Australian Government

Productivity Commission

INFORMATION PAPER

Regulatory Technology

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The Productivity Commission

The Productivity Commission is the Australian Government's independent research and advisory body on a range of economic, social and environmental issues affecting the welfare of Australians. Its role, expressed most simply, is to help governments make better policies, in the long term interest of the Australian community.

The Commission's independence is underpinned by an Act of Parliament. Its processes and outputs are open to public scrutiny and are driven by concern for the wellbeing of the community as a whole.

Further information on the Productivity Commission can be obtained from the Commission's website (www.pc.gov.au).

Foreword

This information paper has its origins in the Council of Federal Financial Relations. Treasurers agreed that the Productivity Commission will support jurisdictions to identify reforms involving the application of regulatory technology ('regtech').

The paper is a discussion starter, targeted at policy makers and regulators. It identifies areas where regtech has been useful and offers further potential. It highlights factors that policy makers and regulators should consider in adopting regtech, and in enabling greater use of regtech. The paper also raises the question of whether there is a gap — is regtech adoption less than some optimal level given the opportunities — and, if so, what is causing it.

This information paper complements other case studies by the Productivity Commission on productivity reforms across the Australian Federation. The aim of the case studies is to inform and diffuse knowledge and practices across all jurisdictions, and to identify reform opportunities.

Key points

- Regulatory technology ('regtech') is the use of technology to better achieve regulatory objectives. Used well, it can support the improved targeting of regulation and reduce the costs of administration and compliance.

- While regtech can improve regulatory outcomes and reduce costs, it is not a substitute for regulatory reform. Indeed, as regtech is intended to make the task of regulating easier, advances in technology heighten the onus on policy makers to ensure the need for, and design of, regulation are soundly-based.

- Australia is viewed as being comparatively well-placed internationally for widespread adoption of regtech. Yet, with the exception of financial system applications, extensive use of regtech remains relatively uncommon.

- There is potential scope in Australia to extend existing low-tech solutions — including digitised data, forms, registers and transactions. These could reduce compliance costs for individuals and businesses, improve the efficiency of regulator practices, and generate flow-on benefits for the community.

- Leading-edge regtech involves the use of data for predictive analytics and real time monitoring, enabling better regulatory outcomes and potentially fewer compliance burdens for businesses. But advanced regtech requires specialised resources and long development times.

- Even in low-tech applications, widespread implementation of regtech can take some years. It can require substantial investment by regulators and businesses in capacity and cultural change while (as with technology solutions generally) enumeration of the scale and timing of the benefits can be difficult.

- There are four key areas where regtech solutions may be particularly beneficial:
    - where regulatory environments are particularly complex to navigate and monitor
    - where there is scope to improve risk-based regulatory approaches, thereby targeting the compliance burden and regulator efforts
    - where technology can enable better monitoring, including by overcoming constraints related to physical presence
    - where technology can safely unlock more uses of data for regulatory compliance.

- Creating and maintaining a regulatory environment that supports the realisation of regtech benefits would mean:
    - improving the consistency and structure of data and the interoperability of, and standards for, technology — these are precursors to wider regtech adoption
    - investing in the technical skills and capabilities of regulators to enable measured steps in regtech adoption
    - determining accountability for outcomes associated with regtech solutions, including with regard to privacy, data security, and responsibility for resolving disputed outcomes
    - reviewing regulation to remove technology-specific requirements that could prevent the take-up of beneficial regtech solutions
    - creating familiarity with the possibilities of regtech (for example, through liaison forums and trials), facilitating collaboration between regulators, regulated entities and regtech developers, and establishing safe environments to develop and test regtech solutions.

1.   What is regulatory technology and why is it of interest?

Regulatory technology ('regtech') refers to technology that enables regulatory requirements to be met more effectively and/or efficiently (Wang 2019).[1] The use of technology for this purpose is not new. The greater use of regtech to support regulatory compliance has, in part, been enabled by reduced costs of technology and the proliferation of data. Relatively low awareness of innovations in regtech and potential barriers to take-up suggest, however, that there may be untapped potential to reduce regulatory costs and improve outcomes.

The sectors that have led use of, and experimentation in, new technologies or applications include those dealing with many rules and/or dealing with large numbers of clients, transactions and digital data (such as the financial services sector and tax administration). Technologies are also being adopted to better undertake more straightforward tasks (such as in the use of drones to monitor geographically-dispersed activity). Recent uses highlight the variety of potential benefits technology offers, as well as some of the costs, risks and hurdles involved.

This paper sets out examples of regtech, both 'high' (or more sophisticated uses) and 'low', to support consideration by policy makers, regulators and regulated parties (businesses and individuals) of potential other applications (section 3). It also discusses some of the conditions that may be needed to support optimal uptake and implications for policy design of greater adoption (section 4). The paper considers, first, how the benefits of regtech can arise and some of the risks and costs associated with its adoption (section 2).

2.   How regtech can help

Supporting sound regulation

A basic principle of regulatory design is that regulations[2] should achieve their goals at the lowest possible costs. They should, therefore (among other things), seek to target the problem they are trying to correct as closely as possible, be a proportionate response to the problem, and use processes that reduce compliance burdens.

Advances in technology can help, and have long helped, to achieve these aims. Obvious examples include Internet-enabled administration of and compliance with regulations, which

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[1] Some commentators confine 'regtech' to refer to use of technology for regulatory purposes by businesses and refer to use of technology by regulatory supervisors as 'suptech'. For simplicity, the Productivity Commission has used the term regtech in its broadest sense to cover uses of technology by either regulators or regulated entities.

[2] In this paper, the term 'regulations' is used to mean any mandatory requirement imposed by governments, unless otherwise described.

have substantially lowered costs and sped up transactions, and the use of information gathered through such processes to refine regulation and better target compliance effort. Tools such as the cloud, artificial intelligence (AI), machine learning, natural language processing, data analytics and data transfer protocols, and technologies used in more specialised or narrow applications, including distributed ledger technology (such as blockchain), have more recently improved the agility of processing, speed of reporting and monitoring, integration of technological solutions and quality of analytics using digital information and big data (PC 2017a; Schizas et al. 2019; Wang 2019).[3]

New technologies have opened up new areas for policy and regulation, such as that involving widescale monitoring of activity (previously impossible or too costly). The COVIDSafe app is an example of a non-mandatory tool introduced to track person-to-person contact among those who have the app, and so enable the tracing of exposed parties if a person with the app has contracted COVID-19 (Australian Government 2020a).

By definition, regtech is intended to make the task of regulating easier.[4] This poses risks as well as potential benefits — the former including expansion of regulatory activity because it is possible.[5] Increasing the reach of regulation and compliance and enforcement activity is only positive if regulations are well-justified and the enforcement and compliance activity is finely-tuned. Given risks of regulatory 'creep' and overreach, as well as the potential to reduce costs and improve regulatory outcomes, advances in technology heighten the onus on policy makers to ensure the need for, and design of, regulation are soundly-based.

Potential untapped opportunities

Some commentators consider there is a growing opportunity — for regulators and the regulated — to use technology to support regulatory compliance (for example, CSIRO 2019; Schizas et al. 2019; Wang 2019). This has been driven by:

- the increased complexity (and quantity) of regulatory requirements in some areas, and resulting compliance burdens

- the greater possibilities offered by technology to tackle areas where the costs of regulatory non-compliance are high (financial and/or detriment to individual or community outcomes)

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[3] Many of these tools and technologies overlap (for example, data analytics is often seen in the AI/machine learning light, and current methods for natural language processing often use AI).

[4] The relationship between regulation and technology is multi-faceted. For example, the emergence of a new technology or application may give rise to the need to regulate it; technological advances can render some regulation obsolete; technology can enable refinement of the targets or objectives of regulation; it can enable different ways for the objectives of regulation to be met, and prompt new ways of writing and reviewing regulations. This paper mainly focuses on how regtech can improve administration and compliance assuming given regulations.

[5] Apart from unjustified regulation, adverse impacts can arise from seemingly beneficial moves, for example, seeking to reduce minor infractions to zero could impose significant downstream costs on courts or engender disrespect for the general rule of law because of overreach.

- reduced costs of, and associated increased reliance on, technology in business operations

- growing recognition of the usefulness of some data collected during business operations in also demonstrating compliance with regulatory requirements.

Internationally, Australia is well-placed for the *development* of regtech solutions, with relatively stable and sophisticated regulatory systems, and with some estimating that around 13% of regtech providers world-wide are based in Australia (figure 1). However, many regulators and businesses remain unfamiliar with the possibilities of regtech, creating barriers for application and procurement. Low awareness can dampen both demand and supply responses — business need to see value in changing their software so that developers see value in investing in applications, which in turn deliver the value businesses need to see.

Uptake of regtech solutions also requires regulators with the capacity and motivation to incorporate regtech, and regulated businesses and individuals that are able to incorporate new approaches in the way they operate. Or are simply more open to it — new ways of operating can be facilitated by trusted third parties or intermediaries (such as for audit functions and the processing of approvals and payments). Past Productivity Commission studies suggest Australia's regulators and businesses are variable in their readiness to adopt regtech (PC 2013; 2016).

The following sections outline more specifically ways in which regtech can ease compliance costs for the individuals and businesses being regulated, enable more efficient and effective administration of regulatory compliance by regulators, and generate additional benefits.

Figure 1   **Top 10 regtech markets[a]**
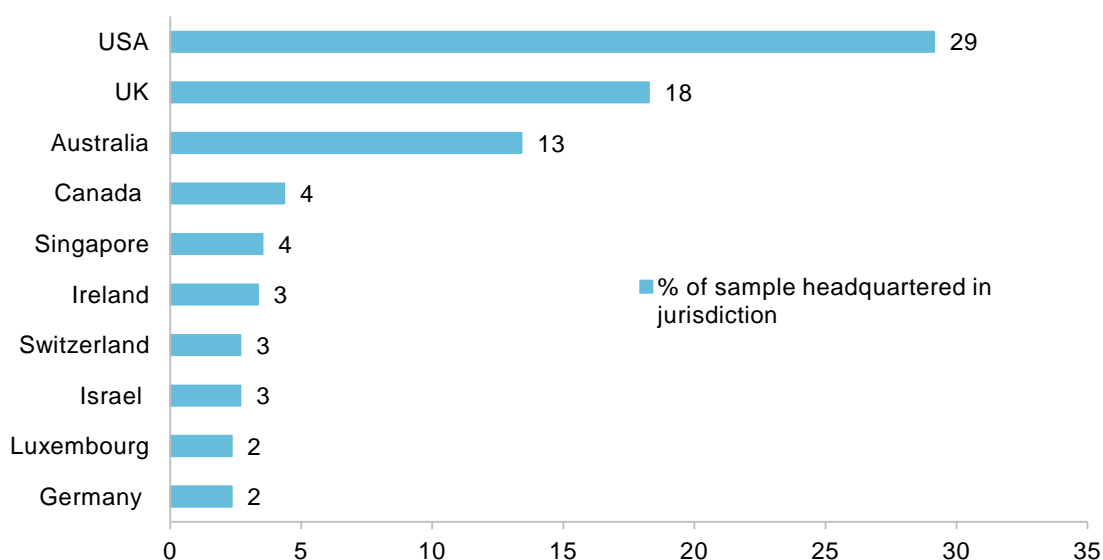
a Sample of 598 regtech organisations globally.

Source: Unpublished data supplied by RegTech Association and BCG FinTech Control Tower.

Use of technology to ease regulatory compliance costs for businesses and individuals

The regulatory compliance costs potentially incurred by individuals and businesses are related to:

- assessments, approvals, authorisations or accreditation for particular products, processes, occupations, business operations or activities (for example, permits, certifications, development approvals, registrations, licensing or other permissions)

- reporting and conduct obligations, including to a regulator and to the public or customers

- industry code of conduct requirements

- inspections, audits and investigations.

There are considerable resources tied-up with regulatory compliance activities, though precise magnitudes are hard to estimate, especially as some compliance activities replicate processes that a business would need to undertake anyway. One survey claimed that about a quarter of small and medium sized businesses spent 11 hours or more per week on compliance, and over 20% of businesses spent between $10 000 and $50 000 per year to ensure they are compliant (ACCI 2015). Furthermore, the number of people employed in compliance activities may be growing (Deloitte 2014). Within the banking and finance sector, advertisements for 'compliance and risk' jobs increased 122% in the five years to 2018 (Seek 2018).

For businesses, regtech may free up resources for more productive uses. Specifically, it may:

- reduce the time needed to identify and understand regulatory requirements, with an associated reduction in the risks and costs of non-compliance

- reduce the time and financial costs (including lost business opportunities) associated with gathering information, form filling or record keeping, and the provision of information and data to demonstrate compliance or enable the regulator to deliver a desired regulatory outcome

- generate a range of additional benefits for the business (discussed below).

For individuals, use of technology can reduce the time and cost associated with identifying regulatory requirements and providing information to demonstrate compliance. It can also provide people with greater assurance that the goods and services they are consuming satisfy quality or safety expectations (as the likelihood of the objective of the regulatory requirements being met may be increased).

Although tempting, the conveniences offered by regtech should not be taken up as a substitute for regulatory reform if regulations are ineffective, or there is a case for reducing regulatory compliance requirements.

Use of technology to reduce the administrative costs for, and improve the efficiency of, regulators

Technology, particularly when combined with data collection and analysis, can help regulators to increase their internal efficiency and improve regulatory effectiveness. The increased use of technology by regulated businesses and individuals adds pressure for regulators to also operate in faster and more sophisticated ways. In some areas, traditional regulatory approaches may no longer be effective in a more digital environment.

For regulators, regtech can enable:

- more timely and useful communication between regulators and regulated individuals/businesses to enable a better understanding of individual/business needs and activities, and facilitate avenues for compliance and non-compliance recourse

- increased volume, variety, speed and accuracy of data available to monitor market places and compliance with regulatory requirements, enable near real-time decision making, undertake more targeted risk assessments (including development of predictive models of non-compliance and harm), identify systemic risks, and be a catalyst for innovation

- standardised regulatory processes and tools to make it easier to coordinate cross-jurisdiction and cross-sector regulatory supervision, and to help bring about regulatory redesign when necessary.

As is the case with regulated entities, the capacity of regulators to adopt technology will depend on their initial capabilities and the time and money they are able to invest in new approaches that support regtech.

Additional benefits from use of regtech

Apart from the direct outcomes from use of regtech outlined above, there can be additional benefits for regulators, those regulated and/or the community more broadly, including:

- greater insights — increased data generated and available for use in improving the efficiency of business operations and enhancing customer experience or service

- implementing changes — more straightforward and timely updating or implementation of changes in regulatory requirements (including changes in the frequency of business or individual reporting), thereby potentially improving the efficiency of regulatory processes and reducing compliance costs for those regulated

- intermediary markets — enable the creation of new markets in intermediary products and services (and possibly reducing dependence on some existing intermediary services) to enhance consumer choice and economic activity.

Some of these benefits follow from the use of data collected, collated (such as in a government register) or verified as part of regulatory processes. Subject to privacy and commercial confidentiality considerations, these data can be used to: streamline other regulatory requirements; business transactions; or deliver commercially valuable insights

about customers and markets that improves the quality and efficiency of products or production processes, or increases a business's competitive advantage (box 1).

Box 1   **Examples of additional benefits from regtech**

Rapid implementation of policy changes for COVID-19 based on timely information

The data collected through Single Touch Payroll (STP) for 12.8 million employed individuals has enabled the ATO and ABS to publish more timely and frequent statistics on jobs and wages, which has been particularly useful for providing more timely insights on the economic impacts of the COVID-19 pandemic (ABS 2020). It also provided the ATO with the necessary information to help determine if a business is eligible for JobKeeper payments, introduced in March 2020 due to the pandemic (93% of those identified eligible for JobKeeper came through STP data (ATO 2020a)) and provided the ATO with an established collaborative network to enable speedy rollout of the JobKeeper program (Xero 2020a).

Compliance data provides commercial insights for business

Non-urban water meters allow both users and water corporations to accurately measure how much water is taken, to monitor compliance with entitlements, and for related resource management (Department of Environment, Land, Water and Planning (Vic) 2020). With the use of sensors and software for remote water monitoring, telemetry enhances the value of meters as a compliance tool as it provides real-time data. The considerable data that can be collected using telemetry is also of value to the water user. Users may have greater access to data on water volume, flow, temperature, and chemical composition.

New markets created by new data that enhance consumer choice

Using artificial intelligence solutions, intermediaries are developing an online way for loan applicants to use their employer's STP data to safely and accurately prove their income (Verifier 2020). It makes loan applications simpler and faster for individuals, while avoiding the risks and imprecision associated with alternative methods (such as use of physical payslips or allowing third party businesses to collect data from bank accounts using screen scraping tools).

Costs, risks and hurdles

Lessons in adopting regtech solutions from past experience include that:

- the potential benefits of regtech can take some years to realise and require substantial investment by businesses and regulators in capacity and cultural change, while enumeration of the scale and timing of the benefits can be difficult (Nicholls 2020; PC 2012)

- ensuring interoperability of processes — aligning the timing of data collection and reporting, data definitions and software, for example — can take some years (Accenture 2018; Beneragama 2018a; 2018b)

- the costs — in money, time, training, other opportunities foregone, ongoing maintenance and so on — involved in adopting new regtech solutions require there be a reasonably high level of confidence in the continuing need for the solution (Cowan 2016)

- smaller businesses have less capacity to keep up with regtech developments, and often rely on trusted third parties or intermediaries (such as accountants) to help them adapt

- the likelihood of implementing solutions *well* and realising a net benefit will depend on a range of conditions, including adequate specification of and provision for the regulatory task, engagement of able third parties, technical and contract management expertise, organisational willingness and capacity to change, adequate coordination of parties to tasks and the adaptability of the technology (Nixon 2017).

As with any business decision (whether for a government or private entity), the decision to adopt new technologies (and, often, to change ways of doing business in parallel) must be based on consideration of the associated costs, benefits and risks, and capacity to manage them. There may be a heightened risk of system compromise, such as hacking and illegal activity, associated with the adoption of new technologies, though some solutions probably also improve cybersecurity (Nicholls 2020). Some general considerations for governments in supporting optimal uptake of regtech are outlined in section 4.

3. Where technology has been useful and offers further potential

The Commission's survey of more recent or prominent regtech initiatives suggests that regtech solutions may be particularly beneficial where:

- regulated parties face complex or onerous regulatory requirements

- there is scope to undertake more risk-based approaches to regulation

- technology can help to better monitor activity, including by overcoming constraints related to physical presence

- technology can safely unlock more uses of data to meet compliance goals.

Where businesses or individuals face complex or onerous regulatory requirements

Understanding and navigating through complex webs of different regulatory requirements can impose undue burdens on businesses and individuals and/or reduce the likelihood of compliance. Complexity can come from:

- numerous regulatory requirements relating to one particular activity, such as opening a café (New South Wales Treasury 2020)

- extensive use by regulators of exceptions, exemptions and qualifications, as in financial services (Hayne 2019)

- frequently changing requirements (Podder et al. 2018)

- the inherent nature of the area being regulated, for example, electricity network regulation.

To some extent, use of regtech could delay the need for reforms aimed at reducing regulatory complexity. While this potentially reduces compliance costs, there would still remain a case to simplify regulatory requirements to minimise undue distortions on business investment and consumer activity.

Easier and cheaper to engage with government via single platforms and registers

In order to comply with their regulatory obligations, businesses and individuals are frequently required to interact with, and provide the same information to, a variety of government agencies (The Treasury 2018a). This can be confusing, time consuming and costly.

Single platforms and registers are typically low-tech solutions that have been adopted to streamline business and individual interactions with government.

- A number of State Governments have centralised their most popular transactions online with services designed around the circumstances of users. On a single platform, for example, individuals and businesses can obtain a national police check, working with children check or fishing licence, register a vehicle and obtain information regarding bushfire recovery support (for example, Service Victoria 2020).

- The Australian Business Licence and Information Service helps business operators and people considering starting a business identify relevant state, territory, local and Australian government licences, permits, approvals, regulations and codes of practice in the one place (Australian Government 2020b). At a slightly more technical level, Australian Securities and Investments Commission (ASIC) have explored the development of a chatbot tool for businesses to more easily enquire about financial service and credit licensing requirements.

- The Modernising Business Registers (MBR) Program is expected to streamline 31 ASIC business registers and the Australian Business Register into a single platform (The Treasury 2018a). This aims to address registry fragmentation, improve business user experience, reduce risks of ongoing operating, foster data driven innovation and enable better use of registry data. The MBR program is creating a contemporary digital registry platform, allowing other registers and information (such as the new Director Identification Number) to be added to the platform over time.

Such platforms and registers provide a foundation for the potential development of further tools to reduce compliance burdens. Other common transactions with governments (such as proof of identity) could similarly be integrated on one site and services extended on existing sites. More generally, situations in which platforms and registers could improve regulatory compliance and reduce compliance costs include: setting up a business; applying for the use of a site, building, land for a specific purpose or event; meeting ongoing regulatory requirements and/or quality assurance processes; or collecting together for consumers information on groups of services or products that all satisfy a particular social objective.

The time and co-ordination required to build even these solutions can be substantial (depending on the breadth of regulatory content included and the number of parties that need

to change their processes), with the benefits often not realised until well into the future. For example, Standard Business Reporting (SBR) was conceived in 2006 and initiated in 2010, but it is only in recent years that many of the benefits initially envisaged for businesses and governments have become evident.

Machine-interpretable rules can help businesses understand complex regulatory obligations and regulators monitor compliance

Technology can provide tools for businesses and individuals to better navigate regulatory requirements and changes to these, as has occurred with, the development of software that can 'read' regulatory rules and help automate compliance (CSIRO 2019). The vision of creating machine-interpretable regulation is sometimes called 'rules as code'. Applications in Australia to date have been small-scale. For example:

- 'PaidRight' uses a rules as code approach and AI to check employee entitlements under Enterprise Bargaining Agreements against what had been paid. Specifically, it helps businesses check if they are meeting their obligations under National Employment Standards, are compliant with the Better Off Overall Test, and to identify if franchises and subcontractors are paying employees correctly. To date, over $3 billion in wages and the employment conditions of 80 000 plus employees have been checked for accuracy (PaidRight 2020).

- Data61 in collaboration the Australian Taxation Office (ATO) developed a prototype concept tool ('PermitMe') that could assist businesses to apply for necessary permits and licences online. To test the prototype, it was applied to an example challenge of opening a café, which can require consideration of over 30 different pieces of legislation and regulations, across local, state and federal jurisdictions. The PermitMe tool identified necessary permits and licences (such as liquor licences if the café was to sell alcohol), and automatically pre-filled any required application forms.[6]

- The Victorian Government has made plans for a rules as code proof of concept in construction, to test buildings for compliance with planning controls and building regulations (Victorian Government 2020).

- The NSW public sector is experimenting with an open source platform for rules as code in its Department of Customer Service. It is also coding parts of the new Community Gaming Regulation to help charities, not-for-profits and other users understand how the regulation applies to them (NSW Government 2020).

There are a number of factors that may limit the benefits of machine-interpretable regulation, at least in the short-term, including that existing options for creating such code may not readily scale up due to resource constraints, may require significant levels of validation to check for accuracy and may also necessitate standardisation that has not yet been developed. Nevertheless, it could be practicable for machine-interpretable text to be developed for

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6 CSIRO (2020), personal communication, 24 August 2020.

selected components of regulation — where coded rules would help create service efficiencies, automate existing manual processes, or attract multiple uses in coded form.

Furthermore, translation of regulation to machine-interpretable text appears to be most readily undertaken with prescriptive regulation (although additional logical rules can be developed to help interpret regulation that is principles-based). While regulatory practice has evolved to become more principles-based, in reality, good regulatory practice incorporates both principles and prescription (including specifying regulatory safe harbour steps) to achieve effective implementation (given the capabilities and circumstances of the regulated entities). Nevertheless, good regulatory practice should not be traded off to implement a regtech solution.

Businesses can implement technology to assess and comply with regulatory requirements

Businesses have an incentive to purchase and use regtech tools. One of the main applications of regtech has been to help businesses assess their regulatory obligations and fulfil regulatory requirements faster and in a manner that is more integrated with their other business processes. For example, the Commonwealth Bank of Australia and ING have drawn on AI technology to interpret about 1.5 million paragraphs of regulation on the European Union's Markets in Financial Instruments Directive. Undertaking this task manually would have taken the banks about 1800 hours (or one year's work for one full-time employee) to complete. However, by adopting natural language processing and AI technology, the banks were able to complete the task in 2.5 minutes (Ascent 2020).

ASIC has been exploring regtech applications in a number of areas to demonstrate its possibilities to businesses, including:

- ensuring financial promotional material delivered in a variety of formats (web banners, billboards, print, television and radio) are clear, balanced, meet disclosure obligations, and are not misleading or deceptive

- exploring less resource-intensive ways to confirm financial advice is compliant, using natural language processing and AI

- checking for poor sales conduct in life insurance sales calls using voice analytics and voice-to-text trial (ASIC 2019a).

Applications of such technology could be extended, for example, helping to ensure compliance of product advertising claims with regulations of therapeutic goods, environmental claims on products, or food labelling. Also, text analytics could be applied to prospectuses or product disclosure statements to ensure they are compliant with regulatory obligations.

There are incentives for both businesses and the regulator in the adoption of these types of regtech solutions. The optimal role for each will need to be explored, and may involve government providing minimum technical requirements to software developers, for example, to provide some certainty for businesses to invest (see below).

In some applications, regtech not only assists with regulatory compliance, but also provides private benefits (such as reduced production costs) to the business, and so may well be adopted even in the absence of regulatory requirements. For example, individual private landowners and state/territory land management agencies spend considerable time and money combatting weed problems and protecting ecosystems and primary production, with the agricultural cost alone of weeds estimated at over $4 billion per year (Natural Resource Management Ministerial Council 2007). Robots have been developed that can drive across paddocks using computer vision and machine learning to identify and classify weeds and then determine the optimum weed removal method, and spray or mechanically destroy weeds (Hajkowicz et al. 2019). In this way, the technology can save land owners time and money on weed control, and also provide some assurance of compliance with environmental management regulations.

Much of the expenditure on regtech in Australia has been among large companies, rather than small and medium sized businesses (Synergy 2019). Many regtech options used by small and medium sized businesses have been developed or enabled by government (such as registries) or intermediaries, rather than by the business itself. Typically, tighter resource constraints of small and medium sized businesses limit their use of regtech to options that are free, of low cost or that come as part of their other business processes (such as accounting software).

Improve regulatory efficiency for business in asset transfers

One of the world's first industrial-scale uses of blockchain in financial services is by the Australian Securities Exchange. Due to go live in 2022, it is using distributed ledger technology in a replacement for its now dated Clearing House Electronic Subregister System and will enable the Australian Securities Exchange to demonstrate the compliance of its processes with domestic and international requirements and standards on the conduct of clearing and settlement facilities (Cotton 2020).

Blockchain technology could also be used to register physical asset transactions. For example, the Swedish Land Registry has begun small-scale official use of blockchain to register land and property ownership (McMurren et al. 2018). The intent is to create a secure, efficient and trusted process of digital end-to-end land transfer, with reduced process time for sales, transparent information and digital records. While the technology has yet to be extended beyond a pilot, it nevertheless provides a good example of how blockchain can be used to make compliance with regulatory requirements on property transfer more efficient. In Australia, electronic conveyancing (or e-conveyancing) has taken off, but use of blockchain has not been tested for property exchange.

Modernising international trade flows to reduce business compliance burdens

Over 40 000 Australian businesses engage in international trade and an increasing number of households are using e-commerce to buy goods overseas. These transactions are regulated

by more than 30 government agencies that administer about 200 pieces of legislation (Department of Home Affairs 2018).

To reduce compliance burdens, the Department of Home Affairs (and the Australian Border Force) is leading the development of a customs and border modernisation agenda (expected to pan out over the next decade in multiple stages) to create a system that is seamless, secure, digital and user-friendly (Australian Border Force 2020). Key components of the agenda include: modernising cross-border policies and legislation, streamlining regulations and business processes, better using data analytics and intelligence, and using new technologies such as blockchain and biometrics. The aim is to reduce the compliance costs of border regulations, while improving security (Outram 2019).

Where there is scope for regulators to better hone a risk-based, outcome-focused approach

Risk-based regulation recognises that the risk of non-compliance with regulatory requirements often varies with the characteristics of businesses and individuals. Regulators can take these variations into account to target compliance and to determine the mix of prescriptive and outcomes based regulation.

With the often very large datasets available to regulators, the application of a risk-based, outcomes-focused approach has the potential to become more precise with the use of data analytical tools to identify new patterns and insights.

At the extreme, use of regtech could allow regulators to significantly scale back their interventions in particular markets (such as through use of smart contracts whereby technology makes compliance automatic and non-compliance very difficult, or where technology provides the means for regulatory objectives such as public safety or fully-informed consumers to be satisfied without intervention) (Hajkowicz 2019; Staples et al. 2017). The technology is not infallible, though, and awareness of the risks is necessary.

Using regulatory engagement with individuals and businesses to head-off risks

The complexity inherent in some legislation can lead to differences in interpretation of how it applies in a given circumstance. Through real-time analytics, the ATO is able to identify potential errors in reporting under tax law to flag what information and messaging needs to be provided to individuals.

Real-time analytics is used to prompt taxpayers completing their tax return online through myTax. Amounts entered into myTax are compared with those of others in similar circumstances. If a claim is significantly different to what is expected, the taxpayer is prompted on their screen in real time to recheck amounts entered. In 2018, about 7% of myTax users received these prompts, and the prompts resulted in taxpayers adjusting entries by about $113 million (ATO 2020b). The ATO has developed real-time analytics for tax

agents and plans to extend it to sole traders to provide timely and useful information that supports more accurate tax reporting.

Early engagement with regulated parties to avert potential non-compliance requires regulators to have the necessary capability and culture , along with well-designed systems, to effectively introduce such initiatives.

Machine learning used to target businesses at high risk of non-compliance

In 2017, the UK Behavioural Insights Team trialled machine learning models to identify underperforming GP clinics, using information such as the types and nature of medicines prescribed and reviews posted by patients on the National Health Service Website. Trial results indicate that inspectors could identify up to 95% of the country's underperforming GP clinics by inspecting only 20% of clinics — those clinics identified by the machine learning model as posing the highest risk (Reynolds 2017).

In Australia, data on Medicare Benefits Schedule and Pharmaceutical Benefits Scheme may similarly allow monitoring of prescription and referral patterns to provide guidance to health professionals and to improve outcomes for consumers and reduce costs to taxpayers.

Machine learning and predictive analytics to identify financial crime risks

In Australia, $8 billion per year is lost in financial crime and sophisticated fraud. The Australian Transaction Reports and Analysis Centre (AUSTRAC) regulates 14 000 reporting entities to detect and investigate financial crimes such as anti-money laundering and counter terrorism financing. Identification of financial crime risks in Australia is being assisted by network graph analytics — processing, analysing and visualising complex logical and physical connections between entities or events (CSIRO 2019). The technology developed in Data61's Investigative Analytics program applies scalable graph machine learning technology to financial transaction data to highlight risk and patterns of behaviour to investigators and intelligence analysts. This is a collaboration between Data61, AUSTRAC, Home Affairs, Australian Criminal Intelligence Commission, and the Australian Federal Police.

Regtech has similarly been applied overseas in identification of financial crime. For example, Nasdaq uses AI to learn individual and group behavioural fingerprint of traders and detect any deviations from the norm that might signify rogue or insider trading activities (Bullock and Arnold 2017). Responsibilities for such supervision in Australia's financial markets largely rest with ASIC, which relies on regtech to analyse approximately 75-150 million messages per day for over 1.5 million equity trades and 45 000 futures trades, and 2-3 million end-of-day positions in over-the-counter markets (Armour 2018).

Regulators matching data to identify children at risk across the country

Australian, State and Territory Governments committed, in 2019, to the use of advanced search software, with rapid and secure matching algorithms and alarm features, to improve collaboration between state and territory child protection agencies (NSW Ministers for the Department of Social Services 2019). The resulting new platform (REACH) is claimed to ensure that Australia's child protection caseworkers will have access to a more extensive and accurate insight into a child's history — particularly vulnerable children who have moved interstate. State-based agencies will be able to exchange relevant information for purposes related to preventing, identifying and responding to situations where children are at risk of harm, and enable compliance with reporting thresholds and with assessment against regulated grounds for being at risk of harm. While the Australian Government is funding most of the upfront costs of development, State and Territory Governments are jointly responsible for funding operational costs (Easton 2019). A key factor in the success of new systems is having sufficient resources beyond the initial set-up.

Such technology could be extended to include other areas where information sharing between jurisdictions is required, for example, to ensure compliance with mental health treatment orders, or to share information across justice systems.

Where there is potential to better monitor regulated activity

Regulators can leverage technology to collect new and better data and better analyse this data for monitoring and compliance purposes. In some cases, this can enable near real-time compliance checking and decision making for both regulators and business. However, the capacity for lower cost population-wide monitoring requires a very strong onus of proof of the desirability of the regulations and their reach.

Monitoring by regulators across widespread geographic areas

Remote monitoring and sensor technology are increasingly being used by regulators to expand the reach of their monitoring capabilities, with potential applications extending to regulatory compliance monitoring of agricultural crops, conservation areas, forest management, fisheries and ecology (Toonen and Bush 2020).

Unmanned aerial vehicles for regulator monitoring

The Victorian Environment Protection Authority (EPA) uses unmanned aerial vehicles (UAVs) or drones to better measure and track illegal dumping across the state (EPA 2017). UAVs calculate the volume of waste on sites, detect 'hotspots' in landfills with the use of thermal imaging and undertake air and water sampling. This improves the Victorian EPA's ability to detect illegal dumping as it happens, by providing greater visibility in areas that are difficult to reach, allow for safer and more efficient gathering of evidence needed to prosecute offenders, and provide information that helps EPA officers prioritise operations.

Accurate and timely data to improve regulator enforcement of heavy vehicle speed limits

A variety of in-vehicle technology has existed (largely underutilised) for at least a decade to ensure compliance with road speed limits. With compliance remaining voluntary, the focus more recently has shifted to better use of data and technology to identify and respond to non-compliance. The NSW Government has, for the past decade, used average speed enforcement as part of an expanded risk-based enforcement program, to increase compliance of heavy vehicles with speed limits (Transport for NSW 2017). Compliance of heavy vehicles with speed limits has been estimated to have reduced the number of heavy vehicle crashes by 29% (NTC 2005). Regtech is an integral part of this enforcement, being used in the processing of images from multiple camera suppliers, analysis of large amounts of data with minimal human involvement, and production of evidential material to the high legal standards required by courts and measurement organisations (itree nd). While not establishing causality with the regtech solution, there has been a substantial reduction in fatal crashes and serious injury crashes since the introduction in New South Wales of heavy vehicle average speed enforcement, representing a saving through reduced fatalities and serious injuries of $138 million to the community (Transport for NSW 2019).

Satellite imagery to improve efficiency for regulator in water management

The Murray Darling Basin Authority trialled satellite imagery to assist with its compliance checking and investigation. Satellite imagery can be used for studies into landscape change and monitoring across large areas. It provides spatial coverage, spatial resolution, a high return frequency and data is provided freely and openly with known specifications. Satellite imagery can consistently measure and track water resources and their use. A review of the trial highlighted the significant benefits to support compliance activities and the potential for technology to improve ecological monitoring in the future (MDBA 2018).

More data in real time for businesses to demonstrate compliance with livestock tracing

In 2018, CSIRO and Ceres Tag trialled smart ear tags for livestock, to give producers greater control over grazing management, allow them to locate livestock remotely and alert them to stock theft, illness or if an animal is giving birth (Koreis 2018). Smart tags enhance existing technology by providing real-time direct to satellite enabled geolocation, with accelerometer and temperature analytic capabilities in on- and off-farm locations — expanding the range of data that can be collected. The ability to trace animal history and disease outbreaks with the commonly used National Livestock Identification System tags is limited by an animal only being identified when leaving a property. With significant take-up of the smart technology in a region, the data generated could be used to facilitate compliance with industry quality assurance requirements, as well as biosecurity and food safety regulatory requirements (PricewaterhouseCoopers 2020).

Where technology can safely unlock more uses of data to improve regulatory compliance

Increasingly, businesses are using software that not only meets the internal needs of the business but is also capable of providing the necessary information to fulfil regulatory obligations or to demonstrate compliance through automation. While it is rational that businesses and regulators would work to ensure the interoperability of their processes to minimise undue compliance burdens, this necessitates deliberate action — aligning the timing of data collection and reporting, data definitions and software, for example. Furthermore, this action can take some years and represent a substantial investment by regulators and businesses, with the scope and timing of the benefits often uncertain.

Data tagging and sharing to reduce tax compliance burdens and improve compliance monitoring

Single Touch Payroll (STP) requires employers to report a range of real-time payroll information digitally to the ATO — each time they pay their employees (ATO 2020c). Based on standardised data definitions across government, the data collected by businesses are tagged 'behind the scenes' with software that is SBR-enabled (using eXtensible business reporting language (XBRL)). The pre-filled reports can then be sent directly to the relevant regulator using a secure electronic interface (PC 2012). In addition, employers do not need to generate and provide annual payment summaries; employees can download their payment summaries from the myGov website (SRJ Walker Wayland 2019). Around 15 years after SBR was first recommended, about 12.8 million individuals now have the ability to view their payroll information through myGov and almost 700 000 employers have begun STP reporting as at 16 June 2020 (ATO 2020d).

Government and regulators also benefit from having more timely information from businesses. Regulators can more effectively monitor compliance with faster identification of a risk of non-compliance — such as the inability of a business to pay Pay-as-You-Go Withholdings or Super Guarantee contributions. With more effective regulatory action, the STP strengthens the Australian Government's revenue base and protects employees superannuation entitlements.

The use of standardised definitions (combined with XBRL) could also be applied to financial reporting statements (known as digital financial reporting (DFR)). Company financial reports are generally lodged with ASIC either in paper or as a PDF. This format makes extraction of data time-consuming, expensive and subject to error. DFR has been recommended as a way to reduce the time and cost of extracting data from these reports, as well as improving the accuracy of analysis (PJCCFS 2020). The data would allow ASIC to more effectively target areas of risk and streamline auditing processes and facilitate analysis of changes in accounting standards (ASIC 2019b). DFR was first developed over 20 years ago but take-up has been non-existent or slow (Roohani 2008). While ASIC permits the lodgement of DFR, this option has not been adopted by Australian companies.

Internationally, the United States of America (2009), Europe (2020), Japan (2008) and Denmark (2012) have introduced DFR (Kjær 2018; Tarca 2020).

E-invoicing to improve tax compliance

Electronic invoicing (or e-invoicing) enables the automated digital exchange of invoice information directly between organisations' accounting systems. E-invoicing is facilitated through a secure network of interoperable 'access points' that connect to each other to exchange e-invoices. International standards allow these access points to speak to each other — similar to a telephone network, which lets users of different mobile phone networks communicate with each other. E-invoicing can provide cost-savings for governments and businesses and it is also a more accurate and secure way to share information (ATO 2020e; MessageXchange 2020; Xero 2020b). Moreover, e-invoicing can improve regulatory compliance because it provides greater visibility to audit tax payments and to regulate them (both for businesses and regulators). It has been estimated that e-invoicing could result in benefits to the Australian economy of $28 billion over ten years (The Treasury 2018b).

4.   Some considerations for policy makers and regulators

The examples in this paper illustrate that regtech offers benefits to government (as policy makers, service providers and regulators) and regulated entities. Individual parties need to identify and pursue specific solutions where they consider this warranted, but there may be more governments can do to ensure opportunities to better regulate through regtech are not closed or missed. This includes:

- for policy makers, designing regulation in a way that avoids the tying of administration and compliance to particular technologies (if this is possible), avoiding undue uncertainty in relation to intentions on regulatory reform, and resolving policy tensions relating to restrictions on and use of data

- for regulators, considering the conditions needed for adoption of regtech solutions, such as 'clean' and structured data, and working with other parties (regulated entities, regtech developers, third party service providers) to collaborate on potential solutions and encourage technological advancement through 'safe' testing.

Approaching regulatory design

Greater regulatory neutrality and the importance of keeping up-to-date

To be effective over time, regulation needs to keep pace with developments in the digital economy. Ideally, regulations should avoid specifying technology-specific requirements not essential to achieving its objectives, which would allow regulators and regulated entities to

more readily adopt new approaches that lower the burdens of assessing and implementing regulatory compliance requirements, and businesses to likewise adopt different processes or products that deliver improved outcomes for consumers.

There is a substantial legacy of regulatory requirements in Australia that are either implicitly or explicitly technology-specific. For example, the National Transport Commission has identified a number of regulatory barriers to fully automated vehicles (including requirements for a human driver and the interpretation of regulatory requirements around vehicle control) that need to be addressed prior to widespread use of automated vehicles (NTC 2016).

Advances in technology and regtech capabilities reinforce the need to regularly review the *form* of regulations, as well as their continuing need (Australian PC and NZ PC 2019). Such reviews should consider whether any regtech solutions employed help meet regulatory objectives or whether the technologies create harms that require management.

- The use of AI, for example, raises the need for governments and regulators to consider: who bears responsibility and accountability when consumers rely on the use of AI to meet compliance requirements; ownership of improvements created by AI; rights to appeal decisions made using AI (including against inbuilt biases and biases that result from historical data analysis); and consequences of contracts premised on technology 'operating as intended' (when the outcomes of the technology are evolving based on the data that it is absorbing) (Gowling WLG 2019).

- Accountability for the outcomes of regtech solutions is untested for some technologies. When underlying codes and platforms of a regtech solution contain even a small error, this has the potential to create widespread errors that can lead to liability risks on a much larger scale than those caused by an individual human error (Wang 2019). This is highly relevant for applications of machine-interpretable text. If, for example, award conditions governing staff employment are converted to rules as code by a third party, regulator endorsement of the code may be seen as necessary to provide assurance to employers relying on the code.

Providing assurance in the face of changing agendas

While regulatory reform inevitably takes time, unfinished, uncertain or frequently changing regulatory agendas can be disincentives for investment in, and implementation of, regtech solutions by regulated entities. Providing greater certainty about regulatory agendas and the timing of reforms can reduce the risks for businesses and regtech developers associated with investing in costly technology changes (Silverberg et al. 2016). Although, good regulatory reform should not be traded off to implement a regtech solution.

Adopting regtech solutions — whether by regulated entities or regulators — requires a range of other coordinated changes. For example, the SuperStream program led by the ATO required new support and enabling services for industry and fund members, and a series of staged technological implementations over several years. Further, it required new legislative

and regulatory instruments such as the expanded use of tax file number powers to use it as an identifier (ATO 2019). Similarly, adoption of digital identity verification schemes would require regulatory coordination of the cross-border use of electronic identities and electronic signatures for digital transactions (Silverberg et al. 2016).

Dealing with data security, privacy and other concerns

Regulations to protect the privacy of individuals or the security of sensitive personal or commercially confidential information are necessary parts of the regulatory frameworks in which data is collected and used. However, aspects of these regulations can limit the use of data in regtech — for example, the use of advanced analytics on large datasets (Silverberg et al. 2016). To the extent that these limitations on data use are reflective of risk averse cultures of non-release rather than any individual or commercial sensitivity, they should be tested (PC 2017b).

A key regulatory challenge for some technologies in Australia — including the internet of things and distributed ledger systems — is the need to comply with the *Privacy Act 1988* (Cth). A feature of blockchain is that once data is added to the chain, it cannot be changed or removed. Yet the Privacy Act requires that data be deleted from a dataset once its purpose has been served (DISER 2020). Blockchain systems are frequently attacked in ways that threaten the privacy and assets of users. The Australian Computer Society notes that there is 'a serious lack of clear governance [in relation to blockchain], not only in terms of rules for compliance with legislation and regulation processes, but also to provide clear guarantees to users, regarding issues such as privacy and ownership' (ACS 2019). Development of standards for blockchain use is an important step in improving the regulatory environment for blockchain use (DISER 2020).

Pre-conditions for adopting regtech

Improving the consistency, structure and use of data

Many regtech solutions require consistent, clean and structured data. This includes standardised data fields and formats. Standard Business Reporting (SBR) is an example that highlights the importance of a single, standardised data structure in enabling regtech solutions. Digital service providers were able to build new compliance solutions to automate regulatory reporting for businesses, partly because the Australian Government developed a taxonomy and list of data fields for use across government applications.

However, standardising of data takes time. For example, with SBR, it took two years from when Australia's governments agreed in 2008 to support adopting a single, standardised structure for information collected by regulatory agencies, before the first list of data fields were published. Other parallel changes were also needed — including government encouragement for the creation of software using these data fields to automate regulatory compliance, and adjustments in regulatory reporting procedures to a data-centric, rather than

document-based, compliance model (Donnelley Financial Solutions 2018). Initially the take-up rate of SBR was low with many key government forms not being SBR compliant, and so the benefits were small relative to the potential available (PC 2012). Take-up rates are much higher a decade after the introduction of SBR (albeit, helped by mandating its use for STP), but illustrates the time and commitment needed to achieve widespread adoption and the benefits for business and government.

Modernising IT systems

A lack of interoperability between regtech solutions and IT systems can be a major obstacle to uptake. For example, a business survey found that 69% of executives at banks said that the costs of reworking legacy systems (so that regtech solutions could be adopted) hindered their ability to respond to market change (Accenture 2018). The cost to rework legacy IT systems is often high, with their inherent limitations a significant stumbling block to regtech adoption. Further, regulated entities and regulators may conduct their operations on multiple different legacy systems, which may limit the ability to efficiently retrieve, transport or share data internally or externally (Identitii 2019).

As IT systems age, the costs of holding on to them (in the form of maintenance costs as well as the costs of lost opportunities) rise — sometimes in both absolute terms and relative to the cost of replacement. The current technology used by ASIC to maintain their business registers is ageing (the companies' register is approaching 30 years old) and there are real challenges in meeting growing future demand in the digital economy. ASIC's systems are expensive to maintain, hard to improve, and increasingly vulnerable to outages and service disruptions (Price 2019). As noted above, the modernised business register is scheduled to be operational by 2021-22.

Collaborating and working with other parties

Governments may play different roles in implementing regtech solutions, including:

- providing a more neutral or supportive regulatory environment (as discussed in the previous section)

- being a procurer of solutions (with government taking responsibility for the parts that provide a public good)

- as a provider (for example, the coding of regulatory rules into machine-interpretable documents could be undertaken by government).

In all of these interests, governments need to collaborate with other parties — regulated entities, regtech developers and, in some cases, third party providers of services.

Building a collaborative regtech ecosystem and opportunities for testing

Collaboration between regulators, regulated entities and regtech developers is needed for the use of regtech to grow (Hugé 2018). This is because the development and application of regtech solutions often requires input from those who understand the regulatory landscape and those who bring the technical expertise. There are some promising examples in Australia of such collaboration, including ASIC's Innovation Hub and RegTech Liaison Forum (ASIC 2019a).

Opportunities that facilitate testing of regtech solutions through trial and error without fear of failure are also in demand (Xero 2020c). Such environments offer assurance processes, support operational integrity, and allow potential adopters of regtech to learn about and experience using different solutions (Silverberg et al. 2016). However, beyond financial services, there is a lack of end-to-end testing environments for developers of regulatory technology in Australia (Xero 2020c). The RegTech Association has advocated for a 'design box' in Australia, to provide regtech developers and regulators an opportunity to test solution designs with a negative assurance program (where regulators provide general guidance to regtech solutions, such as AUSTRAC's RegTech engagement program) (RegTech Association 2019).

Established collaboration hubs and testing environments could also enable access to finance for regtech developers. This is because they provide opportunities for regtech developers to showcase their solutions to potential investors. In Australia, regtech developers face difficulties raising capital, in part due to long sales cycles, which are around 13 months on average, although solutions requiring deep integration can take closer to 24 months (RegTech Association 2019). Long sales cycles often reflect extensive stakeholder engagement when implementing regtech solutions. For example, a regtech developer pitching their solution to a large company must get buy-in from multiple internal stakeholders including compliance management, IT management and finance (Schizas et al. 2019). Accordingly, regtech developers require more 'patient' types of capital investment, which is often difficult to obtain.

Need for a shared understanding of how to comply

Creating familiarity with the possibilities of regtech requires engagement of regulators with businesses, individuals and regtech providers. Building regtech solutions requires detailed knowledge of the relevant business operations and the regulatory architecture (Eyers 2018; Silverberg et al. 2016). Many regtech providers have either the technical expertise but limited regulatory compliance knowledge, or alternatively, are familiar with the regulatory environment from past involvement in a sector, but lack technical expertise (Tennant 2017). With the often large upfront costs involved, many businesses are reluctant to invest in regtech solutions without having either regulator assurance that particular regtech solutions are 'safe' and compliant, or assurance that their peers are using regtech in a similar way (Tennant 2017).

To improve knowledge about regulatory architecture and provide assurance about what is required or acceptable for compliance, there needs to be strong and ongoing engagement between regulators and businesses, including regtech providers. This could include assurance by regulators on necessary design aspects of new regtech, such as guidance on whether technology that has particular characteristics might be capable of achieving compliance, rather than actively endorsing the technology (Verifier 2019). Some of Australia's regulators provide such assurance. For example, the ATO provides a list of requirements for digital service providers (described below) and AUSTRAC provides general guidance about the *Anti-Money Laundering and Counter-Terrorism Financing Act 2006* (Cth) through its RegTech Engagement program (AUSTRAC 2020). As part of this program, regtech providers have the opportunity to engage with AUSTRAC and discuss and/or demonstrate solutions, and ask questions about their regulatory obligations. Different regulatory frameworks may lend themselves to assurance more than others, but the challenge of providing clear expectations to businesses and regtech providers remains.[7]

Government, including regulators, play an important role

Networks of regulators, regulated entities and regtech providers are crucial for regtech development but remain relatively nascent in Australia, and are largely focused on fintech.

Governments can support the development and adoption of regtech by:

- creating a more regtech-friendly culture — For example, regulatory infrastructure relating to data (including the consumer data right) and technology-neutral legislation can influence the applicability of regtech (Senate Select Committee on Financial Technology and Regulatory Technology 2019). The RegTech Association noted that regtech is not yet included in government policies and government agency strategic roadmaps (RegTech Association 2019)

- steering cultural change away from one of risk aversion and reluctance to change towards one that enables innovation, regtech development and knowledge sharing (PC 2017a) — implementing new regtech solutions often requires buy-in from multiple regulators (and their policy departments) to be successful

- developing and supporting system integrity needed for regtech uptake — For example, the ATO has collaborated with regtech providers to develop the Digital Service Provider (DSP) Operational Framework, which sets out the minimum technical and security requirements software developers and their products are expected to meet if they wish to link in to ATO processes through APIs or from within software (Xero 2020c). DSPs that meet the framework's requirements are then listed on a product register available on the ATO's website for businesses and individuals to view. There is considerable scope for other government regulators to introduce something similar to the DSP Operational Framework to mitigate security risks, increase user confidence and better support regulatory technology development

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7 ASIC, personal communication, 23 September 2020.

- driving engagement and collaboration with regtech providers — For example, the ATO's Digital Partnerships Office and ASIC's Regtech Liaison Forum provide leadership to regtech providers, providing opportunities for strategic discussion and collaboration. Once a software developer is registered with the ATO, the Digital Partnership Office provides a dedicated account manager, technical and policy documentation, and customer support for ATO systems in production and accreditation (Xero 2020c).

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