UTS UNIVERSITY OF TECHNOLOGY SYDNEY

A DLT Regulatory Control Framework for Decentrally Governed DLT Systems in the Australian Financial System

by Conrad Gayan Benedict

Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

under the supervision of Associate Professor Dr Asif Gill and Associate Professor Dr Farookh Hussain

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April 2021

CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Conrad Gayan Benedict declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Computer Science, Faculty of Engineering and Information Technology at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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This research is supported by the Australian Government Research Training Program.

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Date: 31 March 2021

“We reject: kings, presidents and voting. We believe in: rough consensus and running code.”

David Clark, 1992

“The faith that technology can redeem all of our sins and fix all of our problems is the ultimate hubris.”

Siva Vaidhyanathan, 2011

Acknowledgements

Research of this nature would not be possible without the significant support and contribution of many important others.

First and foremost, I would like to thank my primary academic supervisor, Dr Asif Gill. His well-timed guidance, coupled with his ability to help me navigate the transition from industry practitioner to researcher over the research span of four years has been invaluable and motivating. My secondary supervisor, Dr Farookh Hussain also provided key support during important stages of the research.

This research was sponsored by my employer, the Reserve Bank of Australia. The RBA made it possible for me to manage my significant research workload, provided access to its own regulatory policy experts and facilitated my engagement with key Australian financial system regulatory experts. I owe significant thanks to these experts who willingly gave their time and effort to support the key co-design evaluation stages of the research study.

Throughout the course of this research, I have benefited from academic mentoring from some of the leading experts in Information Systems research, including Professor Rob Weber and Professor Shirley Gregor. I am greatly indebted to their guidance through key research stages.

And finally, I owe my greatest thanks to my wife Chloe. She has patiently given up our time as I've invested what seems like countless nights, weekends and early mornings on the seemingly ceaseless journey of academic research. Her support and understanding have given me the space to conduct this research while also performing my professional duty as the Chief Information Officer of Australia's central bank. Her sacrifice has in many ways been greater than mine, and I am eternally indebted for her support of this lifelong ambition.

Note from the Researcher

Consider a financial regulator faced with the rapid adoption by consumers of a new online financial system. The system is based on DLT-based blockchain technology and allows participants to exchange value without declaring their identities or affiliations. It's not clear who is operating the system, what transactions are being conducted, or even who its users are and where they are based. Regulated entities start complaining about the new system competing with their regulated business even as participants clamour onto the increasingly popular platform. Other similar systems start emerging and the regulator becomes increasingly concerned about the systemic risks being introduced into the financial system. Suddenly the cryptography that secures several of these platforms is compromised and public confidence in the integrity of their transactions evaporates. Participants lose significant value and businesses which accepted payment from these platforms are left with a worthless digital currency. In the near future, this is how a financial crisis precipitated by a loss of regulatory control over DLT systems may begin…

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Abstract

Distributed ledger technology (DLT) has recently emerged as a disruptive innovation with an expanding range of applications. Distributed ledger and associated blockchain systems use cryptography and incentives to ensure the integrity of distributed systems by establishing trust among unknown parties. In regulated systems such as the financial system however, the use of distributed governance to promote trust among participants risks displacing the conventional role of financial intermediaries as a control point for regulatory supervision. Therefore, the challenge for financial regulators is to understand the risks presented by decentrally governed DLT systems and to implement appropriate regulatory controls to treat these risks. To address this research need, this research adapts a participatory action design research (ADR) to incorporate regulatory practitioner expertise into the development of a practically relevant and theoretically grounded DLT Regulatory Control Framework (DRC Framework) for the Australian financial system. This research method is supplemented by additional theory generating qualitative research techniques to increase the theoretical contribution of the developed framework. The framework was co-designed with Australian DLT experts from the DLT Working Group of the Australian Council of Financial Regulators and is intended to inform Australian regulatory responses to DLT systems.

The developed DRC Framework has five main components: DLT participants and providers, DLT risks, regulatory control treatments, residual risk improvements, and regulatory control design principles. DLT participants partake in financial activities enabled by DLT systems provided by DLT application, platform and infrastructure providers. DLT risks, regulatory control treatments and residual risk improvements are categorised according to whether they impact specific DLT participants, providers or system risks. Finally, the DRC Framework incorporates regulatory control design principles to guide regulators in the ongoing development and adaption of regulatory controls to treat fast-evolving DLT risks.

The developed DRC Framework was iteratively co-developed and evaluated using knowledge, insights and reflection from participating DLT regulatory experts. Later stage evaluation was extended to include international DLT industry experts and a UK financial regulator to support the generalisability of the developed research artefact to global regulatory contexts. Evaluation of the research indicates the developed DRC Framework can effectively support the identification and implementation of regulatory controls by Australian financial regulators to address the risks presented by decentrally governed DLT systems.

It is important to note that this research study is largely limited in its development focus to the Australian financial system context and was not developed to be applied to non-financial, non-Australian regulated contexts without further contextualisation. While steps were taken to mitigate the effects of these limitations, these should be considered when interpreting the theoretical and practical applications of the research. Future research could apply the developed framework to broader regulatory contexts.

1 Introduction

This dissertation implements a participatory ADR approach to developing a framework of regulatory control treatments to address the risks of decentrally governed DLT systems. This chapter begins by discussing the research background in Section 1.1. Section 1.2 discusses the research problem of understanding the risks of decentrally governed DLT systems and identifying the regulatory controls best suited to treating them. Section 1.3 discusses the research questions addressed and Section 1.4 outlines the research design. Section 1.5 presents the developed DRC Framework and Section 1.6 outlines the intended users of the research. Section 1.7 outlines the contributions and impact of the research. Section 1.8 discusses the scope and assumptions of the research and Section 1.9 summarises this chapter.

1.1 Research Background

The research presented in this dissertation has been conducted in the research field of information systems (IS) in the context of the Australian financial regulation of DLT systems. To discuss this research, it is necessary to understand the financial regulation context and the drivers underlying the emergence of decentrally governed DLT systems. This research seeks to understand the risks introduced by DLT systems and how these may challenge the objectives of financial regulation, including the reduction of systemic risks. This research analysis informs the development of a framework for the regulation of decentrally governed DLT systems in the Australian financial system.

1.1.1 Financial Regulation

Global financial regulation was initially conceived to preserve financial stability after the world wars of the twentieth century and was primarily focused with managing risk within organisational contexts (Dionne 2013). As technology adoption proliferated and multi-lateral connectivity among global financial participants increased, modern financial regulation evolved to mitigate risks through systemic resilience to inter-connected risks that could manifest as contagion across financial supply chains (Lupton 1999; Power 2009; Smith & Fischbacher 2009). Following the Global Financial Crisis (GFC) in the late 2000s, financial system risk management primarily addressed the systemic concentration risks presented by very large financial system participants (Power 2009).

An emerging body of financial research is now expanding regulatory controls to address further sources of systemic risk. One emergent source of systemic risk within the highly globalised financial system includes the risk to financial system stability introduced by smaller participants lacking the financial capital to withstand significant economic shocks and whose tight interdependence on other parties could result in financial contagion across

interconnected financial supply chains (Magnuson 2018). More recently, the International Organisation of Securities Commissions (IOSCO) has extended the concept of financial system concentration risk further to encompass financial technology risks (IOSCO 2014, 2017). These risks manifest when there are no effective substitutes to technologies, such as financial market infrastructure providers including clearing and settlement systems. These additional sources of systemic risk present regulators with additional areas of concern in achieving their regulatory objective of controlling systemic risk.

1.1.2 Distributed Ledger Technologies

A distributed ledger is a distributed record of information that is shared and agreed among various parties (Narayanan & Clark 2017). The key attributes of DLT systems are their use of cryptographic techniques and the implementation of incentives to provide confidence to participants that transactions have not been tampered with (Beck, Müller-Bloch & King 2018). A blockchain is a type of distributed ledger that implements agreed data as a chain of grouped transactions called 'blocks'(Nakamoto 2008). Bitcoin is perhaps the most well-known application of distributed ledger technology. It uses a blockchain to maintain a commonly agreed record of electronic value balances among participants without reliance on traditional central authorities or intermediaries such as a central banks or banks (Nakamoto 2008, 2009). Public distributed ledger systems use cryptography and incentive systems to replace the role of central authorities and intermediaries in ensuring the integrity of shared, agreed information (Benkler 2016). DLT systems also mark an evolution in the governance of systems, affording a decision-making scale that exceeds the ability of conventional organisational and market governance (Davidson, De Filippi & Potts 2016; Omarova 2020). While the displacement of intermediaries using DLT addresses issues of scale and trust, it also introduces new challenges for regulators in industries such as the financial system.

1.1.3 DLT Challenges to Financial Regulation

A defining feature of the financial system has been the presence of financial intermediaries. These parties typically extract profitable rents from participants in return for facilitating financial services and assuring the integrity of transactions between otherwise unknown parties (Wright & De Filippi 2015). This concentration of value and profits in financial intermediaries has made them attractive to financial regulators who rely on these institutions and their governing bodies to lever regulatory controls (Benkler 2016). DLT systems that displace intermediaries challenge financial regulators by removing these key control leverage points. Thus, an emergent risk to financial system stability introduced by DLT systems is the disintermediation of conventional regulatory control points (Wright & De Filippi 2015). See Figure 1-1.

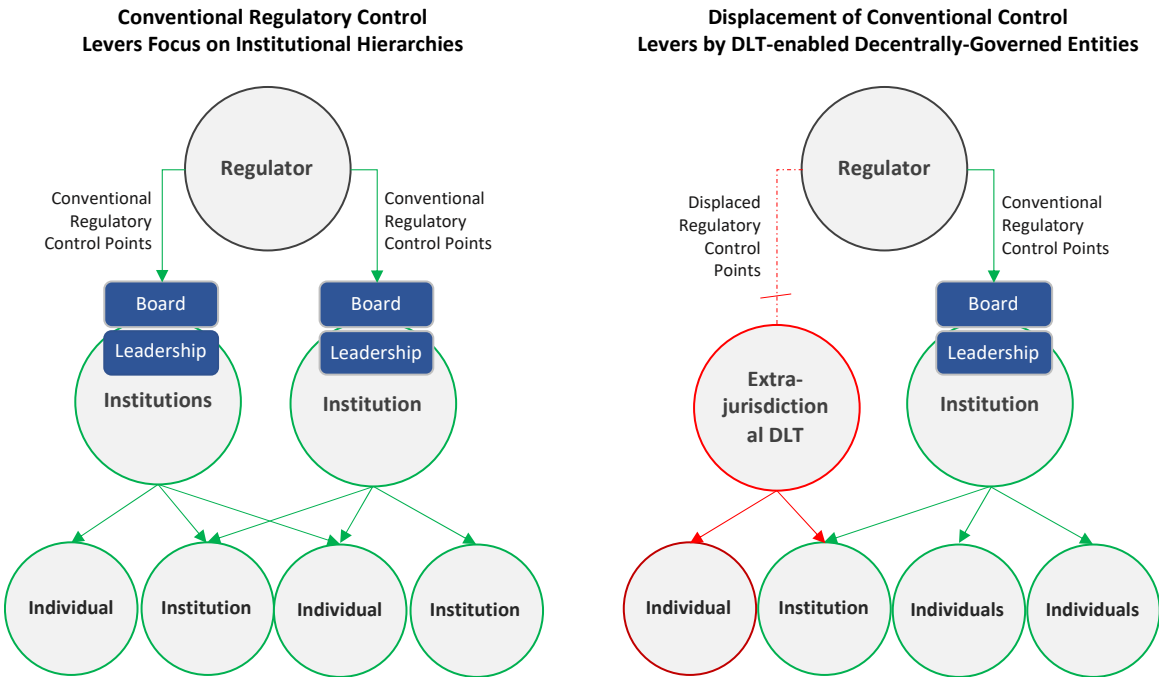


Figure 1-1. The Disintermediation of Financial Intermediaries by DLT Systems

IOSCO (2017) identifies the related development of concentration risks in the financial system as a result of emerging technologies such as DLT. In describing the challenge this type of DLT presents to financial regulators, IOSCO notes that should DLT systems become pervasive, they could introduce systemic concentration risks if they dominate without alternatives. To successfully execute their function of managing systemic risks, regulators must ensure their regulatory control regimes accommodate the emergence of DLTs while mitigating the potential impacts of the risks they introduce.

1.2 Research Problem

While it has been reported in the literature that the decentralisation inherent to DLT systems disrupts conventional governance (Davidson, De Filippi & Potts 2016), the regulatory implications of this disruption for industries such as the financial sector has been to date limited. Despite a growing body of research on alternative DLT-based governance mechanisms, there remain unresolved questions for financial regulators on how to address the regulatory risks introduced by decentralised DLT governance. These risks present a challenge to financial system stability and the confidence participants hold in the integrity of financial markets. While the literature has identified a range of potential controls that could be adopted by regulators to address emerging risks such as those presented by DLT systems, Australian financial regulators have limited research guidance or practical experience in identifying and establishing such controls. Furthermore, regulators lack design guidance on how such controls could be adaptive to address the rapid rate of financial technology

innovation. Thus, there is a need to both identify appropriate regulatory controls to treat the risks of decentrally governed DLT systems in the financial sector and to ensure these regulatory controls remain adaptive to the rapid pace of innovation of DLT systems.

1.3 Research Question and Objectives

The described gaps presented the opportunity for this research to contribute to regulatory outcomes and research into DLT governance by answering the following principal research question:

Principal Research Question: "What regulatory controls should regulators use to treat the risks of decentrally governed DLT systems in regulated contexts such as the Australian financial system?"

To address this main question, there is a need to understand the risks presented by decentrally governed DLT systems and an appropriate portfolio of controls to treat these risks. Hence three subordinate research questions were investigated. See Figure 1-2.

Research Question 1: What risks in the financial system are contributed to by decentrally governed DLT systems?

Research Question 2: What regulatory controls should regulators implement to treat the risks of decentrally governed DLT systems?

The rapid rate of technology and product innovation in the financial system warrant that any regulatory control regime adapt to the rapid evolution of DLT systems and financial services to avoid becoming redundant or inhibiting financial system competitiveness and efficiency (Cortez 2014). To address this regulatory challenge, this study sought to analyse potential design principles to govern the definition and adaption of regulatory controls.

Research Question 3: What design principles should regulators use to define and adapt controls to treat the risks of decentrally governed DLT systems?

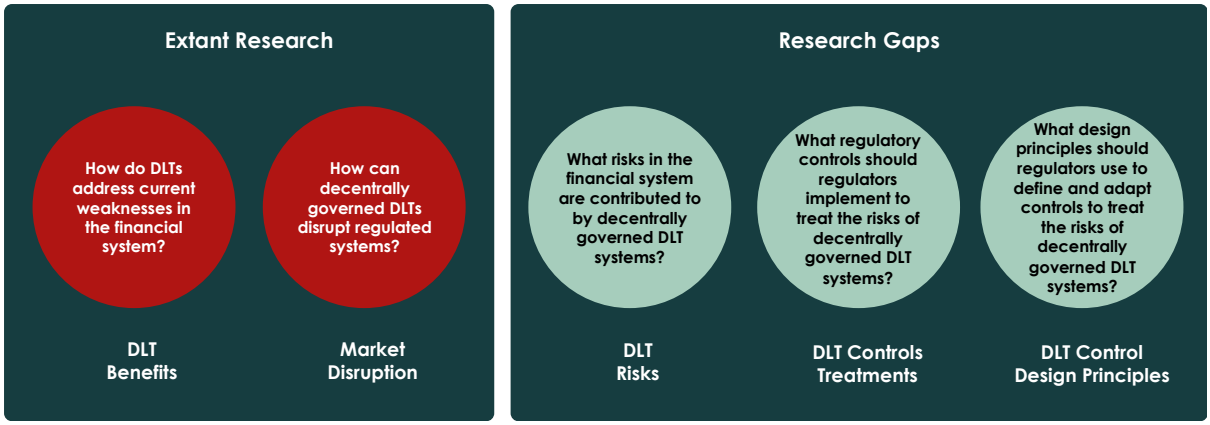


Figure 1-2. Research Questions

By addressing these research questions, this research aims to guide how Australian financial system regulators establish and adapt regulatory controls to address the risks introduced by decentrally governed DLT systems. To achieve this aim, the research develops a DLT Regulatory Control Framework – the DRC Framework – comprising DLT participants, risks, regulatory control treatments and design principles to inform the ongoing development and adaption of regulatory controls.

1.4 Research Strategy

The problem space being addressed by this research is the regulation of DLT systems within the financial system. Research into the governance and regulation of DLT systems has until now been limited (Beck et al. 2018). The research domain within which this research study is implemented is IS research. IS research is characterised by a broad epistemology with economics and IS orientation on the one hand and computer science on the other (Beck, Weber & Gregory 2013). Given its focus on behavioural science, economics and computer science, IS research is an appropriate research epistemology to research the financial regulation of DLT.

The research study explores the risks of decentrally governed DLT systems and develops a framework of regulatory control treatments by using participatory ADR to co-design a DLT Regulatory Control framework with regulatory experts. Additional theory generating qualitative research techniques are incorporated into the implemented ADR research approach to enhance the theoretical contribution of the developed research artefact and further generalise its regulatory applications. The research implements an ADR method based on the framework developed by Sein et al. (2011) and extended by Gill & Chew (2019). The participatory involvement of expert practitioners extends the implemented ADR method using an approach developed by Haj-Bolouri, Bernhardsson & Rossi (2015). This use of

participatory ADR research techniques informs the formulation of the research problem, the co-design and evaluation of the research artefact, and the practical relevance and useability of the developed framework. The co-creation of design artefacts such as the DRC Framework with regulatory practitioners is suitable for research problems with limited existing research and industry adoption (Haj-Bolouri, Bernhardsson & Rossi 2015). The implemented framework also incorporates additional qualitative research techniques such as the incorporation of regulatory control design principles to increase the theoretical validity of the developed design artefact (Beck, Weber & Gregory 2013; Gregor, Kruse & Seidel 2020).

The research commenced with a Formulation of Research Problem research stage. This informed a subsequent Build, Intervene and Evaluation (BIE) Research Stage that consisted of research activities to develop, evaluate and refine the DRC Framework research artefact. Additional theory generation research activities encompassing external observer analysis and the development of design principles to inform the development and adaption of regulatory controls were implemented in the BIE research stage to add further theoretical validity to the developed research design artefact – the DRC Framework. The research progressed to a Formalisation of Learnings Research Stage where the developed DRC Framework was distributed to participating regulatory practitioners and a roadmap developed for future research. To support future practitioner adoption, a hypothetical implementation scenario was prepared in this research stage. This scenario applied the developed design artefact to identify regulatory controls that could be adopted by financial regulators to oversee the operation of DLT-based cross-border payments.

Expert regulatory practitioners from the DLT Working Group of the Australian Council of Financial Regulators as well as other DLT industry and regulatory experts participated in each stage of the research approach to further contribute to the practical relevance and useability of the developed framework. The hybrid ADR research approach incorporating additional theory generating techniques and the participatory contribution of expert practitioners develops a design research artefact with both practical relevance and higher theoretical validity. See Figure 1-3.

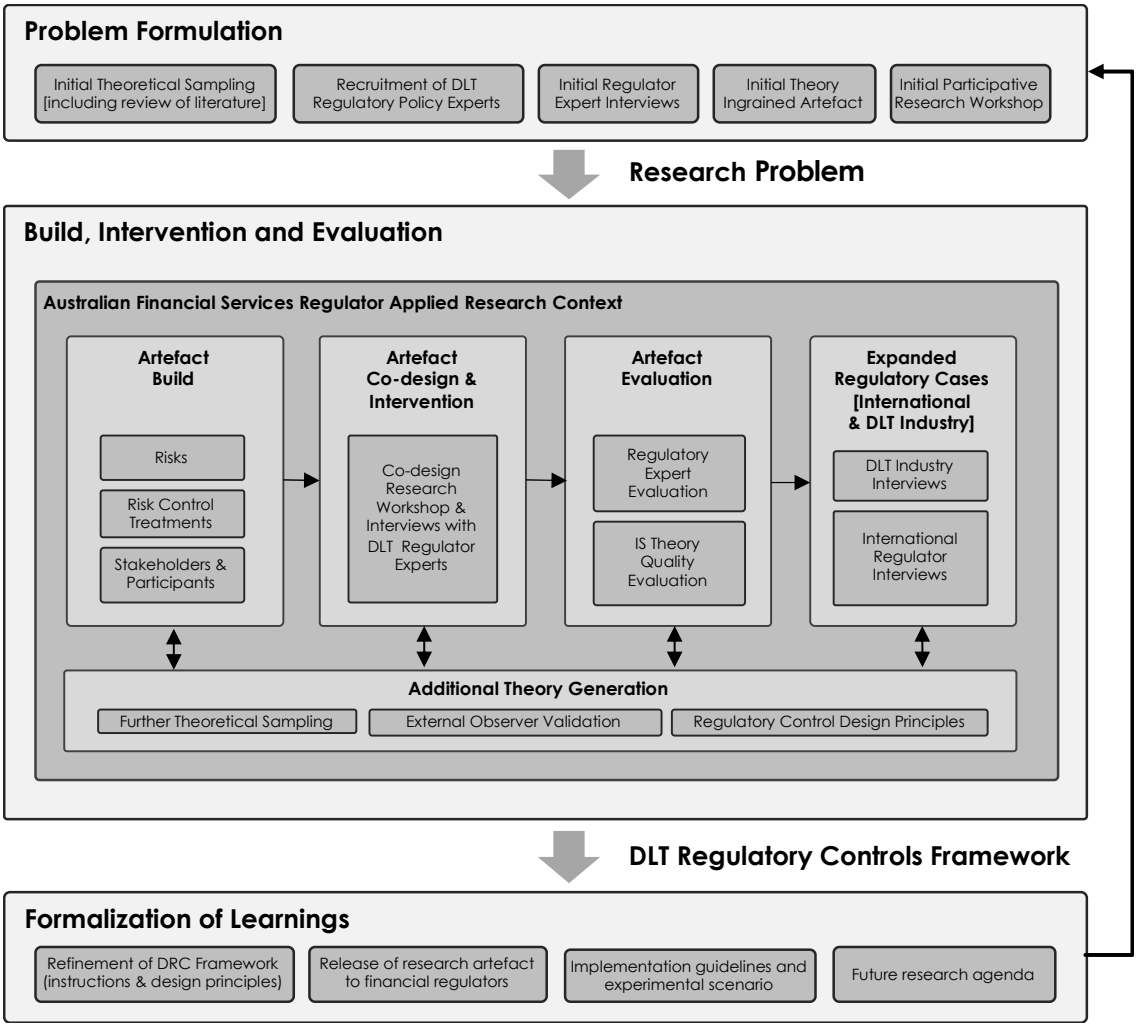


Figure 1-3. Research Design

The research stages implemented in the study are presented in Table 1-1.

Research Stage	Research Activity	Description of Research Activity
Formulation of Problem	*Initial Theoretical Sampling*	Review of literature and identification of IS for research epistemology.
	Recruitment of DLT Regulatory Policy Experts	Recruitment of research participants from the regulatory agency members of the DLT Working Group of the Australian Council of Financial Regulators.
	Initial Interviews with Research Participants	Initial unstructured interviews with regulatory DLT experts from the Reserve Bank of Australia.

	Development of Initial Theory Ingrained Artefact	Abductive development of initial conceptual DLT regulatory framework based on research literature and initial interviews.
	Initial Participative Research Workshop	Initial workshop conducted with research participants to explore and refine the research problem and identify research stakeholders. This workshop ensured that the key concepts and topics were understood and agreed by research participants. Improvements including additional risks and participant types were identified and incorporated into the revised framework artefact.
Build, Intervention and Evaluation	*Artefact Build*	Abductive development of design research artefact consisting of DLT risks, control treatments, participants and stakeholders.
	Artefact Co-design and Intervention	Refinement and revision of DLT Regulatory Control Framework incorporating expert participant input using the Nominal Group Technique-based workshop technique (Dunham 1998). The Intervention phase involved the further development and refinement of the regulatory control framework based on the learning outcomes from the initial awareness of problem workshop and regulatory expert feedback elicited through a structured questionnaire on the quality and relevance of the conceptual design artefact.
	Artefact Evaluation	Practical evaluation of developed DRC Framework using structured questionnaires and participatory workshop output. Theoretical evaluation of developed DRC Framework using the IS theory evaluation criteria developed by Weber (2012)
	Expanded Regulatory Cases (International and DLT Industry)	Unstructured interviews and structured questionnaires with DLT industry expert and DLT regulatory expert from the UK Financial Conduct Authority. This resulted in the identification of additional regulatory controls and the recommendation of incorporation of the IOSCO categorisation of fintech risks (IOSCO 2017).

	Additional Theory Generation	Additional review of literature. Incorporation of external researcher feedback from IS research method experts on improvements to research design. Development of regulatory control design principles using design principl development schema developed by Gregor, Kruse & Seidel (2020).
Formalization of Learnings	*Refinement of DRC Framework*	Reflection emphasised participant learning outcomes throughout the research process, with participants encouraged to reflect upon insights and learning from earlier discussions (Haj-Bolouri et al. 2015). Artefact and theory evaluation were further aided by the maintenance of a design log. A key outcome of this research phase was the development and incorporation of DRC Framework guidelines for use based on expert participant feedback.
	Implementation walkthrough and experimental regulatory scenario	Development of DRC Framework Implementation Walkthrough and experimental regulatory scenario developed to inform regulator adoption of the DRC Framework.
	Release of research artefact	Distribution and presentation of developed DRC Framework to 1) DLT Working Group of Australian Council of Financial Regulators, 2) DLT Working Group of the Reserve Bank of Australia, and 3) Australian government National DLT and Blockchain Community.
	Development of future research agenda	Development of future research agenda for DRC Framework adoption.

Table 1-1. Research Design (Key Activities)

1.5 DLT Regulatory Control Framework

The DRC Framework consists of DLT participants, risks, control treatments, residual risk impacts and general control design principles. See Figure 1-4. The Framework identifies participants affected by the operation of DLT systems in the financial system. These were developed based on the existing literature and refined during the co-design workshops with regulatory experts. Risks are presented according to the parties or markets in which they are realised. Each broad risk category is comprised of more atomic risks, each of which is mapped to a variety of risk dimensions that were informed by IOSCO financial system risk

reports (IOSCO 1998, 2014). Risk control treatments were developed using the existing literature and significantly enhanced through co-design activity with regulatory experts during the PADRE stages of the research. Risk outcomes were defined according to the anticipated effect of control treatments applied against risks. A series of design principles were incorporated into the framework. The principles applied the design principle development methodology developed by Gregor, Kruse & Seidel (2020) and serve to guide the development of ongoing risk control treatments as DLT systems evolve in their application to the broader financial system. Input from research participants identified the need to augment the framework with simple usage guidelines and these have been added to the framework to aid its application.

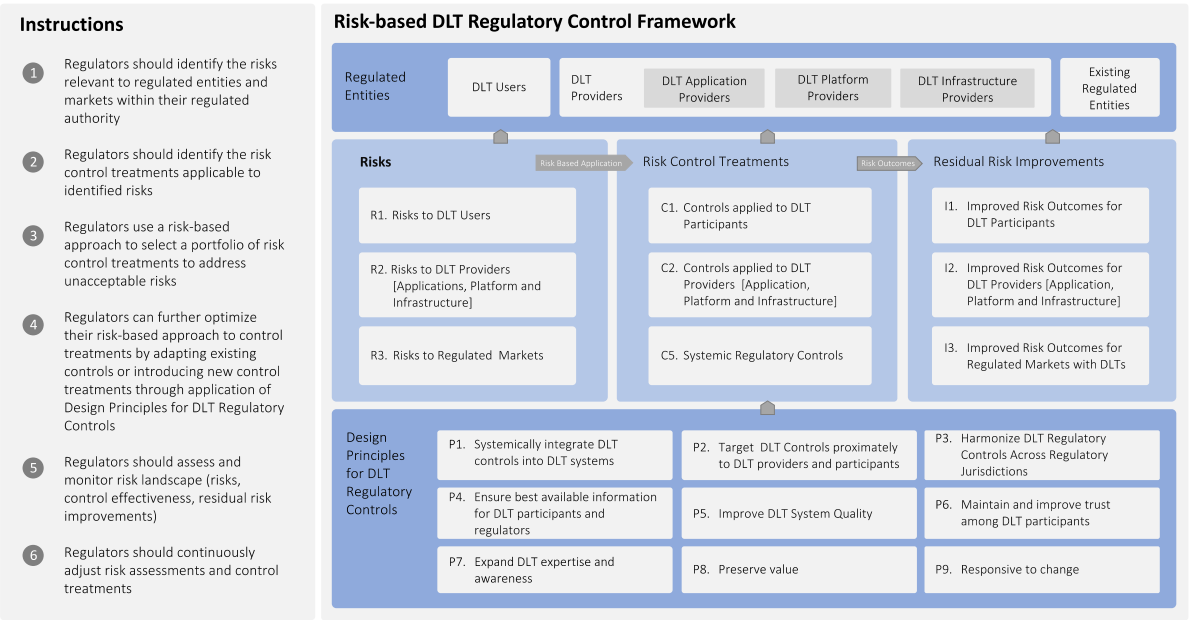


Figure 1-4. Risk-based DLT Regulatory Control Framework (High Level)

The DRC Framework is risk-based and identifies a range of DLT parties that are directly affected by the operation of regulatory controls intended to manage financial stability. These parties were identified and validated in the regulatory workshops with regulatory policy experts. These participants consist primarily of general DLT system users and DLT system providers (DLT application, platform, and infrastructure providers). These participants are variously impacted by the realisation of specific risks categories (risks pertaining to DLT system, DLT system providers and systemic risks to regulated financial markets). These risk categories manifest as a variety of diverse constituent risks. Associated with risks are a range of control treatments identified from the literature and research workshops. These regulatory controls variously treat specified risks and result in residual risk reductions that are identified by the framework. It is important to note that specific control measures can contribute to

reducing the residual risk of multiple risks. Similarly, multiple risks can be treated by a single control treatment. Accordingly, the framework adopts a portfolio-based approach to control treatment, confirming that a basket of control measures is needed to treat various component risks of decentrally governed DLT systems.

1.6 Research Users

This section discusses the users of the DRC Framework. The DRC Framework is intended for use by Australian financial system regulators and existing and potential DLT providers and developers as a general reference model to guide the regulation and regulatory acceptance of DLT systems. The DRC Framework is not intended to be adopted as a prescriptive implementation guide for regulatory controls; instead, it is intended to inform the establishment of a comprehensive portfolio of controls designed to mitigate the diverse risks introduced by DLT systems to financial system stability. Financial regulators may use the framework to inform risk assessments and control options. DLT providers and developers can use the framework to ensure DLT systems are more likely to gain and retain regulatory acceptance to provide financial services in the Australian market.

1.6.1 Australian Financial System Regulators

Financial system regulation in Australia encompasses a broad range of regulatory remits. The Reserve Bank of Australia (RBA) is Australia's central bank and is responsible for the stability of the Australian financial system. The Financial Systems Group (FSG) of the RBA is responsible for the RBA's role in payments system regulation and its broad responsibilities for financial system stability. The Governor of the RBA chairs the peak Australian financial regulatory body, the Australian Council of Financial Regulators (CFR). Each of the CFR's constituent regulators is responsible for various aspects of Australian financial system regulation. The DLT Working Group of the CFR was established to inform and make recommendations to the CFR with regard to the impact and regulation of DLT systems on the Australian financial system. The DLT working group is responsible for understanding the potential opportunities and risks presented by DLT to the Australian financial system advising the full council on potential regulatory responses to the emergence of DLT systems.

Regulators can use the insights developed by this research on the risks of DLT systems to financial system stability and individual agency regulatory objectives. A regulator using the framework will identify those risks that are relevant to a jurisdiction and note the participants for which these risks are relevant. Having done so, the framework then identifies a range of risk control treatments that a regulator can consider for evaluation and adoption in a financial context. These risk controls will map to specific risks and be relevant to specific DLT participants. Having used the DRC Framework to identify and select the DLT risks to be

controlled for, a financial regulator can then use the control treatment library to identify those regulatory controls that can contribute to the mitigation of risks deemed unacceptable and therefore warranting mitigation. The framework identifies residual risk improvements as a result of control treatment, enabling regulators to both consider the impact of regulatory control responses and measure their performance on implementation. Regulatory control design principles provide guidance to financial regulators through the initial definition and implementation of regulatory control treatments and their ongoing adaption to evolving market conditions and technology innovation.

1.6.2 DLT System Providers and Developers

'Fintech' or *Financial Technologies* are defined by the International Organisation of Securities Commissions (IOSCO) in its 2017 research report on FinTechs as 'a variety of innovative business models and emerging technologies that have the potential to transform the financial services industry'. FinTech organisations are increasingly seeking to capitalise on the emerging applications of DLT systems to provide new DLT-based services for the financial system. To the extent they provide financial services to the Australian financial system, DLT providers are subject to Australia financial system regulation. These regulations can impede their ability to participate in financial markets, add cost and complexity to the provision of DLT services, as well as present barriers to financial market participation in the form of costs, effort and regulatory operating conditions required of both DLT providers and their potential competitors. This research can be used by DLT providers to identify and respond to the risks of their participation in the Australian financial system, and better anticipate the compliance of their DLT services with regulatory controls. Using the DRC Framework to inform DLT system design is more likely to result in the regulatory acceptance of DLT-based financial systems.

DLT developers can use the DRC Framework to inform design and development choices pertaining to the DLT systems they build for use in the Australian financial system. Improved awareness and anticipation of regulatory controls that have technical implications for DLT systems will allow DLT developers to build control compliance into their systems, reduce the costs of retrospective alignment to regulatory control regimes and increase the likelihood of regulator acceptance of the developed systems.

1.6.3 General Uses

The research develops abstracted control design principles and involves international fintech and regulatory research participants to improve the general application and extensibility of the DRC Framework. It is expected the framework will be of use to non-financial regulators in both Australia and international jurisdictions. The generalisability of the framework by its non-reliance on Australian-specific regulatory requirements and specifications will allow its risks, control treatments and design principles to be adapted to non-financial regulated

contexts in multiple jurisdictions. Further, the use of FCA research participants and UK-based DLT providers as research participants identified specific globally-relevant risks and control treatments that have specific benefit and applicability to non-financial and international DLT contexts.

1.7 Research Contributions and Impact

This section outlines the main contribution of the research – the DRC Framework. The framework provides guidance on the key considerations for regulators when adapting and implementing a regulatory control regime to address the regulatory risks of decentrally governed DLT systems. This research has had three key impacts. Firstly, it has impacted the regulatory evaluation of and response to the risks of decentrally governed DLT systems in the Australian financial system. Secondly, it has contributed to the emerging body of academic research on the regulation of decentrally governed DLT systems. Thirdly, it has influenced the development of international standards for DLT systems in the fields of governance and regulation.

This research has made contributions in a number of areas associated with the governance and regulation of DLT systems.

1. The research has contributed to the regulatory approach to DLT by Australian financial regulators.
    i. The developed DRC Framework was co-designed and evaluated by DLT policy experts from the DLT Working Group of the CFR. The group of experts who participated in the research are key DLT policy specialists within their respective financial regulatory agencies. Research participation has informed the individual and collective positions of this expert group on DLT regulation in the Australian financial system.
    ii. The developed research has contributed to the policy positions of the DLT Working Group of the Reserve Bank of Australia. This group is tasked with informing the technical and policy considerations relevant to the determination of the RBA's DLT-related payments policies. Several members of the RBA DLT Working Group also directly participated in the research as members of the CFR DLT Working Group.
2. The study has contributed to the development of international standards on the governance and regulation of DLT systems.
    i. The research informed the ongoing contribution of the researcher as Chair of Standards Australia's Governance Working Group of the IT-041 Technical Committee on DLT Standards. IT-041 is the Australian mirror group of the ISO Technical Committee for DLT and Blockchain Standards (TC-307).

ii. A publication on the governance challenges of decentrally governed DLT systems research was distributed as official ISO information publication N65 for Working Group 5 of ISO Technical Committee 307 to inform the working group's development of guidelines for the governance of DLT systems.

3. The research has contributed to the academic body of work on the regulation of DLT systems.
    i. Publication of the developed DRC Framework is being reviewed and has received positive feedback from Information & Management for a special issue on research on distributed ledger technologies.
    ii. The challenges of decentrally governed DLT systems and the research approach implemented by the study were part of the ICIS 2019 TREO discussion on AI and distributed ledger technology research in Munich. The discussion focused on the use of regulatory experts to co-design the DRC Framework and the nature of the risks identified by the research.
    iii. An academic paper was published on the challenges of decentrally governed DLT systems and the need for standards in a special DLT edition of the Journal of ICT Standardization (Benedict 2019).

1.8 Research Scope and Key Assumptions

The scope of this study is the regulatory control regimes of Australian financial regulators with regulatory oversight over the operation of DLT systems in the Australian financial system. Given the specific aim and objectives of this study, this research scope is focused on identifying the control responses that financial system regulators can implement to address the risks relating to the operation of decentrally governed DLT systems. The population considered in the scope are DLT systems operating in the Australian financial system and relevant regulators are the financial regulator constituents of the Australian CFR.

The DCR framework is not designed or intended to replace the financial system's existing regulatory regime, but rather to inform the regulatory controls that financial regulators incorporate into existing regulatory regimes to address the emergent risks of decentrally governed DLT systems.

While the framework is developed for application by Australian financial system regulators, it has been generalised through the incorporation of regulatory control design principles and extended research participation by UK financial regulatory and international fintech industry experts. Future research can extend the research by explicitly adapting the developed DRC Framework to non-financial and broader international regulatory jurisdictions.

Several key assumptions are made by this research study. Firstly, the expertise and knowledge gained from the participating regulatory experts is valid and represents an accurate assessment of the risks and responses relevant to regulators. Secondly, the contribution to systemic risk represents the key risks introduced by decentrally governed DLT systems to the financial system. While this position was confirmed by the expert participants, to date there is limited longitudinal data to validate this position. Thirdly, the techniques and research method used by the research are appropriate research methods to address the research questions investigated Finally, the conclusions reached by the research and the developed DRC Framework are constructed with suitable rigour to merit their application by Australian financial system regulators.

1.9 Chapter Summary

This chapter presented an analysis of the risks inherent to decentrally governed DLT systems in the Australian financial system. To date, there has been limited research that explores the risks presented to regulators by decentrally governed DLT systems and the appropriate regulatory control responses to these risks. This research implements a participatory ADR approach to co-design a DRC Framework with DLT regulatory experts to address the principal research question of 'What regulatory controls should regulators use to treat the risks of decentrally governed DLT systems in regulated contexts such as the Australian financial system?' The principal research question is addressed by three constituent research questions.

1. What risks in the financial system are contributed to by decentrally governed DLT systems?
2. What regulatory controls should regulators implement to treat the risks of decentrally governed DLT systems?
3. What regulatory control design principles should regulators use to define and adapt controls to treat the risks of decentrally governed DLT systems?

The developed DRC Framework consists of five key components: DLT participants, regulatory risks, regulatory control treatments, residual risk reductions and regulatory control design principles. DLT participants encompass DLT system users and providers (application, platform and infrastructure). DLT risks comprise a variety of constituent risks grouped by scope of impact (user, provider or market). Regulatory control treatments and their residual risk impacts are aligned to DLT risk categories. Regulatory control design principles are included to enable controls to be defined and adapted to changing conditions. The framework is a general design artefact that while developed for the Australian financial system can be adapted for non-financial and non-Australian regulatory contexts. The DRC Framework will be discussed in detail in Chapters 3-5. It is intended to be used by Australian financial

regulators as a comprehensive framework for determining and implementing regulatory controls to address the regulatory risks of decentrally governed DLT systems. In Chapter 2, the adopted literature review process attempts to answer the research questions 1 and 2.

2 Literature Review

This chapter is drawn from academic and industry sources and reviews the major fields of research that establish the foundations of the study. Section 2.1 reviews research on distributed ledger and blockchain technology. Section 2.2 addresses conventional and decentralised technology-enabled governance. Section 2.3 then analyses the emerging research on the risks of decentralised technology-enabled governance. Section 2.4 reviews research on the management of systemic financial risk and the regulatory challenges presented by disruptive technologies such as DLT. Section 2.5 reviews research focusing on potential controls to address the risks of decentralised technology-enabled governance. Sections 2.6 discusses the research gaps identified in the literature review and Section 2.7 summarises the chapter. See Figure 2-1.

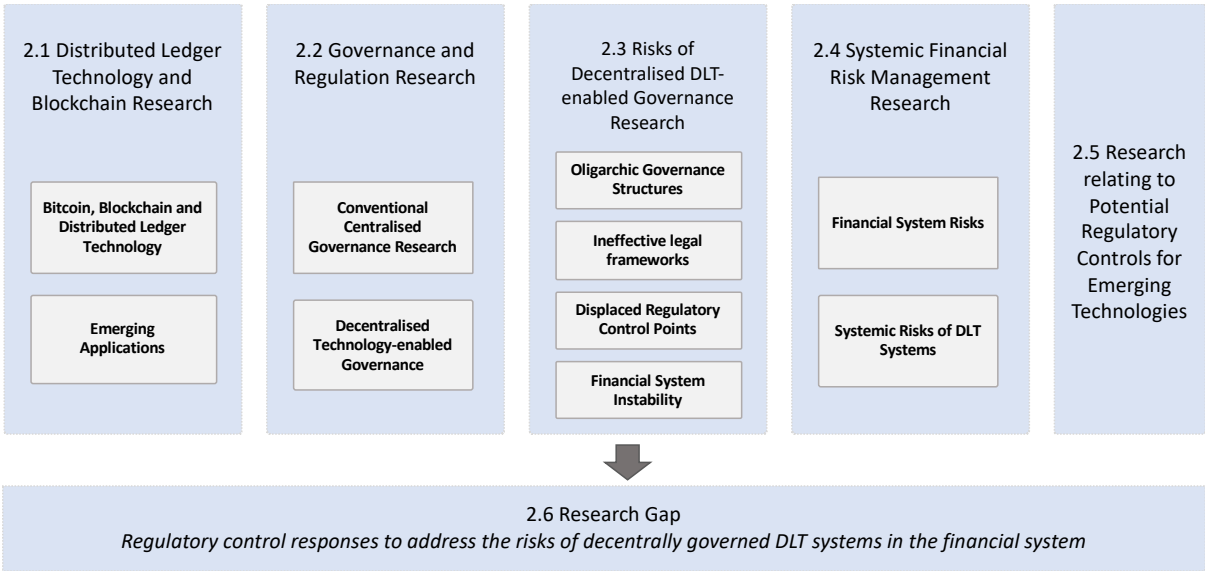


Figure 2-1. Study of Relevant Research Literature

2.1 Distributed Ledger Technology

Released in the aftermath of the Global Financial Crisis, the Bitcoin peer-to-peer electronic cash system was a response by its author, the pseudonymous 'Satoshi Nakamoto', to growing societal alienation from the stewardship of intermediaries and state regulators such as financial institutions and central banks (Atzori 2015; Nakamoto 2008). Nakamoto's 'peer-to-peer electronic cash system' applies cryptographic techniques and economic incentives in a novel way to ensure the integrity of payment transactions without the need for a trusted intermediary such as a financial institution or central bank (Beck et al. 2016; Beck, Müller-Bloch & King 2018; Narayanan & Clark 2017). The term 'distributed ledger' was attributed to its design as the underlying Bitcoin database or 'ledger' of transactions was distributed to

all members of the network, each of whom could see all previous transactions among all participants in the system (Raskin & Yermack 2016). The distribution of data to a diverse set of participants eliminated one of the central tenets of traditional multi-party systems, namely the need for a central party to maintain a trusted version of data for use by all participants as a trusted version of the truth.

A compelling element of Bitcoin's design was achieved by Nakamoto's (2008) incorporation of an incentive model in the design of the system. Bitcoin achieved this by rewarding certain participants called 'miners' for processing Bitcoin transactions and correspondingly managing the system's underlying transactional integrity. Without rewarding miners with the issuance of new Bitcoins, miners would not have been incentivised to continue securing the Bitcoin distributed ledger, a key function required to ensure the overall integrity of the system (Abramaowicz 2016). This intentional circular co-dependence between Bitcoin's incentive structure and the ongoing security of its operational architecture was key to Bitcoin's ability to supplant the role of conventional intermediaries and central authorities in ensuring the integrity of transactions between otherwise unknown parties (Davidson, De Filippi & Potts 2016; Sompolinsky & Zohar 2018).

Distributed ledger technologies have been described as a class of technologies 'that give users confidence that archived information has not been tampered with' (Beck 2018, p. 3; Beck, Müller-Bloch & King 2018). Since the inception of Bitcoin, DLT-based research has expanded to cover a diverse range of research topics. These include the underlying architectural foundations of distributed ledger implementations such as Bitcoin (Mallard, Méadel & Musiani 2014), the cryptographic applications of distributed ledger technologies (Quintana Diaz 2014); the implications for central banking (Raskin & Yermack 2016); and the economic incentives underpinning DLT systems (Davidson, De Filippi & Potts 2016; Ma, Gans & Tourky 2018; Sompolinsky & Zohar 2018). Narayanan & Clark (2017) note that while much of the theory incorporated within Bitcoin's design is an amalgam of previously existing research, its novel contribution is the combination of previously disparate economic and technical concepts into a self-incentivising techno-economic system. It is the combination of these capabilities that allows systems such as Bitcoin to share data efficiently and securely (FCA 2017).

Since their release, the blockchain and distributed ledger technologies underpinning Bitcoin's design have garnered appreciation for their potential to reduce friction in organisational interactions, increase democratic reach, and expand the possibilities of group social ordination beyond the boundaries of institutions and markets (Davidson, De Filippi & Potts 2018; Wright & De Filippi 2015; Yermack 2017).

2.2 Governance

2.2.1 Conventional Centralised Governance

Governance has been broadly defined as a 'means used to ensure order where potential conflict threatens to undo or upset opportunities to realize mutual gains' (Williamson 1999, p. 1090). In the context of public government, governance has been defined as a government's 'ability to make and enforce rules, and to deliver services' (Fukuyama 2013, p. 350). Regulation more specifically is referred to as the 'technology of governance', comprising the 'techniques employed to change production functions to produce fewer of some outputs, such as pollution, or more of others' (Wiener 2004, p. 484).

The role of ensuring good governance over a system or institution has historically been attributed to central governing authorities. A key mechanism of central governance involved the granting of powers by society to central authorities. These powers were used to control dealings among participants and address systemic risks in order ensure the integrity, continuity and efficient operation of the overall system (Benkler 2016).

The ability to trust unknown others has been a distinguishing feature of human society throughout our evolution. In the circumstances of interactions among parties unknown to each other, such parties cannot rely on the experience of previous interactions and must to overcome the perceived risk of engaging with an unknown party who may do harm to them harm (Harari & Perkins 2017). A key vehicle for modern society's mitigation of this risk at scale is through the endowment of 'seals of approval' from trusted centralised institutions (Klein 1997, p. 4). The allocation of such seals through centrally-held public registers (or 'ledgers') have provided society with an efficient means of recording changes of economic state (such as property transfers) as a consequence of transactions. The centralised co-ordination of societal activity arose from a desire to provide efficacy to the administration of complex, voluminous functions such as taxation and maintenance of the public peace (Scott 1998). Despite the emergence of large-scale centralised governance, parties who otherwise do not have trusted relationships rely on the veracity of centrally held information to instil confidence to transact with unknown others (Davidson, De Filippi & Potts 2016). The use of central ledgers and the institutions facilitate their operation have thus become a cornerstone of the modern state.

This centralised facilitation of trust among strangers has not come without cost. Centrally-led government processes have often come at the price of overly simplistic standardisation that does not represent the underlying heterogeneity of society (Scott 1998). Centrally administered governance has also been found to be expensive and unwieldy to undertake (Davidson, De Filippi & Potts 2016). Paquet & Wilson (2015) attribute this unwieldiness to the outstripping of the capacity of centralised institutions such as government agencies to provide requisite coordination in increasingly complex societies. Such complexity is driven

by more complex, frequent transactions among more diverse participants, often in increasingly technology-enabled contexts (Davidson, De Filippi & Potts 2016; Scott 1998).

Such sub-optimal outcomes when combined with rent-seeking from individuals or governing authorities or intermediaries has manifest itself in increased societal alienation with the institutions of central governance. At the heart of this alienation is a diminishing loss of trust in the parties responsible for facilitating transfers of value in society (Scott 1998). This alienation has been exacerbated by public perceptions of declining ethics in public and financial institutions; the emergence of technologies facilitating increased information transparency and dissemination; and the growing expectations by citizenry for participatory decision-making that has been encouraged by the growth of social media (Paquet & Wilson 2015). Instead of providing efficient mechanisms for the allocation of resources and societal management, government authorities are increasingly seen 'as somewhat of an encumbrance – too slow, too corrupt, too lacking in innovation, and benefiting too few' (Paquet & Wilson 2015, p. 21).

In partial response to challenges facing institutions of state, the evolution of institutional intermediaries such as banks and other corporations enabled the specialisation and resource distribution needed for societal activity otherwise beyond the reach of individuals or inefficient state institutions (Allen et al. 2017). As with central authorities however, the rise of institutions to orchestrate complex economic activity also comes with costs. These include rent-seeking opportunism, costly organizational hierarchies, the tendency of powerful institutions to concentrate wealth and power within societies, and the overly complex administration of organisational bureaucracies (Allen et al. 2017; Davidson, De Filippi & Potts 2016).

2.2.2 Governing Ecosystems

As markets and the systems that comprise them have grown in complexity and interconnectivity, there has arisen a body of research on ecosystems and their governance. Ecosystems are complex biological systems that operate in self-sustaining cycles through the complex interchange of inputs and outputs across highly connected component systems. The term ecosystems has also been applied to complex human systems that are broadly self-sustained through the interoperability of highly connected component systems (Wareham, Fox & Cano Giner 2014). To be sustainable in the longer-term, technology-based ecosystems must be able to adapt to changing environmental conditions and external competition for scarce resources, while also being sufficiently stable to ensure the thriving of component systems and their participants (Tilson, Lyytinen & Sørensen 2010). A key goal of the governance of such ecosystems is the balancing of these tensions (Boudreau 2012). To optimise the governance of ecosystems, governance mechanisms should aim to reduce variety of common foundational capabilities to ensure efficient standards, and increase

variance in areas of suitability to general and niche requirements of participants to promote overall ecosystem adaptiveness and competitiveness (Wareham, Fox & Cano Giner 2014).

2.2.3 Decentrallised Technology-enabled Governance

Once the complexity of such social co-ordination exceeds the benefits of central administration and intermediation, the inducement arises for societies to explore more decentralised governance (Davidson, De Filippi & Potts 2018). The emergence of this view is partly fuelled by the growing societal acceptance of technology-enabled approaches for scalable decentralising governance (De Filippi & Loveluck 2016).

Technology has a long history in the implementation of the governance of society. In Ancient Greece, difficult-to-forge bronze-based personal identification devices were deployed to provide integrity to the assignment of citizens to various administrative and judicial responsibilities (Allen et al. 2017). Such technological innovation expanded the democratic expansion of democratic government by lowering the cost of expanding participation in its governance while contributing significantly to its increased legitimacy. Atzori (2015) contends that the advent of distributed ledger systems portends a further advancement for expanded societal participation in democratic governance.

Decentrally governed DLT systems have been argued to introduce a more efficient, sophisticated means of enabling scalable resource transfers among unknown participants (Davidson, De Filippi & Potts 2018). DLT displacement of centralised, institutional intermediaries with cryptographic assurances and incentives is identified as a significant technical advancement that addresses the underlying complexity and needs of today's societies while mitigating the inefficiencies and costs associated with state, firm and market-based approaches to societal governance (Benkler 2016; Davidson et al. 2018; Wright and De Filippi 2015; Yermack 2017). In her speech at the UK Financial Conduct Authority's discussion panel on consumer and market competition, the FCA's Director of Competition Policy noted the potential for DLT systems to improve market competition and potentially revolutionise the financial market by opening them up to 'a whole new world of possibilities' (Starks 2018).

The governance of information technologies, or 'IT Governance,' is defined as the decision-making rights and accountabilities of parties that contribute to the influencing of behaviours and outcomes (Weill & Ross 2004). In organisational contexts, the IT governance model of Weill & Ross (2004) focuses on the decision rights and accountabilities conventionally vested in an institution's executive management or board of directors. Beck, Müller-Bloch & King (2018) expand the Weill & Ross (2004) definition of IT governance to incorporate an additional dimension of economic incentives. In the context of distributed DLT systems that often traverse organisational boundaries, incentives serve to motivate participants to express behaviours that ensure the ongoing operation and integrity of DLT systems. By example,

Bitcoin's approach to disintermediating central authorities is achieved through an incentive system that encourages participants to commit resources to a cryptographically-secured network whose operation is transparently auditable by participants (Nakamoto 2008; Pazaitis, De Filippi & Kostakis 2017; Yermack 2017). This approach overturns the conventional paradigm of central ledgers requiring administration by trusted central authorities.

To successfully implement such a fundamental transition in the way activity and transactions society occur among otherwise unknown participants requires a high degree of societal acceptance (Paquet & Wilson 2015). The willingness of modern society to consider technology as an alternative to centralised governance has been influenced in recent years by the mass adoption of technologies such as always-connected mobile telephony and social media (Paquet & Wilson 2015). The convergence of such capabilities into individuals' hands have wrestled a significant amount of coordination legitimacy away from traditional, centralized authorities (Paquet & Wilson 2015). Enabled by technological empowerment, citizens have in recent years more actively participated in the social co-ordination previously the domain of centralised government and public institutions such as regulators. It is into this environment that distributed ledger technology, with its foundation of democratised, re-distributed governance, has emerged as an institutional technology for decentralization (Benkler 2016).

The growing popularity of Bitcoin and DLT-based platforms such as Ethereum demonstrates a societal willingness to arrive at consensus on agreed economic states without the presence of conventional central authorities or institutional intermediaries (Abramaowicz 2016). They do so by introducing cryptographic-based mechanisms for achieving consensus on economic facts (Davidson, De Filippi & Potts 2018). Using decentralised governance mechanisms facilitated by technology is seen by some as a compelling solution to the problems of rent-seeking opportunism by intermediaries and the inefficient transaction costs of conventional centrally-administered governance (Davidson, De Filippi & Potts 2018).

By allowing for the elimination of the need for central authorities and intermediaries, DLT systems upend modern society's dependence on such governing parties to provide assurance and trust among unknown participants. It is not surprising that MacDonald, Allen & Potts (2016, p. 5) describe blockchain technologies as an 'institutional governance technology of decentralization'. One of the lasting societal contributions for which distributed ledgers are regarded may well be their introduction of a socially accepted means of establishing and maintaining trust among unknown parties without recourse to central authorities and reputable intermediaries. See Figure 2-2.

Figure 2-2. The Evolution of Societal Governance

It is notable that not all DLT systems are decentrally governed. While the distributed nature of DLT systems enable governance to be decentralised, specific implementations can adopt more conventional centralised governance models. While the architecture of such systems are distributed, the authority to make decisions and concentration of accountabilities can be less reliant on technology and instead vest in specific centralised authorities. This is particularly the case in so called 'private' DLT systems, where participation is not open to public membership (Beck, Müller-Bloch & King 2018). It is therefore important to distinguish decentralised governance from distributed ledger technologies. Not all DLT systems are decentrally governed, though they provide a technologically-based means of implementing such decentralised governance of designed accordingly.

In the initial Bitcoin paper, Nakamoto (2008, p. 1) noted the 'inherent weakness of the trust based model', stating that no current mechanism existed for making payments 'without a trusted party'. The weakness of this model was expounded by the contemporary Global Financial Crisis, where the integrity and trustworthiness of financial intermediaries and central financial authorities were being questioned in the face of national financial crises gripping countries such as Greece and Iceland (Atzori 2015). Solutions that advocated the removal of reliance on these intermediaries and central authorities addressed increasingly deep-seated concerns with the state of the global financial system.

The introduction of decentralised co-ordination and governance by distributed ledgers enables a more institutionally varied and complex economy. Davidson, De Filippi & Potts (2018) contend that this increased variety will eventually enable new institutional designs that address the limitations of governance by central authorities and intermediaries in complex societies. The popularisation of Bitcoin and other DLT systems shows that the enablement of scalable decentralised governance is matched by a societal willingness to arrive at a consensus on an agreed economic state without the presence of central authorities or intermediaries (Abramaowicz 2016).

2.3 Systemic Financial Risk

2.3.1 Evolution of Systemic Financial Risk Management

The study of risk management commenced after World War II and emerged from the study of operational and technological risks in the 1950s. The focus of early systemic risk management was to protect individuals and companies from the losses associated with accidents, when insurance for some types of loss could be prohibitively expensive or incomplete (Dionne 2013). The latter half of the twentieth century saw a steady expansion in the number of hazards classified and managed as risks (Lupton 1999). As companies intensified their financial risk management, the use of complex financial instruments arose and resulted in both the organisational development of sophisticated internal risk management models and the development of international risk regulation (Dionne 2013).

Over the second half of the twentieth century, corporate risk models evolved and were supported by the field of Enterprise Risk Management (ERM). This ERM approach to risk management sought to predict the occurrence and manage the consequences of risks occurring through the probabilistic determination of uncertainties (Power 2009). The ERM approach integrated risk management requires enterprises to evaluate, control, and monitor all risks and their dependences to which they are exposed. In general, a risk is formulated as a combination of the probability of an event occurring and the likely impact of its consequences (Dionne 2013).

Since the maturation of risk management the 1980s, international risk regulation has evolved and is most currently based on the current ISO standard on risk management: the ISO 31000 Standard for Risk Management: Principles and Guidelines (ISO 2009). This standard has become the accepted global standard for depicting risks, control treatments, risk evaluation, monitoring and communications (Purdy 2010). The standard among other things provides considerations on how risks should be treated. Risks are defined as the 'effect of uncertainty on objectives' (Purdy 2010, p. 882). Risk control treatments are intended to adjust the uncertainty associated with objectives. ISO 31000 provides guidance to consider when treating potential risks. See Table 2-1.

#	Risk Treatment Approach
1	Avoid a risk by deciding not to start or continue with the activity that gives rise to it
2	Taking or increasing the risk in order to pursue an opportunity
3	Removing the source of the risk
4	Changing the likelihood of risks crystallising

5	Changing the consequences of risks when they crystallise
6	Sharing the risk with another party or parties (including contracts and risk financing)
7	Retaining and accepting the risk by informed decision

Table 2-1. Risk Treatment Approaches (ISO 31000)

Risk treatment in this enterprise context is largely concerned with changing the magnitude and likelihood of consequences, both positive and negative, to achieve a net increase in benefit. Controls are the outcomes of risk treatment, whose purpose is to modify risk (Purdy 2010).

A challenge with the conventional ERM approach has been its narrow focus on factors largely within the locus of control of enterprises (Power 2009). This inward-facing risk-management approach is now increasingly regarded as having resulted in an underrepresentation of risks and factors outside an organisation's control (Van Der Vegt et al. 2015). Increasingly, risk researchers are seeing this focus on enterprise risk as a blind spot of conventional enterprise risk management given the increasing interconnectedness of risks impacting across the global economy (Lalonde & Boiral 2012; Power 2009). Consequently, a more expansive approach to the management of potential risks has recently emerged, accompanying a more expansive consideration of systemic risks that emphasises the inter-connectivity of risks, their causes and impacts (Lupton 1999; Power 2009; Smith & Fischbacher 2009). Magnuson (2018, p. 1189) defines systemic risk in the financial system as 'the probability that economic shocks in one part of a financial system can lead to shocks in other parts of that system'. Smith & Fischbacher (2009) note the fast-growing appreciation of new forms of interconnected risks such as terrorism, pandemic flu and global financial crises as compelling illustrations of the increasingly borderless nature of risks. In these situations, it becomes increasingly important to focus on the consequence management of low probability, high impact events.

As a guidance on how to manage systemic risks, Power (2009) notes the value of incorporating aspects of the emerging discipline of Business Continuity Planning (BCP) to address this more outcome-focused approach to systemic risk management. BCP benefits from its inherent appreciation of the interconnected nature of factors that contribute to the emergence of crises and shocks that are otherwise difficult to quantify or predict using organisationally focused risk models. Inherent to this approach of managing transboundary risks is the appreciation of the tight coupling between systems and the realisation that a breakdown of one system may eventually impact all interconnected systems (Lalonde & Boiral 2012; Power 2009).

A key research development in the move to resilience management of systemic risks is a shift in the focus on risk prediction to the management of consequences (Van Der Vegt et al.

2015). Then Deputy Governor of the Bank of England, Paul Tucker (2009) highlighted the importance of financial regulation to look beyond the risks inherent to individual financial market participants, looking beyond controls targeted at those financial market participants such as banks that were 'too big to fail', and instead to focus on controls that contributed to the resilience of the financial system as a whole. A key component of such resilience measures highlighted by the Deputy Governor should be a shock-absorbing financial market infrastructure. To ensure systemic resilience, Smith & Fischbacher (2009) emphasise the key for systems to be dynamic and the need to minimise reliance on rigid controls. Flexibility of controls applied to the interconnected financial system ensure its adaptivity to environmental changes and allow it to effectively adjust to changes in equilibrium introduced by new innovations, participants and interactions.

In the context of highly complex interconnected risks, resilience allows a system to withstand a multitude of crystallising risks, regardless of their originating cause. In the situation of low probability–high consequence events in highly connected systems, commonly described as 'black swans' by Taleb (2007a), 2007b), a risk management approach is required that accommodates such systemic risks.

The nature of systemic risks is such that individual enterprises or organisations are rarely suited to either define or address such risks that inherently traverse multiple institutional boundaries. In the case of institutionally-spanning system risks, Power (2009) notes that the management of such risks is best addressed by entities designed for such industry or economy spanning purposes, such as financial regulators. This is because institutionally-aligned ERM approaches are not implemented with a view to externalities 'well beyond their design parameters' (Power 2009, p. 853).

The international regulator, IOSCO (International Organization of Securities Commissions (IOSCO), was initially launched as a pan-American securities regulator and expanded over the coming years into a global institution. It is tasked with harmonising domestic legislation on national securities markets and establishing an environment conducive to the easy passing of information among domestic securities regulators with a view to enabling local securities regulation based on common standards (Marcacci 2012). A key role that has evolved for IOSCO is providing guidance on measures relating to the mitigation of systemic risks. After the onset of the Global Financial Crisis, G-20 leaders recommended that regulatory frameworks be augmented with a macro-prudential authority that promoted a system-wide approach to financial regulation and oversight to mitigate the build-up of systemic risk.

2.3.2 Systemic Risks and Distributed Ledger Technology

To address the advent of innovative technologies and their potential to contribute to systemic risk, IOSCO released a discussion paper in 2017 (IOSCO 2017) on the role of financial

technologies such as DLT in the global financial system. In the paper, IOSCO highlighted the role of interconnectedness in contributing to systemic risk. In discussing this, it is noted that while an institution may not be large enough to be systemically important, its nature of being highly connected to others could contribute to it becoming systemically important. The potential for systemic risk is noted as being heightened if participants are interconnected and one is dependent on the other. In this situation, IOSCO emphasises the importance of greater transparency about interconnections to assist regulators and participants understand how systemic risk may be manifest in markets. This in turn will enable the identification of preventative steps to address the spread of adverse effects.

IOSCO (2017) noted the risks presented by financial technologies such as DLT systems when there are no effective or potential substitutes to a financial technology. Historically, financial markets have experienced concentration risk in key financial market infrastructure providers such as clearing and settlement systems which typically lack substitutes. Should DLT systems become pervasive, key DLT platforms or applications that are based upon them could manifest concentration risks if they become dominant with limited alternative providers.

A further financial technology characteristic that IOSCO (2017) highlighted as contributing to systemic risk in financial markets is that of external risks where a systemically important area of the market falls outside a regulators' jurisdiction. This may occur when an attribute of a financial technology is supervised by another regulator, but in a different way, or is otherwise unregulated. In the first scenario, it is key for regulators to cooperate and coordinate with the other regulator to ensure the risk(s) are addressed. In the latter, a regulator should consider how the risk could be brought into it, or another regulator's perimeter of regulation. Due to the global nature of financial markets and the borderless nature of DLT systems, international collaboration among regulators is also essential to address system risk. Tapscott & Tapscott (2017) emphasise the need for regulatory harmonisation in domestic and international spheres to ensure the risks of DLT systems are addressed. Joseph Stiglitz in Moss & Cisternino (2009) recommends overlapping regulatory coverage, noting the costs of duplicative regulatory control coverage across multiple regulators is warranted given the very significant consequences of systemic risks when realised.

While the regulatory response to the GFC has been a focus on addressing systemic risks in the financial system, some researchers have contended this response has unduly focused on the concentration risk that was manifest in large institutions to the detriment of focusing on other sources of systemic risk. The decentralised nature of financial system innovations such as DLT systems themselves introduce systemic risk. This is because due to the currently small size of DLT providers and the highly connected nature of their services they are 'more vulnerable to adverse economic shocks than large financial institutions, and those shocks are

more likely to spread to other firms in the industry' (Magnuson 2018, p. 1172). DLT systems are often more difficult for regulators to monitor and constrain than conventional financial institutions as regulators commonly operate with limited visibility of the structure and operations of these systems (Magnuson 2018).

Magnuson (2018, p. 1189) notes the characteristics of emerging financial technologies such as DLT systems that contribute to systemic risk in the financial system:

1. The extent to which individual actors are vulnerable to rapid, adverse shocks is amplified by the DLT systems' highly interconnected nature, with automated technical integration rapidly accelerating contagion effects in the financial system.
2. The existence of multiple pathways in decentralised systems enabling adverse shocks to spread from a single institution to others.
3. The level of asymmetric information among DLT participants contributing to the risk of uncertainty causing participants to cease market participation in a financial crisis and contributing to the seizing of financial markets.
4. The growing size of elements of the financial system adopting and relying on DLT platforms and applications.

2.4 Risks of Decentrally Governed DLT Systems

Despite the apparent willingness of society to embrace technical and cryptographic forms of governance, an emerging body of research indicates that DLT systems themselves introduce risks warranting mitigation (Benedict 2019). These risks include the emergence of unaccountable, oligarchic governance structures (Atzori 2015); the rise of extra-judicial autonomous agents and smart contracts structurally resistant to the sanctions and influence of conventional regulatory frameworks (Wright & De Filippi 2015); the displacement of institutionally oriented control points conventionally relied on by regulators to manage systemic risk in regulated environments (Benkler 2016); and the systemic risk of an operational failure in a systemically important DLT system.

Unless effectively mitigated, these risks encumber the potential ability of DLT systems to achieve regulatory acceptance and effectively supplant conventional centralised governance models. Importantly, the crystallisation of any such risk is dependent on the actors on which the risk crystallises and the context in which the risk materialises. The specific manifestation of these risks may affect an actor, or part of a stakeholder group more than another or others. As these risks generally exist systemically, they are likely to compound the impact on actors or the broader system that they affect. See Table 2-2.

No.	Risk	Research
1	Unaccountable, oligarchic governance structures	Atzori (2015); De Filippi & Loveluck (2016); Shaw & Hill (2014); Abramaowicz (2016)
2	Inefficacy of traditional regulatory sanctions and legal frameworks in supervising Decentralised Autonomous Organisations (DAOs) and smart contracts	Atzori (2015); Wright & De Filippi (2015); Kiviat (2015)
3	Displacement of central control points	Weill & Ross (2004); Brummer (2015); Pereira & Silva (2012); Benkler (2016); (FCA 2017)
4	Digital disruption of financial system through the systemic risks of DLT systems	FCA (2017); Starks (2018)

Table 2-2. Risks of Decentrally Governed DLT Systems

2.4.1 Unaccountable Oligarchic Governance Structures

Distributed ledger systems that eliminate central authorities or intermediaries risk their replacement by a 'techno-elite' that lack formalized legitimacy (Atzori 2015, p. 18). In such cases, powers invested in central authorities and intermediaries such as central banks and banks are replaced by those that create and enforce the rules that govern supplanting DLT systems. In the case of Bitcoin, such power is concentrated among a handful of individuals that are largely unknown and unaccountable to the participants who partake in the use of the Bitcoin network (Atzori 2015; De Filippi & Loveluck 2016). In such circumstances, Nakamoto's intent of displacing untrusted intermediaries may result in the investiture of such power in other, potentially more unaccountable entities.

Shaw & Hill (2014) identified the tendency for peer production initiatives such as distributed ledger systems to exhibit Michels (1959) 'iron law of oligarchy'. This law contends that early members of larger, complex membership organisations tend to consolidate oligarchic power as their interests diverge from the broader collective over time. This manifests in the general observation that many peer-to-peer systems exhibit entrenched, unaccountable concentrations of authority that frequently leads to oligarchic governance structures (Shaw & Hill 2014).

As an early DLT implementation, Bitcoin has been demonstrated as exhibiting a tendency towards the oligarchic consolidation of control over governance mechanisms within the cryptocurrency's distributed ledger system (Atzori 2015). Such power is consolidated in the form of core developers who decide what code changes to promote into the Bitcoin systems' core protocols, and miners, who decide which protocols to operate and execute transactions

against (Abramaowicz 2016; Atzori 2015). Core developers and miners play specific formalized roles in the Bitcoin network. Their roles have invested in them the ability to influence the direction of the Bitcoin system itself as it contends with the need to adapt to changing needs and environmental conditions needs (De Filippi & Loveluck 2016). Such power in directing the future of Bitcoin's development rests in core developers as only they can commit changes to the system's core code, and miners, as it is through their choice of codebase to operate that ultimately what version of Bitcoin is adopted (De Filippi & Loveluck 2016).

Unlike financial intermediaries and central authorities however, powerful participants in distributed ledger systems including miners and core developers are not meaningfully constrained by regulatory oversight (Atzori 2015). The lack of clear regulatory oversight presents significant challenges to DLT stakeholders and participants, principally due to their limited recourse to hold DLT decision-makers accountable for the outcomes of their actions. While the early proponents of distributed ledger technology such as Satoshi Nakamoto and Ethereum's Vitalik Buterin appear socially conscious, without clarification of Weill & Ross' (2004) formalised decision-making rights and accountabilities, what happens when the benevolent dictator is replaced by one altogether less benign? To whom do DLT participants turn when poor decisions are made in the governance of DLT systems? Are decisions makers accountable for poor decisions that have negative consequences to participants? Do decision makers bear any responsibility to DLT participants for the outcomes of decisions? Without clear DLT accountabilities, where does the DLT buck stop?

2.4.2 DLT Resistance to Conventional Regulatory Control

Among other capabilities enabled by the introduction of distributed ledger systems is the growing deployment of self-executing smart contracts and human-independent Decentralised Autonomous Organisations (DAOs) (Wright & De Filippi 2015). These constructs build on the core distributed ledger technology underpinning Bitcoin and extend them through the application of additional technology concepts such as artificial intelligence and self-executing code. The novel nature of these capabilities presents challenges to the historical sanctions regulators and governing authorities have used to regulate the activities of individuals and organisations.

Smart contracts are a self-enforcing digital code that execute autonomously on distributed ledger systems without the need for human intervention (Atzori 2015; Wright & De Filippi 2015). The benefits of smart contracts are compelling. They offer efficiencies in the form of reducing the cost of contracting and increase the speed of contractual execution (Wright & De Filippi 2015). Smart contracts allow unknown parties to transact at arm's length, with the reduced risk of fraud and the costs of third-party enforcement (Kiviat 2015). In this manner, smart contracts provide an efficient means of addressing the costs and uncertainties associated with counterparty risks.

Smart contracts have also however been conversely claimed to introduce governance risks in the form of uncertainty of their interoperability with existing legal and regulatory frameworks, and the enforceability of legal rulings on their operation (Wright & De Filippi 2015).

DAOs are self-sufficient autonomous agents that leverage artificial intelligence and the economic incentives and operational infrastructure of distributed ledger systems to execute tasks and achieve objectives without human involvement (Atzori 2015; Wright & De Filippi 2015). The emergence of DAO's portend the emergence of new economic institutions that stretch the ability of society's existing legal and regulatory controls. Many of these are grounded in the ability to sanction human actors. With such actors absent, such sanctions and controls are lessened in their ability to influence outcomes and disincentivise behaviour. The predominantly autonomous nature of DAO operations could signal diminished freedom for human stakeholders, and in an extreme progression, even lead to the emergence of a 'modernized version of a totalitarian regime' (Wright & De Filippi 2015, p. 43). DAO operations could also be a cause of harm to others, potentially leaving affected parties without effective legal recourse due to the inability to ascertain culpable human actors (Wright & De Filippi 2015).

DLT-based technologies, such as smart contracts and DAOs, introduce new constructs that challenge the conventional control regimes relied on by central authorities to manage risks. In its discussion paper on the risks and opportunities of DLT systems, the UK FCA (2017) noted the unresolved regulatory and governance questions raised by such technologies included:

- Is the DLT network provider (such as the Ethereum network) the appropriate control point for resolving governance issues?
- Under which regulator's remit do DLT arrangements operate?

By disrupting the recourse of penalties and sanctions on executives and organisations, DLT-based constructs such as DAOs and smart constructs risk upending the controls relied on by regulators to manage risky behaviour and disincentivise decisions, risking harm to participants or the stability of the regulated system.

2.4.3 Displacement of Financial Intermediaries

Financial regulators conventionally rely on central authorities and financial intermediaries to exert control and manage risks within regulated systems (Benkler 2016). Such regulatory oversight is implemented through measures including sanctions, licences, rules and regulations (Moss & Cisternino 2009). In determining their response to disruptive innovations, Brummer (2015) recommends regulators consider the likelihood of regulator disintermediation, with a focus on identifying which actors or aspects of the financial system

are at risk of disintermediation by emerging technologies. Decentralised distributed ledger systems attempt to address societal concerns with the integrity of central authorities and intermediaries by replacing them with cryptographic and socio-economic incentive mechanisms for assuring the integrity of systems. In removing intermediaries and central authorities however, distributed ledger systems also remove the key control points that have been the focus for enforcing governance accountability and governance standards (Benkler 2016).

In its discussion on the risks and opportunities of DLT systems, the UK's FCA notes that in shared networks, particularly those operating in 'trustless' contexts without a single controlling entity, 'it is not always clear who is responsible for what'. The FCA gives the example of stock market trading where multiple firms have visibility of and can act upon a shared order book record, the system underpinning this is conventionally managed by a single market operator or multilateral trading facility. These in turn are regulated entities that operate under significant obligations to ensure they provide robust and reliable trading platforms with adequate controls and governance in place. By contrast, trustless DLT systems may not have any such central point of control with a regulatory nexus, presenting significant risks to participants, regulators and the stability of the system itself (FCA 2017). IOSCO, in its special report on financial technologies, similarly notes that permissionless DLT could potentially present a risk when used to disintermediate financial institutions and central counter-parties (IOSCO 2017).

2.4.4 Disruption of Financial System Stability

The UK FCA in its discussion paper on the risks and opportunities of DLT systems notes the risks of emerging DLT systems contributing to an increased operational risk for firms relying on such untested technologies. These increased risks specifically are related to: '(i) the full range of operational risks that will be posed to network participants; (ii) how these might be addressed; and (iii) what risks arise when a DLT system is deployed at scale' (FCA 2017, p. 13).

The FCA further explores this technology-related operational risk by questioning the risks that arise should a system-wide failure affect multiple participants. Depending on the extent of dependency or range of adoption of such a DLT system, an operational failure on a systemically important DLT system itself (such as caused by an error in the DLT code or compromised cryptography) could contribute to a systemic risk within a regulated financial market. IOSCO in its research report on financial technologies also notes the risks of coding errors contributing to DLT risks for participants and broader markets (IOSCO 2017).

The FCA notes that where a specific participant of a DLT system suffers a participant-specific technology failure, the distributed nature of DLT systems may contribute to increased risks to participants (through their ability to restore distributed data), and the

broader regulated system (through reduced points of failure resulting from distributed infrastructure and data) (FCA 2017).

In discussing the FCA's discussion paper on the systemic risks of DLT systems, FCA Director of Competition, Mary Starks, noted that competition concerns could arise when permissioned DLT systems become essential infrastructure (for example in clearing and settlement) (Starks 2018). In these situations, system risk arises through the concentration of power in the gatekeepers of permissioned DLT systems who ostensibly control the access rights to such systemically important DLT systems.

In its 2016 Risk Report, IOSCO highlighted the risks of digital disruption to regulated markets presented by DLT systems (IOSCO 2016). The report identified a variety of risks and vulnerabilities that could result from digital disruption promoted by DLT systems. See Table 2-3.

No.	Risk	Description
1	Concentration Risk	Concentration of usage of specialized technologies such as DLT systems. If such systems were breached, dependent firms would be vulnerable.
2	Increased Financial System Complexity	The increasing complexity introduced by disruptive financial technologies such as DLT systems. Such complexity may be difficult for investors, supervisors and regulators to understand and respond to.
3	Increased Legal Uncertainty	The ambiguity of law surrounding digitally disruptive technologies. The rate of change of such systems makes them difficult for the legal system to keep up with, resulting in DLT-based financial products and activities being introduced to markets without adequate regulatory oversight.
4	Lack of Investor Knowledge	Investor misunderstanding of the risk and challenges of DLT-based offerings.
5	Malicious activity	New forms of malicious or harmful behaviour facilitated by the innovations introduced by new financial technologies such as DLT systems. Examples noted by IOSCO include cybercrime and market participants manipulating market outcomes using information asymmetries to their advantage.
6	Contagion Risk	Contagion risk facilitated by increasing global interconnection of financial markets using DLT systems.
7	Supervisory Risk	Supervisory risk facilitated by the difficulties faced by regulators and supervisors in monitoring activity conducted through DLT systems.
8	Cyber Risk	Cyber risk facilitated by novel DLT systems that may introduce new systemic risks through technology dependent DLT systems.

Table 2-3. DLT Systems and Financial Risk

2.5 Control Treatments for Decentrally Governed DLT Systems

A key focus of the emergent public policy and research on emerging technologies has been to balance the addressing of risks of emergent technologies such as DLT systems with the societal benefits they afford. In its last Securities Market Risk Outlook report issued in 2016, IOSCO (2016) noted the importance of managing this balance to allow digital disruptive technologies to provide better information to market participants and regulators, expand financing channels for the economy and reduce finance concentration, and increase financial inclusion and accessibility of services through lower cost services. Such means of addressing these risks are informed by the evolving body of research on the regulation of disruptive innovations examined in Section 2.7. Much of this developing research is informed by the appreciation of the complexity of modern regulation and the interconnectivity of risks, causations and impacts. As a result, researchers and regulators are increasingly turning to regulatory control responses that establish resilience to the complex, systemic risks introduced by emerging technologies such as DLT systems.

2.5.1 Multi-risk portfolio approach to build systemic resilience

Wiener (2004) contends that regulatory success is dependent on the cumulative contexts of problems, conditions and institutional settings into which a regulation is applied. In complex settings, the application of narrowly defined regulations to address emerging technology risks will struggle in the face of complexity (Wiener 2002, 2003). To address this challenge, Wiener (2004) recommends a multi-risk portfolio approach that seeks to address a variety of risks, both introduced by emerging technologies or caused by their potential regulation, with a portfolio of regulatory solutions. A key feature of managing an environment of more complex, interconnected risks is to shift the emphasis of risk management from risk prediction to the management of consequences with an emphasis on building systemic resilience (Van Der Vegt et al. 2015). A phenomenon of highly connected systems is the emergence of what Taleb (2007a) describes as ‘black swan’ events. Black swan events are low probability, high consequence events that induce shocks and which are often difficult to predict. Focusing on managing the consequences of low probability, high impact shocks enable financial regulators to better prepare for unforeseen crises and the recoverability of highly connected markets and systems (Kaal & Vermeulen 2016).

One regulatory approach to build systemic resilience and protect against unforeseen shocks is to implement dynamic, adaptive regulatory controls. Ensuring flexibility of controls in the interconnected financial system ensure its adaptivity to environmental changes and allow it to effectively adjust to changes in equilibrium introduced by new innovations, participants and interactions (Smith & Fischbacher 2009).

2.5.2 Addressing information asymmetries through incentive alignment

Joseph Stiglitz notes that the nature of markets involves the presence of information asymmetries between parties and that such parties are incentivised to exploit and increase these asymmetries to their advantage (Moss & Cisternino 2009). If financial system participants cannot assess the status of others in the market during times of crisis, they may assume the worst and take defensive actions, including terminating arrangements and withdrawing deposits (Judge 2012). This can lead to cascading effects, as the lack of information requires parties to act as if the information is bad. Information asymmetries among participants can also contribute to systemic risk by reducing market efficiency when information is unavailable or costly to acquire. When this information cost or complexity results in inefficient markets, they are more susceptible to collapse due to their reduced resilience in crises (Calomiris & Gorton 1991). In the context of financial technologies such as DLT systems, the lack of information transparency of the status or solvency of DLT participants may contribute to uncertainty among participants. This is turn can contribute to a crisis of confidence that may exacerbate the systemic risk of a financial crisis occurring (Magnuson 2018).

To address the systemic risk of endemic information asymmetry among financial participants an objective of modern financial regulation has been to moderate exploitative behaviours and reduce counter-party uncertainty by aligning incentives among participants (Moss & Cisternino 2009). A defining feature of DLT systems has been their use of incentives to motivate the behaviour of participants in ways that have compensated for the lack of central authorities and infrastructure (Beck, Müller-Bloch & King 2018). Bitcoin uses incentives for miners to facilitate transaction processing and protect the overall integrity of transaction history (Atzori 2015; Sompolinsky & Zohar 2018). Without such incentives, DLT systems would lack the drivers to encourage peer-to-peer production and ensure the ongoing integrity of the overall system. This incentive driven model also however has its downsides. De Filippi & Loveluck (2016) note that the misalignment of interests arises among distributed ledger participants, particularly where core developers (whom often are early DLT participants) are incentivised to maintain and develop their reputation as governing authorities of the distributed ledger system. This is achieved through their demonstration of expertise and their ability to influence the development direction of the platform.

To address the distortions of interests introduced by the incentive systems of distributed ledger systems, regulators should target controls towards the realignment of participant incentives to ensure key decision makers are aligned to the longer-term success of the DLT system.

2.5.3 Achieving systemic trustworthiness through transparent decision making

The notion of trust among parties is defined as a parties subjective estimate that another counter-party will behave in a preferred manner (Bauer 2019). The concept of trust is defined as a subjective belief and is separated from whether a system or participant in is 'trustworthy', i.e., deserving of that subjective trust assessment.

Benkler in Moss & Cisternino (2009) emphasises the importance of the perceived trustworthiness of participants in a market system. Such trustworthiness is generally resultant of the controls and regulation of the market system, and not necessarily the inherent integrity of any specific participant within it. The reputation of a participant however is increased if they behave favourably as is predicted by other market participants (Scott 1998). Specifically, such trust in counterparties takes the form of the prediction by participants that other parties will not take advantage of them. To facilitate such trustworthiness, Benkler contends that regulatory controls should be designed to break down cooperative actions into observable and transparent steps as the visibility of such steps inherently engenders trust among participants. Where non-compliant selfish participants do not follow mandated, transparent measures instituted to engender trust, this visibility allows other participants to steer away from being involved with them. Confidence that such non-compliant parties will be punished further increases confidence among complying parties. Benkler notes the positive attributes of rewarding compliant participants, including avoidance of the risks of spirally retaliatory negative action from aggrieved or non-complying participants (Moss & Cisternino 2009).

A successful governance mechanisms for eliciting trust and integrity in DLT systems is to balance the need to arrive at consensus with the transparent management of conflicts (Abramaowicz 2016). Consensus is critical in such systems as it is what is required to compensate for the lack of a trusted central authority. Conflicts and their transparent resolution however are a key mechanism for providing legitimacy to systems seeking to exert authority over participants (Abramaowicz 2016; Habermas 1989). A key goal of conflict management in distributed ledger systems is to encourage debate while avoiding paralysing deadlocks and divisive fights. This balance must be maintained to ensure the ongoing sustainability of a system even under the threat of hostile adversaries seeking to destroy a system or otherwise distort its governance mechanisms (Abramaowicz 2016). Maintaining consensus to compensate for the lack of central authorities while supporting a degree of conflict to ensure ongoing legitimacy is a constant challenge that a distributed ledger's governance system must continuously achieve. If achieved, the ongoing trust of participants is correspondingly increased.

When divisive disagreements do occur, one mechanism available to peer-to-peer systems such as distributed ledger systems are the 'right to fork'. Forking is a process whereby participants adopt differing codebases, with each alternative implementing a different set of

protocols or procedures to which a subset of participants subscribe (Nyman & Lindman 2013). While forking is often seen as a last resort of distributed governance (Abramaowicz 2016; Robles & González-Barahona 2012), its availability is also seen as a mechanism to incentivise participants to arrive at consensus as well as a catalyst for developmental innovation (De Filippi & Loveluck 2016). Abramaowicz (2016) notes that the successful accommodation of the capacity to fork while minimising the need to do so is the key measure to improve the perceived trust and integrity associated with a distributed ledger system.

Abramaowicz (2016) notes that peer-to-peer decision-making could minimise the risk of recourse to a fork in two ways, first, by incorporating a governance mechanism to accommodate the evolution of the system; and second, by incorporating a peer-to-peer decision making mechanism to allow for more rapid evolutionary changes. In implementing these governance designs, Abramaowicz (2016) notes that such extended participant decision-making can also present hurdles to achieve consensus on useful improvements due to decision-making fatigue and lack of expertise.

By incorporating transparent decision making and conflict resolution, the designers of DLT systems improve on the legitimacy and integrity associated with the system. Integrity brings with it the key element of trust that must established with the displacement of traditional central authorities and intermediaries. By ensuring these trust measures are implemented, developers enable the broader benefits of distributed ledger systems to be fully realised.

2.5.4 Adapting regulatory controls using on-ledger and off-ledger governance

Bitcoin's design successfully deploys cryptography and economic incentives to remove the need for intermediaries and central authorities to ensure transaction and system integrity. The use of internal DLT mechanisms to manage the ongoing governance of distributed ledger systems is referred to as 'on-ledger' governance (Abramaowicz 2016). In Bitcoin, participants rely on the operations of such on-ledger governance to maintain and sustain the integrity of the distributed ledger system. The rules governing the system are not enforced by any entity but rather are embedded in the code of the system, eliminating the need for the intermediaries and central authorities criticized by Nakamoto (2008, 2009). Bitcoin's transparent, on-ledger governance mechanisms are largely limited to the operation of the platform and do not extend to encompass key development decisions associated with the system (Abramaowicz 2016). Over time, it is the adaptive development of a distributed ledger system that will ultimately determine their enduring sustainability and longevity.

Decisions regarding Bitcoin's longer-term development are made by core developers and miners. Such decisions are conducted 'off-ledger' and without recourse to any formalized arrangements. Off-ledger governance is not conducted using the technology of DLT systems and is not necessarily transparent to participants. The lack of formalized governance mechanisms for decisions relating to strategic Bitcoin technology design decisions has

allowed the oligarchic tendencies of power concentration in a limited few unaccountable decision makers and power brokers (Atzori 2015; De Filippi & Loveluck 2016). The lack of formalized governance mechanisms and the corresponding emergence of oligarchic power structures has led to a questioning of the legitimacy of governance decisions relating to the Bitcoin system (Böhme et al. 2015; De Filippi & Loveluck 2016). Failure to address such concerns will impact the ability for distributed ledger systems to maintain the trust and integrity that they can no longer rely on intermediaries and central authorities to provide.

An emerging view on how to address the challenge of informal, off-ledger governance is to adopt variations of current on-ledger governance methods for more sophisticated, strategic decision-making on the development direction of distributed ledger systems themselves. Abramaowicz (2016) contends that such on-ledger governance mechanisms could be used to arrive at consensus between custodians of the development directions of distributed ledger systems themselves. Abramaowicz (2016) contends that bringing Bitcoin's improvement proposals on-ledger would improve decision-making transparency, reduce uncertainty around accountabilities and development directions and improve clarity on how decisions should be undertaken that will ensure a distributed ledger system will adapt and evolve as conditions demand.

De Filippi & Loveluck (2016) contend that formalising the governance structures of distributed ledger systems will ensure their sustainability and ability to respond to changing requirements. This contention is based on the views of Habermas (1989) that modern democracies rely on public debate in order to provide legitimacy to collective decisions. De Filippi & Loveluck (2016) argue that for such debate about the development of distributed ledger systems to be binding, it should not be made only by those developing the technology but extend to those affected by such decisions. Such public transparency of the debate associated with the development decisions associated with a distributed ledger system would ensure further legitimacy of such decisions by 'publicly acknowledging its political dimensions' (Abramaowicz 2016, p. 19). On-ledger transparency of decisions regarding distributed ledger development would address the call by Atzori (2015) for the inclusion of social and political dimensions into the formalised governance of distributed ledger systems to safeguard against the emergence of technological dystopias.

Vitalik Buterin, founder of the Ethereum DLT platform, contends that on-ledger governance may itself be too restrictive and that some measure of off-ledger governance provides inherent flexibility that addresses some of the flaws of tightly coupled on-ledger governance. The Ethereum founder notes several benefits of on-ledger tightly coupled governance, including:

1. Avoidance of pitfalls of informal governance through the use of an explicit decentralized framework.

2. Allowing DLT networks to impose high computational performance requirements on validators without introducing economic centralization risks

Buterin goes on to identify a higher order form of DLT governance associated with the 'co-ordination' of how a DLT system will interact with its core platform and surrounding environment and contexts (Buterin 2017). He notes the advantages of 'loosely coupled' voting flexibility for co-ordination-type governance to ensure DLT systems remain resilient to some of the weaknesses of on-ledger 'tightly coupled' governance, including the risks of non-representative minority voters overriding the good of the majority through voter non-participation and the risk of low-value bribes swaying voter decisions in a way that voters may collectively disapprove of.

2.5.5 Adopting multi-party, cross-jurisdictional regulatory regimes

Distributed, or polycentric, regulation arose in the wake of the GFC in recognition of the complex financial system risks that emerged in gaps of jurisdictional coverage that existed across national borders (Black 2010). The decentred regulatory model is predicated on a shift in reliance away from individual regulatory bodies, whether national or international, and instead shifts the regulatory coverage across a multitude of actors. In this way, it represents a manifestation of the multi-party, super-national regulatory regime espoused for DLT systems by Tapscott & Tapscott (2017).

Distributed governance signifies a broader range of governance actors than traditional governance associated with singular centralised authorities. The borderless nature of distributed ledger systems means that the participants involved in their governance are also inherently borderless (Wang & Vergne 2017).

Fintech activity, including that manifested in DLT systems, is in possession of a number of characteristics that warrant an internationally harmonized approach to DLT regulation (Magnuson 2018, p. 1222):

1. DLT systems often traverse national borders and as a result raise complex jurisdictional issues
2. Regulatory actions in one country impact the efficacy of regulatory regimes in other countries
3. Regulators in other countries will have useful information about the effects of particular types of DLT regulation and emerging DLT systems that will benefit other regulators

To ensure the effectiveness and efficiency of DLT regulation, it should be sensitive to a substantive extraterritorial dimension. This is amplified by the fact that overly burdensome regulation in a jurisdiction will have adverse effects on the reputation and efficiency of a country's fintech industry. Regulatory regimes that do not harmonize well with other

international regulatory DLT regimes will provide a disincentive for global DLT systems to operate in such jurisdictions (Magnuson 2018).

Tapscott & Tapscott (2017) associate their recommendation for a multi-stakeholder approach for DLT systems to the historical example of global multi-party Internet governance. Such multi-stakeholder governance spans diverse institutions, including both public and private sectors. Brousseau, Marzouki & Méadel (2012) also point to Internet governance as a source of inspiration for the decentralised multi-stakeholder governance of distributed ledger systems. Both systems traverse multiple organisations, reflect complex and heterogeneous socio-technical constructs, and often operate across multiple jurisdictions.

To achieve an effective governance structure over the Internet, a variety of organisations have arisen which are responsible for specific Internet capabilities and components. Governance bodies include those that govern decisions in relation to the Internet's technical infrastructure (ICANN) as well as broader supporting decision-making superstructure to govern its broader use (such as the IETF – the Internet Engineering Task Force) (Mueller 2009, 2010). In the case of the IETF, some of the governance architecture that manages the Internet is done by organisations with limited organisational structure that are independent of states and markets (Benkler 2016). Successful multi-party governance of DLT systems may warrant governance superstructures such as those established for the Internet, each addressing specific components of the broader governance mechanisms needed to successfully govern the societal adoption of distributed ledger systems.

2.5.6 Establishing DLT-aware legal and regulatory controls

The disruptions to traditional governance oversight posed by the emergence of DLT-based smart contracts and decentralised autonomous organisations warrant the evolution of legal frameworks that addresses their complexities. Wright & De Filippi (2015) note that the failure to properly do so introduces the risks of the disintermediation of human choice and autonomy. Such a framework named 'Lex Cryptographia' provides an ecosystem-level approach to addressing such risks through 'a set of rules administered through self-executing smart contracts and decentralized (and potentially autonomous) organizations' (Wright & De Filippi 2015, p. 48). The administration of such rules would be potentially completed through so called 'oracles' or independent judges. Adjudication could be undertaken by humans called upon by smart contracts to make judgements on conflicts or matters of dispute. Human intervention could take the form of independent judges or judiciaries (Wright & De Filippi 2015). The explicit incorporation of such adjudication for conflict resolution could add legitimacy to the resolution of conflicts in a manner described by Habermas (1989) and contribute to the integrity of a distributed ledger system. The successful transition to a Lex Cryptographia warrants both adjustment to the design and operation of such systems themselves and the legal environments in which they operate (Wright & De Filippi 2015).

In the context of distributed ledger systems, Wright & De Filippi (2015) identify a number of regulatory design mechanisms that fulfil the requirements of Lex Cryptographia. These are specifically designed to address some of the challenges presented by DAOs, smart contracts and the loss of otherwise accountable central authorities and intermediaries. Governance mechanisms identified by Wright & De Filippi (2015) include:

1. The nearest person theory where the party in a DLT system most closely associated with the harm caused would be held accountable.
2. All participants to a distributed ledger system are held vicariously liable for harm if they in some manner receive a direct or indirect benefit from its doing.
3. The decentralized autonomous organisation itself is held liable for its own harm caused. However, unless these mechanisms are authored into the code of the system itself, it would be difficult to impose and recover damages or redress from the system from an externally imposed off-ledger governance or regulatory construct such as a court or tribunal.
4. Laws could be embedded directly into code to ensure their application and influence over the influence over the operation and ongoing governance of a distributed ledger system. The technology and legal framework to enable such a mechanism however would require significant technical and jurisprudential development. It is likely in this case that examples may develop in less contentious scenarios with minimal financial or legal jeopardy for DLT participants before they are considered for broader adoption in potentially litigious contexts.

Regulator nodes are considered an effective way for regulators to maintain the visibility of activity within a DLT system by technically integrating into such systems and analysing the activity occurring upon them. IOSCO notes in their 2017 research report on financial technologies that regulator access to DLT systems allow regulators to have more complete and traceable access to real time DLT records (IOSCO 2017). To achieve this level capability however, IOSCO notes to that employ regulatory nodes effectively regulators must develop and maintain automated surveillance functions and retain highly sought-after technology expertise.

2.5.7 Incorporating regulatory sandboxes into regulatory regimes

The Deloitte Insights report on the future of regulation identifies regulatory sandboxes as a means of prototyping emerging technologies and evaluating the impact of regulations on them in collaboration with industry (Eggers & Turley 2018). Such an approach allows regulators to gain a fast understanding of new technologies and develop relationships with innovators to better assess the effectiveness and impact of potential regulations. The approach also allows innovators to inform regulators and policy makers on the nature of emerging technologies while minimising the possible harm of future regulations.

The UK Financial Conduct Authority notes that firms have found the UK Regulatory Sandbox to be 'a useful mechanism to explore areas where our requirements do not anticipate their type of solution' (Starks 2018). The benefits of sandboxes to industry are that they enable organisations to explore innovative products, services, business models and delivery mechanisms in real markets with actual consumers. In the context of DLT systems in financial systems, sandboxes allow financial regulators to assess market innovations for risks and benefits, while also forming views on potential regulatory control treatments (FCA 2017).

To begin with, given fintech's focus on disruption and innovation, regulation should promote observed experimentation. A benefit of regulatory sandboxes is that they incentivise fintech participants to inform regulators of their products, services and organisations and actively participate in the improvement of regulatory frameworks. Such an approach reduces the opacity of DLT systems to regulators and other participants while also encouraging innovation (Magnuson 2018).

2.5.8 Improving investor and DLT participant literacy

The 2017 IOSCO research report on financial technologies notes concern with the extent of investors' assessments and understanding of risks and benefits, particularly in relation to emerging financing platforms such as DLT systems (IOSCO 2017). These risks related to retail investors who are motivated by short-term gains while lacking the ability to evaluate the longer-term business model and associated risks of DLT systems. The realisation of such risks could then trigger overreaction when significant numbers of such retail investors are faced with market shocks or volatility upon the crystallisation of such risks. Increasing the level of investor education is nominated by IOSCO as a mitigating control to equip DLT investors and participants with the necessary skills to make informed decisions on DLT investment and participation.

2.5.9 Informing regulation with data-centric insights

Kaal & Vermeulen (2016) highlight the interconnected complexities of modern markets and the fast-moving nature of digital disruption as requiring modern regulators to turn to data analysis on market activity and regulatory impacts to ensure regulator interventions effectively address risks. The 2018 Deloitte Insights report on the future of regulation contends that new data analysis techniques allow specific risks to be identified, tracked and controlled for, allowing regulators to move away from one-size-fits-all regulation and moving towards more precise, targeted risk management measures (Eggers & Turley 2018).

The FCA in its discussion paper on the risks and opportunities of DLT systems noted the potential for such systems to permit real-time information transparency with regulators and other DLT participants, reducing the possibility of information asymmetries arising among

participants and reducing the possibility of market instability (FCA 2017). In its paper, the FCA notes that the real-time aggregation of such data could provide efficiencies to DLT participants and regulators, potentially contributing to system-wide efficiencies and lower financial risks to participants.

2.5.10 Integrating regulatory monitoring into DLT systems

DLT systems are often more difficult for regulators to monitor and constrain than conventional financial institutions as regulators commonly operate with limited visibility of the structure and operations of these systems (Magnuson 2018). Modern regulatory regimes have conventionally accepted that regulatory efficacy requires adequate regulatory monitoring (Becker 1968). In the case of emerging risks, regulators are required to monitor and identify the participants contributing to systemic risks in the market and isolate the behaviours that warrant regulatory control to treat such risks (Wansley 2016).

Magnuson (2018) notes that the activities of many fintech firms are not subject to the disclosure regimes of larger financial institutions, hence smaller firms have not conventionally been considered as systemically risky to the financial system as they are not 'too big to fail'. The peril of reduced regulatory visibility of DLT systems is further amplified by the opacity and complexity of their complex algorithms and technology-based foundations (Magnuson 2018; Mills et al. 2016). Without accurate and timely information about the generation and state of risk, regulators are not well positioned to take effective action to prevent or mitigate systemic risks. In the context of financial systems containing DLT systems it is appropriate for financial regulators to conduct appropriate regulatory monitoring of DLT activity to reduce the opacity of the systemic risks within DLT systems and behaviours of their participants.

2.5.11 Implementing regulator stop mechanisms

Contagion is a contributing factor to systemic risk in the financial system. The term 'contagion' refers to the spreading of adverse shocks from a single institution to others via multiple pathways (Schwarcz 2008). In the case of DLT systems, the decentralisation and distribution of participants and information, and the highly interconnected nature the technical infrastructure and participants contributes to the risk of contagion of a single participant or system failure can spread quickly to other participants (Magnuson 2018).

To limit the paths of contagion through DLT systems, Magnuson (2018) recommends that regulators have the authority to limit propagation mechanisms within DLT systems and be given the authority to take action to mitigate shocks after risks crystallise to stabilize fintech markets. The limiting of DLT propagation mechanisms could involve limiting interconnectedness in markets through the incorporation of stop mechanisms into DLT code that 'reduce market volatility and prevent domino effects as parties rush to limit their losses'

(Magnuson 2018, p. 1218). In digital currency DLT systems, such regulatory controls could include 'ensuring the trustworthiness of settlement mechanisms and the accuracy of distributed ledgers in order to prevent breakdowns in the system and curtail herd behaviour by consumers' (Magnuson 2018, p. 1218). A regulatory control to minimise the impacts of contagion shocks could be the provision of regulatory liquidity to struggling financial system participants to reassure counterparties and ensure confidence in the market (Crawford 2014). For DLT systems, such regulatory intervention could extend to the provision of liquidity by regulators to DLT providers and participants (Magnuson 2018).

2.6 Research Gaps

The review of literature identified a key gap in the research on the regulation of DLT systems. This gap in the research is accompanied by limited regulator experience with DLT systems, evidenced by limited Australian and international regulatory policy and response to date with regard to the emergence of DLT systems. This is despite the growing view by global regulatory bodies that DLTs present an emerging systemic risk to regulated markets such as the financial system.

Research Gap: There exists limited academic research and practitioner guidance on appropriate regulatory control responses to the risks of decentrally governed DLT systems in regulated contexts such as the financial system.

The diversity of the research explored in this literature review lacks a research frame of reference for the regulation of DLT systems. The majority of research and regulatory publications either addresses the governance of distributed ledger systems (Atzori 2015; Beck, Müller-Bloch & King 2018; Wright & De Filippi 2015; Yermack 2017), or the regulation of systemic risks relating to general fintech innovation (IOSCO 2017; Magnuson 2018). With limited research and practical guidance available to regulators to address the emerging risks of DLT systems, the potential arises that regulators will not be prepared for the crystallisation of major systemic risks and possible crises induced by decentrally governed DLT systems (Abramaowicz 2016; Böhme et al. 2015; IOSCO 2017; Tapscott & Tapscott 2017). This research aims to address this gap by developing a theoretically valid and practically useful control framework to inform the response of regulators to DLT systems that disrupt conventional centralised regulatory control regimes.

2.7 Chapter Summary

This chapter reviews the literature relating to distributed ledger and related blockchain technologies; conventional and decentralised governance; the management of systemic

financial risk; and the emerging body of research addressing the risks of decentrally governed DLT systems and their regulation. The research examined the emergence of decentralised governance in the context of declining societal trust in intermediaries and authorities conventionally relied on to ensure the integrity of transactions between unknown parties. The potential for decentrally governed DLT systems to contribute to systemic financial risk is then discussed, followed by a review of the research on regulatory controls to address this emerging source of systemic risk. The review concluded with the identification of the key research problem of the scarcity of research guidance for financial regulators on the risks of decentrally governed DLT systems and the appropriate regulatory control responses to address these risks.

3 Research Method

The review of the literature identified a lack of research on the regulation of DLT systems. This chapter describes the research method implemented to address this research gap and provide guidance to regulators seeking to address the emerging risks of DLT systems in the Australian financial system. The research implements the ADR approach of Sein et al. (2011) and Gill & Chew (2019) which is adapted to incorporate early stage practitioner input to ensure the developed design artefact addresses real regulator challenges (Haj-Bolouri, Bernhardsson & Rossi 2015). The ADR-based research method is augmented with additional qualitative research techniques to further improve the theoretical contribution of the developed design artefact (Beck, Weber & Gregory 2013). The research method design was further enhanced using feedback from leading IS research method academics (Gregor 2006; Gregor & Jones 2007; Weber 2012).

3.1 Research Design Requirements

The research domain for the study is IS research. IS research spans an economics and systems orientation on one hand and a computer science dimension on the other (Beck, Weber & Gregory 2013). Consequently, IS research is an appropriate research domain to address the regulatory response of financial system regulators to DLT systems as the problem space being addressed is the introduction and operation of technology systems in the economically and socially bounded financial system.

The analysis of the research literature identified a number of challenges to be addressed by this study's research design. Firstly, the research outcomes should practically guide the response of financial regulators to the challenges of DLT systems. Secondly, the research method should compensate for the lack of significant existing research on DLT regulation. Thirdly, the research method should develop a research outcome that is resilient to the high rate of innovation in the use of DLT systems in the Australian financial system. Finally, the research method should produce a research outcome of sufficient theoretical validity to enable its application to a broader range of non-financial and non-Australian regulatory contexts.

3.2 Review of IS Research Methods

A number of IS research methods were evaluated and reviewed when designing the research method to be implemented for the study. These encompassed design research (DR), Action Design Research (ADR), Participatory Action Design Research (PADRE), and variants of IS

research that augment design research methods with additional theory-building qualitative research techniques.

3.2.1 Design Research (DR)

A range of IS research methods were evaluated for implementation in the research. To address the research challenge of producing a research artefact of practical value to the regulators, Design Research (DR) was evaluated due to its aim of developing theoretically valid research design artefacts (Hevner et al. 2004). DR creates design knowledge through the development and evaluation of novel IT artifacts designed to solve identified classes of problems (Hevner et al. 2004; March & Smith 1995). Gregor (2006) identifies theories for 'Design and Action' as a key class of IS research. Researchers have noted however some weaknesses in DR, including its emphasis on the development of artefacts at the expense of their evaluation (Sein et al. 2011). In this context, DR is criticized for emphasising research artefact development over relevance to practitioners.

3.2.2 Action Design Research (ADR)

Action Design Research (ADR), a derivative of DR, has emerged as an IS research method for developing research artefacts with increased organisational relevance and impact (Gill & Chew 2019; Sein et al. 2011). ADR achieves this by combining theory generation with researcher intervention to solve immediate organisational problems. The ADR approach involves researchers developing an initial view of a research problem and then developing a design artefact that is then collaboratively refined with expert practitioner input before being further reviewed and iteratively assessed by practitioners and end users (Sein et al. 2011). The resulting design artefact is appropriate for the organisation setting it was developed in and is augmented by generally applicable design principles that allow further design artefacts to be developed for other similar problem cases.

A benefit of applying an ADR approach to the research problem of regulatory response to decentrally governed DLT systems is the production of a design artefact with practical relevance to Australian financial regulators. Gill & Chew (2019) recommend maximising the practical relevance of an ADR-developed research artefact by using iterative development in an applied setting to allow a relevant and useful design artefact to emerge from the research. In this variant of ADR, researchers iteratively co-design research artefacts with expert practitioners to increase the organisational impact and relevance of the developed research artefact.

3.2.3 Participatory Action Design Research (PADRE)

To address the challenge of the limited existing research, researchers are advised to incorporate practitioner experts into the research approach (Kothari 2004). The relative immaturity of regulatory responses to the emergence of DLT systems means there is value to

be had in ascertaining the attitudes, opinions and behaviour of specialist practitioners when researching a proposed regulatory response to these emerging challenges. To address this requirement, Haj-Bolouri, Bernhardsson & Rossi (2015) developed the Participatory Action Design Research (PADRE) method. PADRE builds on the ADR method advocated by Sein et al. (2011) by incorporating participatory input solving problems and encapsulating learning outcomes across each ADR research stage (Swantz 2008). PADRE was developed with an appreciation of the benefits of 'incorporating activities for reflection and learning from the beginning to the end' (Haj-Bolouri, Bernhardsson & Rossi 2015, p. 2). This incorporation of participant input into the early stages of ADR is particularly appropriate for research problems with limited existing research literature.

3.2.4 Augmenting Design Research with Additional Theory-generating Qualitative Research Techniques

A challenge faced in developing the research method for this study is to develop a research artefact which is both resilient to the high degree of innovation in the adoption of DLTs in the Australian financial system, while also having sufficient theoretical validity to enable extension to non-financial and non-Australian regulatory contexts. While ADR is regarded for its development of design artefacts with relevance to practitioners, it has been criticised for lacking theoretical rigor and not contributing to higher-level knowledge in research fields (Cohen, Manion & Morrison 2002; Davison, Martinsons & Kock 2004). To address this concern, for action research to be theoretically valid, it should incorporate theory generation techniques and research practices (Beck, Weber & Gregory 2013; McKay & Marshall 2001). Beck, Weber & Gregory (2013) recommend incorporating qualitative research techniques such as external observers and additional theoretical sampling to add further theoretical validity to the development of design research artefacts. The inclusion of design principles into design research has also been identified as adding generalisability to design artefacts, allowing prescriptive knowledge to be applied to a broader range of problem cases (Gregor, Kruse & Seidel 2020).

3.3 Participatory ADR with Additional Theory-generating Qualitative Research Techniques

The research implements a participatory ADR research method supplemented with additional theory-generating qualitative research techniques. This approach aims to develop a practically relevant design research artefact by incorporating regulatory practitioner expertise. The research method also seeks to increase its theoretical contribution by incorporating additional qualitative research techniques, such as the development of design principles and use of additional theoretical sampling and external research observers. See Figure 3-1.

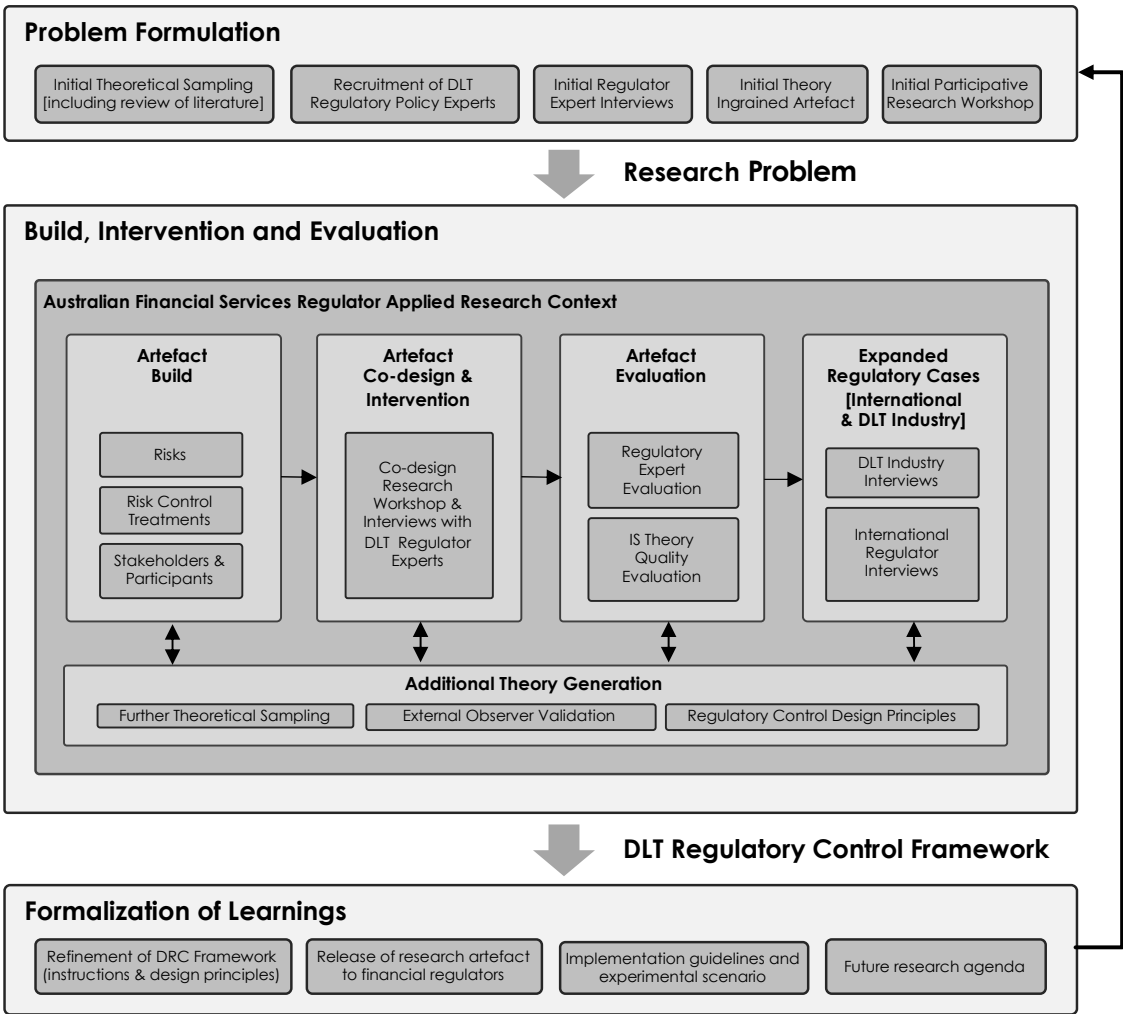


Figure 3-1. Research Design

3.3.1 Problem Formulation Research Stage

The initial Problem Formulation Research Stage identified and defined the research problem addressed by the study. The initial ADR research stage identifies and conceptualises the research opportunity, formulates the initial research question, identifies the class of problems being investigated, reviews the relevant theoretical base, and identifies and secures organisational commitments (Gill & Chew 2019; Sein et al. 2011). In participatory ADR, the research participants are enrolled early and their input is sought to inform the early stage research activities (Haj-Bolouri, Bernhardsson & Rossi 2015). The incorporation of early participation by regulatory experts is useful in addressing the research problem of DLT regulation given the lack of a significant body of research in the field.

3.3.1.1 Review of Literature

The Problem Formulation Research Stage commenced with a review of the research literature. Research categories were developed based on a preliminary review of the literature and the outcomes of early interviews with fintech and RBA DLT regulatory policy experts. These categories were subsequently expanded iteratively through the research as additional theoretical sampling was undertaken. Initial research literature categories were

1. Governance and regulation
2. Technology governance
3. Risk and resilience management
4. DLT and blockchain technology
5. IS research methodology
6. Financial system risk regulation
7. Regulating disruptive and emerging technologies

General research on governance and regulation identified a range of risks and challenges that could apply to the financial system. Available research was also identified in the research fields of technology governance, IS research methodology and financial system risk regulation. Only limited research was found in the field of regulating disruptive and emerging technologies and the literature analysis highlighted a lack of research on DLT regulation in the financial system. An analysis of research literature by theme and categorisation of publication type as academic or non-academic is provided in Table 3-2.

Literature Research Category	**Number of Academic Research Publications Reviewed**	**Number of Non-academic Research Publications Reviewed (including texts, whitepapers, industry publications)**	**Total Publications Reviewed**
1. Governance and Regulation	43	25	68
2. Technology Governance	53	24	77
3. Risk and Resilience Management	12	15	27
4. DLT and Blockchain Technology	15	12	27
5. IS Research Methodology	51	6	57

6. Financial System Risk Regulation	23	8	31
7. Regulating Disruptive and Emerging Technologies	4	0	4
TOTAL	**201**	**90**	**291**

Table 3-2. Literature Analysis

3.3.1.2 Initial Research Participant Interviews and Workshop

To refine the research problem and gather initial expert input on the conceptual DLT regulatory control response framework artefact, regulatory policy experts were recruited from the DLT Working Group of the Australian Council of Financial Regulators (CFR). The research participants are policy makers with a deep knowledge of DLT and its implications for financial system regulation and represent key Australian financial system regulators: Reserve Bank of Australia, Australian Treasury, the Australian Security and Investments Commission (ASIC) and the Australian Transaction Reports and Analysis Centre (AUSTRAC).

An initial research workshop was conducted with the research participants to review the conceptual understanding of the research problem and test a prototype version of the DRC Framework that had been abductively developed from initial regulator interviews and the literature review. The initial DLT regulator workshop ensured that the key concepts and topics were understood and agreed by research participants. The workshop was conducted with the expert DLT regulators recruited from the CFR DLT Working Group and reviewed the nature of decentrally governed DLT systems and how their divergence from conventional centrally governed systems could present risks to the stability of the financial system and conventional regulatory controls. See Figure 3-2.

Figure 3-2. Research Workshop to review initial view of DLT risks and conceptual DRC Framework

3.3.1.3 Initial formulation of research problem and conceptual artefact development

After examining the literature, initial regulator interviews and workshop outcomes, a conceptual DRC Framework was developed as a means of representing the risks, stakeholders and regulator control treatments relevant to the regulatory supervision of decentrally governed DLTs operating in the financial system. The development of the initial conceptual regulatory control framework was abductive in nature, a common approach in design research endeavours (Gregor, Kruse & Seidel 2020). The abductive production of the initial conceptual DRC Framework did not adhere to a pre-conceived sequence, as the framework was regularly iterated and improved based on new and emerging input from the literature and regulator specialists that emerged throughout the Problem Formulation Research Stage.

The initial review of literature and preliminary DLT policy expert interviews led to the identification of the lack of regulatory certainty on the nature and regulatory risks of DLT systems operating in the financial system as a key research question that warranted research investigation. The review of the financial risk management literature identified the ISO risk management standard artefact as a starting point for framing the initial DRC Framework (ISO 31000: Standard for Risk Management: Principles and Guidelines). The review of the literature and preliminary practitioner interviews informed the initial development of a conceptual DRC Framework to represent how the risks, control treatments and participants relevant to the operation of DLT systems in the financial system should be considered by financial regulators. The outcomes of the Problem Formulation Research Stage consisted of a refined formulation of the research problem and an initial conceptual DRC Framework artefact. These became key research inputs into the ensuing Build, Intervene and Evaluate (BIE) ADR Research Stage.

3.3.2 Build, Intervention and Evaluation (BIE) Research Stage

A key feature of the Build, Intervention and Evaluation Research Stage of ADR is the incorporation of stakeholder participation to optimise the impact and relevance of the developed design artefact (Sein et al. 2011). It extends this approach by the incorporating early participant input from the participatory ADR research approach of Haj-Bolouri, Bernhardsson & Rossi (2015) to conduct early stage validation of the research problem and conceptual artefact design. The outcome of this participatory BIE Research Stage is the DRC Framework design artefact consisting of DLT risks, regulatory control treatments, relevant participants and stakeholders, implementation guidelines and regulatory design principles.

The implemented BIE Research Stage is extended to incorporate supplementary qualitative research techniques to enhance the theoretical contribution of the developed design research artefact. The use of additional theory generating techniques addresses a potential weakness of design research that places too much emphasis on artefact creation without sufficient focus

on theoretical validity (Beck, Weber & Gregory 2013). The implemented Build, Intervene, Evaluation Research Stage is therefore optimised to develop a DRC Framework design artefact with both practical relevance and theoretical validity.

3.3.2.1 Build and Intervention

This research step involves the full design realisation of the research design artefact, the DRC Framework, and an exploration by DLT regulatory experts of its application in the Australian financial system's regulatory context. The concurrent building and intervention of design artefacts contributes to the applied practical characteristic of action design research and contributes to its practical impact and relevance of ADR research (Sein et al. 2011). Haj-Bolouri, Bernhardsson & Rossi (2015) further observed the value of incorporating reflection throughout each stage of ADR research to maximise the quality and impact of participant insight throughout the development of the design artefact.

The fully realised version of the DRC Framework artefact was produced using the initial conceptual version of the framework produced in the Problem Formulation Research Stage. A review of the outcomes of this stage during the reflection activity identified additional fields of investigation for a supplementary literature review. This reflective activity identified additional risks, participants and regulatory controls that were incorporated into an iterated version of the DRC Framework. A research workshop was conducted with the research participants to review and refine the drafted DRC Framework. The use of workshops for revising and testing the solution is a useful technique to test and revise prototypes of proposed solutions patterns (Gregor, Müller & Seidel 2013). See Figure 3-3.

Figure 3-3. Artefact co-design and review workshop

The BIE co-design workshop used the Nominal Group Technique (NGT) as the method of participant facilitation. The NGT workshop approach is considered useful for eliciting feedback from expert groups with varying degrees of seniority and extroversion (Dunham 1998; Harvey and Holmes 2012). NGT suited the recruited research participants due to their diversity of personality types and seniority and served to ensure participants' views and inputs were captured equally and each participant was given appropriate opportunity to challenge and vote on group outcomes. Using the NGT approach entailed first capturing a diverse view of the risks and control responses using an exercise where research participants silently documented their perspectives on key risks and controls, then using a silent group voting mechanism to structure these risks and controls into prioritised categories. Results were captured using individual survey forms and group whiteboard captures of both non-prioritised and group prioritised risks and control treatments. The workshop thus allowed participants to further refine and improve on the risks and control treatments captured in the initial regulatory control framework research artefact.

The integrated Intervention step involved the further development and refinement of the framework based on the learning outcomes from the initial Problem Formulation research workshop and regulatory expert feedback elicited through a structured questionnaire. During this research step, the research participant feedback led to the refinement of the conceptual DRC Framework to incorporate formalised aspects of risk management. The conceptual research artefact was reframed using the Risk Management framework of the ISO31000 Standard. This lens was acceptable to participants and was found to be useful in framing risks, control treatments and risk improvement outcomes. It was also useful in overlaying stakeholders and participants who were directly or indirectly impacted by the risks being controlled. Participants discussed the relative strengths and weaknesses of the identified control responses in a research practitioner workshop where decentralised governance risks and control responses were further reviewed and grouped. This step resulted in the refinement of a DRC Framework by representing the risks of the DLT operation in the financial system, categorised as either participant-specific or systemic risks and were mapped to the regulatory controls that mitigated DLT risks.

3.3.2.2 Additional Theory Generation

To enhance the theoretical contribution of the developed design artefact, the research incorporated additional theory generating research techniques. Such additional qualitative research techniques improve the theoretical contribution of the study by moving the overall analysis of the research output to a higher conceptual level (Beck, Weber & Gregory 2013).

During the Additional Theory Generation Research Step of the BIE Research Stage, further theoretical sampling was conducted to explore topics raised by participants during the initial Problem Formulation Research Stage. Such additional theoretical sampling maximises the value of insights from the initial analysis and enables theory to emerge through iterative

cycles of data collection and analysis (Urquhart, Lehmann & Myers 2010). Unstructured interviews were also conducted with the IS research method academic experts to review the early research outcomes and determine optimal ways to enhance the theoretical validity and practical relevance of the research artefact (Gregor 2006; Gregor, Kruse & Seidel 2020; Weber 2012).

A further qualitative research technique applied during this research step was the development of design principles and their incorporation into the DRC Framework. Such principles enable regulators to adapt existing control treatments and develop new controls to for application to broader regulatory contexts. The research implemented the design principle taxonomy developed by Gregor, Kruse & Seidel (2020) to allow prescriptive knowledge to be applied to a broad range of problems. This taxonomy-based design principle model incorporates into each design principle components of the aim, context, actors and mechanism to produce a justificatory rationale for the principle (Gregor, Kruse & Seidel 2020).

The development of design principles to develop and adjust regulatory controls adds to the theoretical contribution of the developed DRC Framework by enabling its application to a broader range of regulatory contexts. With the technological underpinning of distributed ledger technologies facilitating their rapid evolution (Ehrsam 2017), the incorporation of design principles supports the further generalisability and adaptability of the developed DRC Framework.

3.3.2.3 Expanded Research Participant Input (International Regulator and FinTech Experts)

The next research step of the BIE Research Stage was the extension of participant involvement in the research to include international fintech and DLT regulatory experts. Further interviews were conducted with the UK financial regulator, the UK Financial Conduct Authority (UK FCA) and fintech DLT technology experts. These unstructured interviews were followed up with structured questionnaires that were completed by the extended international participants. These participants were identified from their roles in international DLT standards development efforts. They were approached and recruited to participate in the research activity.

This research step proved instrumental in identifying further international financial system risk standards for consideration in the research study, including the 2014 guidance of the International Organization of Securities Commissions (IOSCO) on risk identification and assessment. The IOSCO risk framework for financial regulators identified risk categories that served to inform the risk categories incorporated into the developed DRC Framework. The interviews also identified additional risk control treatments for inclusion into the risk control treatments library of the refined research artefact.

3.3.2.4 Evaluation and Reflection

The next research step in the BIE Research Stage involved evaluation of the developed design artefact and incorporation of learnings and knowledge gained from continuous reflection throughout the research stage. The evaluation and reflection stage of ADR research is key to developing the theoretical contribution of the research. It achieves this by developing knowledge that is applied to conceptually extend a developed solution from an applied instance to a broader class of problems (Sein et al. 2011). Early incorporation of the evaluation of developed artefacts is similarly important to adjusting the developed design artefact to reflect the increasing understanding of the ensemble artifact (Sein et al. 2011). The evaluation and reflection activity incorporated into the research design allows new design artefact features to emerge as the research activity progressed through a process of feedback-based continuous reflection and learning (Gill & Chew 2019).

In this research stage, key research activities included research workshops with regulatory policy experts, distribution and submission of structured questionnaire responses, expert interviews and additional theoretical sampling. These collectively enabled continuous refinement of the DRC Framework to incorporate the increasing understanding and evolution of the research problem and solution.

Evaluation of the developed DRC Framework was undertaken iteratively throughout the BIE research stage. In the co-design research workshop participants discussed the risks of decentrally governed DLT systems and identified regulator control options. Control responses were further evaluated for efficacy by the workshop participants who were invited to critique the control options in structured questionnaires. The use of Nominal Group Technique workshop practices allowed controls to be identified and ranked among the workshop participants and this was used to refactor the subsequent versions of developed DRC Framework. After the co-design research workshop and questionnaire responses were completed, further interviews were undertaken with international policy and fintech experts' to extend the generalisability of the knowledge of the research problem and DRC Framework solution.

Throughout the BIE Research Stage, both the researcher and participants reflected on the research outcomes to ensure synthesis of knowledge into the developed design research artefact. This served to both improve the researcher's understanding of the design context factors and identify unsuccessful design components (Reymen & Hammer 2002). During this ongoing research activity, questionnaire responses were used to review the developed regulatory control response framework with the regulatory policy experts. Reflection emphasised participant learning outcomes from the initial research workshop, with participants encouraged to reflect upon insights and learning from earlier discussions (Haj-Bolouri, Bernhardsson & Rossi 2015). Participants and researchers posed and answered questions on the validity, usefulness and comprehensiveness of the research artefact. Ongoing

artefact and theory evaluation were further aided by the maintenance of a design log. See Figure 3-4. This record of iterative artefact designs served to further identify unsuccessful design components and document successful design components as they were developed and validated with research participants (Daudelin 1996).

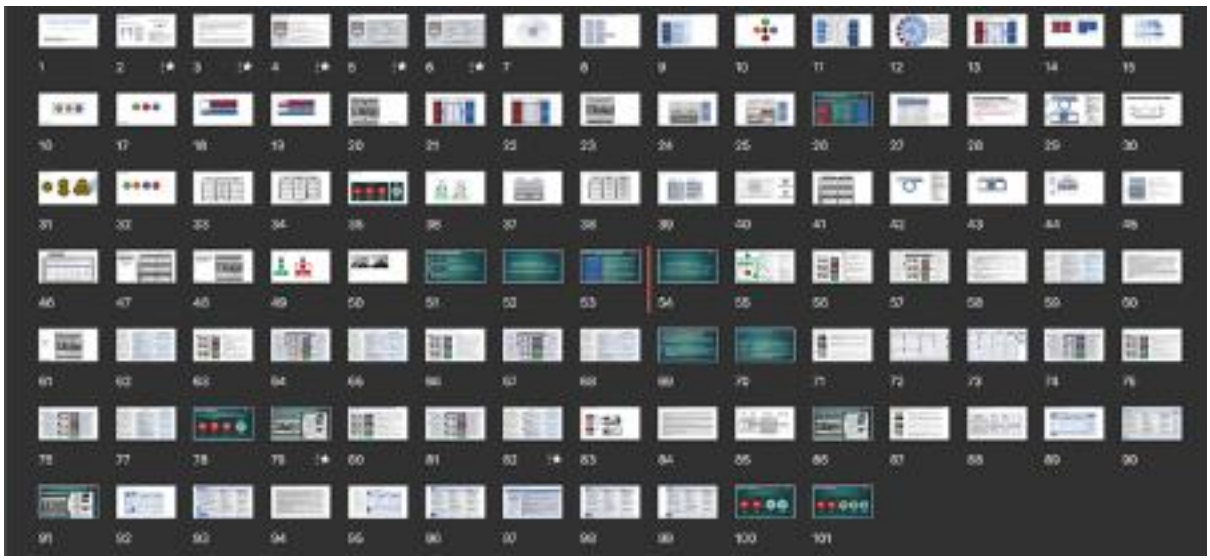


Figure 3-4. Research Design Log

The incorporation of reflective learnings from participants and additional theoretical sampling during this research stage enables anticipated as well as unanticipated insights to inform refinements of the design artefact, including the generation and evolution of design principles (Sein et al. 2011). The regulatory control design principles first developed in the Additional Theory Generation research step of the BIE Research Stage were further refined in the Evaluation and Reflections research activity by gathering and synthesising research participant feedback using a structured artefact evaluation questionnaire.

3.3.2.5 Formalisation of Learnings Research Stage

The final research stage is the Formalisation of Learnings stage. In this final stage of the research, the research contributions are constructed into a foundation for future research and integrated into the knowledge base to inform future initial research iterations (Gregor 2006). During this final stage, the refined regulatory control response framework was disseminated to the Australian CFR DLT Working Group and the Reserve Bank of Australia's DLT Working Group. This process step ensured participants were able to incorporate the outcomes of the research into ongoing financial regulatory DLT policy formulation. In this final phase of the research, participants were encouraged to further reflect upon insights and learning from the research and the developed DRC Framework and identify any further areas for artefact refinement.

To guide the regulatory practitioners in the implementation of the developed DRC Framework, a hypothetical implementation of the framework was developed in this research

stage. The scenario developed was the regulatory oversight of DLT systems enabling cross-border payments. In this scenario, the DRC Framework was implemented for a hypothetical cross-border payments scenario using the developed implementation guide.

3.4 Data Sources and Collection

Effective qualitative research adopts a mix of data collection methods, such as interviews, surveys and analysis of extant literature (Starks & Brown Trinidad 2007). By collecting data from diverse sources, researchers are better able to identify and analyse research problems and identify the need and direction of change warranted to address them (Dickens & Watkins 1999).

This study used an initial data collection survey directed to a select number of expert financial regulators in the Reserve Bank of Australia. Survey responses were used to develop and refine the questions to be used in subsequent interviews and participatory research workshops and provided an initial set of primary data to inform the development of the initial conceptual DRC Framework. Interviews, research workshops with regulatory policy experts and survey responses were also used as primary data sources. Memos produced by the researcher were used throughout the analysis to provide the function of an audit trail, documenting the emerging impressions of the meaning of data, and to track the emerging views of the research problem and solution (Cutcliffe 2000). The research design log provided a useful source of data to refer to during the continuous, iterative development of the DRC Framework.

During the Problem Formulation Research Stage, a participatory research workshop was conducted with expert research participants to solicit feedback on DLT risks and the research problem. During this workshop, the NGT research technique was applied to maximise the data extracted from participants and minimise the influence each participant had on other participants' contributions. A further survey was conducted at the conclusion of this workshop to gather additional primary data to further refine the co-designed DRC Framework and to ensure it addressed feedback and matters of concern to DLT regulatory experts.

During the later stages of the research, the primary data sources of interviews, research workshop and survey responses were combined with secondary sources including the supplementary research literature sampling to reach higher levels of abstraction and conceptualisation. This was achieved through incorporation into the framework of regulatory control design principles and expansion of the control library to accommodate the input gathered from interviews and questionnaires from the UK Financial Conduct Authority (FCA) and Australian and UK DLT product experts. This use of multiple slices of data

enables design research to reach higher levels of abstraction, increase the conceptual power of the developed theory and increase the impact of the developed design artefact (Beck, Weber & Gregory 2013).

3.4.1 Primary Data Sources

3.4.1.1 Interviews

Interviews are a primary method of collecting data that involves the presentation of verbal stimuli that elicit verbal responses (Kothari 2004). They are particularly useful as a qualitative source of evaluation of systemic variables such as ease of adoption, scalability and sustainability in design research (Collins, Joseph & Bielaczyc 2004). Kothari (2004) differentiates structured and unstructured interviews as varying in the flexibility of their approach to questioning and adherence to following a system of pre-determined questions. The research employed largely unstructured interviews as they are more conducive to collecting information in the case of exploratory or formulative research studies (Kothari 2004). These interviews enabled specific topics and matters that were within the domain and expertise of the interviewees to be explored in depth, including variation in the policy expertise, seniority and familiarity with research literature in the domain of DLT regulation. The benefits of using unstructured interviews include (Kothari 2004):

1. The ability to explore specific topics and domains of expertise of interviewees in greater depth.
2. The language used in the interviews was adapted to match the technical expertise and regulatory background of the interviewee (some of which had legal rather than technical backgrounds).

The use of interviews enabled the collection of supplementary information about the respondent's regulatory context. This was of significant value in analysing results as it aided the incorporation of regulators' experience in regulating of other technologies and managing financial crises.

Silverman (1993) notes that interviews may introduce reliability challenges as a result of interviewees interpreting interview questions differently. To address this risk, it is suggested that researchers consider the use of closed-ended questions. However, Silverman (1993) notes that open-ended questions allow interviewees to demonstrate their unique perspectives on research issues, enabling unanticipated matters and topics to be raised. As the research interviews were conducted during the exploratory and validating stages of the research, they

were conducted using open-ended questions and supplemented with structured questionnaires and research workshops to enhance the validity of the research outcomes.[1]

3.4.1.2 Questionnaires

A questionnaire consists of a number of questions presented in a defined order on a documented form or forms (Kothari 2004). The use of questionnaires as a source of primary data reduces the possibility of interviewer bias as the answers are in the respondents' own words and the interviewees have more uninterrupted time to complete their responses (Kothari 2004).

The weaknesses of questionnaire responses encompass their effectiveness being limited to where respondents are educated and co-operating, the lack of flexibility of amending the question approach once questionnaires have been distributed, and the possibility of ambiguous replies to questions (Kothari 2004). To address these considerations, Kothari (2004) recommends conducting a pilot survey to test the proposed questionnaire and identify any weaknesses. A pilot survey of the initial DRC Framework research questionnaire was developed and shared with a number of RBA research specialists. The feedback received allowed improvement to the questionnaire by identifying areas of ambiguity in questions and unclear instructions. These were then corrected before distribution to the recruited research participants from the CFR DLT Working Group.

3.4.1.3 Research Workshops

A series of research workshops were conducted with the research participants. The first of these workshops was conducted at the end of the Problem Formulation Research Stage to incorporate expert participant feedback into the research problem and the emergent view of DLT risks of concern to regulators. The output of this workshop was an initial conceptual design artefact. This conceptual artefact consisted of DLT risks, participants and regulatory control treatments. The initial artefact was a key input into the succeeding BIE Research Stage where the DLT Regulatory Control Framework was developed, evaluated and refined. A second research workshop was held during the BIE Research Stage to solicit research participant feedback and input into the developed DLT Regulatory Control Framework.

During the second DLT Regulatory Control workshop, the Nominal Group Technique was applied to identify and prioritise the regulatory controls that research participants determined were most effective in addressing the risks presented by decentrally governed DLT systems. In adopting the NGT approach to workshop facilitation, individuals were requested to silently

[1] Refer Appendix 1 and 3 for the questionnaires used for the research workshop and evaluation of the DRC Framework.

identify and list the controls they determined most effective in addressing DLT risks. Each participant then took turns to list each nominated control and took it in turns to present the controls they had identified. Once completed, the participants were able to ask questions to clarify the intent of the points made. The participants were then asked to silently and individually prioritise the controls presented. Once the individual nominations were presented, they were grouped, and the participants collectively discussed the groupings of the identified controls. The NGT approach ensured that each participant's unique perspectives were captured and discussed, reducing the chance that variations in seniority and personalities did not distort the outcomes of the collective group. Consensus was accordingly arrived at in terms of the clustered controls.

3.4.2 Secondary Data

Secondary data is data that is already available for research application, having already been collected and analysed by others (Kothari 2004). It can be either published or unpublished. Kothari (2004) notes several sources of published data, including:

1. Research literature publications
2. Technical and trade journals
3. Magazines and newspapers
4. Industry reports and publications
5. Public records and statistics
6. Historical documents
7. Other sources of published information

The study employed research publications, industry reports and journals, and some trade online commentary for blockchain and DLT technologies from influential blockchain pioneers.

3.4.2.1 Research Literature

The published research was searched in relation to the following research topics:

1. DLT and Blockchain Technologies
2. DLT and Blockchain Governance
3. Technology Governance (general)
4. Financial System Regulation
5. Technology Regulation
6. Regulation (general)
7. Emerging Technologies and Innovation
8. Financial System Risk Management
9. Technology Risk Management
10. Risk Management (general)

3.4.2.2 Industry and Policy Publications

DLT and blockchain technologies have generated significant technology sector interest as developers seek to release novel DLT systems to capitalise on investor interest and the known challenges facing specific industries. Significant market commentary exists in technical industry publications and blogs and provide some useful sources of industry-based discussion on the threats and opportunities presented by DLT systems. Consultants and professional service organisations who advise industry and government are also interested in developing value propositions for the use of DLTs and blockchain systems to address industry challenges. These entities also provide useful sources of secondary published material in the form of industry whitepapers and commentary on the possibilities, challenges and use cases of distributed ledger technologies. Central banks and financial regulators have also released a growing number of discussion papers and policy positions on the threats and opportunities presented to financial regulators and broader financial markets by the emergence of DLT systems. These papers provided a useful source of secondary published materials on the risks, opportunities and potential regulatory responses to the emergence of distributed ledgers in the global financial system.

3.5 Ethical Considerations

Researchers should be able to defend their actions and decisions at any time during their research process from an ethical perspective (Kimmel 1988). Ethical research practices is an important aspect of IS research, including IS research thesis development (Davison et al. 2001). Ethical research practices are particularly important where research involves data collection from people. IS research where data is collected from people that clear measures should be undertaken and documented to ensure an appropriate balance is achieved between the research method and achievement of research aims with the rights of participants (Kimmel 1988). Ethical considerations must therefore be balanced to ensure that the research design and the participants' ethical requirements are not compromised.

To ensure ethical research considerations were appropriately and fully followed, ethical research design and recommendations were sought from the UTS Graduate Research School and duly followed. The overall risk assessment of the research by UTS was determined as 'Low' per UTS HREC APPROVAL ETH18-3148. Specific controls were implemented to address the ethical considerations relevant for the nature of the research conducted. These encompass:

1. As the primary researcher was a senior officer in the industry case study, the RBA, invitations to DLT policy experts at the RBA were made by UTS research support staff at the UTS Faculty of Engineering and Information Technology. It was noted in

the invitations to participate in the research that staff were not obligated or required to participate in the research and that they would have the right to anonymity in any published research.
2. Written consent forms were submitted by RBA staff to UTS and not directly the primary researcher.
3. No staff reporting to the primary researcher's technology department at the RBA participated or were approached to participate in the research.
4. Information sessions were conducted with enrolling research participants to ensure that any concerns and issues were discussed and adjustments made accordingly to research design.
5. One such research adjustment was the assurance that the personal identification of research participants would not occur in any ensuing research publication.

The research ethics approval included the ethical considerations to which the researcher must adhere, which strongly enforced the privacy and confidentiality of the participants' identities and personal information, the storage and access procedures for the collected data, the usage of the collected data, the protection of any given responses from misrepresentation, and mechanisms for information disposal.

3.6 Chapter Summary

The research method adopted for this study aimed to ensure both the broader application of the developed design artefact through the development of a strong theoretical research foundation as well as practical relevance through the iterative co-design of the research artefact using DLT regulatory experts. This was achieved through the implementation of a participatory ADR approach augmented with additional theory-generating techniques to develop a DLT Regulatory Control Framework for Australian financial regulators that is both practically relevant and theoretically valid. It is anticipated the developed DRC Framework will be useful for Australian financial regulators and extendible to a broader class of non-Australian, non-financial system regulatory contexts.

4 DLT Regulatory Control Framework

This chapter presents the main contribution of the research, the DLT Regulatory Control Framework. The DRC Framework is a theoretically grounded and practical solution to the research question defined in Chapter 1. The DRC Framework aims to address the research gaps identified in Chapter 2, namely the provision of research guidance to financial regulators on the risks of decentrally governed DLT systems and regulatory control responses to mitigate these risks. The DRC Framework was developed using the participatory ADR method supplemented with additional theory-generating qualitative research techniques that was documented in Chapter 3. The developed DRC Framework is comprised of five components: 1) regulated parties; 2) DLT risks; 3) DLT regulatory control treatments; 4) residual risk outcomes; and 5) DLT regulatory control design principles. This chapter also incorporates a practical implementation template for use by regulators to guide the implementation of the DRC Framework in regulatory contexts.

4.1 DRC Framework Overview

This research has identified the lack of regulatory guidance on the regulatory controls that can be employed to mitigate the risks of decentrally governed DLT systems in the financial system. The analysis and review of relevant research and preliminary regulatory interviews identified the research problem that led to the main research question (Chapter 1). The first of the research questions relating to the identification of regulatory risks was answered in the literature review in Chapter 2 and has been the subject of previous publications (Benedict 2019). The second part of the research question relating to the identification of appropriate regulatory control treatments is also addressed in part by the literature review in Chapter 2. The third part of the research question relates to the design principles for regulators to define and adapt the regulatory controls to address the risks of decentrally governed DLT systems.

This chapter presents the developed DRC Framework. This framework builds on the literature review, the synthesised input and evaluation of the regulatory DLT experts and further theory-building qualitative research techniques to address the three-part research question (see Figures 4-1 and 4-2). The DRC Framework provides knowledge on regulatory controls available to financial regulators to address the risks introduced by decentrally governed DLT systems. The developed DRC Framework comprises five components:

- **Risks**: The framework addresses the risks that manifest to DLT participants as a result of the decentralised governance of DLT systems. Each identified risk category is comprised of atomic risks, each of which is mapped to a variety of risk dimensions that were informed by IOSCO financial system risk categories. Risks are categorised

as risks to DLT system users, risks to DLT system providers (DLT applications, platforms and infrastructure), and risks systemic to the regulated financial system.

- **Regulated Entities**: The DRC Framework identifies the participating classes of parties affected by the operation of DLT systems in the financial system. These parties were derived from the review of the existing literature and were refined during the co-design workshops with regulatory experts. The key parties identified in the research literature and by the regulatory experts as relevant to decentrally governed DLT systems are DLT system users and system providers. DLT system users partake in the services facilitated by a DLT system. DLT providers are identified as the providers of DLT applications, infrastructure or platforms. Other regulated financial entities that use or are otherwise impacted by the operation of DLT systems or the risks they introduce to the financial system in which they operate are also identified as relevant parties in the regulation of DLT systems.
- **Risk Control Treatments**: Risk control treatments were developed using the existing literature and were significantly enhanced through co-design activity with regulatory experts during the study's BIE Research Stage. Regulatory controls are grouped according to their treatment of risks relating to DLT participants or providers, or their categorisation as regulatory controls to address systemic financial system risks introduced by DLT systems.
- **Residual Risk Improvements**: Risk outcomes were defined according to the anticipated effect of control treatments applied against risks. It is important to note that a given risk reduction can be attributed to a compounding effect of a number of regulatory control treatments.
- **Design Principles for DLT Regulatory Controls**: A series of design principles were developed and refined to guide the development of ongoing risk control treatments. The adaption of regulatory controls is important in the context of DLT systems as such systems are the subject of significant innovation in the broader financial system.

Instructions

1. Regulators should identify the risks relevant to regulated entities and markets within their regulated authority
2. Regulators should identify the risk control treatments applicable to identified risks
3. Regulators use a risk-based approach to select a portfolio of risk control treatments to address unacceptable risks
4. Regulators can further optimize their risk-based approach to control treatments by adapting existing controls or introducing new control treatments through application of Design Principles for DLT Regulatory Controls
5. Regulators should assess and monitor risk landscape (risks, control effectiveness, residual risk improvements)
6. Regulators should continuously adjust risk assessments and control treatments

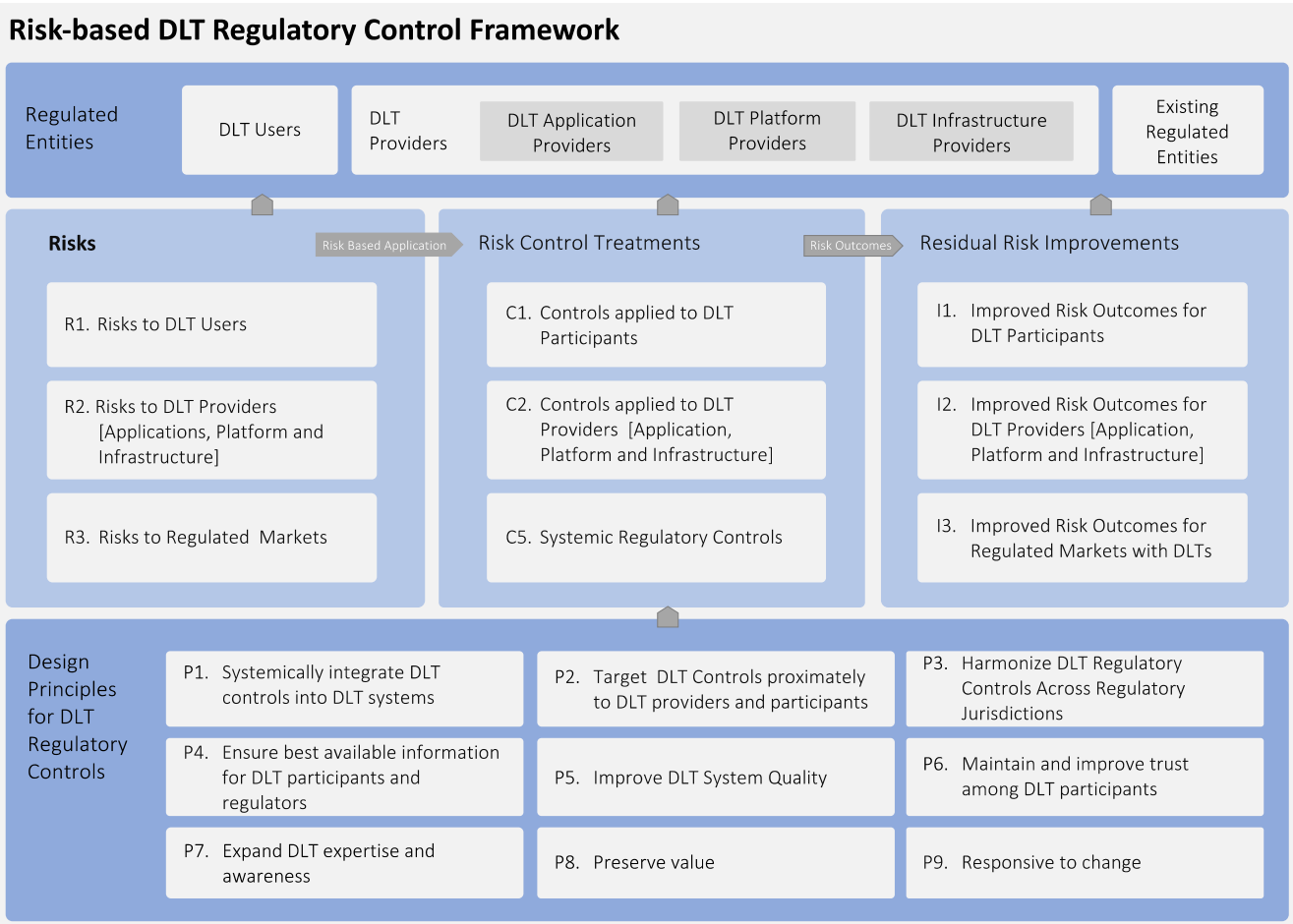


Figure 4-1. DLT Regulatory Control Framework (High Level)

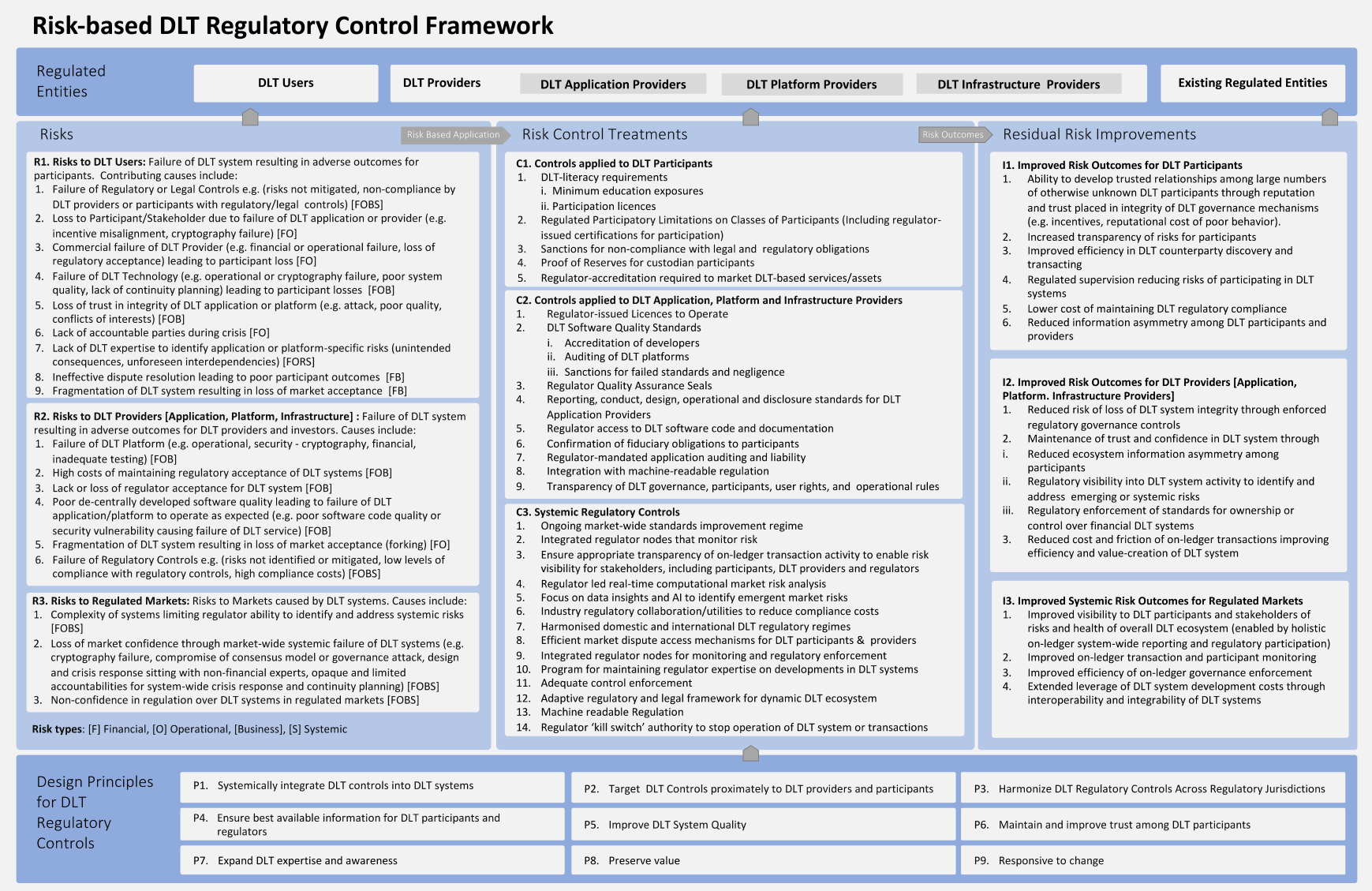


Figure 4-2. DLT Regulatory Control Framework (Detailed)

4.2 Risks

The review of the literature identified a range of risks associated with the DLT-enabled decentralization of governance in the financial system. These risks typically emerge as a consequence of the decentralisation of conventional centralised governance mechanisms and accountabilities. Research on technology governance has typically focused on the importance of clear accountabilities and decision rights typically invested in the executive or boards of organisations (Weill & Ross 2004). In the context of financial system regulation, such accountabilities and decision rights areas are particularly relevant when de-centrally governed DLT systems displace conventional intermediaries with distributed, often opaque decision-making authorities with unclear accountabilities (Atzori 2015). Emerging DLT systems demonstrating decentrally governed characteristics (such as Digital Autonomous Organisations or DAOs), have been identified as resistant to conventional punitive regulatory sanctions that rely on targeting regulatory sanctions at the directors and executives of organisations (Wright & De Filippi 2015). The literature also identified the loss of points of regulatory control leverage as a result of the displacement of intermediaries by decentralised DLTs in regulated environments (Benkler 2016).

With DLT systems only emerging in the last decade, there is very limited practical experience in the operation and regulation of DLT systems in mature regulated jurisdictions such as Australia. To develop a fuller view of regulatory control responses to DLT-enabled de-centralised governance, the input of DLT regulatory policy experts was incorporated in the co-design research steps of the study's BIE Research Stage. The incorporation of expert input enabled the extension of the initial research-grounded view of regulatory risks and control responses. In the initial research workshop held in the Problem Formulation Research Stage, the literature-derived regulatory risks and control responses were reviewed and discussed with the expert research participants. Individual participant responses were also solicited through structured questionnaires. Participant input was then synthesised, and refinements were made to the initial DLT Regulatory Control Framework artefact developed at the end of the Problem Formulation Research Stage.

The interviews with the DLT regulatory experts identified the value of categorising risks using the risk categories defined in the IOSCO framework for financial system risk management (IOSCO 2011, 2014). These were deemed appropriate to the financial regulation of emerging technologies such as DLT systems. See Table 4-1.

IOSCO Financial Risk Category	Number of Academic Research Publications Reviewed
Financial Risks	Risks comprising a variety of financially related credit and liquidity risks. Credit risks are those relating to a counterparty, whether a participant or other entity, or the failure of settlement banks, custodians, or linked financial market infrastructure entities, to meet their financial obligations when due, or at any time in the future (Marcacci 2012). Liquidity-related financial risks are those that a counterparty, whether a participant or other entity, will have insufficient funds to meet its financial obligations as and when expected, although it may be able to do so in the future. Liquidity risk can also arise from other sources, such as the failure or the inability of settlement banks, nostro agents, custodian banks, liquidity providers, and linked FMIs to perform as expected (Marcacci 2012).
Operational Risks	Risks of improper operation of trade processing or management systems resulting in financial loss. These risks encompass the risk of loss due to the breakdown in implementation and enforcement of controls. (IOSCO 1998)
Business Risks	The Bank for International Settlements defines business risks for financial market infrastructure entities as those risks related to the administration and operation of such entities as a business enterprise. General business risk refers to any potential impairment of the financial condition (as a business concern) due to declines in its revenues or growth in its expenses, resulting in expenses exceeding revenues and a loss that must be charged against capital. Reputation risks to such an entity can manifest as a business risk if it impairs its financial condition (BIS 2012).
Systemic Risks	The potential that an event, action, or series of events or actions will have a widespread adverse effect on the financial system and, in consequence, on the economy. Such systemic risks are not limited to sudden catastrophic events and may also take the form of a more gradual erosion of market trust (IOSCO 2014).

Table 4-1. ISOCO Systemic Risk Categories

The initial research workshop and participant interviews expanded on the literature-derived view of the risks of DLT-enabled de-centralised governance. Examples of the additional risks of decentrally governed DLT systems identified by regulatory experts include the risks of limited regulator expertise in distributed ledger and blockchain technologies, poor technology quality introducing latent weaknesses in the underlying DLT platforms, and the potential for

DLT adoption to introduce unforeseen, unmitigated flaws into financial markets. Discussions by regulatory experts in the initial risk workshop in the Problem Formulation Research Stage identified that the specific role of stakeholders influenced the risks and control treatments of regulator responses to de-centralised governance. Participants were identified as parties that used services or functions of the DLT system. DLT providers were defined as parties that provided core infrastructure, including DLT platforms such as Ethereum, upon which DLT applications were built and developed. DLT providers were also defined as including parties that provided applications built upon DLT platforms.

Table 4-2 articulates the risks of decentrally governed DLT systems and presents these risks according to their impact range (encompassing risks to DLT participants, providers and systemic risks) and categorises these risks according to the International Organization of Securities Commissions (IOSCO) risk categories for financial systems. The provenance of risk is presented, designating whether the risk was identified in research literature, by regulatory experts, or both.

R1. Risks to Participants: Failure of DLT system resulting in adverse outcomes for participants				
No.	**Risk**	**Description**	**Risk Category**	**Reference Source**
R1-1	Failure of regulatory or legal controls e.g. (risks not mitigated, low levels of compliance with regulatory/legal controls)	The failure of regulatory or legal controls may result in the realisation of the impacts of risks that such controls were targeted to mitigate. The impact of the failure of these controls will depend on the nature of the risks they treated.	FOBS	Regulatory Experts; Claessens & Kodres (2014)
R1-2	Loss to participant/stakeholder due to failure of DLT application (e.g., incentive misalignment, cryptography failure)	Participants and stakeholders in a DLT application may experience financial or operational loss if the DLT application fails. Such DLT application failure could be caused by technical (technology/cryptography failure), operational (service disruption) or incentive (incentive misalignment, excessive rent-seeking) factors.	FO	Regulatory Experts

R1-3	Commercial failure of DLT provider (e.g., financial or operational failure, loss of regulatory acceptance) leading to participant loss	A provider key to the provision of services to a DLT application or platform could experience a commercial failure, resulting in the cessation of service delivery to a DLT system and impacting the DLT application or platform's ability to continue operations.	FO	Regulatory Experts
R1-4	Failure of DLT (e.g., operational or cryptography failure, poor system quality, poor continuity planning) causes participant losses	Technology underpinning a DLT application or platform could fail, causing disruption to or cessation of operations. Potential sources of technical failure include poor system quality caused by unreliable infrastructure, poor application or platform technology quality and inadequately planned or tested DLT continuity testing.	FOB	Regulatory Experts
R1-5	Loss of trust in integrity of DLT application or platform (e.g., attack, poor quality, conflicts of interests)	The trust mechanisms underpinning a DLT application or platform may experience a loss of integrity through a successful attack, poor technology quality or conflicts among key DLT participants or providers.	FOB	Regulatory Experts
R1-6	Lack of accountable parties during crisis	Lack of central authority or otherwise identified accountable parties result in a DLT application or platform not being able to recover during a crisis.	FO	Regulatory Experts; Atzori (2015); Claessens & Kodres (2014)
R1-7	Lack of DLT expertise to identify application or platform-specific risks (unintended consequences, unforeseen interdependencies)	Limited participant expertise in DLT systems could result in participants being unable to identify and mitigate the risks inherent to a specific DLT application or platform resulting in them being inadequately prepared to mitigate the eventuality of such risks occurring.	FOBS	Regulatory Experts; Gozman, Liebenau & Aste (2020); Sajtos & Tőrös (2018)

R1-8	Ineffective dispute resolution leading to poor participant outcomes	DLT participants could experience financial or reputational loss as a result of DLT applications or platforms not being supported by effective and efficient dispute resolution capabilities to address disputes between DLT participants, or between DLT applications and platforms and extraneous third parties.	FB	Habermas (1989); Wright & De Filippi (2015);
R1-9	Fragmentation of DLT system resulting in loss of market acceptance	The fragmentation or proliferation of DLT variants could diminish the attractiveness of DLT applications and platforms, causing financial and reputation loss to participants who have a financial stake in their ongoing operation and success.	FB	Regulatory Experts; Luther (2016)
R2. Risks to DLT Providers				
R2-1	Failure of DLT platform (e.g., operational, security - cryptography, financial, inadequate testing)	Failure of technology or operational disruptions to a DLT platform could cause significant operational, financial and reputation risk to parties dependent on the operation of the DLT platform (including DLT application providers and participants).	FOB	Regulatory Experts
R2-2	High costs of maintaining regulatory acceptance of DLT systems	Burdensome cost of securing and maintaining regulatory acceptance can result in disincentive for DLT providers to introduce and maintain DLT systems.	FB	Regulatory Experts, Gozman, Liebenau & Aste (2020)
R2-3	Lack or loss of regulator acceptance for DLT system	The removal of or failure to receive regulatory acceptance or support resulting in the loss of investor or participant confidence, financial or reputation losses. Loss of regulator acceptability may also result in the loss of the right to operate in regulated environments.	FOB	Regulatory Experts

R2-4	Poor decentrally developed software quality leading to failure of DLT application/platform to operate as expected (e.g., poor software code quality or security vulnerability causing failure of DLT service)	Poor technology quality can lead to operational disruption or a loss of investor or participant confidence, leading to financial loss, disruption to operations, or reputational damage for investors and participants.	FOB	Regulatory Experts; Nyman & Lindman (2013)
R2-5	Fragmented DLT systems resulting in loss of market acceptance (forking)	The fragmentation or proliferation of DLT variants could diminish the attractiveness of DLT applications and platforms, causing financial and reputation loss to DLT application and platform providers, and financial losses to DLT participants who otherwise benefit from more active participation on a DLT application or platform.	FO	Regulatory Experts; Nyman & Lindman (2013)
R2-6	Failure of regulatory controls e.g. (risks not identified or mitigated, low levels of compliance with regulatory controls, high compliance costs)	Regulatory control design or implementation may not prevent significant costs or risks crystallising for DLT providers. Such controls can also potentially introduce risks and costs by requiring effort and expenditure that puts regulated DLT providers at a disadvantage to non-regulated DLT providers.	FOBS	Regulatory Experts, Gozman, Liebenau & Aste (2020); Gozman & Currie (2014)
R3. Systemic Risks to Markets				

R3-1	Complexity of systems limiting regulator ability to identify and address systemic risks (unintended consequences, unforeseen interdependencies)	The lack of knowledge and awareness of risks inherent in the design and operation of DLT applications and platforms and their market impacts can lead to the emergence of systemic risks that are only appreciated once they are too late to effectively mitigate after having crystallised and resulted in market instability.	FOBS	Regulatory Experts; Claessens & Kodres (2014); Sajtos & Tőrös (2018); Gozman, Liebenau & Aste (2020)
R3-2	Displacement of central control points	Conventional centralised regulatory control points, such as financial intermediaries are displaced resulting in the reduced effectiveness of regulatory controls.	S	Regulatory Experts; Benkler (2016)
R3-3	Resistance of DLT systems designs to regulatory sanctions	Characteristics of some DLT system designs, including decentralization and opaque identification of participants and providers, can render the regulators' ability to impose sanctions less effective.	S	Allen et al. (2017); Atzori (2015)
R3-4	Loss of market confidence through market-wide systemic failure of DLT systems (e.g., cryptography standards failure; compromise of consensus/governance model; unclear accountabilities for crisis response)	Loss of trust among market participants as a result of risks and issues associated with the design or operation of DLT applications or platforms that have materialised and resulted in losses for market participants and stakeholders.	FOBS	Regulatory Experts; Mallard, Méadel & Musiani (2014)

R3-5	Loss of confidence in regulatory or legal controls of use of DLT systems in regulated markets	The emergence or realisation of DLT-related risks and issues in markets despite the presence of regulatory controls resulting in the loss of confidence by market participants and DLT stakeholders in the efficacy of regulatory control regimes.	FOBS	Regulatory Experts; Abramaowicz (2016); Wright & De Filippi (2015)
R3-6	Emergence of unaccountable, oligarchic governance structures	The locus of control and authority underpinning decentrally governed DLT systems may be obtuse and result in the vesting of governance authority in entities that are not identifiable or otherwise within regulatory coverage.	S	Regulatory Experts; Abramaowicz (2016); Atzori (2015); De Filippi & Loveluck (2016); Shaw & Hill (2014)
Risk Categories: [F] Financial [B] Business [O] Operational [S] Systemic				

Table 4-2. Risks of DLT Enabled Decentralised Governance in the Financial System

4.3 Nascent Regulatory Control Design Principles

The research applied additional qualitative research techniques to increase the theoretical contribution of the developed DRC Framework. A key activity in the BIE Research Stage was the development of nascent design principles to inform the development and ongoing adjustment of regulatory risk control treatments. The development of abstracted design principles for DLT-system risk control treatments enhances the general applicability of the research to broader contexts and address unforeseen or uncertain future requirements as they evolve (Gregor, Kruse & Seidel 2020). This approach to theory abstraction raises the level of the theory developed and improves its quality by expanding the applicability of the developed theory to a greater range of problems (Weber 2012). The development of such nascent regulatory control design principles further expands the potential application of the regulatory control response framework beyond both Australian and financial system contexts. The flexibility of design principles to address abstract scenarios is considered particularly relevant given the early stage of DLT introduction into regulated financial systems. These nascent principles are intended to be subject to further analysis and future research.

Design principles provide a degree of flexibility through abstraction that can be useful to address unforeseen or uncertain future requirements as they evolve (Gregor, Kruse & Seidel

2020). The developed design principles are intended to guide the development and application of regulatory control treatments to address the risks of DLT-enabled decentralised governance. The abstraction of design principles further renders the general applicability of the principles for broader research contexts, in this case for potential applications beyond the Australian and financial system contexts in which the research was conducted.

The research applied the schema for developing DR principles by Gregor, Kruse & Seidel (2020). This approach to design principles incorporates its aims, actors, mechanisms and rationale into each design principle. Such taxonomical inclusions contribute to their ability to be applied by researchers and practitioners to novel classes of problems. See Table 4-3.

Number	Principle	Design Principle Schema Description
DP-1	Systemically integrate DLT controls into DLT systems	Regulators should integrate regulatory controls into the technical design and implementation of DLT systems functioning in regulated markets to increase the visibility of DLT risks and provide a lever for policy implementation
DP-2	Tailor DLT Controls more proximately to DLT providers and participants	Regulators should design and implement regulatory controls to be proximate to the provision and consumption of DLT services in regulated markets by minimizing control reliance on intermediaries to mitigate the risk of control points being displaced by decentralized DLT systems. In the context of regulatory controls, this principle entails that regulators shift their reliance from control levers such as the accountable leaders of regulated intermediaries and the withholding of intermediary operating licences and towards the users and providers of DLT systems.
DP-3	Harmonize DLT Regulatory Controls Across Regulatory Jurisdictions	Regulators should harmonize regulatory controls across regulated markets by ensuring controls are compatible and holistic in their coverage to minimize gaps in control coverage across global deployments of DLT systems.
DP-4	Ensure best available information for DLT participants and regulators	Regulators should require DLT applications and platforms operating in regulated markets to ensure the transparency of DLT activity and risks to reduce information asymmetry among stakeholders and reducing reliance on intermediaries for a timely, holistic understanding of DLT risks

DP-5	Continuously improve DLT System Quality	Regulators should ensure DLT system developers continuously improve the quality of the design, operation and governance of DLT systems. This will ensure the ongoing improvement of the DLT system technology, operations and governance quality and ensure they support the ongoing role of a DLT system in underpinning key functions in regulated markets
DP-6	Maintain and improve trust among DLT participants-	Regulators should implement controls requiring DLT developers to foster trust among DLT participants through the design, operation and governance of DLT systems to minimise the likelihood of DLT risks manifesting to adversely affect market integrity and confidence
DP-7	Expand DLT expertise and awareness	Regulators should ensure regulatory policy experts responsible for supervising markets impacted by the adoption of DLT systems should develop their expertise in DLT systems to minimise the likelihood of unforeseen or unmitigated risks jeopardising market stability and confidence
DP-8	Preserve value	When designing and implementing controls, regulators should not unnecessarily reduce the value generated by DLT systems for stakeholders by evaluating the impact of control treatments on the value otherwise created by a DLT system for DLT system participants and broader stakeholders.
DP-9	Responsive to change	When designing and implementing controls, regulators should seek to reduce the impact of such controls on the ability of a DLT system to adapt and respond to changing DLT system participant requirements and environmental conditions.

Table 4-3. Nascent Design Principles for DLT Regulatory Risk Control Treatments

4.4 Regulatory Controls

A second participative co-design workshop was conducted in the BIE Research Stage with research participants to provide input on the risks and control treatments represented in the developing DRC Framework. The second participant workshop identified and reviewed the regulatory controls that could be levered in response to the identified risks of decentrally governed DLT systems. The nominal group technique (NGT) was applied to solicit individual input from the research participants and was then discussed collaboratively among the participants. The NGT technique was identified from the literature and consultations with IS research method experts as an effective mechanism for involving stakeholders as co-researchers (Beck, Weber & Gregory 2013; Dunham 1998). The NGT-based co-design

workshops engaged participants to identify, elaborate, discuss and then vote for their preferred regulatory control responses. Voting was conducted, and grouping and consolidation of controls conducted to cluster controls into related control response themes. The evaluation phase was concluded through an immersed session of reflection, encapsulating and translating the collective experience of expert participants into explicitly described DLT risks and control treatments. Research participants discussed the value of the design guidelines in the research workshops.

The regulatory controls identified during the second co-design research workshop included a range of measures that regulators would target at DLT participants and providers, as well as embed within the general framework for financial system regulation. The key control measures defined include the mandated need for DLT participants to subscribe to specific levels of educational exposure subject to the risk nature of the DLT services in which they participated, the issuance of regulator licences for specific classes of DLT providers, the assurance of DLT quality standards, and the integration of regulator nodes within DLT systems to provide visibility of market activity and emergent market risks. See Figure 4-3.

Figure 4-3. Research Workshop Outcomes on DLT Regulatory Control Responses

A further regulatory control that was identified in the interviews with international regulators at the UK Financial Conduct Authority and which had not been commonly applied in the Australian financial system regulatory context was a regulator 'emergency stop' control to enable financial system regulators to execute a stop instruction on the execution of a specific activity on a DLT application or platform. This control ostensibly serves to prevent risk realisation to a participant, participants or the broader financial system as a result of the

ongoing operation of a DLT-related function. These control recommendations were informed by global DLT and financial system regulatory experiences.

The developed risk control treatments were mapped against the developed design control principles to ensure their alignment to principles and to ensure there were no control gaps against the required principles. No gaps in the design principle coverage were identified, further contributing to confidence in the comprehensiveness of the developed framework. When implementing the DRC Framework, regulators should map the proposed regulatory controls to the framework's regulatory control design principles to maximise the control efficacy of the portfolio of regulatory controls proposed for application in specific regulatory contexts. See Table 4-4.

C1. Controls applied to DLT Participants				
No.	**Regulatory Control Treatment**	**Description**	**Risks**	**Control Design Principle**
C1-1	DLT-literacy requirements	DLT literacy requirements will require participants to have demonstrated specific levels of knowledge and awareness of DLT systems and their risks before being permitted by regulators to participate in their operation. Regulators can specifically target participation license controls on DLT participants that are covered by existing regulatory regimes, such as regulated financial parties such as banks and financial market operators. Regulators can also target participatory controls to end users of DLT applications or platforms by requiring they can demonstrate levels of knowledge on the function and risks associated with DLT participation.	R1.2, R1.4, R1.5, R1.7	P4, P7
C1-2	Regulated Participatory Limitations on Classes of Participants (including regulator-issued certifications for participation)	Certain classes of participants, including those currently regulated for participation in regulated environments such as the financial system, are subject to controls on participation in DLT systems. These controls could take the form of licences or regulator authority to participate and are subject to meeting specific requirements such as documenting participatory activities, reserves set aside for potential future losses to third parties and DLT or broader market stakeholders, and legal accountabilities for executives or other individuals associated with participation in the DLT system. Such licences to participate could be withdrawn in the event of behaviours or activities that demonstrate negative behaviours or poor governance over participation in a DLT system and its role in a broader regulated system.	R1.7	P7, P8

C1-3	Participant sanctions for non-compliance with legal & regulatory obligations	DLT system users are the target of specific regulator controls or legal sanctions as a result of on-ledger or off-ledger behaviours or activities that contravene legal or regulatory requirements as they related to users of DLT systems, or broader user participation in regulated environments. The targeting of users as a lever for regulatory controls may be required if conventional intermediaries are disintermediated by decentralised DLT systems.	R1.1, R3.3	P2, P6, P7, P8
C1-4	Proof of Reserves for custodian participants	DLT participants who purport to hold reserves of value on behalf of other participants or as a function of their own role in DLT applications or platforms are required to verifiably produce proof of reserves to ensure the ongoing integrity and trust of value transactions conducted across DLT systems.	R1.2, R1.3, R2.2	P1, P2, P6, P8
C1-5	Regulator-accreditation required to market DLT-based services/assets	Regulators can require DLT participants who market DLT-based services and assets to meet specific regulator-enforced criteria achieve accreditations required to conduct such marketing activities in regulated environments.	R1.1, R1.2, R1.9, R2.5	P2, P5, P6, P8
C2. Controls applied to DLT Application, Platform and Infrastructure Providers				
C2-1	Regulator-issued Licenses to Operate	Regulators will issue licences to operate as a DLT application or platform provider in regulated environments such as the financial system. Licensing is a control level to enforce specific regulator-imposed requirements such as transparency of governance, equity, accountability and decision rights within DLT systems. Failure to obtain, or withdrawal of operating licences is a sanction that will deny DLT systems the ability to operate in regulated environments and legally gain access to DLT participants.	R1.1, R1.2, R1.9, R2.2, R2.5	P2, P5, P6
C2-2	DLT Software Quality Standards i. Accreditation of developers	DLT software quality standards will require the developers of DLT applications and platforms to ensure adequate system quality and risk mitigation measures are implemented into DLT system design.	R2.1, R2.3, R2.4	P1, P2, P5,

	ii. Auditing of DLT platforms iii. Sanctions for failed standards/negligence	i. Developers are appropriately qualified, trained and ethically aware – achieved through standards that are recognised and demonstrated through developer accreditation. ii. DLT platforms and applications are audited by third parties to provide assurance of technology quality standards and other operational and governance standards. iii. DLT applications and platforms that fail defined standards are subject to regulatory and legal sanctions, including the loss of operating licences, additional market participation requirements such as increased reserve balances, and removal from accredited provider lists. Such standards can either be determined by generally accepted software quality standards (e.g., IEEE or ISO standards), or standards specific to DLT platforms.		
C2-3	Regulator Quality Assurance Seals	Regulators or other standards quality authorities such as professional or industry bodies can issue quality assurance seals to DLT applications and platforms that meet ongoing quality standards. This will increase participant confidence in DLT systems and overall trust and confidence in the regulated environments in which they participate.	R2.1, R2.4, R2.6	P5, P6
C2-4	Reporting, conduct, design, operational and disclosure standards for DLT Application Providers	Standards to manage the conduct of DLT application providers in relation to reporting, disclosure, conduct, operational and design requirements. These will establish base requirements in these areas while also ensuring outcomes deemed inappropriate in these fields are more easily detected, discouraged, and censured.	R1.2, R1.3, R1.4, R1.5	P5, P6, P8
C2-5	Regulator access to DLT code and documentation	Regulator access to DLT code and documentation will allow for independent testing for software weaknesses and quality issues. It will also enable designs considered inappropriate to be detected and redressed through regulator intervention.	R2.1, R2.3, R2.4,	P1, P2, P5, P6, P9

C2-6	Confirmation of fiduciary obligations to participants	Requiring DLT application and platform providers to clarify their fiduciary responsibilities to DLT participants ensures that participants and DLT providers are aware of obligations and responsibilities. In some cases, it will also clarify where such obligations do not exist, allowing participants to assess risks and address them more effectively or otherwise accept them.	R1.2, R1.3, R1.4	P6, P7
C2-7	Regulator mandated application auditing	Requiring DLT applications to be subjected to audits on their operations, governance, design and relevant continuity and investor and participant protections, will increase confidence of current and future DLT participants by reducing and increasing the transparency of relevant DLT risks.	R1.7, R2.1, R2.4	P5, P6, P8
C2-8	Integration with machine-readable regulation	Providing machine-readable regulation that can be integrated into DLT systems will ensure increased compliance with regulatory requirements and provide regulators with improved visibility and transparency of DLT operations and risks.	R2.3, R2.4	P1, P2, P4, P4, P9
C2-9	Transparency of DLT governance, participants, user rights and operational rules	Requiring DLT application and platform providers to provide transparency of the governance, rights and operational rules applying to DLT systems will improve the ability of regulators and participants to assess DLT risks and the adequacy of implemented controls.	R1.2, R2.6	P1, P2, P4, P6, P7, P9
C3. Systemic Regulatory Controls for Markets with Decentrally Governed DLT Systems				
C3-1	Ongoing market-wide standards improvement regime	The dynamic nature of DLT innovation and market adoption will benefit from an ongoing focus on continuous improvement of standards on DLT operation in regulated markets. This continuous improvement regime for standards will ensure inefficiencies and systemic risks are less likely to accumulate over time and instead can be address efficiency and regularly as they are realised and evolve.	R1.2, R2.4, R3.1, R3.2, R3.3	P3, P4, P5, P6, P7, P8, P9

C3-2	Integrated regulator nodes for DLT systems that monitor risk and can execute transactional 'stop orders'	Integrating regulator nodes into DLT applications and platforms will ensure regulators are able to form a market-wide view of DLT-related risks and activities, improving the timeliness of any control response they identify, as well as rendering the implementation of such controls more effective.	R2.6, R3.2, R3.3	P1, P2, P4, P5, P6, P8, P9
C3-3	Ensuring transparency of on-ledger and off-ledger activities to make risks visible to participants, investors, platform providers and regulators	Transparency of on-ledger DLT activity deemed as contributing to the overall risk profile of a DLT system allows stakeholders to identify, detect and mitigate risks that may otherwise contribute to the realisation of loss or harm to parties.	R1.2, R2.6, R3.1, R3.2, R3.3	P1, P2, P4, P5, P6, P7, P8, P9
C3-4	Regulator led real-time computational market risk analysis	Regulatory analysis of known and emerging risks within a DLT application or platform using computational means is able to detect emerging systemic risks in a manner than allows for their prevention and mitigation.	R1.2, R2.6, R3.1, R3.2, R3.3	P1, P2, P4, P5, P6, P7, P8, P9
C3-5	Focus on data insights and AI to identify emergent market risks	Regulatory use of AI to identify and measure DLT-related risk exposures in markets will enable earlier market interventions by regulators to prevent the realisation of systemic market risks.	R1.2, R3.2	P1, P4, P5, P6, P7, P8, P9
C3-6	Industry regulatory collaboration/utilities to reduce compliance costs	Collaboration between multiple parties including regulators and industry participants to lower the per-participant cost of regulatory oversight over systemic DLT-related risks and enable collaborative information gathering and risk-analysis, improving its quality and effectiveness in managing systemic DLT-related risk.	R1.3, R3.1, R3.2, R3.3	P1, P4, P5, P6, P8, P9

C3-7	Harmonised domestic and international DLT regulatory regimes	Harmonised regulatory controls across both domestic and international regulatory boundaries reduces the likelihood of jurisdictionally spanning DLT applications and platforms introducing risks that are not visible or obvious to individual regulatory authorities. Co-ordinated regulation also reduces the overall cost of regulation for both DLT participants and providers by reducing the need to fund diverse regulatory response regimes.	R1.2, R1.3, R3.1, R3.2, R3.3	P3, P4, P5, P6, P8, P9
C3-8	Efficient market dispute access mechanisms for DLT participants and providers	Efficient dispute mechanisms increase the perceived trust and confidence placed by DLT participants and investors in markets containing DLT systems and reduces the ongoing costs of participating in those systems.	R1.1, R1.2, R1.3, R3.1, R3.2, R3.3	P1, P2, P3, P6, P8, P9
C3-9	Integrated regulator nodes to monitor and enforce regulations on DLT systems	Integrating regulator nodes into DLT applications and platforms increases the ability of regulators to assess and manage risk within systems and markets and increases the confidence of participants and investors in those DLT systems and markets.	R1.1, R3.1, R3.2, R3.3	P1, P2, P3, P4, P5, P6, P7, P8, P9
C3-10	Program for maintaining regulator expertise on developments in DLT systems	The ongoing development of regulator expertise in DLT technologies, systems and their market implications reduce the likelihood of new or existing risks to develop and realise the ways which jeopardise individual DLT systems and the markets in which they operate.	R3.1, R3.2, R3.3	P4, P5, P6, P7, P8, P9
C3-11	Adequate control enforcement	Ensuring regulatory controls are adequately enforced ensures the risks for which the controls are established are being appropriately mitigated.	R1.1, R3.2, R3.3	P2, P6, P8
C3-12	Adaptive regulatory and legal framework for dynamic DLT ecosystem	Dynamic, adaptive regulatory and legal control frameworks ensure that risk management controls keep pace with the rapid innovation associated with the development and market adoption of DLT technologies and the concepts they enable. It also reduces the risk of such controls preventing the efficient implementation of new innovations into regulated markets.	R3.2, R3.3	P3, P4, P5, P6, P7, P8, P9

C3-13	Machine readable regulation	Ensuring DLT regulation is machine readable reduces the cost of testing and complying with an evolving regulatory framework and increases the rate at which new regulations can be rolled out and rendered effective.	R3.1, R3.2, R3.3	P1, P2, P4, P6, P7, P8, P9
C3-14	Regulator 'kill switch' authority to stop operation of DLT system	Allowing regulators to stop a transaction, a series of related transactions, or DLT system operation can prevent an unlawful transaction from persisting and minimise the effect of contagion in a regulated financial system. Early intervention can avoid significant cost and complexity associated with unwinding damage across the broader financial system.	R1.2, R1.3, R1.5, R2.2, R3.1, R3.2, R3.3	P1, P2, P6, P8, P9

Table 4-4. Risk Control Treatments for DLT-enabled Decentralized Governance in the Financial System

4.5 Risk Improvements

Improvements to residual risks are established through the full or partial treatment of risks by identified regulatory controls. The impact of regulatory controls on risks were identified from the review of the literature, from abductive analysis and then discussed in the second co-design research workshop conducted with regulatory expert participants during the BIE Research Stage. The risk improvement outcomes of the application of regulatory control treatments to identified DLT risks are presented in Table 4-5. The risk improvements are grouped according to the DLT participant group and are mapped to regulatory control treatments. These control treatments themselves affect the impact of specific risks.

No.	Risk Improvement	Description	Control Treatments
I1 – Improved Risk Outcomes for DLT Participants			
I1-1	Ability to develop trusted relationships among large numbers of otherwise unknown DLT participants through reputation and trust placed in integrity of DLT governance mechanisms (e.g., incentives, cryptography, reputational cost of poor behavior).	DLT governance and reporting mechanisms, including cryptography and transparency of DLT-enabled transactions allows trust and integrity to be established between participants without previous transactional history. This obviates the need for intermediaries who have conventionally established trust over large numbers of unknown parties that do not otherwise possess trust-based relationships.	C1-1, C1-2, C1-3, C1-4, C1-5, C2-1, C2-2, C2-3, C2-4, C2-5, C2-7, C2-9, C3-8, C3-11, C3-14
I1-2	Increased transparency of risks for participants	Disclosure, access to information and transparency of activities and interests contributes to enabling DLT participants to form more informed views of the risks inherent to DLT-enabled transactions and relationships.	C2-4, C2-5, C2-7, C2-9, C3-2, C3-3, C3-4, C3-5, C3-9
I1-3	Improved efficiency in DLT counterparty discovery and transacting	Contribution to the overall efficiencies with which participants, DLT applications and platforms and the markets in which they operate, are able to discover, identify and manage counter-party risks and are associated with conducting DLT-enabled transactions or activities.	C1-5, C2-1, C2-2, C2-3, C2-4, C2-9, C3-3, C3-7, C3-8

I1-4	Regulatory supervision reducing risks of participating in DLT systems	Regulatory supervision can efficiently mitigate some of the risks of participating and investing in DLT applications and platforms, efficiently lowering the risks of participation in DLT systems.	C1-4, C1-5, C2-1, C2-2, C2-3, C2-4, C2-5, C2-6, C2-7, C2-8, C2-9, C3-1, C3-2, C3-3, C3-4, C3-5, C3-9, C3-10, C3-11, C3-12, C3-14
I1-5	Lower transactional costs for DLT participation through technology integration lowers frictions and increases velocity of complex multi-party transactions	Technical integration of regulatory supervision in DLT applications and platforms lowers the costs of overall risk supervision and its ability to detect emergent risks to participants, DLT applications and platforms, and markets in a timely manner.	C2-2, C2-3, C2-5, C2-8, C3-2, C3-9, C3-13
I1-6	Reduced information asymmetry among DLT participants and providers	Information transparency and regulatory oversight reduces the risk of significant information asymmetries emerging in DLT applications, platforms and the markets in which they operate. Reduction of information asymmetries reduces the likelihood of participants experiencing losses due to significant imbalances of risk information in favour of privileged DLT participants.	C1-1, C2-2, C2-4, C2-5, C2-7, C2-9, C3-2, C3-3, C3-9
I2 – Improved Risk Outcomes for DLT Providers			
12-1	Reduced risk of loss of DLT system integrity through enforced regulatory governance controls	The effective operation of regulatory controls designed to assure systemic stability and integrity reduces the chance of instability in regulated markets containing DLT systems.	C1-1, C1-3, C1-4, C1-5, C2-1, C2-2, C2-3, C3-11, C3-14

I2-2	Maintenance of trust and confidence in DLT system through i. Reduced ecosystem information asymmetry among participants i. Regulatory visibility into DLT system activity to identify and address emerging or systemic risks i. Regulatory enforcement of standards for ownership or control over financial DLT systems	Efficacy of controls designed to ensure minimal information asymmetry among DLT participants, regulator visibility into systemic activity to detect emergent risks, and effective regulatory enforcement of systemic regulatory market controls each contribute to the trust, confidence and overall integrity attributed to a DLT system by DLT participants, stakeholders, investors, and broader regulated market participants.	C1-1, C1-2, C1-3, C1-4, C1-5, C2-1, C2-2, C2-3, C2-4, C2-5, C2-6, C2-7, C2-8, C2-9, C3-1, C3-2, C3-3, C3-4, C3-5, C3-8, C3-9, C3-10, C3-11, C3-12, C3-14
I2-3	Reduced cost and friction of on-ledger transactions improving efficiency and value-creation of DLT system	Efficient regulatory monitoring, supervision, and control enforcement through on-ledger regulator integration contributes to more efficient and effective regulation, reducing overall costs to DLT system and market participants and increasing the effectiveness of regulatory oversight.	C2-8, C3-8, C3-13
I3 – Improved System Risk Outcomes for Regulated Markets containing DLT Systems			
13-1	Improved visibility to DLT participants and stakeholders of risks and health of overall DLT ecosystem (enabled by holistic on-ledger system-wide reporting and regulatory participation)	Broad and effective regulator visibility of DLT-related risks inherent in regulated markets improves the ability of regulators to identify and mitigate emerging and systemic risks before they crystallise to jeopardise the stability or integrity of regulated markets.	C1-4, C2-2, C2-4, C2-5, C2-7, C2-8, C2-9, C3-1, C3-3, C3-4, C3-5, C3-9

I3-2	Improved on-ledger transaction and participant monitoring	Regulator access to on-ledger transactions allows regulators to monitor and supervise on-ledger activity and participant behaviour. System-level access affords greater opportunities for regulators to conduct deep analysis for emergent risks and unsanctioned on-ledger activity. This allows the improved detection and identification of risky behaviours and appropriate mitigations or sanctions to be put in place. The adoption of such monitoring also contributes to trust and confidence in regulated DLT applications and platforms and the markets in which they operate.	C1-3, C2-4, C2-7, C2-9, C3-2, C3-3, C3-4, C3-5, C3-9
I3-3	Improved efficiency of on-ledger governance enforcement	On-ledger governance enforcement if conducted efficiently can reduce the cost of regulation, and efficiently engender trust and confidence in the markets in which these systems are regulated.	C2-2, C2-3, C2-5, C2-7, C2-8, C3-2, C3-3, C3-4, C3-5, C3-9, C3-13
I3-4	Extended leverage of DLT system development costs though interoperability and integrability of DLT systems	Encouragement of interoperability among DLT systems extends the leverage of DLT development costs across regulated markets and maximises value from those investments as regulatory compliance costs can be distributed across multiple harmonised regulatory jurisdictions. This is achieved through the reduction of one-off regulatory compliance costs to cater to specific jurisdictional requirements.	C2-2, C3-6, C3-7, C3-10

Table 4-5. Risk Improvements from Regulatory Control Treatments

4.6 Implementation of the DRC Framework

This section presents the steps developed to guide regulators in the implementation of the DRC Framework in a financial system context. The DRC Framework is presented section 4.1 above and is comprised of specific risks, regulated entities, risk control treatments, residual risk improvements and design principles for DLT regulatory controls.

The benefit of providing the following DRC Framework implementation steps was highlighted by research participants in the second co-design research workshop. The Implementation Process is a procedure designed to guide Australian financial system regulator practitioners in the practical planning and implementation of the DRC Framework. The DRC Implementation Process comprises five steps:

1. Initiation of Regulatory Assessment
2. Development of Regulatory Control Portfolio
3. Adaption and Development of Regulatory Controls
4. Deployment
5. Management and Administration

Each step has three elements:

i. Step Goal
ii. Step Checklist
iii. Step Review

4.6.1 Initiation of Regulatory Assessment

Goal: To perform contextual analysis of the current regulatory environment to regulate the operation of decentrally governed DLT systems in the financial system and determine whether the regulator should proceed with adopting the DRC Framework. See Table 4-6.

Checklist:

No.	Activity	Description
1	*Define regulatory jurisdiction*	What are the regulatory accountabilities and jurisdiction of the financial system regulator (domestic and international)?
2	*Define regulatory ecosystem*	What are the jurisdictional and regulatory accountabilities of other relevant financial system regulators (domestic and international)?
3	*Determine regulatory overlap and gaps relating to DLT systems*	What are the gaps and overlaps of regulatory coverage relating to the operation of DLT systems in the financial system being regulated?

4	*Determine the regulator's DLT expertise*	What is the level of expertise of the regulator in DLT systems, risks and controls (limited, moderate, advanced)?
5	*Determine DLT regulatory control concepts*	What regulatory control concepts are applicable to the regulation of DLT systems in the regulator's jurisdiction (participants and stakeholders, risks, control treatments, residual improvements, control design principles)?
6	*Determine DLT system context*	What DLT systems are potentially relevant to the regulator's jurisdictional accountabilities (applications, platforms, infrastructure)?
7	*Define the regulatory control response framework*	What regulatory control framework will be adopted (e.g., DRC Framework?)

Table 4-6. Initiation Checklist

Review: Regulators can decide to implement the DRC Framework based on the review of the Initiation Checklist outcomes.

4.6.2 Development of Regulatory Control Portfolio

Goal: To develop a portfolio of regulatory control responses to treat the risks of decentrally governed DLT systems in the financial system. See Table 4-7.

Checklist:

No.	Activity	Description
1	*Identify accountable regulators*	Which regulator(s) is/are accountable for the relevant regulatory controls relating to the operation of DLT systems in the financial system being regulated (nb. regulatory coverage may overlap in specific domains)?
2	*Identify the process for regulatory control management*	What is the process for defining regulatory controls in the financial system being regulated?
3	*Identify DLT providers*	Who are the key DLT providers in the financial system being regulated?
4	*Identify DLT participants*	Who are the key DLT classes of participants in the financial system being regulated and what regulatory jurisdictions to they fall under?
5	*Identify relevant DLT stakeholders*	Are there any other relevant DLT stakeholders in the financial system being regulated (i.e., those stakeholders not already participating in DLT systems)?

6	*Identify DLT platforms & applications*	What are the current and emerging DLT platforms and application classes operating in the financial system being regulated?
7	*Define portfolio of known DLT risks*	What are the *known risks* relating to the operation of decentrally governed DLT systems in the financial system being regulated?
8	*Define existing financial regulatory controls*	What are the *existing regulatory controls* which are relied on to treat the risks relating to the operation of decentrally governed DLT systems in the financial system being regulated?
9	*Assess efficacy of existing regulatory controls*	What are the *mitigatory impacts* of existing regulatory controls that treat the risks relating to the operation of decentrally governed DLT systems in the financial system being regulated?
10	*Determine usability*	Who will use the DRC Framework and for what purposes?
11	*Determine version control*	Which version of the DRC Framework is being used (version control management) and what is the history of changes to the DRC Framework being used?

Table 4-7. Development of Regulatory Control Portfolio Checklist

Review: Regulators can implement the DRC Framework based on the completion of the checklist. The completion of the checklist will inform whether it is feasible to implement the DRC Framework to guide the regulator's control response to the risks of decentrally governed DLT systems in the financial system. DLT developers and providers can review the DRC Framework to accommodate the likely control responses of the regulators in the design and operation of the DLT systems they operate in the regulated financial system.

4.6.3 Adaption and Development of Regulatory Controls

Goal: To adapt and develop regulatory controls to treat the risks of decentrally governed DLT systems in the financial system. Regulators identify and select regulatory controls to either develop due to a lack of regulatory coverage or adapt where regulatory coverage can be improved through the adjustment of existing controls. Regulators use the Regulatory Control Design Principles to optimise controls to achieve the desired risk treatment and resulting target residual risk. Updated controls are reflected in the adapted DRC Framework. See Table 4-8.

Checklist:

No.	Activity	Description
1	*Identify regulatory control owner*	Who is accountable for the relevant regulatory control relating to the operation of DLT systems in the financial system being regulated (nb, there may exist multiple regulatory owners for different regulatory controls)?
2	*Identify the process for regulatory control management*	What are the processes for developing and implementing the specific regulatory controls in the financial system being regulated?
3	*Identify relevant regulatory control design principles*	What regulatory control design principles are relevant to the development or adaption of a specific DLT regulatory control?
4	*Define portfolio of adapted regulatory control treatments*	What are the *regulatory controls proposed* to treat the risks relating to the operation of decentrally governed DLT systems in the financial system being regulated?
5	*Identify anticipated impact of proposed regulatory controls*	What are the *anticipated mitigatory impacts* of the proposed regulatory controls that treat the risks relating to the operation of decentrally governed DLT systems in the financial system being regulated?

Table 4-8. Control Adaption and Development Checklist

Review: Regulators can use the DRC Framework to both develop new regulatory controls or adapt existing ones using the checklist. The checklist will ensure regulators are managing the development and adaption of regulatory control responses to decentrally governed DLT systems in a structured and repeatable manner.

4.6.4 Deployment

Goal: To deploy regulatory controls adapted and developed using the DRC Framework to treat the risks of decentrally governed DLT systems in the financial system. Regulators deploy these controls using regulatory control implementation procedures appropriate for the exercise of their regulatory authority. Verification of the efficacy of control deployment is guided by use of the Deployment Checklist. See Table 4-9.

Checklist:

No.	Activity	Description
1	*Identify process owner for implementing regulatory control(s)*	Who is accountable for the deployment and ongoing administration of a regulatory financial control selected to treat the risks of decentrally governed DLT systems?
2	*Verify control implementation and efficacy*	Can the regulator confirm the operation of the regulatory control in the regulated financial system?
3	*Determine deployment timeframe*	How long did it take to deploy the new/adapted regulatory control treatment?

Table 4-9. Deployment Checklist

Review: Regulators can confirm the successful deployment of the adapted or new regulatory control based on regulator reviews of the checklist. The checklist determines whether the deployment of the regulatory control is successful.

4.6.5 Management and Administration

Goal: To ensure the efficacy of the regulatory control portfolio in treating the risks of decentrally governed DLT systems in the financial system, it is important to continuously manage and administer the ongoing operation of the regulatory control responses implemented using the DRC Framework. The efficacy of the implementation of the DRC Framework is measured using the Checklist for the Management and Administration of the DRC Framework. See Table 4-10.

Checklist:

No.	Activity	Description
1	*Identify process owner*	Who is accountable for the ongoing management and administration of the regulatory implementation of the DRC Framework?
2	*Manage risk*	Does the portfolio of control treatments administered through the DRC Framework effectively reduce the residual risk associated with the operation of decentrally governed DLT systems in the financial system?
3	*Control efficacy*	Are the regulatory controls effective and do they efficiently achieve the intended regulatory outcomes (costs to implement and maintain, risk mitigation, resource intensiveness, satisfaction of regulated parties)?
4	*Control adaptiveness*	Are the regulatory control responses adaptive to changing risk conditions?

5	*Management feasibility*	Is the DRC Framework considered practical and effective as a useful model for addressing the regulatory risks (participant, provider, systemic) of decentrally governed DLT systems in the financial system?
6	*Regulatory compatibility*	Is the ongoing operation of the DRC Framework cohesive within the overall financial system regulatory ecosystem (compatible, integrated, complementary)?

Table 4-10. Management and Administration Checklist

4.7 Chapter Summary

This chapter presented the developed DRC Framework and guidelines for its implementation by regulators. The DRC Framework comprises five components: participants, risks, regulatory control design principles, regulatory control treatments and residual risk improvements. The developed DRC Framework is intended for use by financial system regulators to develop a portfolio of risks, controls and participants that should be considered and addressed when considering regulatory regimes accommodative of decentrally governed DLT systems.

5 Evaluation

Chapter 2 reviewed the research literature relating to the risks and regulatory control responses to decentrally governed DLT systems in the financial system. Chapter 3 discussed the implemented research method and Chapter 4 presented the developed DRC Framework. This chapter evaluates the theoretical contributions and practical usefulness of the developed DRC Framework. When implementing ADR in IS research, the evaluation of an design artefact occurs throughout its development stages (Sein et al. 2011). To maximise the contribution of expert research participants, such evaluation should incorporate expert participation from the early stages of ADR research, including the initial problem formulation (Haj-Bolouri, Bernhardsson & Rossi 2015). The implemented participatory ADR approach ensured the expertise of DLT regulatory policy experts was incorporated into both the problem formulation of the study and ongoing evaluation of the developed DRC Framework. At key research steps through all stages of the research, expert input was used to develop, refine, reflect on and evaluate the developing DRC Framework. This was achieved through the use of interviews, research workshops and questionnaires completed through multiple research activities.

To further improve the theoretical quality of the research, focus was also applied to the theoretical contribution of the design artefact (Gregor, Müller & Seidel 2013; Weber 2012). In the domain of design-oriented research, the use of supplementary theory-generating qualitative research techniques is beneficial to enriching the theoretical quality of the developed artefact (Beck, Weber & Gregory 2013). The theoretical evaluation of the DRC Framework incorporated the use of additional theoretical sampling during the BIE Research Stage, assessing and refining the developed framework using the criteria for evaluating the quality of IS theory (Weber 2012) and incorporating ongoing IS research method feedback from IS research method experts. This ongoing and iterative evaluation of the theoretical quality of the research and the developing DRC Framework artefact identified numerous improvements that were applied through the research process.

Section 5.1 discusses the iterative ADR build and evaluation stages of the development of the DRC Framework. Section 5.2 evaluates the theoretical quality of the framework and Section 5.3 evaluates its practical usefulness and relevance.

5.1 Iterative Evaluation of DRC Framework

A characteristic of ADR IS research is the iterative evaluation of the design artefact throughout the Build, Intervention and Evaluation Research Stage (Gill & Chew 2019; Sein et al. 2011). Throughout the iterative development of the design artefact, feedback was solicited from research participants and used to refine and improve the quality and usefulness

of the design artefact. Additional theory generating research techniques including the incorporation of IS method improvements from external IS researcher expert observations and the development of regulatory control design principles were also incorporated into this research stage to add to the theoretical quality of the design artefact. The final developed version of the DRC Framework emerged through ten iterations of ongoing evaluation and refinement.

5.1.1 Initial conceptual DRC Framework (July 2018)

The initial version of the DRC Framework was developed in July 2018 during the Problem Formulation Research Stage. The artefact was abductively developed from insights derived from the review of the literature and early interviews conducted with expert regulatory policy practitioners from the RBA. The initial design artefact conceptualised both the challenges of DLTs and consequences of ineffective regulatory design and presented the summarised design measures to treat these challenges and consequences. It is notable that this version did not yet incorporate an industry accepted approach to presenting the components of a risk management framework. The research artefact however was an initial attempt to emphasise the objective of risk mitigation as a key regulatory outcome. See Figure 5-1.

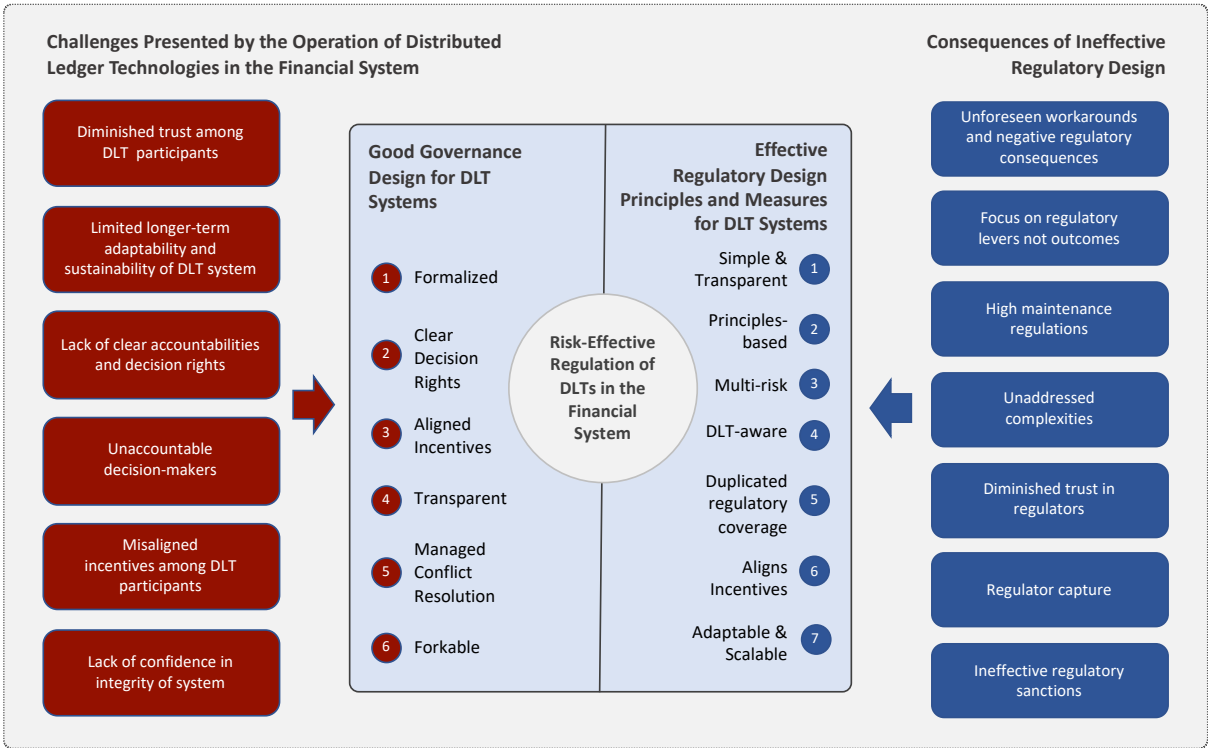


Figure 5-1. Initial Conceptual DRC Framework v1 (July 2018)

5.1.2 Second iteration of DRC Framework (November 2018)

Initial unstructured interviews conducted with RBA DLT regulatory experts in late 2018 provided useful input into the formulation of the research problem to be investigated. These interviews identified practitioner concerns and views on the emergent risks of DLT systems including the perceived complex risk landscape presented by technically enacted governance systems and the need for principles-based regulatory responses. A further review of the literature provided useful academic references for the risks that were emerging that were relevant to the decentralised governance of DLT systems. The second iteration of the conceptual DRC Framework more specifically elaborated on risk elements of poor DLT governance and regulation. This iteration of the DRC Framework made explicit reference to the literature for key risks and control treatments and reflected a more theoretically grounded iteration of the developing framework. This theoretical grounding was directly visible in the specific attribution of the research literature to specific framework components. See Figure 5-2.

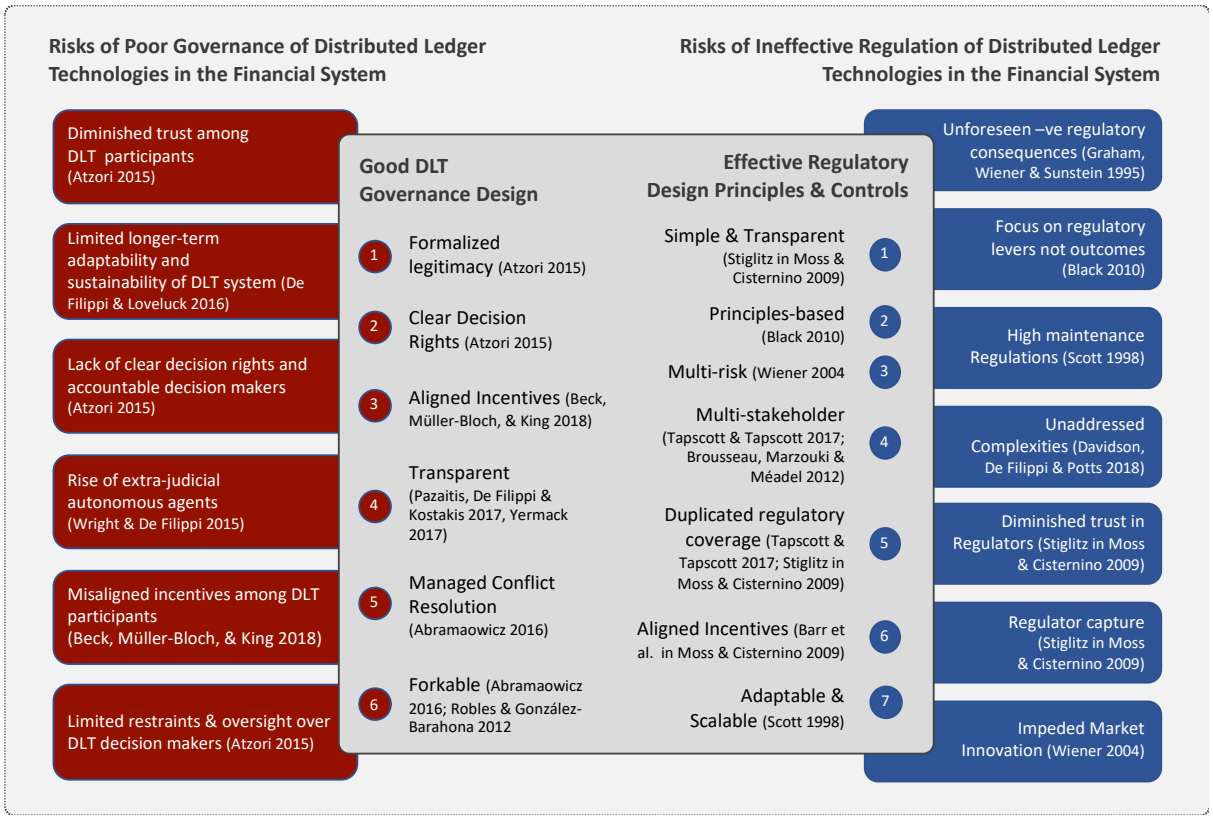


Figure 5-2. DRC Framework v2 (November 2018)

5.1.3 Third iteration of DRC Framework (March 2019)

The third major iteration of the DRC Framework was developed in early 2019 and was heavily informed by the recently published work on DLT governance by Beck, Müller-Bloch & King (2018). This study applied the work on IT governance by Weill & Ross (2004) and extended it to the DLT and blockchain context by supplementing the role of decision rights and accountabilities with an additional emphasis on incentives. The DRC Framework artefact was adapted to introduce the dimensions of decision rights, accountabilities and incentives while include reference to the risks of ineffective regulatory oversight. See Figure 5-3.

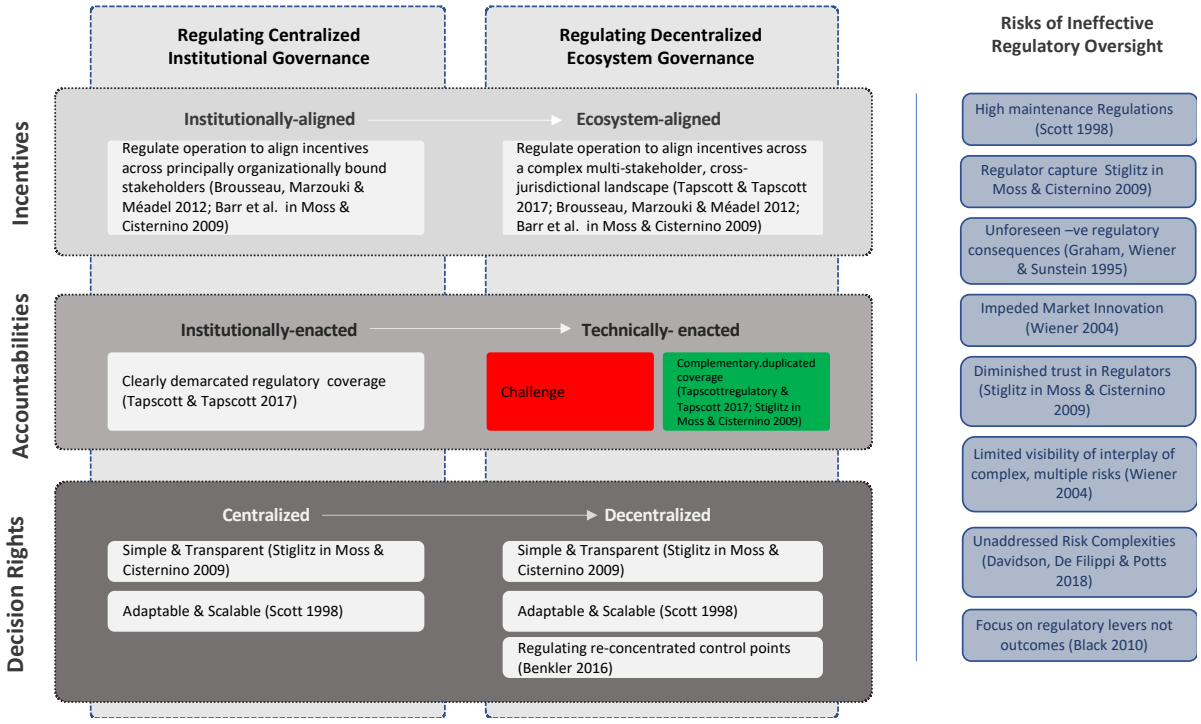


Figure 5-3. DRC Framework v3 (March 2019)

5.1.4 Fourth iteration of DRC Framework (April 2019)

Further development of the conceptual DRC Framework occurred over the course of early 2019. This identified the opportunity to extend the March 2019 iteration to incorporate the regulatory challenges presented by the emerging decentralised governance paradigm enabled by DLT systems. This iteration of the design artefact explicitly identified regulatory challenges resulting from a governance transition to decentralisation. The design artefact also introduced an early version of regulatory responses warranted to mitigate the disruption to convention centralised governance. This early view of regulatory responses was informed

by the initial view of regulatory controls synthesised during the review of literature conducted during the Awareness of Problem and Suggestion research stage. See Figure 5-4.

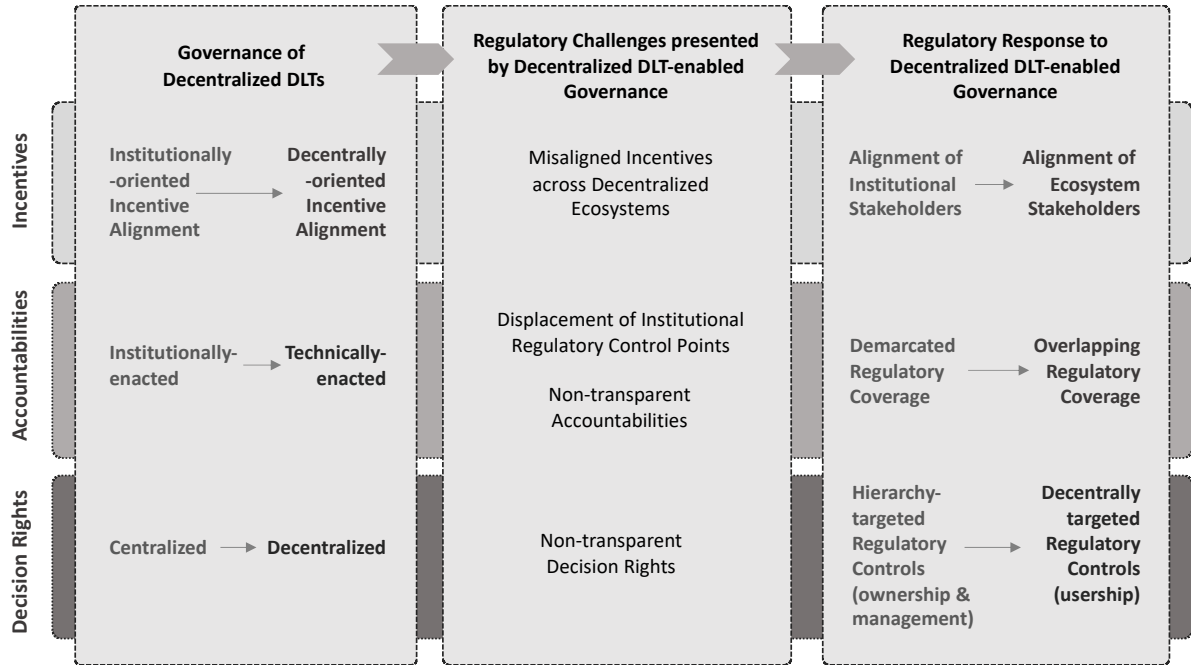


Figure 5-4. DRC Framework v4 (April 2019)

5.1.5 Fifth iteration of DRC Framework (June 2019)

In mid 2019, the conceptual design artefact was further iterated to reflect further insights and knowledge on regulatory responses to conventional centralised and emerging DLT-enabled decentralised governance. The contrast of the regulatory response needed to address the unique challenges of centralised and decentralised governance became a key focus of the review of literature. At this point, an emerging body of research was being published to inform the governance response to decentralised DLT systems. A key published work identified during this stage of the research was by Magnuson (2018) on fintech regulation. A key evolution of the DRC Framework and the theory it embedded in this iteration was the association of emerging DLT research and concepts with regulatory control responses. Of particular importance was the emerging insight of the need to apply regulatory controls to the emerging concept of distributed usership (Wright 2013). See Figure 5-5.

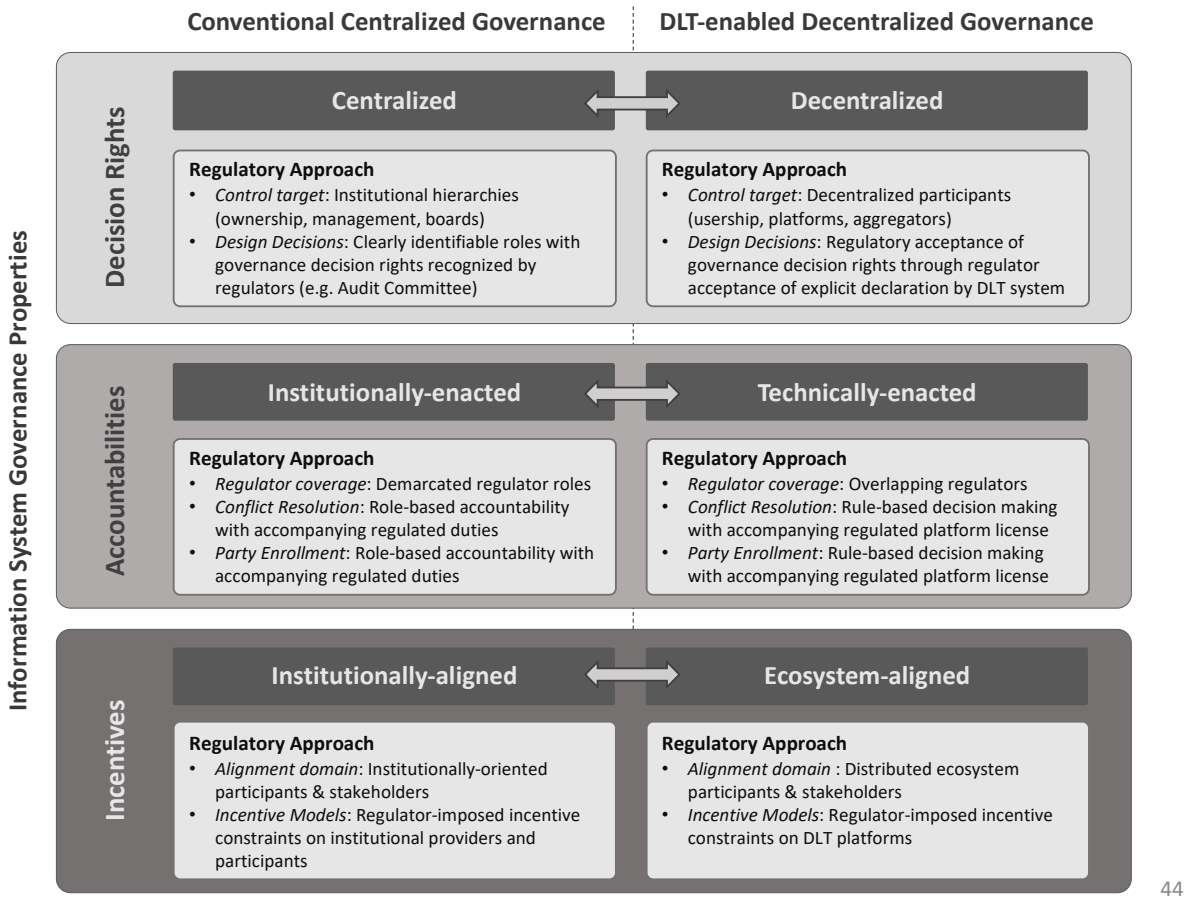


Figure 5-5. DRC Framework v5 (June 2019)

5.1.6 Sixth iteration of DRC Framework (October 2019)

The sixth iteration of the DRC Framework incorporated significant feedback from research participants from the initial co-design research workshop conducted in September 2019 at the conclusion of the Problem Formulation Research Stage. To develop this version, the prior fifth iteration of the DRC Framework was distributed to research participants in the initial research workshop conducted with regulatory policy experts. In this collaborative research session, participants discussed the research problem of the risks associated with the emergence of decentrally governed DLT systems in the Australian financial system. At the conclusion of the workshop, the participants were requested to complete a structured questionnaire to provide an overview of their feedback of the research problem and the conceptual design artefact. See Appendix 1. As a result of the workshop and subsequent questionnaire responses, a sixth iteration of the DRC Framework was developed in October 2019. The changes to this iteration were in response to input from the research participants. These changes encompassed the following:

1. Introduction of DLT participants and stakeholders into the model and control treatments to these parties. It is notable that in this iteration of the framework, the DLT risks were not included. This was due to the emphasis of the framework being on control treatments and the lack of insight at the time of the importance of referencing these controls to the risks they treat.
2. Incorporation of regulator control treatments:

- Regulator and participant DLT literacy requirements
- DLT participant and platform licences
- Seals of quality assurance
- Reporting and conduct standards
- Disclosure standards
- DLT software quality standards
- Machine readable regulation
- Supervisory access for regulators to DLT transactions

The October 2019 iteration of the DRC Framework marked a significant version of refinement and improved resolution in the development of the research artefact. The significant quality enhancements identified for the design research artefact points to the benefit of expert participation in the co-development of a design research artefact where there is an absence of industry implementation experience and a guiding body of existing research. See Figure 5-6.

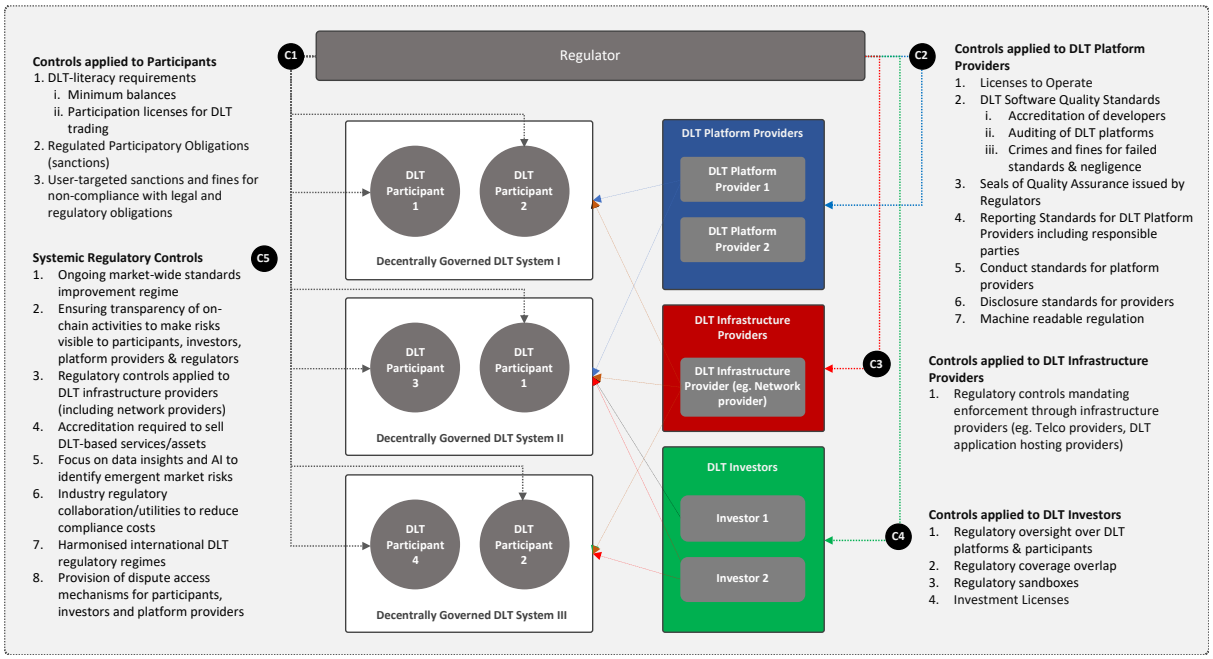


Figure 5-6. DRC Framework v6 (October 2019)

5.1.7 Seventh iteration of DRC Framework (November 2019)

Research participant evaluatory feedback in the first research workshop identified the recommendation to improve the usefulness of the DRC Framework by explicitly referencing risks and risk outcomes in the design artefact. Additional theoretical sampling was conducted at this point to research further the opportunities to incorporate the risk management industry and the research literature outcomes into the framework. The ISO standard for risk management, ISO31000, was identified in this research activity and consequently Risks and Risk Outcomes were explicitly incorporated into the next iteration of the framework. See Figure 5-7.

The seventh iteration of the DRC Framework also incorporates theoretical insights from Walch (2015) on operational risk management considerations of blockchain technology forming part of financial market infrastructure (FMI). Key insights identified in this research include those relating to the software-centric nature of blockchain technology and the consequence inheritance of those risks by FMIs based on this technology. The key risks identified include:

- Software quality concerns and uncertainty on accountability for open-source technology bugs
- Rate of change of software
- Decentralized nature of accountability for the quality of open-source software
- Limited expertise in DLT and blockchain technology

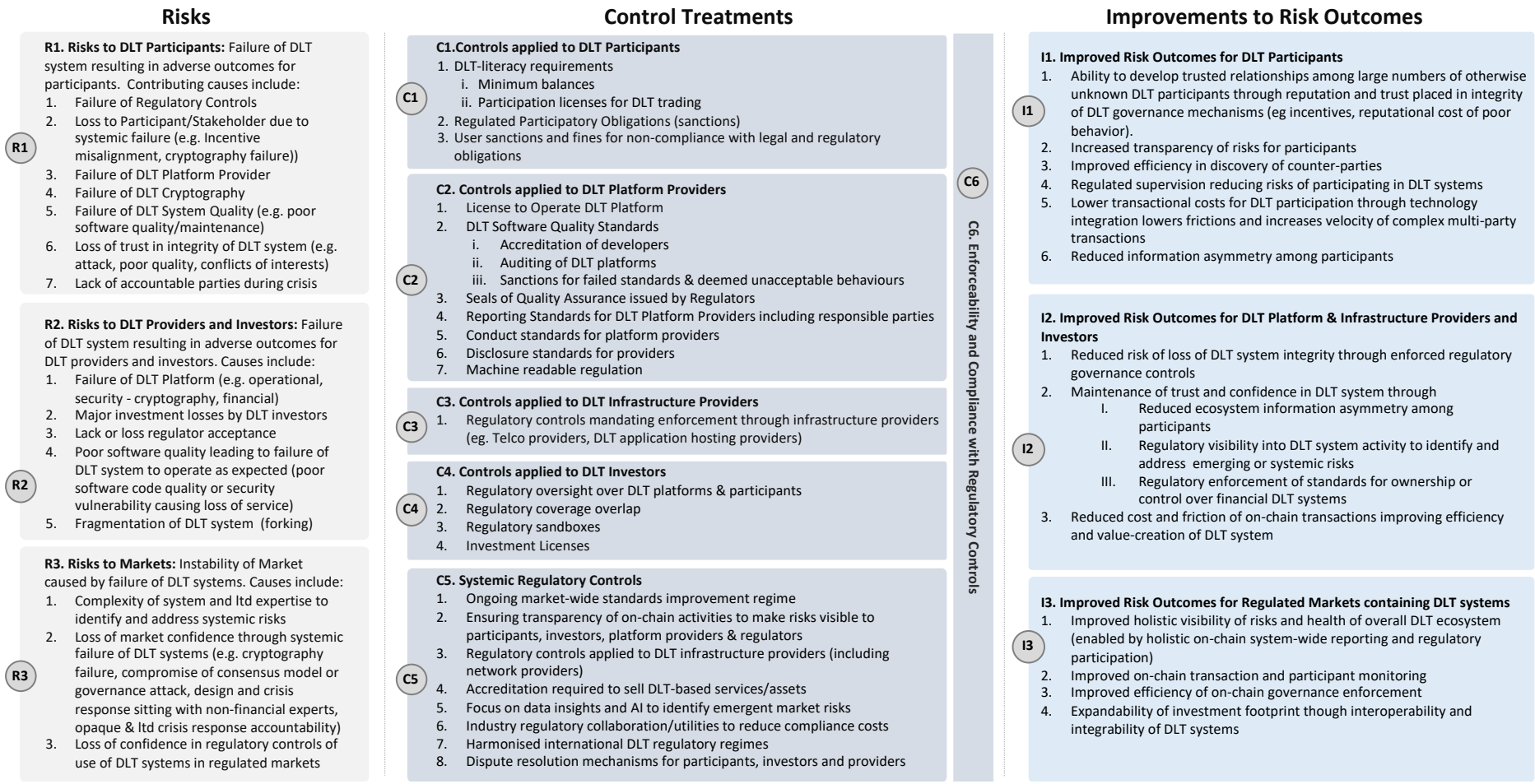


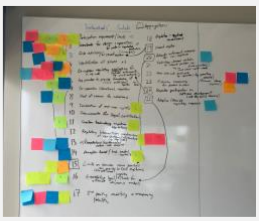
Figure 5-7. DRC Framework v7 (November 2019)

5.1.8 Eighth iteration of DRC Framework (December 2019)

The eight iteration of the DRC Framework was developed after the second research participant co-design workshop, conducted in November 2019 during the BIE Research Stage. The workshop adopted the Nominal Group Technique to ensure participant feedback was effectively captured and synthesised into the co-designed DRC Framework research artefact. The workshop ensured each participant's views on DLT risks and regulatory control treatments were captured, presented, discussed and synthesised. See Figure 5-8.

- Expert Regulator Research Participants were requested to independently and silently describe DLT regulatory risks and controls
- Each Research Participant then relayed their responses in a round-robin fashion, responses being captured for later discussion

- The Primary Researcher then facilitated a Group Discussion with Research Participants to discuss participant responses
- Participant responses were then grouped and clustered to normalise and structure responses



- Participant responses were independently voted on as a group
- Research participants then further discussed clustered control responses, noting relationships among related control responses

Figure 5-8. NGT Research Co-Design Workshop (November 2019)

After the workshop, the regulatory controls that were identified and ranked by the workshop participants were digitised. Controls that were deemed by participants in the workshop as related were then linked and grouped in a further iteration of this control model. See Figures 5-9 and 5-10.

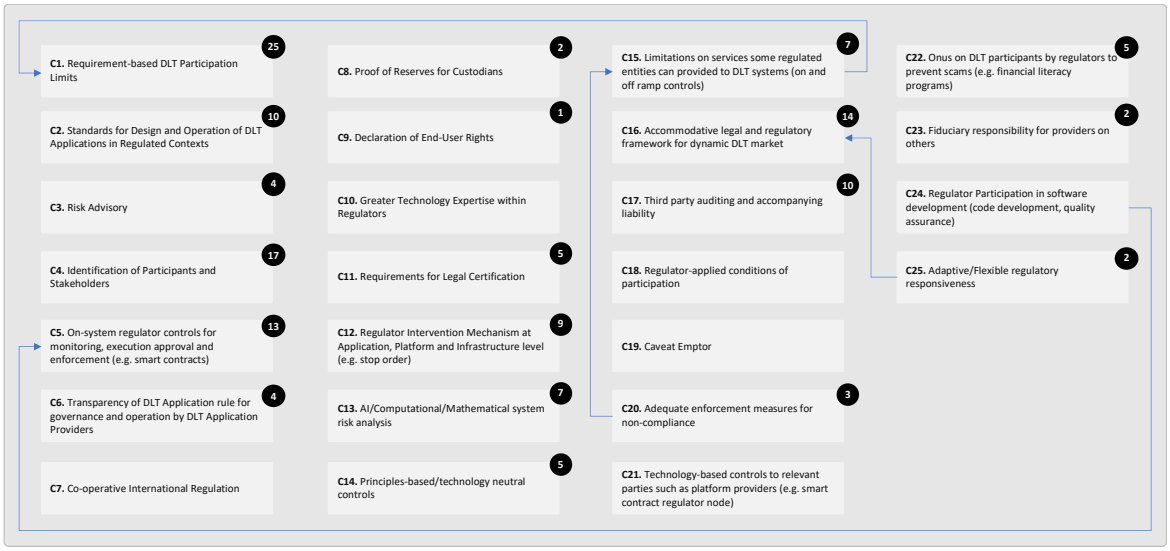


Figure 5-9. Regulatory Control Treatments (Workshop 2 v1)

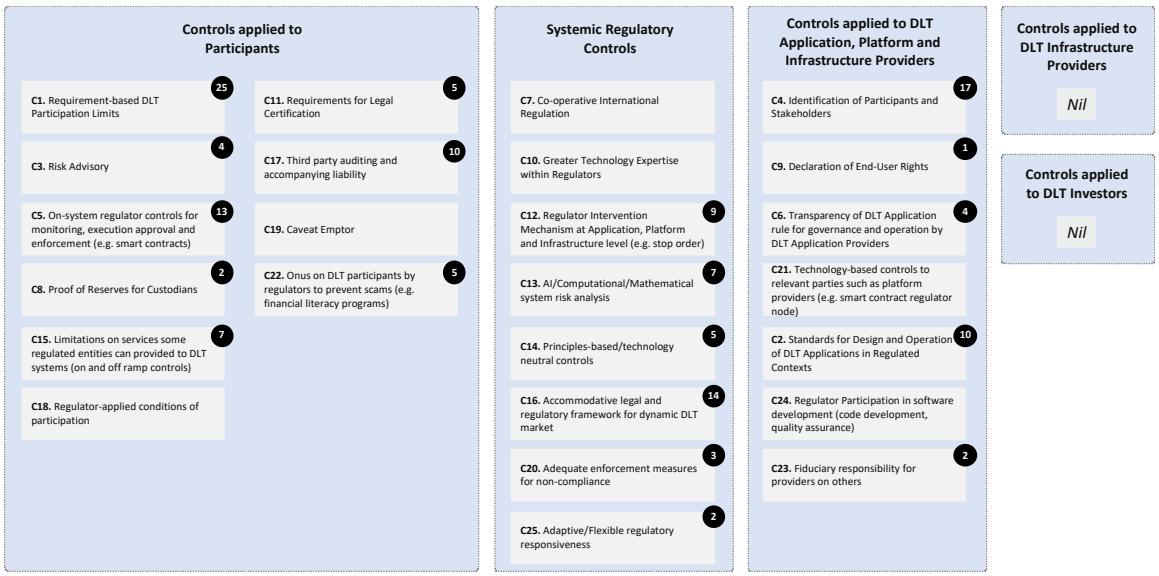


Figure 5-10. Regulatory Control Treatments (Workshop 2 v2)

In the second iteration of regulatory control treatments, the control categories of DLT investors and DLT infrastructure providers were identified as having been selected by research experts as relevant or useful. These categories were then removed from the eighth iteration of the DRC Framework. An interview with the UK Financial Conduct Authority at this stage of research also identified the benefit of incorporating the IOSCO risk management categorisation for financial market infrastructure (IOSCO 2014). These were cross-referenced against the risks identified in the DRC Framework and incorporated into the eighth version. See Figure 5-11.

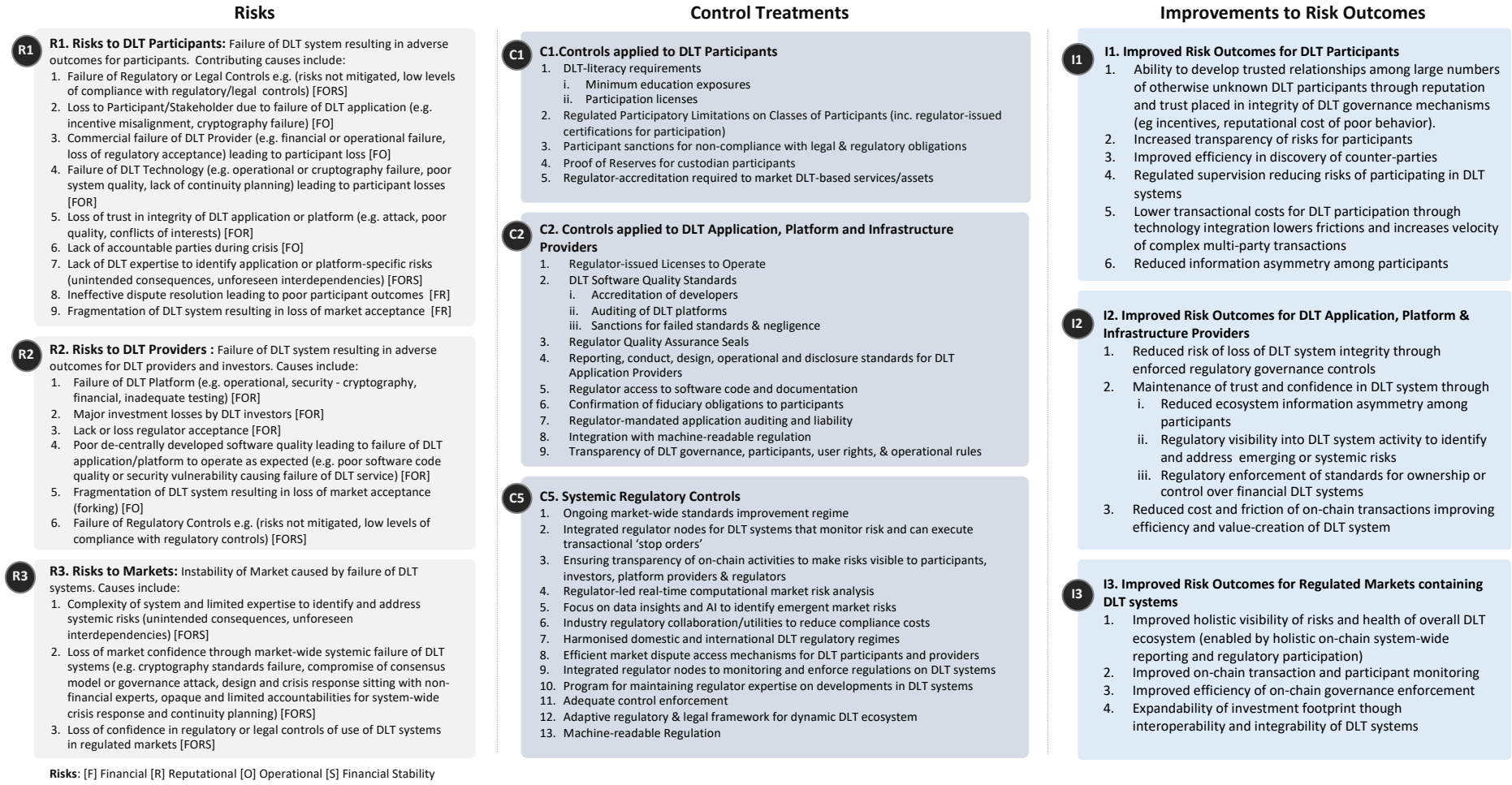


Figure 5-11. DRC Framework v8 (December 2019)

5.1.9 Ninth iteration of DRC Framework (January 2020)

In late 2019, the research was discussed with an external IS research method expert. These discussions identified enhancements to the theoretical quality of the DRC Framework through the incorporation of design principles into the Framework. The method of developing design principles by Gregor, Kruse & Seidel (2020) was applied to ensure the design principles developed presented optimum guidance and value to the intended regulatory implementers of the DRC Framework. This method involves the implementation of a design principle schema that ensures the rationale, actors and application of the principle are clear. This ensures the principle can be applied to multiple contexts and maximises the theoretical abstraction and application of the principle.

The first iteration of the design principles developed are contained in Table 5-1 below. This iteration applies the design principle schema developed by Gregor, Kruse & Seidel (2020).

Originally Drafted Regulatory Control Design Principle (v1)		Revised Regulatory Control Design Principle (v2)					
No.	**Regulatory Control Design Principle**	**Design Principle Title**	**Aim, Implementer & User**	**Context**	**Mechanism**	**Rationale**	**General Design Principle [Updated]**
1	**Systemically integrate DLT controls into DLT systems** - Use technology design and implementation to implement, execute and monitor regulatory controls across DLT systems and regulated markets (Justification: Minimise delays in control enforcement and regulator intervention)	**Systemically integrate DLT controls into DLT systems**	Regulators should incorporate regulatory controls	into DLT systems functioning in regulated markets	through technical integration into DLT systems	to increase visibility of DLT risks and provide a lever for policy implementation	**Systemically integrate DLT controls into DLT systems-** Regulators should incorporate regulatory controls through technical integration into DLT systems functioning in regulated markets to increase visibility of DLT risks and provide a lever for policy implementation
2	**Tailor DLT Controls more proximately to DLT providers and participants** - Tailor regulatory controls to be in closer proximity to DLT service delivery and consumption as possible (justification: alleviating the displacement and disintermediation of intermediaries)	**Tailor DLT Controls more proximately to DLT providers and participants**	Regulators should design and implement regulatory controls to be proximate to the provision and consumption of DLT services	in regulated markets	by minimising control reliance on intermediaries	to mitigate the risk of control points being displaced by de-centralised DLT systems	**Tailor DLT Controls more proximately to DLT providers and participants -** Regulators should design and implement regulatory controls to be proximate to the provision and consumption of DLT services in regulated markets by minimising control reliance on intermediaries to mitigate the risk of control points being displaced by de-centralised DLT systems
3	**Harmonize DLT Regulatory Controls Across Regulatory Jurisdictions** - Harmonize and integrate regulatory controls across distributed regulator networks (reflecting the connected characteristic of DLT systems, and the high likelihood such systems will span multiple regulator jurisdictions)	**Harmonize DLT Regulatory Controls Across Regulatory Jurisdictions**	Regulators should harmonize regulatory controls	across regulated markets	by ensuring controls are compatible and holistic in their coverage	to minmise gaps in control coverage across the global deployment of DLT systems	**Harmonize DLT Regulatory Controls Across Regulatory Jurisdictions -** Regulators should harmonize regulatory controls across regulated markets by ensuring controls are compatible and holistic in their coverage to minmise gaps in control coverage across the global deployment of DLT systems
4	**Ensure best available information for DLT participants and regulators** - Increased DLT participant and regulator awareness of DLT activity through transparent awareness of emerging and current risks (justification: ensuring reduced reliance on need for DLT intermediaries and timely understanding of risks in high velocity DLT environments)	**Ensure best available information for DLT participants and regulators**	Regulators should require DLT applications and platforms	operating in regulated markets	ensure transparency of DLT activity and risks	to reduce information assymetry among stakeholders and reducing reliance on intermediaries for a timely, holistic understanding of DLT risks	**Ensure best available information for DLT participants and regulators -** Regulators should require DLT applications and platforms operating in regulated markets ensure transparency of DLT activity and risks to reduce information assymetry among stakeholders and reducing reliance on intermediaries for a timely, holistic understanding of DLT risks
5	**Improve DLT Quality Standards** - Ensure DLT technology and governance standards are increased to reduce risks of poor quality in the design, operation and governance of DLT systems (reflecting the increased importance of technology in delivering DLT-based services)	**Improve DLT Quality Standards**	Regulators should ensure DLT developers	in the design, operation and governance of DLT systems	through controls that improve DLT technology, operational and governance quality	to address the criticality of DLT system to the performance if key functions in regulated markets	**Improve DLT Quality Standards -** Regulators should ensure DLT developers adhere to DLT standards in the design, operation and governance of DLT systems through controls that improve DLT technology, operational and governance quality to address the criticality of DLT system to the performance if key functions in regulated markets
6	**Maintain and improve trust among DLT participants**- Design, operate and govern DLT systems in a manner conducive to maintaining and increasing trust among DLT participants (justification: minimise the likelihood of system risks to market integrity and confidence emerging)	**Foster trust among DLT participants**	Regulators should implement controls requiring DLT developers	through the design, operation and governance of DLT systems	to foster trust among DLT participants	to minimise the likelihood of DLT risks manifesting to adversely affect market integrity and confidence	**Foster trust among DLT participants -** Regulators should implement controls requiring DLT developers to foster trust among DLT participants through the design, operation and governance of DLT systems to minimise the likelihood of DLT risks manifesting to adversely affect market integrity and confidence
7	**Expand DLT expertise and awareness** - Develop and expand expertise of DLT systems to minimise the likelihood of unforeseen or unmitigated risks jeopardising market stability and confidence	**Expand DLT regulatory expertise**	Regulators should ensure regulatory policy experts	responsible for supervising markets impacted by the adoption of DLT systems	should develop their expertise in DLT systems	to minimise the likelihood of unforeseen or unmitigated risks jeopardising market stability and confidence	**Expand DLT regulatory expertise -** Regulators should ensure regulatory policy experts responsible for supervising markets impacted by the adoption of DLT systems should develop their expertise in DLT systems to minimise the likelihood of unforeseen or unmitigated risks jeopardising market stability and confidence
8	**Preserve value** - Ensure DLT regulations create value and do not unnecessarily curb the innovations rendered possible by decentrally-governed DLT systems (to unlock the value potential of DLT systems)	**Preserve value**	Regulators	when designing and implementing controls	by evaluating their impact on innovation, value creation and destruction	not unnecessarily curb the value generated by DLT systems	**Preserve value-** When designing and implementing controls regulators should not unnecessarily curb the value generated by DLT systems by evaluating their impact on innovation, value creation and destruction
9	**Responsive to dynamic, iterative change** - DLT regulatory controls should be flexible and accommodative to the dynamic, iterative nature of DLT systems	**Responsive to dynamic, iterative change**	Regulators	when designing, implementing and operating regulatory controls	by implemeting flexible controls that are accommodate the dynamic nature of DLT systems	not uneccearily inhibiting the adaptive nature of DLT systems	**Responsive to dynamic, iterative change -** Regulators should seek to not uneccearily inhibiting the adaptive nature of DLT systems when designing, implementing and operating regulatory controls by implemeting flexible controls that are accommodate the dynamic nature of DLT systems

Table 5-1. Regulatory Control Design Principles v1 and v2 (applying Gregor, Kruse & Seidel (2020)

Having developed and revised the regulatory control design principles, these principles were then incorporated into the ninth iteration of the DRC Framework. This now encompassed both high level and detailed versions. See Figures 5-12.

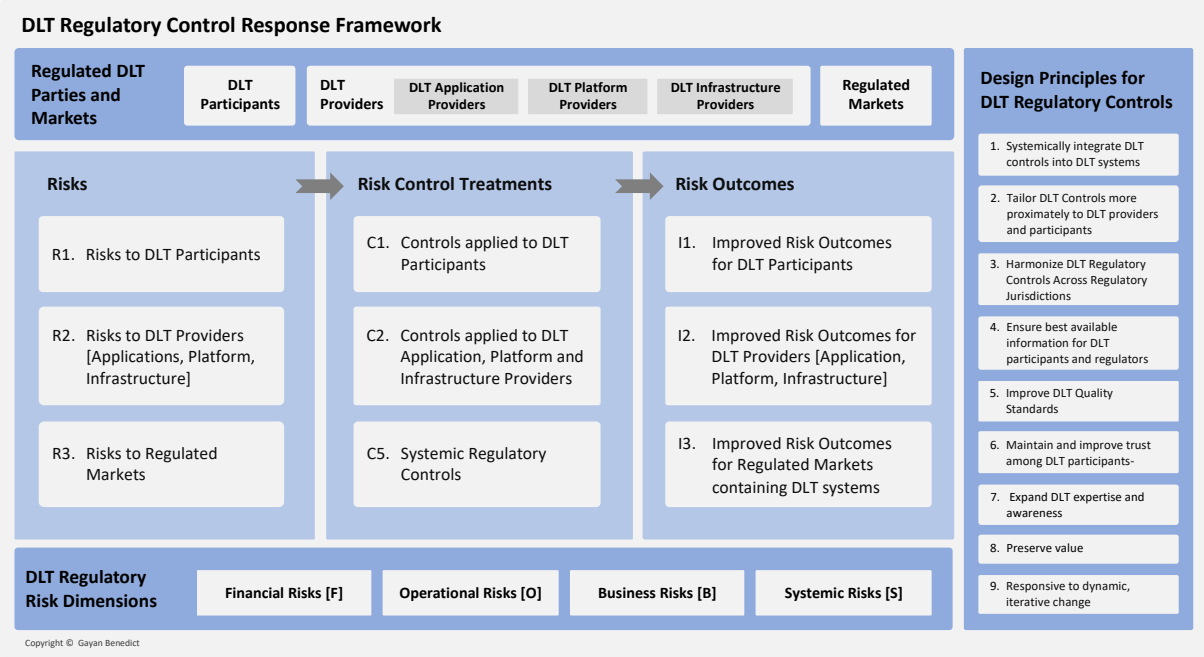


Figure 5-12. DRC Framework [High Level] v9 (February 2020)

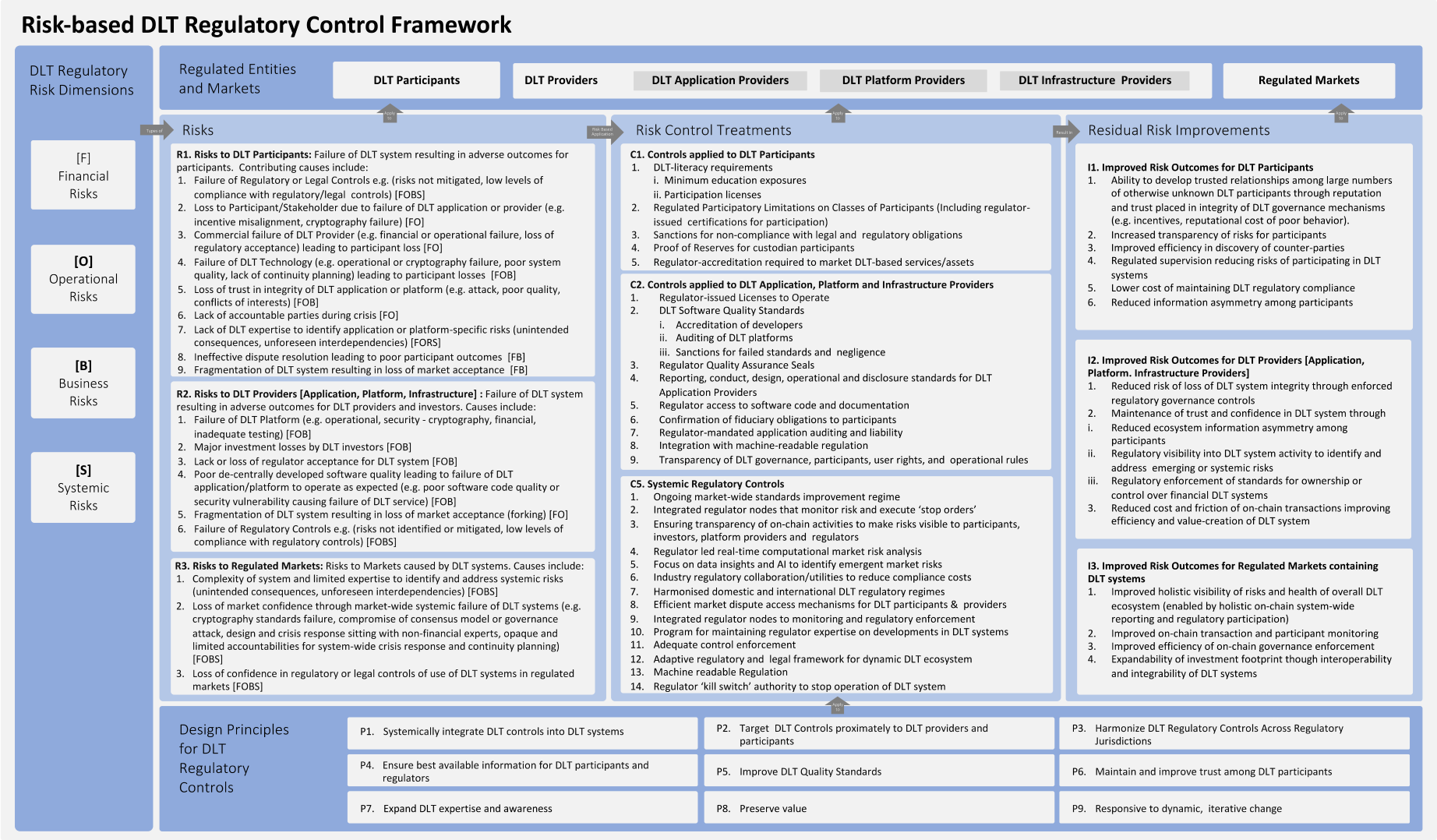


Figure 5-13. DRC Framework [Detailed] v9 (February 2020)

5.1.10 Tenth iteration of the DRC Framework (November 2020)

In the final evaluation step within the BIE Research Stage, the research participants were asked to complete a survey of the developed DRC Framework, which sought feedback on the quality, usefulness and relevance of the developed research artefact. All responding participants noted that they 'agreed' or 'strongly agreed' with the statement that the DRC Framework was useful and relevant to the regulation of decentrally governed DLT systems in the financial system. Solicitation of improvements identified the benefit of incorporating simple instructions on the implementation of the framework into the high-level view of the DRC Framework. The participants also requested clarity on the associations between sections of the framework which were also included in this iteration of the artefact. See Figures 5-14 and 5-15. To further address the feedback from the participants on the need to provide guidance on the implementation of the framework, an implementation template was also developed to provide regulatory practitioners with a step-by-step guide to implementing the framework into a broad range of regulatory contexts.

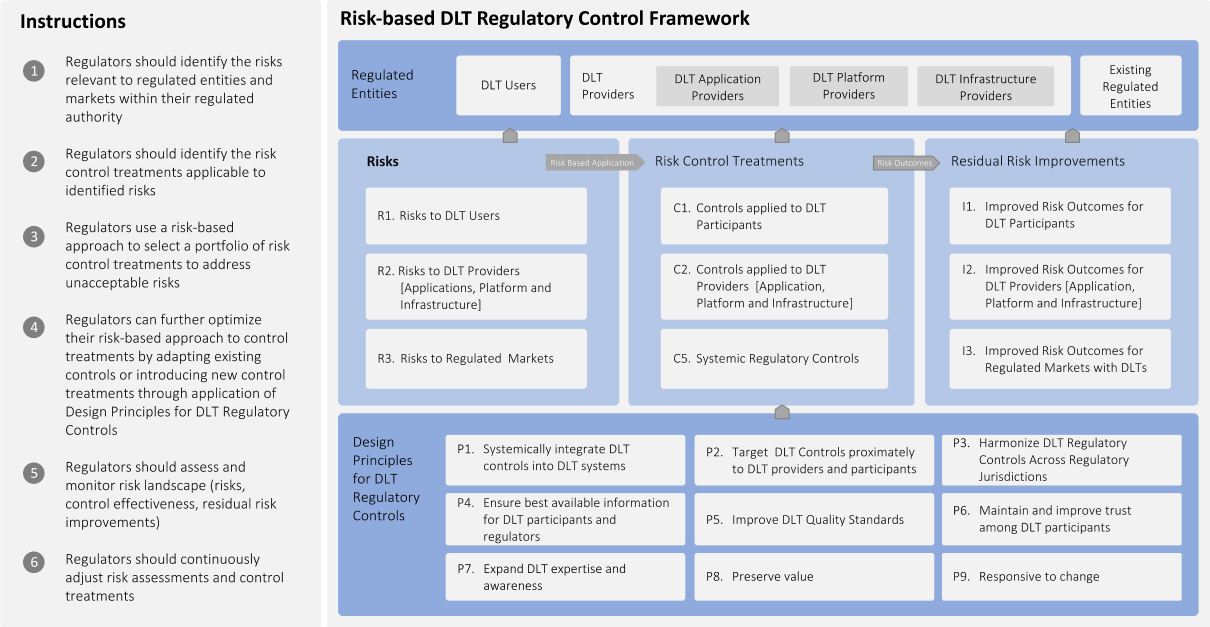


Figure 5-14. DRC Framework [High Level] v10 (November 2020)

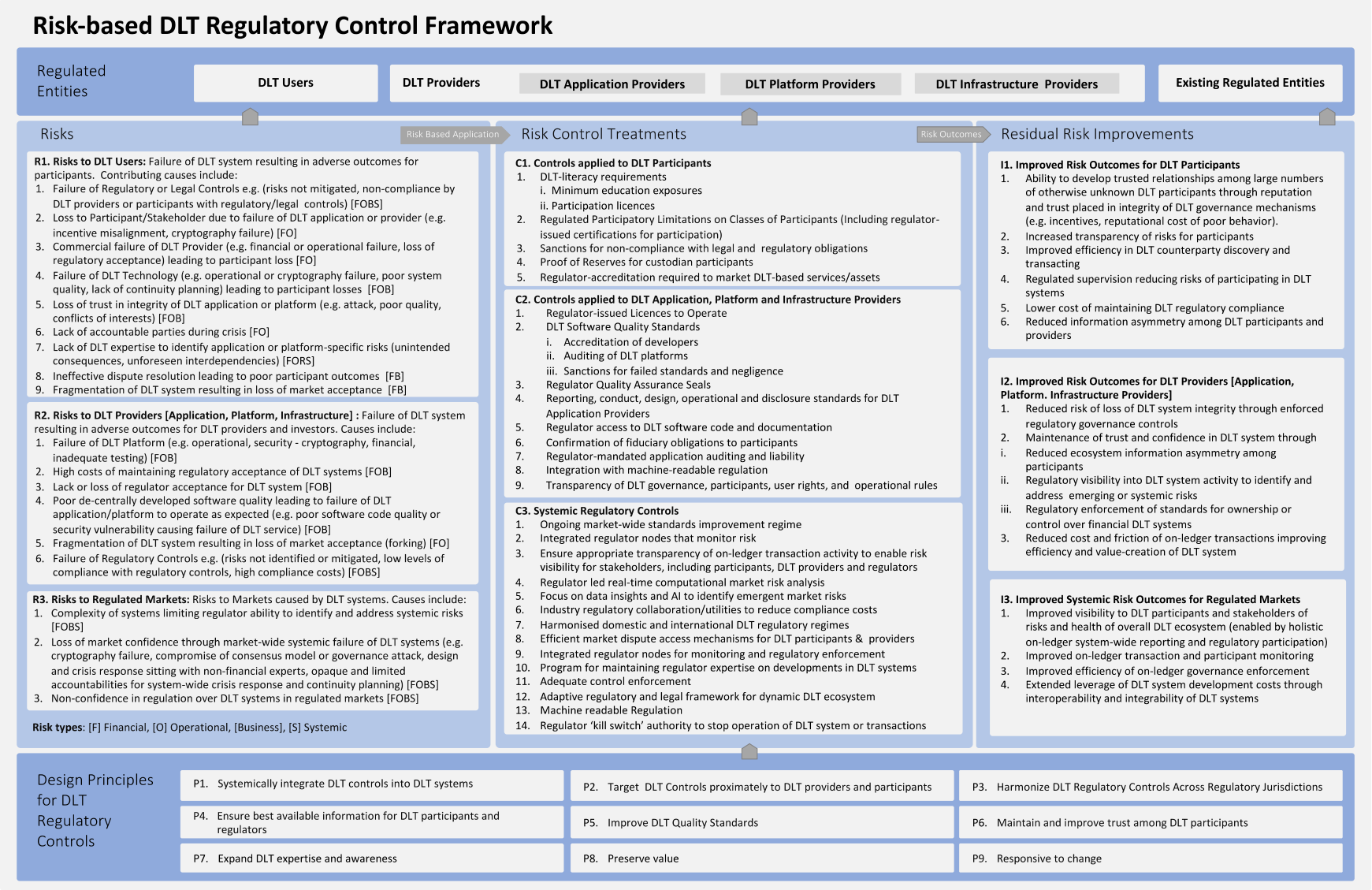


Figure 5-15. DRC Framework [Detailed] v10 (November 2020)

5.2 Evaluating the Theoretical Contribution to IS Research

The theoretical contribution of the developed DRC Framework was evaluated throughout the BIE Research Stage. Having developed the DRC Framework and completed multiple iterations of refinement incorporating insights from additional theoretical sampling, research participant feedback and external observer analysis, a further theoretical evaluation of the quality of the theory of the framework was conducted. The outcomes of this analysis resulted in further refinement to the developed framework to further enhance its theoretical contribution and quality.

Weber (2012) presents the criteria for evaluating the quality of the parts and whole of an IS theory. In this context, a theory is defined as "a particular kind of model that is intended to account for some subset of phenomena in the real world" (Weber 2012, p. 4). See Figure 5-16. The subset of phenomena for which IS theory is developed by this research are the risks of decentrally governed DLT systems in the Australian financial system, the regulatory control responses available to regulators to mitigate these risks and the nascent principles developed to guide the design and adaption of such regulatory controls. The DRC Framework comprises these specific constructs and the theoretical value of the framework comes from the ability to apply these theoretical constructs to a broad range of DLT system implementations within the Australian financial system and potentially to the generalised application of the DRC Framework to non-Australian DLT regulatory contexts.

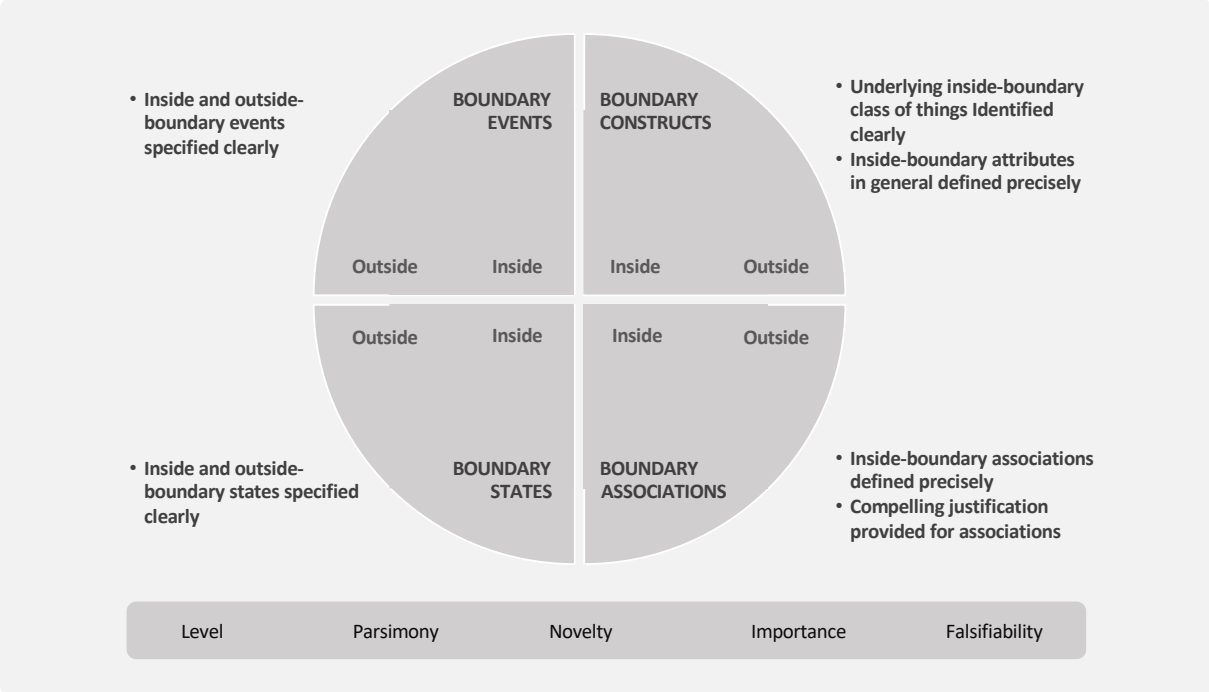


Figure 5-16. Framework for Evaluating an Information Systems Theory in Whole and in Part. Based on Weber (2012)

5.2.1 Quality of the Parts of the IS Theory

To ensure the theoretical quality of the parts of the DRC Framework, the criteria for evaluating IS theory quality by Weber (2012) require an appropriate focus on the framework's constructs, their associations, and the states and events they cover. Applying Weber's quality criteria to the developed DRC Framework, the quality of the theoretical components of the framework is determined by their efficacy in addressing the phenomena they are intended to cover, namely the regulatory mitigation of financial system risks relating to decentrally governed DLT systems.

Weber (2012) characterises IS theories as having three parts: their constructs; the associations between these constructs; and the states they cover. He further notes that IS theories covering dynamic phenomena have an additional fourth part - the events they encompass. Weber (2012) notes that considering the quality of the parts of an IS theory allows researchers to better clarify a theory's boundaries and the subset of phenomena representing the domain the theory covers.

5.2.1.1 Constructs

A construct of a theory represents an attribute in general of some class of things in its domain (as opposed to a particular attribute of a specific thing) (Weber 2012). The class of things to which attributes in general pertain should be defined precisely to ensure that the meanings of each class and the things in each class are clear. Otherwise, the exact nature of the things that the theory covers will not be clear and nor will the meanings of the attributes in general that attach to the classes of things the theory covers be clear. To clarify the meaning of an attribute, the thing to which it attaches should be made clear (Weber 2012).

The relevant constructs of the DRC Framework's theoretical components are presented in Table 5-2. The definition and scope of each of these constructs are governed by industry-accepted definitions in the case of risks and control treatments and the informed input of the expert regulator research participants in the case of regulated parties and markets.

No.	Research Construct	Description
1	*DLT System Design*	Systems that use distributed ledgers to technically-enact incentive mechanisms, accountabilities, decision rights and consensus models. (Beck, Müller-Bloch & King 2018)
2	*Australian Financial System Stability*	The participants and services associated with the conduct of financial activity within the regulated Australian context (CFR 2019).
3	*DLT Participants*	The parties that partake in the function of or are otherwise affected by the operation of DLT systems (Beck, Müller-Bloch & King 2018).

4	*Risks of Decentrally Governed DLT Systems*	The probabilistic occurrence of specified events or outcomes (ISO 2009). In the research context, these refer to the risks associated with the decentrally governed DLT systems in the Australian financial system.
5	*Risk Control Treatments*	Measures and actions implemented by financial regulators to reduce the probability of risks crystallising (ISO 2009). In the research context, these refer to the regulatory controls applied to reduce the probability or impact of the risks relating to decentrally governed DLT systems operating in the Australian financial system.

Table 5-2. Research Constructs

The evaluation of the research constructs of the research identified the need to be clear on the boundaries of the constructs. This specifically informed the need to be clear that the theoretical boundary of the research should be applied to the Australian financial system regulatory context and ensure the focus of the DRC Framework was targeted at supporting Australian financial system regulation. This clarification of the research construct boundaries reinforces the primary focus of the Australian financial system regulatory experts recruited to participate in the research and contribute to the co-design of the risks and regulatory control responses presented in the developed DRC Framework.

5.2.1.2 Associations

Ensuring that the boundaries of the parts of the design artefact are clear and that their states and the associations between them are specified contributes to the overall theoretical quality of these components of the framework (Weber 2012). For the developed DRC Framework, both individually identified risks and regulatory control treatments are associated with

1) Classifications of risks (financial, operational, business or systemic), and
2) Categorisation of relevance to DLT parties (DLT system users and providers (infrastructure, application, platform)).

For regulatory control treatments, these are also associated with the specific risks they treat.

When considering the associations within a theory, Weber (2012) notes the importance of reflecting upon whether a theory covers static or dynamic phenomena, or a combination of both. For this research, the constructs are dynamic. The Australian financial system is a globally connected financial system and is subject to significant change from new entrants, services and technical innovations. The risks and controls relevant to this disrupted landscape are dynamically changing system constructs, requiring participants and regulators to adapt their responses accordingly. The nature of DLT systems and the diversity of their

participants are also rapidly evolving, with new combinations of business models, governance models, underlying technological advancement and evolving participant expectations (Ehrsam 2017).

In situations where construct associations are dynamic, it is important to focus on the historical and often directional relationships between the historical values of these associations (Weber 2012). A theory need not cover all possible associations among its constructs as doing so will reduce the parsimony of the theory (Weber 2012). To ensure an optimal number of identified associations, Weber (2012) recommends considering whether associations should be included or omitted from a theory based on materiality and the need to determine what falls within and outside the boundary of a theory. The application of this evaluation approach enabled key associations relevant to the DRC Framework to be retained while excluding those associations that would not have materially contributed to the quality of the Framework. The key associations identified for the DRC Framework and the justification for inclusions and exclusions of qualities of these associations in the context of the DRC Framework are specified in Table 5-3.

No.	Association Pair of Research Constructs	Association Direction	Justification for Inclusion/Exclusion
1	(4) Risks of Decentrally Governed DLT Systems -> (2) Australian Financial System	Decentral DLT Governance Risks contribute to the instability of the Australian Financial System	Justification for Inclusion: For the theory to be of high value to financial regulators, it must concentrate on the control treatments that address the risks relevant and material to the Australian financial system. Unnecessary regulatory intervention can otherwise contribute to inefficiency and cost to regulation and impede the efficacy of Australian financial regulation. Justification for Exclusion of non-Australian financial systems: The research theory is constrained to application to the Australian financial system. This removes the complicating factors of international regulatory conflict harmonisation which may result in contradictory or diluted control efficacy. The research did extend research participation to UK-based fintech and financial regulatory perspectives to identify opportunities to leverage global regulatory experiences and minimise the likelihood of future control conflicts in international applications of the developed DLT Regulatory Control Framework.

2	(5) Financial DLT Risk Control Treatments -> (4) Risks of Decentrally Governed DLT Systems	Risk control treatments mitigate the decentralised governance risks of DLT systems	Justification for Inclusion: Control treatments are only included if they materially mitigate the probability of occurrence or the impact on the occurrence of a DLT risk. Requiring controls to be effective in mitigating risk improves the efficacy and impact of the developed DLT Regulatory Control Framework.
3	(4) Risks of Decentrally Governed DLT Systems -> (3) DLT Participants and Stakeholders	Risks adversely impact DLT participants and stakeholders in the Australian financial system	Justification for Exclusion: Individual participants and stakeholders may experience losses and costs as a result of specific risks manifesting (e.g., investment risk). The principal role of financial regulation is to ensure overall financial system stability and not to prevent the costs of loss to individual participants or stakeholders. NB. Regulators are interested in such risks that apply to classes of participants. In such cases, these risks jeopardise the overall stability of the financial system and are addressed by regulators systemically.
4	(1) DLT system Decentralised Design -> (4) Risks of Decentrally Governed DLT Systems	DLT system decentralised design attributes creating risks in the Australian financial system	Justification for Inclusion: The research focuses on DLT system designs that contribute to risks in the Australian financial system. Justification for exclusion of non-DLT design related risks: DLT risks not relating to the design of the system (such as the capital adequacy of financial backers) are otherwise addressed by existing regulatory regimes and if included, would expand the scope of the DLT Regulatory Control Framework into an overall Financial Regulatory Control Framework, which would be unwieldy and difficult to encapsulate or maintain.

Table 5-3. Key Research Construct Associations

5.2.1.3 States

An attribute of higher quality IS theories is clarity about the state of a class of things addressed by the theory (Weber 2012). The state of research constructs relevant to the research are described in Table 5-4.

No.	Research Construct	State	Description	Within scope of DRC Framework
1a	DLT System Design	Operational	DLT design is implemented and in operation within the regulated financial system	Yes
1b	DLT System Design	Non-operational	DLT design is not implemented or operational within the regulated financial system	No
2a	Australian Financial System Stability	Stable	The regulated financial system is stable	Yes
2b	Australian Financial System Stability	Unstable	The regulated financial system is unstable	Yes
3a	DLT Participants	Within regulator's jurisdictional coverage	DLT participants are within the jurisdictional accountability of the financial system regulator	Yes
3b	DLT Participants	Outside regulator's jurisdictional coverage	DLT participants are outside the jurisdictional accountability of the financial system regulator	No
4a	Risks of Decentrally Governed DLT Systems	Within regulator's jurisdictional coverage	Risks fall within the jurisdictional accountability of the financial system regulator	Yes
4b	Risks of Decentrally Governed DLT Systems	Outside regulator's jurisdictional coverage	Risks fall outside the jurisdictional accountability of the financial system regulator	No
5a	Risk Control Treatments	Withing regulatory authority	Regulatory controls fall within the authority of the financial system regulator to apply	Yes
5b	Risk Control Treatments	Outside regulatory authority	Regulatory controls fall outside the authority of the financial system regulator	No

Table 5-4. DRC Framework States

Clarification of the accommodated states of the DRC Framework simplifies the application of the Framework by regulators and makes clear that some states of the framework constructs fall outside the scope of the application by regulators. This aids the power of the DRC Framework to remain relevant and useful to regulators seeking to implement it in their unique contexts.

5.2.1.4 Events

Weber (2012) notes that if a theory is intended to cover events, it should specify the conceivable event space within its boundary. For the DRC Framework, the addressable event space encompasses those DLT participants and stakeholders that fall within the jurisdictional authority of Australian regulators. The occurrence of these events happen through the lifecycle of a DLY system. Key governance-related events are mapped to ostensible DLT System lifecycle stages in Table 5-5 below.

No.	DLT System Lifecycle Stage	Event
1	Establishment	Establishment of the DLT Governance Mechanism for the regulated DLT system (including registration, or the establishment of voting rules or rights, consensus models, dispute resolution mechanism)
2	Establishment	Registration, transfer or otherwise enrolment of asset values for use in the DLT system
3	Operation	Transactions involving a regulated DLT system participant (including mining, voting, dispute resolution)
4	Operation	Dispute or conflict resolution involving a regulated DLT system participant
5	Operation	Enrolment of a new DLT system participant falling within the jurisdictional coverage of a regulator
6	Operation	De-registration of an existing DLT system participant within the jurisdictional coverage of a regulator
7	Operation	Update of details of an existing DLT system participant within the jurisdictional coverage of a regulator
8	Operation	Participation in on-ledger decision by DLT system participant within the jurisdictional coverage of a regulator
9	Operation	Participation in off-ledger decision by the DLT system participant within the jurisdictional coverage of a regulator

10	Termination	Termination of DLT Governance Mechanism for the regulated DLT system (including de-registration, or winding down of voting rights, consensus models, dispute resolution mechanisms)
11	Termination	De-registration, transfer out or otherwise de-enrolment of asset values used in a DLT system

Table 5-5. DRC Framework Events

By specifying the addressable events of the DRC Framework, the quality of the theoretical contribution of the artefact is optimised by clarifying which events it is intended and not intended to apply to.

5.2.2 Quality of the Whole of the IS Theory

A theory has attributes that contribute to its holistic quality rather than the quality of its components. These encompass the importance of its *focal phenomena* (Corley & Gioia 2011; Weber 2012); its *novelty* as represented by the value attributed to it by researchers and its likelihood of publication (Corley & Gioia 2011; Weber 2012); its *parsimoniousness* as reflected by predictive and explanatory power using a small number of constructs and associations (Weber 2012); and it being of a sufficient level, encompassing a sufficient range of phenomena to be interesting and important (Weber 2012).

5.2.2.1 Importance

Weber (2003a, p. 13) notes 'there is little point to having a theory with rigorously specified constructs, associations, inside-boundary states, and inside-boundary events if it addresses uninteresting phenomena'. Gregor & Hevner (2013) notes the importance of evaluating an artefact based on its demonstrated worth for criteria such as validity, utility, quality and efficacy.

The importance and quality of the DLT Regulatory Control Framework derives from its focus on enabling financial regulators to address the risks resulting from the emergence of DLTs into the financial system. As new cryptocurrencies and decentralised DLT payment systems emerge, these potential disruptive innovations for the financial system could both herald the introduction of transformative innovations and major disruptions to the status quo of conventional financial system regulatory regimes. One research participant in noting they 'strongly agreed' with the statement that components of the developed research model were important to the regulation of DLT systems, observed that the framework's 'components become more important the more decentralised the governance of the financial network(s), and the more principles-based the regulatory environment is (as opposed to prescriptive-based frameworks, which are more certain and limiting).' Another research participant in

noting they 'agreed' with the statement that the framework was relevant for regulators seeking to address the risks of decentralised DLT governance, commenting the 'risk treatments are a useful list of ideas of tangible controls to apply. The principles are useful, even on their own without risk treatments.' The importance of the research was further highlighted by the sponsorship of the research by the Australian Reserve Bank of Australia and the participation of the majority of the DLT Working Group of the Australian Council of Financial Regulators.

5.2.2.2 Novelty

Weber (2003b) identifies three ways an IS theory can make a novel contribution to a research discipline.

1. Addressing focal phenomena not previous addressed
2. Framing or conceiving existing well-known phenomena in new ways
3. Changing important aspects of an existing theory, including its constructs, associations or theoretical boundaries

The scarcity of research in DLT regulation and the limited involvement of regulatory practitioner experts emphasises the novelty of this research by addressing regulatory risks and controls in the financial system, a field that has received little research focus to date. The DLT Regulatory Control Framework incorporates specific constructs and associations relevant to the operation of DLT systems, including specific DLT participants such as DLT platform providers. This incorporation of DLT-specific constructs, associations and participants adds to the novelty of the research as it seeks to establish a foundational risk and control model for future researchers and practitioners to build upon.

Gregor & Hevner (2013, p. 345) developed a Knowledge Contribution Framework for Design Science Research that noted different types of knowledge contribution by IS theories. This research most suitably fits within the Exaptation category of theoretical contribution, i.e., theory that stands to extend known solutions (in this case regulatory controls) to new or different problems (in this case the circumstance of decentrally governed DLT systems operating in the financial system). This thesis accordingly presents research with the potential to make a valuable practical contribution to the real problem of regulatory response to decentrally governed DLT systems.

5.2.2.3 Parsimony

High-quality theories are parsimonious (Hempel 1966; Popper 2005; Weber 2012). Parsimonious theories 'achieve good levels of predictive and explanatory power in relation to their focal phenomena using a small number of constructs and associations' (Weber 2012, p. 15). The parsimony of the DRC Framework is contributed by prototyping early versions and seeking feedback from regulatory experts as to which components contribute to the

usefulness and completeness of the artefact. The developed DRC Framework incorporates the risks, controls and participants that regulatory experts deem relevant and appropriate for inclusion in the Framework and certain earlier components that are deemed not valuable to the overall framework are omitted.

The initial research co-design workshop in the Awareness of Problem and Suggestion research stage identified the DLT participants that would most typically attract regulatory focus, identifying that further specifying a number of identified potential parties would not add further value by being included in the framework's model. Similarly, control treatments that were not deemed to add further risk mitigation beyond other identified and preferred control treatments were similarly removed from the framework as it was iterated. This process of addition and subtraction ensured the framework was both not unnecessarily complex while including the constructs and associations that maximised its usefulness to regulatory practitioners in as broad a range of cases as possible.

An expert participant's final evaluation of the framework when noting they 'strongly agreed' with the statement that the developed framework was relevant to regulators seeking to address the risks of decentralised governance in DLT systems further expanded that it was a 'very handy framework to begin drilling down to the specific controls and mechanisms needed in various aspects of the financial system'.

5.2.2.4 Level

Weber (2012) notes that a theory's interest and importance to researchers is raised if it is applicable to a greater range of phenomena. Ideally, it would do so without sacrificing its predictive and explanatory powers. Gregor & Hevner (2013) note the importance of an IS theory being more abstract and containing more knowledge that is typically contained in an IT artefact. To address this inherent lack of theoretical contribution, they suggest extracting the underlying principles to enable generalisation of the theory to broader situations. Further, they note the value of including an overall method description and constructs to further add to the theoretical contribution of such research and the ability for such research to be operationalised for a broader set of unstudied research contexts. These instruction guidelines were developed and added to the DRC Framework to support its implementation and extension by Australian financial regulators and regulators in other extended contexts. By developing and including design principles for developing and adapting regulatory controls to evolving regulatory DLT contexts, the research set its framework at a higher level of abstraction.

5.2.2.5 Falsifiability

To be capable of falsifying a theory, researchers must be capable of generating precise predictions about the targeted phenomena so they can undertake reasonably exact empirical

tests of the theory (Weber 2012). The DRC Framework has been defined to allow the efficacy of specific controls to be tested for risks manifested for specific parties. Over time, the efficacy of specific controls can be evaluated in a targeted way by regulators and researchers alike. This will ensure that the predictive theoretical quality and practical value of the framework can be confirmed and adapted over time.

5.2.3 External Researcher Observations

The use of external research observers is a supplementary qualitative research technique that contributes to improving the theoretical contribution of design science research recommended (Beck, Weber & Gregory 2013). To maximise the theoretical contribution of this research of the developed DLT Regulatory Control Framework, feedback was sought from leading IS methodology researchers. Interviews were conducted during the Build, Intervene, Additional Theory Generation and Evaluation Research stage of the research with IS research method experts.

Discussions with an IS research method expert in 2019 and 2020 identified the opportunity to improve the theoretical quality of the research by developing and incorporating regulatory control design principles that would improve the level of abstraction of the research artefact by better enabling control treatments to adapt to evolving risks. The technique developed by Gregor, Kruse & Seidel (2020) was applied to develop and refine general DLT regulatory control design principles and incorporate these into the DRC Framework. The result of this inclusion was a raised level of abstraction of the developed framework, ensuring its adaptability and extensibility to a broader range of problems.

The interview with an IS research method academic expert identified improvements to the research framework by providing guidance on clarifying and distilling the importance of the research. This resulted in a structured evaluation of the DLT Regulatory Control Framework and its theoretical contribution to maximise the theoretical quality of the research.

5.3 Evaluating the Impact of the Research in Applied Regulatory Contexts

A characteristic of ADR is to conduct research in applied settings with a view to increasing its practical relevance and usefulness (Gill & Chew 2018; Sein et al. 2011). The co-design of the DLT Regulatory Control Framework with regulatory and industry experts was centrally important to maximising the relevance, impact and importance of the developed DRC Framework research artefact to real-world regulatory contexts.

To ensure the practical value of the research, practitioner evaluation commenced in the initial Problem Formulation Research Stage. This iterative participatory ADR research style contributes to increased research usefulness and relevance (Haj-Bolouri, Bernhardsson &

Rossi 2015). Early-stage participant involvement was achieved with initial interviews conducted with regulatory policy experts at the Reserve Bank of Australia. These interviews sessions helped frame the initial research problem, specifically the potential for risks to be introduced by the emergence of DLT systems in the Australian financial system. Once the review of the research literature was conducted as part of this research stage, an initial conceptual DLT Regulatory Control Framework was developed. The risks represented in this framework were the topic of review and discussion in the initial DLT research workshop. In this workshop, the participants discussed the research topic and discussed perspectives on the risks that financial regulators would want to address. In this workshop, it was identified that risks relevant to specific participants associated with DLT systems and that did not represent systemic risks to financial stability were not the focus of regulatory supervision. In this way, an initial set of risks relevant to individual DLT participants were excluded from the DLT Regulatory Control Framework. This contributed to the parsimony of the developed artefact by reducing both constructs and associations.

As the research entered the BIE Research Stage, its focus shifted to developing, refining and improving the initial conceptual DLT Regulatory Control Framework. This involved significant incorporation of practitioner expertise into the identification and incorporation of risks and controls into the developed DRC Framework. The use of practitioners to represent real-world regulatory contexts further ensures the practical relevance and impact of the developed design artefact (Gill & Chew 2019; Sein et al. 2011).

To extend the practical usefulness of the developed framework to non-Australian and non-financial contexts, additional participant interviews were conducted with a number of international DLT fintech and regulatory experts. These identified further control responses including a regulator mandated system kill switch that if executed would limit a DLT system's ability to contribute to a financial system in crisis by limiting the contagion of crystallising risks among financial system counterparties trading on a financial DLT application. The evaluation by international DLT regulatory experts also identified appropriate IOSCO international regulatory risk frameworks that when used to categorise DLT-related risks raised the level of abstraction of the DLT Regulatory Control Framework and made it more amenable for global adoption and application.

Questionnaires were completed by research participants at the end of each research workshop. The first of these was conducted towards the conclusion of the Awareness of Problem Formulation Research Stage. The second of these was held during the BIE Research Stage. See Appendices 1-4. In these questionnaires, the research participants were asked to identify areas for improvement of the model. A further research questionnaire was circulated at the conclusion of the research to evaluate the final version of the DLT Regulatory Control Framework. Through the course of evaluation activities, participant satisfaction with the DLT Regulatory Control Framework improved successively until no further substantive

improvements were identified beyond the recommendation that further experience be gained in applying the framework to real-life regulatory contexts.

The research employed expert participant involvement throughout all research stages, involving them in the formulation of the research problem, co-design and evaluation of the developed DRC Framework, and the presentation and walkthrough of the developed DRC Framework at the conclusion of the research. The involvement of practitioners and the implementation of the participatory ADR research method maximised the impact of the research in applied regulatory contexts.

5.4 Experimental Implementation Scenario: DLT-enabled Cross-border Payments

A hypothetical implementation scenario has been developed to assist regulators implement the developed DRC Framework. The developed scenario is one that is the subject of significant central bank analysis and experimentation. In this regulatory scenario, DLT-systems are used to facilitate the exchange of value via payments between entities situated in different national jurisdictions. Existing cross-border mechanisms are both relatively expensive and take time to resolve through existing payment channels. Typically, international cross-border payments are facilitated through the sequenced exchange of value between bank counterparties using the SWIFT international inter-bank payments settlement framework. Analysis by central banks suggests the existing mechanisms for cross-border payments are complex, slow, costly, require complex reconciliation and recordkeeping across institutions, and present opportunities for attack by malicious actors (Mills et al. 2016).

The inefficiencies of cross-border payments present opportunities for DLTs to be introduced to disintermediate intermediaries through use of DLT-enabled transaction transparency and automation. Such DLT-based cross border payments offer counterparties the opportunity to clear and settle payments across national borders using proof of value and payment mechanisms inherent to DLT systems. Using DLT-based payment mechanisms to exchange value between such counterparties offers transaction clearance and settlement times in seconds rather than days, improved data auditability, resilience, and cost efficiency (Mills et al. 2016). Financial regulators, particularly central banks, are addressing this emerging use case for DLTs by contending with how to extend existing financial regulation regimes to accommodate this compelling scenario. Failure to do so may see significant cross-border flows move into unregulated territory, potentially exposing societies to unacceptable risks such as the adoption of such DLT-enabled mechanisms for terrorist funding, tax evasion and other illegal activity.

5.4.1 Initiation of Regulatory Assessment

Summary: Cross-border payments are a developing use case for DLT systems. They facilitate the transfer of value between parties in different jurisdictions. Proof of value transfer is evidenced through confirmation of transaction completion and transfer of value represented by cryptographically assured digital tokens that are transferred between parties. The trigger for exchange of rights to tokens can be the verifiable conduct of some service or exchange of right to a product or other asset. Regulators in these circumstances will be interested in determining if a DLT-based cross-border payment mechanism falls within their existing jurisdictional oversight, how existing controls are impacted or circumvented and whether parties over which regulators have jurisdiction are adversely or otherwise affected by the operation of the DLT system. Completion of the Initiation checklist will help elaborate these matters for a regulator adopting the DRC Framework to inform their regulatory response. In this implementation scenario, the hypothetical financial regulator is the Reserve Bank of Australia, Australia's central bank. See Table 4-11.

Checklist:

No.	Activity	Description	DLT-enabled cross-border payments
1	*Define regulatory jurisdiction*	What are the regulatory accountabilities and jurisdiction of the financial system regulator (domestic and international)?	The RBA has a mandate to maintain the stability of the Australian financial system. To fulfil this mandate, the bank has a role both in mitigating the risk of financial disturbances with potential systemic consequences, and in responding to such events. The RBA implements its regulatory accountabilities by establishing a foundation for low and stable inflation and sustainable economic growth. To achieve this, the RBA monitors the health of the financial system by assessing a range of aggregate financial and economic data and ensuring the Australian payments system is safe and robust. The Payments System Board within the RBA has explicit authority for payments system safety and stability and has strong regulatory powers. The RBA regularly shares its views on these matters with other relevant agencies. Domestically, the main forum is the Council of Financial Regulators (CFR). The CFR is chaired by the Reserve Bank Governor and has a mandate to contribute to the efficiency and effectiveness of regulation and the stability of the financial system. Internationally, the RBA contributes to the debate on the reform of the international financial system, primarily through its membership of the Financial Stability Board (FSB) and the Basel Committee on Banking Supervision (BCBS). The FSB has a mandate to assess the vulnerabilities affecting the financial system, identify and oversee action to address them, and promote co-operation and information sharing among authorities responsible for financial stability. The BCBS provides the international framework for the prudential regulation of internationally active banks.

			The RBA also plays a role in the management of crisis situations in co-operation with the other CFR agencies. In particular, the Bank has responsibility for monitoring financial markets, and payment and settlement systems, and for advising the Treasurer or other relevant Minister on emerging distress in these markets and systems. In addition, the Bank has responsibility for assessing and advising on the nature and scale of the systemic impact of any significant financial stress, including implications for financial markets and the payments system. The Bank is also responsible for evaluating and implementing response options that involve liquidity support or the use of payments system powers. (RBA 2021)
2	*Define regulatory ecosystem*	What are the jurisdictional and regulatory accountabilities of other relevant financial system regulators (domestic and international)?	**Australian financial regulators:** The CFR is chaired by the Reserve Bank Governor and has a mandate to contribute to the efficiency and effectiveness of regulation and the stability of the financial system. The CFR brings together the Bank, APRA, the Treasury, and ASIC, with a mandate to contribute to the efficiency and effectiveness of regulation and the stability of the financial system. **Australian Prudential Regulatory Authority** - The Australian Prudential Regulation Authority (APRA) is an independent statutory authority that supervises institutions across banking, insurance and superannuation, and is accountable to the Australian Parliament. APRA is tasked with protecting the interests of depositors, policyholders and superannuation fund members. (APRA 2021) **Australian Treasury** – The Australian Treasury's role is to anticipate and analyse economic policy issues with a whole-of-economy perspective, understand government and stakeholder circumstances, and respond rapidly to changing events and directions. Treasury provides sound economic analysis and authoritative policy advice on the Australian economy, budget, taxation, financial sector, foreign investment, structural policy, superannuation, small business, housing affordability and international economic policy. (Treasury 2021)

			Australian Securities and Investments Commission (ASIC) – ASIC is the Australian corporate, markets, financial services, and consumer credit regulator. Its role encompasses: 1. Maintaining, facilitating and improving the performance of the Australian financial system and entities in it. 2. Promoting confident and informed participation by investors and consumers in the financial system 3. Administering the law effectively and with minimal procedural requirements 4. Making information about companies and other bodies available to the public as soon as practicable (ASIC 2021) **International Financial Regulators:** **Financial Stability Board (FSB) -** The Financial Stability Board (FSB) is an international body that monitors and makes recommendations about the global financial system. The FSB promotes international financial stability by coordinating national financial authorities and international standard-setting bodies as they work toward developing strong regulatory, supervisory and other financial sector policies. The FSB fosters a level playing field by encouraging coherent implementation of these policies across sectors and jurisdictions. The FSB, working through its members, seeks to strengthen financial systems and increase the stability of international financial markets. The policies developed in the pursuit of this agenda are implemented by jurisdictions and national authorities. (FSB 2021) **The Basel Committee on Banking Supervision (BCBS) -** The BCBS is the primary global standard setter for the prudential regulation of banks and provides a forum for regular cooperation on banking supervisory matters. Its 45 members comprise central banks and bank supervisors from 28 jurisdictions. (BCBS 2021)

3	*Determine regulatory overlap and gaps relating to DLT systems*	What are the gaps and overlaps of regulatory coverage relating to the operation of DLT systems in the financial system being regulated?	The RBA is the payments systems regulator for Australia, and ASIC regulates the conduct of financial institutions that participate in the Australian financial system. To the extent that an ASIC-regulated financial institution that is systemically important to the payments system uses DLT systems for payments, there will be some regulatory overlap across these two regulators. Similarly, the conduct of institutions is governed by APRA and their boards which means this will come into overlap where the institutions are financial service providers (ASIC) that offer payments services (RBA). One of the roles of the CFR is to co-ordinate the regulatory response to these overlapping services. In the case of the Australian CFR DLT Working Group, it is an ideal forum to identify overlapping, potentially conflicting regulatory control responses, determine the means of addressing these overlaps and identify efficient ways of implementing financial system DLT regulatory control regimes.
4	*Determine the regulator's DLT expertise*	What is the regulator's level of expertise in DLT systems, risks and controls (limited, moderate, advanced)	The RBA has a DLT working group. It comprises members from its Payment Policy, Payment Settlements, and Information Technology departments. The bank also has specialised technology and DLT policy staff who have received training and experience in the bank over the course of several years. The Payments Policy department has instituted dedicated innovation specialists who have the key responsibility of investigating DLT regulatory scenarios and have conducted several policy-driven technical experiments to develop this expertise.

5	*Determine DLT regulatory control concepts*	What regulatory control concepts are applicable to the regulation of DLT systems in the regulator's jurisdiction (participants and stakeholders, risks, control treatments, residual improvements, control design principles)?	The RBA regulates the payments system of Australia. The Bank is required to control risk and promote efficiency and competition in the payments system. However, there is a presumption in favour of self-regulation by the industry, with the Bank only intervening where the industry is unable to address a public interest concern. This means that in practice, the Reserve Bank has imposed regulation in a relatively narrow range of payments system activity. Any regulatory action by the Bank is generally preceded by lengthy consultations with the industry to arrive at a non-regulatory solution. The result of this approach is that the scope of the Bank's regulation has been quite narrow, largely covering interchange fees and restrictions on merchants in card systems, along with access regimes for several card systems. (RBA 2021) The regulatory tools at its disposal include: 1. The imposition of interchange fees for payments providers 2. Restrictions on merchants in card systems 3. Reporting and transparency requirements on systemically important payments providers
6	*Determine DLT system context*	What DLT systems are potentially relevant to the regulator's jurisdictional accountabilities (applications, platforms, infrastructure)?	1. DLT systems that enable payments to be conducted with at least one or more participants within the Australian financial system. 2. DLT systems provided by providers of Australian financial payments providers to parties.

7	*Determine the relevant regulatory control response framework*	Is the DRC Framework a relevant fit for the regulator's DLT regulatory control response?	1. The DRC Framework is a comprehensive framework designed for a financial regulator like the RBA 2. There are no other financial regulatory frameworks in Australia or overseas that have been designed to specifically address the specifics of DLT systems. 3. The DRC Framework once applied can be reconciled and integrated into existing control regimes

Table 4-11. Initiation Checklist for Regulating DLT Cross-border Payments

5.4.2 Development of Regulatory Control Portfolio for Cross-Border Payments

Summary: The DRC v1.0 Framework is adapted in this activity to accommodate the risks and challenges relevant to cross-border payments. The library of risks, control treatments, participants and residual risk improvements are adapted for the specific payments context. See Table 4-12.

Checklist:

No.	Activity	Description	DLT-enabled cross-border payments
1	*Identify accountable regulators*	Which regulator(s) is/are accountable for the relevant regulatory controls relating to the operation of DLT systems in the financial system being regulated (nb. regulatory coverage may overlap in specific domains)?	RBA – Reserve Bank of Australia **ASIC** – The Australian Securities and Investment Commission. ASIC is also responsible for licensing and authorising entities to operate in the industries it regulates. ASIC regulates banks and financial service providers, sets and enforces banking standards and investigates and acts against misconduct in the banking sector. **APRA** – The Australian Prudential Regulatory Authority is an independent statutory authority that supervises institutions across banking, insurance and superannuation and promotes financial stability in Australia. APRA supervises banks, credit unions, building societies, general insurance and reinsurance companies, life insurance, private health insurance, friendly societies, and most of the superannuation industry. **AUSTRAC** – The Australian Transaction Reports and Analysis Centre is the Australian Government agency responsible for detecting, deterring and disrupting criminal abuse of the financial system to protect the community from serious and organised crime.
2	*Identify the process for regulatory control management*	What is the process for defining regulatory controls in the financial system being regulated?	▪ Individual financial regulators set regulations pursuant to their regulatory authorities – this is established by the legislative framework that grants them this authority. ▪ Key Australian financial regulators are members of the Council of Financial Regulators (CFR) which is chaired by the Governor of the RBA. ▪ The CFR is a non-statutory group, without regulatory or policy decision-making powers. These powers reside with the CFR membership. The CFR's objectives are to promote the stability of the Australian financial system and support the effective and efficient regulation by Australia's financial regulatory agencies. In achieving these objectives, the CFR aims to achieve the benefits of a competitive, efficient and fair Australian financial system. (CFR 2021)

			▪ ASIC operates a regulatory sandbox that allows fin-techs to test specified services for up to 12 months without an Australian Financial Services License. This reduces the initial cost of establishing a service-provided risk exposure to the market and ensures that ASIC has early visibility to these emerging and innovative services. ▪ If a business holds an AFS License, it is required to enroll with AUSTRAC as an AFS Licensee. It then falls within the jurisdiction of the AML/CTF Act and Rules and becomes obligated under the relevant obligations that relate to being an AFS Licensee. Where a business provides services relating to digital currencies it also falls under the jurisdiction of the AML/CTF Act and Rules. The definition of 'digital currency' under the AML/CTF Act encompasses crypto currencies such as Bitcoin. Such a business is required to register with AUSTRAC and will be encompassed by the Australian AML/CTF Regime regulated by AUSTRAC. AUSTRAC requires regulated entities to establish appropriate AML/CTF compliance program that encompasses the development and implementation of an AML/CTF Policy and Risk Matrix, performing regulator staff training and conducting regular compliance reviews of its implementation of the developed AML/CTF compliance program.
3	*Identify DLT providers*	Who are the key DLT providers in the financial system being regulated?	▪ Key DLT providers in the Australian financial system are the main cryptocurrency platforms of Bitcoin and Ethereum. ▪ The Australian Stock Exchange (ASX) is replacing its current clearing and settlement service (CHESS) with a DLT-based solution. The ASX is regulated by the Payments Policy function of the RBA. This regulation extends to the supervision of the rollout of the DLT-based CHESS replacement. (ASX 2021a) ▪ Fintech and financial service advisors have emerged in the Australian economy that are providing advice on the impact and use of DLT systems. ▪ Australian Stock Exchange through its move to provide DLT-based clearing and settlement services for traded securities. (ASX 2021b)

			▪ ASIC is responsible for the supervision of real-time trading on Australia's domestic markets, including those operated by ASX Group. ▪ The RBA has responsibility for assessing whether licensed clearing and settlement facilities, including those operated by the ASX Group, have complied with the RBA's Financial Stability Standards ('FSS') and done all the other things necessary to reduce systemic risk. ▪ The ASX has trading or market operating recognition or authorisation from several international regulators and is required to comply with certain regulatory obligations issued by those international authorities in order to maintain that authorisation. ▪ Digital currency exchanges have emerged as a significant DLT provider in Australia. Such exchanges are covered by AUSTRAC's AML regulatory regime and requires registration under AUSTRAC's Digital Currency Exchange Register. This requires digital currency exchanges to identify, mitigate, and manage the money laundering and terrorism financing risks. Similar to regulated banks, exchanges must identify and verify the identities of their customers; and report suspicious matters, international transactions, and transactions involving physical currency that exceed AU$10,000. Specified records must be kept for 7 years. ▪ Banks and financial service providers that use or provide DLT-based services. o Fall under the jurisdiction of ASIC as regulated entities. o Fall under the jurisdiction of AUSTRAC's AML regime o Fall under APRA as regulated entities o Fall under RBA as regulated providers of systemically important national payments providers

4	*Identify DLT participants*	Who are the key DLT classes of participants in the financial system being regulated and what regulatory jurisdictions to they fall under?	▪ **Payers** - Consumers or organisations that are the payers of DLT-based payments ▪ **Beneficiaries** - Consumers or organisations that are the beneficiaries of DLT-based payments ▪ **Supervisors** - Participants who have roles that require them to view the conduct of DLT-based payments. These can have assurance or supervisory roles in regard to the conduct of DLT-based payments ▪ **Validators** - Participants who are responsible for the validation of DLT-based payments ▪ **Asset owners** - Participants who can create assets or otherwise own assets that are the subject of DLT-based payments
5	*Identify relevant DLT stakeholders*	Are there any other relevant DLT stakeholders in the financial system being regulated (i.e., those stakeholders not already participating in DLT systems)?	▪ **Australian Regulators** – regulators who are accountable for the regulation of the Australian financial system (RBA, AUSTRAC, ASIC, APRA) ▪ **International financial regulators** – global financial payments regulators responsible for the conduct of payments in national jurisdictions (e.g., UK FCA), or international domains (e.g., BCBS and FSB) ▪ **Australian Banks and payments intermediaries** – providers of core payments infrastructure in the Australian financial system ▪ **International counterparty banks and payment intermediaries** – Counterpart institutions that facilitate the transacting of cross-border payments ▪ **DLT Providers** – providers of DLT-enabled cross-border payment services
6	*Identify DLT platforms & applications*	What are the current and emerging DLT platforms and application classes operating in the financial system being regulated?	▪ **Bitcoin** – global Bitcoin payment system ▪ **Global digital currencies from central banks** – digital currencies enabling cross-border payments (e.g., People's Bank of China's Digital Yuan). ▪ **Lygon** – Australian banking consortium involving ANZ bank, Commonwealth Bank of Australia (CBA), Westpac, IBM and shopping centre company Scentre Group offering DLT-based digitised bank guarantees.

7	*Define portfolio of known DLT risks*	What are the *existing risks* relating to the operation of decentrally governed DLT systems in the financial system being regulated?	**R1. Risks to DLT System Users:** Failure of DLT payment system resulting in adverse outcomes for participants. Contributing causes include: 1. Failure of payments and general financial system regulatory or legal controls (e.g., **AML** risks not mitigated, non-compliance by DLT providers or participants with regulatory/legal controls) [FOBS] 2. Loss to Participant/Stakeholder due to failure of DLT payments application or provider (e.g., incentive misalignment, cryptography failure) [FO] 3. Commercial failure of DLT Provider (e.g., financial or operational failure, loss of regulatory acceptance) leading to participant loss [FO] 4. Failure of DLT Technology (e.g., operational or cryptography failure, poor system quality, lack of continuity planning) leading to participant losses [FOB] 5. Loss of trust in integrity of DLT application or platform [FOB] 6. Lack of accountable parties during crisis [FO] 7. Lack of DLT expertise to identify application or platform-specific risks (unintended consequences, unforeseen interdependencies) [FORS] 8. Ineffective dispute resolution leading to poor participant outcomes [FB] 9. Fragmentation of DLT system resulting in loss of market acceptance [FB] 10. Loss of value to beneficiary or payer [FOB] **R2. Risks to DLT Providers [Application, Platform, Infrastructure]:** Failure of DLT system resulting in adverse outcomes for DLT providers and investors. Causes include: 1. Failure of DLT platform (e.g., operational, security - cryptography, financial, inadequate testing) [FOB] 2. High costs of maintaining regulatory acceptance of DLT systems [FOB] 3. Lack or loss of regulator acceptance for DLT system [FOB]

			4. Poor decentrally developed software quality leading to failure of DLT application/platform to operate as expected (e.g., poor software code quality or security vulnerability causing failure of DLT service) [FOB] 5. Fragmentation of DLT system resulting in loss of market acceptance (forking) [FO] 6. Failure of Regulatory Controls e.g. (risks not identified or mitigated, low levels of compliance with regulatory controls, high compliance costs) [FOBS] **R3. Risks to Regulated Markets:** Risks to Markets caused by DLT systems. Causes include: 1. Complexity of systems limiting regulator ability to identify and address systemic risks [FOBS] 2. Loss of market confidence through market-wide systemic failure of DLT systems (e.g., cryptography failure, compromise of consensus model or governance attack, design and crisis response sitting with non-financial experts, opaque and limited accountabilities for system-wide crisis response and continuity planning) [FOBS] 3. Non-confidence in regulation over DLT systems in regulated markets [FOBS] **Risk types**: [F] Financial, [O] Operational, [Business], [S] Systemic
8	*Define existing financial regulatory controls*	What *existing regulatory controls* are relied on to treat risks relating to the operation of decentrally governed DLT systems in the financial system being regulated?	C1. Controls applied to DLT-enabled cross-border payment participants 1. None/limited C2. Controls applied to DLT-enabled Payments Application, Platform, and Infrastructure Providers 1. RBA-issued licences to operate for financial service providers that provide inter-bank real time gross settlement services in Australia 2. Reporting, conduct, design, operational and disclosure standards for systemically important Australian payments providers 3. Transparency of governance, participants, user rights, and operational rules 4. Fraud prevention regulation (only where the RBA considers a market failure is preventing effective fraud risk management or where public confidence in the payments system is at risk)

			C3. Systemic Regulatory Controls for Payments 1. Presumption in favour of self-regulation by industry, with the RBA only intervening where the industry is unable to address a public interest concern. 2. Formal oversight of systemically important payment systems (SIPS) under the RBA framework for Financial Market Infrastructures (FMIs) 1. Regular formal assessment of SIPS on a regular basis including the RBA's own Reserve Bank Information and Transfer System (RITS) 3. Ongoing review of payment systems with a focus on efficiency and competition (e.g., in the RBA's Strategic Review of Innovation in the Payments System, the bank sought to address concerns about the capacity of the industry to respond to changing user demands. This resulted in new industry governance arrangements through the creation of the Australian Payments Council and the initiation of the project to deliver the Australian New Payments Platform.) (RBA 2021) 4. Ongoing payments systems reviews (e.g., the RBA's Strategic Review of Innovation in the Payments System). 5. Australian payments industry regulatory collaboration to ensure regulatory alignment and reduced compliance costs (facilitated through CFR and the Australian Payments Council) 6. Harmonised domestic and international DLT regulatory regimes through RBA participation in global financial system regulatory standard setting (FSB, BCBS) 7. Efficient market dispute access mechanisms for DLT participants and providers 8. Program for maintaining RBA expertise on developments in DLT systems (staff development, sponsored DLT research, research collaboration with academia, industry, and central banking peers)

9	*Assess efficacy of existing regulatory controls*	What are the *mitigatory impacts* of existing regulatory controls that treat the risks relating to the operation of decentrally governed DLT systems in the financial system being regulated?	I1. Improved Risk Outcomes for DLT-enabled cross-border payments counterparties 1. Ability to develop trusted relationships among large numbers of otherwise unknown DLT participants through reputation and trust placed in integrity of the internal governance and reputation management mechanisms of DLT-enabled cross-border payments systems (e.g., incentives, reputational cost of poor behavior). 2. Regulated supervision reducing risks of participating in DLT-enabled payment systems provided by financial service providers under the jurisdiction of Australian regulators I2. Improved Risk Outcomes for DLT providers of cross-border payments [Application, Platform. Infrastructure Providers] 1. Reduced risk of loss of DLT payment system integrity through regulatory governance controls enforceable on financial service providers of cross-border payments falling under the jurisdiction of Australian regulators 2. Maintenance of trust and confidence in DLT system through i. Regulatory enforcement of standards for ownership or control over DLT payment systems provided by entities regulated by Australian regulators 3. Reduced cost and friction of on-ledger transactions improving efficiency and value-creation of DLT-enabled cross-border payment system I3. Improved Systemic Risk Outcomes for Regulated Markets 1. None/limited
10	*Determine usability*	Who will use the DRC Framework and for what purposes?	For use by RBA Payments Policy department regulators, in collaboration with counterpart CFR DLT working group regulators in ASIC, APRA and AUSTRAC

11	*Determine version control*	Which version of the DRC Framework is being used?	V1.0 DRC Framework

Table 4-12. Development of Regulatory Control Portfolio Checklist for Regulating DLT Cross-border Payments

5.4.3 Adaption and Development of Regulatory Controls

Summary: In this section the library of controls in the DRC Framework are adapted for the specific regulatory case to which the framework is being applied. The range of proposed regulatory control treatments are informed by the regulator's bounds of authority, regulatory ecosystem and the appropriate regulatory control setting process. See Table 4-13.

Checklist:

No.	Activity	Description	DLT-enabled cross-border payments
1	*Identify regulatory control owner*	Who is accountable for the relevant regulatory control relating to the operation of DLT systems in the financial system being regulated (n.b., there may exist multiple regulatory owners for different regulatory controls)?	▪ **RBA's Payment Policy function** – responsible for the regulation of Australian Financial Market Infrastructure Providers and retail payments regulation. ▪ **ASIC** – responsible for Australian corporate, financial markets, financial services and consumer credit regulation. ▪ **APRA** – responsible for the licensing and regulatory oversight of financial entities to protect the interests of depositors, insurance policyholders and superannuation fund members. ▪ **AUSTRAC** – responsible for regulating anti-money laundering and terrorist financing in Australia.

2	*Identify the process for regulatory control management*	What are the processes for developing and implementing specific regulatory controls in the financial system being regulated?	▪ Australian financial regulators are members of the Australian Council of Financial Regulators (CFR) ▪ The CFR is chaired by the Governor of the Reserve Bank of Australia ▪ Member regulators include APRA, ASIC, RBA, and the Australian Treasury ▪ The CFR does not have a specific policy setting or regulatory authority; these reside in the individually legislated accountabilities of its constituent regulator members ▪ The CFR is used to agree on directions and develop collectively agreed and aligned guidance for constituent regulators
3	*Identify relevant regulatory control design principles*	What regulatory control design principles are relevant to the development or adaption of a specific DLT regulatory control?	1. Systemically integrate regulatory payments controls 2. Tailor DLT controls more proximately to DLT payment providers and counterparties 3. Harmonise DLT regulatory payment controls across regulatory jurisdictions 4. Ensure best available information for payments participants and regulators 5. Continuously improve DLT Quality Standards 6. Maintain and improve trust among counterparty participants 7. Expand DLT expertise and awareness among participants and regulators 8. Preserve value 9. Be responsive to change
4	*Define portfolio of adapted regulatory control treatments*	What are the *regulatory controls proposed* to treat the risks relating to the operation of decentrally governed DLT systems in the financial system being regulated?	C1. Controls applied to DLT-enabled cross-border payment participants 1. Mandatory participant DLT risk literacy training required to be provided by DLT payments service providers to participating customers 2. Certifiable Proof of Reserves required of custodian participants C2. Controls applied to DLT-enabled Payments Application, Platform, and Infrastructure Providers

			3. RBA-issued licences to operate for Australian financial service providers of DLT-enabled payment services in Australia 4. Reporting, conduct, design, operational and disclosure standards for systemically important Australian payments providers to encompass DLT payments services provided by these providers 5. RBA-issued regulation of FMIs to encompass disclosure and reporting requirements, and minimal standards for DLT-enabled cross-border payments. Requirements to include: 1. DLT Software Quality Standards 2. Accreditation standards for developers 3. Independently-assurance framework for the auditing of DLT platforms 4. RBA access to DLT payments software code and documentation 5. Sanctions for failed standards and negligence 6. Disclosure and transparency of governance, participants, user rights, and operational rules relating to regulated DLT payments services 7. RBA-issued Quality Assurance Seals 8. Reporting, conduct, design, operational and disclosure standards for DLT-enabled payment providers 6. Confirmation by RBA of DLT payment providers' fiduciary obligations to participants 7. Requirement of regulated payment providers for DLT payment system intergratability with machine-readable regulation C3. Systemic Regulatory Controls for Payments 1. Continuation of presumption in favour of self-regulation by industry, with the RBA only intervening where industry is unable to address a public interest concern.

			2. Formal oversight of systemically important payment systems (SIPS) under the RBA framework for Financial Market Infrastructures (FMIs) 1. Regular formal assessment of SIPS on a regular basis including the RBA's own Reserve Bank Information and Transfer System (RITS) 3. Incorporation of emerging DLT-enabled payment services into the ongoing review of payment systems conducted by the RBA (e.g., in the RBA's Strategic Review of Innovation in the Payments System, the bank sought to address concerns about the capacity of the industry to respond to changing user demands. This resulted in new industry governance arrangements through the creation of the Australian Payments Council and the initiation of the project to deliver the Australian New Payments Platform.) (RBA 2021) 4. Australian payments industry regulatory collaboration to ensure regulatory alignment and reduced compliance costs (facilitated through CFR and the Australian Payments Council) 5. Domestic and international regulatory harmonization mechanism to ensure regulatory co-ordination with other Australian and international financial regulators (e.g. (FSB, BCBS) to minimise conflicting or inconsistent disclosure requirements and regulatory requirements across regulatory jurisdictions). Examples of themes for international regulatory harmonization include: 1. Efficient international-market dispute access mechanisms for DLT cross-border participants and providers 2. International and domestic co-operation in an ongoing DLT regulatory standards improvement regime

			3. Development of standards for implementing, operating and sharing information relating to integrated regulator nodes that monitor on-ledger system, provider and counter-party risk 6. Program for maintaining RBA expertise on developments in DLT systems (staff development, sponsored DLT research, research collaboration with academia, industry, and central banking peers) 7. Ensure appropriate transparency of on-ledger transaction activity to enable risk visibility for stakeholders, including participants, DLT providers and regulators 8. Regulator led real-time computational market risk analysis 9. Focus on data insights and AI to identify emergent market risks 10. Industry regulatory collaboration and market/regulator utilities to reduce compliance and system participation costs 11. Machine readable regulation Regulator 'kill switch' authority to stop operation of DLT payment systems or specific transactions to reduce contagion risk and maintain participant confidence in the integrity of the DLT system and financial markets
5	*Identify anticipated impact of proposed regulatory controls*	What are the anticipated mitigatory impacts of *proposed regulatory controls* that treat the risks relating to the operation of decentrally governed DLT systems in the financial system being regulated?	I1. Improved Risk Outcomes for DLT Participants 1. Ability to develop trusted relationships among large numbers of otherwise unknown DLT-enabled cross-border payment counterparties through reputation and trust placed in integrity of Australian DLT cross-border governance mechanisms (e.g., incentives, reputational cost of poor behavior). 2. Increased transparency of risks for cross-border payment counterparties 3. Improved efficiency in DLT cross-border counterparty discovery and transacting

			4. Regulated supervision reducing risks of participating in DLT-enabled cross-border payments 5. Lower cost of maintaining regulatory compliance 6. Reduced information asymmetry among cross-border payment counterparties and providers I2. Improved Risk Outcomes for DLT Providers [Application, Platform, Infrastructure] 1. Reduced risk of loss of DLT system integrity and market confidence through enforcement of regulatory controls 2. Maintenance of trust and confidence in DLT system through i. Reduced payment system information asymmetry among counterparties and participants ii. Regulatory visibility into DLT system activity to identify and address emerging or systemic risks iii. Regulatory enforcement of standards for ownership or control over financial DLT systems 3. Reduced cost and inefficiency (friction) of cross-border payments I3. Improved Systemic Risk Outcomes for Regulated Markets 1. Improved visibility to DLT participants and stakeholders of risks and health of overall DLT ecosystem (enabled by holistic on-ledger system-wide reporting and regulatory participation) 2. Reduction in loss of market integrity and confidence through identification of participants, providers and counterparties with poor reputations and behaviours 3. Improved efficiency of on-ledger governance enforcement

			4. Extended leverage of DLT system development costs through improved interoperability and integrability of DLT systems

Table 4-13. Controls Adaption and Development Checklist for Regulating DLT Cross-border Payments

5.4.4 Deployment

Summary: In this section, the requirements to deploy the configured DRC Framework are identified. This encompasses the identification of accountable parties for control deployment and confirming the appropriate process for deploying and verifying the regulatory control treatments. See Table 4-14.

Checklist:

No.	Activity	Description	DLT-enabled cross-border payments
1	*Identify process owner for implementing regulatory control(s)*	Who is accountable for deployment and ongoing administration of a regulatory financial control selected to treat the risks of decentrally governed DLT systems?	The RBA's Payments System Board (PSB) has powers set out in four pieces of Australian legislation. These are: Reserve Bank Act 1959; Payment Systems (Regulation) Act 1998; Payment Systems and Netting Act 1998; and Cheques Act 1986. The Governor of the RBA is the Chair of the PSB. The Reserve Bank Act (1959) gives the PSB accountability for payments system policy that must be exercised in a manner that best contributes to: ▪ controlling financial system risk ▪ promoting payment system efficiency ▪ promoting competition in the payment services market consistent with the overall financial system stability

			The RBA's Payments Policy department supports the PSB to fulfil these accountabilities and will be responsible in most circumstances of implementing the PSB's directives as it relates to the RBA's authorized regulatory powers.
2	*Verify control implementation and efficacy*	Can the regulator confirm the operation of the regulatory control in the regulated financial system?	The RBA's Payment Policy (PY) department on behalf of the Governor and the PSB conducts regular reviews of the Australian payment system, and these reviews encompass the efficacy and emerging threats and opportunities to the system. This mechanism will be the one that is used to monitor, assess, and make recommendations on the efficacy of any control regime implemented to manage the risks and opportunities of DLTs in the payments system.
3	*Determine deployment timeframe*	How long did it take to deploy the new/adapted regulatory control treatment?	The regular monitoring of the payments system, and specific reviews on the efficacy of any DLT-related adaptation of the RBA's payment system control regime will be conducted by the RBA's PY function and will assess the deployment schedule and efficacy of the implemented control regime.

Table 4-14. Deployment Checklist for Regulating DLT Cross-border Payments

5.4.5 Management and Administration

Summary: The implementation of a regulatory control regime to address DLT risks warrants ongoing management and administration. This section identifies the accountable parties for regulation management, encompassing risk monitoring and ongoing regulatory control assessment and review. See Table 4-15.

Checklist:

No.	Activity	Description	DLT-enabled cross-border payments
1	*Identify process owner*	Who is accountable for the ongoing management and administration of the regulatory implementation of the DRC Framework?	The RBA's PSB is the process owner for payment systems regulation setting and governance in Australia. The responsibility for administering this accountability sits with the RBA's PY function. PY regularly reports to the PSB on the efficacy of the regulatory control regime and the threats and challenges that must be addressed to ensure the ongoing efficacy of the Australian payments system.
2	*Manage risk*	Does the portfolio of control treatments administered through the DRC Framework effectively reduce the residual risk associated with the operation of decentrally governed DLT systems in the financial system?	The assessment of current and emerging payment-related risks is the accountability of the PSB and is conducted with the support of the RBA's PY function. This risk assessment will likely fall within the specific scope of the PSB's regular review of payment systems' efficiency and stability. It may also be the subject of a specific review relating to DLT if it is deemed this field warrants a focused risk review. These assessments are likely to inform and be informed by reviews commissioned by the CFR, also chaired by the Governor of the RBA, in the context of broader financial system regulation.
3	*Control efficacy*	Are the regulatory controls effective and do they efficiency achieve intended regulatory outcomes (costs to implement and maintain, risk mitigation, resource intensiveness, satisfaction of regulated parties)?	The efficacy of a DLT regulatory control regime must be assessed in the overall context of the stability and efficiency of the Australian payment system. This assessment will be conducted as part of the review of the payment system conducted by PY and reported to the PSB.

4	*Control adaptiveness*	Are the regulatory control responses adaptive to changing risk conditions?	The adaptiveness of the recommended controls will be determined by their ability to adapt to changing payment system conditions and risks. A measure of their adaptiveness will be the extent to which controls can address changing payment system conditions and the extent to which new controls can be identified and implemented as a result of these changing market conditions and risks.
5	*Management feasibility*	Is the DRC Framework considered practical and effective as a useful model for addressing the regulatory risks (participant, provider, systemic) of decentrally governed DLT systems in the financial system?	This will be determined by several factors: ▪ The minimization of regulatory management and operational effort required of regulators and regulated parties to deploy and administer DLT-related control treatments ▪ The degree of integration with existing payment and financial system regulation (for both regulators and regulated entities) ▪ The degree of harmonisation between Australian regulatory requirements and international regulatory requirements. This will minimise the cost and effort required of regulated entities that are subject to multiple regulatory regimes and minimise the cost to regulators of developing and managing regulatory regimes
6	*Regulatory compatibility*	Is the ongoing operation of the DRC Framework cohesive within the overall financial system regulatory ecosystem (compatible, integrated, complementary)?	This will be determined by several factors: ▪ The ability of DLT regulatory control treatments to be integrated into the current regime of payment and financial system regulation. In the case of Australian payment system regulation, this will necessitate the ability of identified controls fitting within Australia's largely self-regulating payments regime with RBA regulatory intervention only when deemed necessary by the PSB or CFR.

			▪ The degree of harmonisation between the operation of Australian regulatory requirements with ongoing international payments regulation. This will require ongoing cooperation, information and risk intelligence sharing between international regulatory regimes.

Table 4-15. Management and Administration Checklist for Regulating DLT Cross-border Payments

5.5 Chapter Summary

This chapter evaluated the DRC Framework both for its theoretical contribution and practical relevance. This is achieved by evaluating the theoretical contribution of the various parts of the developed DRC Framework's components, and as a whole. The developed DRC Framework was holistically assessed for its level, importance, novelty and parsimony. Individual components of the framework were evaluated for the theoretical quality of their constructs, associations, states, and events. The theoretical evaluation indicated areas for some further refinement in its parsimony and construct associations. These improvements were applied to the developed DRC Framework and contributed to the improved theoretical quality of the resulting research artefact. The framework was also evaluated for its efficacy in addressing real-world regulator problems. The use of regulatory practitioner experts to contribute to the evaluation of the practical usefulness of the DRC Framework contributed to the developed research artefact being comprehensive, relevant, important, valid, applicable and fit for purpose. As practitioner evaluation was conducted iteratively using the ADR method, improvements to the DRC Framework were made iteratively through its development. The outcomes of the ongoing practical and theoretical evaluation and refinement of the framework resulted in a practically useful and theoretically valid design research artefact. Chapter 6 discusses the reflections, results, impacts, limitations and future directions of the research.

6 Discussion

This chapter synthesises the research findings, draws additional insights into the developed DRC Framework research artefact and links these insights to the research questions. The chapter starts with an outline of the research journey. It then presents a reflection on the research process and findings. The chapter then discusses the insights drawn from the research and discusses its contribution to regulatory practice, standards development and research. The chapter concludes with a discussion of the research limitations and the steps taken to address these limitations.

6.1 Research Journey

This research began in November 2017 as a doctoral research study under an Australian government research scholarship. The research thesis is submitted for examination in the Australian summer of early 2021 with the research being conducted over the intervening three and a half years. The first year focused on a review of the literature, the formulation of the research question to be examined and the selection of an appropriate research method. The second year of research involved the enrolment and early engagement of regulatory practitioners and industry experts to inform the definition of the research problem and participate in the initial co-design of the DRC Framework. The third year of research involved the iterative development, evaluation and refinement of the developed DRC Framework and the expansion of its theoretical generalisability. Throughout the research period, ongoing research outcomes were presented to Australian financial regulators, contributed to international standards development in the field of DLT governance and were the subject of academic research publications and conference presentations. See Figure 6-1.

In 2017, early-stage UTS coursework on the research literature analysis and research design supported the articulation of a compelling research problem and the development of a theoretically valid research method. The ongoing engagement with regulators and standards developers informed the direction of the research and ensured it remained relevant and focused on addressing problems that reflected the regulatory challenges of DLT systems. An observation of the research experience is that ongoing academic and practitioner consultation ensured the research direction remained relevant to addressing real-life regulator challenges while also serving to fill a notable research gap.

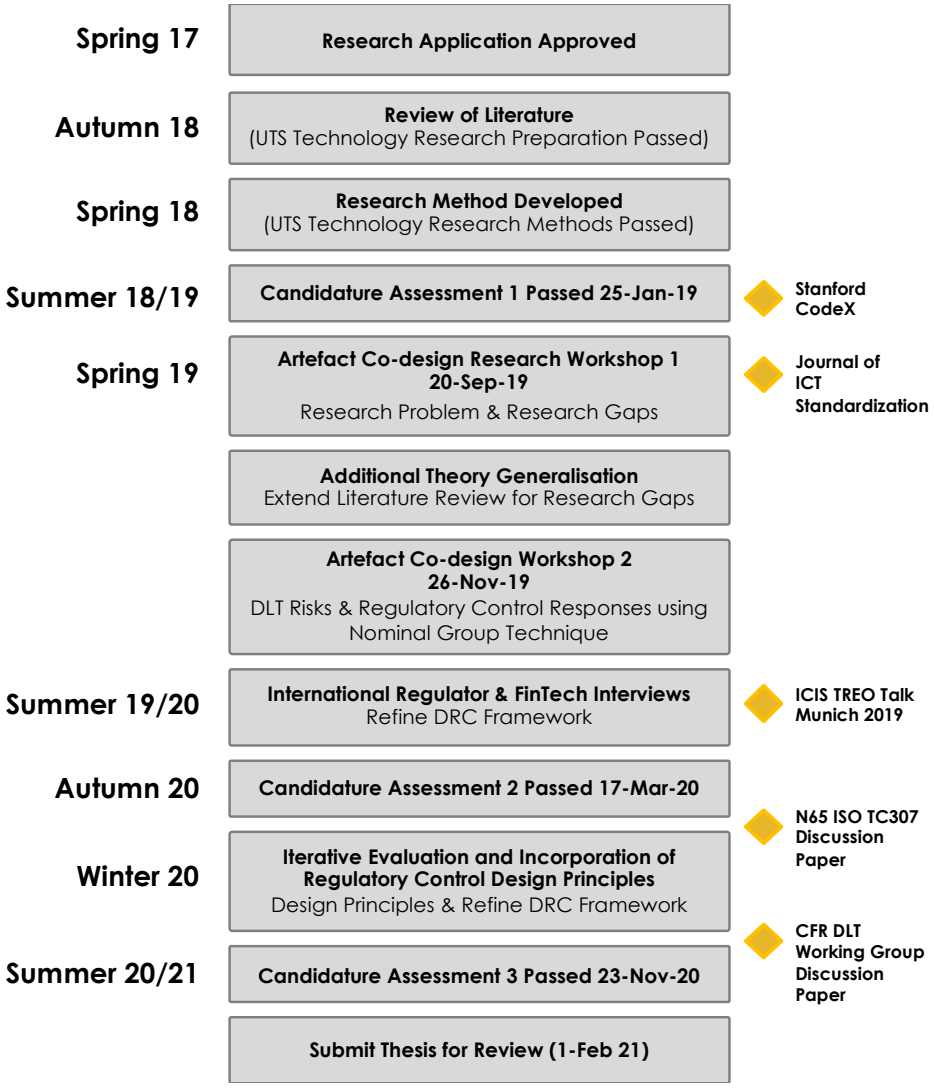


Figure 6-1. Research Journey

6.2 Research Insights and Reflections

The research aimed to develop a framework to guide regulatory control responses to the risks of decentrally governed DLT systems. The implemented participatory ADR approach incorporated regulatory DLT experts into early-stage co-development of the DRC Framework to maximise its practical relevance and usefulness. The research method also implemented additional qualitative research techniques to increase the theoretical contribution of the research.

This collaborative research study developed new knowledge and insights. These are incorporated into both the developed DRC Framework and the research method knowledge gained from conducting the participatory ADR study. Key insights include:

1. Identification of risks pertaining to the decentralised governance enabled by DLT systems.
2. A range of regulatory control responses administered by a variety of collaborating regulators is required to effectively address the pace of DLT innovation in regulated markets.
3. The pace of DLT innovation further warrants the use of adaptive regulatory control design principles to ensure the continuing efficacy of regulatory controls.
4. Regulators benefit from their involvement in academic research on the regulatory challenges of emerging technologies through the acquisition of knowledge and solutions.
5. Conducting research in fields with limited existing research and industry implementation merits the early participation of expert practitioners to guide the formulation of the research problem.
6. The applied characteristics of ADR enhances the industry relevance of the associated standards development.

6.2.1 Identification of risks pertaining to decentrally governed DLT systems

The nature of the risks identified and incorporated into the DRC Framework are largely derived from the decentralised nature made possible by decentralised DLT governance. The DRC Framework identifies the specific decentralised characteristics of the resulting risks, and these are differentiated from more conventional regulatory regimes. A key theoretical contribution of the DRC Framework is to articulate the specific risks of decentralised governance presented by DLT systems. Having articulated these risks regulators and researchers are then in a better position to identify appropriate risk controls to treat these risks.

6.2.2 Importance of regulatory collaboration

The risks of decentrally governed DLT systems are often interconnected and manifest distinctly for diverse DLT participants. The review of the literature and involvement of the expert regulatory practitioners identified the diverse risks of decentrally governed DLT systems. The range and diversity of these risks and the considered guidance of the practitioners point to a need to take a broad ranging approach to regulatory control responses. The DRC Framework identifies the interconnected nature of decentralised governance risks afforded by DLT systems and provides guidance to researchers and regulatory practitioners on ensuring the association between potential regulatory control treatments and multiple related risks are considered when developing a regulatory control regime.

No single regulatory control arose as presenting a ‘silver bullet’ to the complex, interconnected risks introduced by decentrally governed DLT systems. A key insight was that a range of regulatory control responses administered by a variety of collaborating regulators

is required to address the fast pace of DLT innovation in regulated markets. Regulators should consider their role, the complementary or conflicting roles of other regulators, and the holistic effect of their combined regulatory control responses when evaluating the efficacy of regulatory control responses to decentrally governed DLT systems.

6.2.3 Imperative for adaptive regulatory controls

The study identified that prescriptive regulatory controls face possible circumvention by fast moving DLT system designs and innovative DLT providers. To address this challenge, the DRC Framework incorporates nascent regulatory control design principles intended to ensure any implemented regulatory control regime remains adaptive to the fast-moving pace of DLT innovation. By including regulated entities and identifying the important of overlapping regulatory controls and regulatory actors, the DRC Framework encourages the implementation of regulatory control regimes that minimise their reliance on specific intermediaries and controls and encourage the implementation of control regimes that are adaptive to fast-moving DLT innovation in the financial system. The incorporation of adaptive regulator control design principles into the DRC Framework increases the relevance of the framework into a broader range of regulatory contexts.

6.2.4 Benefits of regulator involvement in academic research

While conducting the research, it became apparent there exists limited regulatory practitioner experience with DLTs and their regulation in the financial system. Limited regulatory experience was determined as partly due to the relative recency of DLT innovations and unfamiliarity regulators have with the complex technical underpinnings of their designs. The scarcity of regulator expertise in emerging technologies such as DLT must be addressed if financial regulators are to minimise the likelihood of poorly understood and regulated DLT risks seeding future economic crises.

By participating in the research, the regulators observed that they benefited from the development of further knowledge relating to the regulatory challenges and solutions to DLT systems. This was facilitated by the structured and unstructured co-design ADR research activities with both researcher and other research participants. It was an observed learning that this research partnership provided regulators with insight into the emerging issues of novel and emerging technologies in a timely and coalescing manner.

One example of this emergent learning was the appreciation regulators developed for the pace of DLT innovation and the realisation that regulators should avoid prescriptive regulatory responses that would inhibit innovation and be easily worked around by agile DLT developers. To address this challenge, the participating regulators developed an appreciation of adaptive regulatory controls guided by overarching design principles.

Another example of emergent knowledge by regulators was the appreciation that the intrinsically distributed characteristics of DLT systems required regulators to engage collaboratively not only with domestic peer regulators but also with international regulatory counterparts. Participating in the research crystallised for regulators the realisation that the functionality and risks of DLT systems do not stop at regulators' jurisdictional boundaries. The research highlighted the need for regulators to develop harmonised regulatory control responses to the risks presented by DLT systems. In the future, more and more complex business processes will be digitised, linked and transacted via integrated cross-border DLT systems. To address this likely eventuality, participating regulators gained insight into the need for regulatory controls to traverse regulated contexts and ensure regulatory harmonisation across regulatory jurisdictions.

6.2.5 Benefits of early expert participation in emerging research

When setting out to undertake this research, it was apparent that limited research had been conducted on this research problem. Incorporating input from regulatory practitioner experts by adopting a participatory ADR approach to co-develop the DRC Framework was instrumental in filling this research gap. Addressing a practical regulator challenge without the benefit of access to practitioner expertise would have been a highly challenging research problem and one with a limited chance of successfully developing a practically useful research artefact. The involvement of regulatory experts increased the relevance, impact, usefulness and novelty of the resulting research artefact.

6.2.6 ADR enhances industry relevance of standards development

The alignment of ADR research activity with the development work associated with international standards on DLT governance afforded an ideal environment to gain access to DLT experts representing a diversity of industry and academic research perspectives. It became apparent through the course of the research journey and concurrent development of international DLT governance standards that the two endeavours can be complementary and mutually beneficial. In the case of this research, the academic and practitioner research activity provided valuable input into the effort to develop international DLT governance standards. Conversely, the process of consultation, drafting and validation involved in the development of ISO standards provided invaluable input, guidance, and validation of the relevance and impact of the primary research. This was particularly the case as the ISO standards on DLT governance were oriented around having practical benefit to DLT participants and stakeholders, an objective closely aligned to the practical relevance objective of ADR. Actively seeking opportunities to align ADR with practitioner-centric standards is seen to provide a valuable source of domain expertise, research direction and validation.

6.3 Addressing the Research Question

The primary research question is "What regulatory controls should financial regulators use to treat the risks of decentrally governed DLT systems in the Australian financial system?"

To address the research question, the research investigated the risks of decentrally governed DLT systems and sought to identify appropriate regulatory controls to treat these risks. To leverage regulatory practitioner expertise in financial system regulation and to benefit from their focus on the regulatory challenges of emerging technologies such as DLTs, the research implemented a participatory ADR design by establishing a research collaboration with Australian regulatory DLT experts, to co-design a DRC Framework that identifies the key risks of decentrally governed DLT systems and establishes a portfolio of regulatory controls to treat these risks.

The resulting co-development of the DRC Framework with regulatory DLT experts and the grounding of its design in extant DLT regulatory research addressed the first and second subordinate research questions.

Research Question 1: What risks in the financial system are contributed to by decentrally governed DLT systems?

Research Question 2: What regulatory controls should regulators implement to address the risks of decentrally governed DLT systems?

The use of research workshops and expert interviews that were supplemented by reviews of the research literature enabled the identification, refinement and validation of a portfolio of practitioner-vetted risks of decentrally governed DLT systems (addressing Research Question 1). The use of co-design research techniques to build and evaluate the developed DRC Framework established a range of regulatory controls that were deemed by regulatory practitioners as suitable for addressing these risks (addressing Research Question 2).

To ensure the ongoing efficacy of the regulatory control regime implemented by the developed DRC Framework, the research incorporated a third subordinate research question.

Research Question 3: What design principles should regulators use to define and adapt controls to address the risks of decentrally governed DLT systems?

The extension of the ADR research method to incorporate additional theory generating techniques such as the incorporation of regulatory control design principles into the developed DRC Framework enabled regulatory control regimes to remain adaptive to changing DLT systems and fast evolving regulatory contexts. Regular assessment by regulators of implemented controls against these design principles ensures regulatory control

regimes remain effective in addressing the evolving risks of decentrally governed DLTs and the rapid pace of innovation in DLT systems.

By addressing these research questions, the research seeks to guide Australian financial regulators in the effective regulatory response to the emerging risks of decentrally governed DLT systems. By accommodating practitioner expertise and generalisable theory into the developed design artefact, the primary research question is addressed in both a practically relevant and theoretically grounded manner.

6.4 Research Impact

The research has had three key impacts:

1. Informing the response of Australian financial regulators to the emergence of decentrally governed DLT systems.
2. Informing the development of guidelines for the governance of DLT and blockchain systems by the ISO Technical Committee on DLT and Blockchain standards.
3. Contributing to the emerging body of research on the governance and regulation of DLT systems in the financial system.

6.4.1 Informing the Australian financial regulatory response to DLT systems

The research was sponsored by Australia's central bank, the Reserve Bank of Australia. This research collaboration resulted in access to DLT regulatory policy experts from the RBA's Payments Policy, Payment Settlements, Economic Research and Financial Stability departments. The DLT Working Group of the Australian Council of Financial Regulators agreed to be approached to seek the enrolment of its DLT regulatory policy experts as research participants. Participating DLT Working Group members participated in interviews, research workshops and submitted questionnaires throughout the research process. The participation of these DLT regulatory policy experts informed both the initial formulation of the research problem and the developed DRC Framework research artefact.

At the conclusion of the research, the developed DRC Framework was published and distributed to the CFR DLT Working Group. The research was acknowledged as contributing to the CFR and its DLT Working Group's knowledge of the risks and potential control responses to DLTs in the financial system.

6.4.2 Informing the development of international standards for DLT governance

This research afforded an opportunity to participate in the Australian and international effort to develop guidelines on the governance of DLT and blockchain systems. This encompassed

chairing the Australian mirror group to Working Group 5 of ISO Technical Committee ISO/TC 307 on Blockchain and DLT Standards. This mirror group, Standards Australia's IT-041 Committee on DLT and Blockchain standards, was responsible for Australian contributions and input into the international ISO standards development on the formation of ISO guidelines on DLT and blockchain governance.

A publication resulting from the research on DLT governance and international standards (Benedict 2019) was submitted, accepted and distributed as a formal paper to Working Group 5 of ISO/ TC 307 on DLT and Blockchain Governance as WG5 Paper N65. Research analysis that contributed to the DRC Framework informed recommendations on DLT accountabilities, decision rights and incentives that were submitted and included in the drafted ISO/TC 307 WG5 Technical Specification on Blockchain and Distributed Ledger Technologies – Guidelines for Governance (TS 23635).

6.4.3 Contributions to the emerging body of research on DLT governance and regulation

The research has resulted in a number of industry and academic conference presentations and a research publication. These have contributed to the growing body of work around the development of DLT and blockchain research. Key contributions have been:

1. Presentation at the ICIS 2019 IS Conference in Munich on the topic of Regulatory Control Responses to DLT-enabled Governance in the Financial System. This TREO talk discussed the risks of decentrally governed DLT systems and the ADR method implemented to develop the DRC Framework.
2. Positive feedback relating to a submitted research publication for acceptance in a special 2021 publication in Information & Management on distributed ledger and blockchain technology. This paper is currently under its second editorial review by the journal.
3. Publication in a special edition of the Journal of ICT Standardization. The title of this paper is "Challenges of DLT-enabled Scalable Governance and the Role of Standards" (Benedict 2019). This paper received its first research citation in 2020.
4. Presentation of the Regulatory Challenges of Decentralised DLT Governance at the Stanford's CodeX Computational Law + Blockchain Festival held globally in March 2019. The topic of the presentation was 'Where does the Buck Stop in a Blockchain World?'

6.5 Research Limitations

This study has several limitations that should be considered when assessing its findings and the quality of its research output, principally the DLT Regulatory Control Framework. Where possible, steps were taken to mitigate or minimise the effect of these limitations.

Key limitations of the research include the following:

1. The research primarily addressed the Australian regulatory context and did not encompass other non-Australian regulatory jurisdictions.
2. The research addresses the financial system regulatory context and did not encompass non-financial regulatory contexts.
3. The research did not incorporate time series or quantitative data to confirm the efficacy of the developed DRC Framework.

6.5.1 The research does not address non-Australian regulatory contexts

The research was primarily conducted with research participants from Australian regulators with only limited regulatory participant involvement from other jurisdictions. The DLT risks and regulatory controls comprising the developed DRC Framework were predominantly co-designed and validated by Australian financial regulatory research participants. Consequently, substantial care must be taken to apply the developed DRC Framework to non-Australian contexts to avoid assumptions and characteristics of the Australian regulatory landscape being inappropriately applied to non-Australian contexts.

To partially mitigate this limitation of the research, the literature analysis that informed the development of the DRC Framework incorporated global research on the topic of DLT regulation. Further mitigation of this limitation was sought through the enrolment of expert participants from the UK Financial Conduct Authority as well as DLT experts from two Australian and global DLT Fintech organisations. Incorporation of these non-Australian, non-regulator experts contributed some international context to the risks and control treatments incorporated into the developed DRC Framework. While this served to partially mitigate this research limitation, further international regulator participation would benefit the generalisability of the designed DRC Framework artefact to the global context.

6.5.2 Research does not encompass non-financial regulatory contexts

This research was conducted with experts drawn from financial regulators and the body of research on financial regulation and DLT applications in financial contexts. Therefore, care must be taken in applying the findings of the research and implementing the developed DRC Framework to non-financial regulatory contexts.

To partially mitigate this research limitation, non-financial DLT experts were engaged as research participants to inform the co-design and validation of the developed DRC Framework. These participants brought non-financial experience and guidance to the refinement of the DRC Framework. While involvement of non-financial regulator experts partially mitigates this research limitation, further research into non-financial regulatory contexts is required to fully mitigate this research limitation.

6.5.3 Lack of time series and quantitative data

The research was conducted in a context of limited observable regulation of DLT systems in the financial system. This lack of observable data is attributed to the early stage of adoption of DLT systems and the present limited extension of regulatory frameworks to accommodate DLT systems in financial markets. The lack of observable data on DLT risks and the efficacy of regulatory control responses to these risks is a key limitation of the research.

To partially mitigate this research limitation, the research adopted a participatory ADR research approach to incorporate regulators responsible for the regulation of DLT systems into the co-design of the developed DRC Framework. While this partially mitigates the lack of observable data, further analysis of the implementations of the DRC Framework are required.

6.6 Chapter Summary

This chapter discussed the research journey of developing the DRC Framework. It commenced with a summary of the initiation of research in late 2017, discussed the enrolment of regulatory experts in the research and their involvement in the co-design and evaluation of the DRC Framework, and concluded with the publication of the research findings and the developed DRC Framework. The chapter reviewed the contributions of the research to financial system regulatory practice, to the development of standards for DLT governance, and to the emerging body of academic literature on DLT regulation. Finally, the chapter discussed the limitations of the research. Chapter 7 presents the major conclusions of the research and discusses themes for future research.

7 Conclusion

This research sought to identify the risks associated with the emergence of decentrally governed DLT systems in the regulated financial system. The resulting DRC Framework present these risks, the parties affected by these risks, a portfolio of regulatory controls to address these risks, and design principles to guide the development and adaption of these regulatory controls. In developing the DRC Framework, the study addresses the research question of what regulatory controls Australian financial regulators should implement to address the risks of decentrally governed DLT systems.

DLT systems address known weaknesses in conventionally centralised governance through the use of cryptography and incentives to supplant the need for intermediaries and central authorities. By removing intermediaries however, DLT systems displace the control points relied on by regulators and thus challenge the efficacy of conventional regulatory control regimes. To date, no research has explored the control treatments regulators should use to address the systemic risks introduced by decentrally governed DLT systems.

To address this research gap, the study collaborated with DLT regulatory policy experts and fintech industry specialists to co-design a DLT Regulatory Control Framework that incorporates both the risks associated with the operation of DLT systems in the Australian financial system and the controls available to regulators to treat these risks. To address this gap, a participatory ADR research approach supplemented by additional theory was implemented, generating qualitative research techniques. By incorporating regulatory practitioners into the co-development of the design research artefact, the research aimed to contribute to the improved regulatory oversight of an Australian financial system in which DLT systems are become increasingly prevalent.

The research responds to the challenges presented by Atzori (2015) to address the risks of concentrations of power in unaccountable entities; addresses the prediction of Yermack (2017) of a rebalancing of the relative power of diverse parties in the conduct of institutional governance; answers the call by Wright & De Filippi (2015) and Abramaowicz (2016) to explore the regulatory response to the governance challenges presented by DLT systems; and explores the DLT governance topics of accountability and decision rights raised by Beck, Müller-Bloch & King (2018).

Early incorporation of expert participants into the co-design of the DLT Regulatory Control Framework contributed significant practical insight into the development and evaluation of the research artefact and improved its usefulness, impact and relevance. The extension of the participatory ADR research method with additional theory-generating qualitative research techniques, such as the development of regulatory control design principles, served to further strengthen the theoretical contribution of the research.

This research contributes to the emergent body of academic research in the field of DLT governance and regulation. The research has been published in the field of standards development for emerging technologies and the developed DRC Framework has been conditionally accepted for publication in the Information and Management journal. Emerging insights from the research have been discussed at the ICIS 2019 IS research conference in Munich and the 2018 Stanford Code-X conference on Computation Law. The research has also contributed to international efforts to develop standards to guide the governance of DLT and blockchain systems. The research also provides practical guidance to financial regulators looking to better understand the risks of decentrally governed DLT systems and seeking to identify regulatory controls to effectively treat these risks. It is hoped the research will serve as a foundation for future research on the regulatory response to DLT systems.

7.1 Future research

This study addressed the emerging research field of DLT regulation. The research findings and its identified limitations inform areas for future investigation. These include:

1. Applications of the developed DRC Framework to specific regulatory cases in the financial system
2. Extension of research on DLT regulation into international regulatory contexts
3. Extension of research on DLT regulation into non-financial regulatory contexts
4. Extension of research on DLT regulation to encompass quantitative analysis of observable DLT regulatory interventions

7.1.1 Applications of the developed DRC Framework to specific Australian financial regulatory cases

Future research could apply the developed DLT Regulatory Control Framework to specific cases in the financial system. One example of a relevant regulatory case is the regulation of cross-border payments that are facilitated by decentrally governed DLT systems. Cross-border payments are often identified as presently inefficient and warranting innovation to facilitate digitised global trade and the inherently borderless scope of distributed DLT services. Future research could identify the relevant systemic risks introduced or exacerbated by DLT-enabled cross-border payments and identify regulatory controls that collaborating financial regulators could adopt to treat these risks.

7.1.2 Extension of research on DLT regulation into international regulatory contexts

Future research could apply the developed DLT Regulatory Control Framework to non-Australian contexts. Such contexts would include multi-jurisdictional contexts that span

national boundaries or regulatory control responses specific to the financial system regulatory regimes of individual countries. The extension of the boundaries of the application of the DRC Framework would improve the theoretical quality of the developed research artefact through increased usefulness and importance (Weber 2012). A starting point for research on the global application of the DRC Framework would be the United Kingdom given the contribution of UK FCA DLT policy expertise in the co-design and validation of the developed DRC Framework. Extension to other countries that regularly co-operate with Australian and UK financial regulators present additional opportunities for future research. Such jurisdictions could include the United States, Canada, the European Union, Japan, New Zealand, Singapore and China.

7.1.3 Extension of research on DLT regulation into non-financial regulatory contexts

Future research could extend beyond financial regulation to encompass further non-financial regulatory contexts. Key examples of regulated industries that are likely to experience the material adoption of decentrally governed DLT systems include:

- Bio-medical and pharmaceutical industries
- Manufacturing industries sensitive to proof of supply chain provenance such as organic foods and rare metals
- Industries with complex international supply chains such as automotive and defense contracting
- Industries subject to strict environmental regulation including renewable energy distribution and carbon intensive industries

7.1.4 Extension of research on DLT regulation to encompass quantitative and algorithmic analysis of observable DLT regulatory interventions

Future research could provide quantitative research techniques to analyse observable data on DLT regulation. This would allow validation, refinement and extension of the DRC Framework to accommodate a quantifiably verified analysis of DLT-related risks and regulatory control treatments. An extended duration of regulatory expert participation and sampling in a future research study will further inform the ongoing improvement of the DRC Framework through access to extended regulatory practitioner expertise. Such research could be extended further through incorporation of algorithmic AI risk management techniques and research methodologies.

7.2 The challenge ahead

It is still unclear what course the integration of DLT systems into regulated markets will take in the years ahead. What is clear is that this progression will reflect and impart significant

socio-technical changes and disrupt conventional regulatory regimes dependent on centralised governance models. That society will be influenced by the adoption and evolution of decentrally governed distributed ledger technology is increasingly likely. The potential of technically enacted decentralised governance is momentous, though it represents significant challenges to the institutionally based governance regime that society has established over the preceding hundred years. To meet such opportunities and challenges, regulators must adapt their regulatory regimes to govern the societies and markets they oversee. It is hoped this research will contribute to meeting this significant challenge.

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Appendix 1. Preliminary DLT Regulatory Response Research Workshop Questionnaire (Awareness of Problem and Suggestion Research Stage)

Name: ……

Organisation: …..……

Role: ……..……

Date: **…**……

Please consider the following overview and model for the effective regulatory response to decentralised blockchain and Distributed Ledger Technologies (DLTs) in the financial system.

Three dimensions are employed to characterise the governance of Distributed Ledger Systems:

1) **Decision Rights** – Decision rights reflect who makes and contributes to key decisions relating to the establishment, operation, termination and ongoing governance of DLT systems. This includes who has the right to propose decisions regarding DLT systems and the right to decide on these proposals. Decision rights determine how centralised or decentralised DLT decision-making will be.
2) **Accountabilities** – Accountabilities reflect who is answerable for the making of and implementation of decisions relating to the governance of DLT systems.
3) **Incentives** – Incentives are the motivators (or demotivators) that encourage or discourage action and behaviours in relation to DLT systems. They can be both pecuniary or non-pecuniary.

Attractions of decentrally governed DLT systems

i. **Re-establishes Diminished Societal Trust** - Displaces intermediaries and authorities that have progressively lost public trust.

ii. **Enables Mass Social Co-ordination** - Reduced transactional friction enables mass social co-ordination, allowing governance on a larger scale than conventional (institutional) governance

iii. **Enables Interoperability across Scalable Systems –** The efficiencies of technically-enacted DLT governance enables integration and interoperability with DLT and non-DLT systems processes

1. **Comprehensiveness of Attractions of Decentrally governed DLT Systems**
   Do the items discussed represent the key benefits of decentrally governed decentralised blockchain and DLTs in the Financial System?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

……

……

……

……

Governance Challenges of Decentrally governed DLT systems

The model describes how the characteristics of decentrally governed DLT systems present challenges to conventional institutional governance. The challenges are:

i. **Diminished trust among DLT participants** - Over time, these challenges can reduce confidence in the integrity of DLTs and erode trust among participants

ii. **Lack of accountable decision makers** - The displacement of intermediaries and central authorities may see them replaced by parties with non-transparent accountabilities and decision-making rights.

iii. **Lack of clear decision rights for accountable decision makers** – A lack of clear decision rights creates uncertainty in making key governance decisions (winding-up, protocol changes)

iv. **Misaligned incentives among DLT participants** - Decentrally governed DLT systems involve an expanded range of participants, further complicating the challenge of aligning incentives.

2. **Comprehensiveness of Governance Challenges of Decentrally governed DLT Systems**
   Do these challenges represent the key governance challenges of the decentralised governance of decentralised blockchain and DLTs in the Financial System?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

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Regulatory Challenges of decentrally governed DLT systems

The model describes how the characteristics of decentrally governed DLT systems present regulatory challenges to financial system regulators in environments in which DLT-enabled become pervasive. The challenges are:

1. **Displacement of Conventional Institutional Regulatory Control Levers** - Decentralised DLTs may displace or disintermediate institutional governance structures such as Boards or executive management. They can also eliminate institutions altogether as a focus for regulator sanctions and penalties.
2. **Lack of clarity on decision rights and accountabilities** - Decentralised DLTs can have opaque decision rights, rendering regulatory and legal controls less effective in mandating accountabilities for specific decision makers.
3. **Uncertain regulator coverage** - The rate of innovation and emerging business models based on decentralised DLTs render the increased likelihood of regulator coverage gaps, or the uncertainty of regulatory jurisdiction over emerging decentralised DLT systems.
4. **Uncertain conflict resolution responsibilities** - Uncertainty in rights and accountabilities relating to conflict resolution among DLT participants, and between DLT participants and non-DLT stakeholders, including institutions and regulators.
5. **Complexity in incentive identification and alignment** - Complexity of decentralised DLTs presents additional complexities in identifying and aligning the incentives of diverse decentralised DLT participants, particularly where they traverse jurisdictional boundaries.
6. **Impeded Market Innovation** - Onerous regulator controls can impede innovation and the realisation of benefits associated with decentralised DLT systems.

3. **Comprehensiveness of Regulatory Challenges of Decentrally governed DLT Systems**

Are these the key regulatory challenges regulators will face as a result of the decentralised governance of decentralised blockchain and distributed ledger technologies (DLTs) in the Financial System?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

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Regulatory Response Model for Decentrally governed DLT systems

Regulatory controls for Conventional Institutionally governed vs Decentrally governed DLT systems

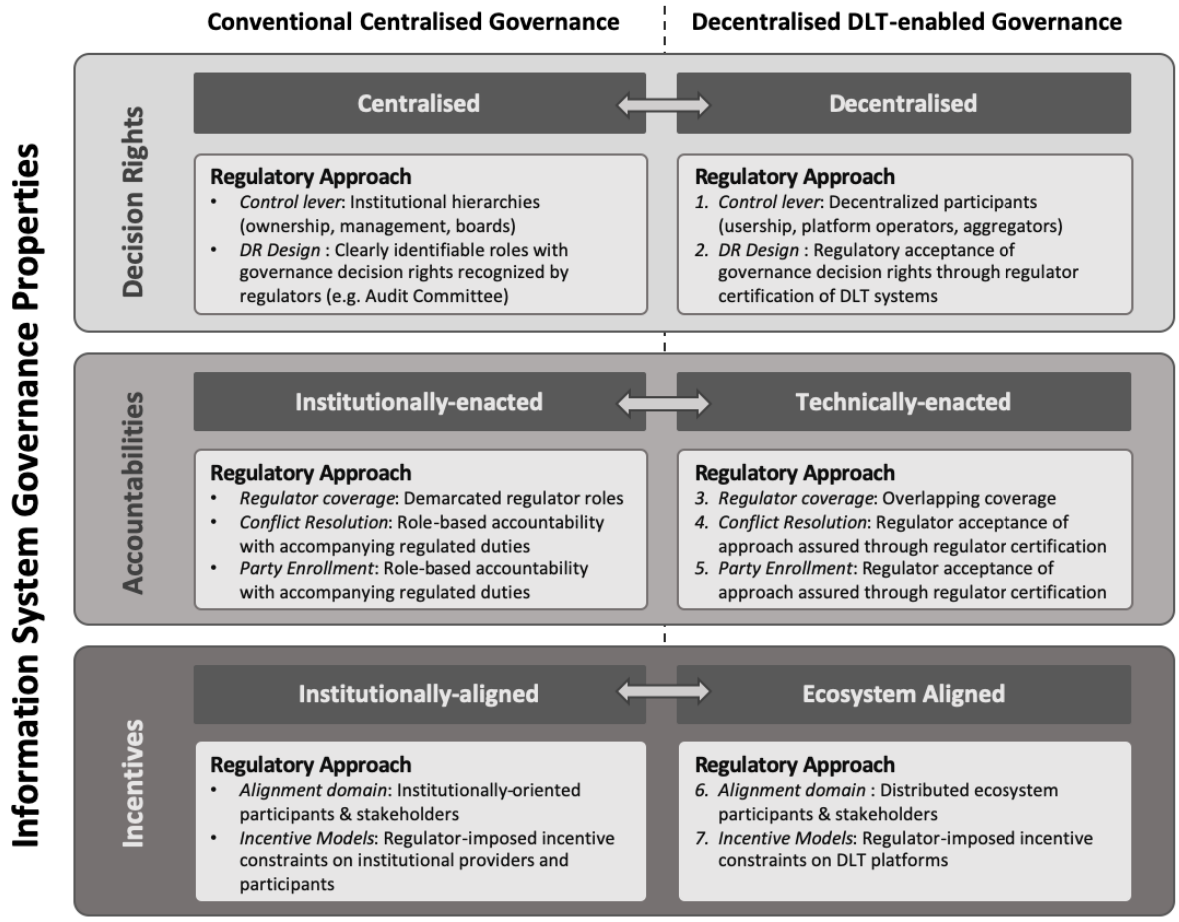
The Regulatory Response Model below describes how regulatory controls are applied to conventional institutionally governed systems and contrasts these to how regulatory controls are to be applied to decentrally governed DLT systems. In the context of DLT systems it envisages:

i. **Decision rights** are decentralized across diverse DLT participants through consensus mechanisms rather than centralised among institutionally-aligned decision-makers
ii. **Accountabilities** of decision makers are enacted via the technology of DLT systems
iii. **Incentives** must be aligned across a broader range of participants and stakeholders

Regulatory Response to Decentralized DLT Governance

The Regulatory Response Model below describes how regulatory responses should adapt to address the disruptive effects of decentralised, scalable DLT-enabled governance on regulated systems. Variations in proposed regulatory responses are contrasted to the

regulatory approach adopted in more conventional, institutionally-aligned governance models.



Regulator Control Responses

1. **New Control Levers** - Regulators must find new control points as conventional ones (financial intermediaries) are displaced
2. **DR Rights Clarification:** Regulatory acceptance of governance decision rights assured through regulator certification of DLT systems
3. **Regulator Coverage** – Overlapping regulator control coverage of risks
4. **Conflict Resolution**– Regulatory acceptance of conflict resolution approach ensured through regulator certification of DLT systems
5. **Party Enrollment:** Regulatory acceptance of enrollment approach ensured through regulator certification of DLT systems
6. **Incentive Alignment:** Regulatory requirements encompasses distributed ecosystem participants & stakeholders
7. **Incentive Models:** Regulator-imposed incentive constraints on DLT platforms

Having considered and discussed the Regulatory Response Model, please answer the following questions:

4. Fit for purpose

   How well do you think this model represents an effective regulatory response to the challenges of decentralised DLT-enabled governance in the financial system?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

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Comprehensiveness

Does the model contain all the key elements needed to inform the effective regulatory response to the adoption of decentralised blockchain and distributed ledger technologies (DLTs) in the Financial System?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

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Relevance

To what extent would you agree that the components of the model are **relevant**?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

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Importance
To what extent would you agree that the components of the model are **important** to the regulation of a financial system containing pervasive blockchain and DLT-enabled systems?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

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Understandable
Do you think the model is clear and **easy to understand**?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

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Applicability
The model is practically adoptable by regulators.

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

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……**I**
mprovements and Suggestions
Are there modifications, deletions, additions or improvements you would suggest?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree.

Comments:

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Thank you - on completing survey, please return it to Gayan Benedict (benedictg@rba.gov.au)

Appendix 2. DRC Framework Co-design Workshop Instructions

DLT Regulatory Controls Research Workshop 2

Date: Tuesday 26 November 2019

Location: Innovation Lab, RBA Offices, 65 Martin Place, Sydney

Regulatory Controls Research Exercise Instructions

1. SILENT GENERATION OF IDEAS BY INDIVIDUALS – 10 mins [10.25]

The following is the second of the two questions we will address today. What regulatory controls could be used to address the risks of de-centrally governed DLT systems?

I would like each of you to take 5 minutes to list your ideas in response to this question. Describe each idea in a brief phrase or a few words on the worksheet in front of you. Please work independently of other members. I ask that you do this quietly, there will be time to discuss your views afterwards.

[NB. Avoid clarification that would suggest ideas]

2. ROUND ROBIN RECORDING OF IDEAS – 25 mins [10.35]

During the last 5 minutes, each of us has used our worksheets to list ideas for dealing with regulatory responses to decentrally governed DLT systems. I would like each of you to share your ideas with the other members of the group. This is an important step as this list of ideas will then be organised and discussed as a group.

To accomplish this goal as quickly and efficiently as possible, I am going to ask each of you, one at a time, to give me one idea from your worksheet, summarised briefly in a few words. After the entire list is on the board, we will have the opportunity to discuss, clarify and dispute the ideas.

If someone else in the group lists an idea which you also had on your worksheet, you need not repeat the idea. If, however, in your judgement the idea on your worksheet contains a

different emphasis or variation, we would welcome the idea. Variations on a theme are important. You can pass if your ideas are already captured on the board.

3. GROUP DISCUSSION – 25 mins [11.00]

Now that we have listed our ideas on the wall, I want us to take time and go back and briefly discus each idea. The purpose of this discussion is to clarify the meaning of each item. It is also an opportunity to express our understanding of the logic behind the idea and the relative importance of an item. We should feel free to express varying points of view or to disagree.

We however, want to pace ourselves so that each of the items on the chart is given the opportunity for some discussion, so I may sometimes ask the group to move to further items.

Finally, let me point out that the creator of the item need not feel obliged to clarify or explain an item. Any member of the group can play that role.

Let's start. Are there are questions or comments group members would like to make about this first item?

4. VOTING

4a – Individual Ranking – 5 mins [11.25]

We have now completed our discussion of the entire list of ideas, clarified their meaning, and discussed the areas of agreement and disagreement. At this time, I would like each group member to give their opinion concerning the most important ideas on the list. To do this, you should each take five cards. I would like you to select the five most important items from our list of items. This will require careful thought and effort.

4b – Group Ranking – 15 mins [11.30]

Please spread out your cards in front of you. Now number then in order of priority from 1 (being highest) to 5 (least important)

We will now tally the ideas.

The cards will be pooled together.

Can one of you now read the idea number and number of points associated with it.

We will now sum the scores to identify those ideas which are most highly rated by the group as a whole. These constitute the most favoured group regulatory control responses.

5. FINAL REVIEW – 10 mins [11.45]

What thoughts do you have on these scores and ratings?

Would you argue the order of priority should change in any way?

Appendix 3. DRC Framework Evaluation Questionnaire Instrument

Research Evaluation

Risk-based Regulatory Control Framework for Decentrally Governed DLTs in the Financial System

Instructions for Research Participants:

1. Please review pages 2-9 below. These present the components of the Risk-based DLT Regulatory Control Framework, the framework itself and instructions for its application. Please feel free to add comments and feedback. If helpful, you can also refer to the attached supporting PowerPoint containing the completed framework, instructions for its use and design principles for regulatory risk control treatments.
2. Complete questions 1-8 on pages 10-11
3. Email your completed questionnaire to Gayan Benedict by Friday 1 May to benedictg@rba.gov.au.

Gayan Benedict

CIO, Reserve Bank of Australia

Framework Components

1. Risks

Overview: Each of the risks below are categorized according to the financial system participants they affect and the type of risk they represent. In some cases, risks can be the manifestation of several types of risks. Each risk is atomic in nature and can manifest to different extents for individual participants. The nature of each risk in terms of its impact and likelihood can vary by participant and financial system. The calculation of such residual risk can change over time and is a function of both the environment and the specific circumstances of participants and providers.

R1. Risks to Participants: Failure of DLT system resulting in adverse outcomes for participants. Risks include:			
Risk	**Description**	**Risk Category**	**Reference Source**
1	Failure of Regulatory or Legal Controls e.g. (risks not mitigated, low levels of compliance with regulatory/legal controls)	FOBS	Regulatory Experts; Claessens & Kodres (2014)
2	Loss to Participant/Stakeholder due to failure of DLT application (e.g., incentive misalignment, cryptography failure)	FO	Regulatory Experts
3	Commercial failure of DLT Provider (e.g., financial or operational failure, loss of regulatory acceptance) leading to participant loss	FO	Regulatory Experts
4	Failure of DLT Technology (e.g., operational or cryptography failure, poor system quality, poor continuity planning) causes participant losses	FOB	Regulatory Experts
5	Loss of trust in integrity of DLT application or platform (e.g., attack, poor quality, conflicts of interests)	FOB	Regulatory Experts
6	Lack of accountable parties during a crisis	FO	Regulatory Experts; Atzori (2015); Claessens & Kodres (2014)

7	Lack of DLT expertise to identify application or platform-specific risks (unintended consequences, unforeseen interdependencies)	FOBS	Regulatory Experts; Sajtos & Tőrös (2018)
8	Ineffective dispute resolution leading to poor participant outcomes	FB	Habermas (1989); Wright & De Filippi (2015);
9	Fragmentation of DLT system resulting in loss of market acceptance	FB	Regulatory Experts; Luther (2016)
R2. Risks to DLT Providers: Failure of DLT system resulting in adverse outcomes for DLT providers and investors. Risks include:			
1	Failure of DLT Platform (e.g., operational, security - cryptography, financial, inadequate testing)	FOB	Regulatory Experts
2	Major investment losses by DLT investors	FOB	Regulatory Experts
3	Lack or loss of regulator acceptance for DLT system	FOB	Regulatory Experts
4	Poor decentrally developed software quality leading to failure of DLT application/platform to operate as expected (e.g., poor software code quality or security vulnerability causing failure of DLT service)	FOB	Regulatory Experts; Nyman & Lindman (2013)
5	Fragmented DLT systems resulting in loss of market acceptance (forking)	FO	Regulatory Experts; Nyman & Lindman (2013)
6	Failure of Regulatory Controls e.g. (risks not identified or mitigated, low levels of compliance with regulatory controls)	FOBS	Regulatory Experts
R3. Risks to Markets: Instability of Market caused by failure of DLT systems. Risks include:			
1	Complexity of system and limited expertise to identify and address systemic risks (unintended consequences, unforeseen interdependencies)	FOBS	Regulatory Experts; Claessens & Kodres (2014); Sajtos & Tőrös (2018)
2	Displacement of central control points	S	Regulatory Experts; Benkler (2016)
3	Resistance of DLT systems designs to regulatory sanctions	S	Allen et al. (2017); Atzori (2015)

4	Loss of market confidence through market-wide systemic failure of DLT systems (e.g., cryptography standards failure; compromise of consensus/governance model; unclear accountabilities for crisis response)	FOBS	Regulatory Experts; Mallard, Méadel & Musiani (2014)
5	Loss of confidence in regulatory or legal controls of use of DLT systems in regulated markets	FOBS	Regulatory Experts; Abramaowicz (2016); Wright & De Filippi (2015)
6	Emergence of unaccountable, oligarchic governance structures	S	Regulatory Experts; Abramaowicz (2016); Atzori (2015); De Filippi & Loveluck (2016); Shaw & Hill (2014)
Risk Categories: [F] Financial [B] Business [O] Operational [S] Systemic			

Table 1. Risks of DLT-Enabled Decentralized Governance in the Financial System

2. Regulatory Control Design Principles

Overview: Design principles govern the design, implementation and operation of risk control treatments. Their application to specific regulatory control treatments should be adaptive and responsive to evolving DLT-related risks and innovations.

No.	Principle	Description
1	*Systemically integrate DLT controls into DLT systems*	Regulators should integrate regulatory controls into the technical design and implementation of DLT systems functioning in regulated markets to increase visibility of DLT risks and provide a lever for policy implementation
2	*Tailor DLT controls more proximately to DLT providers and participants*	Regulators should design and implement regulatory controls to be proximate to the provision and consumption of DLT services in regulated markets by minimizing control reliance on intermediaries to mitigate the risk of control points being displaced by de-centralized DLT systems
3	*Harmonize DLT Regulatory Controls Across Regulatory Jurisdictions*	Regulators should harmonize regulatory controls across regulated markets by ensuring controls are compatible and holistic in their coverage to minimize gaps in control coverage across global deployments of DLT systems

4	*Ensure best available information for DLT participants and regulators*	Regulators should require DLT applications and platforms operating in regulated markets ensure the transparency of DLT activity and risks to reduce information asymmetry among stakeholders and reducing reliance on intermediaries for a timely, holistic understanding of DLT risks
5	*Continuously Improve DLT Quality Standards*	Regulators should ensure DLT developers adhere to DLT standards in the design, operation and governance of DLT systems through controls that improve DLT technology, operational and governance quality to reflect the criticality of DLT systems on the performance of market functions
6	*Maintain and improve trust among DLT participants*	Regulators should implement controls requiring DLT developers to foster trust among DLT participants through the design, operation and governance of DLT systems to minimise the likelihood of DLT risks manifesting to adversely affect market integrity and confidence
7	*Expand DLT expertise and awareness*	Regulators should ensure regulatory experts responsible for supervising markets impacted by the adoption of DLT systems should develop their expertise in DLT systems to minimise the likelihood of unforeseen or unmitigated risks affecting market stability and confidence
8	*Preserve value*	When designing and implementing controls regulators should not unnecessarily add costs to DLT systems by evaluating the impacts of controls on innovation and value
9	*Respond to dynamic, iterative change*	Regulators should seek to not unnecessarily inhibit the adaptive nature of DLT systems when designing, implementing and operating regulatory controls by implementing flexible controls that are accommodate the dynamic nature of DLT systems

Table 2. Design Principles for DLT Regulatory Risk Control Treatments

3. Risk Control Treatments

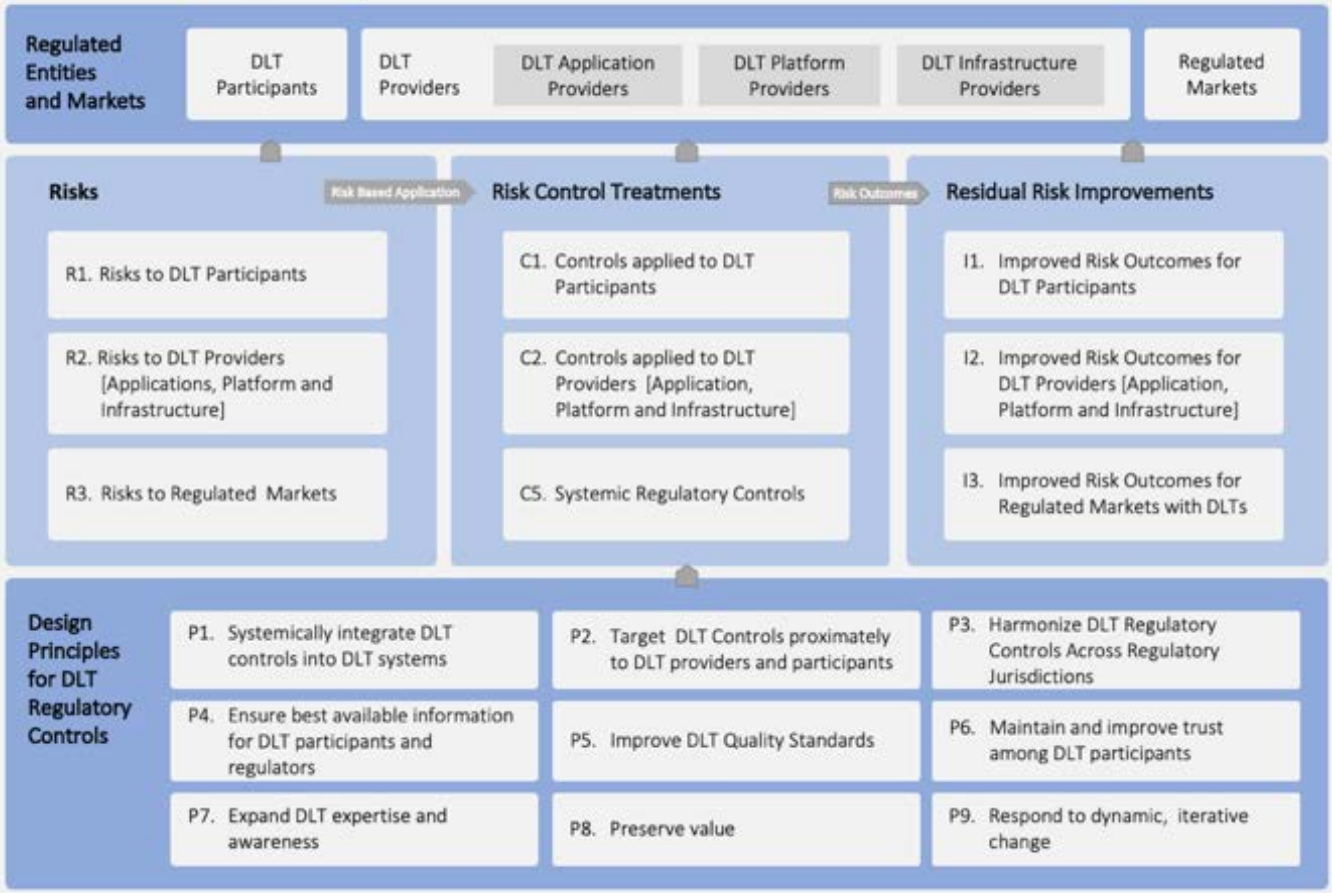
Overview: Risk control treatments should be designed, implemented and operated in a risk-based manner. The portfolio of risk control treatments should be parsimonious by optimising risk treatment for minimal cost and complexity. Risk control treatments should be applied in a risk-based manner by being clearly aligned to relevant risks and ensuring appropriate residual risk reduction.

C1. Controls applied to DLT Participants			
Control	**Description**	**Risks**	**Control Design Principle**
1	DLT-literacy requirements 1. Minimum education exposures 2. Participation licenses	R1.2, R1.4, R1.5, R1.7	P4, P7
2	Regulated participatory limitations on classes of participants (including regulator-issued certifications for participation)	R1.7	P7, P8
3	Participant sanctions for non-compliance with legal & regulatory obligations	R1.1, R3.3	P2, P6, P7, P8
4	Proof of reserves for custodian participants	R1.2, R1.3, R2.2	P1, P2, P6, P8
5	Regulator-accreditation required to market DLT-based services/assets	R1.1, R1.2, R1.9, R2.5	P2, P5, P6, P8
C2. Controls applied to DLT Application, Platform and Infrastructure Providers			
1	Regulator-issued Licenses to Operate	R1.1, R1.2, R1.9, R2.2, R2.5	P2, P5, P6
2	DLT Software Quality Standards 1. Accreditation of developers 2. Auditing of DLT platforms 3. Sanctions for failed standards & negligence	R2.1, R2.3, R2.4	P1, P2, P5,
3	Regulator Quality Assurance Seals	R2.1, R2.4, R2.6	P5, P6
4	Reporting, conduct, design, operational and disclosure standards for DLT Application Providers	R1.2, R1.3, R1.4, R1.5	P5, P6, P8

5	Regulator access to software code and documentation	R2.1, R2.3, R2.4,	P1, P2, P5, P6, P9
6	Confirmation of fiduciary obligations to participants	R1.2, R1.3, R1.4	P6, P7
7	Regulator mandated application auditing and liability	R1.7, R2.1, R2.4	P5, P6, P8
8	Integration with machine-readable regulation	R2.3, R2.4	P1, P2, P4, P4, P9
9	Transparency of DLT governance, participants, user rights, & operational rules	R1.2, R2.6	P1, P2, P4, P6, P7, P9
C3. Systemic Regulatory Controls for Markets with Decentrally Governed DLT Systems			
1	Ongoing market-wide standards improvement regime	R1.2, R2.4, R3.1, R3.2, R3.3	P3, P4, P5, P6, P7, P8, P9
2	Integrated regulator nodes for DLT systems that monitor risk and can execute transactional ‘stop orders’	R2.6, R3.2, R3.3	P1, P2, P4, P5, P6, P8, P9
3	Ensuring transparency of on-ledger and off-ledger activities to make risks visible to participants, investors, platform providers & regulators	R1.2, R2.6, R3.1, R3.2, R3.3	P1, P2, P4, P5, P6, P7, P8, P9
4	Regulator led real-time computational market risk analysis	R1.2, R2.6, R3.1, R3.2, R3.3	P1, P2, P4, P5, P6, P7, P8, P9
5	Focus on data insights and AI to identify emergent market risks	R1.2, R3.2	P1, P4, P5, P6, P7, P8, P9
6	Industry regulatory collaboration/utilities to reduce compliance costs	R1.3, R3.1, R3.2, R3.3	P1, P4, P5, P6, P8, P9
7	Harmonised domestic and international DLT regulatory regimes	R1.2, R1.3, R3.1, R3.2, R3.3	P3, P4, P5, P6, P8, P9
8	Efficient market dispute access mechanisms for DLT participants and providers	R1.1, R1.2, R1.3, R3.1, R3.2, R3.3	P1, P2, P3, P6, P8, P9
9	Integrated regulator nodes to monitoring and enforce regulations on DLT systems	R1.1, R3.1, R3.2, R3.3	P1, P2, P3, P4, P5, P6, P7, P8, P9

10	Program for maintaining regulator expertise on developments in DLT systems	R3.1, R3.2, R3.3	P4, P5, P6, P7, P8, P9
11	Adequate control enforcement	R1.1, R3.2, R3.3	P2, P6, P8
12	Adaptive regulatory & legal framework for dynamic DLT ecosystem	R3.2, R3.3	P3, P4, P5, P6, P7, P8, P9
13	Machine readable regulation	R3.1, R3.2, R3.3	P1, P2, P4, P6, P7, P8, P9
14	Regulator ‘kill switch’ authority to stop operation of DLT system	R1.2, R1.3, R1.5, R2.2, R3.1, R3.2, R3.3	P1, P2, P6, P8, P9

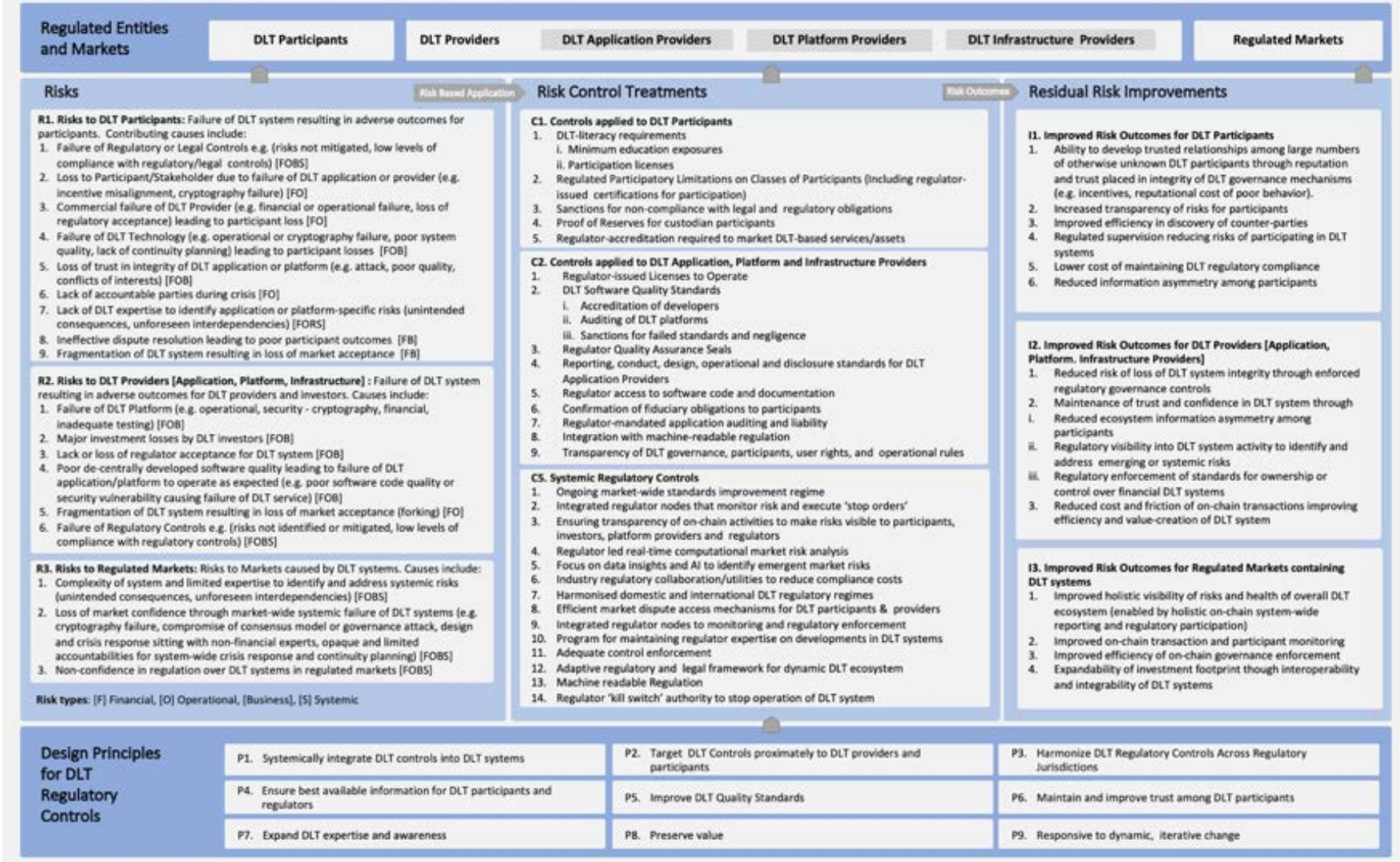
Risk-based DLT Regulatory Control Framework



Instructions

1. Regulators should identify the risks relevant to regulated entities and markets within their regulated authority
2. Regulators should identify the risk control treatments applicable to identified risks
3. Regulators use a risk-based approach to select a portfolio of risk control treatments to address unacceptable risks
4. Regulators can further optimize their risk-based approach to control treatments by adapting existing controls or introducing new control treatments through application of Design Principles for DLT Regulatory Controls
5. Regulators should assess and monitor risk landscape (risks, control effectiveness, residual risk improvements)
6. Regulators should continuously adjust risk assessments and control treatments

Risk-based DLT Regulatory Control Framework



Having considered the DLT Regulatory Control Framework, please answer the following:

5. Fit for purpose
   How well do you think the framework represents an effective risk-based regulatory response to the challenges of decentralized DLT-enabled governance in the financial system?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

6. **Comprehensiveness**
   Does the framework **contain the key elements and associations** needed to inform the risk-based regulation of decentralized DLTs in the financial system?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

7. **Relevance**
   To what extent would you agree that the framework is **relevant** for regulators seeking to regulate the risks of decentralized DLT-enabled governance in the financial system?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

8. **Importance**
   To what extent would you agree the risk-based management of DLT risks is **important** to the regulation of the financial system?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

9. **Understandable**
   Do you think the framework is **easy to understand**?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

10. **Applicability**
    The model is practically adoptable by regulators?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

11. **Improvements and Suggestions**

Are there modifications, deletions, additions or improvements you would suggest?

n/a | 1. Strongly Disagree | 2. Disagree | 3. Neither Disagree or Agree | 4. Agree | 5. Strongly Agree

Comments:

Thank you - on completing survey, please return it to Gayan Benedict (benedictg@rba.gov.au)

Appendix 4. Developing Regulatory Control Design Principles

	Originally Drafted Principle	Revised Principle					
#	Initial Principle	Design Principle Title	Aim, Implementer & User	Context	Mechanism	Rationale	General Design Principle [Updated]
1	**Systemically integrate DLT controls into DLT systems** - Use technology design and implementation to implement, execute and monitor regulatory controls across DLT systems and regulated markets (Justification: Minimise delays in control enforcement and regulator intervention)	**Systemically integrate DLT controls into DLT systems**	Regulators should incorporate regulatory controls	into DLT systems functioning in regulated markets	through technical integration into DLT systems	to increase visibility of DLT risks and provide a lever for policy implementation	**Systemically integrate DLT controls into DLT systems-** Regulators should incorporate regulatory controls through technical integration into DLT systems functioning in regulated markets to increase visibility of DLT risks and provide a lever for policy implementation
2	**Tailor DLT Controls more proximately to DLT providers and participants** - Tailor regulatory controls to be in closer proximity to DLT service delivery and consumption as possible (justification: alleviating the displacement and disintermediation of intermediaries)	**Tailor DLT Controls more proximately to DLT providers and participants**	Regulators should design and implement regulatory controls to be proximate to the provision and consumption of DLT services	in regulated markets	by minimising control reliance on intermediaries	to mitigate the risk of control points being displaced by de-centralised DLT systems	**Tailor DLT Controls more proximately to DLT providers and participants -** Regulators should design and implement regulatory controls to be proximate to the provision and consumption of DLT services in regulated markets by minimising control reliance on intermediaries to mitigate the risk of control points being displaced by de-centralised DLT systems
3	**Harmonize DLT Regulatory Controls Across Regulatory Jurisdictions** - Harmonize and integrate regulatory controls across distributed regulator networks (reflecting the connected characteristic of DLT systems, and the high likelihood such systems will span multiple regulator jurisdictions)	**Harmonize DLT Regulatory Controls Across Regulatory Jurisdictions**	Regulators should harmonize regulatory controls	across regulated markets	by ensuring controls are compatible and holistic in their coverage	to minmise gaps in control coverage across the global deployment of DLT systems	**Harmonize DLT Regulatory Controls Across Regulatory Jurisdictions -** Regulators should harmonize regulatory controls across regulated markets by ensuring controls are compatible and holistic in their coverage to minmise gaps in control coverage across the global deployment of DLT systems
4	**Ensure best available information for DLT participants and regulators** - Increased DLT participant and regulator awareness of DLT activity through transparent awareness of emerging and current risks (justification: ensuring reduced reliance on need for DLT intermediaries and timely understanding of risks in high velocity DLT environments)	**Ensure best available information for DLT participants and regulators**	Regulators should require DLT applications and platforms	operating in regulated markets	ensure transparency of DLT activity and risks	to reduce information assymetry among stakeholders and reducing reliance on intermediaries for a timely, holistic understanding of DLT risks	**Ensure best available information for DLT participants and regulators -** Regulators should require DLT applications and platforms operating in regulated markets ensure transparency of DLT activity and risks to reduce information assymetry among stakeholders and reducing reliance on intermediaries for a timely, holistic understanding of DLT risks
5	**Improve DLT Quality Standards** - Ensure DLT technology and governance standards are increased to reduce risks of poor quality in the design, operation and governance of DLT systems (reflecting the increased importance of technology in delivering DLT-based services)	**Improve DLT Quality Standards**	Regulators should ensure DLT developers	in the design, operation and governance of DLT systems	through controls that improve DLT technology, operational and governance quality	to address the criticality of DLT system to the performance if key functions in regulated markets	**Improve DLT Quality Standards -** Regulators should ensure DLT developers adhere to DLT standards in the design, operation and governance of DLT systems through controls that improve DLT technology, operational and governance quality to address the criticality of DLT system to the performance if key functions in regulated markets
6	**Maintain and improve trust among DLT participants**- Design, operate and govern DLT systems in a manner conducive to maintaining and increasing trust among DLT participants (justification: minimise the likelihood of system risks to market integrity and confidence emerging)	**Foster trust among DLT participants**	Regulators should implement controls requiring DLT developers	through the design, operation and governance of DLT systems	to foster trust among DLT participants	to minimise the likelihood of DLT risks manifesting to adversely affect market integrity and confidence	**Foster trust among DLT participants -** Regulators should implement controls requiring DLT developers to foster trust among DLT participants through the design, operation and governance of DLT systems to minimise the likelihood of DLT risks manifesting to adversely affect market integrity and confidence
7	**Expand DLT expertise and awareness** - Develop and expand expertise of DLT systems to minimise the likelihood of unforeseen or unmitigated risks jeopardising market stability and confidence	**Expand DLT regulatory expertise**	Regulators should ensure regulatory policy experts	responsible for supervising markets impacted by the adoption of DLT systems	should develop their expertise in DLT systems	to minimise the likelihood of unforeseen or unmitigated risks jeopardising market stability and confidence	**Expand DLT regulatory expertise -** Regulators should ensure regulatory policy experts responsible for supervising markets impacted by the adoption of DLT systems should develop their expertise in DLT systems to minimise the likelihood of unforeseen or unmitigated risks jeopardising market stability and confidence
8	**Preserve value** - Ensure DLT regulations create value and do not unnecessarily curb the innovations rendered possible by decentrally-governed DLT systems (to unlock the value potential of DLT systems)	**Preserve value**	Regulators	when designing and implementing controls	by evaluating their impact on innovation, value creation and destruction	not unnecessarily curb the value generated by DLT systems	**Preserve value-** When designing and implementing controls regulators should not unnecessarily curb the value generated by DLT systems by evaluating their impact on innovation, value creation and destruction
9	**Responsive to dynamic, iterative change** - DLT regulatory controls should be flexible and accommodative to the dynamic, iterative nature of DLT systems	**Responsive to dynamic, iterative change**	Regulators	when designing, implementing and operating regulatory controls	by implemeting flexible controls that are accommodate the dynamic nature of DLT systems	not uneccearily inhibiting the adaptive nature of DLT systems	**Responsive to dynamic, iterative change -** Regulators should seek to not uneccearily inhibiting the adaptive nature of DLT systems when designing, implementing and operating regulatory controls by implemeting flexible controls that are accommodate the dynamic nature of DLT systems