements that impact on the safe use of Remotely Piloted Aircraft Systems, Unmanned Aerial Systems and associated systems." Accessed 7 December 2016 http://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Rural_and_Regional_Affairs_and_Transport/Drones

36 Daly, Nadia. "Drone regulations relaxed by CASA, businesses welcome move." ABC News, 12 April 2016 http://www.abc.net.au/news/2016-04-13/drone-boom-prompts-regulation-rethink/7324394?pfmredir=sm

4. The case for cutting commercial line-of-sight restrictions

For Australia to remain at the frontier of global drone regulation we should cut the restrictions on commercial visual line-of-sight (VLOS). That is, CASA should go further in relaxing regulations to enable beyond visual-line-of-sight (BVLOS) flights for commercial operators. This change, as outlined here, may lead to further entrepreneurial application of drone technology.

At present BVLOS flights not only require licenses, but further regulatory approval from CASA.[37] These VLOS restrictions have received various criticisms from industry. For instance, Amazon has spoken out against the restrictions in relation to their delivery service.[38] Australia Post has similarly been examining the potential for drone technology for deliveries BVLOS.[39]

Goldman Sachs has cited line-of-sight restrictions as a potential barrier to the development of drones.[40] In 2014, the Australian House of Representatives Inquiry into Agricultural Innovation, Smart Farming, recommended CASA:

> Investigate regulations requiring unmanned aerial vehicles to be flown within visual line of sight, with a view to amending the regulations to enable agricultural producers to use such vehicles for monitoring purposes beyond line of sight on or over their own properties.[41]

The Mercatus Centre at George Mason University has also noted the need for more flexible regulations regarding line-of-sight requirements:

> Such a prescriptive regulatory approach ignores the way new technologies—such as first-person view (FPV) goggles that allow pilots to guide unmanned vehicles at a distance—might lessen the need for the aircraft to "be visible at all times to the operator" in order to ensure effective and safe operation.[42]

37 See: Civil Aviation Safety Authority. "Commercial unmanned flight - gaining your remote pilot licence (RePL) and RPA operator's certificate (ReOC)" Accessed 13 December 2016 https://www.casa.gov.au/aircraft/standard-page/commercial-unmanned-flight-gaining-your-remotely-piloted-aircraft-pilot

38 Vanian, Jonathan. "Here's why the drone industry just had a milestone moment." *Fortune,* 21 June 2016 http://fortune.com/2016/06/21/drone-faa-rules-commercial-business/

39 Swan, David. "Australia Post launched new drone technology." *The Australian,* 15 April 2016 http://www.theaustralian.com.au/news/nation/australia-post-launches-new-drone-technology/news-story/94fb1d20e88e54571462546a88b7cfad

40 ibid. Goldman Sachs (2016)

41 The Parliament of the Commonwealth of Australia. "Smart farming: Inquiry into agricultural innovation." *House of Representatives Standing Committee on Agriculture and Industry*, Recommendation 17. May (2016) http://www.aph.gov.au/Parliamentary_Business/Committees/House/Agriculture_and_Industry/Agricultural_innovation/Report

42 The Parliament of the Commonwealth of Australia. "Smart farming: Inquiry into agricultural innovation." *House of Representatives Standing Committee on Agriculture and Industry*, Recommendation 17. May (2016) http://www.aph.gov.au/Parliamentary_Business/Committees/House/Agriculture_and_Industry/Agricultural_innovation/Report

One case in Australia is that the Queensland Gas Company (QGC), who is a subsidiary of Shell, announced a contract with a global tech giant to undertake BVLOS flights for various operations including checking gas wells, pipelines and processing facilities.[43] This is one of few companies in Australia permitted to for commercial RPAS operations Beyond Visual Line of Sight (BVLOS).[44] This includes collaboration and funding from the Queensland government.[45] However, this has come after 18 months of successful test flights in close conjunction with CASA.

In Poland, drone businesses have specifically opened services in jurisdictions due to the their relaxation[46] of the VLOS requirements.[47] Given these considerations, there is a substantial case for CASA to enable BVLOS for drone technology, particularly for commercial operators, because these restrictions can act as a barrier on further innovation, and holds back one of the clear comparative advantages of the technology. It is also useful to note the increasing technological developments of drones assist in avoiding collisions.[48]

43 Insitu. "ScanEagle unmanned technology benefits commercial sector natural gas BVOLS operations" Media release, *3 May 2016* https://insitu.com/press-releases/ScanEagle-unmanned%20technology-benefits-commercial-sector-in-natural-gas-BVLOS-operations

44 Insitu. "ScanEagle unmanned technology benefits commercial sector natural gas BVOLS operations" Media release, *3 May 2016* https://insitu.com/press-releases/ScanEagle-unmanned%20technology-benefits-commercial-sector-in-natural-gas-BVLOS-operations

45 Insitu Pacific. "UAV Operators Certificate." (2016) http://insitupacific.com.au/about/casa-certification/

46 In Poland the regulation in relation to VLOS requires a certification. Note also that UAV flights below the line of sight, for safety reasons are possible only specially designated airspace in accordance with the provisions of Art. 126 of the Act.
See: Library of Congress. "Regulation of Drones: Poland." Accessed 12 December 2016 https://www.loc.gov/law/help/regulation-of-drones/poland.php
Civil Aviation Authority of the Republic of Poland. "Current status of RPAS Regulations in the Republic of Poland." (2014) http://jarus-rpas.org/sites/jarus-rpas.org/files/current_status_of_rpa_regulations.pdf
Civil Aviation Authority of Poland. "Remotely Piloted Aircraft Systems (RPAS) in Poland." (2013) http://jarus-rpas.org/sites/jarus-rpas.org/files/rpas_poland.pdf

47 Smith, Geoffrey. "Here comes the latest drone army." *Fortune,* 9 May 2016 http://fortune.com/2016/05/09/here-comes-the-latest-drone-army/

48 e.g. Mims, Christopher. "Drones have a role in your company's future." *The Wall Street Journal*, 27 June 2016 http://www.wsj.com/articles/drones-have-a-role-in-your-companys-future-1467000061

5. Adopting a permissionless innovation approach

The central problem of the regulation of drones is to determine the appropriate trade-off between realising the societal and economic potential of drones, while simultaneously taking into account reasonable protections against excessive risks. This section first outlines this public policy question in terms of comparative institutional economics—using the Institutional Possibility Frontier—and then proposes a consistent and principled approach to the institutional choice of drone regulation, permissionless innovation.

The various complex factors that must be taken into account in the regulation of drones can be framed in a more specific and nuanced framework known as the Institutional Possibility Frontier (IPF).[49] The IPF is a tool used in new comparative economics and has been variously applied to different policy debates, including in Australia.[50] The underlying basis of the IPF is that society decides to impose institutional controls that economise on two different types of costs:

1. the costs of *disorder*, which are the costs of private individuals appropriating others; and
2. the costs of *dictatorship*, which come from state intervention and appropriation of the polity.

These two types of costs can never be perfectly mitigated—there are always social efficiency losses. What theoretically exists, however, and indeed what should be the goal of policymakers, is a point of minimal best practice regulation where the sum of disorder and dictatorship costs are minimised. That is, where there are minimal social losses from too relaxed or too harsh regulatory intervention.

The combination of costs of institutional solutions can be depicted graphically within a space of institutional solutions. Figure 4, for instance, loosely demonstrates the trade-off of the present drone debates in Australia.

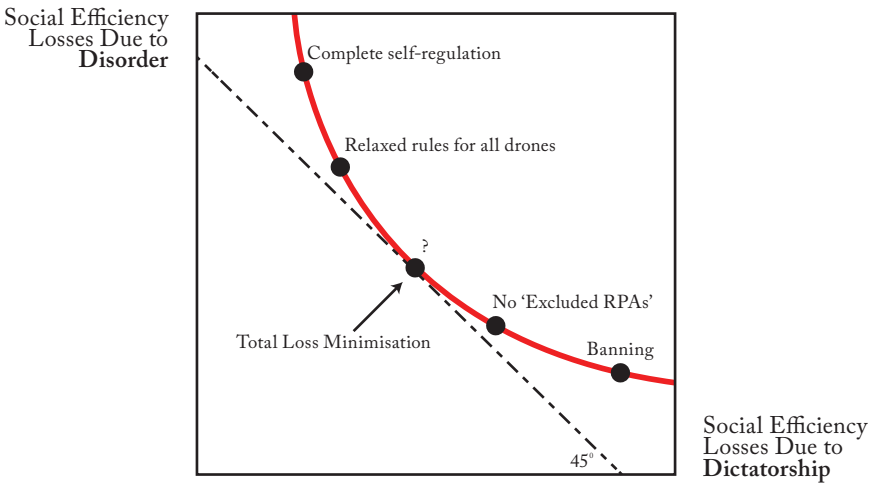
High quality and effective public policy seeks to find the interior economic solution where the costs of dictatorship and disorder are efficiently traded off. This is where the 45 degree cost minimising line is at a point of tangency with the IPF curve.[51]

49 Djankov, Simeon, Edward Glaeser, Rafael La Porta, Florencio Lopez-de-Silanes, and Andrei Shleifer. "The new comparative economics." *Journal of Comparative Economics* 31, no. 4 (2003):595-619

50 e.g. on free speech: Berg, Chris and Davidson, Sinclair. "Section 18C, Human Rights, and Media Reform: An Institutional Analysis of the 2011–13 Australian Free Speech Debate." *Agenda* vol 23 no 1 (2016) http://press-files.anu.edu.au/downloads/press/n2264/pdf/analysis01.pdf

51 To be clear, these costs are subjective costs (*c.f.* objective costs) because they are based on future expectations of the development of drone technology that is unknown. Further, the optimum point of drone regulation will change through time as various private institutional systems are developed for self-regulation, including, for instance, collision-avoiding technology. See Allen, Darcy W.E. and Chris Berg. "Subjective Political Economy." Working Paper Available on SSRN (2016)

Figure 4: Drones and the Institutional Possibility Frontier



While some individuals and groups have praised the recent rule changes on drones (as outlined in the previous section) as helping the industry 'take off',[52] others have heavily criticised these changes as being dangerous. These debates are effectively over what is the efficient interior solution of the drone IPF, or, put another way, about where the IPF sits.

Contemporary debate in Australia—and indeed globally—suggests that the efficient point for drones is somewhere between: (1) having no exclusions from strict drone licenses no matter the risk of the drone activity; and (2) relaxing rules further across the entire spectrum of risk.

While the former option suffers more from the costs of dictatorship—and will stymie the development of the technology—the latter trades this risk off for the higher possibility for danger and accidents. On the extreme ends of either side of these possibilities are outright banning of the technology, on one hand, or complete self-regulation, on the other. These options have now been driven out of the policy debate in this country.

Given this trade-off, the main contribution here is to note that regulators often miscalculate the perceived costs of disorder. Policymakers often overweight the costs of potential harm from a lack of regulation, and underweight the benefits relaxing the rules. This can lead to a movement towards the dictatorship end of the spectrum. This is possible not just for drones, but is common across the regulation of new technologies more broadly.

Let us begin with why the benefits of relaxed regulations are often underweighted. The most basic economic reason for this is that relaxed rules in the early stages of new technologies are imperative for developing that technology because entrepreneurship requires experimentation.

Innovation is now well understood to be the fundamental driver of economic growth, and this comes from devising new ways to apply new technologies and business models to meet human needs. But this process requires experimentation, which requires regulatory flexibility. Indeed, as the empirical literature has suggested, up until a certain reasonable point, there is a positive correlation between freedom and entrepreneurship.[53]

52 Clothier, Reece and Roberts, Jonathan. "New relaxed drone regulations will help the industry take off" *The Conversation*, 7 April 2016 https://theconversation.com/new-relaxed-drone-regulations-will-help-the-industry-take-off-57201

53 Hall, Josh, Pulito, John, and VanMetre, Benjamin. "Freedom and entrepreneurship: New evidence from the 50 states" *Working Paper, Mercatus Center at George Mason University* (2012) https://www.mercatus.org/system/files/Freedom-and-Entrepreneurship-Working-Paper_1_0.pdf

The broader tendency to overweight the costs of disorder is only one of two dispositions towards the regulation of technology. The first, known as the *precautionary principle,* would be to shut down, curtail or restrict the technology until it can be demonstrated that few harms will be caused to individuals. At first the cost of adopting the precautionary principle looks small. That's because there are theoretically high costs *if* an RPA was to cause damage. That is, the precautionary principle is based largely on hypothetical harms, which is the main justification for slowing the development of it.

The real cost of this precautionary principle, however, is the *opportunity cost* of fewer experimental business successes and failures that would occur in the absence of strict regulation. This approach is costly because the future applications of drone technology are presently unclear. The cost of being precautionary are all of the potential applications of drone technology that will be discovered in the future. However, the precise size of the opportunity cost of too much regulation sits under a cloud of uncertainty.

The contrasting disposition towards the regulation of drones can be described as *permissionless innovation*, where:

> Experimentation with new technologies and business models should generally be permitted by default. Unless a compelling case can be made that a new invention will bring serious harm to society, innovation should be allowed to continue unabated and problems, if they develop at all, can be addressed later.[54]

To be clear, a permissionless approach is not to suggest that the role of government is entirely mute, indeed:

> Permissionless innovation ... is an aspirational goal that stresses the benefit of "innovation allowed" as the default position to begin policy debates. It switches the burden of proof to those who favor pre-emptive regulation and asks them to explain why ongoing trial-and-error experimentation with new technologies or business models should be disallowed.[55]

The main rationale for approaching technology from a permissionless approach rather than a precautionary approach comes from the economics of entrepreneurial discovery. Drones, as established earlier, are a potential GPT—but all of the various uses of drones are yet to be discovered. The speed and success of determining the uses and complementarities of drone technology is a function of the institutional environment in which they operate.

Governments and policy makers must understand that it is historically common to overweight the potential harms of new technologies, and underweight their potential benefits. A permissionless approach simply suggests that harm must be demonstrated before government restriction and intervention are justified. This is on the understanding that there are various exsisting laws that would encompass many of the potential harms and dangers of drone technology.[56]

What's more, adopting this approach is known to slow the development of the technology because it holds back the process of entrepreneurial discovery. And, as research in the United States demonstrated, the cost of this delayed development can be substantial.

---

54 Thierer, Adam. *Permissionless Innovation: The Continuing Case for Comprehensive Technological Freedom*. Mercatus Center at George Mason University (2016)

55 Thierer, Adam. "Embracing a Culture of Permissionless Innovation." *Cato Online Forum* (2014) https://www.cato.org/publications/cato-online-forum/embracing-culture-permissionless-innovation

56 This includes, for instance, negligence. See: Clarke, Roger and Moses, Lyria Bennett. "The regulation of civilian drones' impacts on public safety." *Computer Law & Security Review* 30, no. 3 (2014):263-285

> Every year that integration [of drones] is delayed, the United States loses more than $10 billion in potential economic impact. This translates to loss of $27.6 million per day that UAS are not integrated into the NAS.[57]

Australia should be vying to be the global capital of the development of drone technology. This will undoubtedly be partly driven by the comparative efficacy and certainty of drone regulation within our country. For instance, Poland is known as a leader in drone regulation, including, as outlined earlier, in relaxed line-of-sight restrictions. These regulatory conditions were cited as a reason for PwC placing their global Drone Powered Solutions (DPS) office in Poland:

> Established in Poland in early 2015, DPS is the world's first professional services consulting team dedicated to industrial and business applications of drone technology, and its location in Poland is no accident: Poland is one of the first countries worldwide to have adopted detailed laws regulating the industrial use of drones (as early as 2013).[58]

It's not just research centres that move borders in search of effective regulations—it's also entrepreneurs. The recent emergence of Domino's pizza in New Zealand similarly cites the conducive regulatory environment:

> New Zealand was selected as the launch market given its current regulations allow for businesses to embrace unmanned aircraft opportunities, which enable the gradual testing of new and innovative technologies.[59]

This intertemporal process of investment flows between the comparatively attractive regulatory jurisdictions in usefully described by Adam Thierer as innovation arbitrage:

> Innovators can, and will with increasingly regularity, move to those jurisdictions that provide a legal and regulatory environment more hospitable to entrepreneurial activity. Just as capital now fluidly moves around the globe seeking out more friendly regulatory treatment, the same is increasingly true for innovations. And this will also play out domestically as innovators seek to play state and local governments off each other in search of some sort of competitive advantage.[60]

An understanding of how global innovation arbitrage is occurring in the investment market for drones should encourage Australian regulators to develop a flexible regulatory environment.[61] To be clear, Australia is near the frontier of global drone regulation. But to remain there we must constantly be reassessing where and how the regulation of drones can be marginally improved—including restrictions on visual line-of-sight restrictions—and take into account the growing capacity of drones and drone-operators to self-regulate to protect from harm. Similarly, policymakers must remain particularly wary of precautionary calls for further red tape and licenses, including the possibility those calls are coming as forms of protectionist rent seeking.

---

57 Jenkins, Darryl and Vasigh, Bijan. "The economic impact of unmanned aircraft systems integration in the United States." *Association for Unmanned Vehicle Systems International (AUVSI).* (2013):3

58 ibid. PwC (2016):34

59 Domino's Pizza. "The Sky's the Limit: Domino's Announces Partnership with Flirtey for CAA-Approved Drone Deliveries." Media Release August (2016) https://www.dominos.com.au/inside-dominos/media/aug-2016-the-sky-s-the-limit-dominos-announces-partnership-with-flirtey-for-caa-approved-drone-deliveries
See also: de Rugy, Veronique. "New Zealand Has Pizza Delivery Drones." *Reason,* December (2016) http://reason.com/archives/2016/11/13/new-zealand-has-pizza-delivery

60 Thierer, Adam. "Innovation Arbitrage, Technological Civil Disobedience & Spontaneous Deregulation." Technology Liberation Front (2016) https://medium.com/tech-liberation/innovation-arbitrage-technological-civil-disobedience-spontaneous-deregulation-eb90da50f1e2#.k0k5j2wrm

61 Thierer, Adam. "Global Innovation Arbitrage: Drone Delivery Edition." *The Technology Liberation Front,* 25 August 2016 https://techliberation.com/2016/08/25/global-innovation-arbitrage-drone-delivery-edition/

6. Conclusion

Drones should not be considered a hobbyist toy, they are expected to have substantial economic impacts on various private sectors. But this technology has come into tension with existing aviation law, generating policy debate on their correct regulatory treatment.

Developing effective regulation of drone technology is critical for the success of our drone industry, not only because this will stimulate economic growth, but also because it will make us more prosperous.

The first section of this paper revealed some of the potential applications of drone technology, and in particular in our primary industries such as mining and agriculture. Estimates of the value of the drone industry are in excess of US $100 billion.

The second section outlined the current state of the regulation of drones in Australia. This follows the recent decisions of the federal aviation regulator, the Civil Aviation Safety Authority (CASA), removing some burdensome license requirements around low-risk drone use.

By redefining drones into new weight categories, and enabling entrepreneurial flexibility in the low-risk 'very small' drone category, CASA has cut red tape restricting the development of the technology. These changes should be welcomed and encouraged as a reasonable trade-off between safety and freedom for the industry to grow.

While the recent changes are welcomed, and will facilitate the development of the drone industry, two recommendations were made in the final two sections of this paper:

1. Enable commercial drone operators to fly beyond visual line-of-sight (BVLOS) in order to open up further entrepreneurial opportunities; and
2. Adopt a permissionless innovation approach to drone regulation, which holds that innovation is enabled by default, and prescriptive rules are not handed down based on hypothetical future harms.

This page intentionally left blank

References

ABC News. "Senator Nick Xenophon moves to bring down 'dangerous' drone rules recently introduced by CASA." 6 October 2016 http://www.abc.net.au/news/2016-10-06/xenophon-moves-to-bring-down-dangerous-drone-rules/7908070

Allen, Darcy and Berg, Chris. "The sharing economy: How over-regulation could destroy an economy revolution." *Institute of Public Affairs Occassional Paper* (2014) http://ipa.org.au/portal/uploads/Sharing_Economy_December_2014.pdf

Allen, Darcy W.E. and Chris Berg. "Subjective Political Economy." Working Paper Available on SSRN. (2016)

Atmel Team. "18 awesome ways drones are being used today." Atmel Bits & Pieces, *8 August 2014* http://blog.atmel.com/2014/08/08/18-awesome-ways-drones-are-used-today/

Australian Certified UAV Operators Inc. "Disallowance" (2016) http://www.acuo.org.au/industry-information/disallowance/

Australian Government Civil Aviation Safety Authority "UAS Certificate Holders" https://www.casa.gov.au/aircraft/standard-page/uas-certificate-holders

Berg, Chris and Davidson, Sinclair. "Section 18C, Human Rights, and Media Reform: An Institutional Analysis of the 2011–13 Australian Free Speech Debate." *Agenda* vol 23 no 1 (2016) http://press-files.anu.edu.au/downloads/press/n2264/pdf/analysis01.pdf

Bingemann, Mitchell. "CASA sets out regulations for use of drones." *The Australian,* 1 April 2016 http://www.theaustralian.com.au/business/aviation/casa-sets-out-regulations-for-use-of-drones/news-story/4f876cccc1fe97b3c7d015ed97f5d85b

Bingemann, Mitchell. "Drone operators demand tougher legislation." *The Australian,* 1 July 2016 http://www.theaustralian.com.au/business/aviation/drone-owners-demand-tougher-legislation/news-story/9138645fdd96a7b7b25a7540562e6a62

Bingemann, Mitchell. "Drone pro Andrew Chapman challenges CASA over safety regulations." *The Australian,* 8 April 2016 http://www.theaustralian.com.au/business/aviation/drone-pro-andrew-chapman-challenges-casa-over-safety-regulations/news-story/df877029fdc26d85f0c236e906620466

Brann, Matt. "Agricultural drone jobs taking off in northern Australia." ABC News Rural Online, 13 December 2016 http://www.abc.net.au/news/2016-12-13/agricultural-drone-jobs-taking-off-in-northern-australia/8103834

Cantner, Uwe and Simone Vannuccini. "A new view of general purpose technologies." *Jena Economic Research Papers* 54 (2012)

Civil Aviation Authority of Poland. "Remotely Piloted Aircraft Systems (RPAS) in Poland." (2013) http://jarus-rpas.org/sites/jarus-rpas.org/files/rpas_poland.pdf

Civil Aviation Authority of the Republic of Poland. "Current status of RPAS Regulations in the Republic of Poland." (2014) http://jarus-rpas.org/sites/jarus-rpas.org/files/current_status_of_rpa_regulations.pdf

Civil Aviation Safety Authority. "ARN Applications" Accessed 6 December 2016 https://www.casa.gov.au/standard-page/arn-applications

Civil Aviation Safety Authority. "Commercial unmanned flight - gaining your remote pilot licence (RePL) and RPA operator's certificate (ReOC)" Accessed 6 December 2016 https://www.casa.gov.au/aircraft/standard-page/commercial-unmanned-flight-gaining-your-remotely-piloted-aircraft-pilot

Civil Aviation Safety Authority. "Flying over your own land - excluded RPA." Accessed 6 December 2016 https://www.casa.gov.au/aircraft/standard-page/excluded-remotely-piloted-aircraft-flying-over-your-own-land

Civil Aviation Safety Authority. "New Drone Rules Cut Red Tape" 28 September 2016 https://www.casa.gov.au/media-release/new-drone-rules-cut-red-tape

Civil Aviation Safety Authority. "Notice of Proposed Rule Making: Remotely Piloted Aircraft Systems." NPRM 1309O S, May (2014)

Civil Aviation Safety Authority. "Part 101 Amendments." (2016) https://www.casa.gov.au/aircraft/standard-page/part-101-amendments-cutting-red-tape-remotely-piloted-aircraft

Civil Aviation Safety Regulations 1998, Part 101.238 https://www.legislation.gov.au/Details/F2016C00889/Html/Volume_3

Clarke, Roger and Moses, Lyria Bennett. "The regulation of civilian drones' impacts on public safety." *Computer Law & Security Review* 30, no. 3 (2014):263-285

Clothier, Reece and Roberts, Jonathan. "New relaxed drone regulations will help the industry take off" *The Conversation,* 7 April 2016 https://theconversation.com/new-relaxed-drone-regulations-will-help-the-industry-take-off-57201

Daly, Nadia. "Drone regulations relaxed by CASA, businesses welcome move." ABC News, 12 April 2016 http://www.abc.net.au/news/2016-04-13/drone-boom-prompts-regulation-rethink/7324394?pfmredir=sm

de Rugy, Veronique. "New Zealand Has Pizza Delivery Drones." *Reason,* December (2016) http://reason.com/archives/2016/11/13/new-zealand-has-pizza-delivery

Djankov, Simeon, Edward Glaeser, Rafael La Porta, Florencio Lopez-de-Silanes, and Andrei Shleifer. "The new comparative economics." *Journal of Comparative Economics* 31, no. 4 (2003):595-619

Domino's Pizza. "The Sky's the Limit: Domino's Announces Partnership with Flirtey for CAA-Approved Drone Deliveries." Media Release August (2016) https://www.dominos.com.au/inside-dominos/media/aug-2016-the-sky-s-the-limit-dominos-announces-partnership-with-flirtey-for-caa-approved-drone-deliveries

Goldman Sachs. "Drones: Reporting for Work." *Goldman Sachs* (2016) http://www.goldmansachs.com/our-thinking/technology-driving-innovation/drones/

Griffith, Chris. "Certified drone operators left up in the air over the new rules." *The Australian,* 8 November 2016 http://www.theaustralian.com.au/business/technology/certified-drone-operators-left-up-in-the-air-over-new-rules/news-story/112be92d7038ff6039522a7b52453300

Gunders, Jodie and Hough, Cassandra. "CASA develops new regulations for drone operation." 1 April 2016 http://www.abc.net.au/news/2016-04-01/new-drone-regulations-to-benefit-farmers/7293392

Hall, Abigail R., and Christopher J. Coyne. "The political economy of drones." *Defence and Peace Economics* 25, no. 5 (2014): 445-460

Hall, Josh, Pulito, John, and VanMetre, Benjamin. "Freedom and entrepreneurship: New evidence from the 50 states" *Working Paper, Mercatus Center at George Mason University* (2012) https://www.mercatus.org/system/files/Freedom-and-Entrepreneurship-Working-Paper_1_0.pdf

Handwerk, Brian. "5 surprising drone uses (besides Amazon delivery)" National Geographic, *2 December 2013* http://news.nationalgeographic.com/news/2013/12/131202-drone-uav-uas-amazon-octocopter-bezos-science-aircraft-unmanned-robot/

Holcombe, Randall, G. "Integrating Drones into the US Air Traffic Control System." Mercatus Centre at George Mason University Working Paper, Arlington, V.A. October (2016)

Insitu Pacific. "UAV Operators Certificate." (2016) http://insitupacific.com.au/about/casa-certification/

Insitu. "ScanEagle unmanned technology benefits commercial sector natural gas BVOLS operations" Media release, *3 May 2016* https://insitu.com/press-releases/ScanEagle-unmanned%20technology-benefits-commercial-sector-in-natural-gas-BVLOS-operations

Ironside, Robyn. "Aviation watchdog turns up heat on recreational drone use." 8 November 2016 http://www.news.com.au/technology/gadgets/aviation-watchdog-turns-up-heat-on-recreational-drone-use/news-story/221203c6e46c866f9490cac32a6ebeb3

Jenkins, Darryl and Vasigh, Bijan . "The economic impact of unmanned aircraft systems integration in the United States." *Association for Unmanned Vehicle Systems International (AUVSI).* (2013):3

Library of Congress. "Regulation of Drones: Poland." Accessed 12 December 2016 https://www.loc.gov/law/help/regulation-of-drones/poland.php

Lidynia, Chantal, Philipsen, Ralf and Ziefle, Martina. "Droning on About Drones—Acceptance of and Perceived Barriers to Drones in Civil Usage Contexts." In *Advances in Human Factors in Robots and Unmanned Systems*, Springer International Publishing (2017):317-329

Linn, Andy. "Agriculture Sector Poised to Soar with Drone Integration, but Federal Regulation May Ground the Industry before It Can Take off." *Texas Tech Law Review* 48 (2015):975

Lipsey, R. G., Carlaw, K. I., & Bekar, C. T. *Economic transformations: General purpose technologies and long-term economic growth: General purpose technologies and long-term economic growth.* Oxford: Oxford University Press. (2005)

Mims, Christopher. "Drones have a role in your company's future." *The Wall Street Journal*, 27 June 2016 http://www.wsj.com/articles/drones-have-a-role-in-your-companys-future-1467000061

Novak, Mikayla. "The 176 billion tax on our prosperity." *Institute of Public Affairs Occasional Paper* (2016) http://ipa.org.au/portal/uploads/The-176-Billion-Tax-On-Our-Prosperity.pdf

Parliamentary Senate Standing Committee. "Regulatory requirements that impact on the safe use of Remotely Piloted Aircraft Systems, Unmanned Aerial Systems and associated systems." Accessed 7 December 2016 http://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Rural_and_Regional_Affairs_and_Transport/Drones

Peltzman, Sam. "Toward a more general theory of regulation." *National Bureau of Economic Research Working Paper 133.* (1976):1-52

PwC Polska. "Clarity from above: PwC global report on the commercial applications of drone technology." May (2016) https://www.pwc.pl/pl/pdf/clarity-from-above-pwc.pdf

Queensland Government. "Advance Queensland funding to advance remotely piloted aircraft tech in Queensland." *Media Release*, 25 July 2016 http://statements.qld.gov.au/Statement/2016/7/25/advance-queensland-funding-to-advance-remotely-piloted-aircraft-tech-in-queensland

Rao, Bharat., Gopi, Ashwin Goutham and Maione, Romana. "The societal impact of commercial drones." *Technology in Society* 45 (2016):83-90

Sandbrook, Chris. "The social implications of using drones for biodiversity conservation." *Ambio* 44, no. 4 (2015):636-647

Smith, Geoffrey. "Here comes the latest drone army." *Fortune,* 9 May 2016 http://fortune.com/2016/05/09/here-comes-the-latest-drone-army/

Stigler, George J. "The theory of economic regulation." *The Bell journal of economics and management science* (1971):3-21

Swan, David. "Australia Post launched new drone technology." *The Australian,* 15 April 2016 http://www.theaustralian.com.au/news/nation/australia-post-launches-new-drone-technology/news-story/94fb1d20e88e54571462546a88b7cfad

The Parliament of the Commonwealth of Australia. "Eyes in the sky: Inquiry into drones and the regulation of air safety and privacy." House of Representatives Standing Committee on Social policy and Legal Affairs (2014): Chapter 2 http://www.aph.gov.au/Parliamentary_Business/Committees/House/Social_Policy_and_Legal_Affairs/Drones/Report

The Parliament of the Commonwealth of Australia. "Smart farming: Inquiry into agricultural innovation." *House of Representatives Standing Committee on Agriculture and Industry*, Recommendation 17. May (2016) http://www.aph.gov.au/Parliamentary_Business/Committees/House/Agriculture_and_Industry/Agricultural_innovation/Report

Thierer, Adam and Hagemann, Ryan. "Federal Aviation Administration Interpretation of the Special Rule for Model Aircraft." Public Interest Comment, *Mercatus Center at George Mason University.* 23 September (2014):4 https://www.mercatus.org/publication/federal-aviation-administration-interpretation-special-rule-model-aircraft-0

Thierer, Adam. "Embracing a Culture of Permissionless Innovation." Cato Online Forum, (2014) https://www.cato.org/publications/cato-online-forum/embracing-culture-permissionless-innovation

Thierer, Adam. "Global Innovation Arbitrage: Drone Delivery Edition." *The Technology Liberation Front,* 25 August 2016 https://techliberation.com/2016/08/25/global-innovation-arbitrage-drone-delivery-edition/

Thierer, Adam. "Innovation Arbitrage, Technological Civil Disobedience & Spontaneous Deregulation." *The Technology Liberation Front*, 6 December 2016 https://medium.com/tech-liberation/innovation-arbitrage-technological-civil-disobedience-spontaneous-deregulation-eb90da50f1e2#.k0k5j2wrm

Thierer, Adam. *Permissionless Innovation: The Continuing Case for Comprehensive Technological Freedom*. Mercatus Center at George Mason University (2016)

Vanian, Jonathan. "Here's why the drone industry just had a milestone moment." *Fortune,* 21 June 2016 http://fortune.com/2016/06/21/drone-faa-rules-commercial-business/

Villasenor, John. "What is a drone, anyway?" *Scientific American*, 12 April 2012 https://blogs.scientificamerican.com/guest-blog/what-is-a-drone-anyway/

Zhang, Chunhua and Kovacs,John M. "The application of small unmanned aerial systems for precision agriculture: a review." *Precision agriculture* 13, no. 6 (2012):693-712

Appendix

		Year			
		2014	2015	2016	Total
State	VIC	8	27	135	170
	NSW	4	31	231	266
	QLD	4	34	171	209
	SA	1	8	41	50
	WA	4	17	74	95
	NT	0	1	12	13
	TAS	0	1	16	17
	ACT	1	3	7	11
	Total	22	122	687	831

This page intentionally left blank

This page intentionally left blank

Institute of Public Affairs

Institute of Public Affairs
THE VOICE FOR FREEDOM
ESTABLISHED–1943