Paradoxical Tensions in Crown Research Institutes: An Empirical Analysis from a New Zealand Perspective

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Abstract

The purpose of this study is to investigate what tensions surface in biotechnology projects at Crown Research Institutes (CRIs), and how those tensions are understood by CRI employees. CRIs play an important role in New Zealand's emerging biotechnology industry. The biotechnology industry is becoming increasingly essential in the advent of climate change. However, as hybrid organisations, CRIs navigate multiple organisational tensions that potentially limit their contributions to New Zealand's biotechnology industry. Organisational paradox theory and sensemaking literature suggest that an awareness of potential tensions is necessary to facilitate constructive engagement with tensions and prevent tensions from interfering with CRI biotechnology outputs. Organisational paradox theory and sensemaking literature have yet to address biotechnology CRI tensions and sensemaking logics. Furthermore, the Dynamic Equilibrium Model (Smith & Lewis, 2011), a seminal framework in organisational paradox theory, has yet to be associated with sensemaking logics. Consequently, this study draws on the Dynamic Equilibrium Model and sensemaking literature to investigate the tensions surfaced by biotechnology projects at CRIs. A qualitative, abductive approach was used to carry out and thematically analyse 10 semi-structured depth interviews from four CRIs. Four organisational performing tensions were identified to influence organising, belonging and learning tensions at team and individual levels, surfaced by conditions specific to CRIs and New Zealand's biotechnology environment. Paradox logics were found to be associated with learning-performing tensions between biotechnology projects, while dichotomous and business-case logics were associated with organising-performing tensions in the presence of time and resource constraints within biotechnology projects. Based on the empirical findings of this study, a revised Dynamic Equilibrium Model tension framework is proposed. This study addresses several gaps in the literature by linking Dynamic Equilibrium Model tensions to sensemaking logics, identifying

novel tensions in a CRI biotechnology context, elucidating conditions that surface tensions in a CRI biotechnology context, and contributing to the tension complexity perspective. The findings also present practitioners with an awareness of potential tensions, sensemaking logics and their relationship with organisational conditions. As a result, this study identifies opportunities for practitioners to constructively engage with complex tensions in a hybrid research and development biotechnology environment.

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I dedicate this thesis to my parents. Thank you for bringing me to New Zealand for a better life and nurturing the values that allowed me to persevere through this journey. This achievement is as much yours as it is mine.

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Chapter 1: Introduction

The purpose of this study is to explore the tensions experienced by individuals involved in biotechnology projects at Crown Research Institutes (CRIs). Biotechnology represents the transformation of life science breakthroughs into useful, real-world applications. Biotechnology and other multidisciplinary scientific outputs are crucial to adapting earth's societies to global challenges, such as climate change. Climate change is a metaproblem underpinning a multitude of issues that have the potential to devastate human life (Abbass et al., 2022). Climate change adversely affects the world's food supply by damaging agricultural sectors and facilitates the emergence of novel and highly resistant pathogens through extreme weather patterns (Abbass et al., 2022). Furthermore, for isolated countries like New Zealand who are partly economically reliant on primary industries (Ministry for Primary Industries, 2023), improving the biotechnology industry is paramount for building resilience to the unpredictable weather conditions of climate change. New Zealand's biotechnology sector has yet to reach its full potential and is partly supported by the research outputs of public institutions such as universities and CRIs (BioTech New Zealand, 2020). CRIs are a network of research institutes with an explicit duty to perform fundamental and applied scientific research for the benefit of New Zealand while remaining financially viable (Crown Research Institutes Act 1992). Accordingly, the ability of CRIs to transform life science into biotechnology and facilitate its uptake by relevant industries should not be ignored by society and its decision-makers.

1.1 Study rationale and research questions

CRIs have conflicting strategic goals that potentially implicate CRI biotechnology outputs. CRIs must simultaneously advance societal welfare through scientific research, fulfil social and environmental responsibilities, and generate sufficient profits to support further scientific

activities. At an organisational level, CRIs achieve these divergent, overarching objectives by balancing service contracts with industry, research publications and the commercialisation of scientific innovations. Yet, at the level of the team and individual, the additional interplay of environmental conditions unique to CRIs and New Zealand's biotechnology industry may result in tensions, as individuals attempt to prioritise which activities to pursue and to what extent certain goals and agendas should be fulfilled. CRI tensions should not be left unaddressed, as they may negatively affect CRI biotechnology outputs. Organisational tensions are well explored in paradox theory. Empirical paradox theory literature has previously shown that in best case scenarios, tensions stemming from conflicting strategic goals can be leveraged to foster a culture of creativity and innovation (Miron-Spektor et al., 2011). But in worst-case scenarios, one or more goals are subverted in favour of another (Gaim et al., 2021). Therefore, the purpose of this research is to explore the tensions surfaced by biotechnology projects at CRIs and to gain insight into how CRI employees involved in biotechnology projects understand and perceive CRI tensions.

This study is informed by organisational paradox theory and sensemaking literature in its investigation of CRI biotechnology tensions and how these tensions are understood and perceived. Subsequently, this study aims to contribute to paradox theory and sensemaking literature by linking the Dynamic Equilibrium Model (Smith & Lewis, 2011) with sensemaking logics. Paradox theory and sensemaking literature has not previously investigated tensions and logics in CRI biotechnology contexts, presenting a gap for this study to address. Contextual conditions that surface tensions and influence logics is an underrepresented area in paradox research (Schad et al., 2016), warranting empirical research in a variety of contexts, such as the CRI biotechnology project context. Furthermore, specific CRI biotechnology tensions are examined holistically by this study through the Dynamic Equilibrium Model, as paradox theory literature tends to examine general organisational

tensions through a simplistic approach (Sheep et al., 2016). Additionally, the findings of this study may provide insights on the Dynamic Equilibrium Model, as this framework is argued to potentially isolate tensions and overlook the complexity of organisational tensions (Cunha & Putnam, 2019). Accordingly, the following research questions are formulated:

This research aims to answer the following two questions:

1. What tensions are surfaced by biotechnology projects at Crown Research Institutes?
2. How are biotechnology project tensions perceived and understood by Crown Research Institute employees?

1.2 Overview of chapters

The chapters of this study are organised in the following order. Chapter 2 discusses the relevant literature and covers the theoretical background of this study. This chapter defines tensions and describes the biotechnology industry, the Dynamic Equilibrium Model used to investigate tensions, as well as the sensemaking logics literature leveraged to investigate how individuals involved in biotechnology projects understand and perceive tensions. Chapter 3 outlines the methodology of this study and discusses the abductive, qualitative approach taken. Chapter 4 covers the findings of this study by detailing the tensions and logics identified by this study. Chapter 5 provides a discussion of the main theoretical implications for paradox theory, sensemaking, and tension complexity, followed by a discussion of the practical implications of the findings. Chapter 6 concludes this study by summarising the key findings, discussing research limitations, and providing avenues for future research.

Chapter 2: Literature Review

This chapter discusses the literature relevant to this study in four main sections. The first section (2.1) defines tensions and describes the perspective of this study on New Zealand's biotechnology industry. The second (2.2) and third (2.3) sections discuss literature relevant to Research Question 1. Section 2.2 introduces the conceptual framework, the Dynamic Equilibrium Model (Smith & Lewis, 2011), used by this study, and discusses its strengths and limitations, while section 2.3 describes the tensions identified in empirical studies relevant to a CRI biotechnology context. The final section (2.4) reviews the literature relevant to Research Question 2 and discusses a sensemaking logic perspective on individual perceptions and understandings of tensions and the relevance of sensemaking to insights on organisational tensions.

2.1 Tensional perspective on New Zealand's biotechnology industry

Tensions are a prevalent theme in the biotechnology industry. Tensions are defined as "contradictory yet interrelated elements that exist simultaneously and persist over time" (Smith & Lewis, 2011, p. 386). Tensions are an inevitable feature of organisational life. However, tensions are particularly prescient to the biotechnology industry, as biotechnological innovations are at the forefront of scientific discovery and pose transformative potential for many facets of human life, including healthcare, food systems, fuel and materials (Befort, 2020). Life science discovery implicates advances in medicine and agriculture, presenting benefits and risks that have sparked debates among the public, policymakers, and regulatory bodies at national (Levidow & Carr, 2007; Levidow & Marris, 2001) and international scales (Brown & Michael, 2002; Kenney, 1986). To protect public interests, regulatory bodies have imposed high regulatory barriers for scientific discovery and research (Terblanche, 2008). These regulatory hurdles have compounded the existing high

costs of life science discovery (Smyth et al., 2016), and resulted in a scarcity of financial, time and human capital resources known as the *Valley of Death* that life science innovations must cross to reach the market (Kampers et al., 2021). The high investment burden in biotechnology necessitates robust intellectual property protection (Giugni & Giugni, 2010) that has invoked competitive pressures between biotechnology firms. Consequently, the biotechnology industry is fraught with tensions spurred by the uncertainty of life science discovery as well as regulatory, economic, and competitive pressures.

The tensions experienced by New Zealand's biotechnology industry have yet to be explored. Due to the relatively small size of New Zealand's biotechnology industry (Bayne et al., 2021), governmentally supported institutions such as universities and Crown Research Institutes (CRIs) play a large role in New Zealand's biotechnology industry (Fritsche, 2018; Marsh, 2003). Consequently, the tensions experienced by these institutions when engaging with biotechnology reflect on New Zealand's wider biotechnology industry. Unlike universities, CRIs do not have an educational agenda, instead embodying the government's commitment to empower New Zealand's public with scientific research and innovation (Science New Zealand, 2021). On the other hand, CRIs are hybrid organisations. Hybrid research and development (R&D) organisations balancing public and private stakeholder interests are known to foster tensions (Hewitt-Dundas et al., 2019; Kevles, 2001; Noble et al., 2018; Wong & Westwood, 2010). While CRIs have previously been investigated for paradoxical R&D tensions arising from their hybridity (Ashby et al., 2019; Bednarek et al., 2017), the specific tensions surfaced by CRI engagement with biotechnology have yet to be analysed from a holistic perspective. Furthermore, although tensions are accepted as a prevalent theme in biotechnology contexts and are well investigated in isolation, tensions do not occur in a vacuum, implicating the importance of viewing tensions holistically (Sheep et al., 2016). Therefore, to analyse biotechnology tensions in complex CRI environments, the

use of holistic framework on organisational tensions is necessary.

2.2 Dynamic Equilibrium Model framework

Smith and Lewis (2011) provide a Dynamic Equilibrium Model framework that views organisational tensions holistically by consolidating earlier organisational paradox theory literature. Organisational paradox theory was born in the latter half of the 20th century through the application of Eastern and Western philosophical principles on the nature of paradoxes to organisational tensions (Chen, 2002; Li, 1998; Schad et al., 2016). Eastern philosophical principles, such as those from Taoist traditions, stressed the importance of viewing opposites as complementary parts of a whole (Chen, 2002). While Western philosophical principles, from the Ancient Greeks, highlighted the contradictory nature of paradoxes, or "opposite opinions" that "surface unifying principles and underlying truths" (Schad et al., 2016, p. 5). In the 1980s, ancient wisdom found its place in contemporary organisational problems (Quinn & Cameron, 1988; Poole & Van de Ven, 1989), but it wasn't until the foundational work of Smith and Lewis (2011) that organisational paradox theory was formed into a framework for understanding and mitigating organisational tensions (Putnam et al., 2016). The Dynamic Equilibrium Model views tensions as paradoxical relationships between two (or more) elements, meaning that the elements constituting a tension are in opposition to one another, yet they cannot be chosen between and eliminated because they are interdependent. The interdependency between the two elements is such that the tension surfaces repeatedly over time and is never fully resolved.

Smith and Lewis (2011) posited that paradoxical tensions persist over time because tensions exist in latent states, rather than being completely resolved, and are embedded in organisations until certain external and internal conditions render latent tensions salient to

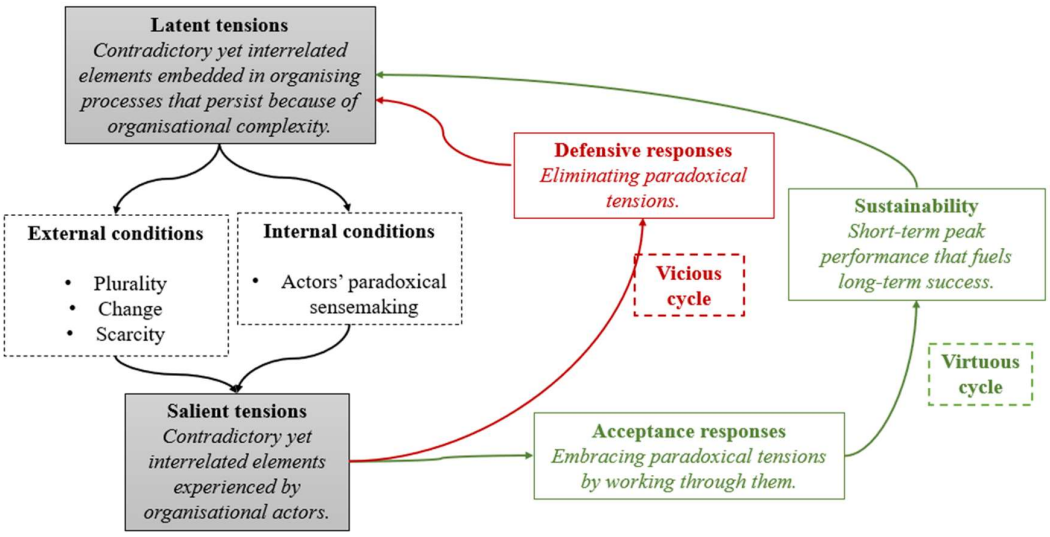
actors. These external conditions include plurality, change and scarcity. Plurality refers to a multiplicity of stakeholders and their varying demands, it results in uncertainty as it gives rise to conflicting goals and organisational processes. Change is an inherent aspect of organisational life, it destabilises existing organisational hierarchies, structures, objectives and roles, leading to ambiguous conditions that actors must make sense of. Whereas scarcity refers to a limitation on resources, including time constraints, financial constraints and lack of human capital. Internal conditions of actors are also important in surfacing tensions as tensions are partially cognitively or socially constructed. Internal conditions that render latent tensions salient involves actors' sensemaking capabilities, or their ability to recognise paradoxical tensions.

Once tensions are salient to actors, actors respond to tensions. Paradoxical approaches to tensions are focused on "constructing a more workable certainty" (Luscher & Lewis, 2008, p. 238). A vast breadth of paradox theory literature concerns responses to tensions. Scholars agree that a general awareness of paradoxical tensions supersedes any formulaic response to tensions because tensions are highly contextual and responses to tensions vary depending on circumstance (Hahn et al., 2017). According to Smith and Lewis (2011), responses are either defensive – seeking to eliminate or ignore tensions, or, accepting – seeking to embrace and work through tensions. Defensive responses are rooted in the emotional discomfort actors experience due to the ambiguous conditions and inconsistencies paradoxical tensions create. Defensive responses temporarily eliminate tensions and are short-term solutions that potentially give rise to vicious cycles. In a vicious cycle, organisations respond to tensions by avoiding or choosing between the elements of tensions repeatedly. Whereas acceptance responses involve viewing the elements of a tension paradoxically and accepting tensions as interdependent, contradictory elements that will persist over time. Navigating paradoxical tensions through acceptance strategies is considered sustainable, and organisations that

engage acceptance strategies achieve a short-term peak in performance that facilitates long-term success. In the framework of Smith and Lewis (2011), external conditions, internal conditions and responses come together to create a dynamic equilibrium of paradoxical tensions, depicted in Figure 1 below.

Figure 1

Dynamic Equilibrium of Paradoxical Tensions



Source: Adapted from Smith and Lewis (2011)

Importantly, the Dynamic Equilibrium Model framework distinguishes between organisational tensions by dividing tensions based on their relation to a core organisational activity: (i) performing – goals, (ii) organising – process and structure, (iii) belonging – identity, and (iv) learning – knowledge. The meanings of these tension types are shown in Table 1 below. Dividing tensions into types allows researchers to identify specific tensions and make empirical observations on the nature of tensions and their dynamics. The tension types detailed by Smith and Lewis (2011) are flexible and may intersect. The intersecting tensions and their meanings are described in Table 2 below. Intersections between tensions confer further nuance to the observations researchers may make on organisational tensions.

Table 1

Dynamic Equilibrium Model Tension Types

Tension Type	Meaning
(i) Performing	Tensions between competing goals or strategies.
(ii) Organising	Tensions between competing processes to achieve a desired outcome.
(iii) Belonging	Tensions between competing identities and roles.
(iv) Learning	Tensions between the integration of new knowledge and the destruction of the old.

Source: Adapted from Smith and Lewis (2011)

Table 2

Dynamic Equilibrium Model Tension Intersection Types

Tension Type	Meaning
Belonging-performing	Identities compete with goals as actors balance their roles or identities with socio-occupational demands.
Organising-performing	Goals compete with organisational processes, for example, means vs. ends, employee vs. customer demands, high commitment vs. high performance.
Learning-performing	A conflict between future capabilities and present success.
Belonging-organising	Individual identities and roles compete with collective action.
Belonging-learning	The need for adaptation and renewal competes with an existing and stable identity or role.
Learning-organising	Focused, stable organisational routines and capabilities clash

	with the need for renewal to enable dynamic and flexible outcomes.

Source: Adapted from Smith and Lewis (2011)

2.2.1 Strengths and limitations of the Dynamic Equilibrium Model

Like any theoretical framework, the Dynamic Equilibrium Model has strengths and limitations. Putnam et al (2016) put forward that the Dynamic Equilibrium Model was essential for bringing paradox theory to a normative status, and that the framework is primarily useful for identifying a variety of organisational tensions in different contexts and therefore assists individuals in recognising tensions. For example, the Dynamic Equilibrium Model has been used in empirical studies to identify performing, organising, belonging and learning tensions in digital industry (Yeow et al., 2018), healthcare (Cleland et al., 2017; Gilbert & Laporte, 2022), human resources management (Keegan et al., 2017), IP consulting (Mastio et al., 2021), hybrid R&D environment (Ashby et al., 2019), manufacturing (Dmitrijeva et al., 2022) and telecommunication firm (Jarzabkowski et al., 2013) contexts. In these studies, the Dynamic Equilibrium Model allowed scholars to examine organisational tensions holistically, across all core organisational activities. Hahn et al (2017) extended this argument by suggesting that the paradox perspective of the Dynamic Equilibrium Model provides instrumental value because it allows practitioners and academics to identify relevant causal factors and outcomes to tension types. Furthermore, the descriptive, empirical findings of studies from the paradox perspective help challenge existing normative principles of paradoxical corporate sustainability practises, preventing stagnation in industry practises by identifying gaps between practise and theory (Hahn et al., 2017). Consequently, the Dynamic Equilibrium Model is inherently valuable for both literature and practise, lending itself to a variety of contexts. Therefore, the Dynamic Equilibrium potentially provides a holistic view of tensions in CRI biotechnology contexts.

In contrast, Cunha and Putnam (2019) argued that the use of the four tension categories described by Smith and Lewis (2011) as a fully developed category system is problematic because it risks exclusion and isolation issues. Cunha and Putnam (2019) stated that the isolation issue refers to researchers examining the tension types in isolation to one another, without investigating their interrelationships empirically. The authors noted that the work of Jarzabkowski et al (2013) is an exception to the isolation issue. Jarzabkowski et al (2013) applied the Dynamic Equilibrium Model to empirically observe that tensions co-occurred and co-evolved across organisational levels in a telecommunications firm. The authors found that conflicting market and regulatory demands encountered by the firm surfaced organisation-level organising tensions as managers across the firm attempted to perform their roles through conflicting organisational processes. In turn, this organising tension influenced how teams experienced and responded to belonging tensions, as role identities and responsibilities were called into question. Competing role responsibilities surfaced individual performing tensions, as individuals grappled with conflicting personal objectives. These findings illustrate how tension types influence one another across different organisational levels and shift over time, existing in a dynamic state and showing that a dynamic and holistic view of tensions is necessary when applying the framework in empirical research. Hence, the Dynamic Equilibrium Model can be applied to identify the tensions surfaced by biotechnology projects but should also provide insights into how biotechnology tension types interact.

Cunha and Putnam (2019) warned of exclusion issues, referring to paradoxes that do not fit within the four categories of the Dynamic Equilibrium Model, as researchers may mistakenly use the Dynamic Equilibrium Model as a map for the entire paradox tension landscape. However, Smith and Lewis (2011) provide flexible categories with intersections that may be applied in the case of more complex tensions. Mastio et al (2021) identified organising-

performing, belonging-organising, belonging-learning and learning-performing tensions in an IP firm grappling with tensions due to changing market and regulatory demands. The use of intersectional tensions allowed the authors to expose and discuss issues of organisational inertia in detail. Furthermore, issues of exclusion imply that organisational tension research should use the Dynamic Equilibrium Model with caution and strongly ground itself in the ontological foundations of paradoxical tensions. Smith and Lewis (2011) suggest that paradoxical tensions are both socially constructed and inherent to organisational systems. Social or cognitive construction of tensions implies that tensions are not statically situated temporally or spatially in an objective reality, and instead reflect the shared reality of perceived tensions experienced within an organisation at one point in time (Hahn & Knight, 2021). Hahn and Knight (2021) suggested that research into paradoxical tensions "represent an awareness of the multitude of organizational issues that may result in organizational paradoxes and how they might shape organizational reality" (p. 372), and that the use of paradoxical tension categories "lies less in definitively characterizing latent paradoxes, and more in sketching out the potentiality for their enactment" (p. 372). Consequently, exclusion issues may be avoided by this study by firstly, considering tensions critically, and secondly, viewing them as inherently subjective experiences that combine to reflect a potential representation of the shared, social reality of CRIs.

2.3 Dynamic Equilibrium Model for biotechnology tensions

The Dynamic Equilibrium Model facilitates the investigation of organisational tensions. The framework of Smith and Lewis (2011) provides a holistic paradox perspective on organisational tensions that is sensitive to context and illustrates the dynamics of specific tensions, potentially identifying organisational and systemic issues that need addressing. Although it has yet to be applied to a biotechnology industry context, the Dynamic

Equilibrium Model has been used to investigate organisational tensions at CRIs (Ashby et al., 2019; Bednarek et al., 2017) and public research institutions (PRIs) (Keller et al., 2020). This prior literature paves the way to investigate CRI biotechnology tensions because it provides an approximate understanding of the conditions and tensions potentially relevant to hybrid R&D contexts. The following sections discuss the potential performing, belonging, organising and learning tensions in CRIs in detail based on these previous findings.

2.3.1 Performing tensions

Performing tensions persist in CRI contexts due to the coexistence of public and private stakeholder objectives. Performing tensions arise from competing divergent goals and strategies of multiple stakeholders (Smith & Lewis, 2011). In CRIs, Bednarek et al (2017) found that employees in scientific and commercialisation roles grapple with performing tensions due to a paradox between public good and commercial objectives. The findings of Ashby et al (2019) similarly reflected that CRI scientists experienced performing tensions because scientific sustainability objectives for public good and commercial research were interrelated yet contradictory. Public good objectives are central to research funded by the government, which focuses on the long-term environmental and social benefits to New Zealand, while commercial objectives emerge from research services performed for commercial partners, which tends to prioritise economic objectives. Unlike their fully publicly funded predecessors, CRIs must face their societal impact mission through a diverse range of funding mechanisms (Davenport & Bibby, 2007). CRIs receive approximately a third of their income from non-contestable government funding streams, a third from contestable funding streams, and a third from commercial activities (Ministry of Business, Innovation and Employment, 2016). As government support for science recedes, commercial partnerships gain importance in their stead, hence both public and private stakeholders influence public science outputs (Coccia et al., 2015; Irzik, 2013). Consequently, performing tensions may surface for individuals involved in biotechnology commercialisation projects at

CRIs, as the finite resources available in CRIs are rationed to meet both public and private stakeholder interests simultaneously.

Scientific R&D activities are resource intensive, resulting in performing tensions surfacing for CRIs attempting to meet divergent stakeholder demands. Bednarek et al (2017) linked performing tensions to the unpredictability of scientific research and financial scarcity. Scientific endeavours have the potential to spur a multitude of positive outcomes for society, however, research outcomes are impossible to predict, and scientific endeavours are associated with high investment costs (Edelman, 2004; Hallonsten, 2014; Vuong, 2018). Hence resource scarcity in scientific research may surface performing tensions experienced in CRIs. Furthermore, public research institutions in New Zealand are susceptible to conditions of resource scarcity, as the proportion of New Zealand's GDP spent on R&D activities is 1.23%, almost half of the national OECD average (Ministry of Business, Innovation and Employment, 2018). Although it is yet to be confirmed empirically whether resource scarcity influences the performing tensions surfaced in CRI biotechnology projects.

A secondary performing tension in CRIs is linked to a paradox between fundamental and applied sciences. Entwined within the paradox of commercial and public good objectives, Bednarek et al (2017) identified a performing tension between science impact and science excellence. Science impact refers to the potential social, environmental and economic impact of applied science through the development of technological breakthroughs, while science excellence refers to a high standard of scientific research and traditional understandings of academic success through publication of fundamental research in top-tier journals and the recruitment of world-class scientists. Keller et al (2020) found similar performing paradoxes when interviewing scientific personnel in a Taiwanese PRI undergoing a merger between applied and fundamental biological sciences. Fundamental scientists at the PRI reportedly

experienced performing tensions because they viewed applied and fundamental sciences as contradictory endeavours that could not be carried out simultaneously. The findings of Bednarek et al (2017) and Keller et al (2020) have implications for the tensions potentially surfaced in CRI biotechnology projects. As fundamental life sciences provide an essential foundation for the applied sciences that develop biotechnology, fundamental and applied sciences are interdependent and potentially contradictory objectives. Consequently, performing tensions may surface in CRI biotechnology projects due to a paradox between science impact and science excellence.

2.3.2 Belonging tensions

For scientific personnel at CRIs, belonging tensions are potentially linked to performing tensions between science impact and science excellence. Belonging tensions arise from the competing values and roles of collective and individual identities, and similarly to performing tensions, are primarily driven by a plurality of stakeholders (Smith & Lewis, 2011). Keller et al (2020) found that in certain cases, responses to performing tensions triggered tensions of belonging for scientists. These belonging tensions arose from scientists' perceiving their existing disciplinary identities as contradictory to the new identity of the organisation. Scientists' roles at the PRI were traditionally academic in the sense that they solely focused on fundamental research, whereas the new identity of the organisation encompassed both fundamental and applied research. Applied research generates technological innovations that require patent protection. The publication of research is interdependent with patenting, as once research supporting an invention is in the public domain, it no longer fulfils the novelty criteria for patenting an invention (Levi-Mazloum & Von Ungern-Sternberg, 1990). Yet, patent applications have long processing times, essentially putting publication on hold, which is problematic for the fast-paced nature of scientific research (Levi-Mazloum & Von Ungern-Sternberg, 1990). While scientists readily recognise the benefits of applied science, research publications remain the primary professional legitimization mechanism for scientists (Vallas

& Kleinman, 2007). Hence, applied and fundamental science presents performing and belonging tensions to scientists, as scientists may experience a normative pressure from their teams and wider disciplinary field to conform to both traditional and entrepreneurial scientific identities.

Belonging tensions are possibly experienced by commercial CRI personnel in a similar way to scientists because they may also grapple with their duties to the public and to commercial partners. For instance, Ashby et al (2019) examined this belonging tension from the perspective of sustainability, finding tensions between CRI scientists' desire to be stewards of change as expert voices on sustainability issues and simultaneously accommodating their roles as commercial allies. The tension identified by the authors arises because the commercial imperative potentially necessitates that social-environmental sustainability objectives are subverted by economic objectives. As the role of commercial role employees is tied to the dissemination of innovative problem-solving technologies, they may experience belonging tensions arising from normative pressures tied to their duties to both clients and the public (Bednarek et al., 2017). There may be further specific aspects to the belonging tensions experienced by commercial personnel related to their role responsibilities. Biotechnology commercialisation requires the collaboration of commercial and scientific research teams, and external industry partners (Engez & Aarikka-Stenroos, 2023). As belonging tensions are surfaced by a plurality of stakeholders (Smith & Lewis, 2011), employees occupying commercial roles potentially experience belonging tensions during their involvement in CRI biotechnology, as they must collaborate across a range of stakeholders to achieve commercialisation outcomes.

2.3.3 Organising tensions

The presence of belonging and performing tensions in CRI and PRI contexts has implications for potential organising tensions. Organising tensions are surfaced by competing yet

interdependent organisational structures and processes that actors must engage with to achieve a desired goal (Smith & Lewis, 2011). Organising tensions influence performing and belonging tensions (Jarzabkowski et al., 2013; Smith & Lewis, 2011) because organising tensions concern the organisational structures that shape individual contexts by introducing boundary conditions for the fulfilment of workplace objectives and socio-occupational identification. Although not a major focus of prior CRI and PRI paradox studies, the influence of organising tensions on belonging and performing tensions is noted by scholars. For instance, Ashby et al (2019) indicated that scientists' ability to generate and communicate sustainability research was influenced by whether scientists were engaging with the academic community or industry clients. Similarly, Keller et al (2020) also noted organising tensions arising from the integration and differentiation of scientific and commercial PRI activities, as the achievement of commercial and scientific objectives require different processes and capabilities. Furthermore, as a result of the high costs associated with R&D and research commercialisation, biotechnology development may operate under conditions of resource scarcity (Danielson et al., 2020; Graff et al., 2010; Mullard, 2017). Scarcity may surface paradoxical tensions because it enforces boundary conditions on how actors are able to achieve certain objectives (Miron-Spektor et al., 2018; Smith & Lewis, 2011) and is therefore likely to trigger organising tensions. Consequently, organising tensions may also manifest in CRI biotechnology project contexts, and potentially have linkage to or influence on performing and belonging tensions.

2.3.4 Learning tensions

Learning tensions are innate to innovation and are therefore inherent to biotechnology projects at CRIs. Learning tensions are surfaced by organisational efforts to embrace change and innovation due to a paradoxical relationship between existing knowledge and new knowledge (Smith & Lewis, 2011). Andriopoulos and Lewis (2009) present learning tensions as exploration-exploitation tensions, where there is an interdependency between new and

existing knowledge because the creation of new knowledge requires an understanding and utilisation of existing knowledge. The two modes of knowledge become conflicting when organisations attempt to balance the use of established practises with innovation, hence surfacing a learning tension (Andriopoulos & Lewis, 2009). Although learning tensions have not previously been observed empirically in CRIs, Jarzabkowski et al (2013) explains that organisations reliant on creative disruption experience learning tensions that may be difficult to observe in isolation, as learning is a process that spans across organisational levels, and therefore underpins other performing, belonging and organising tensions. In PRIs, Keller et al (2020) identified a learning tension nested within the performing tension between commercial and scientific objectives. Keller et al (2020) described the learning tension as a conflict between the harnessing of existing knowledge for commercial objectives and the discovery of new knowledge in the fulfilment of scientific discovery. Innovation is a necessary aspect for the development of scientific breakthroughs, evident by practitioners' attempts to spur disruptive market-led scientific research practises in biotechnology firms, such as open innovation (Caulfield et al., 2012; Inauen & Schenker-Wicki, 2012). Consequently, learning tensions are likely to surface alongside performing, belonging and organising tensions in CRI biotechnology projects as both innovation and knowledge discovery are relevant to the strategic objectives of CRIs.

2.4 Paradox sensemaking of biotechnology tensions

To understand how CRI employees perceive biotechnology project tensions, this study adopts a sensemaking perspective. Sensemaking is broadly defined as "the ongoing retrospective development of plausible images that rationalise what people are doing" (Weick et al., 2005, p. 409). Individuals rely on sensemaking to generate stable meaning (Jay, 2013). Organisational paradox theory views sensemaking as an essential process in managing tensions because it involves the recognition and acknowledgement of tensions as paradoxical and therefore precedes proactive responses to tensions (Carmine & De Marchi, 2022; Lewis,

2000; Miron-Spektor et al., 2018). Miron-Spektor et al (2018) showed that individuals who made sense of tensions as complementary boundary conditions were more likely to approach tensions as opportunities to innovate, thereby improving workplace performance. Whereas individuals who viewed tensions as contradictory elements that required elimination were more likely to fixate on resolving them, thereby diminishing resources available for other organisational activities and lowering overall workplace performance. For practitioners, paradox sensemaking represents an avenue to mitigate organisational tensions cognitively (Carmine & De Marchi, 2022), as sensemaking provides insights into decision-making (Hahn et al., 2014). Hence, sensemaking is a key factor in shaping whether individuals engage with tensions in a constructive manner and is therefore an important perspective for understanding how individuals perceive and understand CRI biotechnology tensions.

2.4.1 Organisational paradox theory in sensemaking

The importance of paradox sensemaking of organisational tensions at CRIs can be understood by applying the theoretical foundations of organisational paradox theory. Paradox theory suggests that rather than resolving tensions by positioning competing demands as options that must be chosen between, such as with dilemmas or trade-offs, organisational actors should view competing demands as complementary and paradoxical conditions that must be embraced. In Gaim et al's (2021) account of the Volkswagen 2015 emission scandal, actors failed to embrace organisational tensions through a paradox lens. In this case, Volkswagen's ambitious plans to develop a high-performing, environmentally and economically sustainable vehicle were positioned as three divergent, paradoxical objectives. The simultaneous achievement of these three objectives was highly sought after by senior leadership and embraced discursively, despite technical personnel's warnings that such an achievement required significant technological advancements, that at the time, were an impossible engineering challenge. Employees instead disengaged from tensions to mediate the technical stalemate by prioritising two of three objectives – economic sustainability and high

performance. This mismanagement of organisational tensions lead to a vicious cycle, resulting in the falsification of environmental sustainability data for many years. Hahn and Aragón-Correa (2015) posit that a disconnect between the organisational sensemaking stance on paradoxical sustainability objectives and individual sensemaking stances on sustainability objectives is a common, yet hidden phenomenon. The authors argue that a balance and acceptance of contradictory views within organisations is a prerequisite to avoid organisational paralysis and embrace substantive organisational action to mitigate sustainability issues. Firstly, the case described by Gaim et al (2021) shows that a paradoxical sensemaking lens, followed by an appropriate response to an organisational tension, is essential for successful technological innovation that may take place in R&D focused organisations like CRIs. Secondly, it shows that the sum of individual sensemaking is a complicated, contextually situated process that has important organisational implications that requires careful consideration.

2.4.2 Sensemaking logics

Sensemaking can elucidate how organisational and individual level factors influence perceptions of tensions and therefore uncover insights relating to organisational tensions. However, sensemaking presents an extremely broad topic that can be difficult to focus empirically. Prior literature in the paradox sensemaking space navigated this challenge by relying on the principle that the tension sensemaking process is influenced by a cognitive frame or logic adopted by individuals (Chen et al., 2021; Hahn et al., 2014; Sharma & Jaiswal, 2017). In a sensemaking context, a logic is described as a mental template that filters information and helps assign meaning to the external world (Hahn et al., 2014; Walsh, 1995; Weick, 1995). Initially, Hahn et al (2014) suggested that the managerial sensemaking of sustainability issues was influenced by whether managers tended towards a paradox or business-case logic. The business-case logic interprets sustainability tensions by only considering environmental and social objectives that align with economic ones, thereby

allowing managers to eliminate tensions between economic, environmental and social objectives. According to Hahn et al (2014), the business-case logic is associated with the prioritisation of efficiency and structured information searching. In contrast, the paradox logic accepts tensions because objectives are interrelated and persistent, and therefore paradox logics attempt to simultaneously accommodate all objectives. The paradox logic is associated with less structured and broader information searching, it tends to be more detail-oriented and creative but less efficient. The authors suggested that sensemaking logics are a spectrum, and that the logic adopted by an individual shifts in response to a variety of internal and external factors, such as resource constraints.

The empirical findings of Sharma and Jaiswal (2017) built on this work by showing how individual logics shifted over time across a large project in a biotechnology firm. The authors found that individual perceptions of project time horizons influenced whether project objectives were viewed through a paradox, business-case or business logic. The business logic was identified by the authors as a logic that entirely ignores objectives other than economic ones. Due to the experience of organisational leaders, they viewed time horizons as smaller at the outset of a project and towards its close, adopting a business logic at these time points to prioritise the survival of the organisation. Organisational leaders briefly deviated towards a business-case logic mid-way through the project when resources were plentiful. Whereas the wider organisation began the project with a paradox logic that shifted towards a business-case logic and finally to a business logic towards the end of the project due to external events changing the way employees perceived the project horizon and what objectives were feasible to achieve in that time horizon. The findings of Sharma and Jaiswal (2017) highlight that sensemaking logics provide a window into the dynamics of organisational tensions by showing how organisational perceptions of those tensions shift in response to external factors and events. Consequently, investigating the sensemaking logics

of CRIs can provide important practical insights into CRI biotechnology project tensions. Sensemaking logics are a relatively new branch in paradox literature that has yet to be explored fully. Chen et al (2021) investigated sustainability tensions between New Zealand and Chinese business partnerships and found that in contrast to the works of Hahn et al (2014) and Sharma and Jaiswal (2017), most managers adopted a paradox logic to interpret sustainability tensions, rather than a business-case or business logic. Additionally, the authors identified the dichotomous logic, which is founded on a similar logic to the business-case, where the contradictory nature of elements within a tension is emphasised. Thus, the dichotomous logic views tensions as a set of contradictory elements that cannot coexist, unlike the paradox logic which allows the coexistence of contradictory elements and may even view them as complementary. The findings of Chen et al (2021) further stress the situatedness of sensemaking and logics and suggest that CRI employees likely engage unique sensemaking logics that cannot be anticipated through prior literature. Further empirical investigation into the logics behind tension sensemaking is necessary to provide clarity on the topic, especially in a context that deviates from issues of sustainability alone, such as CRI biotechnology projects.

2.4.3 Sensemaking logics and tension outcomes

Sensemaking literature links sensemaking logics to tension outcomes by suggesting that the logics adopted by individuals and organisations facilitate paradoxical approaches to tensions. In the field of sustainability, empirical literature has identified that a paradox logic is associated with positive sustainability outcomes. Carmine and De Marchi (2022) investigated organisational-level perceptions of tensions, the sensemaking logics adopted, and the outcomes of tensions. The authors found that paradoxically framing sustainability tensions contributed to better perceived outcomes for social and environmental organisational objectives, but worse outcomes for economic objectives. Paradox logics have also been empirically linked to more innovative outcomes for achieving multiple conflicting objectives

(Andriopoulos et al., 2017), while non-paradox logics that sought to eliminate tensions were associated with limited outcomes that relied on established practices (Sharma & Bansal, 2017). Grewatsch and Kleindienst (2018) similarly found that engaging with a paradox logic influenced how decision-makers in organisations managed and developed organisational capabilities, leading to better market-sensing, organisational learning and integration of stakeholder goals. In contrast, Chen et al (2021) found no evidence to support that a paradox logic can be linked to a paradox approach to tensions, as economic concerns still dominated managerial decision-making, suggesting that institutional-level as well as organisational factors have an important role between the sensemaking of tensions and actions to mitigate tensions. These findings indicate that sensemaking logics potentially play a significant role in organisational outcomes in contexts where paradoxical tensions coexist, and that the empirical investigation of sensemaking logics in response to tensions can elucidate how individuals and organisations navigate tensions.

Chapter 3: Methodology

This chapter discusses the methodology of this study. The first section (3.1) discusses the ontological and epistemological stance of this study. The second section (3.2) outlines the research design and discusses data collection in the form of semi-structured depth interviews, participant selection criteria and processes, and the data analysis process. To address research rigour, the third section (3.3) discusses reflexivity, and fourth section (3.4) discusses trustworthiness.

The methodology of this research is constructed to answer the following research questions:

1. What tensions are surfaced by biotechnology projects at Crown Research Institutes?
2. How are biotechnology project tensions perceived and understood by Crown Research Institute employees?

3.1 Research paradigm

A research paradigm is a set of epistemological and ontological principles and assumptions that guide knowledge inquiry. This study aligns with an interpretivist paradigm, which can be understood as using a "subjective epistemology which anticipates multiple, diverse interpretations of reality rather than seeking to reveal an overarching truth" (Bunniss & Kelly, 2010, p. 360). An interpretivist paradigm is essential for this study's investigation of organisational tensions as this study's view of tensions is that tensions have material and socially created aspects that are inextricable (Hahn & Knight, 2021; Schad & Bansal, 2018; Smith & Lewis, 2011). Socially created meanings implicate multiple and diverse interpretations of reality, unique to individuals. Furthermore, the purpose of this study is not only to characterise the tensions surrounding biotechnology projects in CRIs, but also to describe how individuals experience and make sense of CRI tensions. The interpretivist

paradigm provides a perspective that, due to its epistemological and ontological assumptions, is centred around individual interpretations of phenomena, and is therefore an apt lens for investigating how CRI tensions are experienced.

3.2 Research design

The design of this study is shaped by a qualitative research approach due to the nature of this study's research questions. According to Guest et al (2012), qualitative research is defined through the type of data it collects: "data in qualitative research are nonnumeric and less structured data than those generated through quantitatively oriented inquiry, because the data collection process itself is less structured, more flexible and inductive." (p. 6). The research questions of this study necessitate the association of organisational tensions, as subjective experiences of individuals, to the context of CRI biotechnology projects. Andriopoulos and Gotsi (2017) refer to the association of paradoxical tensions to their specific setting as a contextual approach, which is beneficial for facilitating the collection of rich or nuanced data and is therefore inherently qualitative. Consequently, data collection and analysis methods have been chosen to prioritise flexibility to capture the subjective experiences of individuals. Flexibility is further conferred through an abductive research approach, rather than a purely inductive one. Abductive reasoning makes use of both inductive and deductive reasoning, implying a movement between data-led or pattern-searching activities and the testing of existing theoretical frameworks and hypotheses (Graneheim et al., 2017). Prior literature has also used an abductive reasoning process in the investigation and analysis of sensemaking (Chen et al., 2021) and CRI tensions (Bednarek et al., 2017) to establish an effective linkage between existing theory and empirical data. The following sections describe the data collection, participant selection and data analysis processes in accordance with the research design principles of this study.

3.2.1 Semi-structured depth interviews

The data collection method used in this study is semi-structured depth interviews with CRI employees. Semi-structured interviews are defined as being "organised around a set of predetermined open-ended questions, with other questions emerging from the dialogue between interviewer and interviewees… [and] allow the interviewer to delve deeply into social and personal matters." (DiCicco-Bloom, 2006, p. 315). Semi-structured depth interviews were chosen because they facilitate a flexible data collection process true to the abductive reasoning approach, allowing participant answers to theoretically informed questions to guide the interview and direct further data collection. The pre-determined questions were part of an interview guide and included introductory questions and primary questions. The interview guide may be found in Appendix A. Introductory questions served the purpose of providing background information about participants' roles at their CRIs to the researcher. The primary questions were designed to inquire about each category of tension from the Dynamic Equilibrium Model (Smith & Lewis, 2011) and attempted to gauge participants' views of each tension type. Questions avoided use of the words 'tension' or 'paradox' as they are academic constructs. Questions were instead positioned to inquire about the challenges encountered by participants in life science and biotechnology projects. Questions to identify participant views of tensions were altered to suit participant answers, and additional questions were asked by the researcher to follow up on issues raised by participants.

Participants were given the option to choose an in-person or online interview, at any time that was convenient for them. Interviews lasted approximately 30-45 minutes and were recorded through the Microsoft Teams recording and transcription feature. Following the interviews, transcripts were corrected and de-identified. Denaturalised transcripts were produced that omitted non-essential speech to further de-identify the transcripts and aid the researcher with

data analysis (Mero-Jaffe, 2011). Notes were made by the researcher during and following interviews as an initiation into data analysis.

3.2.2 Participant selection

Purposive sampling was used to identify appropriate interview participants to reflect CRI biotechnology across New Zealand. Industry connections were used to identify CRI employees with experience in CRI life science projects across the entire CRI ecosystem. An initial attempt was made to focus on employees with both commercial and scientific biotechnology experience, however, following initial interviews, it became clear to the researcher that a broader perspective on life science R&D projects is necessary to build contextual understanding of biotechnology projects in the CRI ecosystem. Likewise, an initial attempt was made to recruit an equal number of 'scientific' and 'commercial' personnel from each CRI. However, CRI roles are not cleanly divided into scientific and non-scientific roles, with many participants occupying roles that encompass both scientific and commercial responsibilities. Hence, the selection criteria were limited to CRI employees who have been involved in biotechnology projects in CRIs.

Organisational tensions may span across different organisational levels and be experienced differently as a result (Hahn et al., 2015; Jarzabkowski et al., 2013). Hence, participants occupying varying seniority and role types were chosen. Furthermore, interviewing participants from several CRIs confers environmental triangulation, which increases the trustworthiness of the study's findings (Stahl & King, 2020). Additionally, there was difficulty in arranging interviews with participants, especially with participants in purely scientific roles. This difficulty was possibly due to the busy nature of CRI work resulting in many participants being unable to volunteer their time. Snowball sampling with existing participants was used to mitigate these recruitment challenges. Eventually, ten interviews were conducted with ten employees from four CRIs. The participant pool is shown below in

Table 3, participants were distinguished based on role type, role seniority, CRI experience in years and prior background.

Table 3

Interview Participants

Participant	CRI	Role type	Seniority	CRI experience (years)	Background
1	2	Commercial	Intermediate	5-10	Business
2	2	Commercial	Junior	<1	Business and science
3	4	Commercial	Senior	10-20	Business and science
4	2	Commercial	Senior	<1	Business and science
5	3	Commercial	Intermediate	5-10	Business and science
6	1	Commercial & Scientific	Senior	20+	Science
7	3	Commercial & Scientific	Senior	10-20	Science
8	3	Commercial & Scientific	Senior	20+	Science
9	2	Commercial	Intermediate	5-10	Business and science
10	1	Scientific	Senior	5-10	Science

3.2.3 Data analysis

The data collected by this study was analysed through a thematic analysis process as detailed by Braun and Clarke (2006). Braun and Clarke (2006) provide an accessible and flexible six-phase guide to qualitative thematic analysis, for the purpose of "identifying, reporting and analysing themes or patterns within data" (p. 79). The initial phase involves data familiarisation, which was achieved through the correction of transcripts and re-reading of transcripts to note initial ideas. The second phase involves the systematic generation of initial codes from the entire data set. The second phase was achieved by examining each interview transcript in detail and recording data extracts that contained evidence of performing, belonging, organising and learning tensions, and corresponding sensemaking logics if applicable. Following the recording of tension types or logics, a label was assigned to the data extracts to describe the content of the extract. Label assignment was informed by both

the content of the data and theoretical knowledge on tensions. Hence data analysis followed an abductive approach. In accordance with Braun and Clarke (2006), to maintain the context of the data, each transcript was analysed separately, and extracts were recorded together with their corresponding interview questions in a sequential manner.

Following the generation of codes, the third and fourth phase of thematic analysis took place recursively (Braun & Clarke, 2006). The third phase comprised categorising and grouping codes into potential themes, whereas the fourth phase involved comparing codes and themes, and moving between lower and higher conceptual levels of analysis to ensure codes and themes were consistent. In the fifth phase, themes were developed through definitions and names. The final phase of thematic analysis involved the selection of extract examples and the relation of the analysis back to the research question and literature. The outputs of the final two phases are described in Chapter 4.

3.3 Reflexivity

Reflexivity is addressed by this study because it is critical to the rigour and quality of qualitative research (Johnson et al., 2020). More specifically, subjective perspectives or biases cannot be separated from qualitative research processes, implicating the importance of acknowledging the boundaries of personal biases, rather than attempting to eliminate them (Olmos-Vega et al., 2023). Similarly, the research questions and the interpretivist paradigm of this study prioritise the subjective experiences of individuals and as a result, the interpretation of those experiences is inextricable from the subjective experience of the researcher. To achieve reflexivity practically, the researcher should acknowledge their background and motivations that may influence decision-making throughout the study, as well as the influence of the relationships between the researcher and participants on the study (Olmos-Vega et al., 2023). Consequently, the researcher of this study acknowledges that their

prior training in biotechnology and current study in Masters of Bioscience Enterprise may sensitise them to certain issues in biotechnology and biotechnology commercialisation, thereby influencing the findings of this research. Due to the researcher's internship at one of the interviewed CRIs, the researcher maintained an acute awareness of the influence of their existing experiences at the CRI and relationships with participants on the research. The researcher maintained consistency in their interviews regardless of their prior relationships with participants and clarified references to shared knowledge in interviews. Additionally, this study discusses cultural Māori aspects, the researcher acknowledges that as a pākehā woman, their personal context may influence the interpretation of the findings. Finally, the researcher ensured that reflexivity was maintained throughout the research process and manuscript by detailing the decisions behind the research design in Chapter 3 and presenting the results in a transparent manner in Chapter 4 (Olmos-Vega et al., 2023).

3.4 Trustworthiness

This study prioritises research trustworthiness in place of research validity and reliability, as validity and reliability are evaluation criteria associated with quantitative and positivism-oriented research (Shenton, 2004). According to Lincoln and Guba (1985), the pillars of trustworthiness are credibility, transferability, dependability, and confirmability. The authors define credibility as the qualitative version of internal validity, it is concerned with whether findings are true or how accurately they reflect reality. Firstly, credibility is ascertained by this study through environmental triangulation (Stahl and King, 2020) of interviewees from different CRIs to reflect tensions and sensemaking more accurately across the CRI system. Secondly, credibility was ascertained through member checking of denaturalised transcripts with interviewee participants to ensure that participant answers reflected what participants intended to communicate. According to Lincoln and Guba (1985) transferability refers to the

applicability of findings to other contexts and is achieved through thick description of research context. Consequently, this study addresses transferability through the consideration and communication of relevant contextual information that shaped the tensions experienced. Dependability is the qualitative counterpart of reliability and is concerned with the consistency of the research. Dependability is addressed by this study through transparency of the study's research design and communicating the methodology in detail with the reader (Shenton, 2004). Finally, confirmability concerns the neutrality of the findings or ensuring that findings are shaped by respondents rather than the researcher. This study achieves confirmability by environmental triangulation and engaging with reflexivity, as discussed in section 3.3.

Chapter 4: Findings

The following chapter describes the findings of this study based on the interviews conducted with 10 participants about the tensions encountered in biotechnology and life science projects at their respective CRIs. Four themes were identified in the data following thematic analysis. These themes include: (theme 1) ambiguous NZ biotechnology conditions, (theme 2) CRI impact orientation shift, (theme 3) complexity reduction logic and (theme 4) CRI horizons. Theme 2 was identified to have two sub-themes: (theme 2a) role identity and (theme 2b) process and goals. The themes discussed in this chapter are arranged in relation to the research questions of this study. Themes 1 and 2 are relevant to the first research question: what tensions are surfaced by biotechnology projects at Crown Research Institutes? While themes 3 and 4 are relevant to the second research question: how are biotechnology project tensions perceived and understood by Crown Research Institute employees? The findings are summarised in Table 4 below, depicting themes and corresponding codes, as well as illustrative quote examples.

Table 4

Themes, Codes and Quote Examples

Theme	Codes	Participants	Illustrative Quote Examples
1. Ambiguous New Zealand biotechnology conditions Tensions: Performing, belonging,	Ambiguous cultural issues	4, 5, 8	Q: *Even people within your own project team would have different backgrounds, different values, different norms around that and acceptance of something being or not being* [a cultural issue]. *Its putting a lot of scientists off in terms of progressing some of the science projects.* [Participant 4, CRI 2, senior commercial role] Q: *So if you're CRI then it's kind of difficult because we are required to keep customers happy and generate*

organising, organising-performing, learning, belonging-organising, learning-organising, learning-performing	Regulatory uncertainty	8, 9	*income. In the work that* [the CRI does]*, very seldom is that defined by a regulatory environment, as perhaps it would be if you are developing a pesticide or a medicine or whatever. So it's not like you can just say no, we do what we do, what we absolutely have to, and it's predefined and it's the standard.* [Participant 9, CRI 2, senior commercial role] Q: *And some of that comes down to laws in New Zealand. I mean, we are a little tied behind our back when it comes to some of the latest tools for genetic manipulation.* [Participant 8, CRI 3, senior commercial & scientific role]
	R&D uncertainty	6, 10	
2. CRI impact orientation shift **2a. Role identity** Tensions: Belonging, belonging-organising, performing **2b. Process and goals**	Receding scientist belonging tensions	3, 7, 10	Q: *I think actually things have improved over the years and in 20 years, if I look back… I think people were more of the opinion that the government should just pay for everything. That there's some basic science that needs doing, that we're important as scientists and the government should just give us a whole lot of money, you know, with doing stuff. And that's changed, now that they know how competitive it is to get funding.* [Participant 3, CRI 4, senior commercial role] Q: *And then there was some expectation around coming to the commercialisation office to identify what the highest value chemical is, which in and of itself is too big of an ask of a question. There's too many.* [Participant 5, CRI 3, intermediate commercial role]
	Murky commercial roles	2, 4, 5, 9	

Tensions: Organising, performing, organising-performing	CRI process disconnect with industry goals	1, 2, 3, 4	Q: *So, we have this struggle that when we apply for internal money, even if it's a small amount, like how do you see this progressing to commercialisation and making a thing we can put in a box and– no idea and I don't care, because we need to do this fundamental research to better our knowledge, to better human health, the environment, whatever. But unless we're supporting this fundamental research – we're not going to get anywhere.* [Participant 10, CRI 1, senior scientific role]
	Impact fit on science	1, 10	
	Organising tensions surface performing tensions	1, 2, 10	
	CRI organising tensions leveraged	7	
3. Complexity reduction logics within projects Tensions: Performing, organising, organising-performing	Resource-constraint pathway logic	1, 3, 5, 6, 7, 8	Q: *In this particular instance, the actual issue is that we said we can get more of A, less of B. But B is more valuable than A – so there is a trade-off. And then in this case we got to that* [stage]*, and we said – look let's go with this one, we can debate if we go with A or B forever. Someone just had to make a decision that we'll go with A and see what happens... Scientifically it's probably even a spectrum, but we've targeted A or B, otherwise, it gets too complicated.* [Participant 7, CRI 3, senior commercial & scientific role] Q: I*t's an either-or, if you go start up approach then you've got to be all in, right? Like you've got to raise money and do that whole thing. If it's licensing, then, once you license it, you've got to work with that partner as well. So yeah, they are black and white decisions. It's kind of either-or, you can't really have a middle ground*
	Performing tension elimination through business case logic	3, 5, 8, 9	
	Publish vs. patent decisions separated	2, 6	
	Resolving one tension gives rise to another	6, 9, 10	

			with them. [Participant 1, CRI 2, intermediate commercial role] Q: *You run into the problem, in your own research, you can be researching a thing, but then new opportunities sort of blossom out of those. But you're always constrained by the budget. I guess it's reality, right?* [Participant 8, CRI 3, senior commercial & scientific role]
4. CRI horizons Tensions: Performing, learning-performing, belonging, organising	CRI ahead of industry	7, 8	Q: *The funding mechanisms are highly linked to your publishing track record, particularly if you're going for competitive funding. If you can't show a publication track record, you're not going to get funded because they just won't believe that you've got the track record to undertake a project in that space. The interesting thing about this publish incentive is it isn't necessarily creating impact, at least it's not creating impact for end users and those downstream.* [Participant 6, CRI 1, senior commercial & scientific role] Q: *So that was short-term gain because* [a different CRI team] *wanted to, but it probably wasn't strategically wise in the long-term to notify the rest of the world and the competition that we are doing this, but we don't have any patents in place yet and we're not close to launching a product.* [Participant 2, CRI 2, junior commercial role] Q: *So, as I said,* [the CRI] *has been working with* [biomaterials and sustainability] *for a long while. And now a lot of people are looking for that. Ten years ago, that would have been very different. There were some people out there who sort of wanted to have something green. I guess the difference here was that, organisationally, we saw the potential and the value to New Zealand and mankind in the sustainable options. And then to work with people who don't necessarily see*
	Role responsibilities influence tension interpretation	3, 4, 5, 10	
	Strategic IP tension	2, 6, 9	
	Science excellence-impact paradox	6, 7, 9	

			that, for example, who would say – why do we need to make stuff out of [these] *resources? We're not going to run out of oil.* [Participant 7, CRI 3, senior commercial & scientific role]

4.1 CRI biotechnology tensions

Participants involved in CRI biotechnology projects experienced a range of performing, organising, belonging and learning tension types. Performing, followed by organising tensions were the most salient for individuals in comparison to belonging and learning tensions. However, all tension types were identified in participants' experiences in CRI biotechnology projects and were frequently found to intersect and co-occur. These findings are consistent with prior tensions explored in paradox theory literature, whereby tensions are interwoven and knotted together (Sheep et al., 2016) – presenting a complex environment fraught with interrelated tensions. Interrelated tensions were surfaced by scarcity, plurality and change specific to the CRI and biotechnology environments.

4.1.1 Ambiguous New Zealand biotechnology conditions

Biotechnology spans multiple emerging sectors that are poorly defined through regulations or established protocols, giving rise to ambiguity, as participants struggled to choose between multiple options with uncertain outcomes. Ambiguous New Zealand biotechnology industry conditions surface tensions due the plurality of stakeholders in CRI biotechnology projects, leading to multiple competing interpretations of goals and strategies, as previously suggested by Lewis (2000). As a result, many performing and organising tension types were surfaced by the collaboration of scientific research teams, commercial teams and industry partners in CRI biotechnology projects:

> *That's probably part of the course when research projects are being progressed. The collection of people on the project, the managers who are guiding the project, the organization that is funding it – it's probably not uncommon to disagree on certain aspects of the direction or the opportunity to use the outcomes.*
>
> – Participant 6, CRI 1

Furthermore, the ambiguous conditions of CRI biotechnology projects were compounded by the unpredictable nature of scientific R&D. Uncertainties tied to R&D surfaced exploration-exploitation learning tensions, similar to those discussed by Andriopoulos and Lewis (2009), where participants grappled with the pursuit of conflicting and interrelated scientific research and commercialisation opportunities:

> *It was probably less about the disagreement and more about the uncertainty, and that was a part for each person involved in the decision-making or involved in the project to come to terms with around stepping into that unknown – could we? What would happen if we did? What would happen if we didn't? And then sort of trying to weigh up those different opportunities and the costs associated with each particular decision.*
>
> – Participant 6, CRI 1

Specific to CRI biotechnology projects, is the CRI research agenda for "improved outcomes for Māori" (Ministry of Business, Innovation and Employment, 2020, p. 14), which implicates Māori as an additional CRI stakeholder group and surfaces an organisational performing tension for CRIs between te ao Māori and CRI science systems. CRI biotechnology projects described by participants often involved close collaboration with iwi partners, as certain New Zealand biotechnologies were developed from *taonga Māori* flora and fauna species. *Taonga* is a Māori concept for intangible or tangible assets that require

guardianship, as opposed to ownership (Craig et al., 2012). According to participants, the inclusion of taonga in biotechnology projects necessitated the integration of a te ao Māori worldview. The integration of te ao Māori in biotechnology projects represents an area of uncertainty for CRIs, as it is a cultural worldview that does not have strict definitions and is not based on the same values as CRI science systems, presenting belonging-organising tensions to participants as they struggled to integrate te ao Māori values with CRI R&D and commercialisation processes:

> *As long as you keep people, I think, driving towards the facts as much as possible, but depending on the situation, I would say particularly when dealing with cultural sensitivities, that can be a tad tricky. In that case, the facts can sort of go out the window, because that's not what the other parties are looking to talk about. They want to understand what I would call feelings about things which are sort of cultural, cultural approaches to things which can get a little confusing and a bit of a minefield.*
>
> – Participant 8, CRI 3

The integration of cultural approaches in biotechnology projects surfaced belonging tensions for participants, who felt uncertain about interpretations of cultural issues within their own teams:

> *You can never presume that someone is aligned with your way of thinking, and you have to be really careful about who you talk to and how you talk to them in terms of how you solve for that.*
>
> – Participant 4, CRI 2

When sensemaking belonging-organising tensions surfaced by cultural and CRI approaches to biotechnology projects paradoxically, a learning-organising tension was surfaced for

participants recognising that a change in CRI processes may be necessary to accommodate the integration of cultural approaches in CRI biotechnology projects of the future:

> *I think they would have liked to have really dug down and actually considered it within a te ao Māori context, but within the context of the project, there probably wasn't the time to do that, there was a time constraint around a PhD and its embargo. But I think, going forward, there might be an opportunity for that worldview to be taken at an earlier stage – so during research project proposal development.*
>
> – Participant 5, CRI 3

Additionally, the New Zealand biotechnology industry gives rise to regulatory uncertainty. Without a defined regulatory roadmap or in the absence of regulations for certain biotechnology innovations, CRI employees encountered performing tensions between public good and commercial success, as previously identified in CRI contexts by empirical paradox literature (Ashby et al., 2019; Bednarek et al., 2017), which spurred belonging tensions between different individual and team-level interpretations of CRI values:

> *But yeah, certainly there's a tension there and particularly in that space, which is the Wild West from a regulatory point of view. I mean, people want to make money and I've had a number of people say to me, well, what does it matter if people buy this thinking it will do them some good and it doesn't? Like people want these things, why shouldn't we supply them? Well, they probably don't work well. But they might, who knows? It's like well – is that OK to sell them saying they will? I don't think so.*
>
> – Participant 9, CRI 2

CRIs perform research in sectors that are not yet realised in New Zealand due to regulatory barriers, such as genetic editing and modification. In New Zealand, genetically modified or edited organisms are stringently regulated by the Hazardous Substances and New Organisms

Act (1996) and cannot be released into the environment (Fritsche, 2018). The regulations surrounding genetic manipulation restrict the ability of CRIs to engage with genetic manipulation research. Yet, research in these fields is necessary to CRIs, as CRIs have a duty to anticipate future solutions to future problems for the benefit of New Zealand, as "the core mission of CRIs is to protect and advance Aotearoa New Zealand's current and future prosperity and wellbeing" (Crown Research Institutes, 2021, p. 8). This mission surfaced an organisational level performing and learning type tension for CRIs between present and future science for the benefit of New Zealand. For example, genetically modified or edited crops have the potential to be resilient to climate change (Raza et al., 2019), and can mitigate land use and methane emission issues (Kovak et al., 2022). As a result, the management of research and commercialisation of science in unrealised sectors surfaces organising and organising-performing tensions for CRIs, particularly for decision makers of research projects who must decide to what extent to invest in research in these sectors and how to carry out later stage R&D and commercialisation of biotechnologies:

> *We do what we do in New Zealand, but sometimes you just have to go overseas and arguably that's a little sad that we have to take research overseas that we could do here. Probably rightly so, but the funding bodies in New Zealand see applications with genetic manipulation, probably in a way of – is it ever going to be useful to New Zealand? Because what impact are you going to have if you can never deploy the new construct of the plant or whatever you made in New Zealand?*
>
> – Participant 8, CRI 3

Furthermore, Ishii & Araki (2016) suggested that New Zealand's regulations are ambiguous and therefore may affect future communication pertaining to genetic manipulation regulations between regulatory bodies, research institutes, and the public, implying that the future of regulatory frameworks for genetic manipulation are uncertain, contributing to the learning

dimension of this tension. Participant 8 recognised that changing regulations may influence CRI activities, surfacing a learning tension when they speculated whether laws and regulations in New Zealand surrounding genetic manipulation may change:

> *So, I'd say as long as we are learning from the world and in some ways being a little bit behind in deploying it, maybe we've avoided some of the holes and the pitfalls globally that they may have discovered along the way. So, I'd like to think by now, at least in the world of things like CRISPR, I think pretty much globally there's a bigger awareness of the limitations and the practicalities and the dangers and maybe if New Zealand's just willing to learn from those who have gone before us in this space.*
>
> – Participant 8, CRI 3

4.1.2 CRI impact orientation shift

Consistent with prior literature, participants experienced an overarching organisational performing tension between science impact and science excellence (Bednarek et al., 2017). The shift from being an excellence to an impact and excellence organisation occurred over thirty years ago for CRIs, yet its effects were still found to ripple through the organisation today. This shift is reflective of the saliency condition of change but is also relevant to plurality and scarcity (Smith & Lewis, 2011), and has resulted in additional performing, organising and belonging tensions for CRI employees. Tensions manifested in role identities (theme 2a) and between CRI processes and goals (theme 2b).

4.1.2a Role identity

Participants in commercialisation focused roles experienced belonging tensions as their role responsibilities were unclear to other stakeholders. Participants in these roles engaged with processes unfamiliar to other project stakeholders in order to achieve science impact goals. Their inability to enact those processes surfaced belonging-organising tensions for them:

I guess there was some frustration in the background of you're trying to move things along or things are taking time, but it's outside of your control. And also, working with people in the organization that might not have as much experience with the sort of stuff, so that there's almost a bit of hand holding.

– Participant 5, CRI 3

Interestingly, belonging tensions between commercial and scientific teams were not reported, participants suggested that there was a shared understanding of value of commercially orientated research for the CRI and the impact of applied science:

Luckily, the researchers have been fairly commercially minded. So even though they're scientists, they understand and are interested in the business side of it and realize that something will need to make money to endure.

– Participant 3, CRI 4

You get a certain sort of person, their priorities are to achieve protection of the environment and they tend to be a certain personality type as well, and so we're all working towards the same aim.

– Participant 10, CRI 1

Instead, Participant 10, in their purely scientific role, experienced belonging-organising and performing tensions in relation to role agency and project direction, as opposed to grappling with the values of traditional academic values and commercial research values:

We're supposed to be the experts in the field. And so, we have the internal funding, I'm sure all CRI's do it, they have [internal funding]*, which comes from* [funding body] *into each institute and then the institute decides where it goes. But still, it's contestable, you have to apply to get the money. The chances are greater for getting*

it, but we still have to fight for it as well, and I think some of that needs to be easier to do because we waste a lot of time trying to get money when we should be spending our energies and the money with doing work.

– Participant 10, CRI 1

4.1.2b Processes and goals

On the other hand, the CRI impact shift has resulted in performing and organising tensions for many participants, who described an incompatibility between CRI processes and CRI impact goals. Performing tensions emerged for participants as they attempted to make sense of the purpose of certain life science projects with seemingly no commercial opportunities:

And so we move on and it's always interesting like if we make the assessment and say there's no commercial opportunity for a science project, you would then argue, well, why do they continue with it, right? So, there's obviously some other kind of drivers going on in terms of who's having that input. Yeah, it's kind of an interesting one, it's very difficult to understand for a lot of the science projects exactly what its leading to. So, is it just science for the sake of science?

– Participant 1, CRI 2

Organising-performing and organising tensions surfaced for participants attempting to fit CRI impact goals onto life science discovery projects. The existing project funding mechanisms of CRIs lead to an incompatibility between how research was carried out and CRI impact goals. Participants reported that because industry partners did not inform science discovery, it affected their ability to commercialise research outcomes in the market:

There seems to be a lack of input from industry about what kind of problems there are and how they could get products out the door.

– Participant 1, CRI 2

So, there's nobody that I saw, in the big list that we had, that was an open invitation to try – 'we'll just try any compounds that are possible if only we've got a means of screening them'. No, people tend to have something that they think would work and then they set up a company and get venture capital and run with it for a while.

– Participant 3, CRI 1

Organising tensions surfaced organisational performing tensions for participants, as inefficiencies in the integration of commercialisation processes with scientific research projects at CRIs raised questions about the overarching purpose of CRIs. Participant 2 discussed the challenges of pivoting a biotechnology research project towards commercially relevant information, which surfaced an organising tension for them. They then explained this tension as a difference between stakeholder interpretations of success:

But from a practical point of view, and from actually having impact from the research point of view, I think, my view is probably right that it needs to be done soon-as and the results, it just allows you to say that we have actually done this. It's the main outward-facing point of the whole project. Personally, because CRIs are government institutions, and are publicly funded, success should be measured on impact solely rather than monetary returns.

– Participant 2, CRI 2

However, organising tensions arising from competing CRI processes to achieve impact objectives were not experienced negatively by all participants. Participant 7, occupying a

senior commercial and scientific role, viewed the different approaches encompassed by CRIs can be leveraged to serve industry partners:

> *I guess the strength of any science team is in the complementarity of different approaches sometimes. Especially when we're working with companies, in New Zealand [and] globally. They would come with a specific problem to us, they have defined what the success is and they've obviously very strongly defined the problem. They may have defined a swim lane in between, but often the value that they get out of CRIs and universities is that we can step outside this and we can see things from a different point of view and we can look at it with a different lens and identify different ways of how to get to success.*
>
> – Participant 7, CRI 3

4.2 CRI biotechnology project sensemaking logics

Participants were found to engage with paradox, dichotomous and business-case logics to understand CRI biotechnology project tensions. These findings were consistent with prior empirical literature (Chen et al., 2021; Sharma & Jaiswal, 2017). Within CRI biotechnology project contexts, performing and organising tension types were found to be associated with dichotomous and business-case logic types, due to resource and time constraints, as previously suggested by literature (Hahn et al., 2014; Sharma & Jaiswal, 2017). Whereas between or outside of CRI biotechnology projects, participants engaged with paradox logics to sensemake learning-performing tensions, as tensions were not bound by intense or immediate resource and time constraints.

4.2.1 Complexity reduction logics within projects

Within biotechnology projects, participants with commercial role responsibilities encountered multiple co-occurring performing and organising type tensions between scientific and commercial pathways, strategic IP decisions and social-environmental-economic CRI missions. Dichotomous and business-case logics were engaged to sensemake tensions due to scarcity conditions. Multiple scientific pathways emerge in biotechnology projects as a result of the multitude of opportunities that emerge from scientific research. These opportunities were perceived as performing tensions between distinct scientific pathways and organising tensions between strategies to achieve research outcomes by participants. Participants reported that these opportunities and strategies frequently needed to be chosen between because of time constraints and financial and human resource constraints:

> *Everyone tends to have an opinion on the way to investigate a hypothesis and ultimately, you've got to decide on one way or the other that you're going to do something. Just your lack of resources, time, money, people.*
>
> – Participant 8, CRI 3

Within biotechnology projects, organising and performing tension types were sensemade by participants through dichotomous and business-case logics. Engagement with these logics was facilitated by distinct commercialisation pathways and resource constraints. Participant 1 described commercialisation pathways as “either-or decisions” that do not have a “middle ground”, thereby facilitating a dichotomous logic to sensemake performing or organising type tensions between commercialisation pathways. Resource constraints implicated the ability of CRIs to engage with venturing commercialisation pathways, which conflicted with the overarching impact objective of CRIs, surfacing an organising-performing tension for commercial personnel. Participants were relegated to either-or approaches related

to partnering with industry such as contract research and licensing arrangements towards commercialisation pathway decisions:

> *Because we're CRI, our primary purpose under the 1992 Crown Research Act is to deliver science and either to support industry and what they want or to make new industries. But ultimately, we don't do spinout companies, we don't do any of those sorts of activities which I know some universities do. So, for us, the only way we can get our science into the real world is by partnering with industry.*
>
> – Participant 8, CRI 3

The funding protocols of CRI projects were an additional factor that limited the ability of participants to view or approach tensions paradoxically. Projects at CRIs are reportedly sectioned into funding types at their inception, and commercial personnel are involved in projects once research outputs are being delivered, presenting to them a set of either-or commercialisation pathway decisions bounded by resources and time:

> *So yes, we recognise that our skills can be deployed earlier, but from a revenue generating perspective and priority perspective and funding mechanism perspective, we come in when we do, which is when the research outputs have been generated.*
>
> – Participant 5, CRI 3

> *I think I noticed it a lot, like we do a lot of triage work in terms of commercial assessments, and we often just go – here's a science project, we do a quick assessment, and we'll just say – we don't see a commercial potential for this project, and we then essentially move on because there's only a few of us and there's a lot of projects and stuff… That's essentially kind of what we have to do – go through and*

cherry-pick projects that have a commercial outcome and then try to work on those ones.

– Participant 1, CRI 2

The broader CRI science excellence and science impact objectives were embodied in IP and research publication decisions in biotechnology projects that presented performing tensions for participants. The publication of research was reported to be important for improving CRI image and attracting investment into projects, while IP protection was necessary for ensuring the commercial success of biotechnologies. Within projects, IP performing tensions took place under financial and time constraint conditions, as publication was often an inevitable outcome for research projects, hence it was necessary for participants to view tensions as trade-offs through a dichotomous logic:

If we did progress a patent process, would the costs of that undertaking be justified based on the potential future return? If we chose not to patent at all, if we chose not to file the provisional, then we wouldn't have the option later on because the knowledge would then be in the public domain.

– Participant 6, CRI 1

To sensemake the performing tension relevant to the potential social-environmental impact and economic objectives biotechnology projects, participants often engaged with the business-case logic, highlighting the importance of economic objectives in CRIs:

Some of the social and environmental positives underpin the whole basis for the business.

– Participant 3, CRI 4

4.2.2 CRI horizons

Participants discussed a range of short-term, medium-term, and long-term CRI project horizons. Short-term horizon projects involved specific fee-for-service type R&D activities for industry partners. Medium-term horizon projects were described by Participant 8 as "ongoing relationships" focused on research activities to anticipate future markets and their needs. Long-term horizon projects were referred to as government-funded science projects focused on research that was not incentivised by the market currently but was potentially important for New Zealand industries in the future. The forward-looking nature of CRIs implicates the necessity for certain organisational actors to have a strategic perspective on CRI activities and sensemake learning-performing tensions through a paradox logic. Employees with commercial responsibilities were found to experience learning-performing tensions, as they considered biotechnology project outcomes from a strategic perspective, implicating the internal saliency conditions outlined by Smith and Lewis (2011).

At a broad level across biotechnology projects, a learning-performing tension was surfaced for participants as they considered science-impact and science-excellence tensions between present success and future CRI science capabilities. Participants made sense of this tension through a paradox logic:

> *They definitely go together and it's just really about balancing both of them, being aware of both the short-term needs of the project and the longer-term ambitions of this area of research. So that one doesn't detract from the other or prevent success. So, you don't want this lofty long-term ambition of where you're going to get to, and as a result, there's no progress on the short-term stuff, and then vice versa, you don't wanna be so focused on the short-term that you kind of lose sight of ultimately, what you're trying to deliver.*

– Participant 6, CRI 1

All participants engaged with short-term and long-term considerations, but not all participants experienced a learning-performing tension. For example, Participant 10, as a scientist, engaged with short and long-term considerations through funding applications and instead interpreted these considerations as performing tensions. They recognised an interdependency between the two, as the impact potential of their research had implications for their ability to attain project funding but did not report it as a challenge to do so in their daily activities, noting that they "become very focused into the immediate with the research." In contrast, commercial participants experienced learning-performing tensions when discussing the management of short- and long-term projects and their implications:

> *We can't just keep on having that short sighted, like, let's just do these projects, fee-for-service, at the expense of the commercialisation projects and commercialisation customers that are not getting any attention because all the resources are going on these projects.*

– Participant 4, CRI 2

Within biotechnology projects, strategic decisions surrounding IP surfaced learning-performing tensions for commercial participants. which co-occurred with belonging and organising tensions as they interacted with other stakeholders involved in projects who prioritised different goals, values and organisational processes:

> *And I guess where there was a little bit of conflict, was not the fact that it could be licensed, but the fact that the active licensing would bring with it a considerable amount of restraint of trade in terms of future research opportunities, which may or may not have been more valuable than the actual licensing deal... Everybody's trying to get revenue and run a successful business, but one can prevent the other.*

– Participant 9, CRI 2

Chapter 5: Discussion

The findings of this study present a range of novel insights that support and challenge existing literature and inform tension management in CRI biotechnology and hybrid R&D contexts. Subsequently, this chapter discusses the implications of the findings for theory and practice in two sections, theoretical implications are discussed in section 5.1 and practical implications are discussed in section 5.2.

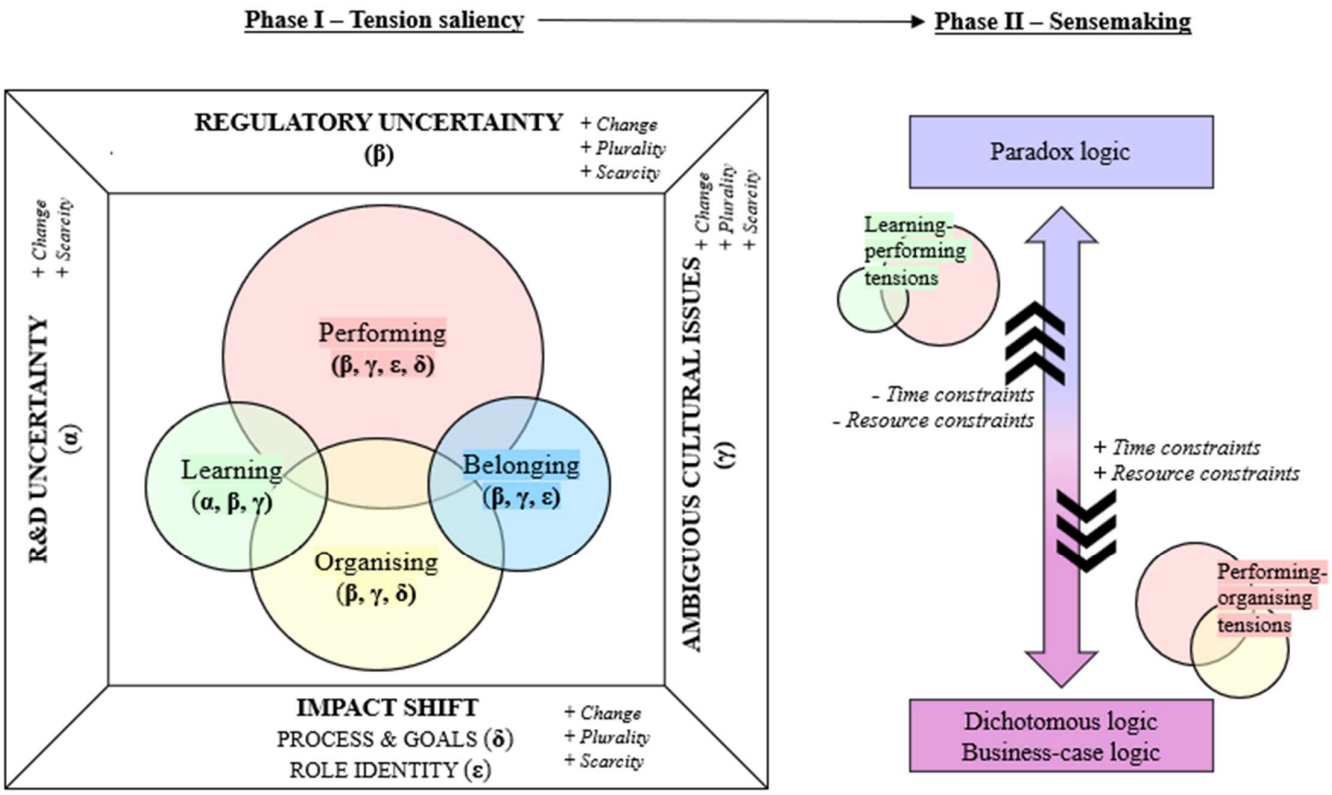
5.1 Theoretical implications

Based on the findings of this study, I provide a revised Dynamic Equilibrium Model tension framework that offers a more nuanced perspective on tensions in CRI biotechnology environments and establishes a connection between tensions and sensemaking logics, shown in Figure 2 below. The revised tension framework is divided into two phases. Phase I represents salient tensions, distinguishing between the saliency of performing, organising, belonging and learning tension types by representing more salient tensions with larger circles. Furthermore, the framework illustrates the complexity of tensions and how they are interconnected by linking circles together. Tensions co-occurred; hence all tensions are linked in the framework. The complexity of tensions is further illustrated by framing tensions with ambiguous conditions and impact shift conditions that surfaced tensions for individuals involved in CRI biotechnology projects. The association between conditions and different tension types is represented by Greek alphabetical symbols. These conditions were amplified by the external saliency factors of scarcity, plurality and change from the original Dynamic Equilibrium Model (Smith & Lewis, 2011). Tension sensemaking, represented by Phase II, is depicted in the framework. Dichotomous and business-case logics are associated with the sensemaking of organising-performing tensions under resource and time constraint conditions. While paradox logics are associated with sensemaking learning-performing

tensions under lower resource and time constraint conditions. The black arrows signify that individuals tend towards dichotomous and business-case logics as time and resource constraints intensify, while individuals tend towards paradox logics as time and resource constraints recede. As a result, the theoretical contributions of this study will be discussed in three sections: theoretical implications for paradox theory tensions, theoretical implications for sensemaking logics and theoretical implications for factors affecting the complexity of tensions.

Figure 2

Revised Dynamic Equilibrium Model Tension Framework



5.1.1 Theoretical implications for paradox theory tensions

The findings of this study provide significant insights into the Dynamic Equilibrium Model (Smith & Lewis, 2011). Although the Dynamic Equilibrium Model divides tensions into four

equal categories, performing tensions were found to be the most salient tension type because participants often discussed the same organisational goals. Performing tensions were therefore more inherent to the shared organisational reality of CRIs. Furthermore, performing tensions were found to be central to other tension types because most of the belonging, organising, and learning tensions discussed by participants were informed by strategic tensions between divergent stakeholder goals. Organising tensions pertained to different approaches to achieve CRI goals, and thus were also tied to performing tensions. As a result, organising tensions were the second most salient tension type for participants. While belonging tensions were reported to have shifted over time following ongoing CRI shifts to embrace both science impact and excellence goals. Learning tensions were often related to either performing or organising tensions in CRIs. Four main organisational performing tensions relevant to CRI biotechnology informed other tension types identified by this study. These tensions were between public good and commercial success, te ao Māori and CRI science, science impact and science excellence, and present New Zealand and future New Zealand science. Therefore, the findings of this study contribute to paradox theory by showing that performing tensions, or tensions between contradictory and interdependent stakeholder goals, are central to other tensions of organising, belonging and learning. As a result, these organisational performing tensions have implications for paradox theory literature in the CRI biotechnology context which will be discussed in this section.

The organisational level performing tension between achieving public good and commercial success goals of CRIs discussed by Bednarek et al (2017) and Ashby et al (2019) was found to surface in undefined regulatory contexts due to ambiguous New Zealand biotechnology conditions, as discussed by theme 1. This performing tension surfaced additional organising and belonging tensions for individuals occupying commercial roles. Biotechnology research outputs frequently span emerging sectors that do not have well defined regulatory

environments, resulting in ethical issues (Hansen, 2001). Regulatory environments impart boundaries on scientific research outputs but are necessary to protect public interests (Kenney et al., 1986; Levidow & Marris, 2001). In the absence of distinct regulatory boundaries, internal stakeholders from the various teams involved in biotechnology projects had to collectively determine whether achieving commercial success was interdependent and contradictory with CRI public interests, resulting in performing tensions. Individual interpretations of CRI success implicate CRI, team and individual role identities and values, thereby surfacing belonging tensions. Boundary conditions implicate how organisational actors achieve desired outcomes (Smith & Lewis, 2011). Thus, the absence of regulations spurs multiple stakeholder approaches to achieving success, resulting in organising tensions in biotechnology projects with undefined regulatory contexts. Consequently, these findings show that the tension between public good and commercial success is not solely a performing tension, as suggested in previous CRI literature (Ashby et al., 2019; Bednarek et al., 2017), but also surfaces belonging and organising tensions for employees. These findings additionally show that regulations have a necessary function in providing boundary conditions that mitigate ethical tensions in the biotechnology industry.

At the same time, overly stringent regulations with uncertain futures may also surface biotechnology tensions for CRIs. Relevant to theme 1, an organisational learning-performing tension found by this study, previously unidentified by CRI paradox literature, was between the divergent duties of CRIs to provide scientific advancements to benefit New Zealand in the present and the future. CRIs experienced a learning-performing tension as they attempted to navigate biotechnology projects that potentially provided solutions for future problems in New Zealand while also focusing on projects that had impact on New Zealand in the present. Genetic manipulation is at the forefront of biotechnological innovation and is potentially relevant to mitigating future climate change issues for New Zealand. Yet, late-stage R&D and

commercialisation of genetic manipulation cannot proceed in New Zealand and offers limited value to New Zealand in the present. Participants with senior commercial role responsibilities had a strategic outlook on CRI success and were familiar with the restrictive regulatory environment and its implications for genetic manipulation research outputs for New Zealand. As decision-makers, senior commercial role participants were also acutely aware of the resource scarcity conditions of CRIs and experienced additional organising tension types when attempting to navigate the extent to which to invest in genetic manipulation projects and how later stage R&D and commercialisation activities should be carried out. These findings show that stringent and uncertain biotechnology regulations impart boundary conditions that are difficult to navigate for CRI decisionmakers, implicating future CRI capabilities and present CRI success, thereby surfacing learning-performing and organising type tensions for CRIs. Consequently, this study contributes to paradox CRI literature by identifying a CRI learning-performing tension at an organisational level that spurs further organising tension types at individual levels; importantly, these tensions are surfaced by New Zealand's uncertain regulatory conditions for biotechnology.

Ambiguous cultural issues unique to New Zealand's biotechnology environment, defined in theme 1, point to an organisational performing tension between te ao Māori and CRI science, presenting a novel tension to paradox theory literature. In contrast to Ashby et al (2019) and Bednarek et al (2017), biotechnology CRI project stakeholders were found to be more nuanced than simply public and private stakeholders. Iwi stakeholders in CRI biotechnology projects may fit both private and public stakeholder categories, depending on the project. Reportedly, iwi stakeholders are typically involved in biotechnology projects when the genetic content of taonga Māori flora and fauna is researched. According to Hudson et al (2019), Māori are a heterogenous group that may have different stances on questions of biotechnology, such as genetic manipulation. The authors further suggest that Māori interests

or goals in relation to biotechnology are those that prioritise community benefits, whereas biotechnology projects may have unclear benefits or even risks for environmental and social causes and are often oriented towards commercial success. As CRIs pursue commercial success in addition to environmental and social goals, an overarching performing tension was surfaced in CRI biotechnology projects with iwi stakeholders who prioritised environmental and social goals above commercial success. These findings provide a more complex understanding of the divergent stakeholder goals CRIs achieve by identifying a novel cultural paradoxical tension between te ao Māori and CRI science systems and linking New Zealand biotechnology to cultural approaches, thereby enriching paradox theory literature.

The prioritisation of social and environmental goals of iwi stakeholders is grounded in Māori cultural values. These values were unclear to participants and participants were uncertain about how cultural values lined up with the scientific or commercial values of CRIs, surfacing additional belonging tensions for individuals and teams. According to respondents, CRIs align commercial, social and environmental objectives, suggesting that performing and belonging tensions in biotechnology projects with Māori contexts are potentially mitigated through a business-case logic. However, organising tensions were particularly salient to participants in these projects, as the heterogeneity of opinions among stakeholder groups necessitates that CRIs embrace flexible procedures, yet flexibility implicates the stability of organisational CRI processes. Organising tensions are surfaced by the integration of flexibility and stability in organisational routines, as flexibility and stability in organisations are interdependent and contradictory modes of organising (Laser, 2020; Smith & Lewis, 2011). Certain CRI procedures are not yet flexible enough to fully accommodate te ao Māori perspectives and approaches, surfacing learning-organising tensions as procedures and knowledge relevant to te ao Māori are still being integrated into CRIs. Prior CRI literature suggested that scientists in CRIs experience organising tensions due to interaction with both

academic communities and commercial clients (Ashby et al., 2019). The findings of this study extend the CRI perspective on organising tensions by showing that commercial role employees experience organising tensions between cultural approaches to biotechnology and traditional scientific or CRI approaches to biotechnology projects due to the involvement of Māori stakeholder groups.

Organisational CRI commercialisation processes and roles similarly have yet to close the gap with CRI impact goals. Theme 2 described tensions relevant to CRI shifts from science excellence to science impact, or a shift from focusing purely on academic success to tangible economic, environmental and social benefits for New Zealand. Theme 2b revisits the organisational performing tension between science impact and science excellence previously identified by Bednarek et al (2017), which was found to surface belonging and organising tension types at team and individual levels in strategic IP, commercialisation pathway and scientific pathway decisions relevant to achieving impact objectives. According to commercial role respondents, tensions between science impact and science excellence limited the ability of individuals to enact change upon stagnant organisational routines that prioritised science excellence to orient them towards science impact goals. Subsequently, the organising and belonging tensions surfaced by the organisational performing tension between science impact and science excellence had a negative effect on commercial team efficiency in achieving CRI impact objectives. From a scientific role perspective, belonging-organising tensions similarly surfaced due to the performing tension between science impact and science excellence as organisational procedures to attain funding for research were contradictory and interrelated with meeting impact objectives, which presented barriers to carrying out scientific research efficiently. As a result, the tensions experienced by individuals involved in biotechnology projects at CRIs had a perceived negative effect on employees' abilities to meet impact objectives effectively. These findings address the gap in paradox theory

literature of the impact of tensions on organisations (Schad et al., 2016). These findings therefore have theoretical contributions for paradox literature, by showing how performing tensions can surface organising and belonging tensions that negatively affect team efficiency.

Theme 2a describes tensions of role identity resulting from performing tensions between science impact and science excellence. As commercialisation focused roles are not as established or numerous as scientist roles in CRIs, commercial role participants experienced belonging tensions as an effect of the performing impact-excellence tension. In contrast, following a shift to impact-excellence CRI goals, belonging tensions experienced by scientists regarding dual scientific and entrepreneurial identities were found to have receded over time. The absence of belonging tensions was reportedly beneficial to the efficiency of collaborative efforts between scientific and commercial CRI teams. Biotechnology is a collaborative field, which requires the integration of scientific and business activities (Hine & Irelend, 2007), therefore the absence of belonging tensions between scientific and commercial teams is a positive development for New Zealand's biotechnology industry as collaboration between scientific and commercial teams is necessary to develop marketable biotechnologies. This finding supports recent literature that suggests that scientists do not experience pronounced tensions from engaging with fundamental and applied science activities (Wang et al., 2021). Furthermore, scientists' identities are flexible and shift in response to contextual needs and are not accurately represented by distinct entrepreneurial or academic categories (Lam, 2010). For paradox literature, this finding suggests that belonging tensions are likely to shift over time due to external events and the fluidity of identity. Additionally, this study contributes to CRI paradox literature by ascertaining the belonging tensions experienced by commercial role employees in CRIs, which has previously investigated scientist's alone (Ashby et al., 2019).

5.1.2 Theoretical implications for sensemaking logics

This study contributes to sensemaking literature by linking sensemaking logics with Dynamic Equilibrium Model tensions. Individuals engaged dichotomous and business-case logics to sensemake performing and organising type tensions due to resource and time constraints. When resource and time constraints were less prescient, as with learning-performing tensions, individuals engaged paradox logics. Although Hahn et al (2014) indicated that sensemaking logics are ideal types and that logics exist on a spectrum, the authors discussed sensemaking logics as discrete frames that individuals adhere to over time. Conversely, the findings of this study suggest that logics are not fixed sensemaking mechanisms, and individuals deviate between dichotomous or business-case and paradox logic types depending on the conditions surrounding tensions. As a result, these findings extend sensemaking literature by showing that sensemaking logics coexist. Furthermore, these findings highlight that logics are dynamic, as suggested by Sharma and Jaiswal (2017) and address the gap in the dynamics between logics and tensions and the contextual conditions that they take place in, which is an underexplored area of organisational paradox theory and sensemaking literature (Schad et al., 2016).

Theme 3 showed that dichotomous and business-case logics were engaged by participants to sensemake performing and organising IP, commercialisation, and scientific pathway tensions under resource constraint conditions within biotechnology projects. Hahn et al (2014) discussed that resource constraints predispose managers to sensemake tensions univalently, or through an either-or lens that is aligned with the dichotomous logic suggested by Chen et al (2021). This study identified that resource constraints reinforced engagement with dichotomous logics and facilitated reliance on distinct CRI commercialisation pathways, such as licensing agreements. Licensing of IP transfers the responsibility for research commercialisation to another party, as a result, the licensee party assumes greater risk and the

licensor party receives lower profits (Van Norman & Eisenkot, 2017). Therefore, for CRIs, licensing is a commercialisation pathway that fulfils the economic objectives to a limited extent. Moreover, the licensee may not have the same strategic goals as CRIs, meaning that the social and environmental impact objectives of CRIs are potentially achieved to a limited extent too. In contrast, venturing commercialisation pathways potentially represent paradoxical approaches to IP commercialisation because they require that research is transformed into a marketable product or service, giving IP owners control over the commercialisation process and generating greater profits. CRIs may therefore achieve economic, environmental, and social objectives to a greater extent through venturing commercialisation pathways. Consequently, this study extends sensemaking literature between logics and outcomes (Carmine & De Marchi, 2022) by connecting dichotomous logics with commercialisation pathway outcomes.

However, venturing commercialisation pathways may require broader and less structured information searches to facilitate creativity (Odei & Novak, 2022), which is a characteristic of the paradox logic (Hahn et al., 2014). Yet, venturing pathways also require high investment costs (Markman et al., 2008) presenting a significant financial risk to CRIs. Markets and industry can inform scientific R&D to de-risk the venturing commercialisation pathway (Bazan, 2019). In CRIs, funding protocols obstruct the influence of commercialisation teams' expertise on markets and industry in many projects until research outputs are nearing completion, further reducing temporal resources available for venturing pathways. Hence, resource constraint conditions of CRIs relegate commercial employees to engage with dichotomous logics to sensemake performing and organising IP tensions. Engagement with dichotomous logics in CRI biotechnology projects allowed participants to eliminate organising and performing type tensions and is likely a necessity to conserve resources and mitigate risk. These findings contribute to sensemaking logic literature by

empirically identifying the conditions that facilitate engagement with dichotomous logics in a CRI biotechnology context and illustrate the relationship between non-paradox sensemaking logics and commercialisation pathways.

In contrast to the dichotomous and business-case logics engaged by participants to sensemake tensions within biotechnology projects, when participants perceived tensions between biotechnology projects, a paradox logic was used. The findings from theme 4 show that learning-performing tensions between scientific advancement for New Zealand's future and New Zealand's present were sensemade through paradox logics. Learning-performing tensions span across time (Smith & Lewis, 2011) and are therefore not bound by immediate resource or time constraints. In the absence of intense resource and time constraints, individuals are more likely to engage with a paradox logic. The relationship between time and paradox logics was previously discussed by Sharma and Jaiswal (2017) in a sustainability context, consequently, the authors found a fluctuation between paradox, business-case and business logic types. However, the findings of this study found that individuals primarily fluctuated between paradox and the dichotomous logic type identified by Chen et al (2021), because environmental, social and economic objectives were not always relevant to CRI biotechnology project tensions. Prior sensemaking literature predominantly takes place in a sustainability context, hence, these findings build on sensemaking literature by linking time perception to paradox and dichotomous logics in a novel field, New Zealand's biotechnology industry.

5.1.3 Theoretical implications for tension complexity

This study contributes to the Dynamic Equilibrium Model and wider paradox theory by addressing the complexity of organisational tensions. Specifically, the revised framework suggested by this study avoids the isolation issues suggested by Cunha and Putnam (2019) because the framework stresses the interconnectedness of tensions and therefore suggests that

tensions are inherently complex. The empirical findings of this study support the complexity of tensions because the performing, organising, belonging and learning tensions were identified to co-occur and surface one another, and hence cannot be discussed separately. Tensions found in this study were reflective of the findings of Jarzabkowski et al (2013), as tensions at the organisational level were found to influence team and individual level tensions. In contrast to the findings of Jarzabkowski et al (2013), organisational level performing tensions, rather than organising tensions, gave rise to other team and individual level organising, belonging, and learning tensions. This difference is likely due to the situatedness of tensions, as tensions are context dependent (Sheep et al., 2016; Smith & Lewis, 2011). These findings support prior paradox literature that suggests organisational tensions are knotted together and amplify each other (Sheep et al., 2016), as demonstrated by the four main organisational performing tensions identified in CRI biotechnology projects and their interconnectedness with other tensions. Tension complexity is underrepresented in paradox theory literature and tends to describe general organisational tensions in an oversimplified manner (Sheep et al., 2016). Subsequently, this study contributes to the complexity of tensions in paradox theory by viewing CRI biotechnology tensions through a holistic perspective that captures the dynamic and interconnected nature of paradoxical tensions.

The complexity of tensions is further illustrated by the revised framework and empirical findings of this study through the conditions that give rise to complex tensions. These conditions were specific to a CRI biotechnology context and were described in theme 1 and theme 2. In theme 1, ambiguous New Zealand biotechnology conditions included R&D uncertainty, ambiguous cultural issues and regulatory uncertainty, which surfaced biotechnology project tensions in CRIs. Ambiguity or uncertainty were frequently discussed by participants, both as inherent to scientific R&D and as features of regulatory and cultural

environments of New Zealand biotechnology. As scientific R&D outcomes could not be predicted, they were uncertain, and multiple scientific R&D opportunities created ambiguity around which opportunity to pursue. Whereas regulatory and cultural conditions created multiple competing options that spurred ambiguous conditions and multiple competing options with uncertain outcomes and future. Smith and Lewis (2011) briefly described ambiguity as co-occurring with paradoxical tensions due to competing demands, while uncertainty was implied to be intensified by the saliency factor of plurality. Whereas the findings of this study suggest that all external saliency factors described by Smith and Lewis (2011) amplify uncertainty and ambiguity surrounding competing demands and surface tensions. Therefore, ambiguous conditions are included in the revised Dynamic Equilibrium Model tension framework, and as a result, this study contributes to the complexity of the Dynamic Equilibrium Model.

In theme 1, scarcity conditions limited the resources available to CRIs for clarification on ambiguous and uncertain issues pertaining to R&D, cultural issues and regulations. CRI biotechnology projects were found to operate with limitations on financial, human capital and time resources, extending the findings of Bednarek et al (2017) and confirming that scientific R&D at CRIs is resource intensive and uncertain. Resource scarcity gave rise to boundary conditions that surfaced the four organisational performing tensions identified in this study as well as other belonging, organising and learning tensions. Plurality was similarly found to surface all tension types, as CRI biotechnology projects involved a range of stakeholders such as industry partners, public funding bodies, commercialisation teams and research teams, the public and iwi. This was particularly prescient in cases involving iwi partners and participants' understandings of te ao Māori worldviews. Scarcity limited the ability of employees to understand and address the te ao Māori worldview, hence scarcity and plurality contributed to interrelated performing, belonging and organising tensions experienced by

participants. Plurality intensified ambiguity, as it contributed to multiple competing options and demands, and was hence relevant to regulatory and cultural biotechnology issues. R&D, cultural approaches and regulatory conditions were subject to change, challenging the ability of CRIs to rely on established routines and protocols. The inability to rely on a predefined roadmap gave rise to ambiguous and uncertain conditions and surfaced all tension types. Therefore, this study expands on the connection between saliency factors, uncertain and ambiguous conditions and their relationship to tensions in the Dynamic Equilibrium Model of Smith and Lewis (2011), as ambiguity and uncertainty are not only features of tensions, but also directly relevant to the saliency of complex tensions.

Whereas in theme 2, impact shift conditions specific to CRIs pertained to changes in impact shifts in role identity and impact shifts in goals and processes. The condition of change was embodied by the shift to science impact and excellence objectives and other related restructures that CRIs have undergone since their inception (Ministry of Business, Innovation and Employment, 2020). Hence change surfaced all tension types and was not exclusively associated with learning tensions (Smith & Lewis, 2011). Scarcity was relevant for imparting boundary conditions on achieving science impact and science excellence objectives. Whereas plurality contributed to multiple competing goals, approaches, values and role identities, and knowledge. The saliency conditions identified in these findings co-occurred and created situations where tensions were interrelated. For example, performing, belonging and organising tensions were interrelated, as they were surfaced by change and plurality conditions of CRIs shifting towards science impact goals and the creation of impact-oriented CRI roles. Sheep et al (2016) previously connected scarcity conditions to complex tensions. This study draws additional connections between the other saliency conditions of change and plurality to tension complexity. Therefore, this study enriches the complexity of paradox

tensions by exploring the saliency conditions specific to CRI biotechnology environment tensions and capturing their relationship with tensions holistically.

5.2 Practical implications

This study identifies four organisational performing tensions and other tensions at team and individual levels that provide CRIs and similar research institutes operating in New Zealand's biotechnology industry with an awareness of the potential tensions (Hahn & Knight, 2021) surfaced by biotechnology projects. An awareness of tensions is an essential prerequisite for managing organisational paradox tensions effectively (Hahn et al., 2017). Tensions can lead to paralysis and impact team efficiency (Hahn & Aragón-Correa, 2015). This issue was demonstrated by the science impact-excellence organising-performing tensions, that negatively influenced team level efficiency. For hybrid R&D organisations like CRIs, scientific and commercialisation processes are contradictory at different points in time (Ireland & Hine, 2007), suggesting that a careful balance between these processes is necessary across the entire time horizon of R&D projects. Furthermore, the revised tension framework suggests that organisations encounter complex tensions, indicating that organisational tensions should be viewed and managed holistically. CRIs and similar hybrid R&D organisations may therefore benefit from more deliberate and flexible strategies to manage the processes associated with science impact or research commercialisation. Tensions between commercial success and public good, te ao Māori and CRI science, and present and future science to benefit New Zealand became particularly salient in ambiguous regulatory and te ao Māori contexts for commercial role employees. These tensions suggest that CRI employees may benefit from additional support in navigating these ambiguous contexts, possibly in the form of expert advice and opinion.

Tensions between te ao Māori and CRI science systems were particularly difficult for participants to navigate as participants were unfamiliar with cultural Māori approaches. The interplay of time constraints with these performing, organising and belonging tensions indicates that participants potentially engage dichotomous and business-case logics to sensemake these tensions. As a result, time constraints may detract from employees' ability to engage with these tensions paradoxically. By introducing expert advice, the time constraints employees experience in biotechnology projects with te ao Māori contexts are potentially mitigated. As a result, employees may be positioned to engage with tensions between te ao Māori and CRI science systems paradoxically, enhancing their ability to achieve better CRI research outcomes that fulfil both science impact-excellence goals-and Māori goals.

The tension framework provided by this study also highlights the influence of saliency factors and provides practitioners with an awareness of the importance of these factors in surfacing tensions. Organisational resilience to the external conditions of scarcity, plurality and change can mitigate the saliency of complex tensions. However, the conditions of scarcity, plurality and change may be difficult to influence, as they are inherent to CRI biotechnology and potentially other hybrid R&D contexts. Alternatively, scholars suggest paradoxical managerial discursive strategies to reframe tensions as opportunities rather than threats, which can mitigate tension complexity (Sheep et al., 2016), emphasizing the importance of engaging paradox sensemaking logics. Practitioners may engage with discursive sensemaking strategies when external saliency conditions are prescient. For example, CRIs may engage with paradox logics strategically amid CRI and national science ecosystem changes and restructures to mitigate performing tensions that become more salient during organisational restructuring (Jarzabkowski et al., 2013). Paradox logics may facilitate acceptance responses to tensions as opposed to defensive responses that seek to eliminate

tensions (Hahn et al., 2014), presenting a more holistic approach to tensions that may fuel virtuous cycles and give rise to organisational sustainability (Smith & Lewis, 2011). Furthermore, biotechnology is an inherently innovative field, and engagement with paradox logics is suggested to improve organisational creativity and innovation (Miron-Spektor et al., 2018). Therefore, practitioners in CRI biotechnology contexts may benefit from strategically engaging with paradox logics.

The revised tension framework embodies the sensemaking findings of this study, showing that sensemaking logics are influenced by time and resource constraints. Prior empirical literature suggests that a balance between paradox and non-paradox logics is necessary to achieve divergent goals simultaneously and effectively (Carmine & De Marchi, 2022). Paradox logics may lead to more detail-oriented approaches that consider all aspects of a situation, but may be less efficient, whereas non-paradox logics facilitate efficient decision-making but may neglect important details (Hahn et al., 2014). Practitioners may benefit from an awareness of sensemaking logics, as well as the influence of time and resource constraints on sensemaking. Within CRI biotechnology projects, dichotomous logics were shown to dominate tension sensemaking to conserve resources and manage risk. However, to maximise fulfilment of social, environmental and economic objectives, CRIs may engage with venturing commercialisation pathways through the adaption of organisational conditions to facilitate engagement with paradox logics. These organisational conditions are CRI funding mechanisms and the integration of commercialisation procedures with R&D procedures. Procedures associated with funding mechanisms require more flexibility so that commercialisation personnel can enter projects during early-stage research, allowing CRI biotechnology research to be informed by commercial knowledge of markets and industry and thereby decreasing time resource constraints on commercialisation procedures. Resource and time scarcity conditions remain a primary factor in surfacing CRI biotechnology tensions

and limiting their mitigation through paradoxical approaches. Consequently, change is required at a systemic level to improve CRI capabilities, New Zealand's biotechnology industry, and the wider national science ecosystem.

Chapter 6: Conclusion

This chapter summarises the key findings of this study in relation to the research questions (section 6.1), followed by a discussion of the limitations of this study (section 6.2) and potential avenues for future research (section 6.3).

6.1 Summary of findings

This study investigated the tensions surfaced in CRI biotechnology projects, as tensions potentially interfere with CRI biotechnology outputs. CRI biotechnology outputs are essential contributions to New Zealand's emerging biotechnology industry. Consequently, this study endeavoured to answer two research questions: (1) What tensions are surfaced by biotechnology projects at Crown Research Institutes? And (2) how are biotechnology project tensions perceived and understood by Crown Research Institute employees? The abductive thematic analysis of 10 semi-structured depth interviews identified key findings that addressed these research questions. The first research question of this study was addressed by utilising the Dynamic Equilibrium Model (Smith & Lewis, 2011) to identify paradoxical performing, organising, belonging and learning tensions. Four overarching performing tensions between contradictory and interrelated organisational goals were found to surface in CRI biotechnology projects. These performing tensions were between commercial success and public good, te ao Māori and CRI science, science impact and science excellence, and scientific advancement for New Zealand's future and scientific advancement for New Zealand's present. Organisational performing tensions surfaced a variety of team level and individual level belonging, organising, and learning tensions specific to the CRI biotechnology context. The hybridity of CRIs and ambiguities in New Zealand's biotechnology industry were central to these tensions. The second research question was addressed by investigating the sensemaking logics individuals involved in CRI biotechnology

projects engaged to understand tensions. Dichotomous and business-case logics were predominantly engaged by individuals sensemaking tensions within CRI biotechnology projects. Whereas paradox logics were engaged by individuals sensemaking tensions between CRI biotechnology projects.

Firstly, the key findings of this study supported the development of a revised Dynamic Equilibrium Model tension framework and addressed several gaps in paradox theory and sensemaking literature. The revised tension framework extended paradox literature and improved the Dynamic Equilibrium Model by differentiating between the saliency and centrality of tensions, with performing tensions being central to other tension types, and showing that performing and organising tensions are more salient than tensions of belonging and learning. The revised tension framework contributes to the tension complexity perspective (Cunha & Putnam, 2019; Sheep et al., 2016) by showing that tensions are interrelated and are potentially surfaced by conditions of ambiguity and uncertainty, amplified by external saliency factors (Smith & Lewis, 2011). Furthermore, by applying the Dynamic Equilibrium Model to a CRI biotechnology context, novel cultural tensions were identified that were previously unknown to literature, and knowledge on Dynamic Equilibrium Model tensions in CRI contexts was extended. CRI biotechnology conditions that surfaced tensions and the influence of tensions on team level efficiency addressed the gap of impacts of paradoxical tensions on organisations and the conditions that give rise to paradoxical tensions (Schad et al., 2016). This study also linked sensemaking logics to Dynamic Equilibrium Model tensions, establishing a stronger connection between paradox theory and sensemaking literature. Business-case, dichotomous and paradox logics were shown to coexist, highlighting that logics exist on a spectrum and not as inherent frames (Hahn et al., 2014). Sensemaking was investigated in a novel context, outlining the

importance of dichotomous and paradox logics in non-sustainability contexts, and the influence of resource and time constraints on the logics engaged with by individuals. Secondly, the revised tension framework and findings of this study provided implications for the management of CRIs and similar hybrid R&D organisations operating in the biotechnology industry. The revised framework provided practitioners with an awareness of tensions and the influence of resource and time constraints on sensemaking logics. The framework showed that tensions should be viewed and managed holistically, and that practitioners may mitigate the saliency of tensions by improving organisational resilience to conditions of plurality, scarcity and change. Alternatively, practitioners may reframe tensions by engaging paradox logics when saliency conditions are prescient. In CRI contexts, venturing commercialisation pathways can be accessed by engaging with paradox logics to sensemake science impact-excellence tensions if practitioners mitigate resource and time constraints. Ultimately, reducing resource and time constraints is key to maximising the achievement of divergent goals in CRI biotechnology contexts, necessitating change at a systemic level to improve New Zealand's science ecosystem and biotechnology industry. Additionally, New Zealand's biotechnology industry presents ambiguous regulatory and te ao Māori contexts that CRI employees require additional support in to mitigate tensions. Consequently, this study identifies opportunities for improvements in New Zealand's CRI system, the broader national science ecosystem and New Zealand's biotechnology industry.

6.2 Limitations

The primary limitation of this study is its transferability to other contexts. The tensions investigated by this study are highly situated in New Zealand's CRI biotechnology context. Similarly, sensemaking logics are unique to individuals in a specific time and place, meaning the logics identified by this study are embedded in a CRI biotechnology context. As a result,

the tensions and logics identified by this study are potentially unique to CRIs and may not be reflective of the tensions surfaced and their associated logics in other types of organisations. Organisations that have a similar hybrid business model and R&D focus to CRIs, such as PRIs in other countries, may not experience the same tensions or logics identified by this study, as other countries may have a different set of biotechnology and science ecosystem conditions. This study addressed transferability by describing contextual conditions relevant to the findings of this study in section 3.4. Consequently, scholars and practitioners should be aware of the limitations to the transferability of these findings to other contexts.

6.3 Future research

The findings of this study presented several avenues for future research. Firstly, this study investigated tensions and logics. According to Smith and Lewis (2011), tensions are informed by responses. Future research investigating CRI biotechnology tensions may investigate responses to tensions, how tensions are influenced by individual responses and possibly draw connections to sensemaking logics as well. Secondly, this study provided a revised Dynamic Equilibrium Model tension framework. Future research may investigate the relevance of this framework to other organisations or research institutes to identify whether it is applicable to other contexts. Thirdly, this study identified that time significantly influences sensemaking logics and influences belonging tensions. Future research may address the relationship between time, sensemaking logics and Dynamic Equilibrium Model tensions further through longitudinal research. Finally, this study found novel cultural paradoxical tensions in R&D organisations. Te ao Māori worldviews and their interplay with New Zealand biotechnology R&D is a topic that warrants further research and elaboration. As a full-scale exploration of this topic is outside the scope of this study, future research may investigate the nature and

impact of cultural tensions in organisations from a New Zealand context, as this is an area in paradox literature that has not yet been explored.

Appendix A: Interview Guide

a. Introductory Questions

1. *What is your role at this CRI? Is this the only role you've had here?*
2. *How long have you been employed here?*
3. *Have you participated in many life-science projects or very few?*
4. *What is your professional/academic background?*

b. Performing

1. *Was there a situation where you had different opinions with others [stakeholders] while working on a [specific] life-science project?*
2. *Can you describe the situation and why there were different opinions?*
3. *What do you think of these opinions and how do you understand them?*
4. *Do you see them as more conflicting or complementary?*
5. *How do you understand the relationship between the opinions?*

c. Organising

1. *In life-science projects, have you found that you had different approaches to others [stakeholders] on how to achieve success?*
2. *Can you describe the situation and what the different approaches were?*
3. *What do you think of these approaches and how do you understand them?*
4. *Do you see them as more conflicting or complementary?*
5. *How do you understand the relationship between the approaches?*

d. Belonging

1. *Have there been situations in life-science projects where you found you had different values, assumptions, or norms to people you're collaborating with?*
2. *Can you describe the situation and what the different values, assumptions, or norms were?*

3. *What do you think of these values and how do you understand them?*
4. *Do you see them as more conflicting or complementary?*
5. *How do you understand the relationship between the values/assumptions/norms?*

e. Learning

1. *In life science projects, have you found it challenging to accommodate short term and long-term considerations?*
2. *Can you describe the situation and what the different considerations were?*
3. *What do you think of these considerations and how do you understand them?*
4. *Do you see them as more conflicting or complementary?*
5. *How do you understand the relationship between them?*

f. Snowballing

- *Do you know anyone else from commercial or scientific teams who have been involved in life-science projects who I can speak to?*

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